# EMPA Activities 2003

## Report on technical and scientific activities

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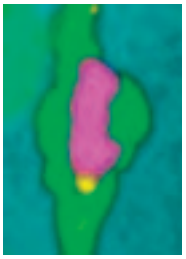

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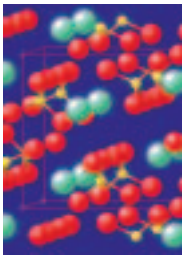

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Information, Reliability
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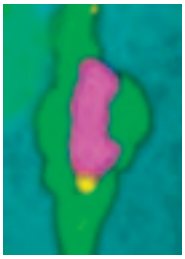

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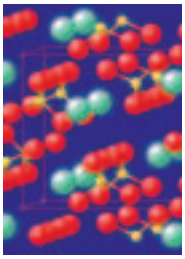

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# WELCOME

2003

**Knowledge Generation –**
**Knowledge Transfer**

Empa as a Materials Science and Technology Institution within the ETH domain is part of the Swiss Science-Technology-Education community. Generating and transferring knowledge are our main tasks. We generate knowledge to fulfill the needs of the society in the materials related technologies in the fields of wellbeing and health, mobility, communication, constructions, energy, atmosphere and environment. Sustainability and safety for human beings and for nature are integrating and cross sectional themes, which require our interdisciplinary approach. We acquire results of fundamental research on materials properties and phenomena, and create new ideas for innovative solutions, which we offer to our partners in the private and public sectors, and to the knowledge society, in general. The acquirement of knowledge and the dissemination of our knowledge are the major steps of Empa's bidirectional knowledge transfer. Accordingly, we are active on five levels, with

1. the international science and technology community, by means of high quality journals, books and conferences
2. partners from the public and private sectors, many of which are SMEs
3. eager and motivated citizens and politicians
4. teaching activities and PhD formation
5. Empa staff, for improving interdisciplinarity across different departments and laboratories.

A few years ago, Empa developed a first tool to support knowledge transfer, namely the Empa Academy. In various types of events, the Academy offers the Empa knowledge to a growing audience (cf. pages 111–114). Reciprocally, the Academy invites guest speakers as specialists to stimulate discussions and support continuous formation of the Empa staff and guests. Soon, the Academy together with library and other services will form a general knowledge management unit. Printed products like this report "Activities 2003", the Empa Annual Report and the periodically published "empaNews" are well established transfer tools. In addition, a new brochure called "Reise in die Welt des Nanometers" (Journey into the World of Nanometers) for high-school level has recently been created and is at the disposal for whoever requests it.

Quality control of newly generated scientific knowledge is a necessary task but far from easy. High level journals with good peer review systems and rapid editorial work are available for science and technology domains with a well developed culture of publication. In some engineering fields, especially in civil engineering, this particular culture is not worldwide well developed yet; delays are still the same as in the pre-IT-times. The visibility of Empa's performance is suffering from this lack of culture, foremost due to Empa's rather high amount of engineering activities.

We are proud of the achieved scientific output 2003 as 60 PhD studies are in progress, more than 120 SCI/E publications have appeared and 12 patents have been submitted. Our goal for the near future remains intact, namely that each scientist generates knowledge worth publishing in a high quality paper, and this once a year.

Louis Schlapbach
CEO EMPA

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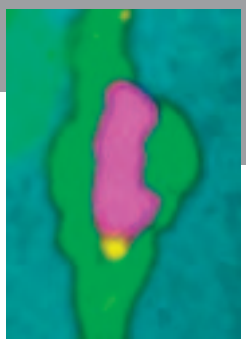
# EMPA Activities 2003
# Advanced Materials and Surfaces



## Mission

Our design and development of advanced materials and surfaces with novel properties are based on the efforts of fundamental understanding on the microscopic and nanoscopic levels. We focus on high performance ceramics, functional polymers and selected metallic systems, their surfaces and interfaces, on coatings as well as on composites. Process technology and functional behavior, reliability and sustainability are important evaluation criteria.

## Activities

In 2003, we strengthened considerably, our activities in **nanotechnology**. In view of display and X-ray technologies, our knowledge and reputation in the field of electron emission from carbon nanostructures led to industrial collaboration with national and international companies. A new laboratory "nanotech@surfaces" was built and equipped with photoemission and low temperature SPM techniques. We signed an agreement with the University of Basel, established a common professorship. We are planning projects to join their National Competence Center for Research (NCCR) named "Nanoscale Science". With our experience in **nanomechanics,** we initiated industry collaborations focusing on functionalized hard coatings, nanopatterned surfaces for implant technology, as well as micro-and nanomanipulation for nanofactory tools. We built two manufacturing pilot plants for **nanopowders,** namely by a flame pyrolysis process and a plasma synthesis route. These powders are integrated into bulk materials or coatings promising outstanding property profiles, such as novel polymers with tailored refractive index, lacquers with excellent abrasivity or nanostructured brazings with gradient properties. Nature's principles are the guideline for our initiative in molecular surface engineering.

**Functionalization of materials and surfaces** is our second integrating task. Plasma treatment of surfaces as well as thin coatings by mixed carbide-nitride-silicide ceramics with integrated metallic nanosized particles and by quasicrystalline materials are developed in view of improved behavior, for adhesion, friction, wear and fretting.

We developed new **composites** with anisotropic heat conductivity or with adjustable thermal expansion for superior joining technologies, e.g. in energy, tooling and space applications. Highly flexible PZT fibers processed in our ceramic laboratory are integrated into composites and evaluated in our research program "Adaptive Materials and Systems".

We investigate into a better understanding of the **initial stages of corrosion** applying modern electrochemistry on the micro/nano-scale, on one hand by advanced capillary tools, and on the other hand by detailed studies of thin passivation and conversion layers at the surface of complex light metal alloys.

In the field of future **energy conversion systems,** we focus on advanced materials concepts for the management of electric and thermal conductivities as a function of temperature; solid oxide fuel cells, hydrolysis and thermoelectricity are our targets.

The Swiss “Commission of Technology and Innovation” provides adequate funding for related national projects with industrial partners, whereas several Empa initiatives have been successful on the level of EU’s 6th Framework Research Program regarding internationally integrated projects. In the last few years, we have successfully built up a widespread network involving not only industry but also academia; our research and development projects are more and more carried out by postdocs as well as PhD students joining Empa from all over the world. Today, our materials research and development activities compete with those of the best groups worldwide. Results are published in prestigious journals and presented as invited lectures at international conferences.

*Walter Muster, Department Head*

# Glow discharge optical emission spectroscopy for depth profiling of medical implant surfaces

Johann Michler,
Max Aeberhard,
in collaboration with
Richard Payling,
University of
Newcastle (Aus),
Dirk Velten,
Jürgen Breme,
University of Saarland (D)

**Through newly developed GDOES depth profiling data evaluation algorithms we were able to obtain composition depth profiles from different thin oxide films on Ti6Al4V medical implants. Analysis of oxide films prepared by different processing routes demonstrate that the composition, in particular the vanadium content of the oxide layer, can be controlled by means of the oxidation procedure in order to guarantee the demands for biocompatible surface properties.**

Titanium and its alloys are the metallic biomaterials of choice e.g. for use in artificial hip or knee joints because of their biocompatibility, bioadhesion and mechanical properties. The excellent biocompatibility is linked with a stable and dense surface layer of titanium oxide. The bioadhesion is provided by a hydroxylation of the oxide layer. Anodic and thermal oxidation are commonly used industrial procedures to increase the thickness of the oxide layer. In the case of Ti6Al4V, however, it has been speculated that the toxic element vanadium may be incorporated within the oxide layer. Sol-gel processes are, therefore, under development for deposition of pure titanium oxide layers. Such process development needs the knowledge of hydrogen and vanadium distribution over the film thickness.

GDOES is an emerging technique for depth profiling of thin films: Ar ions and Ar neutrals of very low energy, typically 50eV-200eV, erode the thin film more or less “atomic layer by layer” and at every instant of the sputtering process, the most recently removed atomic layer is present in the plasma that is analyzed by optical emission spectroscopy (Fig. 1). We applied recently developed data evaluation algorithms for GDOES to quantify depth profiles obtained from titanium oxide film prepared by sol-gel deposition, and conventional thermal oxidation and anodization (Fig. 2). Anodic and thermal oxidized films were found to contain significant amounts of aluminium and vanadium, whereas through the sol-gel process we were able to deposit almost pure titanium oxide films. Different depth had to be sputtered until the composition of Ti:O = 1:2 was found, which may be related to different thicknesses of the hydroxide surface layer on the differently prepared oxide layers.

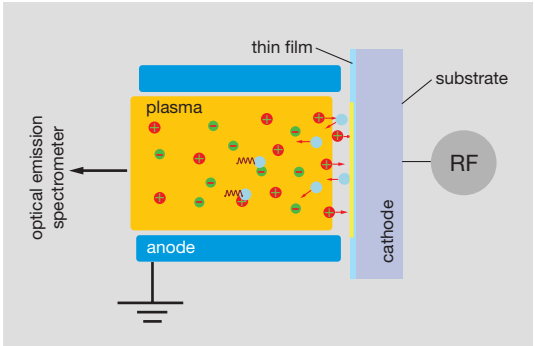



***Fig. 1:*** *Scheme of sample sputtering and optical emission in a glow discharge.*

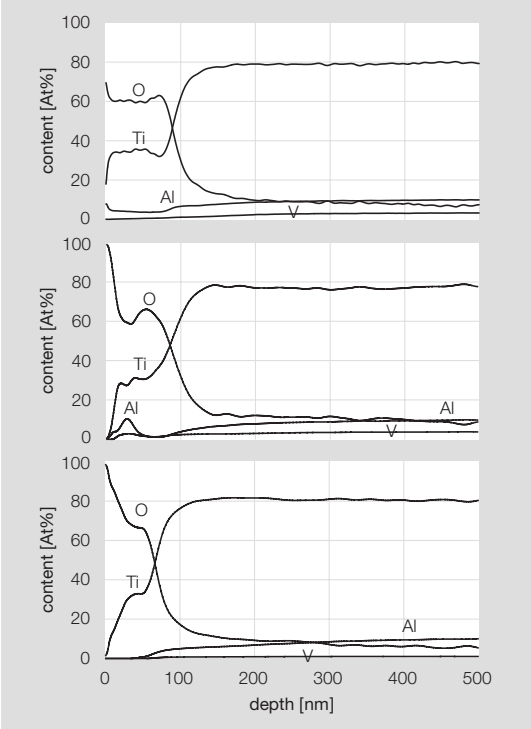



***Fig. 2:*** *Quantitative depth profiles of thin titanium oxide films obtained using different processing routes (a) anodic oxidation (b) thermal oxidation and (c) sol-gel deposition.*

Current projects are related to the control of composition, porosity and microstructure of anodic titanium oxide films. GDOES with its unique combination of fast sputtering rate, high depth resolution, excellent sensitivity and multi-element capability will be used to quantify the hydrogen content within the thin films.

**Links:** www.glow-discharge.com/

***Contact:*** *johann.michler@empa.ch*

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*J. Michler, R. Payling et al., Thin Solid Films, in press (2003)*
*R. Payling, J. Michler et al., Surface Interface Analysis 37, 583 (2003)*
*R. Payling, J. Michler et al., J. Analytical Atomic Spectrometry 18, 658 (2003)*
*R. Payling, J. Michler et al., Surface Interface Analysis 35, 334 (2003)*
*R. Payling, J. Michler et al., in: Glow Discharge Plasmas in Analytical Spectroscopy, R.K. Marcus, J.A.C. Brokaert (eds), Chichester, John Wiley & Sons (2003)*

# Direct determination of the absolute conformation of adsorbed molecules

**The interaction of chiral molecules with solid surfaces plays an important role in biomineralisation, enantioselective heterogeneous catalysis, enantioselective sensing, and chiral chromatography. On the microscopic scale these processes are not well understood, because of the lack of information on the local geometry of the molecules in their adsorbed state. We demonstrate that angle-scanned X-ray photoelectron diffraction (XPD) allows to determine the absolute chirality of adsorbed chiral molecules in a straightforward way and delivers detailed information on the molecular conformation.**

Roman Fasel,
Karl-Heinz Ernst,
in collaboration with
Joachim Wider and
Christoph Quitmann,
SLS/PSI (CH),
Thomas Greber,
University of Zürich (CH)

Chiral molecules adsorbed on a surface play an important role in stereoselective heterogeneous catalysis. For example, tartaric acid serves as chiral modifier for enantioselective hydrogenation of β-ketoesters over supported nickel catalysts. In order to understand the mechanism of enantioselectivity in surface reactions, the local modifier structure in connection with the local prochiral precursor geometry must be known, since it has a great influence on the handedness of the product. For molecules larger than a few atoms, however, the determination of molecular orientation and conformation is by no means a trivial task. Most traditional structural methods fail in the case of too many atoms per unit cell, and spectroscopic methods probing transition matrix elements rely on the existence of a few but well defined and separated symmetry elements.

We demonstrate that the absolute conformation of chiral molecules adsorbed on single-crystal surfaces can be determined in a straightforward fashion by means of synchrotron-radiation angle-scanned X-ray photoelectron diffraction (XPD). In the so-called "forward-focusing" regime, this method delivers direct real-space structural information without the need for complex calculations (Fig. 1). For our study we chose the "classic" tartaric acid molecule adsorbed on the Cu(110) surface. This adsorbate system has previously been studied in great detail. At low coverages and after activation at 405 K, tartaric acid becomes doubly deprotonated, with the resulting bitartrate species forming long-range ordered chiral structures on the surface.

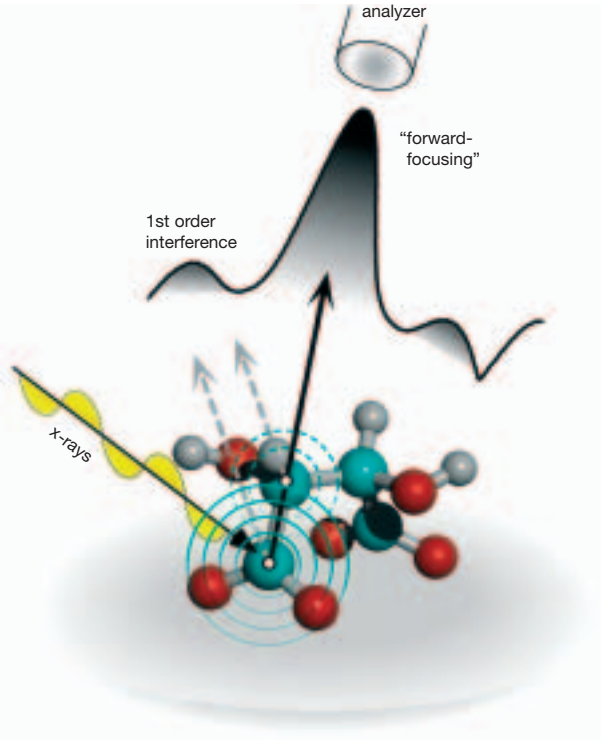


***Fig. 1:*** *Illustration of the general principle of the angle-scanned XPD experiment.*

Figure 2 shows the experimental C 1s XPD patterns from the *(R,R)*- and *(S,S)*- bitartrate enantiomers adsorbed on the Cu(110) surface. Ten prominent intensity maxima are observed in the XPD patterns, and it is obvious that the patterns from the two enantiomers are mirror images with respect to each other. Furthermore, the chirality of each tartaric acid enantiomer is directly reflected in the corresponding XPD pattern. Due to the fact that strong intensity maxima correspond to emitter-scatterer directions and the emitters are known to be the carbon atoms, the conformation of the carbon backbone and the positions of the OH-groups relative to the C-skeleton are easily determined from the XPD patterns by applying purely geometrical arguments.

In addition to the absolute conformation that results from this straightforward geometrical triangulation, detailed structural parameters can been determined by comparing the experimental XPD pattern to those obtained via calculations, systematically optimizing the structural parameters until best agreement is achieved. The best-fit structure (Fig. 3a) is identical to the structure derived from the purely geometrical arguments given above (Fig. 2c), thus yielding a consistent picture of the molecular conformation. The conformation of the *(R,R)*- bitartrate enantiomer on Cu(110) as predicted from density functional theory (DFT) calculations (Fig. 3b) is qualitatively similar to

the one determined here, but with significantly smaller angular distortions. Such conformational changes upon adsorption are driven by the subtle energy balance between bonding to preferred substrate sites, intermolecular interactions, and the stability of the molecular bonds. Investigations on the conformational change of adsorbed molecules, as presented in this work, therefore have the potential to give detailed insight into the mechanisms of molecular chemisorption and provide a stringent test for results obtained from DFT calculations.

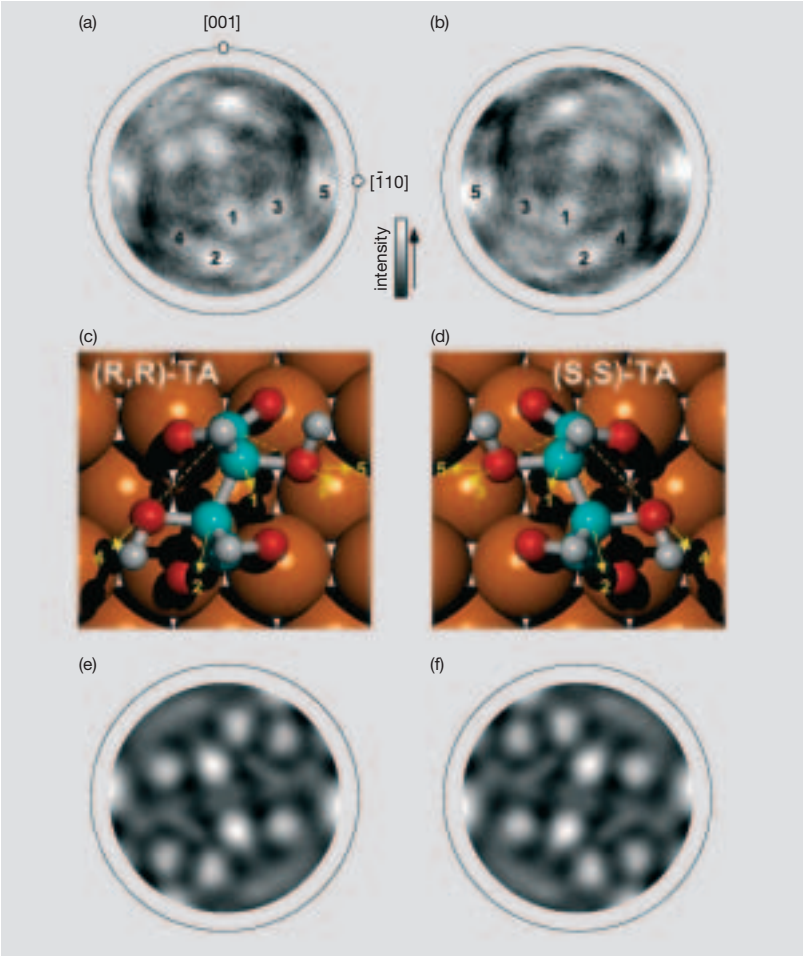


***Fig. 2:*** *(a), (b): Experimental C 1s XPD patterns from the (R,R)- and (S,S)-bitartrate adsorbed on Cu(110), respectively. (c), (d): Molecular conformations deriving from a purely geometrical evaluation of the positions of the prominent forward-focusing maxima labeled 1-5 in (a) and (b). As indicated by the arrows, each peak can be associated to photoelectron emission from one of the C-atoms and forward-focusing by a particular O or C-atom. (e), (f): Best-fit single-scattering cluster calculations for the (R,R)- and (S,S)-isomers, respectively. The simulations for the optimized molecular conformations accurately reproduce the experimental XPD patterns.*

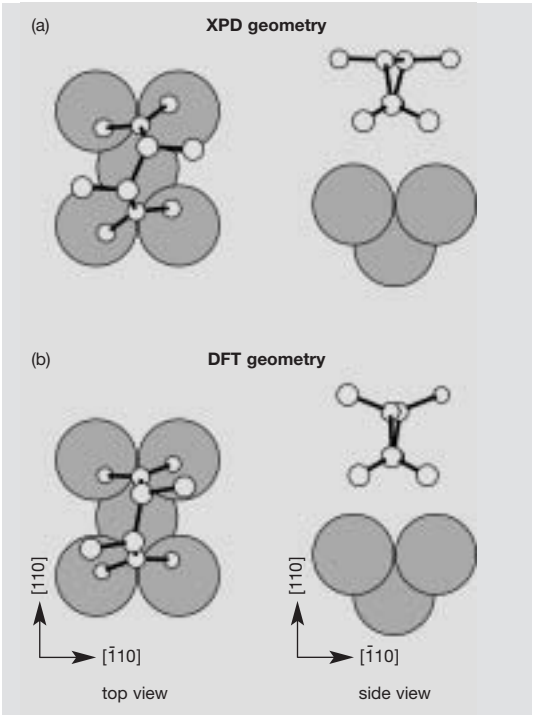


***Fig. 3:*** *Best-fit molecular conformation determined in the present work (a) compared to the molecular conformation predicted from DFT calculations (b).*

Such experiments rely, however, on an advanced synchrotron radiation source where a high signal-to-background ratio allows the structure determination of low density and low Z molecules in dilute adsorbate systems. With further increasing brilliance and stability of new synchrotron radiation sources it will become possible to achieve additional chemical sensitivity in XPD by selecting a specific chemically shifted core-level emission line. This opens the exciting opportunity to selectively investigate the local geometrical environment of an atomic species in different chemical surroundings within a molecule.

**Support:** SNF, Board of the ETH

**Links:** www.empa.ch/oft

***Contact:*** *roman.fasel@empa.ch*
***References:***
*R. Fasel, J. Wider, C. Quitmann, K.-H. Ernst, T. Greber; Angew. Chem. Int. Ed., in press*

# Exploring the mechanism of chirality transfer via molecular mechanics calculations

**We have investigated the transfer of chirality from single helical molecules into self-assembled monolayers by means of scanning tunneling microscopy and molecular mechanics calculations. We find that the intermolecular interaction is dominated by steric repulsive forces between the rigid helices, causing a direct transfer of chirality.**

Roman Fasel,
Manfred Parschau,
Karl-Heinz Ernst

Although the self-organization of chiral molecules into helical architectures is of fundamental importance in nature and has found important applications such as in liquid crystal (LC) technologies, the mechanism of chirality induction is still poorly understood. We focus on the self-assembly of chiral molecules on solid surfaces, where the transfer of chirality can be studied in two dimensions. Helical heptahelicene molecules ([7]H, $C_{30}H_{18}$) adsorbed on Cu(111) form handed supramolecular structures that can be rationalized using a simple model based on hexagonal packing and systematically varying azimuthal orientations of the molecules (Fig. 1). In the framework of this model, the symmetry of the close-packed layer is lowered due to the $C_1$ symmetry of the adsorbed [7]H molecules and due to their chirality. Consequently, particular combinations of neighboring azimuthal orientations are energetically more favorable than others. This leads to a distinct transfer of the structural information – the chirality in this case – into the two-dimensionally organized layer. Therefore, it is the shape of the molecule under repulsive conditions that governs the transfer of chirality.

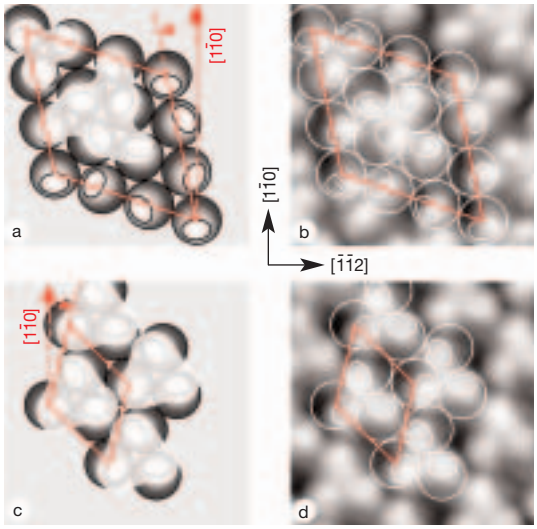


***Fig. 1:*** *Structure models for the (M)-heptahelicene 6&3-molecule cluster (a, b) and the 3-molecule cluster structures (c, d) based on a hexagonal packing of the molecules and systematically varying azimuthal orientations. The model structures are superimposed on the corresponding STM images in b) and d).*

In order to corroborate this transfer mechanism and to confirm the proposed azimuthal arrangement, we have performed molecular modeling calculations for the 3-molecule cluster structure. The total energy of the system was calculated (AMBER force field) for all combinations of adsorption sites and azimuthal orientations. In the two lowest total energy configurations (Fig. 2) neighboring molecules differ in azimuthal orientation by 120°. The first geometry (Fig. 2c) is clearly identical to the topographic model shown above (Fig. 1), thus confirming our simple model and the proposed chirality transfer mechanism. The second configuration corresponds to the other rotational domain observed in the STM image (Fig. 2b).

The 2-D orientation mechanism observed here can be considered as the analogue of the helical twisting in three-dimensional cholesteric phases. This shows that surface studies of 2-D model systems are an excellent approach towards an understanding of the far more complicated 3-D LC systems.

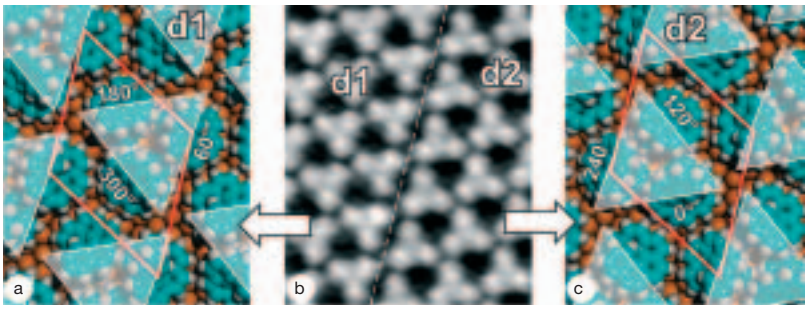


***Fig. 2:*** *a) and c) The two lowest total-energy configurations of the 3-molecule cluster structure. White semi-transparent triangles highlight the topmost parts of the molecules that are imaged brightest. Both geometries are in excellent agreement with the observed d1 and d2 domain structures. b) STM image of a domain boundary between the two rotational domains d1 and d2.*

**Support:** SNF, Board of the ETH

**Links:** www.empa.ch/oft

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***References:***
*R. Fasel, M. Parschau, K.-H. Ernst, Angew. Chem. Int. Ed. 42, 5178 (2003), Angew. Chem. 115, 5336 (2003)*

# Mg(0001) surface oxidation: A two-dimensional oxide phase

**First-principles electronic structure calculations and angle-scanned X-ray photoelectron diffraction experiments reveal the geometrical structure of the Mg(0001) surface upon oxidation. In contrast to previous studies of Mg(0001) oxidation and unlike the case of aluminum oxidation we determine a new surface oxide structure, consisting of mixed oxygen-magnesium layers on top of an almost unchanged Mg(0001) surface. This unusual, directionally bound, surface oxide is locally formed already at very low dosing and grows laterally with increasing oxygen coverage up to at least 3 monolayers coverage.**

Understanding the oxidation pathway of metallic surfaces remains one of the challenges of today's surface science. Up to recently it was believed that surface oxide structures were identical or closely related to the corresponding bulk oxides. However, recent studies have shown that transition metal surface oxides may form two-dimensional structures that are nothing like their bulk oxides. Although there is no a priori reason to expect a similarly complex process for simple, free-electron-like metals, we have shown that oxygen adsorption on Mg(0001) leads to a rather unanticipated layered, graphite-like (Fig. 1) surface oxide.

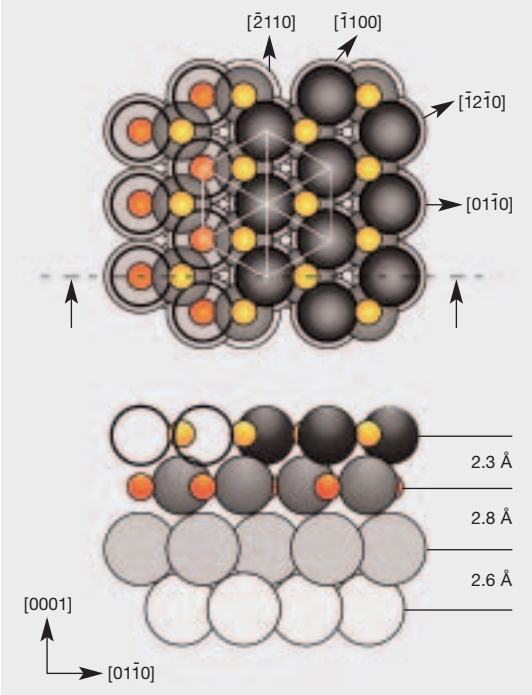


***Fig. 1:*** *Sketch of the layered Mg-oxide structure as determined by combined photoelectron diffraction experiments and first-principles electronic structure calculations.*

We find that after adsorption of the first oxygen atoms further oxygen atoms are accommodated as close neighbors within the topmost magnesium layers. This leads to the formation of a thin layered and directionally bound surface oxide not previously reported. The layered structure grows laterally with increasing oxygen exposure and represents the characteristic phase for coverages up to at least 3 monolayers.

An analysis of the calculated change in charge density due to the presence of the oxygen atoms shows a distinct difference in the character of bonding in the layered and rocksalt surface oxide structures (Fig. 2). For the layered system a clear directional bonding between oxygen and nearest neighbor magnesium atoms is found. This is in contrast to the ionic type of bonding observed for the rocksalt configuration with the electron charge distribution spherical around the position of surface ions. The directional bonding character of the layered surface-oxide may give arguments for an unusual reactivity and special catalytic properties of the oxidized Mg(0001) surface.

Roman Fasel,
in collaboration with
Elsebeth Schröder,
Chalmers University of Technology (SE),
Adam Kiejna,
University of Wroclaw (PL)

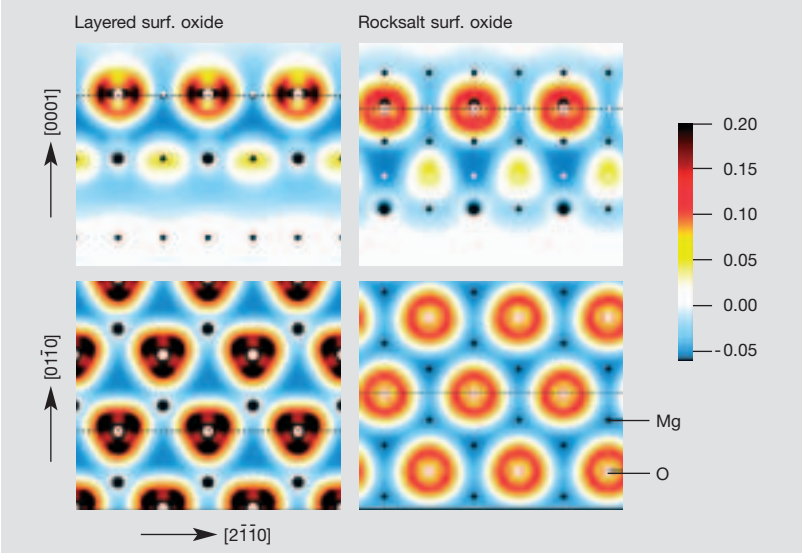


***Fig. 2:*** *Difference electron charge distribution due to the presence of the oxygen atoms for the layered surface oxide (left) and the rocksalt structure (right) cut perpendicular (top) and parallel (bottom) to the surface. Negative/positive difference charge corresponds to depletion/accumulation of electronic charge.*

**Links:** www.empa.ch/abt127

***Contact:*** *roman.fasel@empa.ch*
***References:***
*E. Schröder, R. Fasel, A. Kiejna, Phys. Rev. Lett., submitted (2003); Phys. Rev. B, submitted (2003)*

# Interface reactions during HIPping of Ni-base superalloys

**Future generation of gas turbine rotors are required to fulfill higher safety and environmental standards combined with increased efficiency. Therefore, the concept of bi-metallic turbine discs has been investigated in a European project, with EMPA being task leader of microstructure characterization. The investigation of different material combinations by means of FIB, TEM and EPMA revealed critical precipitation phenomena during HIPping in some cases. This gave important indications for material selection for such applications.**

Ulrich E. Klotz,
Philippe Gasser,
Manfred Roth

In order to achieve higher efficiency and safety of gas turbines and to comply with future environmental legislation, a research project to develop bi-metallic turbine discs was carried out by a consortium of ten European partners. The concept of bimetallic gas turbine discs enables the different mechanical property requirements for the hub and the rim section of a disc to be reconciled in a single disc structure instead of a mono-alloy disc. Such components are manufactured by hot isostatic pressing (HIP) of concentric cylinders of the Ni-base superalloys U720Li and IN738LC to form a single dual alloy disc. The integrity of the bond line produced during HIP processing is of paramount importance. This paper describes the micro structural characterization of the joint between the two materials by means of FEG-SEM and TEM using the FIB lift out technique for the TEM sample preparation.

The bond line was investigated using a field emission gun (FEG) SEM. The sample was mechanically polished and finished on colloidal silica and examined using both secondary and backscattered electrons. This technique was used to determine the width of the interdiffusion zone, possible precipitation of secondary phases, and the size and distribution of the primary and secondary γ‘ particles. Figure 1 shows a typical region along the bond with the original interface being easily identified from the impurities present along the entire length. The interdiffusion band of about 10 µm is clearly visible, consisting of fine recrystallized grains on the IN738LC side of the interface. The black area just inside the IN738LC indicates large amounts of deformation as a consequence of creep during the HIP cycle. EDX analysis of the particles (size ≤ 250 nm) at the bond interface revealed two different particle types to be present: one tungsten rich and the other aluminum/tungsten/oxygen rich.

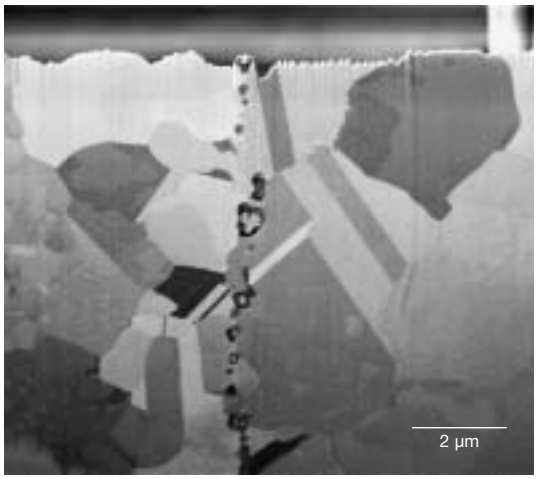


***Fig. 1:*** *FEGSEM back scattered electron image of the IN738LC / U720Li bond.*

A detailed examination of the precipitates at the interface was performed in the TEM using scanning transmission electron microscope (STEM)-EDX elemental mapping. Specimen preparation was achieved using the focused ion beam (FIB) lift out technique. A large stair-step FIB trench is milled out on both sides of the area of interest. Afterwards the sample is thinned to electron transparency (~100 nm thick) and removed from the bulk material and transferred to a TEM grid (Fig. 2). The method is very site-specific, which is of great interest for this study because of the narrow interdiffusion zone. The size of the lamella prepared was about 25 x 15 µm with an electron transparent thickness of ~100 nm.

Figure 3 shows the STEM bright field image of the precipitates at the interface. The locally high mass-thickness contrast indicates precipitates of different chemical composition, assuming that the foil has a

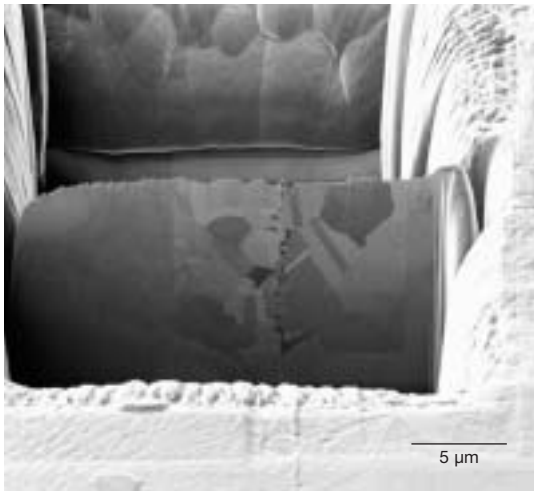


***Fig. 2:*** *TEM sample preparation using the lift-out technique.*

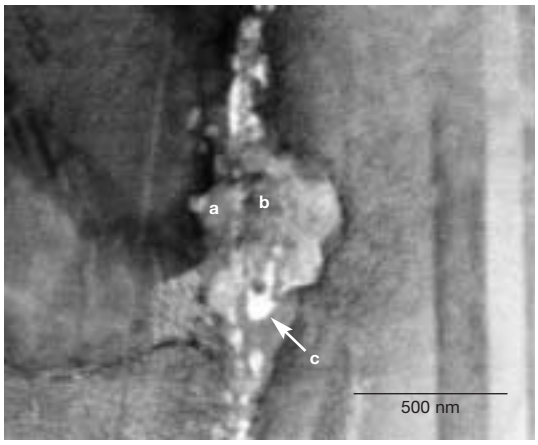


***Fig. 3:*** *STEM bright-field image of interface region and diffusion zone.*

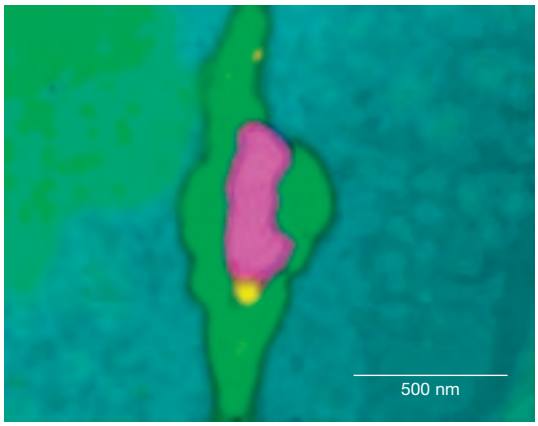


***Fig. 4:*** *Elemental map of Ni (blue), Ti (green), Zr (magenta) and Cl (yellow).*

similar overall thickness, as expected using the FIB sample preparation. The precipitates appear film-like across the whole interface, ranging from 100–200 nm in thickness, and up to 500 nm at the widest points.

The elemental maps (Fig. 4) revealed the complex nature of the precipitates, consisting of several phases. Most of the precipitates (labeled a) were found to be rich in Ti, Ta, Nb, W, Mo, and Zr (in order of decreasing amounts). Comparison with literature suggests that this type of precipitate is derived from primary carbides of MC type within the IN738LC and was formed as a consequence of the recrystallization next to the interface and rejection of these constituents ahead of the recrystallization front. It was not possible, however, to detect the presence of C by means of EDX because of the matrix of heavy elements. At the wider regions of the precipitate film a second precipitate type was found at the centre of the film, which appeared to be Zr- and Mo-rich oxides (labeled b). It is assumed that these were as a consequence of oxygen remaining after the HIP evacuation process. The white particles (labeled c) in the STEM bright field image seem to be of a third phase, which was found to be rich in Cl and K. These impurities arise from the pre-HIP cleaning process.

To sum up, FEG-SEM and STEM-EDX investigations showed complex precipitation reactions and impurities at the interface of two HIP-bonded Ni-base superalloys. The results are very important in the context of mechanical properties of the bond and will be instrumental for the further optimization of the HIP process.

**Support:** Brite EuRam III

**Links:** www.empa.ch/GVE

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# Thixocasting, texture, and mechanical anisotropy of extruded magnesium alloys

**The investigations have proven that Mg-thixocasting is feasible by using extruded magnesium alloys as feedstock material, but metallurgical and physical features of the Mg-Al alloys turned out to be rather inappropriate for semi-solid processing. The very pronounced mechanical anisotropy of the extruded magnesium alloys was found to be in agreement with calculations of the mean orientation factor for basal slip and the mean strain caused by pyramidal twinning.**

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Olivier Beffort,
in collaboration with
Peter J. Uggowitzer,
ETH Zürich (CH)

Magnesium, the lightest of all the commonly used metals, is increasingly used in transportation especially in automotive applications. The mechanical properties of parts produced by means of the well-established high pressure die casting (HPDC) process are impaired by porosity due to the turbulent die filling and solidification shrinkage, especially in thick-walled sections. This limits possible applications of magnesium castings to non-structural or weak-loaded components. Semi-solid metal processing is known to provide castings with low porosity and enhanced mechanical properties, but research and development have only concentrated on aluminum alloys so far. The aim of this study is to investigate the suitability of Mg-Al alloys for semi-solid processing.

An alloy has to fulfill several criteria to be suitable for thixocasting. The main requirements for processability in the semi-solid range are that the alloy should exhibit a fine globular grain structure devoid of dendrites and an adequate volume fraction of liquid. Viscosity of the liquid phase, spatial distribution of the liquid phase and connectivity of the solid phase also play an important role in semi-solid processing.

The extruded feedstock materials AZ61 (Mg-6%Al-1%Zn) and AZ80 (Mg-8%Al-0.5%Zn) as well as their Zn-free versions AM60 and AM80 turned out to be suitable precursor materials for thixocasting. Dynamical recrystallization during the extrusion process destroys the coarse, dendritic microstructure of the cast billet and leads to a fine, equiaxed grain structure. The microstructure evolution during reheating in the semi-solid state was found to be characterized by quite an inhomogeneous distribution of solid and liquid during the early stages of remelting: an excellent sphericity of the solid particles and a considerable amount of entrapped liquid (Fig. 1). All these features can be explained by metallurgical considerations. The key to a successful thixoprocessing lies in a symmetrical heating layout combined with an appropriate homogenization period at the end of the heating cycle and in a proper gate design, flow velocity and metal pressure during casting. Even if cast under optimized conditions the thixocast parts showed only modest values of strength and ductility. A comparison based on metallurgical and physical considerations with the established aluminum thixo alloy A356 revealed that the system magnesium-aluminum does not fully comply with the requirements needed to achieve high strength and ductility levels in thixocast parts. The amount, morphology and spatial distribution of the eutectic phases in the as-thixocast condition (Fig. 2) and the rather poor response to age hardening have been identified as the weak points of the investigated AZ- and AM-alloys.

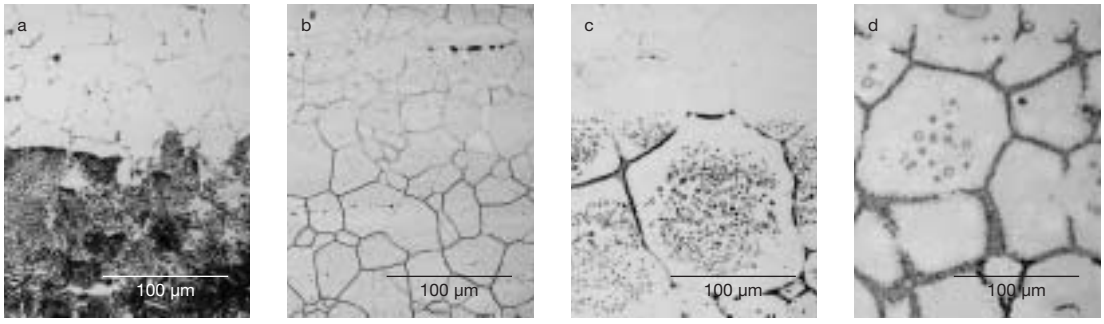


***Fig. 1:*** *Microstructural changes during reheating of extruded AZ80: a) 5 min at 200 °C, b) 5 min at 400 °C, c) 5 min at 500 °C and d) 5 min at 570 °C.*

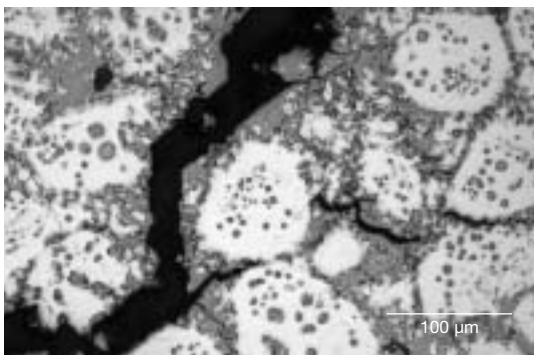


***Fig. 2:*** *Easy crack propagation through the brittle $Mg_{17}Al_{12}$ in the divorced eutectic of thixocast AZ80.*

While determining the mechanical properties of thixocast parts, it was found that the tensile stress-strain-curve is highly influenced by an antecedent plastic deformation by compression that happened accidentally when machining the tensile test specimens. This finding triggered a more detailed investigation of the deformation behavior of magnesium-aluminum alloys. Special attention has been paid to the mechanical anisotropy of extruded rods (Fig. 3) featuring a strong texture with the majority of the basal planes lying parallel to the extrusion direction. The Schmid factors for basal slip and the strains caused by twinning have been quantified for different directions of tensile and compressive loads. Although no constraints in the deformation of the individual grains in the polycrystalline material have been taken into account, the observed deformation characteristics of textured magnesium-aluminum alloys could be explained very well by means of the two main deformation mechanisms. Cyclic deformation experiments confirmed the overwhelming importance of twinning for the deformation behavior of magnesium. Twinning accounts for the marked Bauschinger effect and it also causes texture alterations even at quite low strains. A stress relief heat treatment unmakes the Bauschinger effect but the deformation induced transition of texture persists and influences the material behavior upon reloading in the reversed direction so that a predeformed specimen always shows a very different deformation behavior as a specimen in its initial state.

The very pronounced anisotropy of extruded magnesium-aluminum alloys and the marked Bauschinger effect has to be taken into account when designing parts that are subjected to alternating loads. It is known that particular slip and twinning systems may be blocked or activated by addition of certain alloying elements and/or an increase in temperature. This makes the understanding and modeling of the deformation behavior of magnesium alloys a very challenging task which needs to be solved in order to allow for a more widespread use of lightweight magnesium extrusions, sheets and forgings.

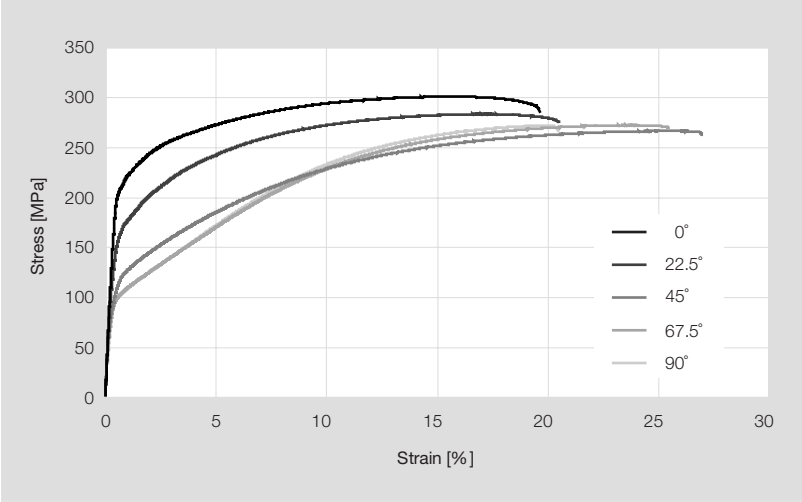


***Fig. 3:*** *Stress-strain curves of extruded AZ61 for different specimen orientations, i.e. different angles between the specimen axis and the extrusion direction.*

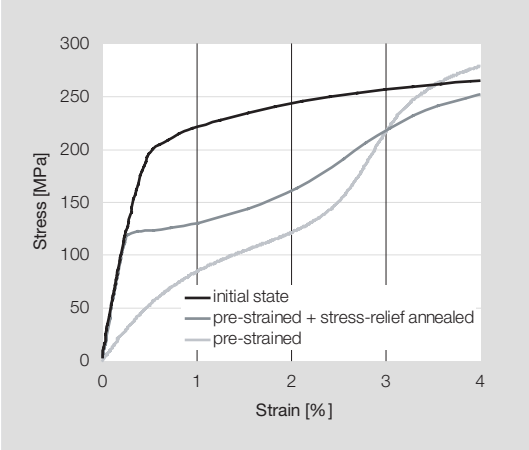


***Fig. 4:*** *Stress-strain curves of longitudinal specimens of AZ61 in different conditions (compressive pre-strain of 3%).*

**Support:** KTI, Swiss casting industries

**Links:** www.empa.ch/abt126
> Metal Matrix Composites

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# Nanocomposite protective coatings: arc-PVD and UBM-PVD for an industrial process

**Nanocomposite TiN/a-$SiN_x$ hard coatings deposited by Unbalanced Magnetron Sputtering (UBM-PVD) exhibit superior hardness and oxidation resistance with respect to pure TiN. However, for industrial applications the arc PVD deposition process is preferred over sputtering processes by most coating companies. In this project we investigated the possibilities to deposit TiN/a-$SiN_x$ protective coatings using arc PVD deposition instead of sputtering. Out of different approaches a hybrid process with the simultaneous operation of a Ti-arc source and a Si-magnetron sputtering source was the most successful one. TiN/a-$SiN_x$ coatings with various Si-contents were grown; the hardness as well as the oxidation resistance are markedly improved by the Si incorporation.**

Franz-Josef Haug,
Patrick Schwaller,
Jörg Patscheider,
in collaboration with
Markus Tobler,
Ionbond AG,
Ayat Karimi,
EPF Lausanne (CH)

Hard coatings of TiN are frequently used for wear protection of tools for chipping and forming. Requirements of the industry aim at higher machining speed and prolonged lifetime. Thus, an everlasting issue for the improvement of protective coatings is increased hardness to reduce tool erosion and improved oxidation resistance to withstand the high temperatures during high speed cutting.

The incorporation of $SiN_x$ into TiN layers by an unbalanced magnetron process was shown to significantly improve the hardness and the oxidation resistance of TiN. The presence of silicon nitride, known for its outstanding diffusion barrier properties, causes the increased oxidation resistance. The improved hardness is directly related to the nanostructure of the composite material because the elastic properties of such TiN/$SiN_x$ composites are governed by nanometer-size effects rather than bulk phenomena. Deformation is only possible by sliding of whole grains, which results in increased hardness. For Si concentrations between 5 and 10 at% the hardness increase amounts to almost 100% as compared to pure TiN.

However, for industrial coatings arc evaporation processes are preferred over sputter processes for economic reasons. They yield higher deposition rates, and a high rate of ionization of the target material allows for a better control of the layer properties by the application of a bias voltage. Unfortunately, silicon cannot be used as target material in arc evaporation due to its brittleness and low electrical conductivity. However, Silicon can easily be sputtered, thus, we have developed a hybrid process for depositing TiN/$SiN_x$ composite layers by combining arc evaporation of titanium and sputtering of silicon in a reactive nitrogen/argon gas mixture.

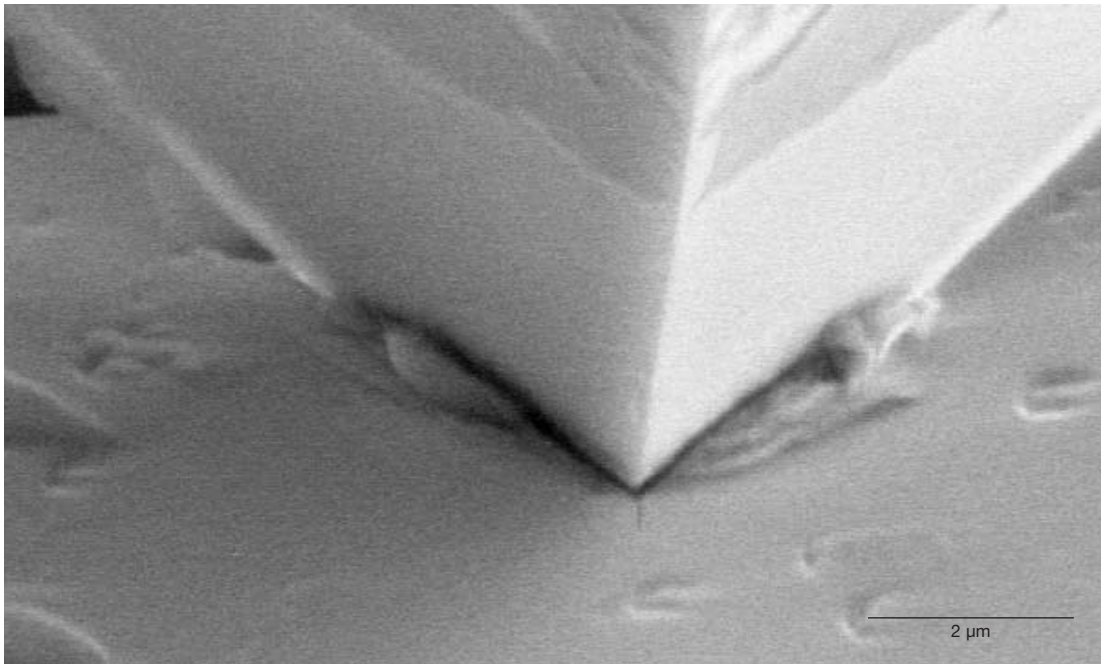


***Fig. 1:*** *Indentation measurements show that the TiN/$SiN_x$ nanocomposite coatings do not undergo cracking or delamination, even under extreme loads.*

The oxidation resistance of TiN/$SiN_x$ nanocomposite layers has been investigated by annealing of layers with different Si contents in air at different temperatures. At high temperatures, the TiN/$SiN_x$ composite decomposes and forms a soft surface layer of $TiO_2$. A thinner oxide layer indicates an improved oxidation resistance; tools protected with such coatings can, therefore, withstand higher temperatures, and can be used for higher cutting speeds or will provide a longer lifetime. Measurements of the oxide layer thickness are presented in Figure 2.

Figure 3 shows results of hardness measurements by nanoindentation. For pure TiN the hardness values lie between 25 an 30 GPa. For Si contents between 5 and 10 at% the TiN/$SiN_x$ composite material shows increased hardness values and reaches into the range of so called superhardness at or above 40 GPa. At higher Si contents the hardness gradually decreases and at Si contents exceeding 15 at%, it approaches 24 GPa, the hardness value of $Si_3N_4$. The overall dependence of hardness on Si content is typical for a nanocomposite of two materials where nanocrystals of one material are fully percolated by a second material, which forms an amorphous matrix.

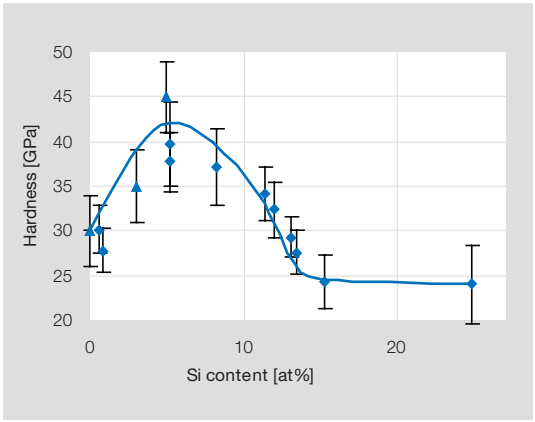


***Fig. 3:*** *Dependence of the hardness on the Si content in TiN/$SiN_x$ composite material. For Si contents between 5 and 10 at% hardening due to percolation of TiN nanocrystals in an amorphous $SiN_x$ matrix is observed.*

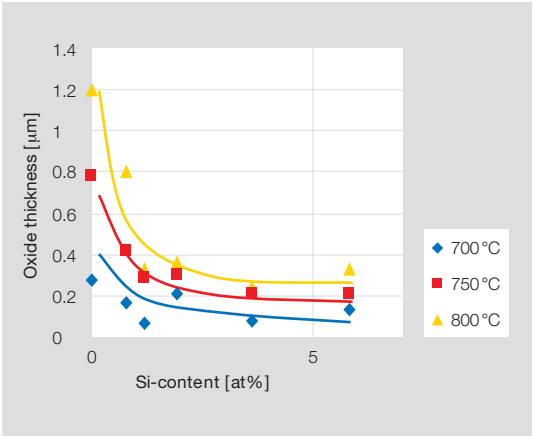


***Fig. 2:*** *The addition of $SiN_x$ improves the oxidation resistance of TiN. Layers with various Si contents have been air annealed at different temperatures. The reduced oxide layer thickness indicates a three- to fivefold improvement in oxidation resistance for Si contents exceeding 3 at%.*

We have demonstrated in this feasibility study that the hybrid process is able to produce coatings in the laboratory environment with similar properties as when deposited by UBM-PVD. We plan to exploit the results of this feasibility study together with the industrial partner in an ongoing project.

**Support:** TOP Nano 21

**Links:** www.empa.ch/abt125

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***References:***

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# Prescratched semiconductor surfaces for electrochemical nanowires processing

**We demonstrate nanoscale electrochemical deposition and porosification selectively on mechanically induced defects on semiconductor surfaces. Mechanical lithography was achieved by a diamond tip mounted on an atomic force microscope (AFM) or a dedicated nanoscratch device. A 10 nm thick oxide on silicon was machined to serve as a mask for electrodeposition. Dislocations at the surface of InP were generated during force controlled nanoscribing and subsequently etched to obtain porous nanopipes.**

Rémy Gassilloud,
Johann Michler,
in collaboration with
Lionel Santinacci,
Patrick Schmuki,
University of Erlangen (D)

Approaches to produce nanostructures not based on conventional photolithography have increasingly become important over the past few years, in particular driven by the semiconductor industries, which points to feature sizes well below 100 nm already in the near future. AFM was developed for topography measurements, but it rapidly found many other applications as nanolithography, nanomachining and nanohandling tool.

Recently, we demonstrated that it is possible to exploit AFM-induced nanoscratches produced through a 10 nm thick thermal $SiO_2$ film on silicon for highly selective electrochemical palladium deposition (Fig. 1). The AFM scratching force was evaluated to be approximately 20 µN. We demonstrated that the oxide films can serve as an efficient mask, *i.e.* may be used to suppress electrodeposition outside the scratched locations. The principal drawback of the scratching approach is that an undesired irreversible deformation of the single crystalline substrate may take place: for instance crack initiation, particle generation or dislocation nucleation around the scratch.

We analyzed in depth the contact mechanics of the nanoscratching lithography step and performed a microstructure analysis of the potentially deformed zone around the scratch by transmission electron microscopy (TEM). We proved theoretically that by a suitable choice of applied force for a given tip radius the oxide film can be nanomachined without creating defects in the silicon substrate. Moreover, Figure 2

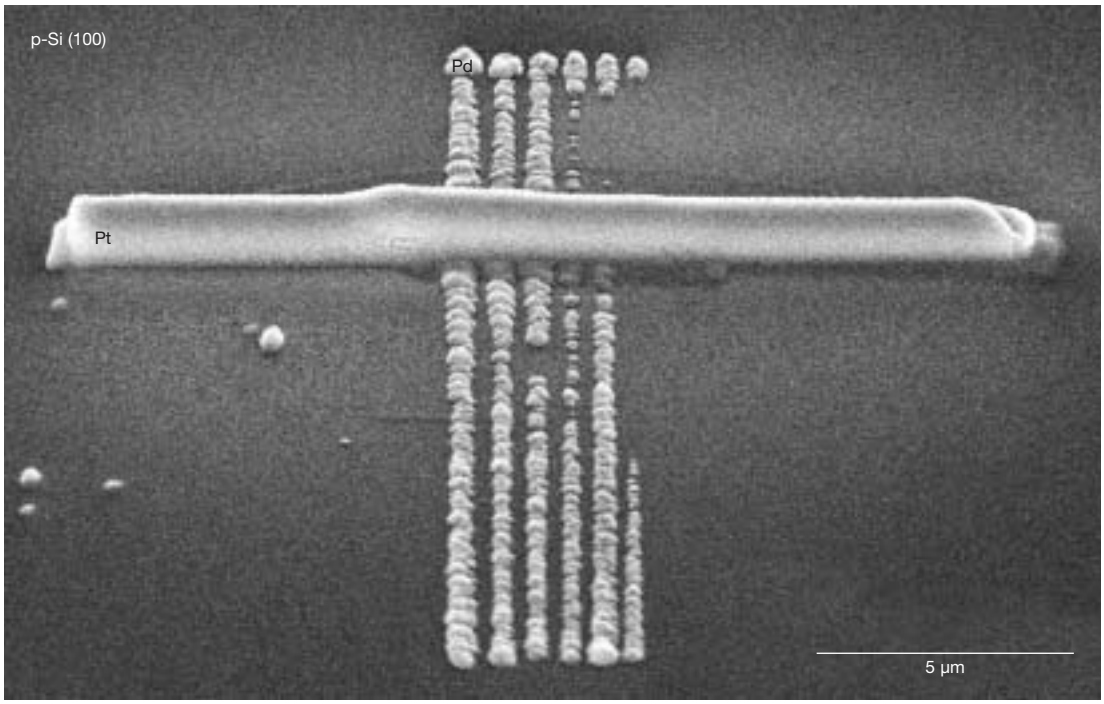


***Fig. 1:*** *Scanning electron microscopy image of Palladium (Pd) nanowires deposited within grooves produced by AFM nanoscratching. A platinum layer has been deposited for TEM sample preparation.*

shows experimental evidence: an XTEM bright field micrograph with a {110} cutting plane perpendicular to the nanowire line direction acquired from a nanowire similar to those shown in Figure 1. Within the silicon substrate there is a complete absence of crystal defects such as cracks or dislocations. This has been confirmed by lower magnification micrograph and by investigating other nanowires.

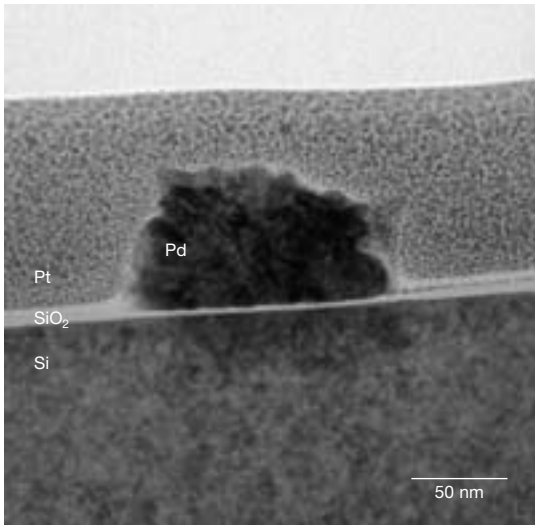


***Fig. 2:*** *Transmission electron micrograph of nanowire. Bright field image (<110> projection), cross-section perpendicular to the nanowire line direction (Fig.1). Please note that the V-shape of the scratch is not visible in the silicon substrate due to the flat opening angle of the groove (approx. 175°).*

The investigations on control of defect generations in semiconductor surfaces during mechanical nanolithography have been extended to the InP semiconductor. This semiconductor is used in optronics applications such as laser devices. Recently, the electrochemical formation of porous InP in halogen acid solutions has been investigated. Different properties from that of bulk InP were found in porous n-InP (100) obtained in HF etching, i.e. a yellow to red photoluminescence (PL) emission that can be easily seen by eye under UV illumination. We scratched InP n-type (100) surfaces and showed that it is possible to trigger pore formation in HCl electrolyte selectively at surface defects. The scratches were generated with our nanoscratcher at a low and well controlled force of 50 µN. Figure 3 shows a porous nanopipe approximately 500 nm width. The process of activation of the InP surface is different from that on silicon because of the non-presence of an oxide on InP. We suggest that dislocations under the scratched surface that were revealed by TEM are the main sites for selective porosification.

To sum up, we showed that using nanoscratching techniques we are able to machine 10 nm thick oxide layers that serve as an efficient mask for subsequent electrodeposition of palladium nanowires. We proved both theoretically and experimentally that the process can be applied without producing significant damage to the underlying silicon. Using the same concept of defect engineering, we were also able to produce a well defined porous nanopipe of approximately 500 nm width on InP. The technique may be extended in future to electrodeposited copper and gold or to nanoscale porosified silicon and other semiconductors.

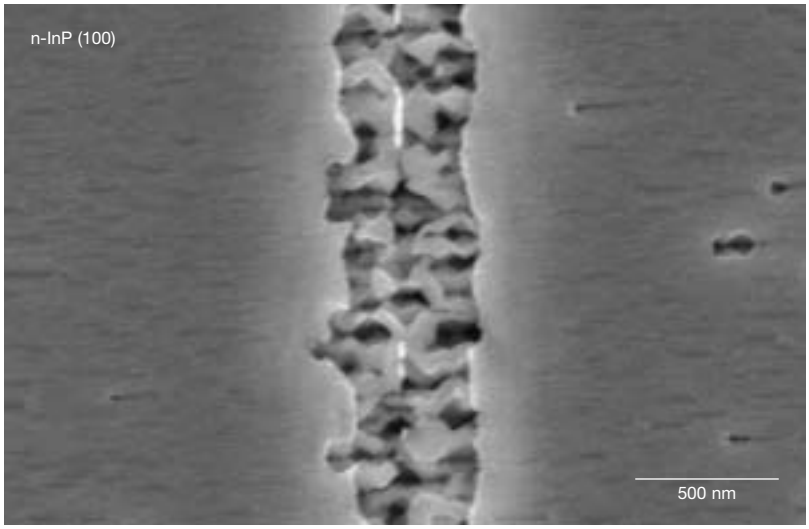


***Fig. 3:*** *Scanning electron micrograph of porous nanopipe.*

**Links:** www.empa.ch/abt126
> Nanomecanics

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# Macro – Micro – Nano – Which size is responsible for what effect?

**The insights from different projects in the field of surface science of thermally sprayed metallic coatings were consolidated to a comprehensive study by correlating quantitative microstructural and material property data. The experiments were carried out on nickel based alloys produced by various thermal spray processes. As an example, four advanced measurement methods are presented covering a range from a few tens of microns down to nanometer scale.**

Nikolaus Margadant, Stephan Siegmann, in collaboration with Thomas Keller, PSI (CH), Anand Kulkarni, University Stony Brook (USA)

The knowledge of the impact of the individual microstructural features on the macroscopic properties is required for the interpretation, optimization and modeling of the material behavior of thermally sprayed coatings. New and complementary analytical techniques were developed, modified and applied to thermally sprayed coatings. However, in general, with one specific analytical method mostly the empirical function of two quantifiable material parameters (e.g. elasticity and porosity) is determined, but this does not allow for revealing straightforward the main influencing factors dominating a specific material property. In addition, the intrinsic material behavior of thermally sprayed coatings can hardly be understood by concepts of thin films or bulk materials only, because its peculiarity bases on a broad variation of structural features. Therefore, a comprehensive statistical evaluation of various properties and of microstructural data of thermally sprayed metallic coatings was performed to draw conclusions from these correlations.

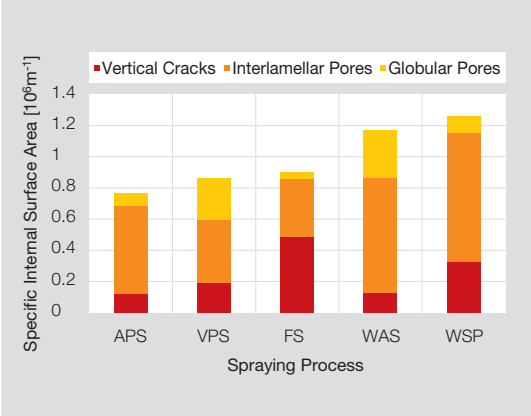


***Fig. 1:*** *Contribution of interlamellar, globular pores and cracks of nickel based coatings produced by atmospheric plasma (APS), vacuum plasma (VPS), flame (FS), wire arc (WAS) and water stabilized plasma (WSP) spraying to the specific internal surface area as determined by multiple small angle neutron scattering (MSANS).*

The characterization of structural features starting at a few nm in size was performed by small angle neutron scattering (SANS) in the framework of a PhD thesis in collaboration with PSI Villigen. Multiple small angle scattering (MSANS) technique allows a more detailed quantification of the void morphology. In Figure 1, the internal surface arising from interlamellar and globular pores or cracks of NiCrAlY coatings produced by different spraying techniques is shown.

On a rather mesoscopic scale, namely in the size range of a single splat/particle, the morphology could be examined by means of high resolution CMT (computerized micro tomography) using synchrotron radiation in collaboration with University of Stony Brook, USA. The permeability and conductivity of highly porous coatings strongly depend on the inter-connectivity of the pore system. The 3-dimensional data set allows for rendering any virtual cross section as visualized in Figure 2.

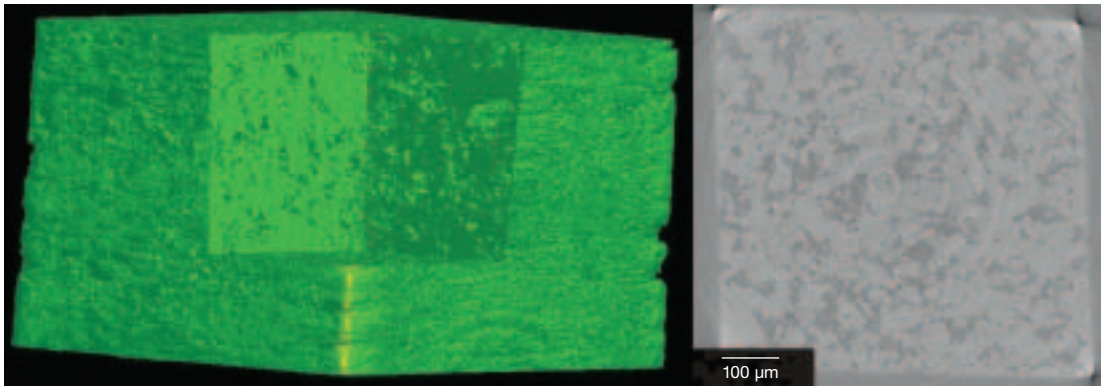


***Fig. 2:*** *Computed microtomography (CMT) pictures from plasma sprayed, highly porous sample as a 3-dimensional body with intersection and 2-D cross-section.*

For the overall performance of a coating system on a macroscopic scale the state of the residual stresses can be crucial. Spatially resolved measurements of residual in-plane stress profiles over the cross sections could be realized by neutron diffraction as well as by mechanical hole-drilling method (Fig. 3). The diffractive strain mapping was carried out using collimated neutron beam with a wave length of 0.2994 nm.

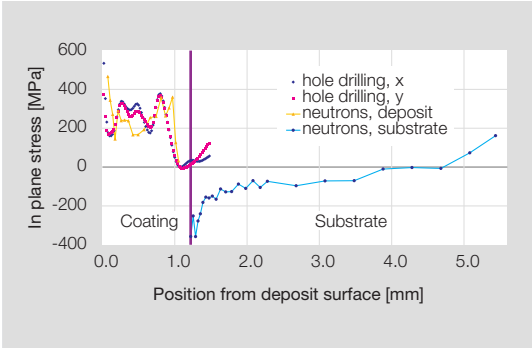


***Fig. 3:*** *Residual in-plane stress profile in a wire arc sprayed coating determined by neutron scattering and by the mechanical hole drilling method.*

From the correlation more general relationships between defect structure and properties were revealed. The knowledge of empirical material functions allows an assessment of hardly accessible measurands by more efficient methods. Such a relation could be established between thermal and electrical properties and specific pore and oxide phase content (Fig. 4). Electrical conductivity data determined by a modified Van-der-Pauw method allow correlation with thermal conductivity data as obtained by laser-flash and thermographic measurements.

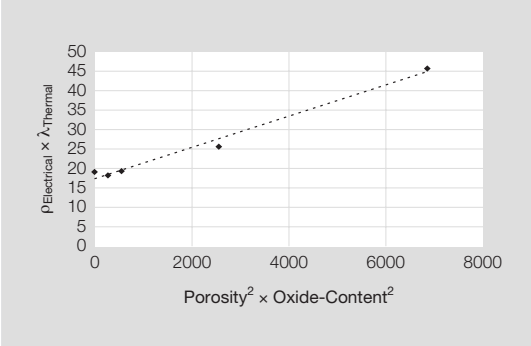


***Fig. 4:*** *Relation between electrical and thermal conductivity and pore and oxide content.*

**Support:** EUREKA, BBT-KTI, Swiss industries

**Links:** www.empa.ch/abt126

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# Interaction of hydrogen with $sp^2$-bonded carbon: Effects on the local electronic structure

Pascal Ruffieux, Oliver Gröning, Michael Bielmann, Pierangelo Gröning, in collaboration with Manuel Melle-Franco, Francesco Zerbetto, Universitá degli Studi di Bologna (I)

**The adsorption of hydrogen on $sp^2$-bonded carbon has attracted considerable interest in the past few years. One of the main driving forces for studies in this field has been the ongoing effort to store hydrogen in carbon nanostructures, which requires a detailed knowledge of the interaction of hydrogen with the carbon network. Prominent examples belonging to the family of $sp^2$-bonded carbon are graphite, carbon nanotubes and $C_{60}$ molecules (Buckminster Fullerenes). Our main motivation stems from the possibility to locally modify the electronic properties of the carbon structure by chemically binding hydrogen to the $sp^2$-bonded carbon network. This so-called chemisorption of hydrogen is particularly interesting since it locally changes the coordination number of the carbon atoms, which is expected to have a large influence on the charge transport properties. The influence on the electronic properties is known to be especially large on carbon structures in the nanometer range, where the introduction of individual defects completely changes their conduction behavior.**

We have investigated the interaction of atomic hydrogen and low-energy hydrogen ions with graphite, single-walled carbon nanotubes and $C_{60}$ molecules, which allowed us to study the influence of the curvature of the carbon network on the adsorption properties of hydrogen. These structures cover a radius of curvature in the range of $r = \infty$ (graphite) to $r$ = 3.55 Å ($C_{60}$). Hydrogen chemisorption on $sp^2$-bonded carbon structures locally removes the delocalized $\pi$-states of the valence band due to the local change in hybridization from $sp^2$ to $sp^3$. This can be observed by photoelectron spectroscopy whereby the lowering of the intensity on the $\pi$-related features gives a measure for the amount of hydrogen that is chemisorbed on the carbon network. Our study shows that the energy barrier for hydrogen adsorption is lowered for increased curvatures in the $sp^2$-bonded carbon network. Whereas in the case of $C_{60}$ and single-walled carbon nanotubes can be achieved by exposure to atomic hydrogen, the hydrogen adsorption on graphite requires hydrogen ions of low kinetic energy (~1 eV). This lowering of the adsorption energy barrier is attributed to the small admixture of $sp^3$-bonding, which is present as soon as curvature is introduced in $sp^2$-bonded carbon networks and, therefore, has atomic configurations that are nearer to the purely $sp^3$-bonded structure after hydrogen adsorption.

Furthermore, hydrogen adsorption on $sp^2$-bonded carbon structures leads to an important lowering of the electron work function, i.e. the minimum energy that is required to remove an electron from the solid. The lowering of the work function depends nearly linearly on the hydrogen coverage and amounts to up to 1.3 eV for $C_{60}$. The observed effect is attributed to a change in the surface dipole due to the on-top adsorption of hydrogen, which is less electronegative than carbon and thus lowers the energy barrier at the surface.

The study of the local electronic modifications of single point defects such as hydrogen adsorption sites and atomic vacancies has been performed on graphite using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). Due to its flat and largely defect free arrangement of the $sp^2$-bonded carbon layers, graphite is the ideal substrate for the study of long-range modifications of the electronic structure induced by artificially introduced defects. The combination of AFM and STM using conductive AFM cantilevers has allowed the identification of two types of point defects, namely hydrogen adsorption sites and atomic vacancies (Fig. 1). A common feature of both defects is the long-

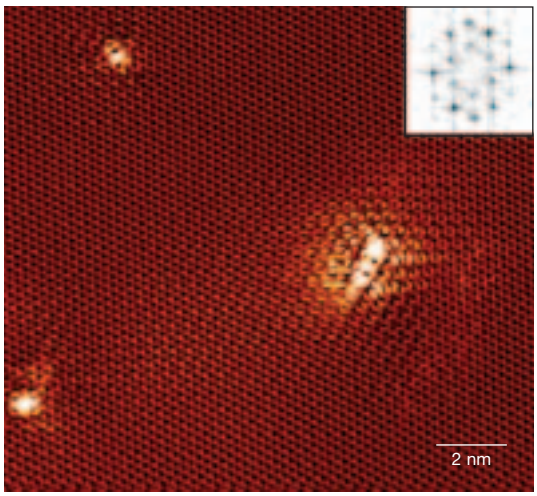


***Fig. 1:*** *Overview current image acquired in the combined AFM/STM mode showing two hydrogen adsorption sites (left) and a vacancy type defect. The inset shows the Fast Fourier Transform (FFT) of the same image. The small hexagon reflects the defect-related (√3 x √3)R30° superstructure.*

ranged (~5 nm) redistribution of the charge density in the vicinity of the defect. This redistribution is observed as a $(\sqrt{3} \times \sqrt{3})R30°$ superstructure in the current image. It reflects the standing wave that is created by the scattering of the delocalized electrons at individual point defects. The structure of the standing wave is given by the allowed wave vectors of the incoming and the reflected electrons and thus reflects Fermi surface of graphite, which has a point-like structure.

As soon as the defect density is increased in a way that the typical distance between individual defects is smaller than the range of the standing waves of single defects, interference gives rise to new patterns in the charge density, which are completely different from the usually imaged charge density distribution of an undisturbed graphite lattice (Fig. 2).

The observation of standing wave patterns for hydrogen adsorption sites and atomic vacancies demonstrates the strong scattering behavior of both types of defects. The presence of such defects on carbon nanostructures should, due to their low dimensionality, considerably change their conduction behavior.

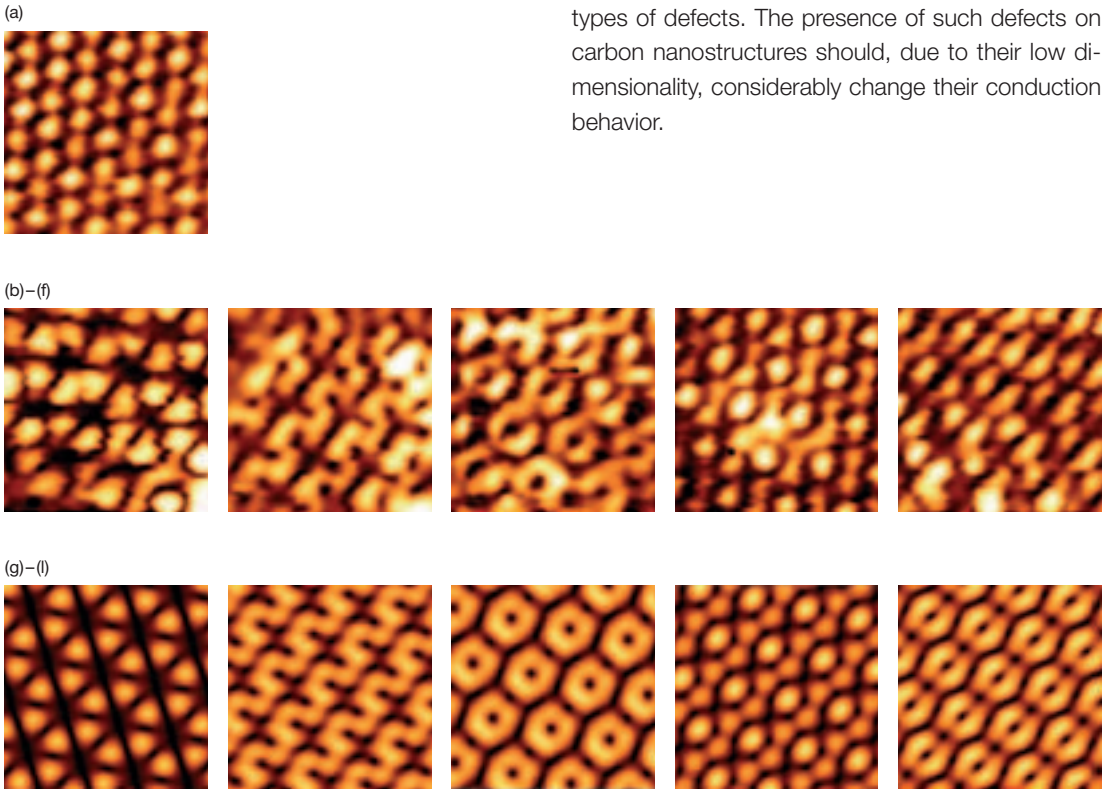


***Fig. 2:*** *Current image details (1.7 x 1.7 nm$^2$) of a sample with high defect density. (a) normal atomic lattice imaged in defect-free region. (b)–(f) details from regions between defects. (g)–(l) calculated spatial maps of the charge density with adjusted parameters [3].*

**Support:** SNF, EU Program V

**Links:** www.empa.ch/oft

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# Application of ceramic nanopowders in solid oxide fuel cell cathodes

**The performance of solid oxide fuel cells is to a large extent determined by the structure and composition of materials for the air electrode. Perovskite powders with medium particle size of 200 to 500 nm have been developed and applied as electrodes.**

Peter Holtappels,
Ulrich Vogt,
in collaboration with
Jan Van Herle,
EPF Lausanne,
Joseph Sfeir,
Olivier Bucheli,
HTceramix (CH)

Solid oxide fuel cells (SOFC) operating at temperatures around 750 – 850 °C become attractive electricity sources in both small scale units of around one to several kW as well as larger stationary powder plants of several 100 kW. A huge effort is still attributed to the development of efficient and cheap electrode materials especially for the air electrode.

Small particles – preferably in the nano size – leading to large surface areas and the use of highly catalytically active materials are seen as the key to high performance and high fuel cell efficiency. In collaboration with the start-up company HTceramix and the EPF-Lausanne, new perovskites and their application as nanopowders for the air electrode (cathode) in solid oxide fuel cells have been evaluated in addition to the state-of-the-art material La(Sr) $MnO_3$.

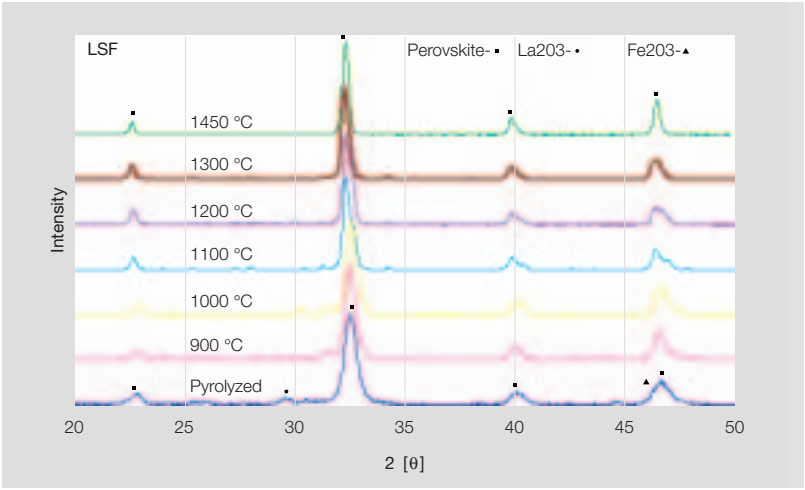


***Fig. 1:*** *X-ray diffractograms of La(Sr)$FeO_3$ for different calcination temperatures.*

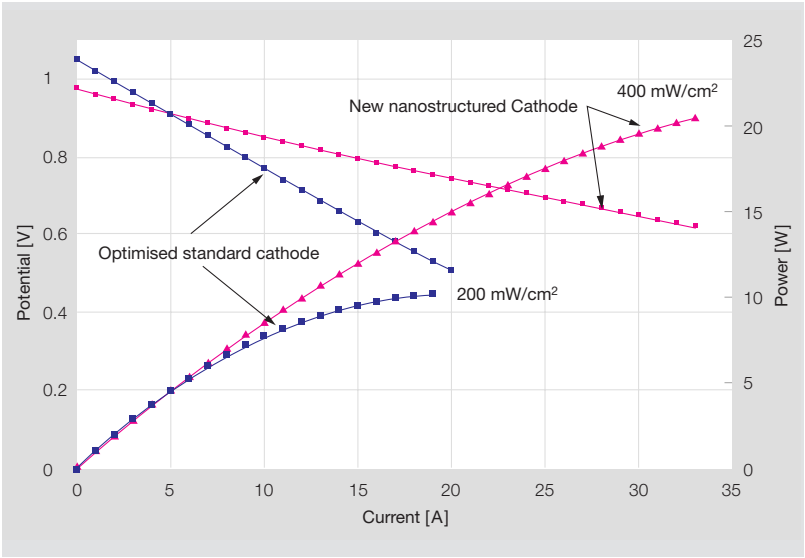


***Fig. 2:*** *I/V-characteristics of an HTceramic cell with integrated EMPA cathode at 750 °C.*

The perovskites have been synthesized at EMPA by using a modified Pechini process. From aqueous solutions of salts, ceramic powders are formed by spraying the solution into a hot chamber of 500 °C. The “as prepared” powders are further heat treated (calcination) in order to form the desired phase pure perovskites. In case of La(Sr) $MnO_3$ we could produce powders with a medium particle size of 200 nm without using expensive preparation steps. For the new La(Sr)$FeO_3$ composition a higher calcination temperature of 1450 °C resulted in further grain growth and consequently in a medium particle size distribution of 500 nm.

The “as prepared” perovskites have been applied as air electrodes in HTceramix cells and tested under technically relevant conditions. One of the new perovskites showed a promising increase in performance both on small cells and on repeat elements under real fuel utilisation. The nano-sized cathode was preserved after testing in $H_2$/air. With the new nanostructured cathode the electrochemical performance could be doubled from 0.2 W/cm$^2$ to 0.4 W/cm$^2$, resulting in a maximum power output of more than 20 W for a single repeat element of 50 cm$^2$ effective area.

This result allowed HTceramix to reach its first milestone of a 100 W stack. Furthermore, long-term tests were continued on a repeat element for more than 3000 h showing no degradation over the first 1000 h, followed by an overall degradation of 3.8% each 1000 h, at a moderate and constant load.

**Support:** TOP Nano 21

**Links:** www.empa.ch/ceramics
> Processing

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***References:***
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# Functional ceramics for miniature heating elements

Stefan Köbel, Ulrich Vogt, in collaboration with Alberto Ortona, Manlio Molinari, PTC (CH)

**An electrically-conductive ceramic composite for application temperatures up to 1500 °C has recently been developed at EMPA in collaboration with an industrial partner. The conductivity of the composite can be precisely controlled over more than four orders of magnitude thanks to a new processing procedure (Swiss patent pending). This material will be applied in a new class of hot-surface igniter, an energy saving and environmentally-friendly starting device for gas-powered heating systems.**

Hot-surface igniters provide for reliable ignition and increased fuel-efficiency in modern gas burners. The challenge for this application is to provide an electrically conductive material which at the same time can resist, ideally for the lifetime of the device, the harsh environment and high temperatures inside the flame. Due to its excellent oxidation resistance, we chose $MoSi_2$ as the conducting phase, however, the conductivity of pure $MoSi_2$ is about three orders of magnitude too high to make a small size conductor from this material alone.

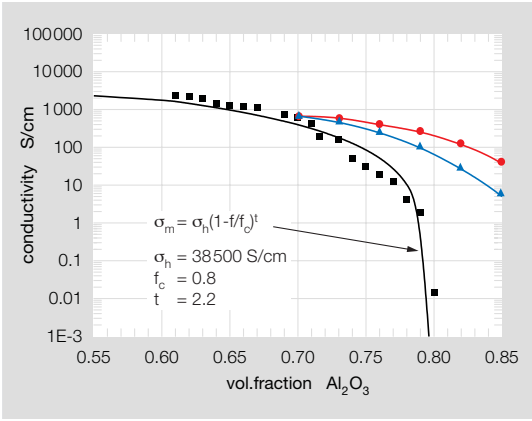


***Fig. 1:*** *Conductivity versus composition at T = 25 °C for three different microstructures. Black: unchanged microstructures (squares: measured data; solid line: fitted curve), blue and red: cellular microstructures.*

We, therefore, embedded the $MoSi_2$ particles ($D_{50}$ = 2.2 µm) in a matrix of aluminum oxide ($D_{50}$ = 0.75 µm) and were thus able to reduce the room-temperature conductivity from 38000 S/cm to the required 1 S/cm to 100 S/cm range. However, the variation of the conductivity with small compositional variations for these mixtures is too large for industrial manufacturing of the composite.

Simulation of the electrical properties of these composite materials suggested that a modification of the microstructure could facilitate the desired control of conductivity, and on this basis we developed a composite microstructure which allows for a precise control of the conductivity. This new microstructure is cellular with two types of cells: one type has a high conductivity, the other a fairly low conductivity. In the new composite, several parameters determine the overall conductivity: the conductivities of both type of cells, their size ratios and their respective volume fractions.

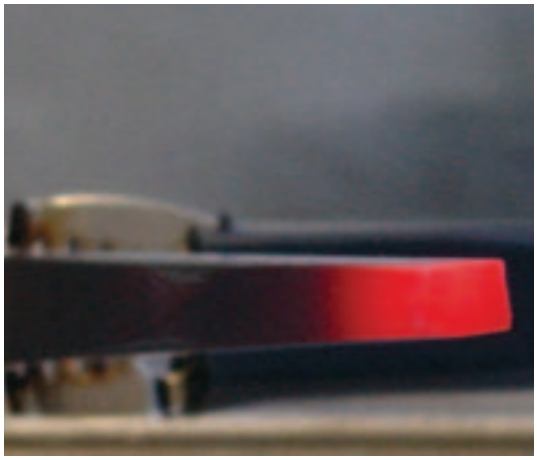

***Fig. 2:*** *Hot-surface igniter in operation at T = 1100 °C. The hot zone has a size of 3 x 4 x 5 $mm^3$.*

The newly-developed composites fulfill all requirements for the application as hot-surface igniters, particularly with regard to their corrosion resistance. Moreover, the new microstructure might also be useful for many other applications where the conductivity of a composite must be precisely controlled.

**Support:** BBT-KTI

**Links:** www.empa.ch/ceramics

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# $BaTiO_3$-based thermistor fibers for rapid-response sensor applications

**Sensitive rapid-response thermistor elements based on lanthanide-doped barium titanate ($BaTiO_3$) have been developed in a Ph.D. thesis. Manufactured using a ceramic fiber microextrusion process, these ultra-small temperature-sensitive sensors with diameters under 300 µm exhibit much faster responses than conventional commercially-available millimeter-scale PTCR elements and show great potential for use in thermal anemometry applications, for example.**

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Frank Clemens,
Thomas Graule,
in collaboration with
Alan Hendry,
University of Strathclyde
(GB)

Positive temperature coefficient of resistivity (PTCR) thermistors based on lanthanide-doped $BaTiO_3$ exhibit unique reversible electrical behavior as a function of temperature. Below a characteristic temperature $T_c$ which is adjustable between -30 and +240 °C with appropriate additions of strontium and lead, the material possesses a relatively low resistivity (10 –100 Ω · cm). Upon heating above $T_c$, the resistivity increases to a level 3 – 7 orders of magnitude higher. This discontinuous behavior lends thermistors to being used as temperature and airflow sensors. However, because the switching process depends on heating or cooling a volume of ceramic, the smallest commercial PTCR elements, which are on the order of a few millimeters in size, require several seconds to sense a temperature change. The response time can be reduced and the sensitivity increased by reducing the physical size and thermal mass of the thermistor. We have been developing a fabrication process for ultra-small thermistor elements based on ceramic powder extrusion in cooperation with the University of Strathclyde (Glasgow, GB).

A commercial submicron barium titanate powder is first coated with either cerium oxide ($CeO_2$) or lanthanum oxide ($La_2O_3$) and mixed with a sintering-aid consisting of $Al_2O_3$, $SiO_2$ and $TiO_2$ nanopowders. This powder premix is then compounded with a thermoplastic binder and the resulting mixture is subsequently extruded through circular dies between 300 and 60 µm in diameter at elevated temperature to form fibers. By subjecting these fibers to suitable heat treatments up to 1360 °C in air, the binder is removed and the dense ceramic material is formed which exhibits the desired equilibrium PTCR behavior (Fig. 1 and 2).

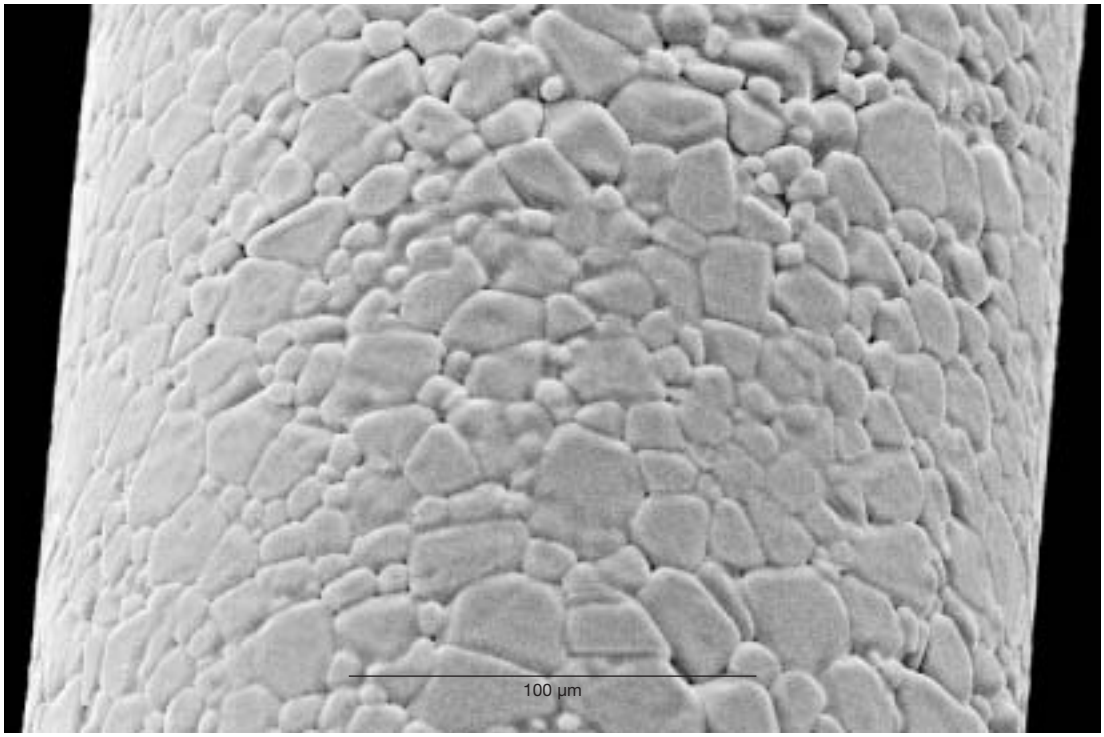


***Fig. 1:*** *SEM micrograph of a sintered La-doped $BaTiO_3$ thermistor. Due to shrinkage during sintering, the final thermistor diameters are reduced from their extruded diameters by approximately 20%.*

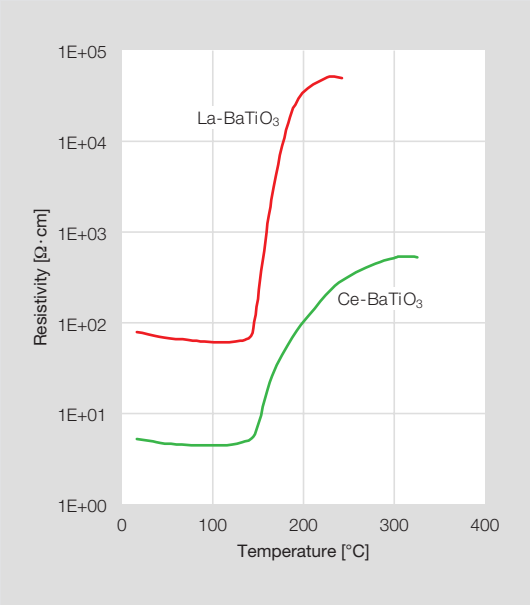


***Fig. 2:*** *Equilibrium resistivity-temperature characteristics of 2 mm-long 250 µm-diameter thermistors. The samples were heated in 1°C increments and equilibrated 5 minutes before the resistivity was measured (2-point zero-power DC measurements with In-Ga amalgam electrodes).*

The nonequilibrium PTCR response of the fiber thermistors is measured by monitoring their resistance while increasing the ambient temperature from 25 to 300 °C in 1 second. The results (Fig. 3) show clearly that the fiber thermistors respond to the abrupt temperature change significantly faster than conventionally-sized reference thermistor disks made of the same material. Whereas the disks only begin to respond to the temperature change after 6–8 s and require close to 30 s to reach maximum resistance, the 250 µm-diameter elements respond after 2–3 s and reach their maximum resistance after only 7–8 s. By reducing the element diameter to 125 µm, the initial response time is reduced below 2 s, and only 5 s elapse before maximum resistance is achieved.

In addition to imparting rapid response behavior, the small size of these thermistors renders them less prone to thermal shock damage than large conventional PTCR elements in which very steep temperature gradients are commonplace during fast heating. Furthermore, the room-temperature resistance rating of an individual thermistor can easily be tailored by cutting the sintered fiber to the correct length. Currently the microstructural and electrical properties of the thermistors are being optimized by doping the premix powder with manganese and by replacing the conventional sintering procedure with a microwave sintering process. The optimized thermistor fibers will be incorporated into demonstrators of a rapid-response thermal switch and a sensitive thermal anemometer (airflow sensor).

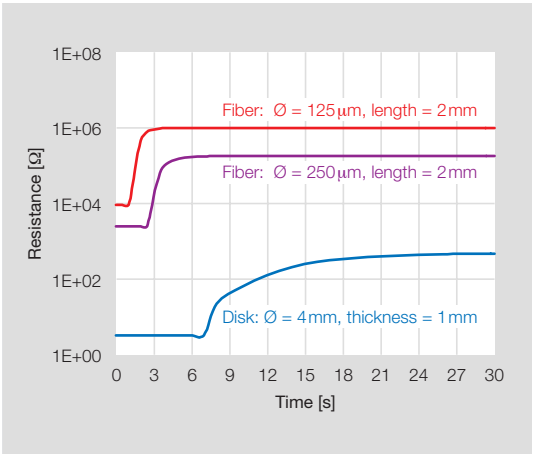


***Fig. 3:*** *Nonequilibrium resistance response of Ce-$BaTiO_3$ fiber thermistors to a rapid temperature change from 25 to 300 °C in air. The conventionally-sized reference thermistor disk was uniaxially-pressed from the same mixture used to extrude the fibers and was subjected to the same heat treatments.*

**Support:** University of Strathclyde

**Links:** www.empa.ch/ceramics

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***References:***
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# Active fiber composite sensors for acoustic emission monitoring

**Forced deformations of Active Fiber Composites (AFC) with piezoelectric fibers produce a voltage signal that can be used in sensor applications. The performance of AFC for Acoustic Emission (AE) monitoring is compared with commercial AE sensors. The sensitivity is characterized by signal attenuation curves and polar diagrams. The comparison indicates a higher sensitivity of AFCs along the direction of the piezoelectric fibers. Permanently bonded AFC show promise for health monitoring of composite structures by integrated AFC.**

Michel Barbezat,
Andreas J. Brunner,
Christian Huber,
Xavier Kornmann

In our research program Adaptive Materials we produce piezoelectric fiber composites that can be activated by an applied electric field. Upon deformation of the AFC due to external loads, the reversibility of the piezoelectric effect yields charge separation and corresponding potential differences. Consequently, AFC will basically allow the detection of acoustic waves traveling in a structure as AE sensors do. AE sensing properties of AFC are compared with conventional AE sensors. Simulated AE applied on test plates showed that AFC connected to a commercial AE data acquisition system are capable of detecting transient elastic waves in a frequency range between about 50 and 300 kHz. A quantitative comparison with one type of AE sensor is based on signal attenuation curves as a function of distance and on polar diagrams at constant distance.

The signal attenuation curves (Fig. 1) on a PMMA-plate show comparable behavior for both AFC and AE sensors. The latter yields a factor 3–5 higher sensitivity than AFC (10–15 $dB_{AE}$). The polar diagram (Fig. 2) obtained on a unidirectional glass fiber laminate (GFRP) shows higher sensitivity of the AFC along the direction of the piezoelectric fibers than perpendicular, independently of the fiber orientations of the GFRP. The anisotropy ratio of the sensitivity amounts to about 1.3. This applies for reversibly mounted AFC with frequency filtering between 100 and 1000 kHz and is attributed to the unidirectional lay-up of the piezoelectric fibers. Permanent adhesive mounting improves the sensitivity of the AFC by 5 to 10 $dB_{AE}$. The frequency dependence of the sensitivity of AFC is currently investigated as a basis for further optimization.

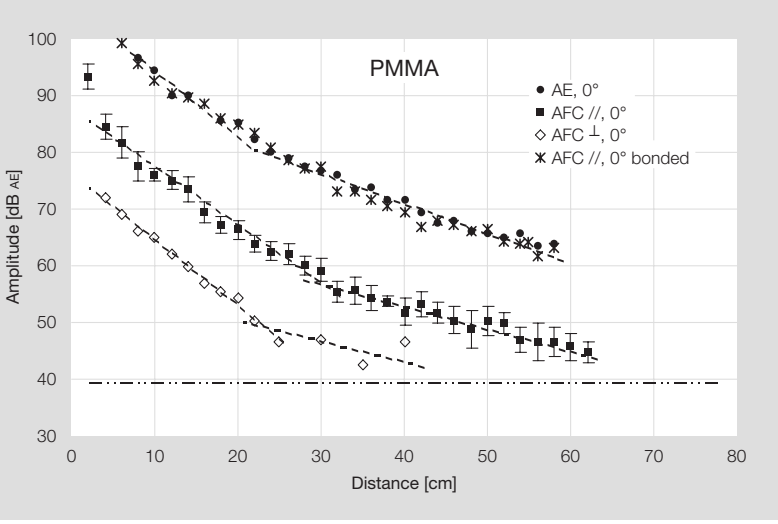


***Fig. 1:*** *Attenuation curves from pencil lead breaks (simulated AE) on PMMA (maximum amplitudes in $dB_{AE}$) as a function of distance from the center of the sensor for different AFC orientation. The horizontal line represents the detection threshold.*

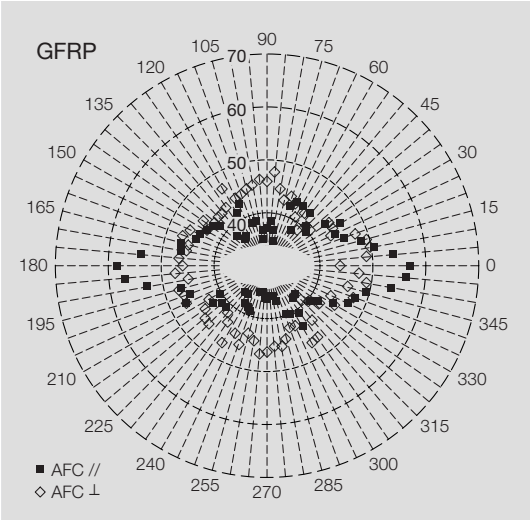


***Fig. 2:*** *Polar diagram from pencil lead breaks (simulated AE) on unidirectionally fiber-reinforced GFRP (maximum amplitudes in $dB_{AE}$) at 20 cm from the center of the sensors.*

Due to their performance combined with their flexibility and low thickness (300 mm), AFC seem promising as integrated AE sensors for health monitoring of composite structures. Recently, first laminates with integrated AFC have been manufactured and successfully tested.

**Links:** www.empa.ch/abt114 > Adaptive Material Systems & Functional Polymers

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# $^{31}$P MAS NMR as analytical tool in combinatorial chemistry

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in collaboration with
Sophie Barthélémy,
René Steinauer,
Merck Biosciences AG (CH)

**We investigated the stability, composition and loading of solid-phase bound phosphines used in combinatorial chemistry for applications in organic synthesis or as ligands for heterogeneous catalysis.**

Polystyrene bound phosphines used in solid-phase organic synthesis (e.g. for Wittig or Mitsunobu reactions) or as ligands in heterogeneous catalysis were investigated by $^{31}$P MAS NMR spectroscopy. A picture of the probe head used for the NMR experiments is shown in Figure 1. The loading of such resins may be determined by elemental phosphorous analysis or by elemental bromine analysis after chemical derivatization of the phosphines to the corresponding benzylbromides. To circumvent these material and time consuming steps, an NMR method was developed to quantify resin loading via addition of triphenyl phosphate as reference compound. Results for a series of phosphines are consistent with those obtained from well-established analytical methods. The formation of by-products (**B** and **C**) was monitored under different oxidative conditions (Fig. 2).

The nature of size, shape, and functional groups of resin beads can have significant effects on the reproducibility and yield of solid-phase organic reactions. These properties vary considerably within and among batches of commercially available beads and also depend on their production conditions. After a simple cleaning procedure of the starting material, the use of polystyrene resins from 7 different manufacturers with different bead sizes and degrees of cross linkage used for intermediate products in combinatorial chemistry was investigated. The cross linking degree of the resins was estimated by the swelling and thermogravimetric properties of the purified material. We have shown significant differences between the data indicated by the manufacturers and the results obtained by our experiments. The reproducibility of a 5-step reaction cascade was investigated with the purified material. Only small differences in overall yields were found, whereas unpurified resins showed decreased reactivity. With $^{31}$P MAS NMR the loadings of the final products (polystyrene bound carboxy triphenylphosphines) were quantitatively determined. The results were in excellent agreement with the data from phosphorous elemental analysis.

***Fig. 1:*** *Opened 4 mm CP MAS probe used for the $^{31}$P NMR experiments. The samples were rotated in the rotor (brown and white device tilted by 54.7° from the vertical axis) at a spinning frequency of 2000 Hz.*

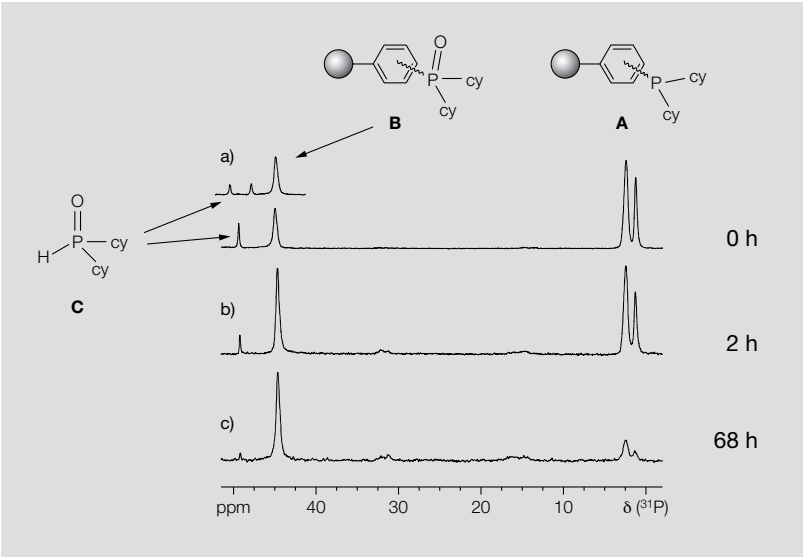


***Fig. 2:*** *Oxidation progress of PS-P(cyclohexyl)$_2$ monitored by $^{31}$P{$^1$H} MAS NMR after a) 0h, b) 2h and c) 68h, respectively, with b) and c) subjected to 7 bar $O_2$ atmosphere. The insert of a) shows the spectral region without $^1$H decoupling.*

**Support:** BBT-KTI

**Links:** www.empa.ch/abt140

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# Functionalized polyhydroxyalkanoates with tailor-made properties: biosynthetic and chemical approaches

**We produce a large amount of bacterial polyhydroxyalkanoates (PHAs) with terminal side chain double bonds in chemostat cultures. By varying the feeding conditions, we are able to produce amorphous PHAs with adjustable glass transition temperatures over a range of 50 °C. These PHAs can be further converted into highly crystalline materials via polymer-analogous reactions on the double bonds. The combination of both concepts opens the doors to the multitude of applications of functionalized PHAs in industry.**

Roland Hany,
René Hartmann,
Christine Böhlen,
Thomas Geiger,
Manfred Zinn

Polyhydroxyalkanoates (PHAs) are natural polyesters that are produced by many bacteria as intracellular carbon and energy sources. PHAs with short side chains, such as polyhydroxybutyrate and its copolymers with hydroxyvalerate, poly(HB-*co*-HV), are highly crystalline, thermoplastic materials with a degree of crystallinity of 60% or more at all compositions (Fig. 1a). PHB has a melting point close to that of polypropylene, better oxygen barrier properties than those of polyethylene-terephthalate and polypropylene, and mechanical properties resembling those of polystyrene and polypropylene. However, its brittleness and narrow processing temperature window limit its application. On the other hand, medium-chain-length (mcl-)PHAs, which contain C6 – C12 alkanoate monomers (Fig. 1b), are soft to sticky elastomeric thermoplastics of lower crystallinity, with melting points in the 45 – 60 °C range and glass transition temperatures down to – 40 °C. Mcl-PHAs can contain side chains with functional groups and, among many others, polymers with double and triple bonds, acetoxy and ketone, or aromatic groups have been produced. These groups provide sites for further chemical modification, directed to modulate the basic polymer properties or to create functionalities which are impossible to introduce by biosynthesis.

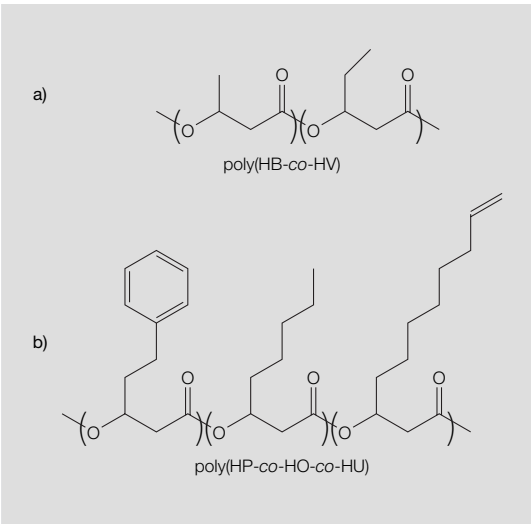


***Fig. 1:*** *Chemical composition of bacterial polyesters. a) poly(hydroxybutyrate-co-hydroxyvalerate), poly(HB-co-HV), and b) poly(hydroxyphenylvalerate-co-hydroxyoctanoate-co-hydroxyundecenoate), poly(HP-co-HO-co-HU).*

PHAs are biocompatible polyesters and have gained considerable significance in medical and industrial applications, which include release systems, implant materials, scaffolds in tissue engineering, and packaging. However, the controlled design of PHAs for these value-added applications is still a challenge. A number of obstacles remain to be solved, notably with regard to the tailoring of the mechanical materials properties, the adjustment of the biodegradation rate, the hydrophilic-hydrophobic balance, or the functionalization with bioactive compounds. We pursue both biosynthetic and chemical approaches to overcome some of these problems.

PHAs from different feed mixtures of 5-phenylvaleric acid, octanoic acid and 10-undecenoic acid were produced in chemostat cultures of *Pseudomonas putida* Gpo1. The steady-state conditions in a continuous culture are ideally suited to produce PHAs with tailored copolymer composition by taking advantage of the adjustable effect of feed mixture on polymer composition (Zinn et al., 2003). Various random, amorphous copolymers poly(hydroxyphenylvalerate-*co*-hydroxyoctanoate-*co*-hydroxyundecenoate), poly(HP-*co*-HO-*co*-HU), were produced (Fig. 1b). They contained variable amounts of aromatic units (0 – 59 mole %), 10 mole % unsaturated side chains, and octanoate units forming the remaining part (Hartmann et al., 2003). The aromatic fraction determined the glass transition temperature ($T_g$) of these copolymers, and $T_g$ increased linearly from – 38.7 °C for poly(0%HP-*co*-90%HO-*co*-10%HU) to – 6.0 °C for poly(59%HP-*co*-31%HO-*co*-10%HU). Extrapolation leads to a $T_g$ of about 14 °C for the homopolymer polyhydroxy-5-phenylvalerate, close to the literature value of 13 °C. In this way, we are able to produce PHAs containing unsaturated side chains with adjustable glass transition temperatures over a wide range of 50 °C.

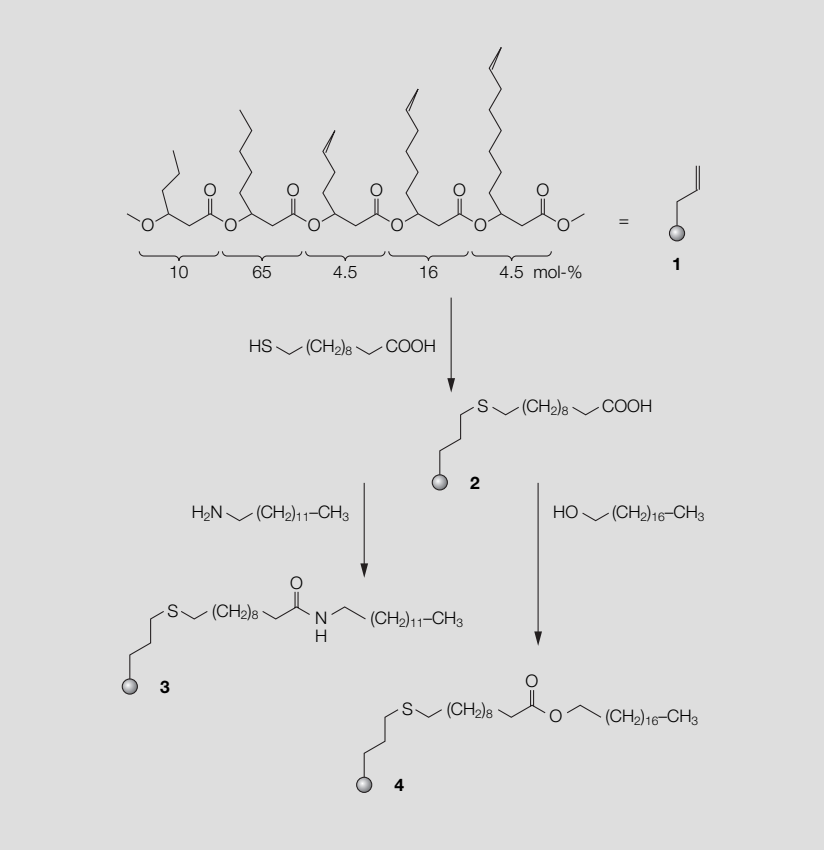


***Fig. 2:*** *Synthetic route to comb polymers **3** and **4**.*

We extended the existing library for polymer-analogous reactions on mcl-PHAs (Fig. 2). Comb polymers were produced in a two-step synthesis from a PHA containing 25 mole % terminal side chain double bonds (Hany et al., 2003). The radical addition reaction of 11-mercaptoundecanoic acid to the side chain alkenes of **1** produced derivative **2** containing thioether bonds with terminal carboxyl functionalities, which were subsequently transformed into the amide (**3**) or ester (**4**) derivatives using tridecylamine or octadecanol, respectively. The reactions proceeded to completion with nearly no side reactions, which was confirmed with NMR and GPC experiments. The resulting comb polymers **3** and **4** were white crystalline materials. $^{13}C$ CP/MAS NMR spectra and X-ray diffraction results suggested a crystalline textural two-phase organization into polyethylene-like domains and regions characteristic of PHAs. The breadth of the decomposition steps in thermal gravimetric analysis and the diffuse melting endotherms confirmed the solid-state organization as composed of nanosize crystallites of both polyethylene and PHA. The sketch in Figure 3 is meant to show the solid texture of the polyethylene-like phase, which could be a useful property for stabilizing the crystallization of PHAs and eliminating its well known stickiness.

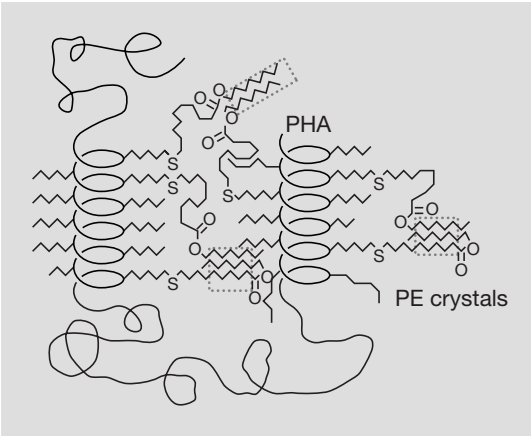


***Fig. 3:*** *Proposed model of PHA derivative **4** shown in Fig. 2. The polyethylene crystals are surrounded by a dotted line.*

**Links:** www.empa.ch/abt140

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***References:***
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*R. Hany et al., Macromol. in press (2003)*

# Service life prediction of GRP pipes in aggressive environments

**The objectives of this EU project were investigation of the long term behavior of glass fiber reinforced polymer (GRP) pipes and pipe connections in the wet condition and in the acid environments, long term extrapolation and service life prediction, and establishment of new testing and design standards. Long term creep tests were carried out on the GRP pipe samples in the wet conditions. Furthermore, the strain corrosion behavior of the GRP pipe sections was experimentally and theoretically studied. The long term response of the samples in the wet condition and in the sulfuric acid environments was experimentally determined and was theoretically extrapolated to fifty years of the pipe service life. The long-term extrapolation of the data related to the wet pipes tested in water to 50 years showed a reduction of strength by about 55%. This project is carried out in the framework of the 5th EU innovation program with participation of 11 European partners.**

Mehdi Farshad,
Adly Necola,
Peter Flüeler

Glass fiber reinforced polymer (GRP) pipes are composite structures consisting of glass fiber reinforced polymer resins. They are composed of short or long glass fibers, and thermosetting resins like polyester or vinyl ester. GRP pipes have various industrial applications in the fields of chemistry, petrochemistry, food, and energy technology as pressure pipelines as well as in drainage and sewerage piping systems. In these applications, pipes may come in contact with various mediums that may have damaging effect on the material of the pipe.

This research project deals with experimental and theoretical investigation of the long-term behavior of GRP pipes in the wet condition and also in the acid environments and the long-term extrapolations. For this purpose, long-term experiments are to be carried out for shorter periods (up to about 2 years) and the experimental results should be extrapolated to the longer period of the service lifetime. The final objectives would be optimization of the long- term investigations and prediction of the service life. In addition, the behavior of GRP flanges and pipe connections has also been investigated. For this purpose, numerical Finite Element simulation of the composite flange under various loading conditions has been carried out.

To predict the long-term behavior of GRP pipes, creep experiments were carried on the pipe ring sections. The specimens used for the creep tests consisted of GRP pipe segments with nominal diameter (DN) of 500 mm and for a nominal internal pressure of 10 bars. The nominal stiffness (SN) of the ring samples amounted to 10,000 N/m$^2$.

The first group of direct creep tests was performed on the wet pipe samples, which were conditioned for over 1000 hours. The creep testing was carried out under constant dead weight on conditioned samples submerged in water containers (Fig. 1). The long-term tests showed that, for the pipes tested, the strength corresponding to 1000 testing hours was about 55% of the short-term strength.

***Fig. 1:*** *Testing systems for long-term creep test of pipes in wet condition.*

For long-term extrapolation of the experimental data, a regression analysis was used. The extrapolation model assumed a linear relation between the logarithms of diagonal load to the logarithm of time to failure. Through the experimental-theoretical correlation the functional relation was established and the trend of vertical load versus time to failure of

the sample group was obtained. The extrapolation of the data to 50 years showed a reduction of strength by about 55% (Fig. 2).

In another part of this project, the long-term creep behavior of GRP pipes in acid environment was experimentally investigated. The samples were exposed to 5% sulfuric acid at the inside bottom zone of the ring (Fig. 3). Failure of samples occurred at the inside of the bottom zone, where the strain corrosion took place. For the long-term extrapolation of experimental data a regression analysis was used and the trend of relative vertical deflection versus time to failure of sample group was established. The theoretical model was similar to the one used previously. It related the logarithm of strain to the logarithm of time to failure. The theoretical correlation showed that under the influence of constant diametrical deflection and sulfuric acid, the maximum strain after 1000 hours would reach to about 0.5% (Fig. 4).

***Fig. 3:*** *Testing systems for long-term strain corrosion testing of GRP pipes.*

The results of this work have led to quantitative predictive statements about the long term behavior of GRP materials and pipes in wet condition and in the acid environments. The result of this work can be used in the service life prediction of GRP pipes in these environments. The knowledge gained from this research and other project work packages shall be exploited through European standardization and shall be used in the new standard for the design and the lifetime prediction of GRP pipes and flanges.

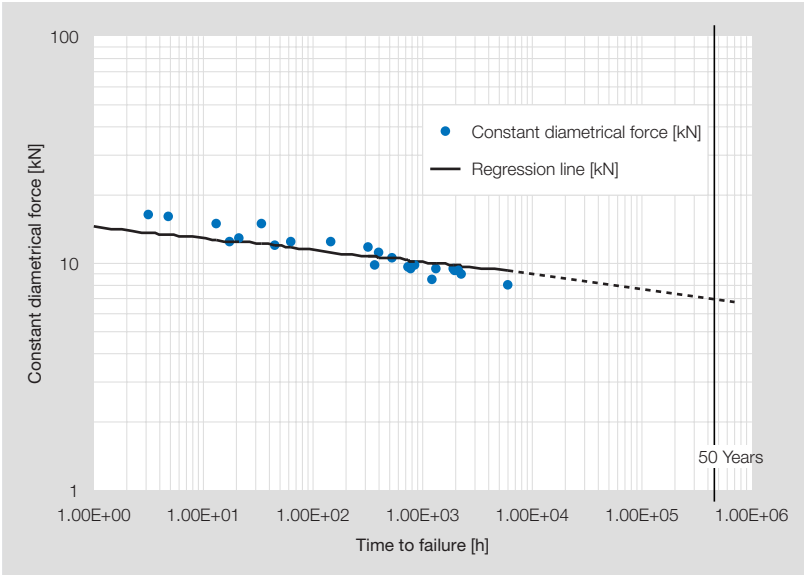


***Fig. 2:*** *Long-term (creep) response of GRP pipe ring specimens in wet condition under vertical diametrical compressive force. The figure also shows the result of regression analysis and extrapolation to 50 years.*

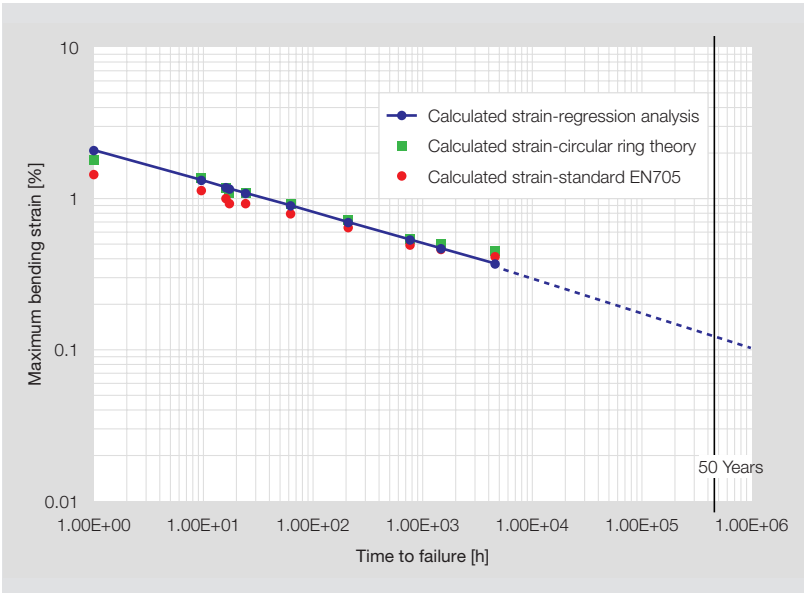


***Fig. 4:*** *Strain at failure: the experimentally based values, the regression curve, and the long-term extrapolation.*

**Support:** BBW, EU Program V

**Links:** www.empa.ch/abt114

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***References:***
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# Service life prediction for aircraft coatings

**A model with three stress types, the temperature, UV and aerosol, for estimating the service life of organic coatings under service conditions has been proposed. The model has been applied to the estimation of the service life for aircraft coatings concerning loss of gloss. The results obtained from a unique natural exposure program for a reference polyurethane coating have been compared with the results from the specially designed accelerated aging tests, which were performed with a new designed and constructed weathering device. As a special point of interest, the influence of sulfuric aerosol, which has simulated the stratosphere conditions after a big volcano eruption, on the service life of the reference coating has been investigated.**

Olga Guseva,
Samuel Brunner,
Oliver von Trzebiatowski,
Peter Richner

The organic coating industry has been performing research in order to find new chemical formulations with enhanced stability against environmental influences, and at the same time with possibly smaller contents of hazardous substances. The service life of these new chemical formulations is often unknown. Usually, the field experiments (natural exposure) for modern coatings take prolonged time of several years, which is not acceptable for manufactures. Here we applied the Service Life Prediction approach to the aging of aircraft coatings concerning the gloss loss. The validation of the model was performed for reference polyurethane coating with a light blue color.

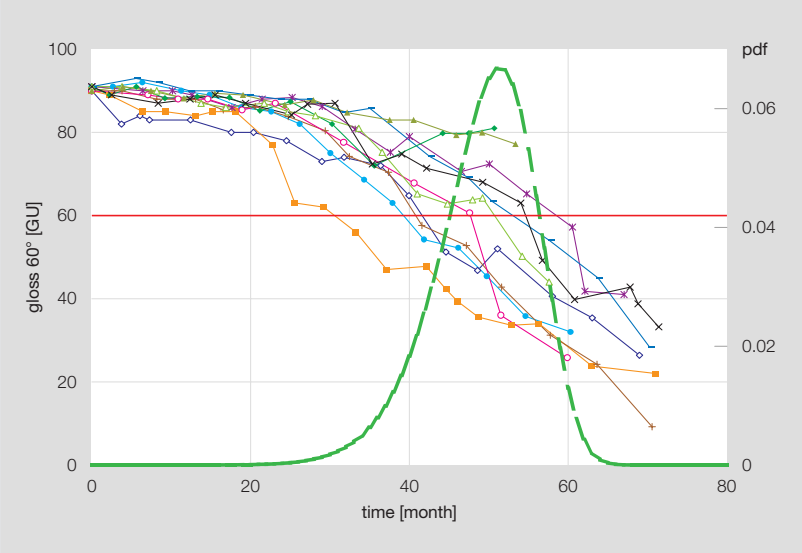


***Fig. 1:*** *Gloss 60°-curves for the reference coating applied on escape hatches. The red horizontal line represents a failure criterion of 60 GU and the green dashed curve – the probability density function.*

Firstly, gloss degradation curves for the reference coating were obtained in a unique natural exposure program (Escape Hatch Program) and the service life was calculated using the Weibull distribution (Fig. 1). Secondly, the specially designed accelerated aging tests were performed with the same coating (Fig. 2) using the new designed and constructed weathering device. In order to compare both results, the life-stress relationship was found and the use level conditions were determined. For the temperature, the Arrhenius life-stress relationship with a value for the apparent activation energy of 8.4 kcal/mol was used, and for the UV-A irradiance at 340 nm the inverse power life-stress relationship with a power coefficient of 0.46 was taken. The third stress, the aerosol, was treated as an indicator variable taking discrete values of zero (no aerosol application) and one (aerosol application).

The estimation of the service conditions for aircraft coatings was performed by using an Arrhenius weighting term for temperature and a power weighting term for UV. Here we based on the climatic data for air temperature and UV irradiance at some randomly chosen destination sites together with the specially performed experiment for determination of the difference between air and panel temperatures. The calculated service conditions (the use level) were 32 °C for the panel temperature, 0.24 W/(m$^2$ nm) for the UV and zero for the aerosol parameter.

The calculations of the service life were made assuming the Weibull distribution (Fig. 3). The calculated mean life for the gloss loss of reference coating at the use level with a failure criterion of 60 GU measured at gloss 60° was 42.0 months, and the 90% warranty time (time at which only 10% of the panels had reached the failure criterion) was 38.4 months. The mean life and the 90% warranty time obtained from the natural weathering (Escape Hatch Program) of the same coating were 49.3 months and

40.9 months, respectively. Both experimental results were in good agreement, which validated the model (Fig. 4).

Our method gives a unique opportunity to investigate the aerosol influence on coatings. Starting from the fact that the service life of aircraft coatings was reduced by approximately 50% in the years from 1992 to 1995 following the eruption of the volcano Pinatubo in June 1991, the specially designed weathering experiment was conducted which simulated the post-eruption stratosphere conditions. The most simple mathematical model for the aerosol parameter showed that the sulfuric aerosol shortened the service life of the reference coating by at least 40%, which suits perfectly with the above mentioned 50% reduction. Regarding the degradation of the reference coating, the conclusion can be made that the reference polyurethane coating under investigation was sensitive to the sulfuric aerosol.

For new coatings now under development, it can be a question of interest whether a new product is resistant to sulfuric aerosol. Moreover, other pollutants, for example, acid rain simulation can be included into the investigation, which is important for automotive coatings.

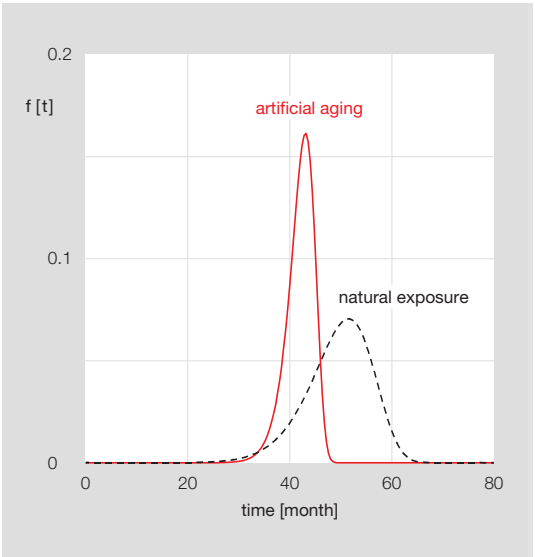


***Fig. 4:*** *Probability density functions for gloss loss with a failure criterion of 60 GU measured at gloss 60° for the reference coating obtained from the natural exposure experiment (dashed line) and the artificial aging (solid line) calculated for a use level of 32 °C (305 K), 0.24 W/(m² nm) and zero for the temperature, UV and aerosol parameter, respectively.*

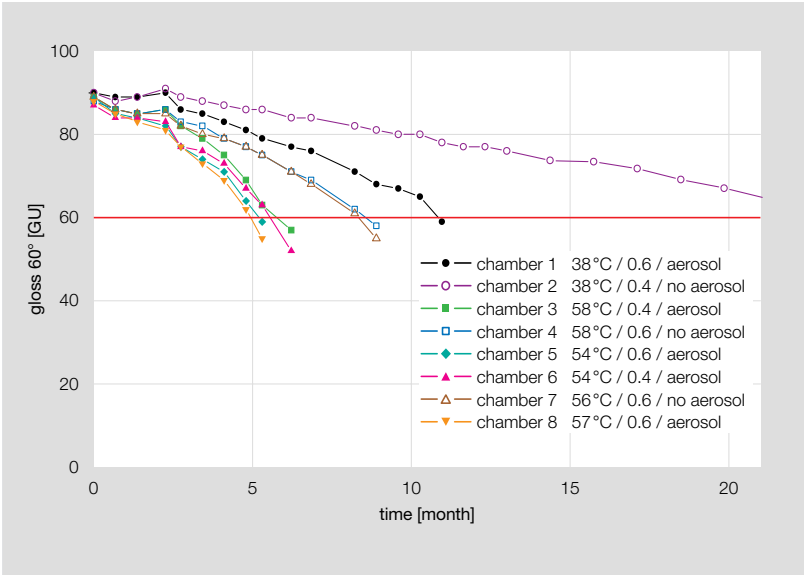


***Fig. 2:*** *Experimental gloss 60°-curves for the reference coating for chambers 1–8. Filled symbols denote the chambers with aerosol application.*

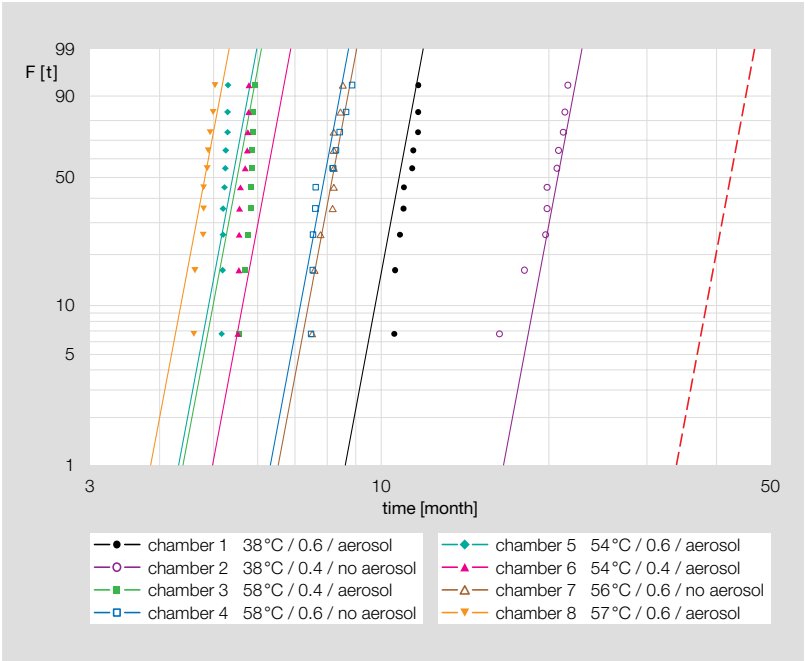


***Fig. 3:*** *Cumulative distribution functions for gloss loss for the reference coating with a failure criterion of 60 GU for gloss 60°, shown on Weibull paper assuming the common shape parameter across all chambers. The red dashed line represents the extrapolation to the use level.*

**Support:** BBT-KTI, Akzo Nobel, SR Technics, KLM

**Links:** www.empa.ch/abt136

***Contact:*** *olga.guseva@empa.ch*
***References:***
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# Biomimetic engineering: Natural wood structures for energy storage

**Hierarchical structures which can be modified by biomimetic engineering to the particular demands of energy storage applications make wood an interesting candidate as an electrode material.**

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in collaboration with
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University Fribourg;
Ruediger Koetz, PSI;
Roland Gallay, Maxwell;
Fabrizio Corti, Timcal
Graphite & Carbon
(CH)

Depending on the power and energy demanded in a certain unit of time for a given electrical device or system, an optimum electrical energy storage system can be defined. Storage devices such as capacitors, electrochemical double-layer capacitors (EDLC) and batteries differ form each other in regard to their stored energy density (Wh/l) and power density (W/l) during discharging. For systems which demand high power density in a period of 1–100 s, electrochemical capacitors are the ideal supplier.

The active layer in today's electrochemical double-layer capacitors may consist of a large amount of inactive material which does not contribute to the overall capacitance of the device. In order to fully utilize the porous active electrode material, a pore size tailored to the electrolyte ion size is crucial. Furthermore, the undesired decrease in capacitance with increasing frequency can be minimized by controlling the pore size distribution. These demands can be met with an electrode containing well-defined micro-scaled (d < 2 nm) and meso-scaled (2 nm < d < 50 nm) porosity. The micropores guarantee a large surface area which is necessary to obtain a large capacitance, while mesopores provide good ionic transport and contact to the nanopores deep in the active layer, (Fig. 1). Artificial forming of this advantageous bimodal pore size distribution appears to be difficult at first glance, but in fact is easily to achieve using biomimetic wood transformation.

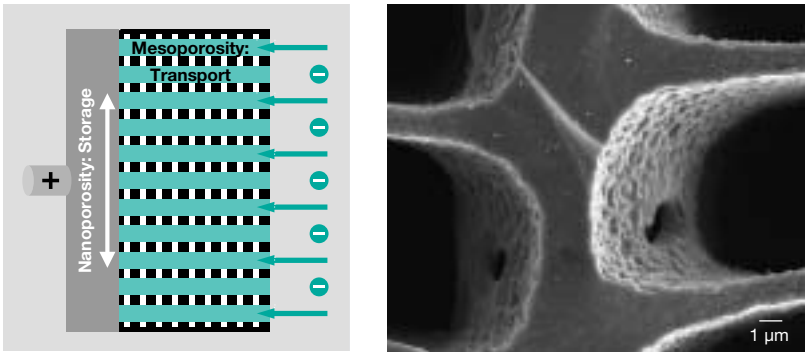



***Fig. 1:*** *Schematic model of an ideal electrode with porosity tailored for surface charging in the nm-range and ion transport in the sub-µm-range (left), and nm-range and sub-µm-range porosity in the natural cell wall of carbonized and activated pine (right).*

In order to produce the electrode material, we transform wood structures into a carbonized preform (template) by pyrolysis in an inert atmosphere at 1100 °C. The hierarchical wood morphology is maintained during this step. Careful selection of the properties of the starting wood and process control during the following activation by water steam or $CO_2$ permits the meso- and the nano-porosity to be precisely tailored. This transformation process was carried out with beech, maple, poplar, pear and ebony and together with the project partners, a large number (40) of the resulting carbon templates were characterized and compared with commercial graphites and activated carbons. Electrochemically relevant parameters including the specific surface area, density, porosity, serial resistance and specific capacitance were analyzed.

Figure 2 shows the specific capacitance as a function of the specific surface area. Despite significant data scatter, it is clear that the specific capacitance increases with increasing surface area and almost reaches the maximum theoretically-predicted values. The capacity saturates at around 70 F/g for a specific surface area greater than 1000 $m^2/g$. This exceeds the 50 F/g measured for an activated reference carbon derived from artificial carbon precursors designed especially to meet the demands of electrodes (Timcal).

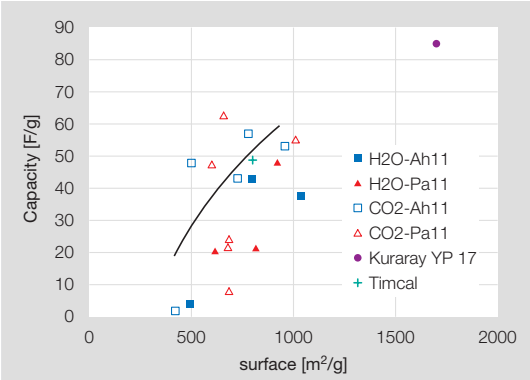



***Fig. 2:*** *Specific capacitance of wood-derived electrodes and commercial graphites and activated carbon as a function of surface area determined by nitrogen adsorption, (Ah = maple, Pa = poplar).*

**Support:** TOP Nano 21

**Links:** www.empa.ch/abt123 > Biomimetic

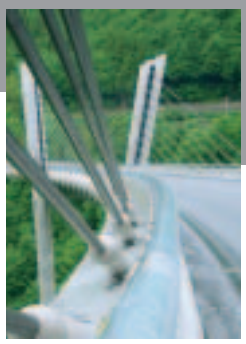
***Contact:*** *andreas.herzog@empa.ch*

***References:***
*R. Klingner, J. Sell, T. Zimmermann, A. Herzog, U. Vogt, T. Graule, P. Turner, F. Beckmann, B. Müller, Holzforschung, Wood Science, 57, 4, (2003)*
*A. Herzog, U. Vogt, T. Graule, R. Klingner, J. Am. Ceram. Soc. accepted (2003)*

# List of abbreviations

| | |
|---|---|
| armasuisse | Swiss Defence Procurement Agency |
| ASTRA | Swiss Federal Roads Authority |
| BAG | Swiss Federal Office of Public Health |
| BAKOM | Swiss Federal Office for Communication |
| BBL | Swiss Federal Office for Constructions and Logistics |
| BBT-KTI | Swiss Federal Office for Business Formation and Technology – Commission for Technology and Innovation |
| BBW | Swiss Federal Office for Education and Science |
| BFE | Swiss Federal Office for Energy |
| BLW | Swiss Federal Office for Agriculture |
| Brite EuRam III | Basic Research in Industrial Technologies in Europe and European Research in Advanced Materials |
| BUWAL | Swiss Agency for the Environment, Forest and Landscape |
| EAWAG | Swiss Federal Institute for Environmental Science and Technology |
| EC | European Commission |
| EFD | Swiss Federal Forest Agency |
| EPFL | Swiss Federal Institute of Technology Lausanne |
| ETHZ | Swiss Federal Institute of Technology Zürich |
| EU Program V | European Community, 4th Framework Program |
| EU Program VI | European Community, 5th Framework Program |
| FAM | Swiss Federal Dairy Research Station |
| Holz-21 | Swiss Federal Stimulation Program for the Wood |
| IT'IS | Foundation for Research on Information Technologies in Society |
| IZT | Institute for Future Studies and Technology Assessment |
| MaNEP | Materials with Novel Electronic Properties |
| NCCR | National Center of Competence in Research |
| MIBD | Swiss Dairy Inspection and Advisory Services |
| PSI | Paul Scherrer Institute |
| SLS | Swiss Synchrotron Light Source |
| SNF | Swiss National Science Foundation – National Research Progam |
| TA Swiss | Swiss Center for Technology Assessment |
| TOP Nano 21 | Research Program of the Board of ETH |
| UAS | University of Applied Sciences |
| UVEK | Swiss Federal Department of the Environment, Transport, Energy, and Communication |
| VST | Swiss Federation of Door Manufacturers |

# EMPA Activities 2003
# Materials and Systems for Civil Engineering



## Mission

The overall consumption of energy and raw materials in our society is highly determined by the construction and the operation of the built environment. The activities of the department are, therefore, focused on the development and the assessment of materials, systems and processes which lead to a decrease in the consumption of resources. Thereby we support the transformation process towards a sustainable society.

## Activities

**Consumption of energy and other resources:** In order to realize the vision of a 2000 Watt society, new solutions are needed to reduce the energy consumption of buildings. Renewable energy and increased energy efficiency in new buildings and especially in retrofitted buildings are among the top priorities. Examples are the development of vacuum insulation panels with a thickness of only 1–2 cm or thermally activated ceiling panels for retrofitting. Methods and concepts are developed which can be used to evaluate whether a new material, system or process fulfills the criteria of sustainability. One of them is the *ecoinvent* database, which was developed in collaboration with other federal research institutes and which can be accessed over the internet. Furthermore, the use of recycled materials for the substitution of primary materials is supported by several research projects, mainly in the area of bituminous and cement-bound materials.

**Materials:** The macroscopic behavior of construction materials can only be fully understood and optimally tailored for a specific application if their behavior on a microscopic and even nanoscopic level is understood as well. New analytical tools such as AFM, FIB and others are used together with the modeling of the thermodynamics to gain new insights in the hydration of cement-bound materials. Based on these results it is possible to get a new approach to questions such as durability of concrete or the function of admixtures. The use of wood, the most important renewable material on national and world-wide scale, is supported by the improvement of the technical, ecological and economical quality of wood, wood based products and systems. A fascinating example is the extraction of cellulose fibrils out of wood with a diameter of only a few nm and length of several µm which can be used as polymer reinforcement, preferably in combination with a biodegradable polymer.

**Durability and Safety:** Premature failure of materials and systems is prohibited by the systematic characterization of their behavior over time. One example is the development of structural health monitoring systems for civil infrastructures with a focus on online collection and processing of data delivered by various sensor systems. Composite materials such as carbon fiber reinforced polymers (CFRP) are used for the post-strengthening of existing structures in order to adapt them to enhanced static and dynamic loads. Service life

prediction models are developed for materials and systems based on the realistic determination of the environmental parameters relevant for their ageing process and on a profound understanding of the associated physical and chemical processes.
The expected durability of new materials and systems is determined by tailor-made accelerated laboratory tests which lead to realistic deterioration processes. Failure analyses and expertises for public authorities are an important part of the services provided by the department.

**Adaptive Systems:** The combination of smart materials, sensor technology, miniaturized electronics and sound engineering knowledge allow the creation of new solutions in a variety of areas.
The use of lightweight structures e.g. in bridge construction theoretically permit a wider span than with conventional design; however, it is limited due to the increasing susceptibility to vibrations caused by ambient factors such as wind, rain or traffic. Therefore, a cable-stayed bridge model was constructed which serves as a research platform for different projects such as the comparison of different controled damping devices for the mitigation of cable vibrations. Another area of activity is the use of electroactive polymers which are of great interest due to there large deformation of 10% to 100% upon reversible activation in electric fields. First prototypes of devices are constructed with the aim to use them on a mid-term range as artificial muscles, active protheses or for the activation of large surfaces of shallow structures. In all areas, the experimental work is always accompanied by intensive modeling.

*Peter Richner, Department Head*

# A simple approach to the localization of flaws in large diameter steel cables

Andrea Bergamini, Rouven Christen

**Following the successful application of magnetic flux leakage (MFL) testing for inspection of stay cables in 2001, new developments in the analysis of the MFL data make the 3D localization of flaws in steel cables possible. The developed analysis method is a useful tool for the inspection and maintenance of modern multi-strand stay cable systems.**

In the summer of 2001, EMPA used for the first time its nondestructive magnetoinductive evaluation system for large diameter steel cables. The method is based on the detection of the magnetic leakage fields originating from flaws within the inspected sample. Object of the inspection were the locked-coil stay cables of RAMA IX Bridge in Bangkok Thailand.

For this inspection, the information obtained from the recorded data (intensity of the MFL on the surface of a magnetically saturated cable) was limited to the accurate position of detected flaws along the axis of the cable and of a qualitative indication of the position of the flaws within the cross-section. While this information is sufficient to assess the conditions of the free length of locked coil or parallel wire cables, more detail is needed in the case of multi-strand systems.

The currently popular multi-strand stay cable systems allow, in principle, for the replacement of individual faulty strands. In order to perform this type of maintenance operation, it is necessary to localize the position of broken wires within the cross-section of the bundle.

Such information can be obtained by iterative computation of the finite element model solving for the measured MFL as a function of the position of the flaw. An alternative to such a computing intensive approach, based on a simple mathematical model of the MFL function, was developed. The function approximating the MFL of a sub-surface flaw (eq. 1) is used for a non-linear fit of the measured data.

$$\vec{H} = \begin{vmatrix} 0 \\ 0 \\ H_a \end{vmatrix} + \frac{\mu_m - \mu_i}{2\mu_m + \mu_i} H_a a^3 \begin{vmatrix} 3d_z d_x / d^5 \\ 3d_z d_y / d^5 \\ (3d_z{}^2 - d^2) / d^5 \end{vmatrix}$$

with $\vec{d} = \vec{S} - \vec{D}$, see Fig. 1 (1)

where $H_a$: applied magnetic field, a: diameter of the flaw, $\mu_i$ and $\mu_m$ permeability of the cable material and of the inclusion, respectively. The localization algorithm method has been tested successfully on simulated and measured data for a 31 strand stay cable.

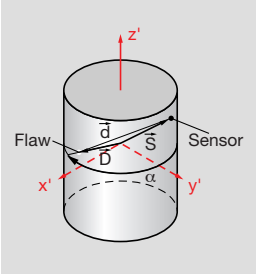



***Fig. 1:*** *Schematic representation of the cable with position of the flaw and a sensor.*

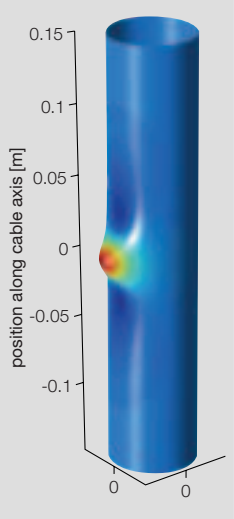



***Fig. 2:*** *MFL intensity on the surface of a flawed cable, calculated with (1).*

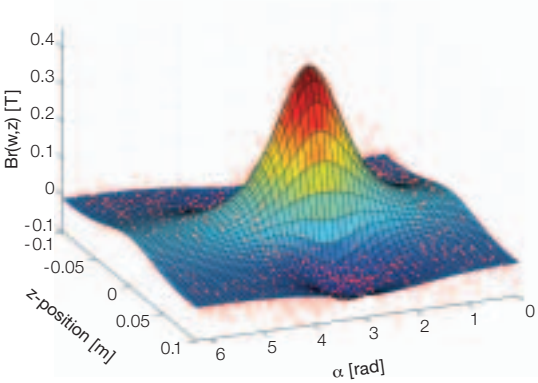



***Fig. 3:*** *Measured MFL data (red dots) and fitted approximation (surface plot).*

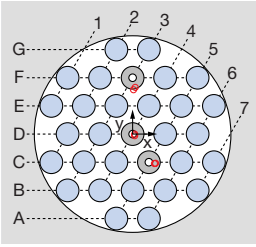



***Fig. 4:*** *Actual position of flaws in a 31-strand cable (dark grey) and calculated position (red circles).*

**Support:** ASTRA

**Links:** www.empa.ch/abt116/
Investigation of cables

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***References:***
*A. Bergamini, R. Christen, Conf. Proceed., SPIE's 8th Ann. Int. Symp. on NDE for Health Monitoring and Diagnostics (2003)*
*R. Christen, A. Bergamini, M. Motavalli, J. of Nondestructive Evaluation, in press, v. 22 No. 3 (2003)*

# A smart cable-stayed bridge model

**A cable-stayed footbridge has been erected in the testing hall at EMPA. The bridge girder consists of glass-fiber reinforced plastic (GFRP) profiles and is therefore a light and slender structure which is susceptible to structural vibrations. This bridge will be used as a realistic testing object for applied research and education in structural dynamics, control, and health monitoring.**

Daniel Gsell,
Glauco Feltrin,
Felix Weber,
Masoud Motavalli

In today's bridge design, a trend towards bigger spans can be observed. Moreover, the material is stressed closer to its strength limit (Fig. 1). Consequently, modern bridge structures are becoming increasingly prone to vibrations. The reasons for these dynamic problems are the stiffness and mass reduction of the structural components. Since the reduction in stiffness is larger than in mass, lower resonance frequencies result. Due to the low-frequency excitation, the resonance hazard of buildings increases. The reduction of inertia results in larger vibration amplitudes due to dynamic loading caused by traffic, wind, and earthquakes. Since the structure is subjected to a strongly increased fatigue loading, lifetime decreases. Visible and noticeable structural vibrations may force the bridge users to feel unsafe. Therefore, the development of appropriate vibration mitigation set-ups and health monitoring systems become essential.

***Fig. 1:*** *Sunniberg Bridge at Klosters, by Prof. Dr. Christian Menn.*

In autumn 2002, the project Smart Cable-Stayed Bridge was launched by the Structural Engineering Research Laboratory. The main purpose of the first project phase was to erect a cable-stayed bridge in the testing hall of EMPA (Fig. 2). The objective was to construct a bridge structure with well defined boundary and environment conditions, thus enabling systematic investigations of its dynamic behavior. In order to study the vibration problems described above, the structure was designed to be susceptible to structural vibrations. Due to the laboratory's research activities in the area of cable dynamics and their non destructive testing, a cable-stayed bridge was built. The maximum dimensions of the bridge were given by the available space in the testing hall (length: 20.0 m, width: 2.5 m, height: 7.5 m). Because of the limited dimensions, the structure is designed as a footbridge. The bridge girder consists of GFRP profiles. Due to the high ratio of strength to mass density as well as durability, this material finds increasing applications in the construction industry. GFRP side members supported by rigid ropes may lead to an elegant, slender, and light weighted construction. In a first project phase, seven wire steel strands are used as stay cables. Later on, they will be replaced by carbon-fiber reinforced plastic cables.

***Fig. 2:*** *Cable stayed footbridge model at EMPA.*

With this project, an important link between simplified laboratory experiments and more complex real-world applications has been created. Different subprojects of our laboratory and of external partners will be integrated into this project. The bridge itself becomes a research platform covering the following topics:

- Passive, semi-active and active vibration mitigation
- Structural health monitoring
- Distributed, integrated and smart sensing
- New structural materials

In addition, the bridge will be used as a demonstration object in training courses for students and professionals. Topics like dynamic measuring techniques and experimental modal analysis will be treated.

Up to now, the following subprojects have been planned to be integrated into the bridge project:

- Cable vibration mitigation using controlled magnetorheological fluid dampers. The control strategy developed on a simple test set-up will be verified on the more complex and realistic situation given by the dynamics of bridges. Furthermore, the efficiency of the control strategy will be tested for parametric excitation of the cables.

- Fault detection by curvature estimation with fiber optic sensors. Today's modal analysis, based on measured translation degrees of freedom, is used with rather moderate success to assess existing buildings. Here, the monitoring is based on directly measured curvatures. In contrast to displacements, curvatures are in a more direct relation to the structural damage, which expresses itself in form of a stiffness reduction of the cross sections.

- Adaptive Tuned Mass Damper. One of the problems of lightweight structures is the change of their resonance frequencies depending on live loads (Fig. 3). In order to guarantee optimal damping of the structure, the frequency of Tuned Mass Dampers must be adapted to the actual loading.

- Smart wireless sensing. Dynamic measurements of large buildings are cost-intensive. Each sensor must be connected individually and a large quantity of data is acquired. Therefore, a system will be developed consisting of satellites, i.e. wireless sensors and a base station. An intelligent data reduction strategy will be implemented into such satellites.

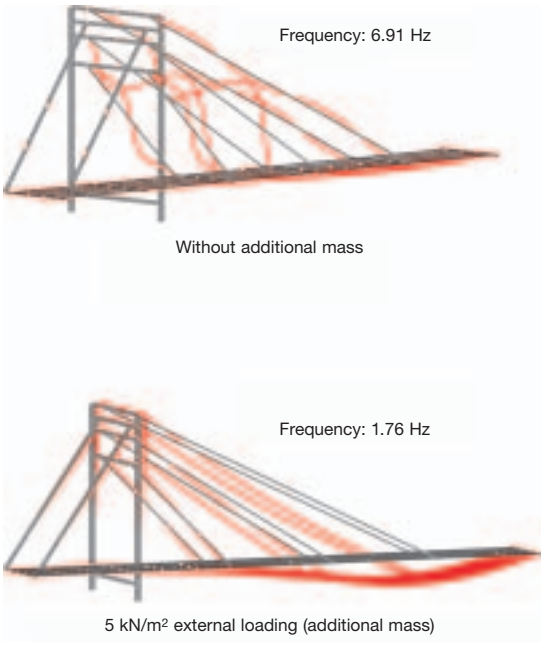


***Fig. 3:*** *Dependency of the resonance frequency of the first bending-mode on the loading condition. Calculated by a linear FE-Model based on 3D Timoshenko-Beam-Elements.*

Until now, several collaborations with industries, universities, and other domestic as well as foreign institutions have been established. Two PhD theses have been started within the bridge project. Professor Dr. Hugo Bachmann could be won as external scientific consultant.

**Support:** EU Program VI
Gebert Rüf Stiftung
Board of ETH
Fiberline Composites (DK)
Maurer und Söhne (DE)
Maag Technic (CH)

**Links:** www.empa.ch/abt116
> Smart structures

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***References:***
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# Evaluation of porous asphalt by various test methods

**In an international co-operative research project between JHRI and EMPA, porous asphalt specimens produced by an improved mix design method were compared with both Swiss and Japanese standard mixes of conventional empirical mix designs.**

Lily D. Poulikakos, Manfred N. Partl, in collaboration with Shigeki Takahashi, Japan Highway Public Corporation (JHRI)

Porous asphalt or open-graded asphalt is the result of *advanced technology* in pavement design. It is used in the top layers, usually has an air void content of 20% or greater, due to higher proportions of coarse aggregates and lower sand and filler content. As a result of this composition, interconnected voids are created which, in wet weather, allow the surface first to absorb water like a sponge, preventing ponding on the road surface, and then leading it away, like a series of micro pipes, into a drainage system. Figure 1 demonstrates the reduction of splash and spray in a porous asphalt pavement in Japan.

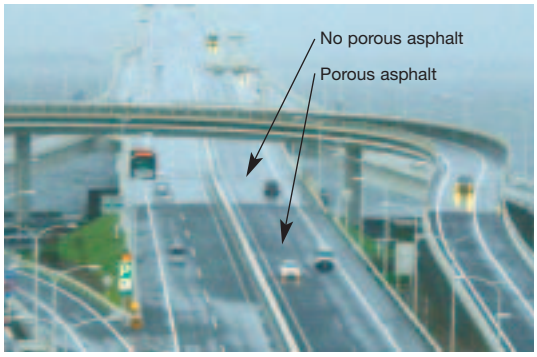


***Fig. 1:*** *Aqua line crossing Tokyo Bay during a rain storm (EMPA).*

Porous asphalt is used worldwide and offers a number of solutions to pavement problems. It is appreciated for its benefits in noise reduction and *improved safety* under wet conditions. Despite the environmental benefits, it can suffer from problems which can affect both its performance and service life. The open structure exposes a large surface area to the effects of air and water leading to rapid ageing of the binder which in turn leads to loss of adhesion and particle loss. Over time, the blockage of pores by road debris and post-compaction under traffic loads leads to loss of permeability. In order to reduce the problems associated with porous asphalt and retain the benefits, the study of porous asphalt has become an important objective within the main focus of advanced pavement materials development at EMPA.

Several industry standard tests, namely laboratory ageing of mixes, Cantabro (particle loss), water permeability, binder penetration, binder softening point, rheology of the binder using the dynamic shear rheometer (DSR), interlayer shear strength, indirect tensile, shear modulus of mixes using the Coaxial Shear Test (CAST), special to EMPA, and wheel tracking, were carried out to compare performance related properties of both theoretically and empirically designed porous asphalt specimens.

This joint Swiss-Japanese research project concentrated on the experimental aspects of this still ongoing research. Two mix design approaches with materials from both countries were considered as given in Table 1. The JPPA and SPPA approaches are based on the improved packing theory for aggregate gradation optimization based on theoretical considerations, reducing the post-compaction effects on the pavement under traffic. For the tests conducted at EMPA, the mixes have been short term (STOA) and long term (LTOA) oven aged in accordance to Industry standards. Short term ageing simulates the pre-compaction phase of the construction phase, and long term ageing simulates ageing that occurs over the service life of the pavement.

| Mix Design Method | Materials | |
|---|---|---|
| | Japan | Switzerland |
| Traditional (Empirical) | JPA | SPA |
| Packing Mix (Theoretical) | JPPA | SPPA |

***Table 1:*** *Type and notation of mixes used in this study.*

The Swiss standard porous asphalt (SPA) from a motorway paving job site was used to compare the mix properties with the theoretically packed SPPA. Both gradations have the same target porosity of around 22% as obtained on the job site. The recovered binder of 4.8 Mass-% from SPA was a 50/70 penetration graded straight run bitumen with Trinidad NAF 501. For the SPPA, 4.1 Mass-% of a penetration graded SBS polymer modified bitumen (PmB-C 50/70-53) was used. On the other hand, both Japanese mixes JPA and JPPA with the same target porosity of 23% use exactly the same aggregates (hard sand rock) and penetration graded polymer modified bitumen with 9% SBS.

Once the pavement is placed in service, secondary compaction or post-compaction due to traffic can lead to loss of porosity. In order to simulate this secondary compaction from traffic loads, after reaching target porosity or 50 revolutions of the initial compaction with the superpave gyratory compactor (SGS), a selected number of specimens were post-compacted using the SGC with up to 204 revolutions, at 1.25° degree angle of gyration and 600 kPa

axial pressure. Figures 2 and 3 show the effect of post-compaction on the porosity and water permeability of the mixes.

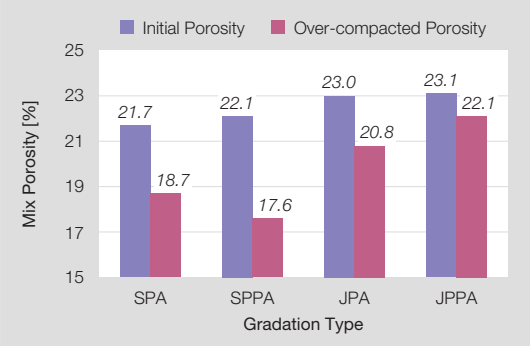


***Fig. 2:*** *Mix porosity of porous asphalt mixes with different gradations before/after post-compaction (JHRI).*

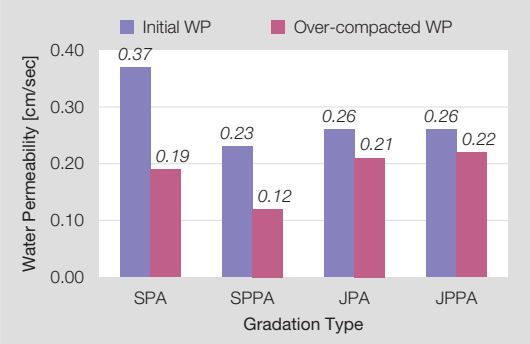


***Fig. 3:*** *Water permeability of porous asphalt mixes with different gradations before/after post-compaction (JHRI).*

The Layer Parallel Direct Shear (LPDS) test, originally developed in Germany (Partl et al. 1999), was used to analyze interlayer adhesion between porous asphalt wearing course and base course (HMT22 in this case). The direct shear until failure is applied at a controlled speed of 50.8 mm/min at 20 °C to the SGC specimen (Ø = 150 mm). The results are shown in Figure 4 where the mixes fall into the following categories: MIU = mix initial unaged, MPU = mix post-compacted unaged and MPA = mix post-compacted aged. Interlayer shear strength increased for JPA, JPPA and SPPA both after post-compaction and ageing, regardless of dry/wet conditions. The decrease of shear strength for SPA after aging and post-compaction can be attributed to binder properties.

The positive effects of the packing theory can be clearly observed from the results of JPA and JPPA since exactly the same type and amount of binder were used. In addition to better resistance against over-compaction, the clearest advantage of the theoretical mixes was observed by the Cantabro (particle loss) test (Fig. 5). Both SPPA and JPPA decreased in Cantabro loss value, compared with SPA and JPA respectively.

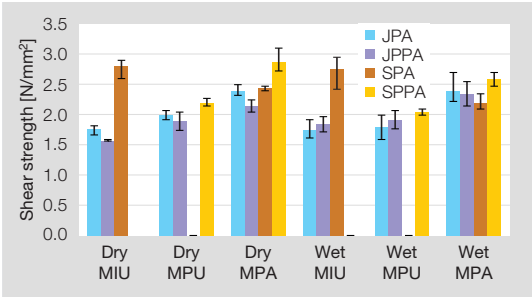


***Fig. 4:*** *LPDS interlayer shear strength between porous asphalt and base course (EMPA).*

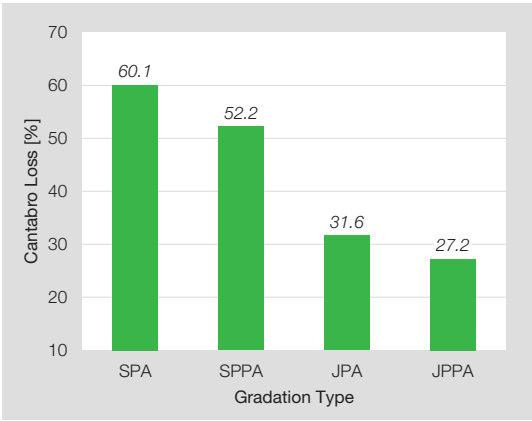


***Fig. 5:*** *Cantabro loss value of porous asphalt mixes with different gradations (JHRI).*

The results of this research indicate that the new packing method has a potential to design porous asphalt mixes with superior quality as compared to traditional standard mixes provided that the influence of the binder is considered accordingly. In addition, it is shown that the different test methods applied in this study generally lead to comparable results.

Due to its clear advantages, further research and development in porous asphalt is pursued at EMPA. Recently, EMPA has been appointed leader of a new project funded by the Swiss Roads Authority, ASTRA, in cooperation with EPFL, the goal of which is to define the requirements for mechanical properties specific to porous asphalt for the revision of the Swiss standards. This research project is expected to set the stage for improvements in durability and bearing capacity of this important and promising pavement material.

**Links:** www.empa.ch/abt113
> Porous asphalt

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***References:*** *S. Takahashi et al., Proceed. 6th Int. RILEM Symposium (2003)*

# Long-term behavior of polymer bitumen joint sealants on a trial road section

**In a research project sponsored by ASTRA, long-term performance of seven joint sealant systems on an alpine concrete motorway was experimentally investigated. The study focuses on the change of material properties during installation (Fig. 1) and 5 years of service, as well as the influence of material composition, concrete joint edges, installation equipment and procedures.**

Sivotha Hean,
Manfred N. Partl

***Fig. 1:*** *Joint installation on the trial road section.*

Hot applied joint sealants made of styrene-butadiene-styrene copolymer (SBS) modified bitumen are used for the sealing and filling of joints in concrete surfacing (road, airport etc) and for surfacing decks on bridges. Typical damage occurring with joint sealants includes debonding, formation of bubbles and cracks.

The investigations reveal clearly that the polymer components in the joint sealants are the key factor in the durability of joints and that the type and quantity of the polymers in the joint sealants are crucial. The content of polymer in the joint sealant must be sufficiently large, and polymers should be resistant to ageing and temperature induced stresses.

During installation, SBS polymers of three joint systems were severely decomposed due to overheating and instability. The polymer components in all joint sealants remained practically unchanged during 5 years of weathering but the joint sealants became gradually harder (Fig. 2). Three of the joint sealants with a GPC-polymer content ≥ 4.2% per unit area (GPC: gel-permeation-chromatography) after installation displayed fairly good edge adhesion.

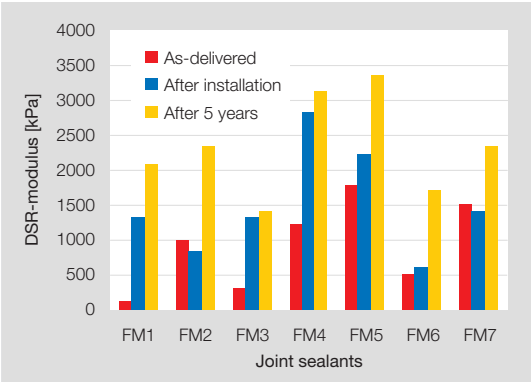


***Fig. 2:*** *DSR G* moduli at 10 °C and 1.5 Hz.*

It was observed that blisters in the joints occurred precisely where small holes (2 – 3 mm) and cavities in the contact area of the concrete were found (Fig. 3). It was also observed that air voids of this type in the vertical surface of the concrete adjacent to the joint cannot be filled completely with joint sealant and grow under service conditions. For this reason, polymer bitumen joint sealants are unsuitable for concrete with such imperfections.

Contact area of the sealant (joint side)

Contact area of the sealant (concrete side)

***Fig. 3:*** *Formation of bubbles after 2.5 years of weathering. Opposing contact area between joint sealant and concrete edge.*

Some of the joint sealants were found to be structurally damaged despite strictly following the standard installation procedures. Hence, the material properties should not be determined and assessed on joint sealants in the original state but only after pre-aging, simulating the effect of installation.

With this research project it was possible to contribute significantly to the Swiss and European standards and the improvement of durability for the sake of reducing life cycle costs of joint sealants.

**Support:** ASTRA

**Links:** www.empa.ch/abt113

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***References:***
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*S. Hean et al., 3rd Eurasphalt & Eurobitumen Congress 2004, accepted (2003)*

# Modeling pore solutions in the cement-water system

Barbara Lothenbach,
Frank Winnefeld

**The interactions between cement clinkers, pore solution and hydrate phases determine the setting and hardening of cementitious mortars and concretes. The thermodynamic modeling of these interactions and of the composition of the pore solutions in hydrated cements is a basis for the chemical understanding of these processes and for further improvements.**

Most important material properties of cementitious materials such as workability, setting behavior, strength development but also durability are related to the cement hydration process. Thus, specific material design must be based on a profound understanding of the processes during the hydration. Thermodynamic modeling – combined with an empirical model that describes the slow dissolution of the clinker minerals as a function of time – allows to follow the observed changes in the solid and the liquid phase during cement hydration on a molecular scale. In addition, adequate thermodynamic models allow easy and fast parameter variations and make it possible to predict the composition of hydrate assemblages under different conditions and to extrapolate to longer time scales.

A model based
i) on the measured composition of the cement,
ii) on the slow dissolution of the cement clinkers as a function of time and
iii) on the use of thermodynamic calculations in order to describe the precipitation and dissolution of hydration products,

has been developed. The modeled data compare well with the measured composition of the pore solutions (Fig. 1) as well as with the observed changes in the solid phases (Fig. 2). The thermodynamic calculations indicate that in the presence of carbonates (from the calcite present in the cement), calcium silicate hydrate (C-S-H), portlandite ($Ca(OH)_2$), ettringite and monocarbonates are the main hydration products of Ordinary Portland Cement (OPC). Only in the absence of carbonate, other metastable phases such as monosulphate are predicted to precipitate. However, upon carbonation, these phases become unstable and monocarbonate is formed.

The model presented provides a basis for the interpretation of the experimental data and allows to calculate quantitatively the composition of the hydrate assemblage. It can be used to predict the influence of changes in the original clinker composition or of the environment (e.g. temperature, carbonation) on the resulting hydrate assemblage and thus on the properties of the resulting cements or concretes.

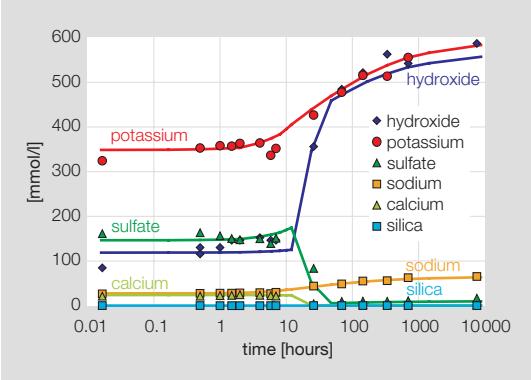


***Fig. 1:*** *Measured composition of the pore solution (symbols) during the hydration of OPC (w/c = 0.50) compared with modeled concentrations (lines).*

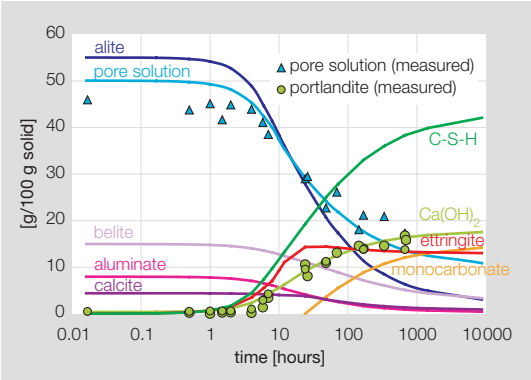


***Fig. 2:*** *Modeled evolution of the solid phase during the hydration of OPC (w/c = 0.50) compared with the experimentally determined amount of pore solution and portlandite (symbols).*

**Links:** www.empa.ch/abt135
> Construction chemistry

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***References:***
*B. Lothenbach, F. Winnefeld, L. Holzer, 15. Intern. Baustofftagung (ibausil). Tagungsbericht Band 1, 1-0457 - 1-0466 (2003)*
*B. Lothenbach, F. Winnefeld, Cement and Concrete Research, submitted (2003)*

# Pressure of self-compacting concrete on the formwork

**The vertical distribution of the lateral pressure caused by self-compacting concrete (SCC) pumped into the formwork from the top and at its base is investigated. The results show that the maximum pressure of SCC filled into a formwork from the top is depended on the speed of casting and the rate of continuous pressure decrease of the SCC already cast. The SCC pumped into the formwork at its base reaches comparatively high values which are in the range of the hydrostatic pressure because the concrete is in motion during the whole casting process.**

Andreas Leemann,
Cathleen Hoffmann

In recent years, the use of self-compacting concrete (SCC) in Switzerland has increased. An important advantage in comparison to conventional concrete is the higher productivity made possible because no work for compacting is required. But the high casting speed used for SCC and its flowability lead to an increased lateral pressure on the formwork which in several cases has caused deformations and failures. So far, only few studies have been carried out dealing with the factors influencing the pressure on the formwork. The results show big differences and are often contradictory. Most likely, differences in the properties of the SCC used, in the way of casting and in the method applied to determine the pressure can be attributed to this situation.

In this study, the vertical distribution of the lateral pressure caused by three SCC (SCC 1–3) with varying workability was measured in the laboratory filling a formwork (h x w x d = 270 x 75 x 20 $cm^3$) from the top. Furthermore, the pressure of SCC 4 pumped into a formwork (h x w x d = 470 x 490 x 25 $cm^3$) through a valve at its base was determined in a field study (Fig. 1). Five sensors located on the inner surface of both formworks at different heights were used to determine the pressure during casting. The principle of the sensors is based on the change in electrical resistance of thin-film metal wire strain gauges when they are deformed due to pressure.

***Fig. 1:*** *Formwork used for the field study with a valve located at its base (pointer).*

The highest values measured for SCC 1–3 with the lowest sensor range between 87 and 90% of the hydrostatic pressure (Fig. 2). Obviously the workability of the SCC used has no significant influence on the maximum pressure at the relatively high rising rate used (8 m/h). After casting the concrete, the pressure of all mixtures immediately starts to de-

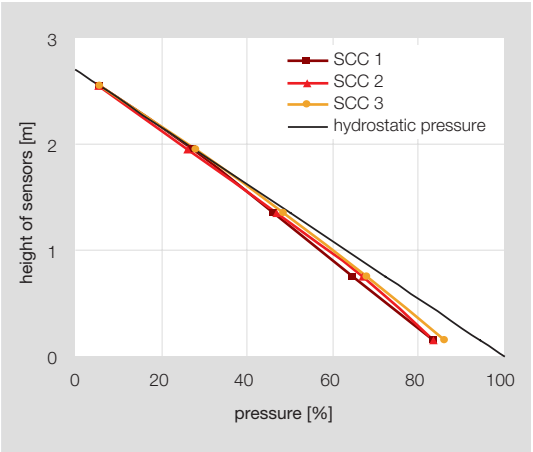


***Fig. 2:*** *Lateral dynamic pressure in relation to the hydrostatic pressure of SCC 1–3 after filling the formwork with a rising speed of 8 m/s.*

crease (Fig. 3). As soon as the concrete is not in motion anymore, a thixotropy starts to develop as it is typical for colloidal suspensions leading to a progressing decrease of pressure with time. This is important in connection with the casting speed. If the SCC in the formwork was in motion during the whole casting process, the resulting pressure would always be hydrostatic. But during the filling of a formwork the SCC already cast does not move anymore. Therefore, its pressure is continuously decreasing. Consequently, a high rising rate results in a comparatively high maximum concrete pressure, and a low rising rate in low pressure.

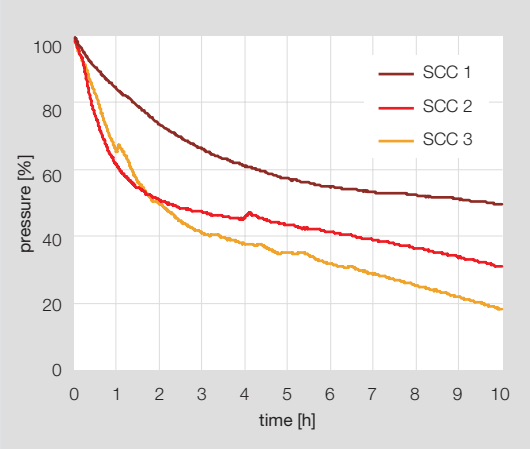


***Fig. 3:*** *Decrease of the maximum pressure of SCC 1–3 after casting measured with the lowest sensor.*

The rate of the pressure decrease is different for SCC 1–3, but it does not show a relation to their workability. The slower pressure decrease of SCC 1 may be caused by the absence of a viscosity agent in the mix design. More work is needed to understand the relation between pressure decrease and mix design.

The pressure for different rising rates was calculated based on the values measured in the experimental set-up, and it was compared to the pressure for highly flowable concrete calculated according to the DIN 18218. The comparison indicates that the DIN 18218 can be used to get a reasonable approximation for the pressure of SCC pumped into a formwork from the top.

SCC 4 was pumped into the formwork through a valve at its base with a rising rate of 19 m/h. It caused a higher pressure (Fig. 4) than SCC 1–3 which were cast from the top. The SCC above the valve is in constant motion during the pumping resulting in a hydrostatic pressure. Because the pump has to surmount the resistance of the concrete already in the formwork, the resulting values in the lower part of the formwork even exceed the hydrostatic pressure. The amount of added pressure might be smaller or larger depending on the pump pressure used.

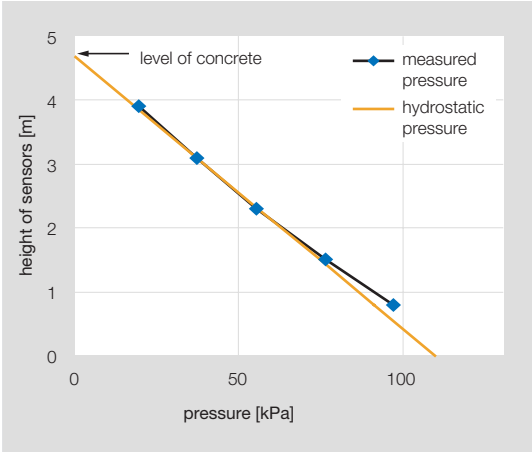


***Fig. 4:*** *Pressure of SCC 4 at the end of the casting.*

The danger of damaging a formwork is greater when SCC is pumped into the formwork at its base because of the higher pressure. Furthermore, interruptions of several minutes during the pumping have to be prevented. Otherwise the SCC might build up agglomerates due to its thixotropic behavior and the pump pressure required to start the casting of the next batch increases.

Based on the results of this study, the building industry is able to optimize the casting of SCC taking advantage of its potential for increased productivity.

**Support:** ASTRA

**Links:** www.empa.ch/abt135

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***References:***
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# Thermally activated ceiling panel with PCM for application in lightweight and retrofitted buildings

**Due to the lack of forward-looking concepts which allow use of renewable energy sources for the heating and cooling of refurbished buildings, a thermally activated ceiling panel for incorporation in lightweight and retrofitted buildings has been developed. The design exploits the high thermal storage capacity of the phase change material (PCM) paraffin. With a newly developed numerical model for wall and ceiling systems incorporating PCMs, the necessary thermal properties of the ceiling panels were determined. Subsequent laboratory tests have shown the applicability of the concept.**

Beat Lehmann,
Markus Koschenz

Thermally activated building systems *(tabs)* are a recently used technology for the heating and cooling of commercial buildings with renewable energy sources. Using the building structure as a heat sink, heat gains during the day are stored in solid floors and slabs, which then are recooled by means of a water pipe system at an appropriate time. The extracted energy can be rejected to the outside, e.g. via cooling tower. Whereas the pipework can easily be incorporated in new buildings, the retrofitting of pipes as part of an alteration scheme is problematic. The increasing proportion of construction activity in the sector of refurbishment gave the idea to develop thermal storage units suitable for local installation in altered or refurbished buildings.

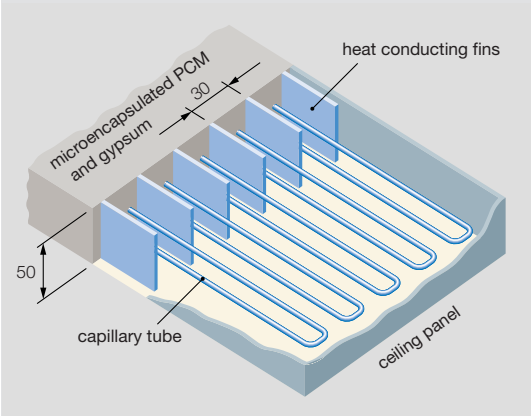


***Fig. 1:*** *Schematic drawing of the thermally activated ceiling panel with PCM.*

To achieve a thermal storage capacity approximately equal to the heat gains within the space during the daily cycle, a new storage concept had to be found. Phase change materials (PCMs) offering latent heat emerged as the prime option as the phase change undergone by these materials allows storage and release of substantial quantities of heating or cooling energy. The PCM in the ceiling panels melts during daytime upon exposure to the thermal loads and freezes overnight when cooled by means of an integrated water pipe system. The overall concept for the ceiling panels adopts the following arrangement (Fig. 1): A sheet steel tray serves as a container for the composite comprising gypsum and microencapsulated paraffin as PCM. Active control of the thermal mass is achieved by incorporation of a capillary water tube system in the gypsum compound, and the thermal conduction in the composite is improved by the inclusion of aluminum fins. An international patent application has been filed for the system.

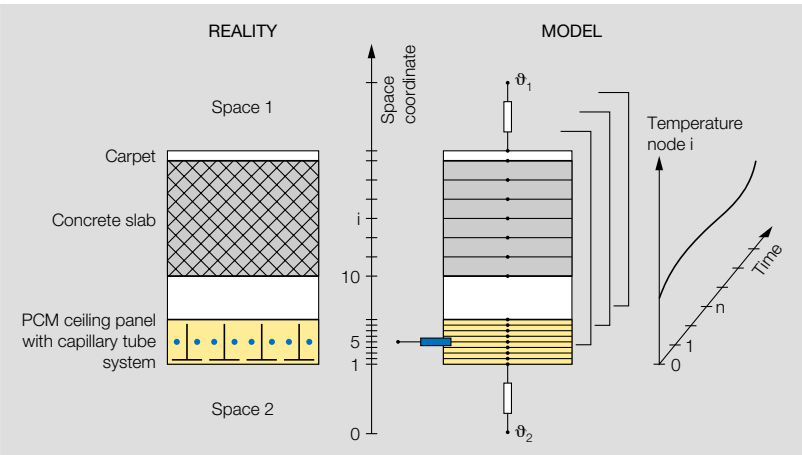


***Fig. 2:*** *Model for computation of wall system with integrated PCM layers.*

Development work was as far as possible computer-based. A special thermal model (Fig. 2) was developed which allows computational simulation of the thermal behavior of one-dimensional wall systems comprising common construction materials in conjunction with PCM. The material properties of the single layers are entered as mathematical functions or as measured data, especially in the case of PCM thermal capacity. A water piping system for cooling and heating purposes can be coupled to any node of the model. Simulation calculations were performed to determine the required ceiling panel characteristics. Key parameters included the thickness of the PCM/gypsum composite layer (5 cm), the proportion of paraffin (25% by weight) and the minimum requirements placed on the microencapsulated PCM in terms of melting range (20 – 24 °C) and latent heat of fusion (110 kJ/kg). Through integration of the model in the TRNSYS building and system simulation environment, similar calculations can be performed for real buildings with integrated PCM ceiling panels.

Following the optimization in the simulation process prototype modules were produced. The aim of the subsequent laboratory tests was to verify the performance of the system in real operation. The test set-up shown in Figure 3 served to provide a realistic simulation of the processes occurring in both room and ceiling panel. The hot box tests were designed to allow cyclical heating and cooling of the ceiling panels and collection of data on temperature conditions and energy storage capacity. An electrical heating plate (a) was used to simulate the environmental thermal loads. The heat transfer coefficient of the adjacent neoprene layer (b) corresponds to a realistic value between the room temperature and the surface temperature of approx. 10 W/m$^2$K. The temperature measured on the heating plate (c) was, therefore, roughly equivalent to the corresponding room temperature.

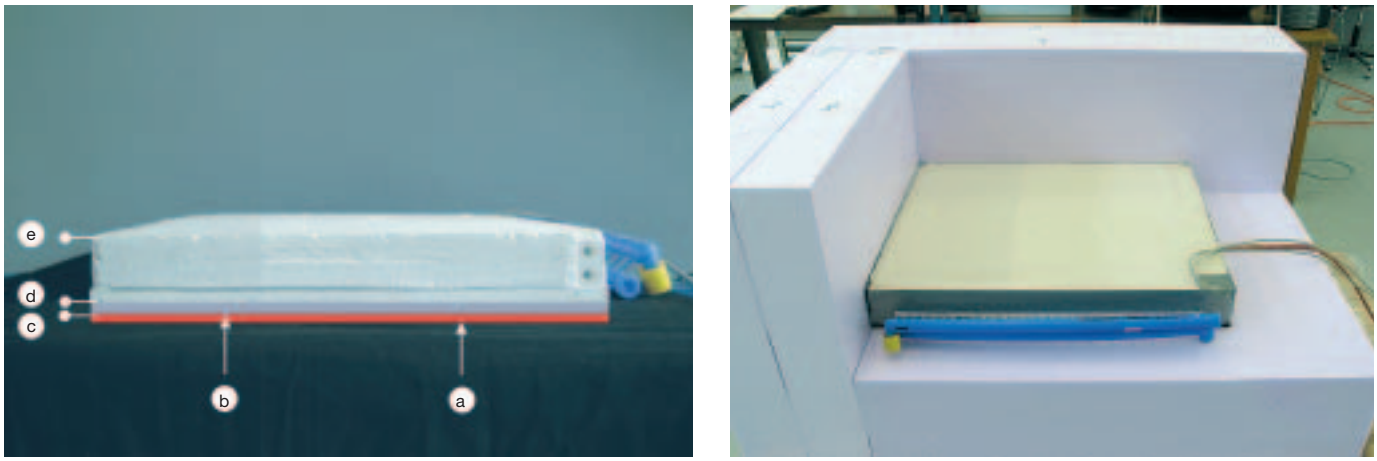


***Fig. 3:*** *Laboratory test set-up with prototype ceiling panel.*

Fig. 4 shows a measurement cycle for a ceiling panel which was subjected to a constant heat load of approx. 40 W/m$^2$. The applied heat load corresponds with the internal and external heat gains in an open-plan office building. The phase change process undergone by the paraffin in the ceiling panel is clearly reflected by the leveling off of the heating curves after 8 hours. The required operating range in the real application is limited to this phase change region as the energy storage here slows down the rise in temperature. In this particular case, the melting process lasted for 7.5 hours, during which a total energy of 290 Wh/m$^2$ was stored. The fact that phase change commences at 20 °C confirms that the paraffin's melting range was ideally adjusted to requirements. At the end of phase change, the panel temperature is up by 4 K to 24 °C. During this period, the (virtual) room temperature rises to approx. 28 °C.

Prototype modules installed in a pilot building will provide a further check on the practicability of the concept. The system's features also make it ideal for use in lightweight structures, the incorporation of additional thermal mass offering an efficient means of moderating temperature amplitudes in this type of building.

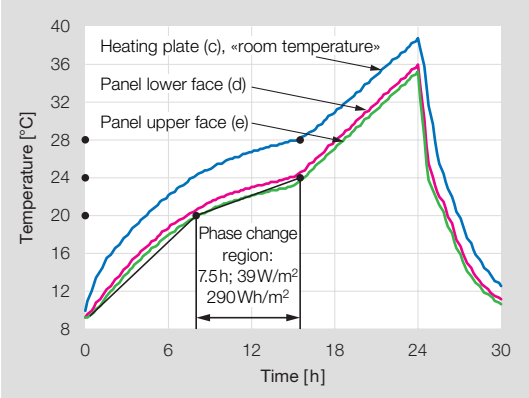


***Fig. 4:*** *Temperature profiles for test cycle recorded in laboratory.*

**Support:** TRANSSOLAR, D-Stuttgart

**Links:** www.empa.ch/abt175
> Thermally activated building systems tabs

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***References:***
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*B. Lehmann et al., velta kongress 2003, Conf. Proceed., 59 (2003)*
*Patent PCT/CH03/0081 (pending)*

# Thermo-mechanical simulation of fire resistance

**There is an increasing interest in reducing the number of repetitive fire resistance tests in general and of door assemblies with their multitudes of frames, leaves and supporting constructions in particular. The combination of thermo-mechanical simulations with consecutive parameter studies is a promising tool to meet this interest. Substitution of complementary tests needs reliable models which are validated by measured data. As a preliminary effort towards this aim a steel-framed wooden door built in a steel-framed wall was exposed to the standard fire of ISO 834 and the measured temperatures and deformations were used to validate the model.**

Karim Ghazi Wakili,
Christian Affolter,
in collaboration with
VST Zurzach (CH)

The finite element (FE) method is a well established tool for calculating stress, deformation or temperature distribution of large structures where no analytical solutions exist. The aim of this work was to establish the applicability of this method to fire resistance. A structure subjected to fire may fail with respect to different criteria. Besides too high temperatures on the cold side, one possible failure criterion is the opening of gaps between door and frame due to thermal stresses so that hot gases can emerge from the fire room. The occurrence of these gaps is expected to be predictable by numerical simulations. Thus, the actual possibilities of FE simulation tools were analyzed and calculated results were validated with performed tests.

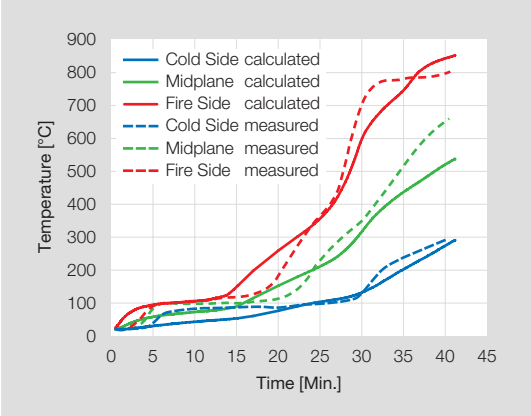


***Fig. 1:*** *Temperature evolution including an effective specific heat and the falling off of gypsum boards (solid lines: calculation, dashed lines: measurement).*

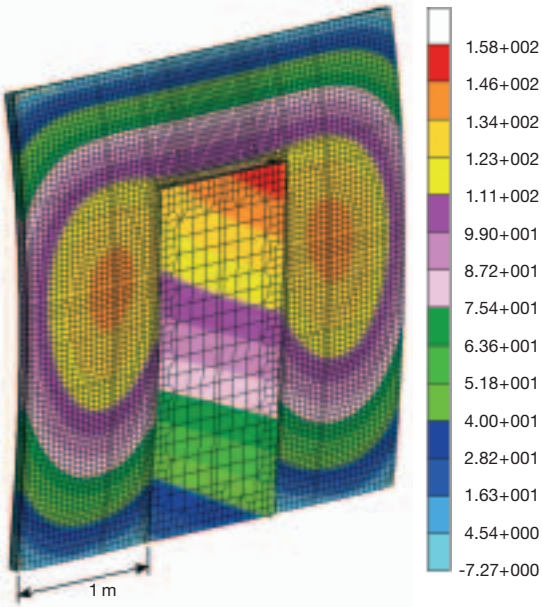


***Fig. 2:*** *Maximum calculated displacements after 45 minutes exposure to the ISO 834 standard fire.*

The geometric model consists of a combination of 3D solid elements and 2D shell elements to reduce the calculation time without neglecting the temperature gradient perpendicular to the shell surfaces. For the thermal model temperature dependent physical properties were considered. The influence of phase changes and heat of evaporation of bound water was summarized once in a so called effective specific heat capacity and once in the form of additional heat sinks. It seems that the model with the effective heat capacity reproduces the measured values better. For the mechanical model, too, temperature dependent properties extracted from literature were assumed. A major effort was the appropriate modeling of the mechanical boundary conditions between different materials and at fixation points.

The thermal calculations are in satisfying agreement with the measurements (Fig. 1). A phenomenon which needs further investigations is the moisture transfer in the wall during the test. This effect was simplified by assuming increased thermal conductivity for both gypsum and mineral wool. The result of the mechanical simulations (Fig 2.) revealed a weaker correspondence to the measurement as it overestimates the displacements. The mechanical behavior of wood and plaster during fire incidents needs further study.

**Support:** VST

**Links:** www.empa.ch/abt176
> Numerik

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***References:***
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*Ch. Affolter et al., Fire Safety Journal, submitted (2003)*
*Ch. Affolter et al., invited lecture, VIB-Meeting (Verein zur Förderung von Ingenieur-Methoden im Brandschutz) Basel (2003)*

# Vacuum insulation panels in building applications

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Samuel Brunner,
Reto Bundi,
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IEA Annex partners in
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Italy, and Israel

**Vacuum insulation panels (VIPs) provide new design options for slim, energy efficient building envelopes. Key points such as service life and thermal performance are investigated at EMPA within a collaboration in IEA Annex 39 "High Performance Thermal Insulation Systems" and industrial partners. Intermediate results of accelerated aging and thermal performance are now available.**

VIPs consist of a micro-porous evacuated core which is sealed in a thin, virtually gas tight envelope. Gaseous heat transport in the usual fumed silica core ($SiO_2$) is negligible at a pressure around 1 mbar. Thus, the thermal conductivity is about 8 times lower than with conventional thermal insulation (Fig. 1). Generic barriers are based on laminated aluminum foil (ca. 10 microns Al) or multi-layer aluminized polymer film (ca. 0.1 micron Al), both sealed by heat welding of adjacent PE layers.

***Fig. 1:*** *Conventional mineral wool thermal insulation board and a VIP with equal thermal resistance.*

Gas diffusion through the envelope is a significant aging mechanism. For long-term performance, the pressure increase in $SiO_2$ should not exceed 1 to 2 mbar per year. At EMPA, the internal pressure is determined by optical detection of the onset of envelope displacement at pressure balance in a depressurization chamber. First screening tests on VIP with metallized polymer barrier indicate sufficient service life at ambient temperatures and dry conditions but inacceptable pressure increase rates at elevated temperature and/or humidity (Fig. 2). As the permeability for $H_2O$ is much higher than for other atmospheric gases, service life prediction models must include moisture loads in particular.

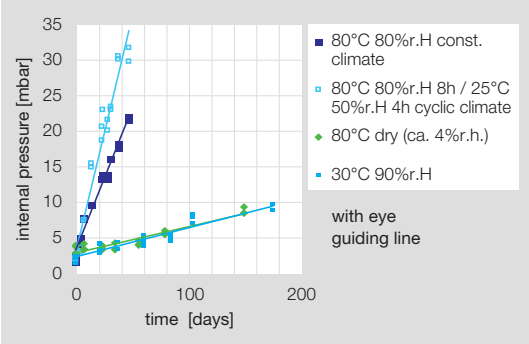


***Fig. 2:*** *Time dependence of the internal pressure in small VIPs (25 x 25 x 2 cm³) with metallized polymer barrier for various environmental conditions.*

Focused ion beam (FIB) imaging, used for the first time to visualize layer structures and defects in metallized films, may be a valuable tool to improve those barriers. The problem of large area damage caused by a single leak could be defused by the agglomeration of small evacuated cells. Respective feasibility studies are running at present.

Better barriers are obtained with laminated aluminum foil. However, there is a trade-off between gas tightness and edge conduction. For example, the thermal resistance of a 1 x 1 $m^2$ VIP with an 8 micron Al barrier is less than half the core value. Even larger thermal bridge effects may occur in building components with well conducting materials, e.g. in a metallic façade panel. Nevertheless, calculations on properly designed constructions show the great potential of VIP, in particular with space restrictions. In the example in Figure 3, the heat loss is lowered more than 15 times by a VIP renovation. Performance data of various VIP constructions will be published in a design guide.

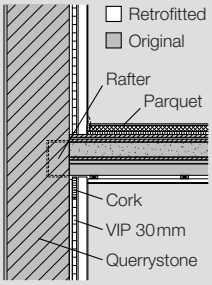


***Fig. 3:*** *VIP retrofitted building envelope (interior insulation).*

**Support:** BFE

**Links:** www.empa.ch/bauphysik
www.vip-bau.ch

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***References:***
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*K. Ghazi Wakili et al., Building Research and Information, in press (2003)*

# Dielectric electroactive polymer (EAP) actuators for adaptive material systems

**Adaptive material systems with large deformations need actuators with a high strain capability. A dielectric EAP actuator basically consist of a compliant capacitor which can directly transform electrical energy into mechanical work. Material development, theoretical modeling and experimental work are needed to exploit the high theoretical performances. First results show the promising potential of this technology for future adaptive lightweight structures.**

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Electroactive polymers (EAPs) are promising material systems as actuators in adaptive structures where large deformations are required. Electromagnetic or piezoelectric actuators for these applications are heavy and complex. EAPs, however, are relatively light and rather simple. They transform electrical energy directly to mechanical work and produce large strains (20% and more). Especially dielectric electroactive polymers were recently shown to have good overall performances. Pressures of 16.2 MPa, free area strains of 215% and specific elastic energy densities of 3.4 J/g could be shown. Because these capabilities correspond to the performance of natural muscles, dielectric EAP actuators are often referred to as “artificial muscles”.

A dielectric EAP actuator is basically a compliant capacitor where a passive elastomer film is sandwiched between two compliant electrodes. When an electrical voltage is applied, the electrostatic (Coulomb) forces arising from the charge displacement on the electrodes squeeze the elastomer film (Fig. 1). The electrode pressure p [MPa] is given by the following equation:

$$p = \varepsilon_0 \varepsilon_r \left(\frac{U}{d}\right)^2$$

where

$\varepsilon_0$ is the free-space permittivity ($8.85 \cdot 10^{-12}$ As/Vm)
$\varepsilon_r$ is the relative dielectric constant [-]
U is the electrical voltage applied [V]
d is the thickness of the polymer film [m] (equivalent to the distance of the electrodes)

This electrode pressure mechanically loads the polymer film. Because such elastomers are essentially incompressible, the area of the capacitor is enlarged. As soon as the voltage is switched off and the electrodes are short-circuited, the capacitor contracts back to its original shape.

The mechanical reaction of the elastomer film to the electrode pressure depends on its visco-elastic material properties. Theoretical methods that would allow predicting the forces and deformations of any actuator design are not yet available. To improve the performance of an EAP actuator, various characteristics of its elements have to be optimized: the polymer film acts as a dielectric and should, therefore, have a high permittivity, a high break-down potential, low viscosity and long-time stability. The electrical coating should be compliant and easy to cling to the polymer film. A detailed material development was performed in order to achieve such material properties.

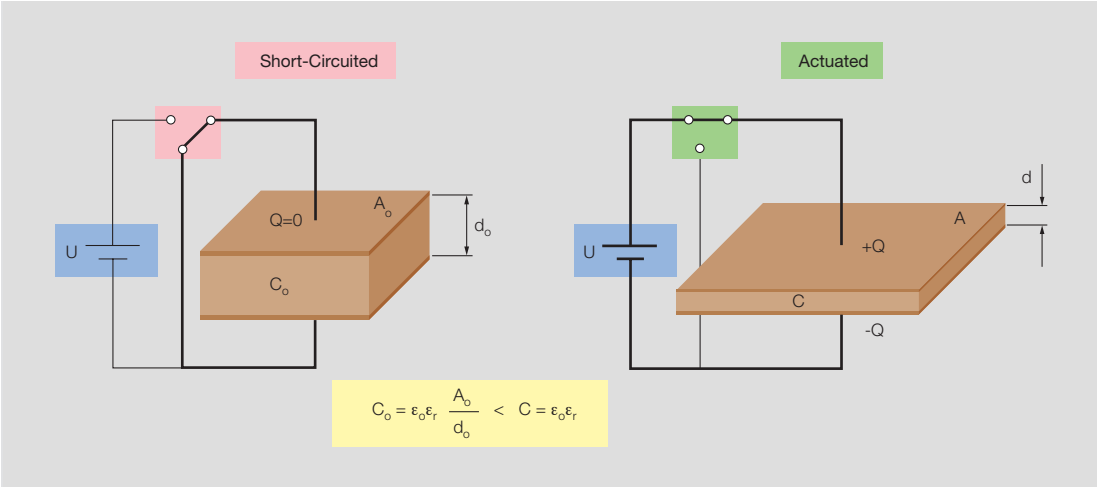


***Fig. 1:*** *Working principle of a dielectric electroactive polymer (EAP) actuator.*

The main objective of this work was to develop a material which is able to generate free strains of 10% but at lower electric fields in order to decrease actuation voltages. In a first step, a blending technique was evaluated using an acrylic matrix. However, it was not possible to get a stable and homogeneous film. Better results have been attained with silicone materials. A comparison between a blended silicone and pure silicone can be seen in Figure 2. At an electrical field of 25 MV/m, the blended silicone reaches a strain which is about 1.8 times higher than the pure silicone.

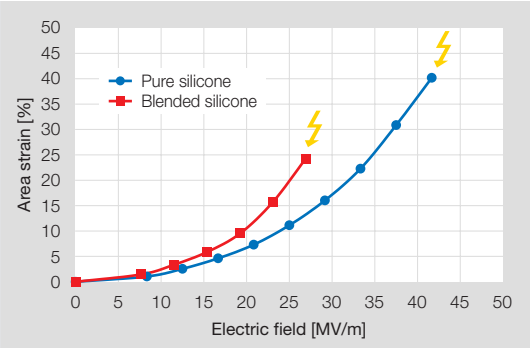


***Fig. 2:*** *Actuated area strain up to the electrical breakdown of pure and a blended silicone.*

Theoretical electromechanical models of EAP actuators are still subject of ongoing research. First studies have shown that the electrical part could be decoupled from the mechanical system. By applying non-linear continuum mechanics in three dimensions, the hyper-elastic as well as the time dependent behavior can be modeled. With the help of electrical and mechanical material characterization tests the necessary model parameters are defined. Creep, relaxation, cyclic load tests as well as tests for measuring the dielectric constant and the electric breakdown potential can be performed now in our lab. A first one-dimensional constitutive model for an acrylic material has been developed (Fig. 3).

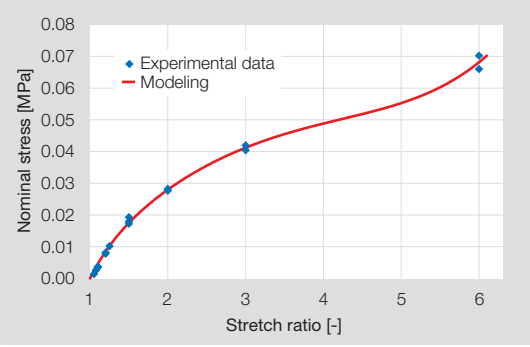


***Fig. 3:*** *One-dimensional constitutive model for an acrylic material.*

In the last years, possible fields for applications using this technology have been identified such as microrobotics or lightweight structures for space. We have focused our activities on the development of macro scale actuators. Such actuators can be used to move forward the structure through the surrounding medium or vice versa either by undulatoric or peristaltic movements. In a first phase of the project, concept and feasibility studies have been performed to evaluate such possible future applications. In addition, basic practical experience was gathered by manufacturing various types of actuators. Linear and circular shaped actuators, actuators with a metal coil spring (to allow high pre-strain of the elastomer film) and balloon actuators have been realized (Fig. 4). A systematic variation of coating technologies has shown that changing the tested coating material cannot significantly increase the basic performance of the actuator. With carbon powder based coatings the actuator is destroyed by an electrical breakdown. However, for one coating the actuator could be recharged after a breakdown without any impact on the actuator performance.

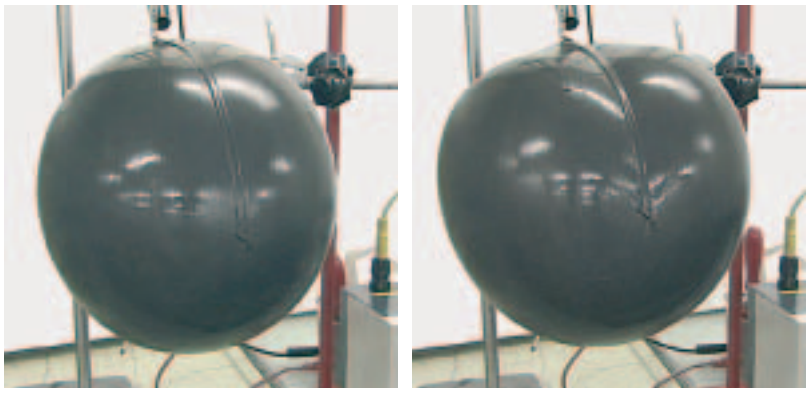

***Fig. 4:*** *Balloon actuator: non actuated (left) and actuated shape (right).*

**Links:** www.empa.ch/abt121
> Smart structures
www.erg.sri.com/automation/actuators.html

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***References:***
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# Storm-induced compression failures in spruce wood

**The destructive impact of hurricanes does not only result in devastated forests but can also lead to serious mechanical damages in the stems of affected trees, which hampers the utilization of the wood as structural timber. The objective of an extensive research project started after the hurricane "Lothar" (1999) is to study open questions regarding the extent and location, the causes, the detection and the consequences of compression failures.**

Martin Arnold

Frequent or strong winds can bend the stems of trees so much that the axial compressive strength of the wood on the inward side of the bow will locally be exceeded (Fig. 1). This causes a buckling of the cell walls of the wood fibers, so called "compression failures" (Fig. 2). The distorted fibers of compression failures are defects in the wood structure which can lead to characteristic brittle fractures already at a relatively low stress in bending or tension. Compression failures are thus a potential safety risk and must be excluded with a reasonable certainty particularly in timber used for load bearing structures.

The consequences of compression failures have two main aspects. The first one is of bio-mechanical nature, since compression failures may impair the stability of the affected trees. A tree can survive a storm with many compression failures and will try to locally strengthen the wood structure by forming callus swellings and reaction wood. But the compression failures will remain as weak and potential failure zones in the stem. The second aspect is concerning the utilization of wind-damaged timber. Because of their potential safety risk and their difficult detection, compression failures can impose serious restrictions on the utilization of wind-damaged timber and require additional efforts regarding grading and quality control.

***Fig. 1:*** *Unrecoverable stem bending as a consequence of storm-induced compression failures in a spruce tree.*

***Fig. 2:*** *Massive compression failures on the girth of a debarked log (top) and in a planed board (bottom). More than half of the stem cross-section can be affected by such particularly large compression failures.*

The heart piece of the project is a case study with an extensive examination of 30 spruce trees (Picea abies) harvested from a heavily storm-damaged forest stand. 10 trees from each of the "damage" categories "Blown-down", "Broken" and "Standing" were selected for investigation. The cut logs were carefully visually inspected for compression failures after partial debarking and were afterwards sawn into boards according to a systematic sawing pattern adjusted to the previously marked main wind direction of the storm. These boards were subsequently cut into test pieces (full-size structural timber as well as small clear specimens) for the assessment of var-

ious mechanical wood properties (bending, tension and compression). Before testing, all sawn pieces were planed and again visually inspected for compression failures.

The investigated trees were fully-grown and about 120 years old at the time of the hurricane. The diameter at breast height ranged from 39 to 72 cm, and the tree height varied between 35 and 43 m. In total 961 compression failures of various sizes were identified in 29 of the 30 investigated trees. Considering the 713 m of investigated stem length, on average 1.35 compression failures per meter were recorded. Regarding the sawn timber, 289 (41%) of the 700 blanks of 5 m length for the full-sized bending and tension tests contained compression failures.

The vertical distribution of the compression failures in the stems showed a great variety of patterns, as illustrated with five examples in Figure 3. The highest intensity of compression failures is located between 10 and 30% of the tree height, with a considerable number of compression failures up to 60% of the tree height. However, compression failures were found starting at a height of only 0.9 m (2% relative tree height) up to 28 m (75%). The distribution of the compression failures in the cross-section of the trees is illustrated in Figure 4. As expected, the compression failures were concentrated mainly on the leeward side of the stems. No significant difference was found between the 3 “damage” categories “Blown-down”, “Broken” and “Standing” trees, neither regarding the tree characteristics nor regarding the number and average width of the detected compression failures.

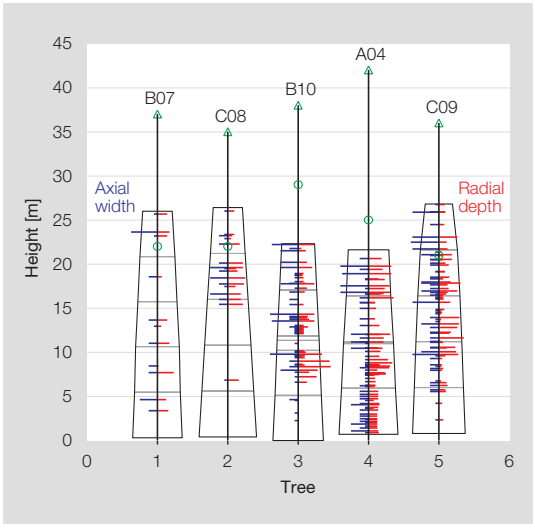


***Fig. 3:*** *Vertical distribution and size of compression failures in the stems of five selected trees. The trapezoids show the investigated parts of the stems. The triangles indicate the height of the trees and the circles the beginning of the crown. The rays extending from the centre line to the left are indicating the width of the compression failures, the rays extending to the right are proportional to their radial depth.*

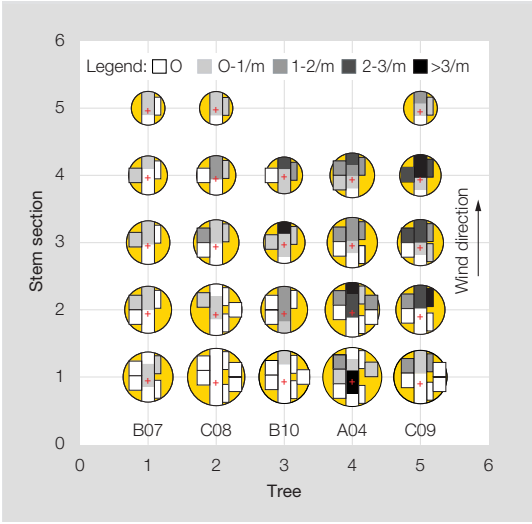


***Fig. 4:*** *Occurrence and intensity of compression failures in the stem cross-sections at different tree heights (approx. 5 m intervals) of the same five spruce trees as in Figure 3. The cross-sections are idealized as (yellow shaded) circles with the approximate position of the pith marked with a “+” sign. The drawn rectangles show the number and the position of the sawn test pieces. The intensity of compression failures (number per meter in 5 m stem sections) is indicated by different grey levels.*

This improved knowledge of the frequency and the location of compression failures within the stems of affected trees is the basis for the ongoing assessment of the consequences of compression failures and a future development of effective detection strategies. The results of this study will help to draw conclusions and recommendations regarding the grading and the safe utilization of wind-damaged timber.

**Support:** BUWAL, EFD

**Links:** www.empa.ch/holz
> Holztechnologie

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# Algae and fungi on façades – Growth analysis and growth prevention

**Despite the use of biocides, thermally insulated façades are often covered by visible biofilms mainly consisting of algae and fungi. The emphasis of our research was to identify reasons for microbial growth in order to protect plasters and paints from quality degrading biofilms. Laboratory methods were developed and validated for practical use in laboratory and outdoor experiments to determine the resistance of coatings against microbial growth. Different products exhibited individual growth patterns, confirming that growth conditions depend mainly on the local situation and the formulation of the products, rather than on deposition.**

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Michael Nay,
in collaboration with
Fraunhofer Institute,
Holzkirchen (D)

Presently, visible biofilms are an economically important problem of thermally insulated façades. In Switzerland, annual application is approx. 4 mill $m^2$. Although respective coatings are usually protected by film preservatives, growth frequently occurs after weathering (up to 5% within the first five years). The main objective was to ascertain whether specific formulations prevent or promote visible growth. Additionally, manufacturers as well as European and OECD regulation bodies for biocides require a validated reliable laboratory method.

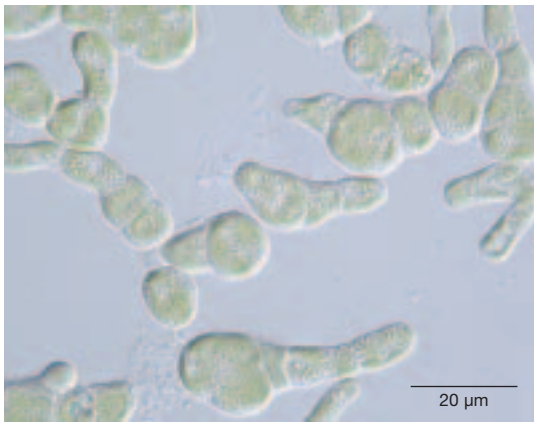


***Fig. 1:*** *Microscopic view on algae isolated from façades (Heterococcus crassulus).*

75 commercially available coatings and 15 defined reference formulations were assessed in artificial ageing experiments and subsequent biotests. Results were compared with outdoor experiments at St. Gall and at Fraunhofer IBP to include differing regional aspects and then used to validate the methods requested by our industrial partners. These methods can be used to predict the resistance of coatings against microbial growth.

The results obtained from laboratory biotests after artificial ageing correlated in general with outdoor results. Outdoor weathering also confirmed the prominent role of condensation, resulting in favorable conditions for the development of biofilms. Obviously, some microorganisms prefer special substrates: e.g. the green algae *Trentepohlia* sp., forming distinct red colonies, mainly grew on cement containing coatings, probably due to the initially higher pH.

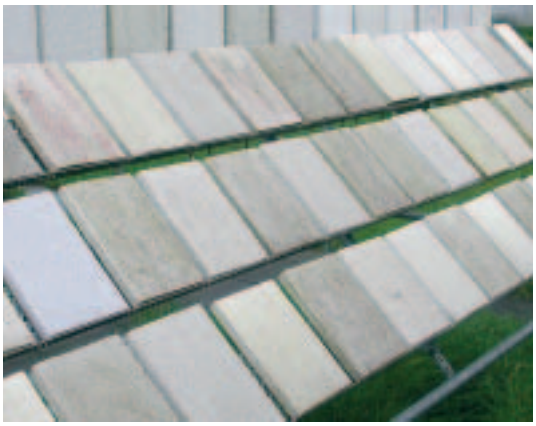

***Fig. 2:*** *Outdoor exposition of specimen, coated with different plasters/paints. Different colors indicate different biofilm communities.*

On the basis of the results obtained with different cleaning measures and different coatings for the restoration of strongly discolored façades, a leaflet providing guidelines for the restoration practice of strongly discolored facades was published. Monitoring will be continued to evaluate the long term durability of the products.

**Support:** BBT-KTI, coating and chemical industries

**Links:** www.empa.ch/abt115
> Microbiology
www.empa.ch/abt176
> Building damages

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***References:***
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# Ecoinvent 2000

**With the project "ecoinvent 2000", the Swiss Centre for Life Cycle Inventories under the leadership of EMPA achieved to combine and extend the different LCI databases of the ETH Domain and other Swiss federal institutes. Since the new data on materials are more comprehensive than most of the data used so far, in future LCA studies the ecological impact of material used in products or processes will gain on relevance compared to energy consumption.**

As part of the project lasting several years, more than 2500 data sets have been recompiled, updated and unified by the cooperating organizations. This means that high quality, harmonized LCIs are available today covering the energy, transport, waste disposal, building material, chemical, detergent, paper and agricultural sectors. The data is based on the production and supply situation in the year 2000 and is valid for Swiss and Western European conditions.

While comprehensive data on energy transformation have been available since 1996, data on material production were rather poor. Thus, LCA studies so far often concluded that a major part of the environmental burdens implied by a product or process is due to energy consumption. With the new database including much more comprehensive information on resources and material used in and emissions form material production, this picture will change. The environmental impact of the energy conversion generally decreased by 10 to 40% (exception nuclear power production) while the impacts of material production generally increased by 20 to >100%.

An important new finding is that the environmental impacts of alloying elements such as Nickel, Molybdenum and Chromium are relevant even in low alloyed steel. Figure 1 shows that more than 40% of the ecoindicator 99 (H/A) and the ecological scarcity (UBP) scores for converter steel with 1% Ni, Cr and Mo each are due to these alloying elements. In this data, the disposal of sulfidic tailings – the waste of the beneficiation of sulfidic ores like Ni, Cu or Mo ores – has not yet been reflected due to the lack of reliable data and models. A crude estimation indicates, however, that the impacts of this disposal could easily be twice to ten times as high as the impact of the production as it is inventoried in ecoinvent v 1.01.

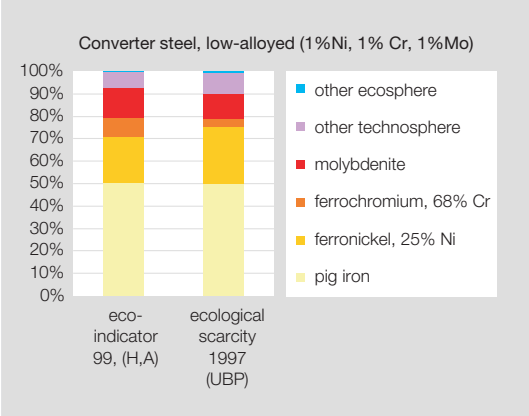


***Fig. 1:*** *Life cycle impact assessment results for low alloyed converter steel.*

These findings suggest that the ecoprofile of metals very much depend on the specific alloys. Thus, a careful selection of a specific alloy can make a considerable difference in the sustainability of a product.

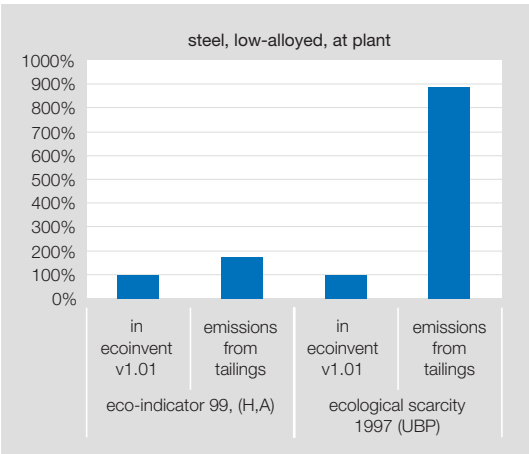


***Fig. 2:*** *Comparison of impacts included in ecoinvent v 1.01 with a crude estimation of the impacts of sulfidic tailing deposition.*

Hans-Jörg Althaus,
Mischa Classen,
in collaboration with
ETH Zurich and
Lausanne,
FAL/FAT,
esu-Services (CH),
ifu (D)

**Support:** ASTRA, BBL, BFE, BLW, BUWAL, Holz-21

**Links:** www.ecoinvnet.ch
www.texma.org/LCA-Forum/
ecoinvent_2000/ecoinvent_2000.html

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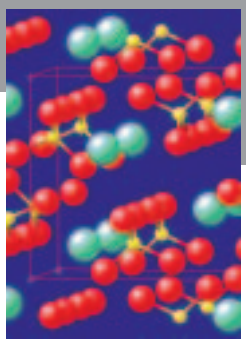
# List of abbreviations

| | |
|---|---|
| armasuisse | Swiss Defence Procurement Agency |
| ASTRA | Swiss Federal Roads Authority |
| BAG | Swiss Federal Office of Public Health |
| BAKOM | Swiss Federal Office for Communication |
| BBL | Swiss Federal Office for Constructions and Logistics |
| BBT-KTI | Swiss Federal Office for Business Formation and Technology – Commission for Technology and Innovation |
| BBW | Swiss Federal Office for Education and Science |
| BFE | Swiss Federal Office for Energy |
| BLW | Swiss Federal Office for Agriculture |
| Brite EuRam III | Basic Research in Industrial Technologies in Europe and European Research in Advanced Materials |
| BUWAL | Swiss Agency for the Environment, Forest and Landscape |
| EAWAG | Swiss Federal Institute for Environmental Science and Technology |
| EC | European Commission |
| EFD | Swiss Federal Forest Agency |
| EPFL | Swiss Federal Institute of Technology Lausanne |
| ETHZ | Swiss Federal Institute of Technology Zürich |
| EU Program V | European Community, 4th Framework Program |
| EU Program VI | European Community, 5th Framework Program |
| FAM | Swiss Federal Dairy Research Station |
| Holz-21 | Swiss Federal Stimulation Program for the Wood |
| IT'IS | Foundation for Research on Information Technologies in Society |
| IZT | Institute for Future Studies and Technology Assessment |
| MaNEP | Materials with Novel Electronic Properties |
| NCCR | National Center of Competence in Research |
| MIBD | Swiss Dairy Inspection and Advisory Services |
| PSI | Paul Scherrer Institute |
| SLS | Swiss Synchrotron Light Source |
| SNF | Swiss National Science Foundation – National Research Progam |
| TA Swiss | Swiss Center for Technology Assessment |
| TOP Nano 21 | Research Program of the Board of ETH |
| UAS | University of Applied Sciences |
| UVEK | Swiss Federal Department of the Environment, Transport, Energy, and Communication |
| VST | Swiss Federation of Door Manufacturers |

# EMPA Activities 2003

# Materials and Systems for Protection and Wellbeing of the Human Body



## Mission

The increasing human life expectancy, especially in industrial countries and the Western world, drives the need for innovative means to preserve the vitality of the body well beyond the age of retirement. On the other hand, labor is increasingly expensive. Accidents and illness, therefore, cause not only personal suffering but also absenteeism, both with economic consequences. Our concept "Wellbeing" is relevant for healthy people to maintain their quality of life, health, and productivity, but also for people on their way back to healthy life. Materials for protection, sports, gerontotechnology and rehabilitation are in the focus of our work.

## Activities

One of our core activities is **clothing physiology,** which is the investigation of the interactions between textiles and the human body. This includes phenomena like heat and moisture transport in the clothing systems considered, as well as their friction and skin sensitivity aspects. These themes entail a variation in focus from macroscopic systems perspectives to microscopic materials properties. Connected to this area is that of safeguarding the body from extreme temperatures, mechanical shock and fire. The higher the priority on personal protection of a clothing system, the more the comfort/wellbeing and the productivity of the person tend to suffer. The unification of these contrary objectives in an optimal solution is the aim of many projects. Specially developed manikins facilitate the investigation and understanding of the relevant phenomena under realistic conditions. One result of such activities is a variable insulation developed and patented at Empa, which is presently being prepared for introduction to the market by "outdoor"-jacket and bed manufacturers. Together with the Swiss Army, a new concept for winter ready equipment was developed. The resulting systems were given a positive evaluation presently used by troops, and will soon be employed on a wider scale. New materials are identified, which could be exploited in systems to protect against heat and flame in, e.g. firefighter protective clothing, and form the basis for corresponding development projects. The prevention and reduction of injury due to accidents is being pursued, for example, in a project on hip-protectors, which reduces the risk of injury for older persons who fall.

Many of these research and development results are based on textile related materials. The development of **functional textiles** and **textile surfaces** is, therefore, another focal area in our work, whether it concerns plasma technology or wet chemical methods. For this work, a highly developed infrastructure, built in-house or via collaborative efforts, is available. E.g., the plasma coating facility for textile fibers and filaments is unique in Switzerland and neighboring countries. This competence is being augmented via a newly started project for the researching and development of new material combinations for chemical fibers. A corresponding laboratory scale production of bicomponent fibers has been initiated.

EMPA

Yet another research focal area is concerned with **medical materials** and **tissues**. The goal is, on one hand, the development of optimized implant materials for bone and nerve implants. On the other hand, scaffolds are defined *in vitro* among others for the engineering of tissues. Material surfaces are defined to achieve an optimal cell proliferation and differentiation. The basis for this is a good understanding of the interaction between biological cells and extracellular biological matrices and/or non biological materials. Besides simple *in vitro* biocompatibility tests, the most modern molecular-biological and microscopic tools are being employed, e.g. online-monitoring of cell migration and the activity of particular genes. To be able to differentiate between general and cell-specific phenomena, we carry out studies using a variety of cell types. Application-oriented projects are being carried out in the areas of wound healing support and implant surfaces.

New biodegradable implants and scaffolds are developed and produced based on own research on tailor made **biopolymers** of the type polyhydroxyalkanoate (PHA). Besides their use in production of medical materials, they are envisioned as possible materials for other applications, e.g. carrier of antifouling agents. The research covers the isolation of targeted productive microorganisms, the determination of optimal production conditions, and the chemical modification of PHAs. All of the above require a measurement and analysis technology which can support the research projects at a high level, and which is constantly being improved or, in many cases, invented.

*Markus Rüedi, Department Head*

# High precision ion analysis for inhomogeneity estimation of chemometrological intercomparison samples

Michael Weber,
Jürg Wüthrich,
Sergio Rezzonico,
Helene Felber

**The homogeneity of samples intended for metrological intercomparisons must be granted without ambiguity. Due to the expected small inhomogeneities in aqueous solutions, measurement techniques offering extremely high precision were developed. This enabled EMPA to provide samples for four international metrological intercomparisons and to become a leading pilot laboratory in this field.**

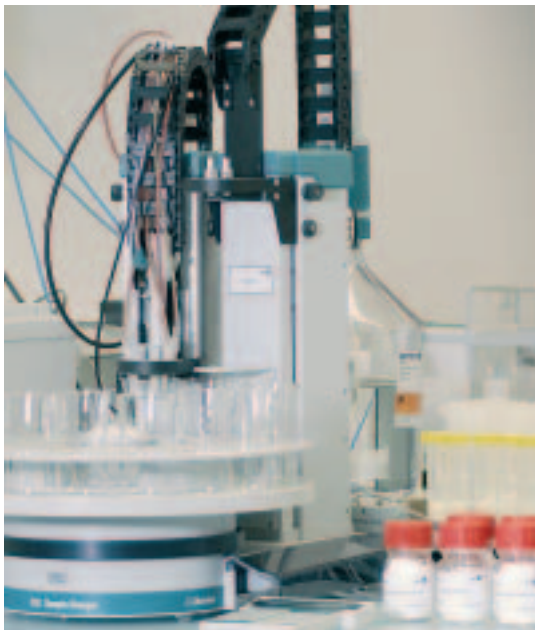


***Fig. 1:*** *Automated titrimetry system in a climate-controlled laboratory.*

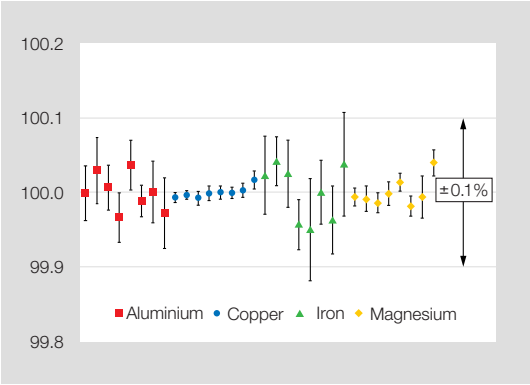



***Fig. 2:*** *Results (normalized to 100) from titrimetry measurements of aqueous 1 g kg$^{-1}$ cation solutions.*

Under the umbrella of the Consultative Committee for Chemistry (CCQM) the National Metrological Institutes (NMIs) continuously compare their analytical measurement skills by participating in metrological intercomparison studies, so-called Key Comparisons. Herein, the individual NMI results typify the measurement capabilities of the participating countries and serve for the realization of the Mutual Recognition Arrangement (MRA). For each intercomparison, the leading pilot NMI coordinates the activities and prepares the samples, thereby assuring their analyte content as well as their uncertainty. For this goal, measurement series were designed for highly automated analysis techniques such as titrimetry and optical atomic emission spectrometry (ICP-OES), which offer highest precision of results (Fig. 1).

After preparation and bottling of 1 g kg$^{-1}$ single ion solutions of aluminum, copper, iron, magnesium, chloride and phosphate, these sample solutions were investigated with regard to amount content variations between the bottles. Between-bottle standard deviations of at best 0.008 % were obtained with complexometric titrimetry whereas optical emission spectrometry with internal standard technique led to also satisfying between-bottle precisions of 0.02 % (Fig. 2). The contributions from these measurement series were finally included into the uncertainty budgets of the reference value leading to total uncertainties in the range of 0.005 % – 0.05 %. With regard to the average accuracy of the NMIs intercomparison results of about 0.2 %, it could be demonstrated that solution preparation and handling capabilities at EMPA are fit for purpose at the highest metrological stage.

**Links:** www.empa.ch/abt273
> Metrologie

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***References:***
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*M. Weber et al., Microchimica Acta, accepted (2003)*
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*H. Felber et al., Metrologia 40, 249 – 254 (2003)*
*M. Weber, invited lect. at Conference of Ion Analysis (CIA), Berlin (2003)*

# The uncertainty of atomic mass fractions in a molecule

**Atomic weights are only known with some uncertainty, individual for each element. Therefore, the formula weight of a molecule has an uncertainty, too, as well as the mass fraction of a certain element in a molecule. For the determination of the measurement uncertainty of some chemical analyses, the mass fraction uncertainty needs to be known.**

Veronika R. Meyer

In chemical laboratories, the preparation of solutions with a well-known concentration of an ion, e.g. $K^+$, is an important step of many quantitative analyses. If KCl (potassium chloride) is weighed and then dissolved, it is easy to calculate the needed amount from the atomic weights of both elements involved, namely $m_K = 39.0983$ and $m_{Cl} = 35.453$ (note that the atomic weight of Cl is known less exactly than the one of K). Atomic weights $m_X$ and their uncertainties $U(m_X)$ are published bi-annually by IUPAC (International Union of Pure and Applied Chemistry) for all elements. The relative uncertainties vary between $6.5 \cdot 10^{-4}$ for boron ($m_B = 10.811$, $U(m_B) = 7 \cdot 10^{-3}$) and $2.6 \cdot 10^{-8}$ for fluorine ($m_F = 18.9984032$, $U(m_F) = 5 \cdot 10^{-7}$).

The mass fraction of K in KCl is
$39.0983/(39.0983+35.453) = 0.52445$.
Its uncertainty is obviously a function of the two atomic weight uncertainties. For a molecule or compound with composition $A_aB_bC_c \ldots N_n$, the mass fraction $f_A$ of element A is:

$$f_A = \frac{a \cdot m_A}{a \cdot m_A + b \cdot m_B + c \cdot m_C + \ldots + n \cdot m_N} = \frac{a \cdot m_A}{m_M}$$

with $m_M$ being the formula weight of the molecule.

We developed the equation which describes the uncertainty $u(f_A)$ by partial derivation of this function with respect to all masses involved, adding the squares of the derivatives and extracting the root; this gives after factoring out:

$$u_C(f_A) = \frac{a}{m_M^2} \sqrt{(m_M - a \cdot m_A)^2 \cdot u^2(m_A) + m_M \sum_{x=b,\, X=B}^{n,\, N} \left(x^2 \cdot u^2(m_x)\right)}$$

The equation for $u_C(f_A)$ needs standard uncertainties $u(m_X)$, which are obtained as $u(m_X) = U(m_X)/\sqrt{3}$ because the IUPAC uncertainty values are treated as rectangular distributions.

As an example, the sulfur content in foods can be determined by precipitation of the analyte in the form of barium sulfate $BaSO_4$. With $m_{Ba} = 137.327$, $U(m_{Ba}) = 7 \cdot 10^{-3}$, $m_S = 32.065$, $U(m_S) = 5 \cdot 10^{-3}$, $m_O = 15.9994$, and $U(m_O) = 3 \cdot 10^{-4}$ we obtain:

$f_S = 0.1374$
$u(f_S) = 1.1 \cdot 10^{-5}$
(calculated with the equation presented above)
$u_{rel}(f_S) = 8 \cdot 10^{-5}$

These numbers are low. However, keeping in mind that weighing operations can be performed with a relative uncertainty in the same order of magnitude, it turns out that the contribution of the atomic mass fraction to the overall uncertainty of an analysis must not be disregarded before the complete uncertainty budget is set up and calculated.

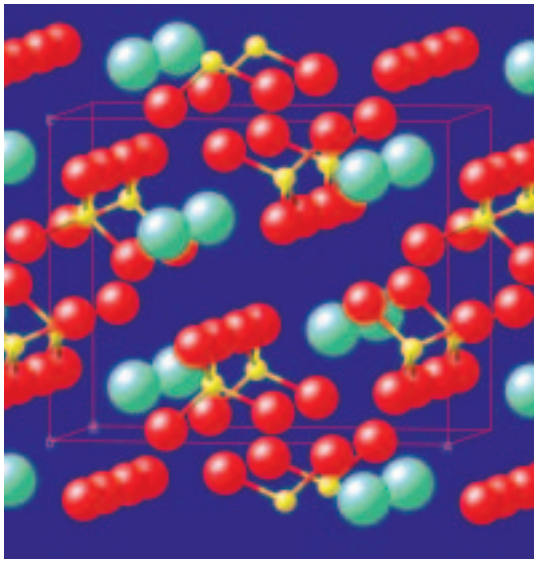

***Fig. 1:*** *How much sulfur (yellow) is in barium sulfate $BaSO_4$? What is the uncertainty of its portion? (Model drawn with CrystalMaker 6.3.0, Bicester, UK)*

**Links:** www.empa.ch/abt273
> Metrologie

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***References:***
*V.R. Meyer, Anal. Bioanal. Chem. 377, 775 (2003)*
*S. Wunderli, G. Fortunato et al., Anal. Bioanal. Chem. 376, 384 (2003)*

# Application of strontium isotope abundance ratios measured by MC-ICP-MS for food authentication

Giuseppino Fortunato, Kristina Mumic, Samuel Wunderli, in collaboration with FAM and BAG (CH)

**Multiple-collector inductively coupled plasma mass spectrometry (MC-ICP-MS) has been used for the precise determination of variations in the isotopic composition of Strontium (Sr) including estimation of the involved measurement uncertainties. The method described has been applied for the establishment of the potential and limits to determine the geographical origins of different «Emmental» type cheese samples.**

Strontium (Sr) has four naturally occurring stable isotopes $^{88}Sr$, $^{87}Sr$, $^{86}Sr$ and $^{84}Sr$. Natural variations of the isotopic abundance ratio of $^{87}Sr/^{86}Sr$ mainly arise from the natural β-decay of $^{87}Rb$ to $^{87}Sr$. The $^{87}Sr/^{86}Sr$ isotope abundance ratio varies from place to place both on global and local scale according to geological properties.

Food authenticity is one aspect which is receiving more attention with the increasing mobility of our society and low transport costs. For the protection of the consumers and the producers, for the prevention of frauds such as mislabelings and for the guarantee or proof for the origin of the products, analytical methods have to be validated. A number of different analytical techniques and parameters have been evaluated for the purpose of Emmental authentication such as infrared spectroscopy, light element stable isotope mass spectrometry, major and trace elemental analysis, pH-value determinations, etc. It was shown that one single method or one single parameter of its own is generally insufficient to achieve this task, and that results from several methods should be combined using multivariate statistical analysis.

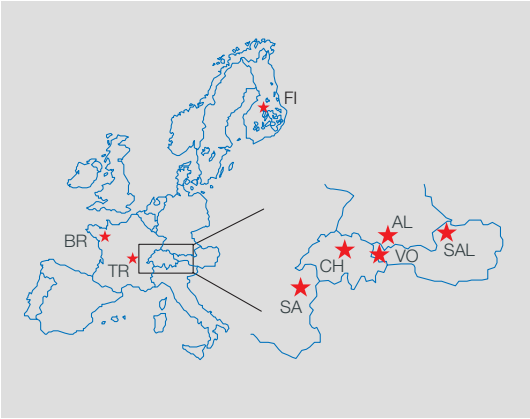


***Fig. 1:*** *European sampling sites for «Emmental» type cheese samples.*

Naturally occurring isotopes like Sr have proved to be good tools for detecting trends in the soil-vegetation system and the tracing of a variety of objects. Using MC-ICP-MS measurement, combined uncertainties for the isotope abundance ratio $^{87}Sr/^{86}Sr$ of 0.01 % are attainable, which assures the distinction of very small physical and chemical effects. The $^{87}Sr/^{86}Sr$ isotope abundance ratios in cheese originating from different regions (Alps, pre-Alps, Bretagne, Finland, Australia) showed accordance with local geological properties where the products had been produced (Fig. 1). A separation was possible for samples originating from Scandinavian, Australian and alpine regions, whereas for samples originating from alpine and prealpine regions no clear distinction was observed (Fig. 2). This can be attributed to the uniform geological age of the soil where the cheese was produced.

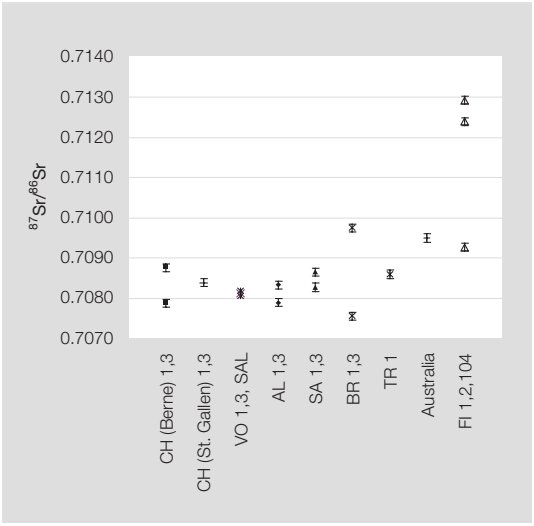


***Fig. 2:*** *$^{87}Sr/^{86}Sr$ isotope abundance ratio values and origins for different cheese samples (2-3 samples per region).*

**Links:** www.empa.ch/abt273
> Metrologie

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***References:***
*G. Fortunato et al., Anal. Bioanal. Chem. 377, 111-116 (2003)*
*G. Fortunato et al., J. Anal. At. Spectrom. DOI:10.1039/B307068A (2003)*

# Control of physical properties of BIOPOL® during biosynthesis in *Ralstonia eutropha* (DSM 428)

Manfred Zinn,
Roland Hany,
Manfred Schmid,
in collaboration with
Thomas Egli,
Hans-Ulrich Weilenmann,
EAWAG (CH)

**Industrial production of BIOPOL® (poly([R]-3-hydroxybutyrate-*co*-3-hydroxyvalerate) (PHB/HV)) is performed in fed-batch cultures of the bacterium *Ralstonia eutropha*. However, under such growth conditions the polymer composition could not be controlled in an accurate way. The design of a production process with multiple nutrient limited growth conditions in a chemostat allowed tailoring of BIOPOL® with respect to composition and physical properties.**

Polyhydroxyalkanoate (PHA) is a class of biopolyester that is accumulated by bacteria under growth conditions where one nutrient is limiting growth and the carbon source is in excess. The industrial production at a large scale was first established in the mid-eighties by ICI (GB) with a mutant of *Ralstonia eutropha* for the copolymer poly([R]-3-hydroxybutyrate-*co*-3-hydroxyvalerate) (PHB/HV) also known under the trade name BIOPOL®. Shampoo bottles and other biodegradable products have been produced from this polymer. Today's biosynthesis by Metabolix (U.S.A.) was not changed essentially and consists of two main phases: In a first phase, the cells were cultured in a minimal medium which contained the essential growth nutrients, glucose, and low amounts of phosphate, supporting cell growth to a certain biomass concentration and only minor PHA accumulation. In a second phase, after all phosphorus was consumed by the cells, PHA accumulation took place. PHA accumulation was driven through the continuous addition of glucose and propionic acid to the culture at well defined rates. After 48 hours of feed, the PHA consisted of 3-hydroxybutyrate and maximal 30 mol% 3-hydroxyvalerate. The advantage of fed-batch cultures in general is the high cell densities that can be obtained which reduce the costs of PHA production significantly. A disadvantage of the process is that the cells grow at a decreasing growth rate, which can lead to unexpected losses in PHA production and a shift in copolymer composition.

We have developed an alternative production method, namely the continuous cultivation of *Ralstonia eutropha* under conditions where nitrogen (N) and carbon (C) are limiting growth simultaneously. The influence of various carbon feed mixtures from butyric and valeric acid on the BIOPOL® composition was assessed in a series of chemostat experiments where the total C/N ratio was fixed to 17 mol $mol^{-1}$. The optical density of all steady-states was OD450 = 34 ± 4 and the PHA content of *Ralstonia eutropha* was 40 ± 5% (w/w) based on weight measurements of dried cell material and extracted polymer.

Figure 1 summarizes the ability of *Ralstonia eutropha* to produce tailor-made PHB/HV. Up to a ratio of 20 mol% valeric acid (VA), 3-hydroxyvalerate (HV) was detected in PHB/HV at the same proportion as VA supplied in the feed. Above 20 mol% VA feed, the content of HV in PHB/HV was significantly lower than expected. This phenomenon is best seen when pure valeric acid was used as carbon source. Instead of the homopolymer poly(3-hydroxyvalerate), a co-polymer was extracted that consisted of 62 mol% HV and 38 mol% 3-hydroxybutyrate (HB) based on $^1$H-NMR spectroscopy.

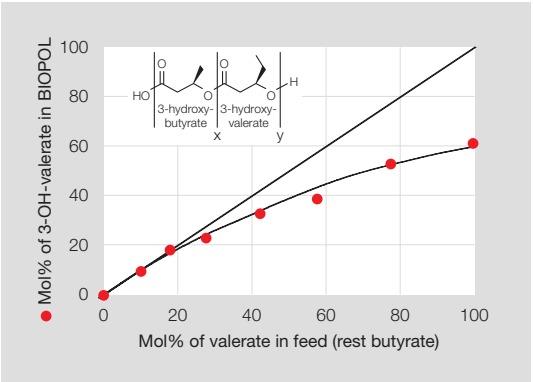


***Fig. 1:*** *Tailor-made PHB/HV can be produced in dual (C, N) limited chemostat cultures with HV contents between 0 and 62 mol%.*

The growth conditions also significantly influenced the thermal properties of PHB/HV (Fig. 2). For example, the highest melting temperature ($T_m$) was 178.2 °C for pure PHB and the lowest temperature was 76.8 °C for a HV content of 52 mol%. The glass-transition temperature (Tg) of PHB/HV samples decreased from 5.9 °C to -4.1 °C with increasing HV content. A minimum $T_m$ at around 75 °C was observed for an HV content of 40 – 50 % where the crystal lattice transition from PHB to PHV has been reported to take place.

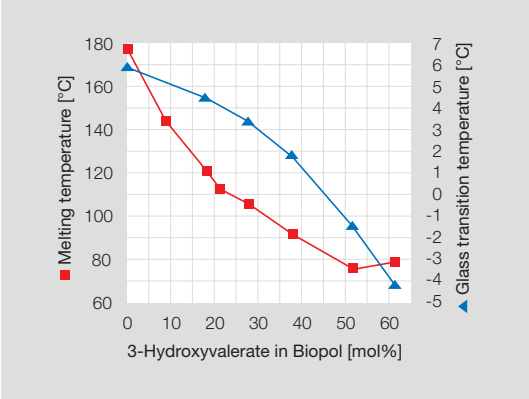


***Fig. 2:*** *Melting and glass transition temperatures of PHB/HV samples.*

The molecular weight analysis indicated that the carbon substrate mixture had neither significant influence on the molecular weights nor on the weight distribution. The molecular weights ranged for $M_n$ (number average) between $2.7 – 4.6 * 10^5$ and for $M_w$ (weight average) between $0.9 – 1.2 * 10^6$. The molecular weight distribution ($M_w/M_n$) was on average $3.0 \pm 0.3$, which is typical for biopolymers.

The reason why no higher than 62 mol% HV contents were produced has to be searched for in the metabolic activity of the culture. In contrast to nitrogen starved cells in batch culture (no cell division is taking place), chemostat grown cells divide and accumulate PHA simultaneously. We, therefore, propose that in continuous culture the biosynthetic pathway to PHB/HV has to be the product of substrate derived catabolism and non-substrate related anabolism (Fig. 3). For example, valeric acid is taken up by the cell and partially transformed into R-3-hydroxyvaleryl-CoA and finally polymerized by the enzyme PHA polymerase (substrate derived catabolism). The other part of valeric acid (C5) is degraded to C2 (acetyl-CoA) and C3 (propionyl-CoA) units that may recombine to HB and HV (non-substrate related anabolism). The mixed synthesis of PHB/HV from both sources is detectable for valeric acid contents in the feed medium between 20 and 100 mol%.

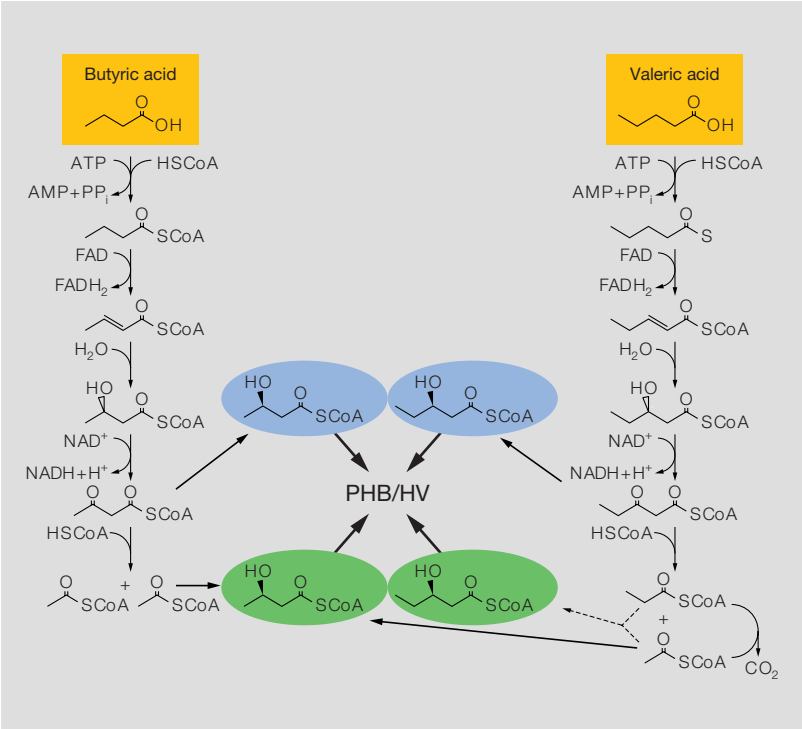


***Fig. 3:*** *PHB/HV is produced from substrate derived (blue) and non-substrate related (green) precursors.*

In conclusion, the chemostat cultivation of *Ralstonia eutropha* under dual (C, N) limited growth conditions enables, besides a constant production of BIOPOL®, also an accurate control of the polymer composition. The latter is especially important when the polymer is used for medical applications. Here, the property of the polymer needs to be well defined otherwise the function of a PHA (drug carrier, medical implant) cannot be reproducibly controlled because of different degradation rates.

**Links:** www.empa.ch/abt273
> Biopolymers

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***References:***
*Th. Egli et al., Biotechnology Advances 22:35 (2003)*
*R. Hany et al., Macromolcules, in press (2003)*
*M. Zinn et al., Acta Biotechnologica 23, 309 (2003)*

# Design of plasma polymerized thin films

**Plasma technology is a versatile tool to ablate, modify and coat surfaces of many different materials (artificial as well as natural) and geometries like e.g. foils, fibres, and textile fabrics. Plasma polymerization allows the growth of functional gradient layers from gaseous monomers beyond conventional chemistry. The evaluation of the deposition rates of plasma polymerized thin films gives hints to find optimum deposition conditions and enables the comparison and up-scaling of plasma reactors.**

Dirk Hegemann,
Urs Schütz,
Armin Fischer

Low temperature plasma technology is applied at the Laboratory for Functional Fibers and Textiles and covers a wide range of materials processing (Fig. 1). Using non-film-forming gases like $N_2$, $O_2$, Ar, and $H_2$, surfaces which typically show contamination or adsorption can be cleaned on a microscopic level. Moreover, functionalities might be formed on polymer surfaces increasing the surface tension. Thin film deposition can be performed by a physical vapor deposition (PVD) or a plasma-enhanced chemical vapor deposition (PECVD). In case of a PVD process, magnetron sputtering is applied to deposit metallic (e.g. Ag, Al) or ceramic (e.g. ITO, PZT) films continuously on single fibers as well as on textile fabrics. Plasma polymerization, on the other hand, enables the deposition of polymer-like as well as quartz- or diamond-like films through variation of cross-linking by PECVD processes. Furthermore, mono-functionalizations can be achieved e.g. for the biomedical field.

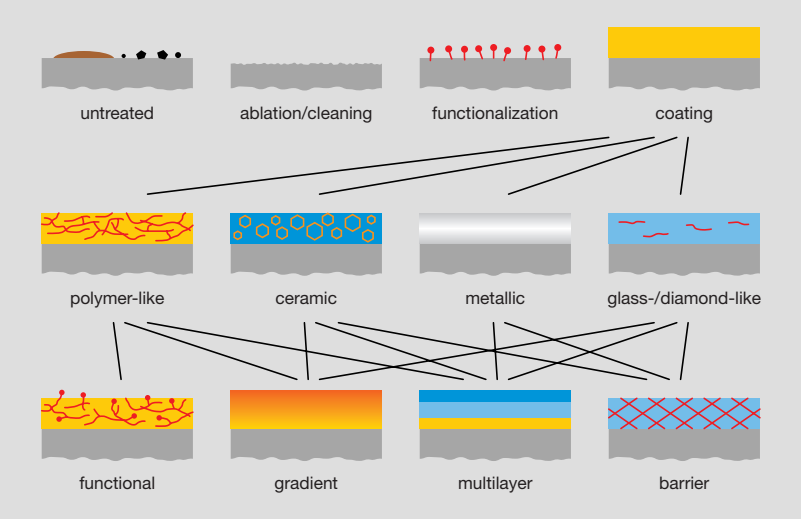


***Fig. 1:*** *Scope of plasma treatment.*

Not only different materials and geometries can be processed (Fig. 2), but also multilayer or functionally gradient films can be deposited in a one-step process using plasma technology. In addition, pre- and post-treatments are applicable. In particular, plasma polymerized gradient layers can be used to enhance the adhesion of hard coatings on flexible substrates like foils, textiles, and fibres.

At our laboratory, different plasma reactors (batch reactors, web coater, fiber coater) with different excitation modes (radio frequency, microwave, dc-magnetron) are available. For plasma polymerization, 13.56 MHz RF at low pressures is used, since this frequency enables well-defined plasma conditions by a proper power matching. Using hexamethyldisiloxane (HMDSO) with or without oxygen, SiOC:H films with defined wetting properties between 20° (quartz-like) and 110° (siloxane) on flat surfaces can be obtained. Highly cross-linked $SiO_x$ films with low carbon residuals as well as amorphous hydrocarbon

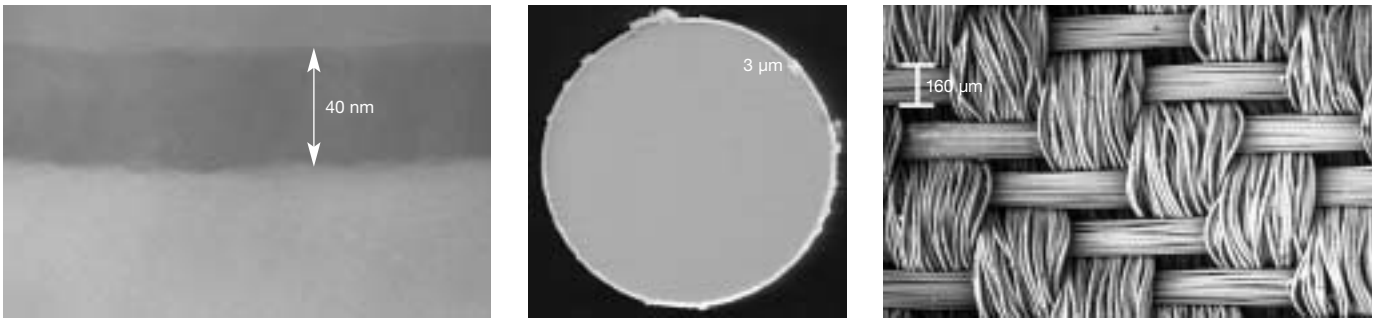


***Fig. 2:*** *Homogeneous coatings on polymer foils, single fibres, and textile fabrics.*

(a-C:H) films derived from $CH_4$ or $C_2H_2$ can also be used for protective or barrier coatings. By evaluation of the deposition rates of these plasma polymerized films, we found that hints for the optimum deposition conditions can be inferred. Since plasma polymerization is a radical dominated process, the deposition rate is determined by the reaction parameter power per gas flow W/F. As shown in Figure 3, the apparent activation energy $E_a$ can be deduced from the deposition rates. At an energy input below $E_a$ the films are rather weak, oligomer-like, whereas a 2–3 fold energy of $E_a$ was found to allow optimum barrier properties. Thus, plasma coatings can be designed regarding film thickness, chemical composition, density as well as wetting, mechanical, and barrier properties. Moreover, using this concept plasma processes can be scaled up by comparison of different reactors on the basis of the activation energy.

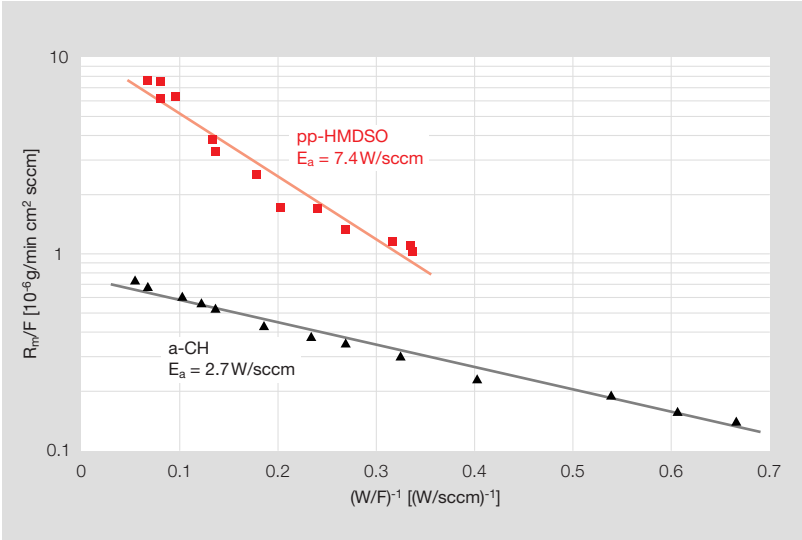


***Fig. 3:*** *Mass deposition rates of pp-HMDSO and a-C:H films. Each data set in the Arrhenius-type plot can be fitted by straight lines, where the slope indicates the apparent activation energy $E_a$.*

Examples of the hydrophobization of a textile fabric (silk) and the barrier coating on polymer foils (PET) are given. To demonstrate the effect of the modification, the silk textile is only partly coated with a thin siloxane film (Fig. 4). Using the structure of the textile fabric, water contact angles up to 150° are obtained. These films show almost no aging.

***Fig. 4:*** *Drop of colored water on a silk fabric which was rendered hydrophobic by a plasma polymerized HMDSO film (left). On the untreated material, the drop spreads immediately (right).*

Combining a $SiO_x$ with an a-C:H layer, excellent barrier improvement factors on PET foil are attained. The two-layer system with a total film thickness below 50 nm exhibits an oxygen transmission rate of about 0.2 $cm^3/m^2$ d bar (OTR) and a water vapor transmission rate of about 0.2 $g/m^2$ d (WVTR). Further improvements can be achieved by adding sputter coatings or inorganic/organic hybrid coatings.

Conclusively, plasma technology is a well-suited tool to modify and coat flexible substrates like foils, fibres, and textile fabrics, whereby the conducted surface functionality can be adapted to the user's demand. The evaluation of the deposition rates with plasma diagnostic showed that the process conditions can be optimized to yield defined wetting or barrier properties. Thus, the design of plasma coatings as well as the up-scaling of plasma reactors are enabled.

**Links:** www.empa.ch/abt272
> Plasma technology

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***References:***
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# Reinforcing foundation layers on soft subgrade

**The aim of the study was the elaboration of basics for the design of geosynthetic reinforced soil structures. Field tests at a 1:1 scale concentrated on questions about improving the compaction properties and the long-term bearing capacity of foundation layers on a soft subgrade reinforced with geosynthetics. The test track was built with three 0.2 m thick soil layers, the geosynthetic reinforcement laid underneath. The state of the track was monitored from installation to removal, focusing on static plate compression tests and profile measurements to assess the formation of ruts. The geogrids were instrumented to measure the strains. The results show that geosynthetic reinforcement only has an effect on a soft subgrade, which allows the geosynthetic to deform, thus mobilizing tensile forces.**

Rudolf Hufenus,
Rolf Brönnimann,
Glauco Feltrin,
in collaboration with
Rüegger Systems AG,
ETH Zürich (CH)

Geosynthetic reinforcement is used in foundation layers on soft subgrade to improve the characteristics of the subgrade with regard to compaction and load-bearing capacity under use (road traffic), with the aim of reducing the necessary depth of the layer and extending the service life (Rüegger and Hufenus, 2003). Field trials on a scale of 1:1 were undertaken in the autumn of 2002 in order to ascertain the effect of geosynthetics on the load-bearing capacity of foundation layers on soft subgrade (Hufenus et al., 2003). Compaction and in-service tests were undertaken on the foundation layers on a construction track of modest dimensions, reinforced with various geosynthetics.

An area within a brickworks clay pit was available for use as a test track. The subgrade consisted of a clayey silt with a very low load-bearing capacity. Loose recycled material (crushed concrete) was used to build the foundation layers. The test track was constructed adjacent to an existing road, with a length of about 130 m (Fig. 1). The plan for the test track was for 3 layers of 0.2 m thick fill (Fig. 2), with the 1st layer compacted statically (2.5 t tandem flat roller, 3 – 4 passes) and the 2nd and 3rd layers compacted dynamically (8.0 t roller with constant energy, 3 – 4 passes). Trafficking tests were conducted with an empty 13 t truck (1st layer) and with a loaded truck (2nd and 3rd layers).

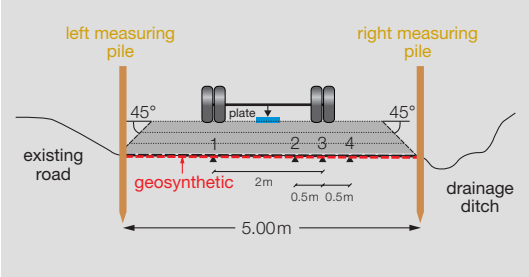


***Fig. 2:*** *Cross section of the test track with positioning of the transverse strain gauges.*

10 different geosynthetics were tested for the reinforcement layer, with weighing given to the most representative selection possible with regard to raw materials and type of manufacture. These included five geogrids, one geocomposite, two nonwoven geotextiles and two slit tape woven geotextiles (one deliberately weak). The geogrids were equipped with strain gauge instrumentation in order to detect the local short-term and long-term deformation. 4 strain gauges were fitted in a line at right angles to the track axis for each sample under test. Figure 2 shows their positions.

***Fig. 1:*** *Test track within the brickworks clay pit.*

The condition of the track and the geosynthetics was monitored by instruments from installation to removal, using a California bearing ratio penetrometer, a shear vane, profile measurements (ruts) and strain gauges on the geogrids. Control of the compaction was carried out in the field, using radioactive isotopes (measurements of the density), static and dynamic plate load test, overall dynamic compaction control and a dynamic falling weight deflectometer.

The profile measurement used to assess the formation of ruts is carried out using a cross bar which rests on the left and right measuring piles driven in on either side of the track, and the distance of the piles from the track is given by measuring sticks. With reinforcing geosynthetics able to withstand a force per meter width of > 8 kN/m at 2 % axial strain, ruts form at a depth of between 20 and 40 mm in very soft subgrade (Fig. 3).

Figure 4 shows an example of the results of static (continuous) strain measurements taken during compaction and driving passes over the 3 layers. The measurements taken during the time the track is being trafficked demonstrate relatively large strain maxima of more than 1% (1st layer trafficked), under the direct load influence. Nevertheless, the residual deformations still stay modest.

The results show that geosynthetic reinforcement only has an effect on a soft subgrade, which allows the geosynthetic to deform, thus mobilizing tensile forces of up to around 8–12 kN/m. Higher traction forces might have no effect, due to the limited lateral anchoring forces. Residual strains in the geosynthetic remain below 2 % under static loads, but may reach somewhat higher levels with dynamic loads. Regarding reinforcement on soft subgrade, and taking into consideration geosynthetics with comparable load-strain behavior (stiffness modulus), the product type is somewhat irrelevant.

It appears that given comparable subgrade conditions and an equal depth of layer, with reinforcement, the degree of compaction (measured by in situ density) is approx. 10–30 % more than without any reinforcement. The formation of ruts is reduced with a depth of layer of up to 0.4 m. This leads to a considerable reduction compared with the depth of layer that would be required without reinforcement, and leads to significant savings in materials. With thicker layers, the reinforcement no longer has any significant effect.

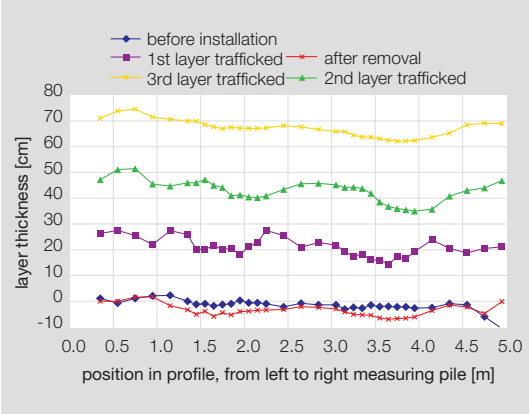


***Fig. 3:*** *Development of ruts (PET flat rib grid reinforcement).*

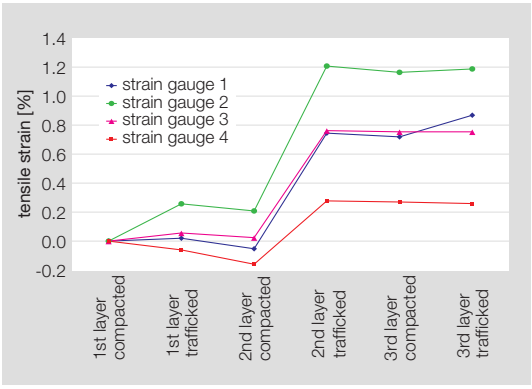


***Fig. 4:*** *Reaction of the strain gauges to the various loads (extruded biaxial PP grid reinforcement).*

**Support:** ASTRA, Geosynthetics industry

**Links:** www.empa.ch/abt272
> Technical textiles
www.geotex.ch

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***References:***
*R. Rüegger, R.Hufenus, Bauen mit Geokunststoffen, ISBN 3-9522774-01, SVG, St. Gall, 192 p. (2003)*
*R. Hufenus et al., Proceed. 8th Conf. on Synthetics in Geotechnics FS-KGEO, 171-179 (2003)*

# Microstructuring of textile fibers

**Microstructuring textile fibers using thermoplastic moulding opens ways for new applications. A simple roll embossing set-up was developed. By careful adjustment of process parameters, periodic gratings with sub-µm dimensions were transferred onto polyester fibers.**

Marcel Halbeisen,
Urs Schütz,
in collaboration with
Helmut Schift, PSI (CH)

Many of the advances of synthetic fiber technology are based on the enlargement of the fiber surface. Mostly the fibers are profiled by adequate spinneret nozzles, which enables a surface profile during fiber spinning. This technology occurs only in the direction of spinning and is limited by the fabrication fidelity of the process. The fiber surface is, therefore, rather coarse and so many effects based on surface micro- and nanostructures cannot be applied sufficiently.

By generating an arbitrary topographical relief, the important properties of the fiber surface can be largely improved. Possible examples are:

- Textiles which can take up large quantities of moisture and are able to dry quickly. A directed water flow may be induced by a defined capillary structure.
- Fibers with enhanced adhesion of coatings, which allows to achieve specific finishes.
- Stents or artificial tissue for biomedical applications with controlled cell growth.

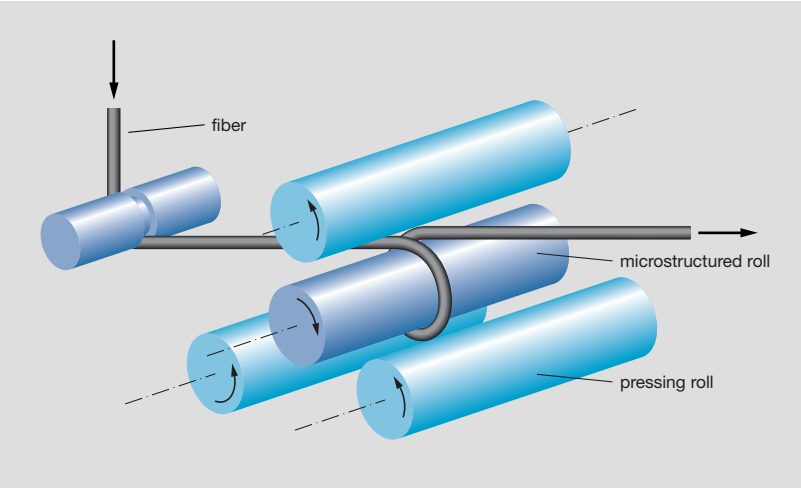


***Fig. 1:*** *Principle of fiber-microstructuring.*

To produce microstructures on fibers, the surface relief of a stamp is transferred onto the surface of a fiber by moulding at a temperature well above its glass transition temperature (Tg). This process has similarities to the hot embossing lithography for the fabrication of diffractive optical elements (Fig. 1). The stamps are generated by lithographical methods and transferred into different materials. For micro- or nanostructuring of fibers, structures are copied into metal using electroplating. Thin metal shims of about 100 µm with feature sizes below 100 nm are used and can be mounted on a cylinder for continuous work.

Figure 2 shows a microstrucured PES fiber (diameter 180 µm), with a fine grating of 1 µm period and 200 nm depth. The result shows that this method can be applied for the lateral structuring of polymer fiber surfaces. A temperature-pressure-speed regime was found for homogeneous fibers, which allows moulding a sub-µm pattern onto the surface of the fiber while the core of the fiber is only slightly deformed. This is important because the fiber needs to keep its macroscopic geometrical and mechanical properties, which are relevant for the post processing and use of fibers.

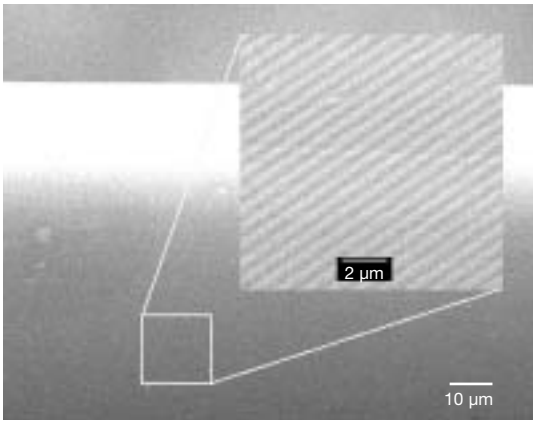


***Fig. 2:*** *Microstrucured PES fiber.*

The process is still slow and cannot be applied online. Also the structured area is only one tenth of the fiber surface. Further development is ongoing to emboss the whole fiber surface at elevated speed.

**Links:** www.empa.ch/abt272
> Fiber development

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***References:***
*Schift H. et al., Applied Nanoscience, accepted (2003)*
*Patent CH 01135/03 (published)*

# Humidity transport in multilayered clothing systems measured with neutron radiography

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Paul Brühwiler,
Urs Herzig,
Roman Huber,
in collaboration with
Gabriel Frei,
Eberhard Lehmann,
PSI (CH)

**Neutron radiography has been applied to study moisture transport across layered textiles. Five clothing systems, each composed of four layers with different water transport properties, have been studied. The results agree with gravimetric studies, and provide a lateral visualization of the distributions.**

For physically active workers and athletes, the transport of perspiration through a clothing system is very important. As clothing systems become more sophisticated, there is a need for methods which can follow the layer-by-layer water distribution in real time, without disturbing the transport process. Since neutrons are strongly scattered by hydrogen, water is easily detected, making neutron radiography an attractive method.

The textile systems were mounted on the apparatus depicted in Figure 1, with the neutron beam directed perpendicular to the figure plane. Water was emitted at a rate of 3.5 g over 13 min to simulate intense perspiration, and the holder surface temperature was held at 35 °C. The results are shown in Figure 2. The dark stripes in the left image are the textile layers of the indicated systems. Air layers between the textile layers are also visible as grey stripes. Radiographs taken after 5 minutes of heat/moisture treatment are shown on the right, after being processed to emphasize changes; darker color corresponds to greater water concentration. Some caution has to be used when interpreting the images, due to possible small changes in the sample positions between the measurements.

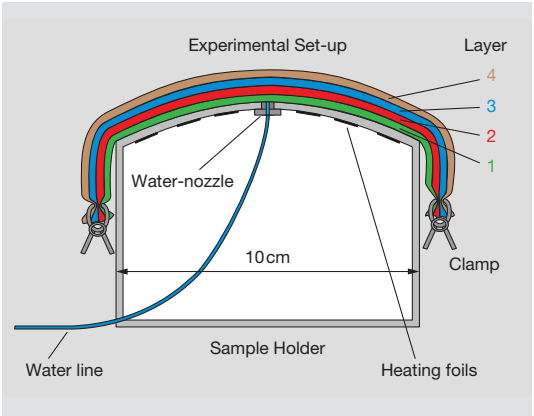


***Fig. 1:*** *Schematic of the apparatus used to support, heat, and inject water into the samples.*

For the combination Phil1 very little water remains in the hydrophobic Layer 1, with significant amounts in the hydrophilic Layer 2. For Phil2 the hydrophilic Layer 1 retains most of the injected water on the timescale of the measurement, with some having been transferred upward to hydrophilic Layer 2. The large contrast in the uppermost layers is attributed primarily to slight displacements. For the Hygro and PhiPho combinations virtually all water is retained in the first, hydrophilic layer instead of being transferred up to the hygroscopic and hydrophobic second layers, respectively. For the Phob combination most of the water added is expected from the gravimetric measurements to remain between the hydrophobic Layer 1 and the sample holder, with some being rapidly transferred to Layer 1 and significantly less to Layer 2, consistent with the difference image observed. The images show that the moisture disperses very little laterally, demonstrating a strength of this method. Future work will concentrate on gaining access to the fine-scale time dynamics of moisture transfer processes.

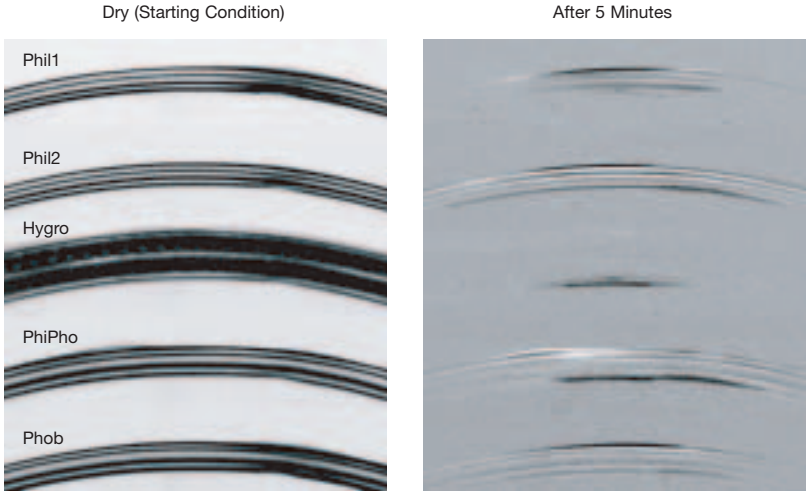


***Fig. 2:*** *Neutron radiography images of the indicated samples.*

**Links:** www.empa.ch/abt271
> Clothing physiology

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***References:***
*M. Weder, G. Frei, P.A. Brühwiler, U. Herzig, R. Huber, E. Lehmann, Textile Res. J., accepted (2003)*

# Angle dependence of bicycle helmet ventilation and comfort

**The head-angle and wind-speed dependence of the ventilation performance of five bicycle helmets as measured by a heated manikin headform agrees well with human subject tests, and shows that ventilation of some helmets is optimized with the head tilted forward.**

Paul Brühwiler,
Charline Ducas,
Roman Huber,
in collaboration with the University of Alabama (USA)

Bicycle helmets protect their wearers from debilitating injuries, and are most often used when the weather is warm. Airflow through the helmet to cool the head is important, since it can influence the willingness of people to wear helmets, and may alleviate overheating. The present study is a first attempt to measure bicycle helmets for ventilation properties with a heated manikin headform, and to determine if human subjects can sense the differences found.

| Helmet | Median | Trimmed Mean | Std Dev | Preferences |
|---|---|---|---|---|
| 1 | 2 | 2.5 | 0.6 | 30° |
| 2 | 0 | 0.6 | 0.8 | – |
| 3 | 0 | −0.2 | 1.1 | – |
| 4 | 3 | 2.9 | 2.0 | 30° |
| 5 | 3 | 0.9 | 0.9 | 30° |

***Table 1:*** *Median and mean values of the subject head tilt angle preference as a function of helmet.*

The heated manikin headform used is shown in Figure 1, tilted forward 30°. Summer conditions were chosen for the climate chamber (25 °C, 65 % RH), and the wind speed was set using a homebuilt wind channel, as shown. The head angle was 0° (straight up) or 30 °. The results for the cooling ability of a helmet, defined as steady state power required to keep the skull at 35°, are shown in Figure 2. The helmet-to-helmet and angle variations in cooling power are quite similar at both wind speeds used. Two helmets show almost no variation with head angle, like the bare headform, whereas the other three show a noticeable increase in cooling power at 30°.

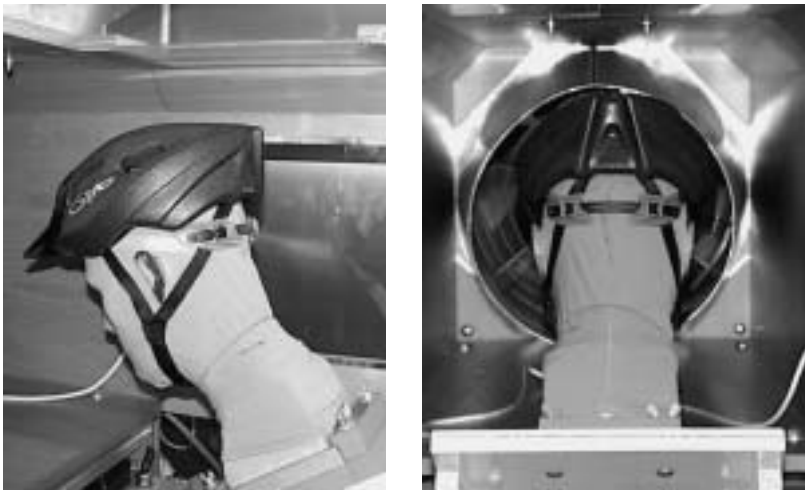

***Fig. 1:*** *Apparatus used. The headform is shown at the 30° tilt angle, placed at the mouth of the wind tunnel, all located in a climate chamber.*

Seven human subjects sat with their heads positioned as the headform, with the wind set at 10 km/h to optimize sensitivity. Each was fitted with a helmet and instructed to evaluate which angle provided the better ventilation to the area of the head covered by the helmet. The maximum possible evaluation was 10, with negative (positive) values corresponding to better cooling at 0° (30°). The median responses are shown in Table 1, and compared to mean values with two outliers removed. Values close to 0 for helmets 2 and 3 are in excellent agreement with the lack of angle dependence for these helmets in the headform tests. The positive values for helmets 1, 4, and 5 are also nicely consistent with the headform results.

Future work will concentrate on the physical basis of the angle- and helmet-dependence of the skull ventilation.

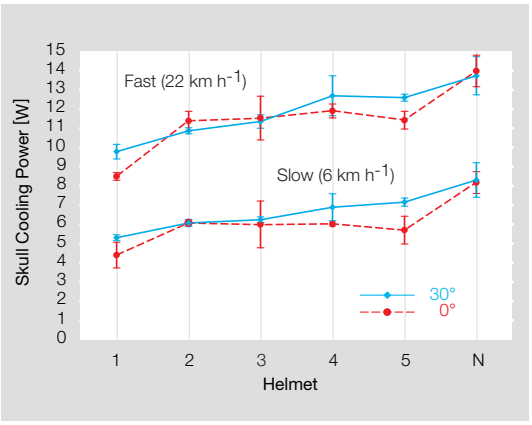


***Fig. 2:*** *Cooling power as a function of helmet, wind speed, and head tilt angle. N denotes the headform with no helmet.*

**Links:** www.empa.ch/abt271
> Mechanical protection

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***References:***
*P. A. Brühwiler, Meas. Sci. Technol. 14, 217-227 (2003)*
*P. A. Brühwiler, C. Ducas, R. Huber, P. A. Bishop, Eur. J. Appl. Physiol., accepted (2003)*

# Firefighting and its influence on the body

René Rossi

**The skin temperatures as well as the sweat production of fire fighters and the relative humidity in the microclimate in the different layers of the protective clothing combination were assessed during simulated fire fighting situations. The results showed that the skin temperatures nearly reached pain level in several cases and that a large part of the produced sweat remained in the clothing layers.**

The primary function of fire fighter's protective clothing is to protect the wearer from external heat and flame sources. The high thermal insulation hinders the heat and moisture produced by the body to escape to the atmosphere. The goal of this study was to measure the skin temperature and moisture of fire fighters during exercises in a fire training building. For this purpose, the firefighters as well as their equipment were weighed before and after the exercise, and temperature and humidity sensors were placed on their shoulder.

The temperature on the skin were assessed with six fire fighters. Values between 39 °C and 45.5 °C were measured. The limit where the skin usually starts feeling pain is about 44 °C but can slightly vary depending on the location and the individual. One fire fighter suffered burns at a maximum temperature of 42.7 °C (Fig. 1). This means that he got burnt at a lower temperature than the others. The fact that several fire fighters reached higher temperatures without feeling pain may be because burn injuries are not only due to a temperature increase but also due to the heat intensity.

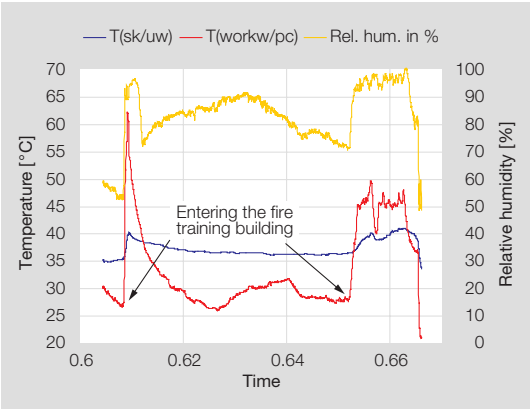


***Fig. 1:*** *Temperature between skin and underwear (T(sk/uw)), and temperature and relative humidity between jacket and workwear (T(workw/pc)) during a fire fighting exercise.*

There were hardly any differences in relative humidity in different jacket types during the time in the fire training building: in every case, humidity jumped near to 100 % when the fire fighters entered the building. This can be explained by the fact that heat and relative humidity were higher in the environment than near the body and that even breathable jackets could not evacuate sweat (water vapor) to the outside under these circumstances. The underwear of the fire fighters was mostly made of cotton and took up large amounts of moisture (typically 100 to 200 g). However, it was not possible to determine the amount of evaporated sweat during these exercises exactly as the garment combinations partly absorbed extinguishing water.

***Fig. 2:*** *Firefighters during the fire training course.*

The fire fighter who got burnt on the shoulder was wearing a PVC coated jacket which stores all the moisture in the textile layers. It may be supposed that he got scalded through his own sweat. Condensed sweat can evaporate because of external heat and come back towards the body, which could cause burns. This kind of burn is less common with breathable jackets.

The moisture distribution in the different layers of fire fighters combinations and its influence on the protection of the body, especially steam burns will be analyzed in future studies.

**Links:** www.empa.ch/abt271
> Heat and flame protection

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***References:***
*R. Rossi, Ergonomics, 46 (10), 1017–1033 (2003)*

**Materials and Systems for Protection and Wellbeing of the Human Body**

# The choice of serum and its pretreatment determine human bone (marrow) derived progenitor cell performance

**Cells cultured in untreated human serum (HS) containing media behave differently from that kept in medium containing other sera (with or without heat inactivation). Latter finding may have a large impact on the predictive value of current in vitro research generally performed using heat inactivated foetal calf serum (FCS).**

Arie Bruinink,
Ursina Tobler,
in collaboration with
Magnus Hälg, UAS Wädenswil, Jörg Grünert, Hospital of St. Gallen (CH)

The present study was performed to investigate the effects of serum heat-inactivation and serum source on human trabecular bone (HBC) and bone marrow derived mesenchymal progenitor cells (HBMC) under cell proliferation and under osteoblast differentiation inducing conditions.

Today, knowledge concerning the control and modulation of mesenchymal stem cell differentiation is merely based on FCS, often heat inactivated, containing cultures. Although cells behave well in these media, it must be kept in mind that latter addition is rather artificial. The role of serum source and serum treatment on the behavior of cells including cell-environment reactions has long been neglected. In addition, the use of animal sera introduces potential risks of immunological rejection and transmission of viral or prion-related diseases in case of cultured cells are intended for human re-implantation.

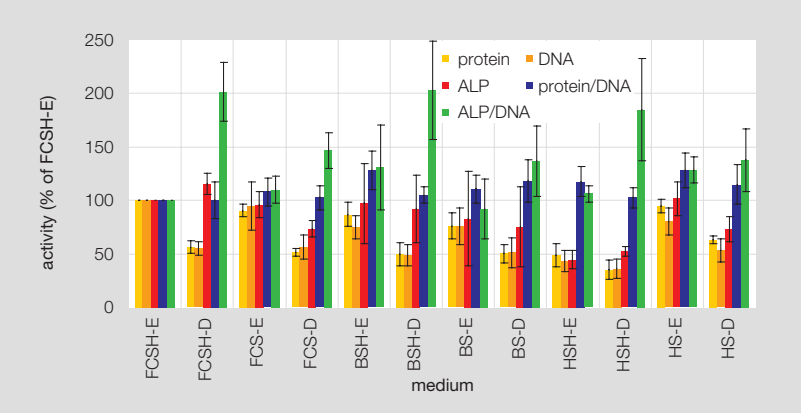


***Fig. 1:*** *HBMC cell performance in the presence of expansion and osteogenic media containing FCS, BS or HS being heat inactivated or not in comparison to cells cultured in expansion medium in the presence of heat inactivated FCS (FCSH-E) for 3+7 days. –E and –D in combination with a serum: expansion medium (– E) and osteogenic medium (–D). ALP, alkaline phosphatase; BSH: heat inactivated BS. Data are presented as mean ± S.E.M. of 5 independent experiments.*

Among others we could show that in the presence of fibroblast growth factor type 2 and dexamethasone (expansion medium) serum heat inactivation resulted in increase in HBMC cell proliferation and/or cell mass levels in case of FCS and bovine serum (BS), but significantly reduced these values in case of HS. In case of HBC, these values were generally lower in HS in comparison to FCS, independent of the serum treatment. If, instead of in expansion medium, cells were cultured in medium containing osteogenic supplements (β–glycerophosphate, ascorbic acid -phosphate, dexamethasone and 1,25 $(OH)_2$-vitamin $D_3$), cell proliferation was found to be reduced independent of the serum source and serum treatment. Simultaneously, a promotion of osteoblast differentiation was achieved, but only in the presence of a heat inactivated serum.

The clinical success of implants is predominantly determined by their interactions with the surrounding tissue cells. The reaction of cells on implant surfaces is largely dictated by the protein layer covering the implant surface. Latter protein layer is largely determined by the composition of the surrounding fluid. Latter layer also plays an important role in in vitro studies. As result of serum heat-inactivation, the cell – substratum surface interaction is changed. Our study indicates that HBMC and HBC performance and by that the functional state of the cells are changed by using FCS, heat inactivated FCS (FCSH) or heat inactivated HS (HSH) instead of untreated HS. The simplification of the human in vivo situation towards the in vitro test system has consequences on the predictive value of the results. However, in vitro models not making use of untreated human serum and/or human primary cells of a cell type that normally, i.e., under in *vivo* situations, will interact with the investigated implants surfaces, will produce results with a rather undefined and even more limited predictive value.

**Support:** Regional Blood Donor Centre St. Gallen

**Links:** www.empa.ch/abt273

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***References:***
*A. Bruinink, et al., J. Mat. Sci. Mat. Med., accepted (2003)*

# List of abbreviations

| | |
|---|---|
| armasuisse | Swiss Defence Procurement Agency |
| ASTRA | Swiss Federal Roads Authority |
| BAG | Swiss Federal Office of Public Health |
| BAKOM | Swiss Federal Office for Communication |
| BBL | Swiss Federal Office for Constructions and Logistics |
| BBT-KTI | Swiss Federal Office for Business Formation and Technology – Commission for Technology and Innovation |
| BBW | Swiss Federal Office for Education and Science |
| BFE | Swiss Federal Office for Energy |
| BLW | Swiss Federal Office for Agriculture |
| Brite EuRam III | Basic Research in Industrial Technologies in Europe and European Research in Advanced Materials |
| BUWAL | Swiss Agency for the Environment, Forest and Landscape |
| EAWAG | Swiss Federal Institute for Environmental Science and Technology |
| EC | European Commission |
| EFD | Swiss Federal Forest Agency |
| EPFL | Swiss Federal Institute of Technology Lausanne |
| ETHZ | Swiss Federal Institute of Technology Zürich |
| EU Program V | European Community, 4th Framework Program |
| EU Program VI | European Community, 5th Framework Program |
| FAM | Swiss Federal Dairy Research Station |
| Holz-21 | Swiss Federal Stimulation Program for the Wood |
| IT'IS | Foundation for Research on Information Technologies in Society |
| IZT | Institute for Future Studies and Technology Assessment |
| MaNEP | Materials with Novel Electronic Properties |
| NCCR | National Center of Competence in Research |
| MIBD | Swiss Dairy Inspection and Advisory Services |
| PSI | Paul Scherrer Institute |
| SLS | Swiss Synchrotron Light Source |
| SNF | Swiss National Science Foundation – National Research Progam |
| TA Swiss | Swiss Center for Technology Assessment |
| TOP Nano 21 | Research Program of the Board of ETH |
| UAS | University of Applied Sciences |
| UVEK | Swiss Federal Department of the Environment, Transport, Energy, and Communication |
| VST | Swiss Federation of Door Manufacturers |

# EMPA Activities 2003
# Information, Reliability and Simulation Technology

## Mission

The development of advanced materials and systems requires novel measuring, simulation, modeling and information technologies. Data and image processing are of importance in acquisition, transfer and presentation of data. Non-destructive and imaging techniques ensure adequate reliability and safety of systems and structures from the macro- to the nanoscale dimension. Noise emission of components and systems has an important environmental impact. This impact can be reduced by the application of innovative materials and adaptive systems supported by modeling and simulation. Information technologies can contribute to minimize material flows, providing thus sustainable use of resources. We strive to be at the forefront in these technologies and methods.

## Activities

**Electronics and metrology:** We carry out experimental research, physical modeling and simulations in the field of reliability, safety and security of materials, devices and systems. Sensors and measurement devices are developed, and experimental facilities for micro- and nanotechnology are operated, e.g. a focused-ion-beam (FIB) instrument, optical full field methods and X-ray microtomography both at Empa and at the Synchrotron Light Source, SLS, at Paul Scherrer Institute. An illustrative example is the visualization technique of biological cells with SLS using hard synchrotron light which allows three-dimensional information about individual cells in the µm-range.

In **acoustics,** we are involved in research concerning vibroacoustic system dynamics and modeling, especially in novel adaptive materials systems applied for active noise and vibration control. A successful example is the “active window” which allows the reduction of environmental noise impact especially in the low frequency range. Innovative concepts for sensors, actuators and control systems are implemented. In the field of building acoustics, the technical fundamentals of noise abatement in structures support high living quality and wellbeing, especially in connection with lightweight constructions.

In **environmental acoustics,** we apply unique calculation methods for outdoor sound propagation where the characterization of the source (road, railway, aircraft, military sources) is based mainly on own measurements, which are needed for research on the numerical simulation of sound propagation and on modeling sound propagation affected by variable conditions. The unique advanced aircraft noise simulation program, our own development, is used for sophisticated noise calculations for customers in Switzerland and abroad. It enjoyed an excellent reputation in the discussions about noise impact on the population who live in the vicinity of airports.

**Mathematics, imaging and materials:** The main focus is the development of innovative mathematical and algorithmic methods. Important results have been achieved in the projects “Color predic-

tion for electrographic prints on common office paper" and "A random walk approach for light scattering in material".

In the field of **sustainable information technology** we perform analyses and development projects of ICT applications with the aim to evaluate negative impacts and stimulate positive ones, e.g. reducing the consumption of materials or energy. Methods such as technology and life cycle assessment, spatial information processing, and advanced modeling and simulation are being used. Our study "Technology assessment of pervasive computing", which we carried out with national and international partners, has led to important results.

The Swiss Center for **Life Cycle Inventories** – established in the framework of the "Ecoinvent 2000 Project" – with contributions of most of the institutions of the ETH domain and the federal agricultural research institute FAL, is located at Empa. The database in its extent and its quality is unique and has reached international recognition.

In the field of our **technology cooperations,** an expansion strategy and a new orientatation of the "Technology Center for the Euregio Bodensee, TEBO" has been worked out and will be implemented in 2004. The project "Knowledge partnership with developing countries in E-waste recycling", which has been implemented in India, China, and South Africa and mandated by the Swiss Secretary of Economy (seco) has got excellent media response in connection with the recent "World Summit on the Information Society" of the United Nations in Geneva.

*Xaver Edelmann, Department Head*

# NANOXID: Reliability limits of ultra-thin semiconductor oxides

Joachim Reiner,
Urs Sennhauser,
in collaboration with
Philips Semiconductors Zürich (CH),
Philips Research Leuven (NL)

**As industry keeps scaling down dimensions in IC technology, the thickness of the dielectric layers used in field effect transistors will soon reach its physical limits. Basic, yet unexplained new failure mechanisms in extremely thin $SiO_2$ layers (2–5 nm) as soft breakdown are investigated.**

CMOS technology is expected to reach the limits of $SiO_2$ layer thickness with respect to reliability and leakage current in the near future. Research activities are ongoing worldwide to find suitable dielectric materials with a higher dielectric constant to replace it. A new breakdown mechanism, called soft breakdown, occurring in these thin $SiO_2$ layers has not yet been completely understood. This effect, which might also affect new dielectric materials, is investigated in the project NANOXID.

The degradation kinetics under voltage stress is observed by periodical electrical characterization during the stress. For p- and n-FETs (field effect transistors), the electric field direction in the gate oxide is opposite. Nevertheless, they show similar leakage fluctuation signatures before the final breakdown (Fig. 1), indicating similar degradation processes.

A correlation between the physical appearance of the soft breakdown site and its electrical characteristics is still missing in the literature. Therefore, a new preparation approach for TEM lamella has been developed using EMPA's dual-beam FIB (*fo*cused *i*on *b*eam) instrument "FEI 235". A patent application has been filed. Figure 2 shows a TEM (*t*ransmission *e*lectron *m*icroscope) image of a transistor gate region with a hard breakdown, which is the classical kind of breakdown of thicker gate oxides and is easily observed.

Current reliability prediction models are semi-empirical. The most popular one, the "trap percolation model", predicts the failure statistics well without specifying the physical nature of the involved defects. Therefore, it is another aim of this project to clarify the relevant processes involved in oxide degradation and breakdown on the atomic scale. This is currently addressed in a Ph.D. work. Several software packages for quantum mechanical (ab initio) calculations exist. To include the electrical field and to calculate trap-induced leakage current, extensions of models and software will be necessary.

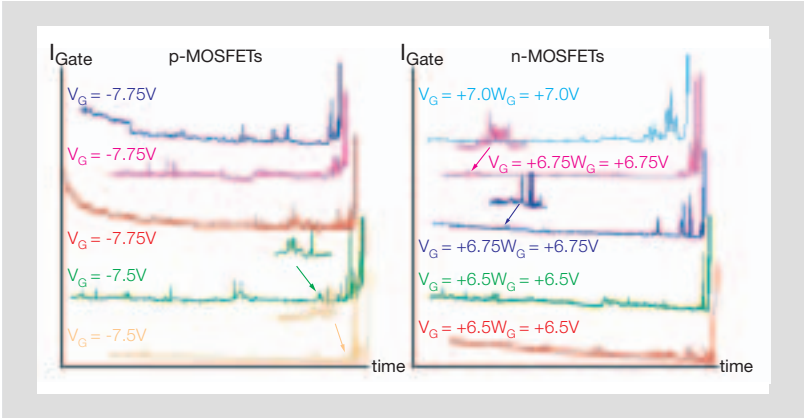


***Fig. 1:*** *Gate leakage current of p- and n-FETs during stress. $t_{OX}$ = 5 nm, $A_{OX}$ = 2.5 µm².*

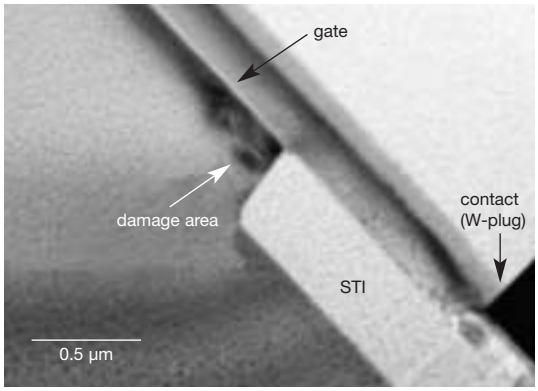


***Fig. 2:*** *TEM image: cross section of a silicon transistor gate region with hard breakdown.*

**Support:** TOP Nano 21, Philips Semiconductors

**Links:** www.empa.ch/abt173
> Reliability

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***References:***
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*J.C. Reiner, IRW2003–Final report, in press (2003)*
*Patent, Europe EP 1 355 143 A2 USA 10/414.422, applied for (2003)*

# HIRONDELLE – High-resolution optical non-destructive evaluation for electro-optical leading-edge microsystems

Erwin Hack,
Peter Dias-Lalcaca,
in collaboration with
Dantec Ettemeyer GmbH,
Chemnitzer Werkstoff-
mechanik GmbH (D),
Alcatel Space Ind.,
ENSEIRB-IXL (F),
Centro Ricerche Fiat (I)

**The EU-FP5 GROWTH project HIRONDELLE (high-resolution optical non-destructive evaluation of leading-edge microsystems) addresses the problem of thermo-mechanical deformation of microsystems or general material interfaces. One objective of the project, and EMPA's main task, is to develop a high-resolution laser-based optical measurement system for in-situ and in-operation analysis of the shape, three-dimensional deformation, strain-stress and flaws in microsystems. The measurement system is based on electronic speckle pattern interferometry (ESPI) and image correlation, and is intended to measure the deformation fields developed in Ball Grid Arrays (BGAs) and other high density electronic packages under thermal load. The die and substrate generally have widely differing coefficients of thermal expansion, which results both in residual stress in the assembly on cooling after the soldering process and stress during operation cycles.**

Flip chips and BGAs have their electrical contacts buried beneath the chip. Therefore, side-view imaging is necessary to observe the individual solder joints. A novel imaging scheme is employed based on so-called coherent or imaging fiber bundles. Fiber bundle imaging is a powerful extension of ESPI techniques to measure deformations at otherwise inaccessible locations. Progress in fiber bundle manufacture enables very good imaging quality for ESPI measurements. The versatility to arrange individual bundles into geometries adapted to the measurement problem at hand lends itself to microelectronic component testing. It allows the user to have multiple and distributed areas of interest, imaged into a single frame of the camera, but not limited to the 3:4 aspect ratio of a CCD-chip. This will speed up inspection and allow for easy comparison of quality indicators.

We have performed tests on seven different types of bundles, both flexible and rigid, to evaluate the characteristics for optimum image quality in optical setups relevant to our micro-imaging ESPI-application: modulation transfer function (MTF), limiting resolution, cross-talk between adjacent fibers, and optical transmission quality. Figure 1 shows the end face of a rigid fiber bundle with 10 µm individual fiber diameter. Single defects and rotated orientation of sub-bundles are clearly visible. It turned out that the fiber bundle with the smallest pitch of 5 µm performed best, in MTF, transmission, quality and – fortuitously – price.

For the measurement of the modulation transfer function, a spatially modulated target (Moiré grating slides of 10, 20, 40 and 80 lp/mm chrome on glass) was back-lit by a white diffuse reflecting surface illuminated by a white-light source. The target was imaged onto the input face of the coherent image bundle under test by a gradient index (GRIN) lens (Dias-Lalcaca 2003a). An image of the output end of the bundle was recorded using the video camera. The bundle was then removed and the image of the target formed by the GRIN lens alone was recorded. The modulation depths seen in the two images were then compared to give a value for the Modulation Transfer Function or MTF. A typical image, with corresponding line profile, is shown in Figure 2.

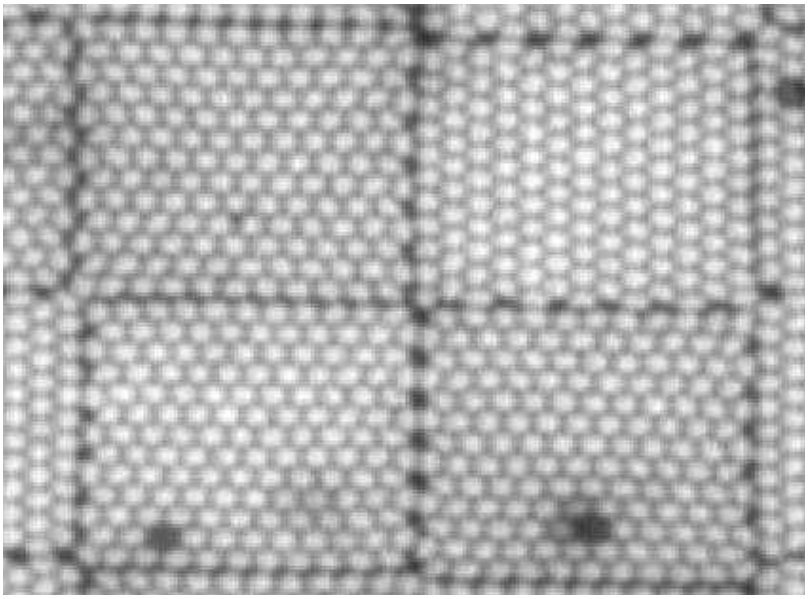

***Fig. 1:*** *Detail of the end-face of an imaging fiber bundle. The individual fibers are 10 µm in diameter.*

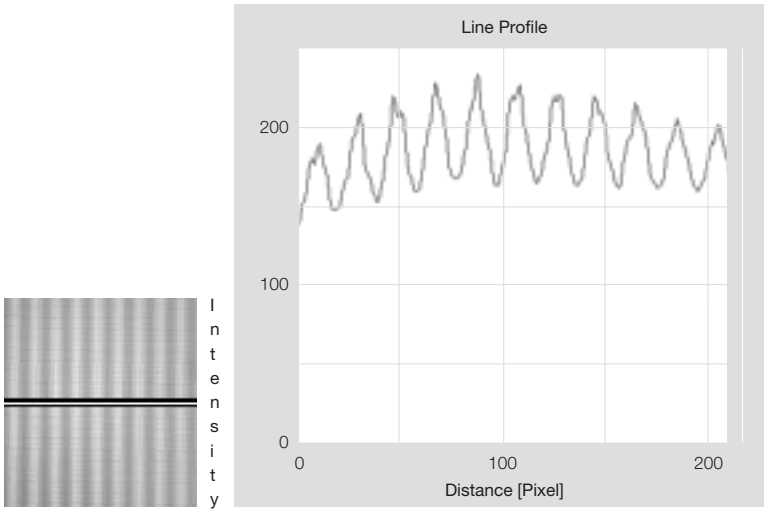


***Fig. 2:*** *MTF measurement of a fiber bundle.*

To prove the principle of operation, first tests with rigid body displacements of a flat object have been performed. The HIRONDELLE instrument uses a NIR laser diode source to illuminate the device under test edge-on from three directions. A linear array of fiber bundles is used to transfer the images of the individual solder balls to the object plane of the camera. Figure 3 shows a package of five fiber bundles lined up in such a way as to look through 90° on the image side and to transfer the image to the camera into a stacked configuration. The 90° bend is induced by a row of mirror micro prisms. Imaging is performed by a row of lenslets. Figure 4 shows an out of plane fringe pattern induced by object tilt (Hack 2003). Note that the parallel fringe pattern is skew in the upper left image bundle due to a tilt of the bundle itself.

In a next step, a total of 15 fiber bundles will be arranged into a linear 15 x 1 array on the test object side and a 3 x 5 array on the camera side. Then, a complete row of solder balls on a 25 mm chip can be imaged in a single frame with high resolution (Dias-Lalcaca 2003b).

***Fig. 3:*** *Package of five imaging fiber bundles, each 1.7 mm square, as used for proof of operation.*

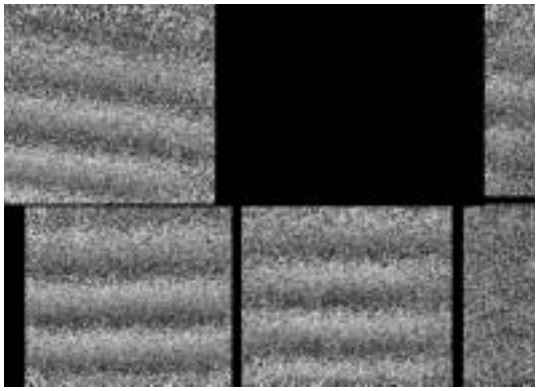

***Fig. 4:*** *ESPI displacement measurement through stacked fiber bundles.*

**Support:** EU Program V, BBW

**Links:** www.empa.ch/abt173
> Metrology > HIRONDELLE

***Contact:*** *erwin.hack@empa.ch*

***References:***
*P. Dias-Lalcaca, E. Hack, U. Sennhauser, Proceed. TEST 2003, A6.2, 123–128, (2003a)*
*E. Hack, P. Dias-Lalcaca, U. Sennhauser, SPIE Vol. 4933, 256–260 (2003)*
*P. Dias-Lalcaca, E. Hack, U. Sennhauser, Opt. Las. Eng. submitted (2003b)*

# 3D visualization of biological cells using hard synchrotron light

**We developed a technique for cell imaging using synchrotron radiation micro-computed tomography (SRμCT), with μm spatial resolution. Human foreskin fibroblasts (HFF) are seeded on a polymer yarn, and stained with highly absorptive agents. Retrieved images from SRμCT are similar to the ones from scanning electron microscopy and light microscopy and uncover the sample microstructure in 3D space.**

Philipp Thurner,
Urs Sennhauser,
in collaboration with
ETH Zurich,
University Zurich,
SLS/PSI (CH),
HASYLAB/DESY (D)

Tissue engineering usually relies on 2D cell culture experiments. In many cases this is not feasible, since human tissue has almost exclusively 3D shape and structure. For the visualization of the individual cells within a 3D arrangement, light or electron microscopy techniques are unsuitable, since the information in the third dimension is only accessible to a maximum depth of about 0.5 mm. X-rays are an alternative probe and can penetrate also through opaque objects. We showed that SRμCT is a suitable tool for cell imaging, giving 3D information about cell distribution.

The high intensity of synchrotron light allows the selection of the photon energy. For composites, the contrast-yielding differences in absorption depend on the selected photon energy. In the case of cell cultures this is crucial because the cells and the surrounding isotonic medium consist mainly of water and exhibit almost no difference in absorption.

Thus, cells in a hydrated environment have to be stained by highly absorptive contrast agents. Suitable agents for SRμCT are osmium in the form of the post-fixative $OsO_4$ and gold nanoparticles. They are connected to lectins or antibodies that label features of interest on the cell membrane after cell fixation, as depicted in Figure 1.

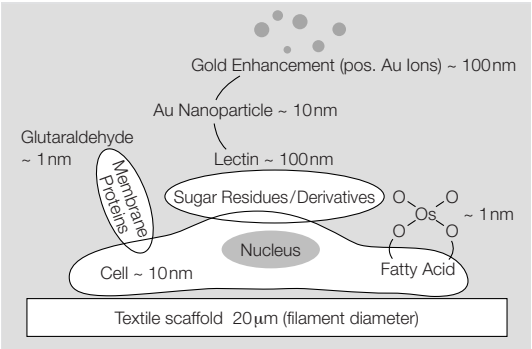


***Fig. 1:*** *Schematic of cell fixation and staining processes. Here the lectin from Triticum Vulgaris is used, which binds to sugar residues on the cell membrane.*

In order to achieve sufficient contrast in reconstructed tomograms, the so-called critical concentration of a contrast agent must be reached. The critical concentration can be calculated and, for example, for gold the lowest critical concentration of about 3.8 mmol/l is reached at a photon energy of 14.5 keV at the HASYLAB BW 2 beamline in Hamburg.

This photon energy was used for imaging of a model system in which HFF cells are seeded on a polyethylene multifilament yarn. 3 days after seeding, the yarn is fixated and stained.

In Figure 2, the result of an experiment performed at HASYLAB is shown. The initial transparency-based visualization is compared to the visualization of segmented cells after image processing.

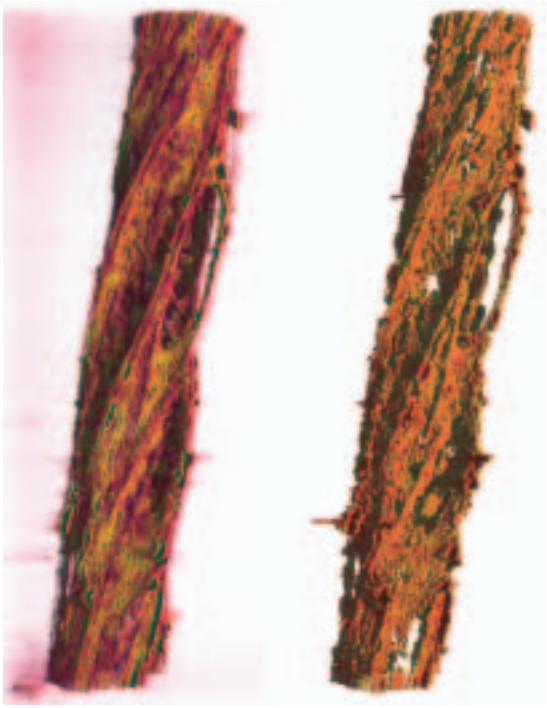

***Fig. 2:*** *3D visualization of the sample, acquired with SRμCT, before (left) and after (right) segmentation of stained cells. The cell-seeded yarn is approx. 300 μm in diameter.*

**Support:** SNF, Board of the ETH

**Links:** www.empa.ch/, search for “SLS”.

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***References:***
*Ph. Thurner et al., Nuclear Instruments and Methods B 200, 397–405 (2003)*
*Ph. Thurner et al., Microscopy and Microanalysis, submitted (2003)*

# Line availability of aerial optical cables

Philipp M. Nellen, Marcel Held

**We estimated polarization mode dispersion induced line availability of major optical transmission lines crossing the Alps in Switzerland in terms of outage probability $P_{out}$, mean outage rate $\lambda_{out}$, and mean outage duration $t_{out}$, which allows now to decide on the appropriate bit rate.**

The ongoing exploitation of optical bandwidth raises the question to what extent optical fibers in already installed cables are capable to transfer data at rates of 10 to 40 GBit/s or beyond in one or several channels by using dense wavelength division multiplexing. For cables installed in the early and mid 90's mainly loss and chromatic dispersion were considered. More recently, several physical effects in optical fibers have been identified to seriously limit high transmission rates. In addition to e.g. high power and nonlinear effects, also polarization mode dispersion (PMD) restricts data rate especially in older deployed fiber cables. PMD is characterized by the mean value $\langle\tau\rangle$ with respect to time and wavelength of the differential group delays $\tau$ (DGD), which are caused by polarization effects. It leads to a broadening of optical pulses and consequently to an increase in bit error rate especially at bit rates higher than 10 Gbit/s. In consequence, this reduces line availability due to physical constraints depending on required bandwidth and environmental influences.

We monitored aerial optical cables crossing the Alps in Switzerland with respect to PMD. Due to the extreme environmental conditions all weather data from the surrounding weather stations were logged and taken into consideration. In addition, laboratory experiments allowed studying PMD under stable conditions.

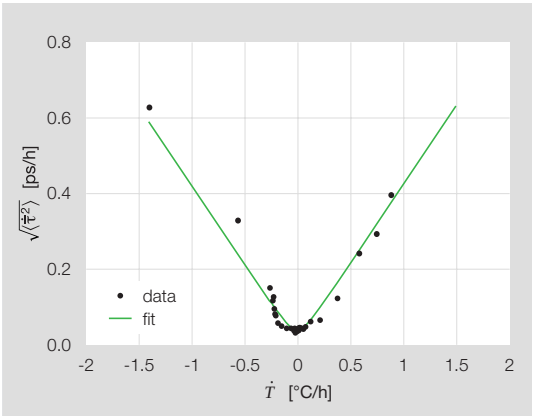


***Fig. 1:*** *Laboratory data.*

We found, as expected, no deterministic relation between temperature T and wavelength averaged DGD $\bar{\tau}$. However, the expectation value $\langle\dot{\bar{\tau}}^2\rangle$ of the square of the change of $\bar{\tau}$ depends on the temperature change $\dot{T}$. Data in Figure 1 is fitted by $\langle\dot{\bar{\tau}}^2\rangle = \alpha^2 + \beta^2 \dot{T}^2$ with the two constants being $\alpha$ = 0.04 ps/h and $\beta$ = 0.42 ps/h/K.

Single point measurements of $\tau$ produce random results and are useless to characterize line availability. Long term monitoring is required to properly determine the underlying Maxwellian distribution of $\tau$ and the distribution of the rate of change $\dot{\tau}$. From these two distributions, line availability can be calculated in terms of outage probability $P_{out}$, mean outage rate $\lambda_{out}$, and mean outage duration $t_{out}$, which allow deciding on the appropriate bit rate. Figure 2 shows $t_{out}$ versus $\langle\tau\rangle$ calculated for three bit rates, 2.5, 10, and 40 GHz, from field data of two periods A and B, in summer and winter, respectively. Here, bit rates above 10 GHz would have doubtlessly unacceptable mean outage durations and rates (not shown).

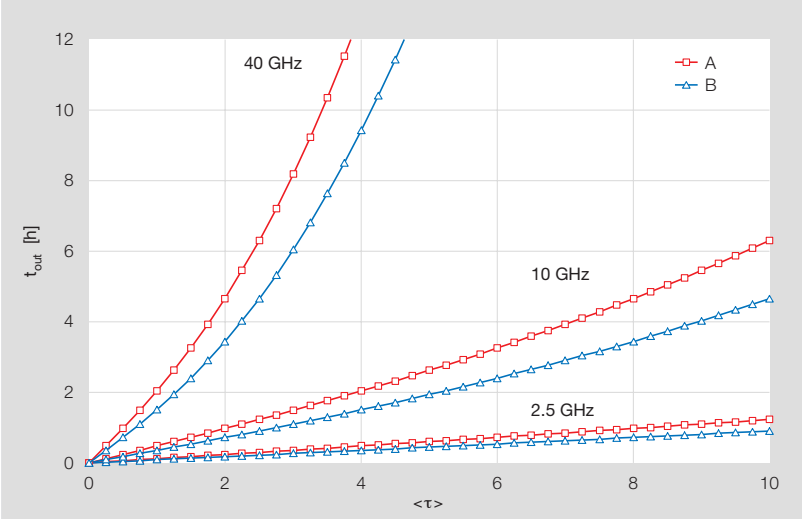


***Fig. 2:*** *Field data.*

**Support:** PSEL, COST 270

**Links:** www.empa.ch/abt173
> Metrology

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***References:***
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# Industrial X-ray computer tomography of lake sediments

**Industrial Computer Tomography (CT) was used for the study of structures and the determination of physical properties in weakly consolidated late Pleistocene and Holocene lake sediment drill core samples. CT images revealed various types of sedimentary structures which can be used for palaeoenvironmental and palaeoseismological analysis of lake deposits. They also helped to discriminate between drill core artifacts and natural structures, which is of special interest in palaeoseismological investigations using drill core samples. Calibrated gray-scale values supplied continuous information about density variations in extremely thin core sections, which is a type of information that cannot be obtained by conventional geotechnical methods.**

Alexander Flisch, in collaboration with Arnfried Becker, ETH Zurich (CH)

Sediment drill cores from Lake Seewen in northern Switzerland and Lake Bergsee in southern Germany were analyzed. The drill core samples, with a diameter between 5 and 10 cm, were taken as part of a palaeoseismological research project searching for deformation features (seismites) related to strong pre-historical earthquakes, occurring in Holocene and late Pleistocene lake deposits. Earthquakes may create characteristic soft-sediment deformation structures, sand dykes and fractures or changes in physical properties of the sediment such as bulk density. The core samples were first split parallel to the long core axis for visual logging and then scanned by X-ray radiography, followed by X-ray CT analysis.

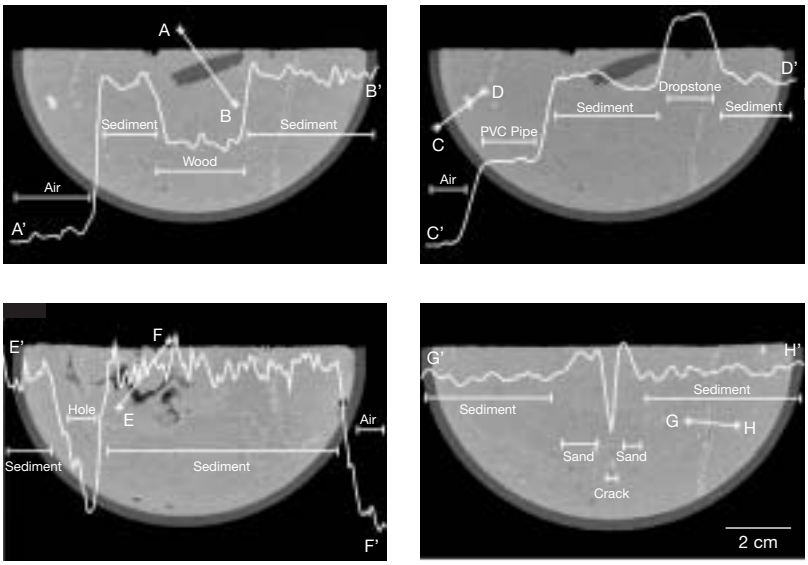



***Fig. 1:*** *Examples of the use of gray-scale values for qualitative investigations of natural features and artifacts in CT images. Transects are indicated by lines A-B, C-D, E-F, G-H, and the corresponding gray-scale value graphs by lines A'-B', C'-D', E'-F', G'-H'.*

Grey-scale value graphs along selected lines in CT images were used to clarify the nature of recognized features (Fig. 1). This is possible because gray-scale values are closely related to density, especially for sediments with a nearly uniform composition. The qualitative gray-scale curves help to clarify the nature of objects and their origin. The short lines A-B, C-D, E-F and G-H in Figure 1 mark the positions along which the gray-scale values were determined and the curves A'-B', C'-D', E'-F' and G'-H' indicate the corresponding gray-scale values.

Detailed investigation of the Lake Seewen sediment revealed several examples of mainly angular rock fragments (dropstones) with a size of up to 3 cm, embedded in the fine-grained lake deposits. Figure 2 shows three CT images with rock fragments, seen as light patches. In addition to the dropstones, large plant remains can be seen as dark patches in slice (b) and especially in slice (c). The presence of large rock fragments in fine-grained lake deposits is not possible under normal lacustrine hydraulic conditions. However, transport of fragments of all sizes is possible by floating ice or wood. The occurrence of large rock fragments can, therefore, be related to: (i) the melting of icebergs derived from glaciers in an ice-dammed lake; (ii) the melting of the ice of a seasonally frozen periglacial lake covered with rock debris by spring floods or slope failures; or (iii) the decay of tree trunks and root bales that float on the lake surface.

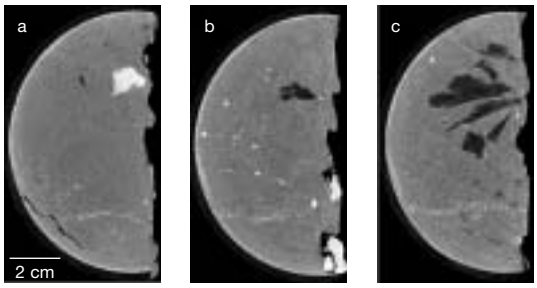



***Fig. 2:*** *Three CT images, up to 5 cm apart, showing angular to sub-angular dropstones (white) (**a, b**), large plant remains (dark gray) (**b, c**) and a sand dyke in the lower half of the pictures (**a, b, c**).*

The core sample of Lake Seewen revealed a 52 cm long sand dyke. To obtain additional information about the structure of the sand dyke, 250 CT slices were recorded perpendicular to the long core axis. A section of 5 cm was scanned with a spacing of

0.5 mm for 3D visualization (Fig. 3). The reconstruction shows dropstones and twigs, as well as the sand dyke, traversing the whole width of the core sample. The CT slices and the 3D visualization show that the sand dyke is a planar structure and not a cylindrical de-watering or de-gassing tube, or a root canal. The core casing cuts the dyke abruptly and there is no relationship with the slight disturbance of the sediments near the edge of the core. Therefore, it can be concluded that the dyke is a natural feature rather than an artifact. The orientation of the dyke shows only minor variations. Such a consistent orientation is another argument in favour of a geological origin.

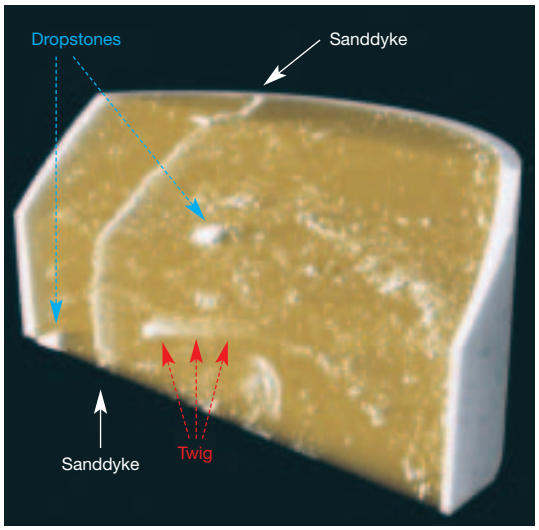
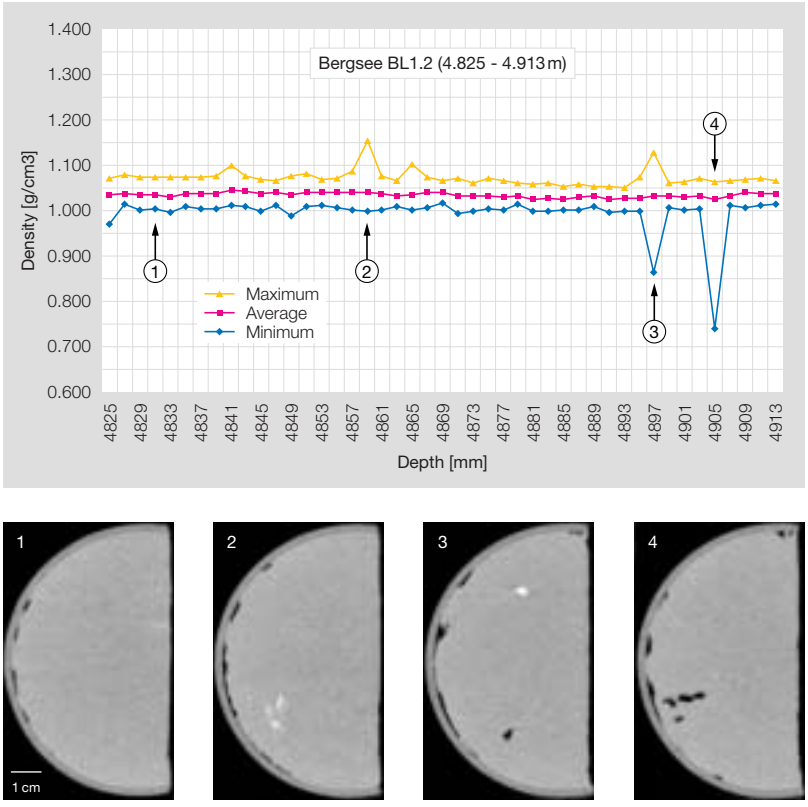



***Fig. 3:*** *3D visualization of a 5 cm high section of the core sample. The image has been created using the volume rendering technique.*

CT data were used to determine the density of almost purely organic sediments (gyttja) to establish a density profile for the deposits of Lake Bergsee (Fig. 4). 3905 slices were scanned, with a distance between 2 and 5 mm. For every slice, the average of the gray-scale values of 16 counting squares was computed for the undisturbed central part of the slice. For every core section the density of the sediments were determined conventionally using a 5 cm thick sample. These density values were used to calibrate the gray-scale values derived from the CT images. The diagram in Figure 4 shows an example of the density distribution for a 9 cm long profile along a typical core section. Slice 1 is a typical example of an almost homogeneous core section. Slices 2 to 4 include some single mineral grains and holes, recognized as light and dark patches, which influence the reported maximum or minimum densities. Because only few of these features occur, they do not strongly affect the average density values. No significant variations or trends in average density of the gyttja are recognized. These measurements were carried out because gyttja, with its weak jelly-like consistency and very high water content, may have a structure that is susceptible to collapse following earthquake shocks. However, a general increase of the density which might have indicated such changes could not be found in the Lake Bergsee deposits.




CT analysis, which is entirely non-destructive, is especially suited for the study of sedimentary and deformation structures. It preserves drill core samples for additional investigations and is faster than methods based on thin section preparation.

**Support:** SNF

**Links:** www.empa.ch/tomography
www.seismo.ethz.ch/hazard/risk/PaleoSeis/lakes2.htm

***Contact:*** *alexander.flisch@empa.ch*
***References:***
*A. Flisch, A. Becker; Geological Society, London, Special Publications (2003)*
*A. Becker, F. Bucher, C.A. Davenport, A. Flisch; Engineering Geology, submitted (2003)*

***Fig. 4:*** *Density profile of a 9 cm long core section using calibrated gray-scale values determined by CT analysis (top), and four representative CT images (bottom), showing the effects of single mineral grains (white) and holes (black) on the density curves of a largely homogeneous organic lake deposit (gray).*

# Novel sensing and actuating systems for active control of sound radiated by vibrating surfaces

**The active control of noise radiated from vibrating structures asks for sensors and actuators at optimal locations which are not always accessible. The project focuses on design, placement and shaping of spatially distributed sensors as used for smart adaptive systems. A novel type of virtual sensors has been investigated, and a new technique was found for placement of modal acoustical sensors to be used with low order, robust, high performance control systems.**

Stanislaw Pietrzko
in collaboration with
ETH Zurich (CH),
TU Delft (NL),
University of Adelaide (AU)

The poor sound insulation properties in the low frequency range of lightweight constructions may be improved by active control. The present work expands knowledge from work on the "active window". Vibrating structures radiate sound below the material dependent coincidence frequency for diverse classes of structural modes with different radiation efficiencies. The control of sound radiation may be optimized using an array of virtual sensors and/or modal sensors. The virtual sensors are a class of mathematical functions predicted or identified for a real structure for sensing the sound radiated from vibrating surfaces into a coupled cavity. This method is aimed at overcoming observability problems associated with traditional error sensors such as microphones and accelerometers. The new virtual sensor approaches are based on estimating the disturbing sound field by Kalman filters or measurement of the acoustic pressure transfer function between a permanently placed remote microphone and a microphone temporarily located at the inaccessible observer location. With the temporary microphone subsequently removed, the signal from the permanent microphone can be modified with the transfer function to create a mathematical virtual microphone at the inaccessible location. In this project, we realized a prototype of virtual sensors by an array of conventional microphones. Together with piezo fiber based patches, a novel array of collocated pairs of virtual sensors and actuators for acoustic duct was constructed.

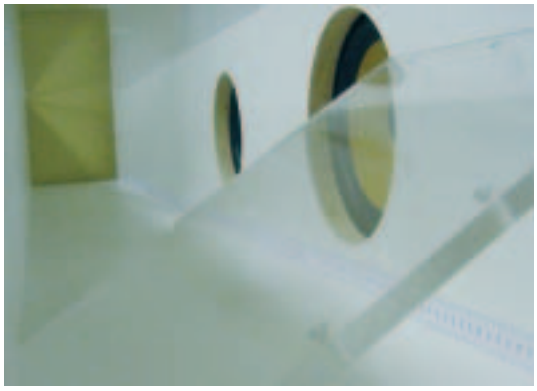


***Fig. 1:*** *Acoustic duct with to loudspeakers for testing virtual sensors.*

Within the project, we also investigated another class of sensors, the "modal radiation filters". A prototype of radiation mode sensor was built, based on the theory that the radiation of acoustic modes can be estimated by weighting the output signals of a grid of discrete velocity sensors. The problem of frequency dependence of the radiation modes was overcome by estimating the amplitude of the frequency independent elementary radiation shapes. A spatial filter was realized in analog hardware as presented in Figure 2. This allowed realizing a simple, robust system for control of sound radiated by vibrating surfaces from a beam.

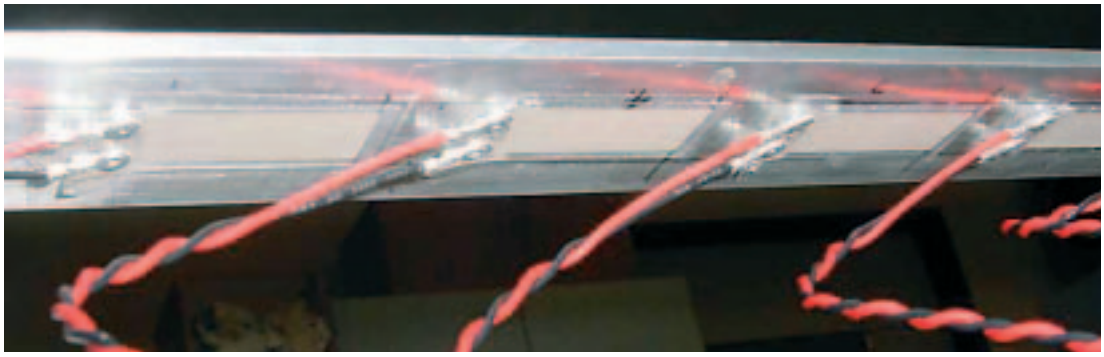


***Fig. 2:*** *Prototype of radiation mode sensor (detail).*

**Links:** www.empa.ch/akustik

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***References:***
*P. Moll, S. Pietrzko, Journal of Smart Materials and Structures, submitted (2003)*
*O. E. Kaiser, S. J. Pietrzko, M. Morari, Journal of Sound and Vibration 263, 775–795 (2003)*

# The influence of the ground in source strength models of explosions

**A method has been developed to model the source strength of explosion in vicinity of complex ground surfaces. The model will be used to plan noise reduction measures at military shooting ranges and is currently being included in the advanced EMPA-calculation model.**

The laboratory of acoustics of EMPA has been dealing with shooting noise from military training areas for many years. A frequent reason for complaints are explosions and detonations of hand grenades. A common method to reduce the noise is to shield the sources either by putting them in cavities or by placing barriers nearby. To be able to predict the effect of those noise reduction measures, a calculation method has been developed. This method combines a theoretical approach to calculate the source strength of explosions, the Weber model with an empirical model, the height of burst gain, which is described in common standards. Based on measurement results from a series of explosions of 200 g TNT set off at 9 different source positions and firing site geometries, the following conclusions can be taken:

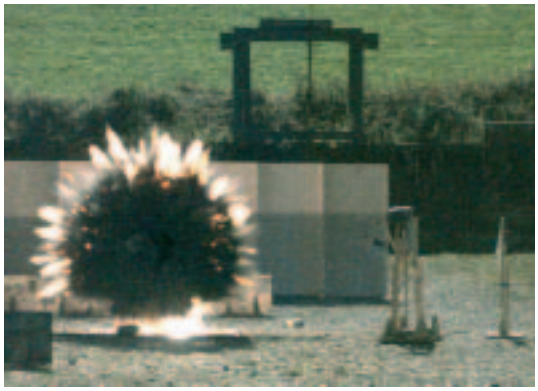

***Fig. 1:*** *Example of an explosion close to the ground with barriers in the back (picture by GR).*

For situations with source positions above surface level the two models can successfully be combined by applying a constant correction term. However, to reproduce experiments from cavities, the definition of the source location has to be adapted. Additionally, the fraction of energy that is transferred into the ground has to be considered and a spectral shift towards lower frequencies has to be taken into account. With these corrections, calculations and measurements agree very well. This good agreement is surprising when considering how little information the model needs to yield reliable predictions. Furthermore, the ability of the so called Weber model is very convincing (Fig. 2), not only to predict the acoustical source strength in terms of overall sound energy levels but also to yield accurate spectral information.

Jean Marc Wunderli

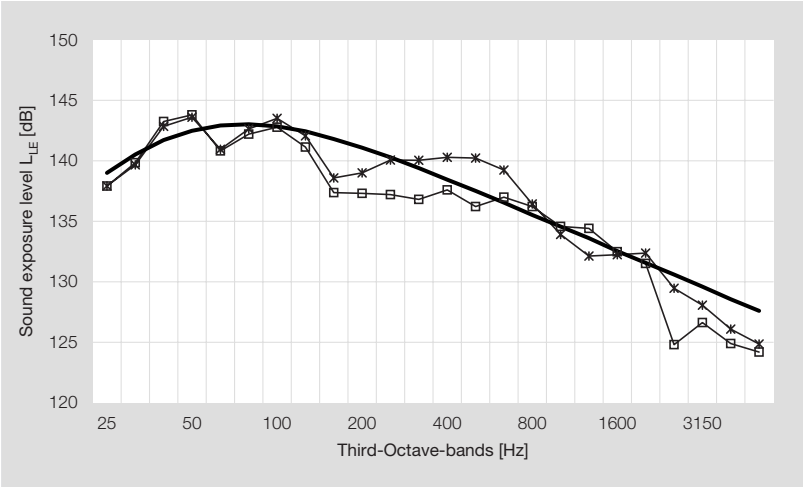


***Fig. 2:*** *Comparison of measured sound exposure spectra calculated back to a reference distance of 1 m with predicted source spectra for explosion directly from grassy ground. (Bold line: calculation; line with stars: source values based on measurements at 4 m height; line with squares: source values based on measurements at 1.5 m height).*

The measurements can also be used to draw conclusions on how to model propagation of explosions. When using classical linear sound propagation models, it is proposed not to employ shielding effects within the region of non-linear conditions and to assume strong turbulence for the calculation of the ground effect.

The results of this study are included in the advanced EMPA-calculation model that is currently developed in the laboratory of acoustics of EMPA by order of the Defence Procurement Agency of Switzerland (GR).

**Support:** armasuisse

**Links:** www.empa.ch/akustik

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***References:***
*J.M. Wunderli, Acta Acustica, accepted (2003)*

# Numerically exact simulation of sound propagation in large geometries

**A computer model was developed that allows for wave based numerical simulations of sound propagation in large geometries in two dimensions. The algorithm works in the time domain and can handle different source types as well as locally inhomogenoeous atmosphere to simulate meteorological effects.**

Kurt Heutschi

Nowadays, the calculation of sound propagation between source and receiver is based mainly on empirical approximate formulas. As a consequence, the uncertainty of the results is rather high. Current computer power introduces the possibility of numerical simulations that are based on exact wave theory. By application of such models sound fields in complicated geometries as for instance in galleries for noise protection of inhabitants can be calculated.

Numerical sound field simulations based on classical finite elements or boundary elements have successfully been used in small geometries for about ten years. Recently, the concept of finite differences in the time domain – originally developed for the calculation of electromagnetic fields – was transferred to sound fields. This approach seems especially well suited for large regions as the computational effort increases linearly with the size of the geometry.

Within the framework of an ASTRA research project, we developed a computer model FDTD (Finite Differences in the Time Domain) to simulate sound propagation in two dimensions in the time domain. By the application of variant coordinate systems it is possible to handle different source types. In contrast to frequency domain models, FDTD allows for the investigation of the temporal evolution of sound fields. It is possible to judge the relevance of single reflections and, therefore, to determine for example the effect of an absorbing treatment. The program serves as a reference model for investigations of meteorological effects on sound propagation over larger distances. Thus, large set of test cases of different sound propagation situations and weather conditions were created. These cases serve for the calibration of simplified calculation algorithms such as ray tracing models that are developed for every day application. Moreover, parameter studies of typical diffraction phenomena have been performed (Heutschi 2003).

On behalf of the Cantonal Authorities for the Environment and Energy Basel-Stadt, the FDTD program was used to investigate different types of sound protecting measures at the Dreirosen-Bridge in Basel (Fig. 1). The computer simulations replaced costly scale model experiments and helped to minimize noise immission in the inhabited area.

Up to now, the model can handle two dimensional geometries. As the extension to three dimensions corresponds to an increase in computational effort in the order of magnitude of 1000, an intermediate “2.5-dimensional” solution has to be sought. Within the classical 2-dimensional simulation, line sources are interpreted as coherent sources. Actually, roads or railway lines with independent vehicles should be regarded as incoherent line sources. Preliminary ideas to model such sources on a statistical basis will be investigated. Furthermore, possibilities to incorporate temporally inhomogeneous atmosphere to simulate the effect of turbulences will be studied.

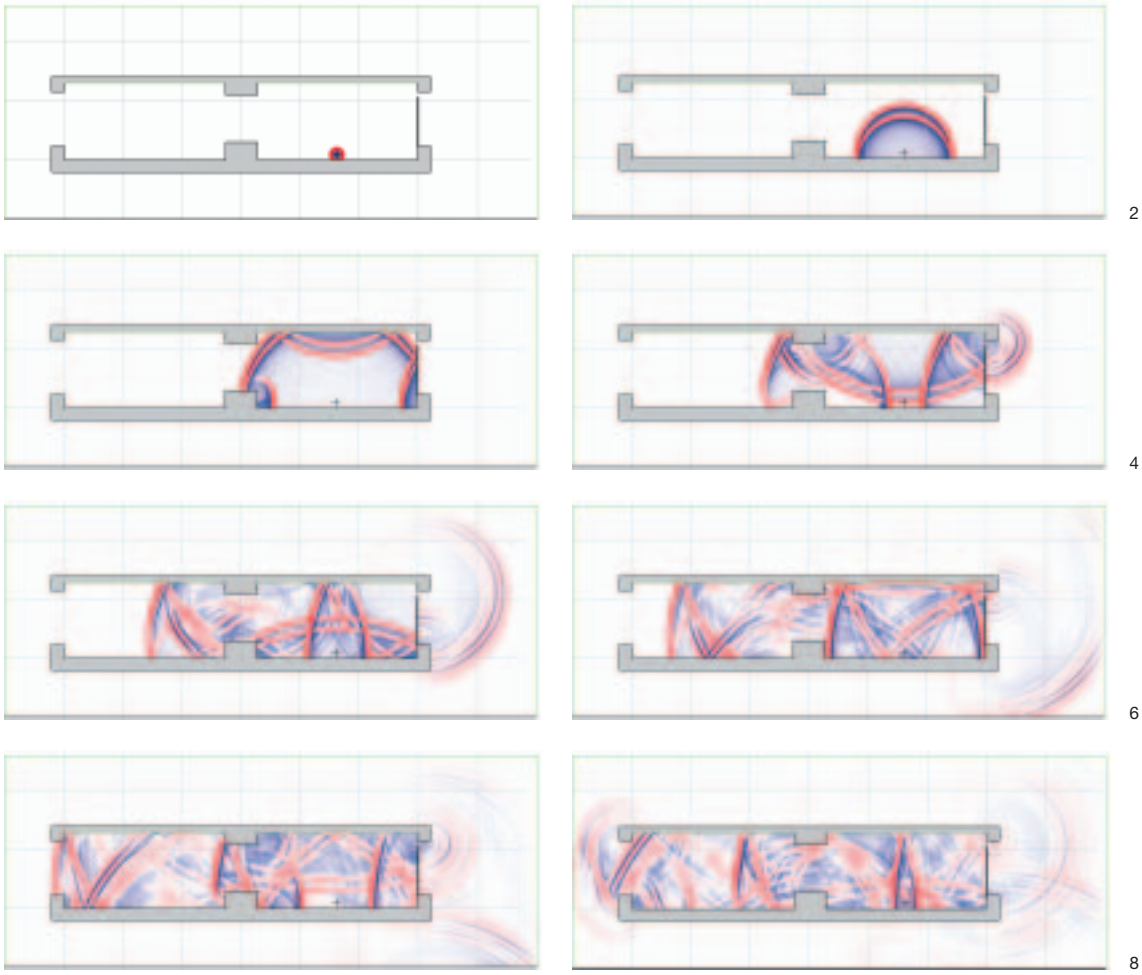


***Fig. 1:*** *Cross sectional view of one variation of sound protecting measures at the Dreirosen-Bridge in Basel. The bridge consists of two floors whereas the highway with the sound emission to be considered here is located on the lower floor. The strength of the sound pressure is color-coded with dark red for high positive and dark blue for high negative pressure values. The immission points in question are located on the right hand side (outside the sketch). The gray lines indicate a grid of 5 m spacing. Each frame shows the temporal evolution of the sound field for an initial sound pulse emitted at the source point (marked by a cross) 0.5 m above the road surface. The time step between the frames is 12 ms.*

**Support:** ASTRA

**Links:** www.empa.ch/akustik

***Contact:*** *kurt.heutschi@empa.ch*
***References:***
*K. Heutschi, Acta Acustica united with Acustica, 89, 909–913 (2003)*

# Technology assessment for pervasive computing

**A technology assessment study on pervasive computing identified the main opportunities and risks of this new type of information and communication technology. The main opportunities can be found in the health sector and in new types of services. Social and environmental risks have to be taken into account where the ubiquitous use of wireless ICT creates conflicts or stress. It also brings about embedded electronic waste and an increasing energy demand for stationary network infrastructure.**

Lorenz Hilty,
in collaboration with
Siegfried Behrendt,
IZT (D);
Niels Kuster, IT'IS,
ETH Zurich;
Mathias Binswanger,
UAS Solothurn (CH)

The term "pervasive computing" refers to visionary new ways of applying information and communication technology (ICT) to our daily lives. It involves the miniaturization and embedding of microelectronics in non-ICT objects and wireless networking, making computers ubiquitous in the world around us. Unlike most of today's ICT products, pervasive computing components will be equipped with sensors enabling them to collect data from their surroundings without the user's active intervention.

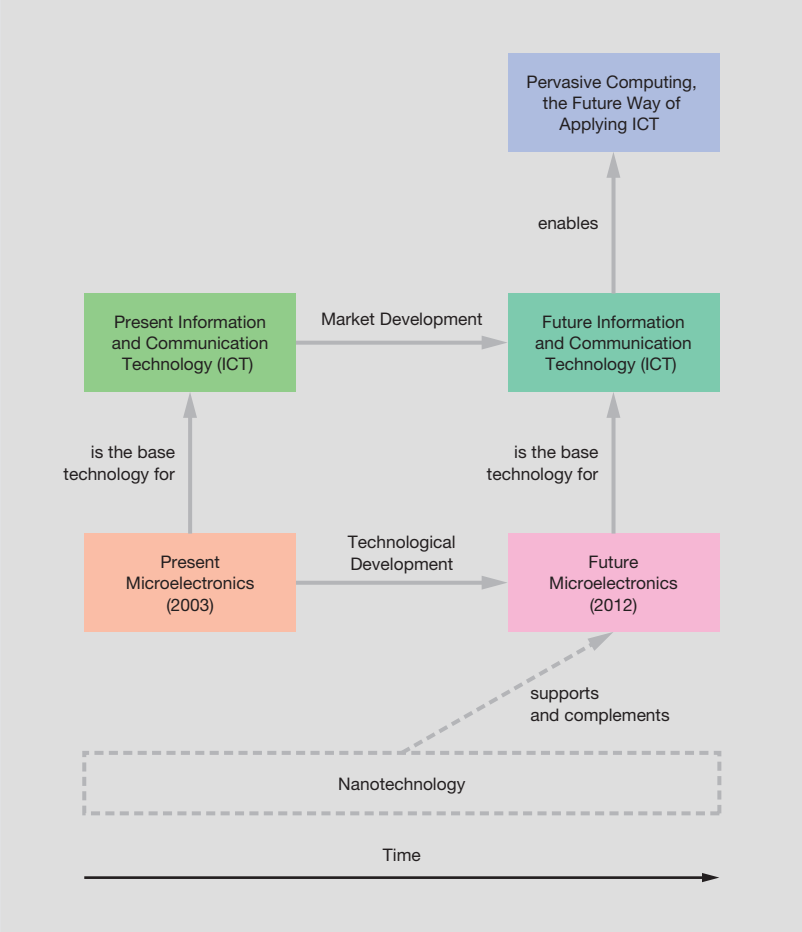


***Fig. 1:*** *Connection of Microelectronics, Nanotechnology, ICT, and Pervasive Computing.*

The purpose of the study was to make a contribution to objectively display the opportunities and risks of pervasive computing, focusing on impacts on human health and the environment. The first step of the assessment was a prospective analysis of technical and market trends: The miniaturization of microelectronics is bound to continue for about another 10 years without breaking the trend and will be supported by nanotechnology. Further development of wireless communications by means of mobile phone networks and wireless local area networks (W-LAN) will play a decisive role. The number of mobile components per person will rise so fast into the hundreds that it will no longer be practical for the energy supply to be provided in the form of batteries that have to be replaced or recharged using AC adaptors. Other energy supply technologies such as solar cells or fuel cells, or the use of body energy will become more common than today.

Pervasive computing will only gain acceptance if progress is made in user interfaces. A major innovation over current ICT applications will be the context sensitivity of this technology: Components will react to their environments and thus will operate without being activated explicitly by the user. On the software level, so-called agent technologies will gain in importance.

The application areas "housing", "traffic", "work" and "health" were chosen for developing three scenarios, each set for a 10-year time horizon, corresponding to three possible development paths of pervasive computing: a "cautious", an "average" and a "high-tech" scenario. They differ mainly in the penetration rate and the degree of connectivity supposed to be reached by pervasive computing. The main results can be summarized as follows:

Pervasive computing offers great opportunities for medical treatment and care. In particular the quality of life for patients who are chronically sick, undergoing rehabilitation or are at high risk can be improved. Their dependence on hospital facilities will be reduced by new remote methods of personal health monitoring and by active implants. These medical opportunities will be accompanied by the risk that active implants might have unexpected side-effects or that an "over-instrumented" medicine might have negative psychological impacts on patients subjected to close observation.

Regarding health effects, the current controversy on the non-ionizing radiation (NIR) of mobile phone networks is an important issue. Only under far-reaching assumptions might pervasive computing make possible a stabilization of, or decrease in, our daily exposure to NIR. An increase is more probable, as wireless local area networks (W-LANs) are being built in addition to mobile phone networks. In spite of their lower transmission power, they will add to the total exposure, unless they are used as a substitute for existing networks. Questions on possible health hazards caused by NIR below the threshold of thermal effects are still open. Considering the fact that pervasive computing involves wearing radiation sources on the body (wearables) and even inside the body (implants), there is a need for further research. Even sources of low transmitting power may cause high exposure to radiation if they are very close to body tissues.

Pervasive computing will bring about both additional loads on and benefits to the environment. The prevailing balance of positive and negative effects will depend on how effectively energy and waste policy govern the development of infrastructures and applications in the coming years. Direct (primary) effects of ICT on the environment will result from material and energy consumption in the production and use phases, including pollution caused by disposal of the resulting waste. Pervasive computing is not expected to radically change the environmental impact of this life cycle. Greater quantities and shorter service lives of components will most probably counterbalance or even outweigh the benefits of progressing miniaturization. The energy demand of the network infrastructure needed for pervasive computing might be as large as several percent of total power consumption if there are no incentives for using the technical energy saving potential. More and more microelectronic throw-away products, including batteries, will be found in waste streams outside that of electronic waste (packaging, textiles).

These primary environmental impacts of pervasive computing are to be seen in opposition to the secondary effects it provides in *optimizing* material and energy intensive processes, or in *substituting* pure signal processing for such processes (dematerialization). The potential environmental benefits from such secondary effects are considerable and can even outweigh the primary effects, if, for instance, the increasing independence of activities from defined locations reduces traffic. But using these potential environmental benefits requires that there will be enough incentives to manage natural resources more economically. Otherwise, the growth in demand (tertiary effects) will counterbalance these savings.

***Fig. 2:*** *Wearable computing@ethz.ch (Bernt Schiele)*

Pervasive computing becomes interesting for business and consumers when it is filled with local contents and services. The context sensitivity of pervasive computing favors locally differentiated products: Information is made available and services proposed according to one's precise position and individual preferences.

However, distributed information processing systems make it difficult to isolate the cause of damages due to the combined effects of several components, as it is practically impossible to cope with the complexity of such systems, neither mathematically nor legally. As society's dependence on systems of this kind will grow with pervasive computing, a net increase in the damage derived from unmastered technical complexity has to be expected. As a consequence, a growing part of day-to-day life will, virtually, be removed from liability under the causation principle.

The study (350 p.) is available in German at www.ta-swiss.ch, a short version of the study is obtainable in English, German, French and Italian.

**Support:** TA-SWISS, BUWAL, BAG, BAKOM

**Links:** www.ta-swiss.ch
www.empa.ch/sit
www.vision.ethz.ch/pccvl/
www.itis.ethz.ch

***Contact:*** *lorenz.hilty@empa.ch*
***References:***
*L. Hilty et al., TA-Swiss Study, TA 46 (2003)*
*L. Hilty et al., Special issue of Human and Environmental Risk Assessment, submitted (2003)*

# Halftone color prediction model

**Printing can be understood as designing a macroscopic appearance by controling its color halftone microstructure. In this sense, the Phd-thesis (refered to below) offers a set of several computation models and concepts ranging from the spectral properties of paper to the macroscopic appearance. For a xerographic printer, the approach allows highly accurate predictions of the spectral color response and a precise description as a function of the given input halftone color separation layers.**

Safer Mourad

In modern offices, digital color printers are widely used. However, the printer's ability to reproduce input colors accurately is limited and, hence, it needs frequent recalibrations. In order to facilitate the calibration process, this project proposes models which describe the main contributing physical phenomena and which offer support for controling the color halftone printers online in a closed loop.

A first model concerns the phenomenon of light scattering within paper and takes into account multiple internal reflections and the fluorescence of brightened office papers. As shown in Figure 1, the model is based on a three-dimensional intensity analysis of six orthogonal light fluxes which pass through a diffuse substrate losing and gaining intensity due to scattering, absorption and fluorescence. Performing the analysis on a tiny volume cube yields a coupled system of six linear partial differential equations. As a result, the system's solution describes an optical modulation transfer function which allows calculating the microscopic spectral reflectance distribution of printed brightened office papers as a function of a given spatially resolved spectral transmittance distribution of the halftone sample.

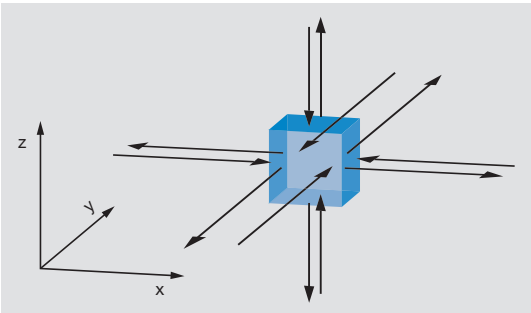


***Fig. 1:*** *Considered optical fluxes across a tiny cube in a three dimensional coordinate system.*

The independent optical model may be easily calibrated with simple measurements of printed full primary color samples. The model is verified with spectral microscopic measurements and is able to estimate the effects of the optical dot gain on the color reproduction curve of common printed papers.

A second model simulates the behavior of the xerographic printing process. In contrast to the ideal case, observations under the microscope show that the xerographic dots are spread beyond the theoretical dot area and have extremely ragged edges. Starting from the input color halftone image, the model computes the microstructure of the toner deposition on a given printing substrate based on a physical understanding and taking into account the stochastic behavior of the process. Assuming non light scattering toners, the obtained deposition relief is transformed into a microscopic spectral transmittance distribution required by the first model.

By simulating the micro-distribution of a xerographic print, as shown in Figure 2, the model's aggregate is capable of accurately predicting the whole printer's spectral color gamut with mostly indistinguishable deviations by the human eye.

***Fig. 2:*** *A simulated microscopic toner profile of a "clustered dot halftone" at nominal 30% area coverage. The illustrated area has a dimension of 1 x 1 mm and is illuminated from the rear right corner.*

**Support:** Thesis supervisor: Prof. R. D. Hersch, EPFL

**Links:** www.epfl.ch/w3lsp/publications/colour/

***Contact:*** *safer.mourad@empa.ch*
***References:***
*S. Mourad, PhD thesis No. 2708, EPFL (2003)*

# List of abbreviations

| | |
|---|---|
| armasuisse | Swiss Defence Procurement Agency |
| ASTRA | Swiss Federal Roads Authority |
| BAG | Swiss Federal Office of Public Health |
| BAKOM | Swiss Federal Office for Communication |
| BBL | Swiss Federal Office for Constructions and Logistics |
| BBT-KTI | Swiss Federal Office for Business Formation and Technology – Commission for Technology and Innovation |
| BBW | Swiss Federal Office for Education and Science |
| BFE | Swiss Federal Office for Energy |
| BLW | Swiss Federal Office for Agriculture |
| Brite EuRam III | Basic Research in Industrial Technologies in Europe and European Research in Advanced Materials |
| BUWAL | Swiss Agency for the Environment, Forest and Landscape |
| EAWAG | Swiss Federal Institute for Environmental Science and Technology |
| EC | European Commission |
| EFD | Swiss Federal Forest Agency |
| EPFL | Swiss Federal Institute of Technology Lausanne |
| ETHZ | Swiss Federal Institute of Technology Zürich |
| EU Program V | European Community, 4th Framework Program |
| EU Program VI | European Community, 5th Framework Program |
| FAM | Swiss Federal Dairy Research Station |
| Holz-21 | Swiss Federal Stimulation Program for the Wood |
| IT'IS | Foundation for Research on Information Technologies in Society |
| IZT | Institute for Future Studies and Technology Assessment |
| MaNEP | Materials with Novel Electronic Properties |
| NCCR | National Center of Competence in Research |
| MIBD | Swiss Dairy Inspection and Advisory Services |
| PSI | Paul Scherrer Institute |
| SLS | Swiss Synchrotron Light Source |
| SNF | Swiss National Science Foundation – National Research Progam |
| TA Swiss | Swiss Center for Technology Assessment |
| TOP Nano 21 | Research Program of the Board of ETH |
| UAS | University of Applied Sciences |
| UVEK | Swiss Federal Department of the Environment, Transport, Energy, and Communication |
| VST | Swiss Federation of Door Manufacturers |

# EMPA Activities 2003
# Mobility, Energy and Environment

## Mission

Our mission is the reduction of anthropogenic air pollutants relevant to climate change, human health, ecosystems and materials. We quantify pollution-fluxes in exhaust gases and in the atmosphere and develop technical solutions to reduce these fluxes. Sustainable mobility is a prerequisite for a sustainable development. Therefore, we work for a mobility technology which is based on efficient and emission-free vehicles powered by $CO_2$-neutral fuels.

## Activities

**Vehicles for a 2000 Watt-Society:** Mobility substantially contributes to personal quality of life as well as to economic development. However, mobility also has negative impacts on the local and global environment. Our motivation for engine and emissions research is to solve the conflict of aims between the need of individual mobility and environmental aspects. The main focus is the development of extremely clean and efficient methanegas driven powertrains for passenger cars. We, therefore, study combustion, flame propagation and knock behavior of methanegas engines as well as control strategies and the implementation of hybrid technologies for such engines. The results of these studies will be transferred in prototype vehicles which will be tested under real conditions.

**Exhaust gas aftertreatment** in mobile and stationary systems is an important issue to lower the atmospheric pollution through technical processes. Finding the right catalyst is a challenging task in this field. Enhancement of the automotive emission control requires approaching of the catalyst very close to the engine where conventional Pt-Rh catalysts have problems with the severe conditions. We, therefore, want to replace rare and expensive noble metals by more stable candidates among the perovskite-type transition metal oxides. By utilization of hydrogen rich fuels like methane or desulfurised fuels, the former sulfur poisoning of the transition metal catalysts becomes a minor problem compared to former attempts. Perovskite type metal oxides exhibit excellent catalytic activity and stability for this application. Their composition can be varied in a wide range changing the physical and chemical properties. With appropriate controled substitutions in the range of ppm to several percent, tailor-made solutions for different exhaust problems shall be developed.

**Quantification of atmospheric pollution fluxes:** Man-made pollutants have considerable impact on the environment. To promote the abatement of these emissions into the atmosphere, both transport processes on different scales as well as direct emissions from industrial processes or vehicle exhaust are studied. Ground based ambient air measurements, measurements from space by satellites and atmospheric model calculations are combined to achieve information covering the whole area. We employ backwards models in the form of resource friendly trajectory statistics and more elaborate Lagrangian particle dispersion

models to appoint source regions and source strengths of pollutants. This research activity allows estimating regional and European emission and provides an independent verification of emission assessments and claims under the Kyoto-Protocol. Furthermore, ambient air pollution is allocated to specific sources and regions by means of chemical and morphological analysis combined with model calculations. Emissions from industrial sources are scrutinized and attributed to certain process steps. This research provides the scientific basis for technical solutions to reduce emissions as well as for decisions in the field of environmental politics.

**Persistent organic pollutants (POPs)** include industrial chemicals and substances being released from the technosphere as unintended by-products of combustion and industrial processes. POPs are toxic, and some of them do act as endocrine disrupters, interfering with the hormone system. POPs are persistent, last for years or even decades before degrading into less dangerous forms. POPs evaporate and travel long distances through the atmosphere and accumulate in the fatty tissue of creatures, including human beings. Reduction and eventual elimination of these chemicals is one of the aims of the Stockholm Convention, a treaty established by the United Nations Environment Program in 2001. Our contributions to achieve these goals include the investigation of sources, atmospheric transport and environmental fate of selected POPs, including dioxins, polychlorinated biphenyls, pesticides, brominated flame retardants as well as the search for emerging POPs. Better knowledge of the environmental fate of POPs in compartments such as air, soil and water is a prerequisite for the establishment of chemical risk assessments and successful emission reduction strategies.

*Peter Hofer, Department Head*

# Regional emissions of anthropogenic halocarbons derived from continuous measurements of ambient air in Switzerland

Brigitte Buchmann,
Konrad Stemmler,
Stefan Reimann

**Modeling of continuously measured time series with meteorological information allows an estimation of regional emissions of compounds regulated by the Montreal Protocol. In contrast to trade survey statistics, this method is an efficient tool to track the real-world development of diffusive emissions of substances banked in foams or refrigerant systems. The analysis confirms a substantial decline of these substances in Switzerland within the last years.**

Man-made halocarbons have a considerable impact on the environment. Chlorine- and bromine-containing organic compounds such as chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) and halons are responsible for the decline of stratospheric ozone, and their use has, therefore, been regulated in the Montreal Protocol.

We measured ozone destroying CFCs and chlorinated solvents continuously with a GCMS (gas chromatography mass spectrometer) at Duebendorf and since 2000 at the high alpine site of Jungfraujoch (Fig. 1). Regional emissions of these substances have been assessed by modeling the height of the boundary layer with a meteorological preprocessor and the determination of the increase of the concentration during nighttime. The modeled emissions indicate the largest decay of about 98% for trichloroethane.

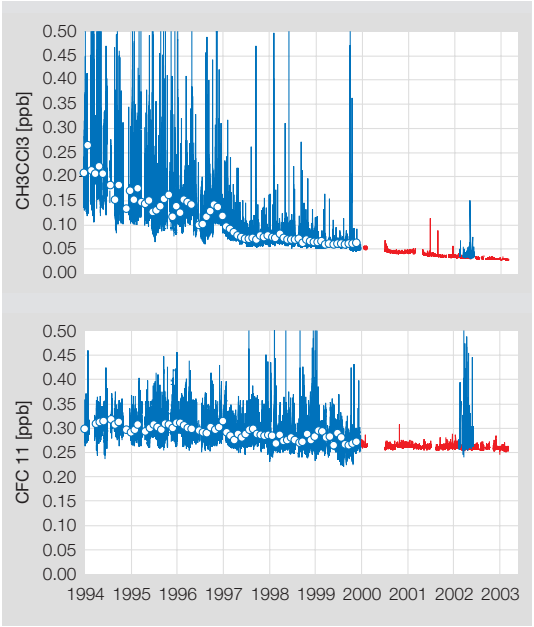


***Fig. 1:*** *Measured mole fractions of trichloroethane ($CH_3CCl_3$) and CFC 11 for Duebendorf (blue line) and at Jungfraujoch (red line). Monthly mean values (open circles).*

The CFC emissions have declined as well, but to a smaller extent, i.e. 85% for CFC 12 and 82% for CFC 11 since 1993 (Fig. 2).

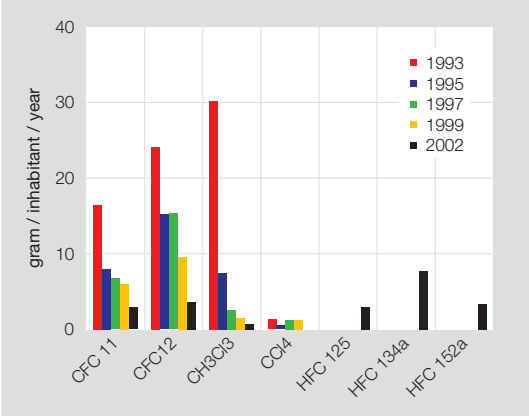


***Fig. 2:*** *Regional emission estimates of chlorofluorocarbons (CFCs), chlorinated solvents 1,1,1-trichloroethane ($CH_3CCl_3$), tetrachloromethane ($CCl_4$) and their substitutes HFCs (125, 134a 152a) derived from ambient air measurements.*

For 1995, the Swiss import statistics assumes zero consumption for the ozone layer depleting compound CFC 11, as the import of CFCs for foam blowing applications has been forbidden since 1994. Nevertheless, the model estimation still has indicated substantial diffusive emissions until today. They originate from the banking of these compounds in materials such as foams. This clearly demonstrates the advantage of model estimations based on ambient air measurements in contrast to trade statistics.

Additionally, our model allows to estimate emissions for the hydrochlorocarbons (HFCs), substituting the ozone depleting CFCs. The calculated emission rates for these substitutes (HFC 125, HFC 134a and HFC 152a) are in the same order of magnitude as the rates for the forbidden CFCs.

**Support:** BUWAL

**Links:** www.empa.ch/abt134
www.nilu.no/niluweb/services/soge/

***Contact:*** *brigitte.buchmann@empa.ch*
***References:***
*B. Buchmann et al., CHIMIA 57, 522 (2003)*

# Detection of previously unknown nitrated phenolic compounds in rain

**Nitrated phenolic compounds – classified as priority pollutants by the U.S. Environmental Protection Agency – are toxic secondary air pollutants formed by atmospheric oxidation and nitration of benzene and alkylated benzenes, originating from the technosphere (traffic, industrial processes, and solvent evaporation). Due to their high water solubility, nitrated phenols are efficiently removed from the atmosphere by precipitation and can be detected in rain, fog and snow. We developed a sensitive and specific method for trace analysis of nitrated phenolic compounds in the nanogram-per-liter range, based on atmospheric pressure chemical ionization mass spectrometry. In individual rain samples, up to 27 different nitrophenol as well as 16 dinitrophenol isomers were detected. The highest levels and number of isomers were found in winter rain samples. From the presented data we conclude that environmental concentrations of nitrated phenols were underestimated in the past, since only a few selected isomers were considered in all previous investigations.**

Martin Kohler,
Norbert Heeb

A complex mixture of alkylated benzenes is emitted from the technosphere, mainly from incomplete combustion of gasoline and from fuel and solvent evaporation. An even more complex mixture of nitrophenols is formed via atmospheric transformation reactions from these primary pollutants (Fig. 1). In order to detect and quantify unknown nitro- and dinitrophenols at ultra-trace level, a specific and sensitive analytical method was developed.

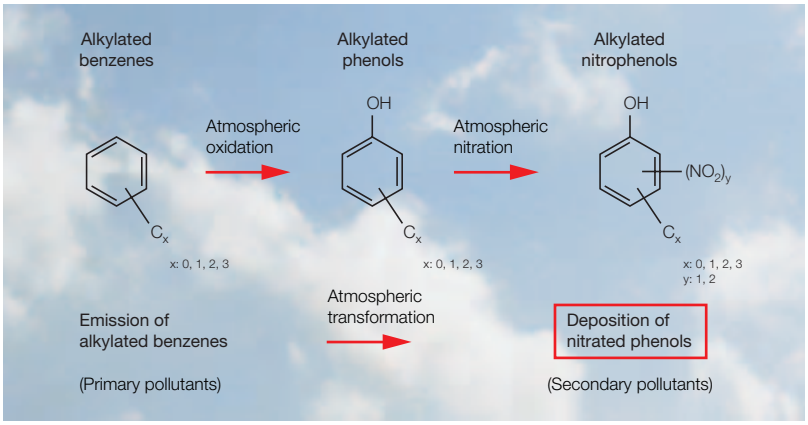


***Fig. 1:*** *Nitrated phenolic compounds – secondary air pollutants formed by atmospheric oxidation and nitration of benzene and alkylated benzenes originating from the technosphere.*

Getting a better knowledge of the occurrence of nitrated phenolic compounds in the atmosphere is important for many reasons. Nitrophenols are expected to contribute to secondary aerosol formation and may be involved in atmospheric oxidation of nitrogen oxide (NO) to nitrous acid (HONO). The U.S. Environmental Protection Agency (EPA) has classified 2,4-dinitrophenol and 2-methyl-4,6-dinitrophenol as priority toxic pollutants. Interestingly, dinitrated phenols are not only formed by atmospheric transformation processes, but are also manufactured as herbicides. Due to their toxic effects on plants, nitrated phenolic compounds have been suggested as possible contributors to forest decline. Detection and quantification of nitrated phenolic compounds in rain water is a challenge due to their low concentrations and the large number of isomers present. Being able to detect, identify and quantify these compounds is the key to study a variety of atmospheric processes.

Our selective and sensitive analysis of nitrated phenolic compounds in rain water is based on four steps: (i) enrichment of the analytes from a large sample volume, (ii) selective extraction from the water-matrix, (iii) chromatographic separation of the individual isomers, and (iv) sensitive and specific detection based on atmospheric chemical ionization mass spectrometry (APCI-MS). Rain water samples taken in Zurich and Winterthur were collected and stored at 4 °C prior to analysis. Aliquots of each sample were acidified and an internal standard was added prior to extraction. Nitrated phenolic compounds were separated on a $C_8$-reverse phase liquid chromatography system (LC) and analyzed on-line by APCI-MS in negative ion mode. An independent confirmation of the presence of nitro- and dinitrophenols was achieved by multiple reaction monitoring (MS/MS mode), recording the neutral loss transitions from nitrophenolate to phenolate ions corresponding to a loss of $NO_2$ (46 amu).

Figure 2 shows the LC/APCI-MS analysis of alkylated nitro- and dinitrophenols of a typical winter rain sample. The mass traces of the phenolate ions $[M-H]^-$ of the $C_0$- to $C_3$-nitro- and dinitro-phenols were recorded. Based on the growing number of isomers with increasing degree of alkylation, the complexity of the LC/APCI-MS chromatograms increases from top to bottom of Figure 2. All isomers being at least partly resolved are labeled with a black vertical bar, and the minimal number of detected isomers is given on the respective mass trace. Out of

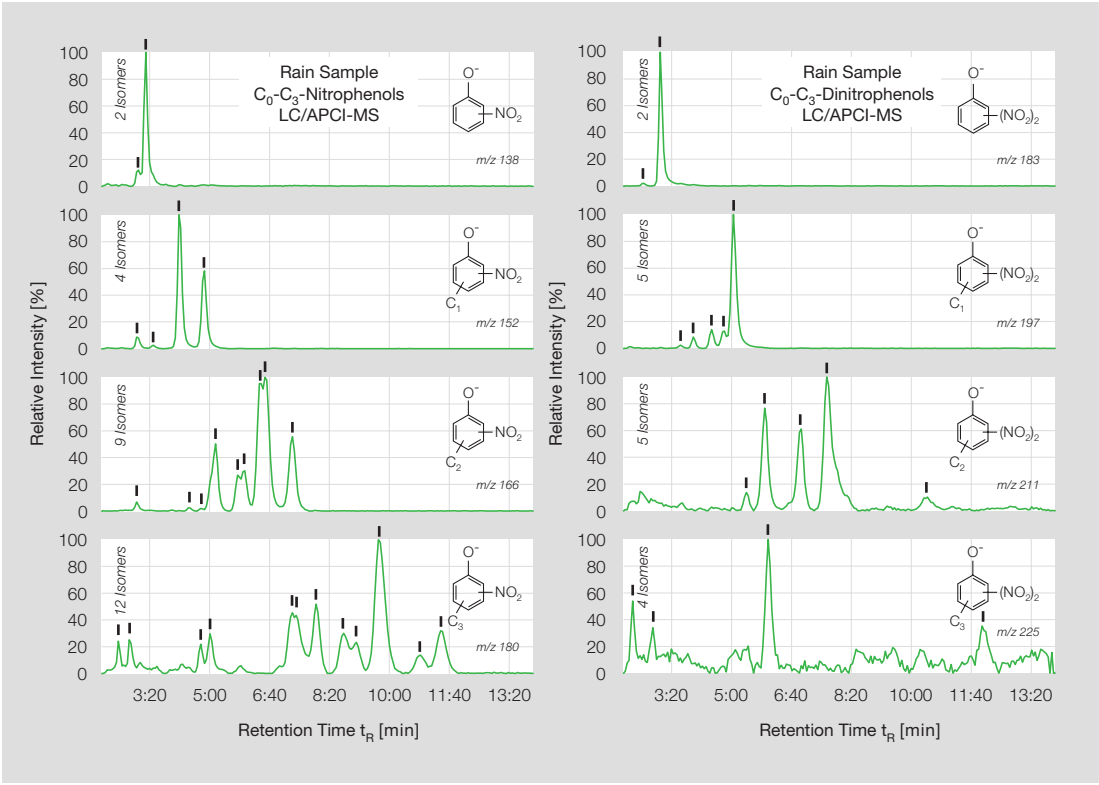


***Fig. 2:*** *LC/APCI-MS analysis of alkylated nitro- and dinitrophenols in a rain sample. Each bar represents a nitro- or dinitrophenol isomer.*

the 99 $C_0$- to $C_3$-nitrophenol isomers being theoretically possible, 27 species could be detected. Out of the 122 $C_0$- to $C_3$-dinitrophenols, 16 species were found in the same sample. The highest levels and number of isomers were found in winter rain samples, and distinctive isomeric patterns were observed for individual samples. Total concentrations of nitrated phenols were between 33–78 µg/l. Concentrations between 1–36 µg/l were estimated for the nitrophenols. For the corresponding dinitrophenols, lower levels between 0.1–2.1 µg/l were estimated. $C_1$- and $C_2$-nitrophenols and $C_0$- and $C_1$-dinitrophenols represent the major part of nitro- and dinitrophenol species detected in the investigated rain samples (Fig. 3). It is important to notice that the nitrated phenolic compounds reported in most publications on this topic represent only a small molar proportion of all nitrophenols detected in our study. We conclude that the higher alkylated nitro- and dinitrophenols described in this work have not yet been considered adequately in previous studies, and environmental concentrations of nitrated phenolic compounds have been underestimated in the past.

This work sets the starting point for further research on nitrated phenolic compounds. Research areas include occurrence and fate of nitrated phenolic compounds in the environment, phytotoxic effects of airborne nitrophenols compared to those of dinitrophenol herbicides emitted from the technosphere, atmospheric transformation of combustion side products, and production of nitrated phenols in technical processes such as exhaust gas aftertreatment.

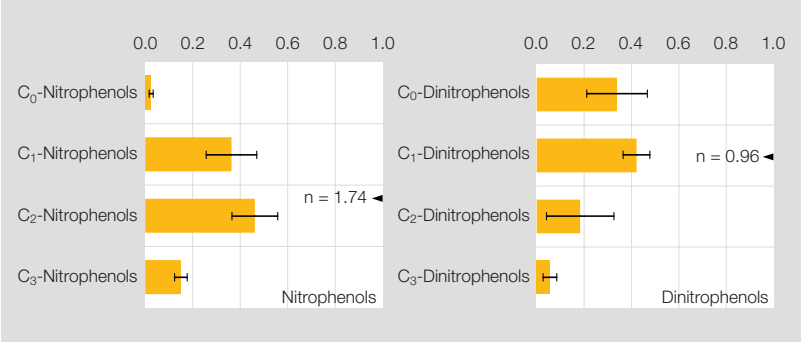


***Fig. 3:*** *Average molar distribution of the $C_0$- to $C_3$-nitro- and $C_0$- to $C_3$-dinitro-phenols in all rain samples examined.*

**Links:** www.empa.ch/abt132

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***References:***
*M. Kohler, N.V. Heeb, Anal. Chem., 75, 3115 (2003)*

# Road traffic raises dust – fine particle emissions from abrasion and resuspension processes

**Little is known about the relevance of mechanically produced particles of road traffic from abrasion and resuspension processes in relation to the exhaust pipe particles. Field measurements of PM10 and PM1 at the curbsides of streets with different traffic regimes showed that mechanically produced particles represent an important fraction of the total fine particle emissions of road traffic.**

Robert Gehrig,
Matz Hill,
Brigitte Buchmann,
in collaboration with
David Imhof,
Ernest Weingartner,
Urs Baltensperger,
PSI (CH)

High mass concentrations of PM10 (fine particles with an aerodynamic diameter < 10 µm) are frequently observed and affect not only polluted "hot spots" but spread typically over large areas of Switzerland. This presents a health risk for the population. In order to take efficient actions to abate fine particle emissions, detailed quantitative knowledge of the emission sources is vital. Exhaust pipe emissions of road traffic are generally recognized as an important contribution to atmospheric particle pollution. However, up to now there has virtually been no information about the relevance of mechanically produced particles of road traffic from abrasion and resuspension processes. A project which was jointly realized by EMPA and PSI aimed at closing this serious knowledge gap.

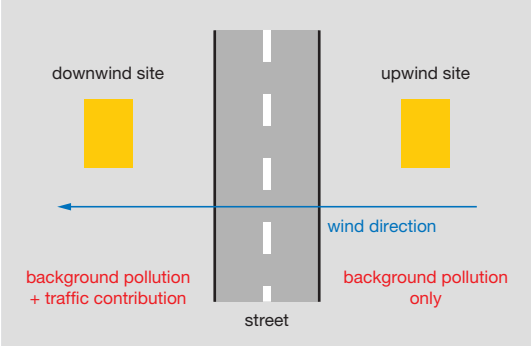


***Fig. 1:*** *Schematic view of the measurement concept.*

***Fig. 2:*** *Measurement site at Weststrasse, Zurich.*

We performed concentration measurements of particles and nitrogen oxides ($NO_x$) in ambient air on both sides of busy roads. During meteorological conditions with winds across the street it is possible to determine the contribution of the local traffic from downwind-upwind differences (Fig. 1). Alternatively, these contributions can also be obtained from differences between curbside sites and nearby background sites.

Hourly dilution factors were calculated from the measured concentration differences of nitrogen oxides ($NO_x$), the number of vehicles, and published $NO_x$ emission factors. The emission factors for particles were then calculated from the measured concentration differences, assuming that these undergo the same dilution as nitrogen oxides. Two vehicle categories were distinguished: LDV (light duty vehicles < 6 m, i.e. petrol and diesel passenger cars, vans, motor cycles) and HDV (heavy-duty vehicles > 6 m, i.e. lorries, coaches and buses).

In order to distinguish between exhaust pipe emissions and emissions from abrasion and resuspension, the PM10 and PM1 fractions were measured separately. PM1 was interpreted as direct exhaust pipe emissions, and PM10 as total fine particle emissions. The difference PM10-PM1 thus represents the emissions from abrasion and resuspension. Additional size distribution measurements confirmed that PM10 and PM1 are well suited to distinguish between emissions from exhaust pipes and abrasion/resuspension processes.

The measurements were performed at different busy roads, representing the following important traffic regimes:

- Outside built-up area, speed ca. 50 km/h (Aathal/Seegräben),
- Motorway, speed ca. 120 km/h (Birrhard),
- Motorway, speed ca. 85 km/h (Humlikon),
- Built-up area, speed ca. 50 km/h, slope 8% (Zürich Rosengartenstrasse),
- Built-up area, speed 0–50 km/h, directly at traffic lights (Zürich Schimmelstrasse),
- Built-up area, speed 0–50 km/h, 50 m from traffic lights (Zürich Weststrasse, Fig. 2).

Figures 3 and 4 show the emission factors of PM10 and PM1 for LDV and HDV, which were derived for these sites. It turned out, that abrasion and resuspension processes represent a significant part of the total primary PM10 emissions of road traffic. At sites with relatively undisturbed traffic flow (Aathal, Birrhard, Humlikon, Rosengartenstrasse), they are in the same range as the exhaust pipe emissions. At sites with disturbed traffic flow (Schimmelstrasse, Weststrasse) emissions from abrasion/resuspension are even higher than those from the exhaust. German studies showed similar results, and, furthermore, indicated a pronounced impact of the paving condition. In one case, the emissions on a road with damaged paving and dusty roadsides were by factors higher than those on roads with intact paving.

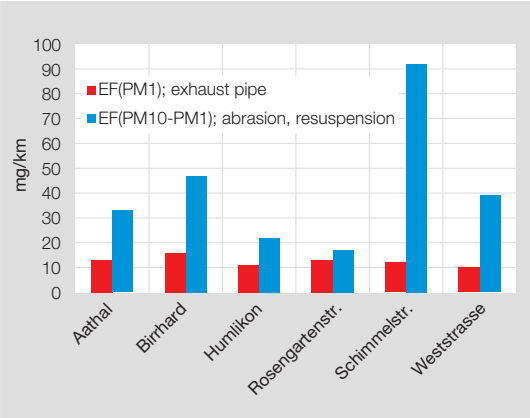


***Fig. 3:*** *Mean PM10 emission factors for LDV (petrol and diesel passenger cars, vans, and motor cycles).*

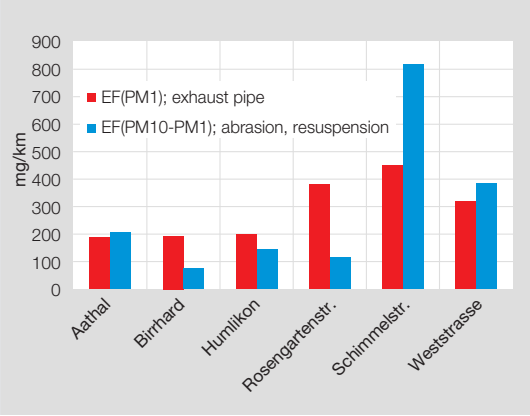


***Fig. 4:*** *Mean PM10 emission factors for HDV (lorries, coaches and buses).*

Given the fact that the emissions from abrasion and resuspension processes represent roughly half or even more of the total primary particle emissions of road traffic, the question of the impacts of these emissions has to be raised. Though quantitatively highly significant, these contributions exhibit a completely different particle size distribution and chemical composition than exhaust pipe emissions. While the latter consist mainly of fine soot and organic particles (partly known as carcinogenic), abrasion and resuspension predominantly lead to coarse mineral and metallic particles. However, the current knowledge of the mechanisms for health effects of fine particles does not yet allow a conclusive judgment of the relative importance of the exhaust emissions as compared to abrasion and resuspension.

Based on the new information from this project, the total primary PM10 particle emissions of road traffic in Switzerland were recalculated by the Swiss Federal Agency for the Environment, Forests and Landscape. For the year 2000, road traffic contributed approximately 20% to the total primary PM10 emissions in Switzerland.

**Support:** ASTRA, BUWAL

**Links:** www.empa.ch/abt134
> Pollutant source identification

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***References:***
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# Volatile nanoparticles from motor vehicles

**Volatile nanoparticles (typically smaller than 50 nm) from motor vehicle exhaust are receiving increasingly intense scrutiny as ambient measurements in urban areas also show a high number concentration of particles of similar size and volatility. There are still open questions about their composition and the formation process in the exhaust. Within the EU-project Particulates EMPA extensively investigated the influencing sampling parameters and studied the formation process by looking at key-compounds that affect the nucleation process.**

Urs Mathis,
Martin Mohr

Exhaust from vehicle engines represents an important anthropogenic source of particles below 1 µm in ambient air. Adverse effects of particles on human health are well documented in many publications. Exhaust particle sampling and conditioning have become a major issue over the last years as the particle characterization becomes more and more sophisticated. The objective of the EU-project Particulates was to develop a sampling procedure and to produce a database that allows to calculate emission factors and to study the health impact of particle emissions. It is evident that the sampling conditions are of high importance for engine and vehicle testing in laboratory to obtain representative and comparable results. Figure 1 shows the set-up for a comprehensive particle characterization at well-defined sampling conditions, as it was developed in the project.

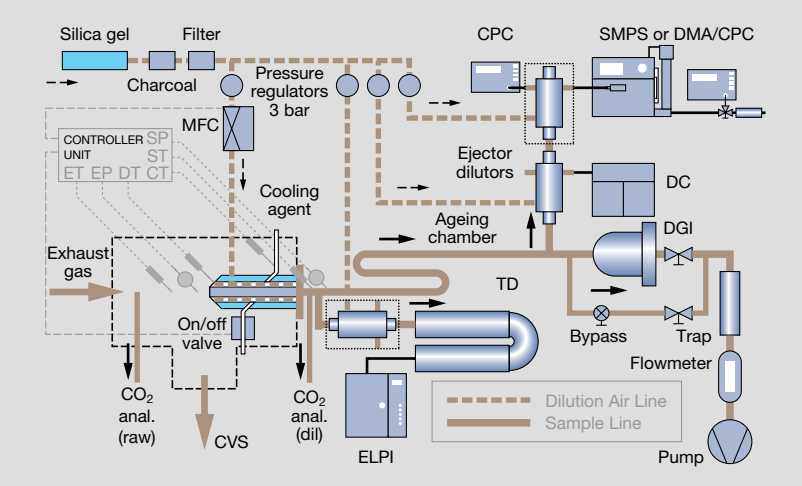


***Fig. 1:*** *Sampling system and instrumentation for comprehensive particle characterization at well defined sampling conditions. Exhaust gas is drawn with a porous dilutor and then split into two branches: in the "dry" branch, a TD strips condensable material and solid particles are measured for size and number (ELPI). In the "wet" branch, particles are aged in an ageing chamber and subsequently measured for number (CPC), surface (DC) and mass (DGI). Various controllers are used for the sampling conditions.*

Particle emissions in engine exhaust can be divided in a solid and volatile fraction. The solid particles mainly consist of agglomerated carbonaceous primary particles, which are usually described as soot. The volatile nanoparticles are formed by nucleation of supersaturated sulfuric acid, water, and hydrocarbons. Formation of these volatile nanoparticles strongly depends on the dilution and cooling process of the exhaust. One main contribution of EMPA was to investigate the sensitivity of the sampling parameters and to define conditions that allow the measurement of the volatile particles in a reproducible way.

Figure 2 shows the highly flexible dilution unit that facilitates the variation of the relevant sampling parameters dilution ratio, residence time, temperature and relative humidity of the dilution air in a wide range. As an example, Figure 3 shows the enormous effect of the relative humidity on the particle number size distribution of the emitted particles

***Fig. 2:*** *Set-up of the primary dilution unit attached to the exhaust system of the vehicle.*

during a steady state test. It was verified that the moisten dilution air did not contain any water droplets. In Figure 4, a typical example of volatile nanoparticle emissions is shown for a modern diesel passenger car on the chassis dynamometer during a real world test cycle. Volatile nanoparticles were mainly emitted to a large extent after strong accelerations at high loads.

To gain a better understanding of which compounds are involved in the initiation of nucleation, we carried out additional experiments with contaminated dilution air. Volatile organic compounds (VOCs) with different functional groups were added in different concentrations to the dilution air, and the response on the particle emission was investigated. The concentration of organic compounds was controlled to be lower than 5% of the saturation ratio. Figure 5 demonstrates the different response on alcohol, aliphatic hydrocarbon and ether with increasing vapor pressure. While for 2-propanol a clear increase of the nucleation particles is observed, there is a decrease for methyl tert-butyl ether (MTBE), and hexane do not show any effect.

These results reveal that hydrophilic hydroxyl groups are involved in the nucleation process while short aliphatic hydrocarbons do not affect volatile nanoparticles implying no hydrophobic interactions. MTBE as a hydrophobic compound was considered to have a similar impact on volatile nanoparticles as hexane. However, MTBE completely suppresses the formation of volatile nanoparticles. The mechanism leading to this surprising result will be the topic of a further project.

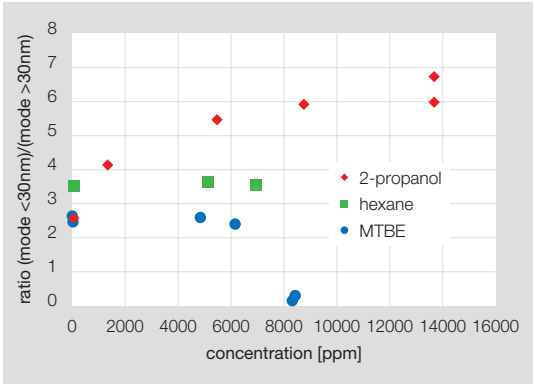


***Fig. 5:*** *The ratio of the maximum number concentrations in nucleation mode to accumulation mode is shown as function of the vapor concentration of the organic compounds.*

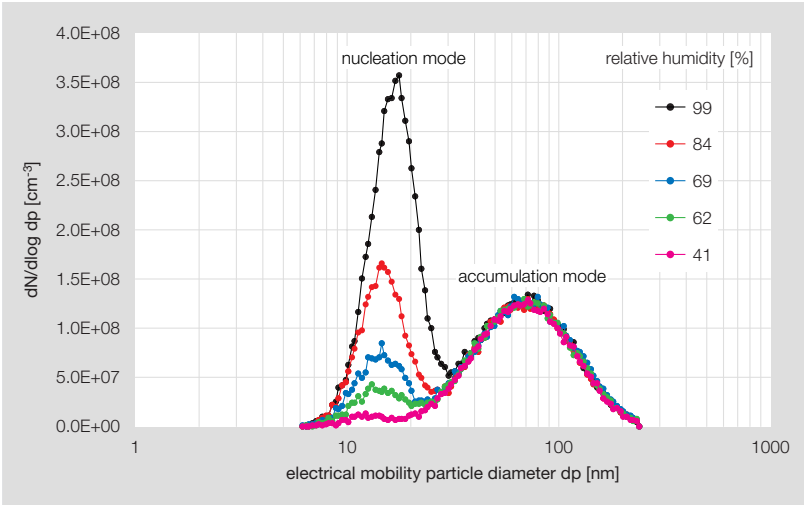


***Fig. 3:*** *Effect of relative humidity in the aerosol sample on the particle number size distribution.*

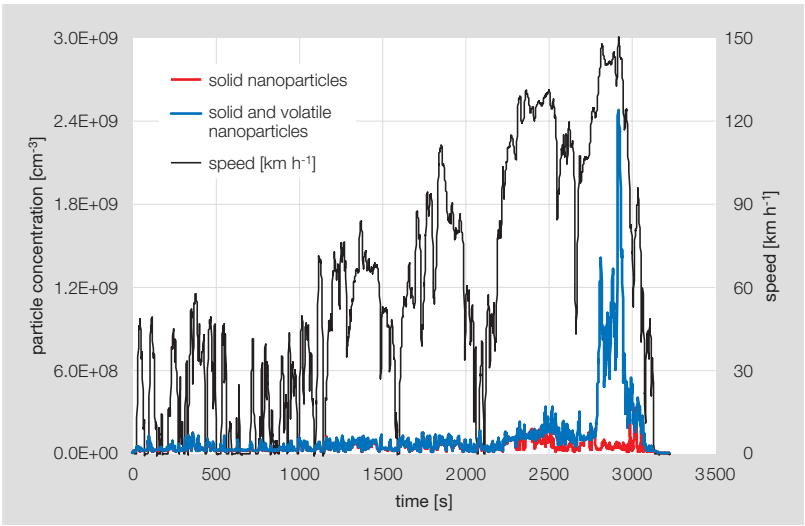


***Fig. 4:*** *Nanoparticle emissions of a modern diesel car during a driving cycle.*

**Support:** BBW, EU Program V

**Links:** vergina.eng.auth.gr/mech/particulates/

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# Particle separator for small wood fired furnaces

Volker Schmatloch,
Stephan Rauch,
Jürg Brenn

**One major advantage of wood combustion is the use of a renewable source of energy. Recent research projects, however, have shown that small wood fired heating appliances are an increasingly important emission source of nanoparticles. These emissions are known to cause severe health problems. As a possible solution for this problem, a particle separator based on electrostatic precipitation has been developed in this project. The aim was a low cost system suitable for retro-fitting and able remove more than 80% of the ultrafine particles.**

Small wood fired furnaces, below 70kW, are an important group of anthropogenic emission sources of fine particles. Figure 1 illustrates the importance of the contribution from small wood fired furnaces to the overall particle emissions in Switzerland. The comparison to traffic related tail-pipe emissions is based on statistical data and shows that emissions from wood combustion can be expected to become more important in the near future.

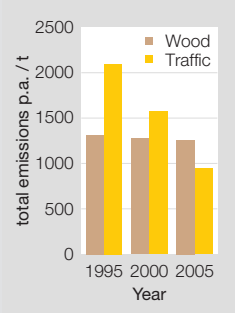


***Fig. 1:*** *Annual particle emissions in Switzerland.*

Previous investigations showed that small wood fired appliances emit particles at number concentrations in the order of $10^8/cm^3$ at a typical size between 80 nm and 180 nm. Especially for the very small appliances considered here, further possibilities for emission reduction by improving the combustion process are limited. Exhaust gas aftertreatment, however, may still be a good way towards lower particle emissions. Among several technical methods available, the electrostatic principle was considered to be most promising, especially because of the low pressure drop achievable.

Figure 2 shows the separator setup. The key element of the separator is the electrode in the flue pipe. A high voltage applied to this electrode causes ionization processes that in turn lead to a charging of particles in the flue gas. Consequently, the charged particles are collected at the wall of the flue pipe due to electrostatic forces. Another crucial element besides the electrode is the electric feedthrough which has to withstand thermal, electrical and mechanical stress. The control unit with the power supply, which is the third important component, is not shown here.

With this setup, more than 80% of the particles can be removed from the flue gas under realistic conditions. This is shown in Figure 3, which also illustrates

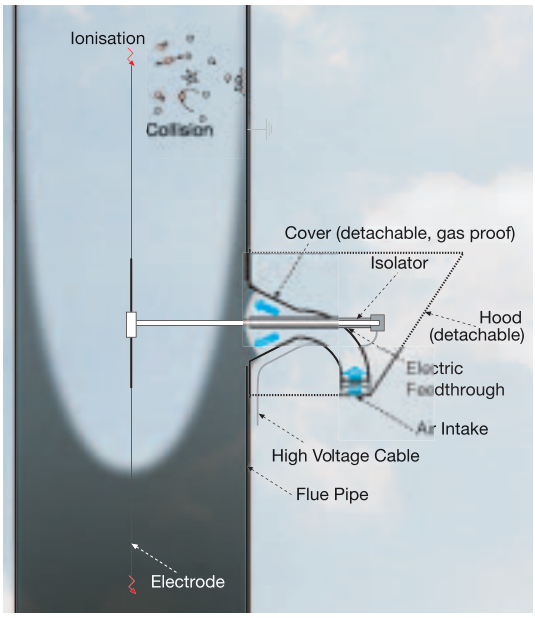


***Fig. 2:*** *Particle separator setup.*

the dependence of the separation efficiency on the particle diameter for an ionization voltage of 15kV. At higher voltage, efficiencies of above 90% were feasible.

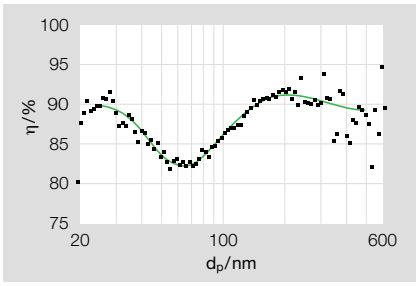


***Fig. 3:*** *Separation efficiency $\eta$ vs. particle diameter $d_p$.*

Reliable operation in realistic installations has been shown under different conditions. In cooperation with industry, this particle separator will be adapted to a specific kind of installation with the aim of series production.

**Support:** BUWAL

**Links:** www.empa.ch/abt137
> Exhaust gas aftertreatment

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***References:***
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# Infrared spectroscopy for gas analysis in the semiconductor industry

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Lukas Emmenegger,
in collaboration with
Ernst Sandmeier,
E4 Technologies (CH)

**Extractive Fourier Transform Infrared Spectroscopy (FTIR) is a flexible and reliable method for gas analysis in technical processes. However, dealing with complex mixtures of reactive and corrosive gases is demanding in many respects. We have developed a procedure for sampling and analysis focused at a variety of important chemical vapor deposition processes.**

A wide range of specialty gases is used in the production of microelectronic devices, such as LEDs, TFTs and CMOS (Complementary Metal Oxide Semiconductor). These gases include mainly (per)-fluorocompounds (e.g. $CF_4$, $WF_6$, $NF_3$), silanes ($SiH_4$, $[(C_2H_5O)_4Si]$), and dopants ($AsH_3$, $PH_3$). Their use in the semiconductor industry must be optimized because of high costs, aggressive properties and strong global warming potential. To understand the process chemistry, there is a need for rapid and sensitive real-time gas analysis.

We used extractive on-line FTIR for qualitative and quantitative analysis of the main gaseous products. Spectra were obtained using a transportable, 0.5 $cm^{-1}$ resolution FTIR analyzer with a fully gold plated 2.4 m path length cell, maintained at 120 °C. Materials and analytical parameters were optimized to achieve rapid instrumental response at high spectral resolution. Special attention was paid to the selection of the analytical wavelength regions with respect to linearity, limits of detection and interferences. Quantification was done by classical least-square algorithms. One main challenge was the measurement of adequate reference spectra because of the reactive and uncommon gases studied. Validation of on-line gas analysis was achieved using standard addition and applied successfully at semiconductor plants.

To reduce gas consumption, we studied chemical vapor deposition processes for tungsten, silicon dioxide, silicon nitride and borophosphosilicate glass (Fig. 1). The results indicate large optimization potential for several process steps. During tungsten deposition, an undesired side reaction was identified leading to particle generation (Fig. 2). Several process modifications were tested, and improved process conditions were implemented to increase overall yield. Rapid on-line and on-site analysis permitted the optimization of cleaning processes, leading to enhanced gas utilization efficiency. This allowed significant increase in waver throughput, cost reduction of specialty gases and lowering of hazardous emissions.


*Fig. 1: Temporal variations of main gases in tungsten deposition quantified by FTIR spectroscopy. Tungsten deposition is initiated by deposition of a nucleation layer (tungsten silicide). After deposition, the reaction chamber is cleaned by a $NF_3$ plasma.*

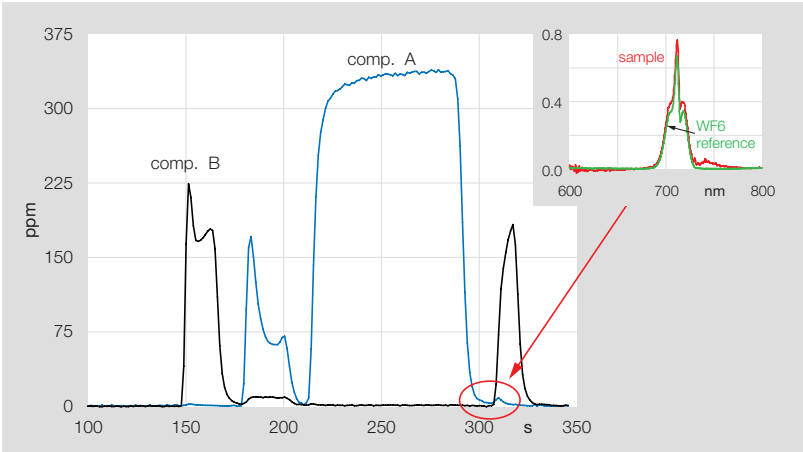


*Fig. 2: Unused educts of tungsten deposition. The unexpected peak was identified by its IR spectra as $WF_6$.*

**Support:** BBT-KTI

**Links:** www.empa.ch/abt134

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***References:***
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# Spatially resolved quantitative profiling of fuel cell building layers using LA-ICPMS

**A trade-off between spatial resolution and detection power currently limits the potential of several beam-assisted techniques for solid analysis. The ability to produce quantitative data on the chemical features of a solid sample is still a major challenge in spatially resolved analysis. Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICPMS) fills this gap offering access to elements at trace level concentration on a micrometer scale.**

Davide Bleiner,
Peter Lienemann,
Andrea Ulrich,
Heinz Vonmont,
Adrian Wichser

Fuel cell cathodes were realized and analyzed in collaboration with the EMPA Laboratory for High Performance Ceramics by sintering a mixture of Mn- and Co-perovskite ceramic powders in variable proportions. The changing proportions of the mixture led to concentration gradation along the depth, which ensured continuity and mechanical stability. Chemical gradation was quantitatively characterized by LA-ICPMS. The rapidity, flexibility and detection power of LA-ICPMS are advantages that integrate and extend analytical capabilities of other well-established beam-assisted techniques (Fig. 1). Lateral resolution below 100 µm and depth resolution of 0.1–0.2 µm were obtained. Quantification was performed by means of own developed algorithm. The composition of the stock powders was initially determined by sample digestion and ICP-MS analysis, obtaining two databases on Mn- and Co-perovskite composition. Using LA-ICPMS, the ratio Mn/Co in the samples was determined as depth profiles which was related to the proportions of the Mn- and Co-perovskite at a certain depth in that sample. Finally, the depth-wise content of a given element was calculated as the sum of the element's content in Mn-perovskite fraction plus its content in Co-perovskite fraction at that depth (Fig. 2). Comparison to semi-quantitative data obtained from SEM-EDX at the surface of the sample showed that the developed method provided reliable responses. The occurrence of bands of elemental distribution was observed and used for a realistic description of the chemical structure of the samples. The fluctuation of elemental concentration at low-scale < 1 µm suggests that improvement in depth resolution conflicts with robust and powerful quantification. Therefore, pulse-related depth resolution of 100–200 nm represents a compromise between spatially resolved approach and quantification capability.

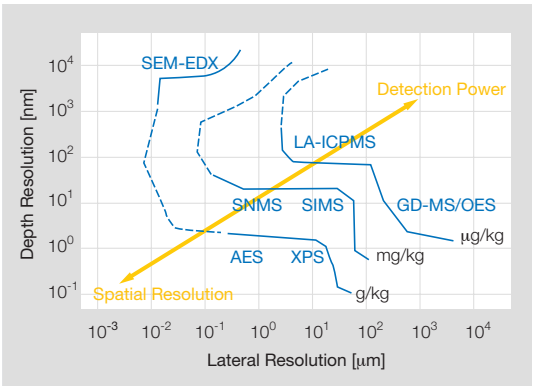


***Fig. 1:*** *Spatial resolution and detection capabilities of popular beam-assisted analytical techniques.*

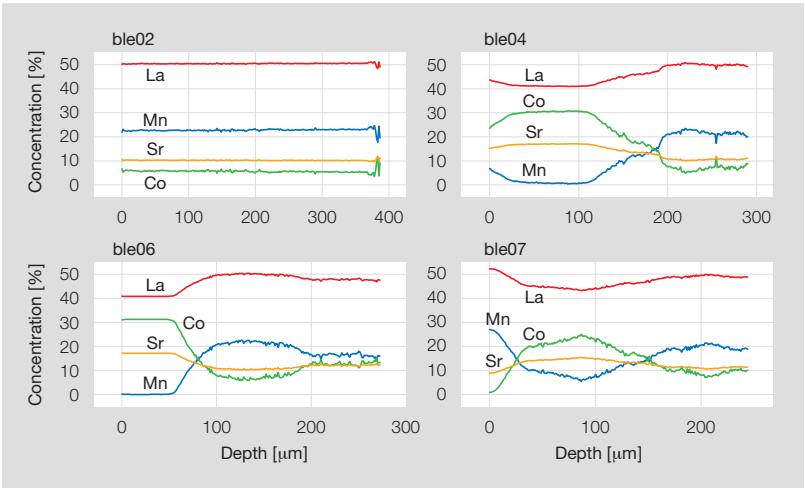


***Fig. 2:*** *Concentration depth profiles of four perovskite samples.*

The method finds application in the improvement and quality control of fuel cells. In fact, LA-ICPMS determines layers thickness and the occurrence of heterogeneities. Thus, the technique has the capability to identify ageing processes in operating devices. If element migration within different layers is a reason for the ageing of a fuel cell, LA-ICPMS provides the possibility to perform long term studies on the cells with minimal consumption and preservation of their functionality.

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# Temporal trends of dioxins in Switzerland

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Markus Zennegg,
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MIBD (CH)

**Dioxin concentrations in cow milk collected in 2001 were compared to the corresponding data from 1984 and 1991 from the same sites: Milk in 2001 was significantly less contaminated than the samples collected in 1991 and 1984. The reduction in dioxin levels is paralleled by the remediation of known dioxin emitting sources, as enforced by federal authorities.**

Dioxins are one of the most important classes of POPs (persistent organic pollutants). The ubiquitous contamination of the environment by these contaminants is primarily caused by atmospheric transport and deposition of emissions from various sources (e.g. waste incineration and other industrial thermal processes) on soil and leafy vegetation, such as grass, which is ingested by grazing cows. Due to their lipophilic and persistent properties, dioxins are distributed in the fat compartment including milk fat of the cow. It has been demonstrated that dioxin levels in milk are correlated to the actual average local dioxin exposure of the soil by atmospheric deposition.

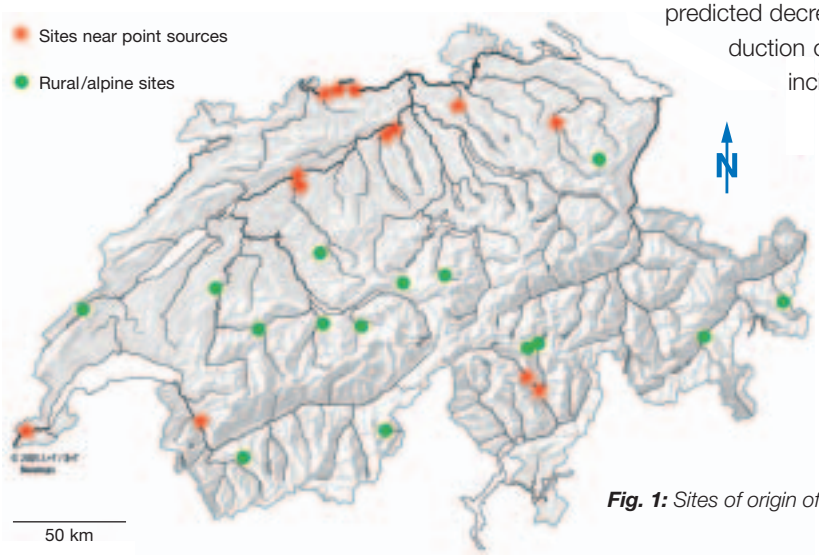


***Fig. 1:*** *Sites of origin of cow milk samples.*

30 cow milk samples were taken in 2001 during the outdoor feeding season between June and August. Samples were collected at dairy farms in the vicinity of point sources, in rural/alpine areas distant to known sources (Fig. 1), and from tanks in industrial milk processing plants. The levels from farms near point sources (0.63 ± 0.26 ng I-TEQ/kg milk fat) were distinctly higher than milk from remote areas (0.36 ± 0.09 ng I-TEQ/kg milk fat). Consumer milk from processing plants originating from larger catchment areas had intermediary levels (0.51 ± 0.19 ng I-TEQ/kg milk fat). In all cases, milk in 2001 was significantly less contaminated than samples collected in 1991 and 1984. Figure 2 shows the average dioxin levels in Swiss consumer milk, calculated by averaging the levels in the milk samples from industrial milk processing plants for the three sampling periods, indicating a steady decrease since 1984. Similar downward trends have been observed in other European countries. The reduction in dioxin levels in dairy milk, which also indicates a decrease of atmospheric deposition, is correlated to the estimated total annual emissions of dioxins in Switzerland (BUWAL, Schriftenreihe Umwelt Nr. 290, 1997). The predicted decrease is mainly due to the reduction of the emissions from waste incineration.

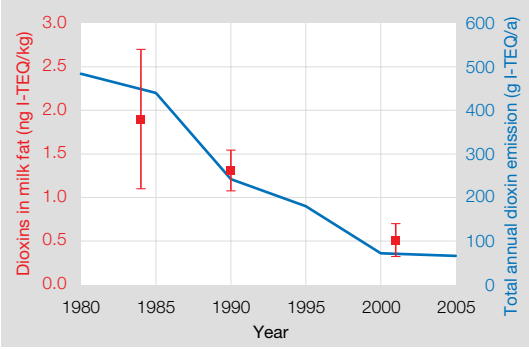


***Fig. 2:*** *Temporal trend of average dioxin levels in Swiss consumer milk from industrial milk processing plants (error bars indicating standard deviations) and estimated total annual dioxin emissions in Switzerland.*

**Support:** BUWAL

**Links:** www.empa.ch/abt132
> Schadstoffanalytik
www.umwelt-schweiz.ch/buwal/de/fachgebiete/fg_stoffe/projekte/gruppen/index.html

***Contact:*** *peter.schmid@empa.ch*
***References:***
*P. Schmid, Chemosphere 53, 129 (2003)*

# List of abbreviations

| | |
|---|---|
| armasuisse | Swiss Defence Procurement Agency |
| ASTRA | Swiss Federal Roads Authority |
| BAG | Swiss Federal Office of Public Health |
| BAKOM | Swiss Federal Office for Communication |
| BBL | Swiss Federal Office for Constructions and Logistics |
| BBT-KTI | Swiss Federal Office for Business Formation and Technology – Commission for Technology and Innovation |
| BBW | Swiss Federal Office for Education and Science |
| BFE | Swiss Federal Office for Energy |
| BLW | Swiss Federal Office for Agriculture |
| Brite EuRam III | Basic Research in Industrial Technologies in Europe and European Research in Advanced Materials |
| BUWAL | Swiss Agency for the Environment, Forest and Landscape |
| EAWAG | Swiss Federal Institute for Environmental Science and Technology |
| EC | European Commission |
| EFD | Swiss Federal Forest Agency |
| EPFL | Swiss Federal Institute of Technology Lausanne |
| ETHZ | Swiss Federal Institute of Technology Zürich |
| EU Program V | European Community, 4th Framework Program |
| EU Program VI | European Community, 5th Framework Program |
| FAM | Swiss Federal Dairy Research Station |
| Holz-21 | Swiss Federal Stimulation Program for the Wood |
| IT'IS | Foundation for Research on Information Technologies in Society |
| IZT | Institute for Future Studies and Technology Assessment |
| MaNEP | Materials with Novel Electronic Properties |
| NCCR | National Center of Competence in Research |
| MIBD | Swiss Dairy Inspection and Advisory Services |
| PSI | Paul Scherrer Institute |
| SLS | Swiss Synchrotron Light Source |
| SNF | Swiss National Science Foundation – National Research Progam |
| TA Swiss | Swiss Center for Technology Assessment |
| TOP Nano 21 | Research Program of the Board of ETH |
| UAS | University of Applied Sciences |
| UVEK | Swiss Federal Department of the Environment, Transport, Energy, and Communication |
| VST | Swiss Federation of Door Manufacturers |

# EMPA Academy

## Mission and Activities

The Academy is Empa's knowledge transfer platform. It initiates and organizes the dissemination of topical, high-quality knowledge and offers a forum for the discussion and sharing of findings from the scientific world and society at large that are connected with Empa's fields of specialization. It gives interested members of the public access to the results of Empa's Research and Development activities and stages continuing training events for people from both inside and outside Empa.

The Academy's guest speakers are specialists and scientists drawn from Empa's own ranks and from external organizations. Events are designed to appeal to the scientific community, industry specialists, managers of public and private institutions and political decision makers. They are also organized for interested members of the general public. Such events provide an arena for addressing topical technical and scientific subjects.

The Academy stages its seminars, courses and lectures at Empa's sites in Dübendorf, St. Gallen and Thun, and in further regions of Switzerland and in neighbouring countries. In all cases it collaborates with other research and educational institutions.

*Dr Anne Satir, Academy Manager*

# “Nano: is the future quite as bright as it seems?”

Anne Satir

At the end of June the Empa Academy hosted a one-day meeting with this title, which was attended by about 40 representatives from the fields of science, economics, and the media. Initiated and organized in collaboration with the Risiko-Dialog Foundation, St. Gallen, the seminar focused on the perspectives and risks in nanotechnology.

The first speaker, Dr. Christoph Meili, of the foundation, maintained that at present, the nanotechnology world is in the grip of a gold rush mentality, with research funding in the field having been hugely increased in Switzerland, the EU and the USA. This has raised the hopes of gaining significant competitive advantages in certain circles of the research, political, and economic worlds, some even claiming to see the third industrial revolution on the horizon.

**Nanotechnology from the scientific and ethical point of view**

Nanotechnology is pushing the frontiers of research down to the level of atomic dimensions, but what relevance does this have in the future for mankind in the street? Empa Director Prof. Louis Schlapbach gave the audience a taste of what is soon to come, citing the example of superflat television and computer displays in which the picture is created by millions of tiny carbon tubes of nanometer dimensions. Industrial contacts have already been established, and the new application has all the signs of being a winner. But Prof. Schlapbach also emphasized the need for caution to be exercised in the practical aspects of handling and using such nanoparticles to avoid problems in the future. It is not yet known, for example, what health effects nanoparticles might have when inhaled by workers.

The philosopher and ethicist Dr. Klaus Peter Rippe gave the audience a view of the topic from a different perspective. Nanotechnology, as the “key technology of the 21st century”, is certain to have a significant impact on society, and as an ethicist, he was particularly concerned that three decisive aspects in which the new technology would interact with society – respect, fairness and sustainability – not be neglected, as has happened so frequently in the past.

**Nano – an early opportunity for risk dialog**

Although public discussion about the potential benefits and risks of nanotechnology is still at an early stage, Christoph Meili of the Risiko-Dialog Foundation, in summing up, felt that there was a certain similarity to the gene technology debate. In his opinion there was already a great opportunity for risk dialog – the exchange of ideas between various interest groups – to begin right away. This process, however, would need to involve interactive communication, not just a passive exchange of information. At the moment the first signs of such a process are beginning to appear. One of these early signs was itself the discussion meeting at the Empa Academy. Here, participants were able to get a feel for the practical meaning of nanotechnology at first hand during the laboratory visits and subsequently discuss their ideas in detail during the intense discussions held during the workshops.

***Contact:*** *anne.satir@empa.ch*
***Links:*** *www.empa-akademie.ch*

# List of Courses and Conferences in 2003

## Courses

| | | |
|---|---|---|
| **January** | **21** | Neue Wege bei der Durchführung von Audits |
| **February** | **07** | The Power of Networks |
| **March** | **25** | Validieren von Analysenverfahren |
| | 28 | JDF – Die Druckerei von morgen? |
| **April** | **01/02** | Kunststoffrohre richtig planen, berechnen und verlegen |
| | 07/11/14 | Workshop: Wirkungsvoll präsentieren |
| | 23 | Farbe im digitalen Workflow – Color Management |
| | 24 | Farbe im digitalen Workflow – Digitales Proofing |
| **July** | **01** | KTI-Anträge erfolgreich verfassen |
| **August** | **27** | SNF-Anträge erfolgreich verfassen |
| **September** | **02/03** | Emissionsmessungen |
| | 16 | Oracle User Group |
| | 29 | Systematische Qualitätskontrolle |
| | 30 | Sauberes Datenhandling |
| **October** | **15** | Neue Wege bei der Durchführung von Audits – Umsetzungserfahrungen |
| | 24 | Alles im Griff? Zeit- und Selbstmanagement |
| **November** | **4** | JDF – Die Druckerei von morgen? |
| | 17/21/24 | Workshop: Wirkungsvoll präsentieren |
| | 20 | Sicherer Workflow mit Ugra-Kontrollmitteln |
| | 27/28 | Kunststoffrohre richtig planen und berechnen |
| **December** | **09** | Farbe im digitalen Workflow – Color-Management |
| | 10 | Farbe im digitalen Workflow – Digitales Proofing |

## Conferences

| | | |
|---|---|---|
| **January** | **09** | CFK im Bauwesen – heute Realität |
| | 16 | SCC – ein Beton mit Potential und Tücken |
| | 17 | Wood Research knowledge and concepts for future demands |
| **March** | **28** | Bleifreies Löten |
| **April** | **09** | Swiss Knowledge Management Forum |
| | 10 | Porosität von Zementmaterialien |
| | 11 | 1. Nationales Treffen von Fachfrauen aus der Haustechnikbranche |
| | 14–16 | 6th internat. RILEM Symp. on Perform. Testing and Evaluation of Bituminous Materials |
| | 29 | Web-Based Training 2003: Mensch- und E-Learning |
| **May** | **06** | Energie aus dem Untergrund |
| | 16 | 12. Internationales Automobiltechnisches Symposium 2003 |
| | 21–24 | Europ. Conf. Protective Clothing NOKOBETEF 7: Challenges for Protective Clothing |
| | 27 | Wärme- und Feuchteschutz im Holzbau |
| **June** | **18** | Nano: Zwischen Zweifel und Zuversicht |
| | 24 | Umgang mit brandbedingten Kontaminationen |
| **July** | **04** | Nanotechnologie für Textilien |
| **August** | **21** | Frequenzmodulations- und Hybrid-Rasterung |
| **September** | **10–12** | STLE-Conference: Smart Surfaces in Tribology |
| | 19 | 20. Diskussionsforum Ökobilanzen (ETH Zürich) |
| **October** | **17** | Materiali moderni |
| | 30 | 8. Internet/Crossmedia-Tagung |
| **November** | **07** | TECAT-Infotag zu Emissionen des Strassenverkehrs |
| | 12 | 3. Wirtschaftsforum: Ethik und erfolgreiche wirtschaftliche Tätigkeit in schwierigen Zeiten |
| | 18 | 7. Textiles Schadenfall-Meeting |
| | 27 | Analytik und Massnahmen an Baudenkmälern und Kulturgütern |
| | 28 | Functional Optical Polymers |
| **December** | **3** | Materials Science Seminar |
| | 3/4 | 20. Diskussionsforum Ökobilanzen (EPF Lausanne) |

# EMPA Activities 2003
## Appendix

# EMPA Activities 2003
## Awards

| | | |
|---|---|---|
| Acoustics | Emrich, Frieder/Walk, Michael | Poster Award, DAGA 2003 in Aachen, Germany |
| Air Pollution/ Environmental Technology | Schaub, Daniel | Poster Award, Session World Climate Research Program, Swiss Global Change Day |
| CFRP in Structural Engineering | Meier, Urs | Fellow of International Institute for FRP in Construction (IIFC) |
| | Stöcklin, Iwan/Meier, Urs | Best Paper Award, 6th Int. Symposium on Fibre-Reinforced Polymer Reinforcement for Concrete Structures 2003, National University of Singapore |
| | Winistörfer, Andreas/Meier, Urs | Best Basic Research Paper, ASCE ICI Journal of Composites in Construction |
| Concrete/Construction Chemistry | Holzer, Lorenz/Kaufmann, Josef | Poster Award, 5. GDCh-Tagung Bauchemie 2003, München, Germany |
| High Performance Ceramics | Heiber, Juliane | Hans-Walter-Hennicke Award 2003 |
| | Heiber, Juliane | Poster Award, EUROMAT 2003, Lausanne, |
| | Heiber, Juliane | Award 2003, Verein Deutscher Ingenieure VDI |
| Inorganic Analytical Chemistry/Characterization of Solids | Bleiner, Davide | Poster Award 2003, European Winter Conference on Plasma Spectrochemistry |
| Materials Technology | Fuhrer, Katrin (TGZ Thun) | Vigier Award 2003 |
| | Hadad, Mousab | Price of Vallorbe Metallurgy, best examination, best diploma thesis |
| | Margadant, Nikolaus | Best Paper Award, ITSC 2003 Orlando |
| nanotech@surfaces | Ruffieux, Pascal | Charmey Prize 2003, Excellent PHD thesis, Annual Conference of SAOG, Fribourg |
| Protection and Physiology | Rossi, René/Becker, Cordula/ Bolli, Walter/Bruggmann, Georg | Award of recognition, Schweiz. Verein von Brandschutz- und Sicherheitsfachleuten |
| | Stämpfli, Rolf | LISTA Award, diploma thesis Mechatronic |
| Road Engineering/ Sealing Components | Partl, Manfred N. | RILEM Fellowship |
| Structural Engineering | Weber, Felix | Thomas Hawksley Gold Medal |
| | Weber, Felix | Crompton Lanchaster Prize |
| Wood | Werner, Felix | EMPA Research Award |
| | Zimmermann, Tanja/ Pöhler, Evelyn | Collano Innovation Award |

# EMPA Activities 2003
## PHD Theses

| | | | | |
|---|---|---|---|---|
| Acoustics | Thomann, Georg | Zuverlässigkeit von Fluglärmprognosen und die raumplanerischen sowie wirtschaftlichen Folgen von Berechnungsunsicherheiten<br>Co-Supervisor Empa: Dr Robert Hofmann | 2 | ETH Zürich,<br>Geomatics Engineering Dept. |
| Adaptive Material Systems | Belloli, Alberto | Active Control via Shunted Embedded Piezoelectric Fibers<br>Co-Supervisor Empa: Prof Urs Meier | 2 | ETH Zürich,<br>Information Technology and Electrical Engineering Dept. |
| | Niederberger, Dominik | Active Control via Shunted Embedded Piezoelectric Fibers<br>Co-Supervisor Empa: Prof Urs Meier | 2 | ETH Zürich,<br>Mechanical Engineering Dept. |
| Air Pollution/Environmental Technology | Gascho, Astrid | Simultaneous Characterisation of Oxygenated Volatile Organic Compounds in the Gas and Aerosol Phase<br>Co-Supervisor Empa: Dr Stefan Reimann | 2 | ETH Zürich,<br>Environmental Science Dept. |
| | Legreid, Geir | Emissions of Non-regulated Oxidised Volatile organic Compounds in the Polluted Troposphere by advaced GC-MS technology<br>Co-Supervisor Empa: Dr Stefan Reimann | 2 | ETH Zürich,<br>Environmental Science Dept. |
| | Li, Yingshi | Analysis of VOC data in Arosa in relation with ozone formation in the European background<br>Co-Supervisor Empa: Dr Stefan Reimann | 2 | ETH Zürich,<br>Environmental Science Dept. |
| | Schaub, Daniel | Pollution Transport to Switzerland Inferred from Satellite Observations<br>Co-Supervisor Empa: Dr Andrea Weiss | 2 | ETH Zürich,<br>Environmental Science Dept.. |
| | Ubl, Sandy | Source regions meteorological transport of air pollution modelled with a Lagrangian Particle Dispersion Model<br>Co-Supervisor Empa: Dr Andrea Weiss | 2 | ETH Zürich,<br>Environmental Science Dept. |
| Applied Physics in Building | Bionda, Davide | Sustained care of sensitive historical monuments<br>Co-Supervisor Empa: Dr Hans Simmler | 2 | ETH Zürich,<br>Architecture Dept. |
| | Tracy, Craig | Fire resistance of water-cooled FRP load carrying components<br>Co-Supervisor Empa: Dr Erich Hugi/Dr Karim Ghazi Wakili | 2 | EPF Lausanne,<br>Physics Dept. |
| Biocompatible Materials | Baumgartner, Franziska | Topographical surface effects on performance of adult human mesenchymal stem cells<br>Co-Supervisor Empa: Dr Arie Bruinink | 2 | ETH Zürich,<br>Materials Science Dept. |
| | Furrer, Patrick | Extraction, purification and customizing of PHA for medical applications<br>Co-Supervisor Empa: Dr Manfred Zinn | 2 | ETH Zürich,<br>Mechanical Engineering Dept. |
| Concrete/Construction Chemistry | Jenni, Andreas | Microstructural evolution and physical properties of polymer-modified mortars | 1 | University of Bern,<br>Microengineering Dept. |
| | Yang, Tianhe | AFM study of water sorption on surfaces of cementitious phases | 2 | ETH Zürich,<br>Materials Science Dept. |

1: submitted in 2003
2: in progress

# EMPA Activities 2003

## PHD Theses

| | | | | |
|---|---|---|---|---|
| **Corrosion and Materials Integrity** | **Hochstrasser, Sabine** | Corrosion Aspects of the EDM Process<br>Co-Supervisor Empa: Dr Patrick Schmutz | 2 | ETH Zürich, Materials Science Dept. |
| **Electronics/Metrology** | **Farnesi, Matteo** | Reliability and degradation physics on ultra-thin dielectrics<br>Supervisor Empa: Prof Louis Schlapbach<br>Co-Supervisor Empa: Dr Urs Sennhauser | 2 | EPF Lausanne, Microengineering Dept. |
| | **Gundu, Phanindra** | Adaptive phase and amplitude modulation of speckeld laser light<br>Co-Supervisor Empa: Dr Erwin Hack/ Dr Urs Sennhauser | 2 | EPF Lausanne, Physics Dept. |
| | **Jud, Pascal** | Reliabilty of lead-free solder<br>Co-Supervisor Empa: Dr Urs Sennhauser | 2 | ETH Zürich, Materials Science Dept. |
| | **Thurner, Philipp** | Imaging of cellular and extra-cellular stressed matter using synchrotron radiation based micro-computed tomography<br>Co-Supervisor Empa: Dr Urs Sennhauser | 2 | ETH Zürich, Materials Science Dept. |
| | **Zhou, Ling** | Reliability, Availability and Maintainability of Optical Networks<br>Co-Supervisor Empa: Dr Urs Sennhauser | 2 | ETH Zürich, Informatics Dept. |
| **Energy Systems/ Building Equipment** | **Weber, Tim** | Low Energy and Low Exergy Buildings<br>Co-Supervisor Empa: Markus Koschenz | 2 | Stockholm Royal Institute of Technology (SE), Civil Engineering Dept. |
| **Functional Fibers and Textiles** | **Hufenus, Rudolf** | Basics and Parameters for the Design of Geosynthetic Reinforced Soil Structures | 2 | ETH Zurich, Industrial Management and Manufacturing Engineering Dept. |
| **Functional Polymers** | **Hartmann, René** | Functionalized Polyhydroxyalkanoates with Tailor-Made Properties: Biosynthetic and Chemical Approaches | 2 | ETH Zürich, Materials Science Dept. |
| **High Performance Ceramics** | **Heiber, Juliane** | Herstellung flexibler piezoelektrischer Fasern | 2 | Technical University Illmenau (DE), Mechanical Engineering Dept. |
| | **Akurati, Kranthi Kumar** | Synthesis and characterization of photocatalytic active nanoparticles | 2 | University of Duisburg/Essen (DE), Materials Science Dept. |
| | **Bayraktar, Defne** | Modelling and operation analysis of dense ceramic oxygen separation tubes used in partial oxidation of natural gas to synthesis gas | 2 | EPF Lausanne, Materials Science Dept. |
| | **Guo, Zhiquan** | Development of nanostructured $Si_3N_4$ and $Si_3N_4$-based composites for high temperature sensing | 2 | University of London (GB), Microengineering Dept. |
| | **Alexandre, Thomas** | Solid free-form fabrication of porous ceramic parts from ceramic powders and preceramic polymers<br>Co-Supervisor Empa: Dr Oliver Beffort/Dr Ulrich Vogt | 2 | EPF Lausanne, Mechanical Engineering Dept. |
| **I.C. Engines/Furnaces** | **Ajtay, Delia** | Transient modelling of motor vehicle emissions | 2 | ETH Zürich, Materials Science Dept. |
| | **Lämmle, Christian** | Modelling of natural gas driven engines | 2 | ETH Zürich, Materials Science Dept. |
| | **Mathis, Urs** | Investigation of nanoparticles from combustion processes<br>Co-Supervisor Empa: Martin Mohr | 2 | ETH Zürich, Materials Science Dept. |
| **Inorganic Analytical Chemistry/Characterization of Solids** | **Barrelet, Thimotée** | Quantification of sulfur content in living Picea abies (Norway spruce)<br>Co-Supervisor Empa: Dr Andrea Ulrich | 2 | University of Bern, Physics Dept. |
| | **Senn-Bischofberger, Marianne** | Das Schmiedehandwerk in der nordalpinen Schweiz von der Eisenzeit bis ins Frühmittelalter<br>Co-Supervisor Empa: Dr Heinz Vonmont | 1 | University of Zurich, Primitive and Ancient History Dept. |
| **Joining and Interface Technology** | **Galli, Matteo** | Metal-Ceramic Joints<br>Co-Supervisor Empa: Dr Jolanta Janzcak-Rusch | 2 | EPF Lausanne, Engineering Dept. |

1: submitted in 2003
2: in progress

# EMPA Activities 2003

## PHD Theses

| | | | | |
|---|---|---|---|---|
| | Wilhelm, Gerald | MSG-Hochleistungsschweissen standardaustenitischer Stähle<br>Co-Supervisor Empa: Dr Marc Harzenmoser | 2 | Technical University of Chemnitz (DE), Materials Science Dept. |
| Materials Technology | Gassilloud, Rémy | Metallic nanopatterning by electrochemical deposition on prescratched semiconductors<br>Co-Supervisor Empa: Dr Phillipe Kern | 2 | Universitiy of Erlangen (DE), Materials Science Dept. |
| | Jäggi, Christian | Electrochemical micro- and nano-machining of titanium through an artificially grown oxide mask<br>Co-Supervisor Empa: Dr Phillipe Kern | 2 | University of Bern, Materials Science Dept. |
| | Keller, Thomas | Pore morphology in thermally sprayed nickelbased deposits and the influence on deposit properties<br>Co-Supervisor Empa: Dr Stefan Siegmann | 1 | ETH Zürich, Physics Dept. |
| | Kleiner, Simon | Thixocasting, Textur und mechanische Anisotropie von stranggepressten Magnesiumlegierungen<br>Co-Supervisor Empa: Dr Oliver Beffort | 1 | ETH Zürich, Materials Science Dept. |
| | Niederberger, Christophe | Experimental study and numerical modelling of intragranular variations of the crystallographic orientations in hot dipped Al-Zn and Zn-Al coatings<br>Co-Supervisor Empa: Dr Johannes Michler | 2 | EPF Lausanne, Materials Science Dept. |
| | Pouvreau, Cédric | Fundamentals of Nano-scaled Crack Propagation for Processing of Semiconductor Devices<br>Co-Supervisor Empa: Dr Christophe Ballif | 2 | EPF Lausanne, Microeingineering Dept. |
| | Rabe, Rodolfo | Development of a Smart Nanorobot for Sensor-based Handling in a Scanning Electron Microscope<br>Co-Supervisor Empa: Dr Johannes Michler | 2 | EPF Lausanne, Microengineering Dept. |
| | Schreuders, Cornelis | Fundamentals of nanopowders made by RF-Plasma synthesis<br>Co-Supervisor Empa: Dr Marc Leparoux | 2 | ETH Zürich, Engineering Dept. |
| | Shin, Jong-Wong | In-situ-monitoring of the Systhesis of Nano-Powders by a RF Thermal Plasma<br>Co-Supervisor Empa: Dr Stefan Siegmann | 2 | EPF Lausanne, Research Center of Plasma Physics |
| | Stauss, Sven | Assessment of mechanical properties at the micro- and nanometre range by indentation techniques<br>Co-Supervisor Empa: Dr Johannes Michler | 2 | EPF Lausanne, Materials Science Dept. |
| | Zenke, Jörg | Development of a Smart Nanorobot for Sensor-based Handling in a Scanning Electron Microscope<br>Co-Supervisor Empa: Dr Johannes Michler | 2 | University of Oldenburg (DE), Informatics Dept. |
| Mathematics, Imaging and Materials | Mourad, Safer | Color predicting model for electrophotographic prints on common office paper | 1 | EPF Lausanne, Mechanical Technology Dept. |
| nanotech@surfaces | Bielmann, Michael | Surface Science Aspects in Tribology<br>Supervisor Empa: Prof Louis Schlapbach<br>Co-Supervisor Empa: Dr Pierangelo Gröning | 2 | University of Fribourg, Physics Dept. |
| Organic Chemistry | Dietsch, Hervé Alain | Nanoparticles hybrid systems: interactions, local structure and mobility<br>Co-Supervisor Empa: Dr Beat A. Keller | 2 | University of Fribourg, Physics Dept. |
| | Tang, Clarence | Electric Field Assisted Bottom-Up Formation of Patterned Self-Assembly and Thin Film Structures on Various Substrates<br>Co-Supervisor Empa: Dr Beat A. Keller | 2 | ETH Zürich, Materials Science Dept. |
| Polymers/Composites | Snedeker, J.G. | A Detailed Finite Element Model of the Kidney for Use in Trauma Research<br>Co-Supervisor Empa: Prof Dr Mehdi Farshad | 2 | ETH Zürich, Materials Science Dept. |

1: submitted in 2003
2: in progress

# EMPA Activities 2003

## PHD Theses

| | | | | |
|---|---|---|---|---|
| **Strength and Technology** | **Lochmatter, Patrick** | Development of a Shell-like Electroactive Polymer (EAP) Actuator<br>Co-Supervisor Empa: Dr Gabor Kovacs | 2 | ETH Zürich, Materials Science Dept. |
| | **Wissler, Michael** | Modelling of Electroactive Materials<br>Co-Supervisor Empa: Prof Mehdi Farshad | 2 | ETH Zürich, Materials Science Dept. |
| | **Zhang, Rui** | Advanced actuators for a portable force feedback device | 2 | ETH Zürich, Materials Science Dept. |
| **Structural Engineering** | **Barrot, François** | Smart sensors network for seismic and structural health monitoring<br>Co-Supervisor Empa: Dr Glauco Feltrin | 2 | EPF Lausanne, Mechanical Engineering Dept. |
| | **Hejll, Arvid** | Fault Detection by Curvature Estimation with Fiber Optic Sensors<br>Co-Supervisor Empa: Dr Glauco Feltrin/Dr Masoud Motavalli | 2 | University of Technology, Lulea (SE), Civil Engineering Dept. |
| | **Ludescher, Hannes** | Berücksichtigung von dynamischen Verkehrslasten beim Tragsicherheitsnachweis von Strassenbrücken<br>Co-Supervisor Empa: Dr Glauco Feltrin | 1 | EPF Lausanne, Mechanical Engineering Dept. |
| | **Schubert, Sandy** | Influence of fungal decay on elastic wave propagtion in wood<br>Co-Supervisor Empa: Dr Masoud Motavalli/Dr Daniel Gsell | 2 | ETH Zürich, Forest Science Dept. |
| | **Ullner, Robert** | Verbund von Spanngliedern<br>Co-Supervisor Empa: Dr Masoud Motavalli/Christoph Czaderski | 2 | ETH Zürich, Mechanical Engineering Dept. |
| | **Vanomsen, Pierre** | Einfluss der Durchforstung auf die Wurzelverankerung<br>Co-Supervisor Empa: Dr Glauco Feltrin | 2 | ETH Zürich, Forest Science Dept. |
| **Surfaces, Coatings, Magnetism** | **Behzadi-Arab, Bahar** | Synthesis of Supramolecular Chiral Films<br>Co-Supervisor Empa: Dr Karl-Heinz Ernst | 2 | ETH Zürich, Physics Dept. |
| | **Cancio, Joao Carlos** | Multilayer and Nanocomposit Hard Nitride Coatings<br>Co-Supervisor Empa: Dr Jörg Patscheider | 2 | EPF Lausanne, Physics Dept. |
| **Technology and Society** | **Ossés, Margarita** | Development of Remote Sensing and GIS-based Indicators for the sustainable management of jute<br>Co-Supervisor Empa: Dr Rainer Zah | 2 | University of Zürich, Geography, Remote Sensing Laboratories |
| | **Scharnhorst, Wolfram** | Transition from the second generation to the third generation mobilephone system in Western Europe – environmental assessment of the use and disposal phases<br>Co-Supervisor Empa: Prof Lorenz Hilty | 2 | EPF Lausanne, Mechanical Engineering Dept. |
| **Wood** | **Klingner, Raoul** | Thermodynamics of hornet nests<br>Co-Supervisor Empa: Prof Dr Jürgen Sell | 2 | ETH Zürich, Architecture Dept. |
| | **Zimmermann, Tanja** | Structural and chemical analysis of the wood cell wall fine structure by innovative methods<br>Co-Supervisor Empa: Prof Dr Jürgen Sell | 2 | University of Hamburg (DE), Wood Biology Chair |

1: submitted in 2003
2: in progress

# EMPA Activities 2003
## Patents

### Patents granted

| | | | |
|---|---|---|---|
| CFRP In Structural Engineering | Meier, Urs | Verankerung für Hochleistungsfaserverbundwerkstoff-Drähte | NO 315951 |
| | Meier, Urs/ Stöcklin, Iwan | Verfahren und Vorrichtung zum Applizieren von vorgespannten, zugfesten Verstärkungsbändern an Bauwerken | EP 1058 761 B1 |
| | Meier, Urs/ Winistörfer, Andreas | Mehrlagiges Schlaufenelement | EP 0815 329 B1 |
| Functional Fibers and Textiles | Moser, Eva Maria | Polar Polymeric Coating | EP 1051266 |
| High Performance Ceramics | Englisch, Christian/ Berroth, Karl | Keramik-Metall oder Metall-Keramik-Komposite | CH-692 296 |
| Materials Technology | Kleiner, Simon/Fuchs, Marc/Bologna, Roberto | Verfahren und Vorrichtung zum Druckgiessen | DE 101 58 218 A 1 |
| Mathematics, Imaging and Materials | Dätwyler, Markus/ Heuberger, Karl/Künzli, Hansjörg/Paritz, Stefan | MiniTarget | 196 38 967.4 |
| | Heuberger, Karl/ Dätwyler, Markus | Messfeldblock | 197 38 992.9 |
| Polymers/Composites | Farshad, Mehdi | Verankerungssystem zur Aufnahme der Zugkräfte von kohlenstofffaserverstärkten Zugbändern (CFK-Bänder) | 693 616 |

### Patents applied for

| | | | |
|---|---|---|---|
| Concrete/Construction Chemistry | Kaufmann, Josef | Hochleistungsmörtel auf der Basis von Feinzement | 02012/03 |
| Electronics/Metrology | Reiner, Joachim/ Gasser, Philippe | Präparationsmethode für eine TEM-Lamelle | EP03 405 261.3<br>US10/414.422 |
| Energy Systems/ Building Equipment | Koschenz, Markus/ Lehmann, Beat/ Holst, Stefan | Thermoaktives Wand- und Deckenelement | PCT/CH03/00081 |
| Functional Fibers and Textiles | Halbeisen, Marcel/ Schift, Helmut/ Schütz, Urs | Verfahren zur Oberflächenstrukturierung einer synthetischen Faser, Vorrichtung zur Durchführung des Verfahrens sowie rundum flächig profilierte Faser | CH P-7404 00 |
| High Performance Ceramics | Köbel, Stefan/ Vogt, Ulrich/Ortona, A. | A.Composit-Werkstoff für keramische Heizelemente sowie Verfahren zu seiner Herstellung | 0161/03 |

# Patents

| | | | |
|---|---|---|---|
| | Lemster, Katja/ Kübler, Jakob | Keramik-Metall oder Metall-Keramik-Komposite | PCT/CH 03/007 |
| I.C. Engines/Furnaces | Schmatloch, Volker | Elektrodenmerkmale für Rauchgasreinigung an Kleinfeuerungen | CH 02042/03 |
| Joining and Interface Technology | Zigerlig, Benno/ Burkhard, Gregor/ Kiser, Manfred | Verfahren zur Herstellung eines abrasiven Werkzeugs | 0726/03 |
| Materials Technology | Siegmann, Stephan/ Zysset, Lukas/ Brenner, Max | Keramisches Kochgefäss, insbesondere ein Fonduecaquelon | 02 203/03 |
| Polymers/Composites | Farshad, Mehdi | Verfahren und System-Anordnung zur magneto-elastischen Erzeugung von Schwingungen in magneto-aktiven Elastomeren sowie deren Verwendung | 01854/03 |
| Protection and Physiology | Weder, Markus | Kühlender Helm | 02085/03 |
| | Weder, Markus | Kühlendes Kleidungsstück für Sportler | 0106/03 |

# EMPA Activities 2003
## Teaching Activities

**Swiss Federal Institute of Technology, Zürich (ETH)**

| | | |
|---|---|---|
| Architecture | Eggenschwiler, K. | Raumakustik |
| | Frank, Th. | Special issues on building physics |
| Civil Engineering | Flüeler, P. | Baustoffkunde Teil II: Kunststoffe |
| | Flüeler, P./Dr Geiger, T. | Kunststoffe im Bauwesen |
| | Prof Dr Sell, J. | Baustoffkunde II: Holz |
| | v. Trzebiatowski, O. | Baustoffkunde II: Metalle |
| | Prof Dr Sell, J. | Holz und Holzwerkstoffe |
| Computer Vision Laboratory | Dr Bruinink, A. | Physical methods of cell biology |
| Electrical Engineering | Dr Sennhauser, U. | Physik der Ausfälle und Ausfallanalyse elektronischer Schaltungen |
| | Dr Sennhauser, U./Held, M. | Zuverlässigkeit von Schaltungen und Systemen |
| Forest Sciences | Dr Richter, K. | Qualität und Dauerhaftigkeit im Holzbau |
| | Prof Dr Sell, J. | Holz/Holzverwendung Umwelt |
| | Dr Steiger, R. | Maschinelle Holzsortierung und Holzbaunormen |
| Geomatics Engineering | Eggenschwiler, K. | Lärmbekämpfung |
| | Dr Hofer, P. | Luftreinhaltung I |
| | Dr Hofer, P. | Luftreinhaltung II |
| | Dr Hofer, P. | Luftreinhaltung – gesetzliche und technische Möglichkeiten |
| Informations Technology | Dorer, V. | Technik erneuerbarer Energien |
| | Dr Heutschi, K. | Akustik 1 und 2 |
| | Dr Heutschi, K. | Akustisches Kolloquium |
| | Dr Simon, K. | Bild – Farbe – Reproduktion |
| Photogrammetry and Remote Sensing | Dr Zah, R. | NDS-RIS |
| Materials Engineering | Dr Beffort, O. | Metallische Verbundwerkstoffe |
| | Flüeler, P. | Werkstoffversagen in der Praxis, Teil Kunststoffe |
| | Dr Graule, T. | Werkstoffversagen in der Praxis, Teil Keramik |

# Teaching Activities

| | | | |
|---|---|---|---|
| | | Dr Harzenmoser, M./ Neccola, A. | Moderne Fügetechnik |
| | | Keller, B.A./Heuberger, M./ Spencer, N. | Surfaces and Interfaces |
| | | Dr Roth, M. | Angewandte Metallkunde II |
| | | Dr Roth, M. | Werkstoffversagen |
| | Materials Science | Dr Clemens, F. | Verbundwerkstoffe |
| | | Dr Lienemann, P. | Materialwissenschaften |
| | | Dr Lüthi, Th. | Werkstoffprüfung |
| | | Prof Meier, U. | Grundlagen zum Bemessen von Kunststoffbauteilen |
| | | Prof Meier, U. | Verbundwerkstoffe |
| | | Prof Meier, U. | Materialwissenschaften |
| | | Dr Schmutz, P. | Korrosion und Korrosionsschutz I |
| | Mechanical Engineering | Kovacs, G. | Seilbahntechnik |
| | Mineralogy, Petrography | Dr Vonmont, H. | Physikalische Methoden der Mineral- und Gesteinsanalyse |
| | Process Engineering | Prof Dr Farshad, M. | Dimensionierungskriterien bei Strukturinstabilitäten |
| | | Prof Dr Farshad, M. | Anwendung der Methode der Finiten-Elemente in der Biomechanik |
| Insitute of Applied Sciences, Yverdon (EIVD) | Media | Hischier, R. | Ökobilanzen/UMS |
| National School for Textiles, Roubaix, France | | Dr Rossi, R. | L'être humain et son environnement – Introduction à la thermophysiologie |
| | | Dr Rossi, R. | Vêtements de protection: le dilemme entre la protection et l'ergonomie |
| School of Engineering, Lausanne | Informations Technology | Dr Münger, K. | Ecology, Quality |
| | | Schefer, H. | Informatik |
| Swisscontact Costa Rica | Environmental Engineering | Dr Emmenegger, L. | Emission monitoring |
| Swiss Federal Institute for Environmental Science and Technology (EAWAG), Dübendorf | | Dr Meyer, V.R. | Measurement Uncertainty in Analytical Chemistry |
| Swiss Technical School of Graphics, Zürich | | Hischier, R./Dr Harzenmoser, M. | Ökologie |
| University of Applied Sciences, Basel | | Baschnagel, K./Würzer, M./ Eggenschwiler, K./Emrich, F./ Dr Heutschi K./Studer M./ Walk, M./Wunderli, J. M./ Würzer M. | Messpraktikum Umweltakustik/Bauakustik |
| University of Applied Sciences, Bern | Materials Engineering | Dr Graule, T. | Werkstofftechnik |
| | | Kübler, J. | Werkstofftechnik |
| | | Dr Vogt, U. | Werkstofftechnik |

# EMPA Activities 2003

## Teaching Activities

| | | | |
|---|---|---|---|
| University of Applied Sciences, Biel | Materials Technology | Dr Lienemann, P./Dr Vonmont, H. | Chemische Analytik in der Werkstofftechnik |
| University of Applied Sciences, Burgdorf | Mechanical Engineering | Dr Beffort, O. | Leichtmetalle |
| | | Dr Keller, B.A. | Werkstofftechnik |
| | | Dr Michler, J./Dr Schwaller, P. | Tribologie, Topografie |
| | | Dr Rohr, L. | Einführung in die Oberflächentechnologie |
| | Materials Engineering | Dr Siegmann, St. | Thermische Beschichtungstechnik |
| University of Applied Sciences, Chur | Materials Science | Dr Schirle, M. | Kleben und Klebstoffe |
| University of Applied Sciences, Luzern | Building Technology | Dorer, V. | Natürliche Lüftung |
| | | Frank, Th./Dr Ghazi K./ Dr Hugi, E./Dr Manz, H./ Dr Simmler, H. | Bauphysik / Energie III |
| | | Koschenz, M. | Thermoaktive Bauteilsysteme |
| University of Applied Sciences, Rapperswil | Materials Engineering | Kübler, J. | Werkstoffkunde – Teil Hochleistungskeramik |
| | Civil Engineering | Dr Manz, H. | Bauphysik |
| | Mechanical Engineering | Dr Weilenmann, M. | Messtechnik |
| University of Applied Sciences, Wädenswil | Biotechnology | Dr Buchmann, B. | Luftschadstoffe |
| University of Applied Sciences, Windisch | Technology | Flüeler, P. | Kunststofftechnik, Spezialkurs Spritzgiessen und Extrudieren, Teil: Methode der Fertigteilprüfung |
| University of Applied Sciences, Winterthur | Chemistry | Dr Lienemann, P. | Elementanalytik |
| | | Dr Lienemann, P. | Organische Strukturanalyse |
| | Analytical and Bioanalytical Chemistry | Dr Wampfler, B. | Validation of analytical procedures – basics |
| University of Applied Sciences, Zürich | Civil Engineering | Dr Moser, K. | Materialtechnologie Beton |
| | | Zimmermann, T. | Materialtechnologie Holz |
| University of Basel | | Prof Dr Hilty, L. | Informationsgesellschaft und nachhaltige Entwicklung |
| University of Bern | Chemistry and Biochemistry | Dr Meyer, V. | Measurement Uncertainty in Analytical Chemistry |
| University of Frascati (I) International Summerschool | Physics | Dr Gröning, O. | Field Emission of Carbon Nanostructures: From Diamond to Nanotubes |
| University of Freiburg (D) | Forest Sciences | Schwarze, F. | Forstpathologie |
| | Mineralogy | Dr Vogt, U. | Hochleistungskeramik |
| University of Fribourg | Physics | Dr Gröning, P./Dr Ruffieux, P. | Einführung in die kondensierte Materie |
| University of Leoben (A) | General and Analytical Chemistry | Dr Rösslein, M. | Measurement Uncertainty in Analytical Chemistry |
| Webster University, Geneva | Ecology | Ruddy, T. | Challenges of Diplomacy |

# Publications

## Special Topics


**Cetinkaya, N./Viehweg, S.** Mentoring – Talentförderung konkret. Alpha – der Kadermarkt der Schweiz 2003, July 5, 1 p.

**Edelmann, X.** Stellenwert der Normung im Welthandel, für die Schweiz und für die KMUs. SNV Bulletin 2003, 52(7/8), 85–86

**Meier, U.** Die Empa – von der Materialprüfungsanstalt der Gründerzeit zur Technologieinstitution des 21. Jahrhunderts. Die Volkswirtschaft 2002, 75(12), 58–60

**Meier, U.** L'Empa: du laboratoire d'essai des matériaux de la seconde révolution industrielle à l'institution technologique du XXIe siècle. La Vie économique 2002, 75(12), 58–60

**Schlapbach, L.** Innovation für die Gesellschaft. Vision 2002, 10(2), 6–9


## Advanced Materials and Surfaces


**Bielmann, M./Ruffieux, P./Schwaller, P./Sudan, P./Schlapbach, L./Gröning, P.** The H-2 plasma treatment of silver contacts: Impact on wire-bonding performance. Journal of electronic materials 2003, 31(12), 1316–1320 (second entry; for main entry, see under first author in Dept "Advanced Materials and Surfaces", Lab "nanotech@surfaces") ⋆

**Bovet, M. /van Smaalen, S./Schlapbach, L. et al.** Interplane coupling in the quasi-two-dimensional 1T-TaS2. Physical review B 2003, 67(12), 125105 ⋆ •

**Collaud Coen, M./Lehmann, R./Gröning, P./Schlapbach, L.** Modification of the micro- and nanotopography of several polymers by plasma treatments. Applied surface science 2003, 207(1–4), 276–286 (second entry; for main entry, see under first author in Dept "Advanced Materials and Surfaces", Lab " nanotech@surfaces ") ⋆

**Emmenegger; C./Bonard, J.M./Schlapbach, L. et al.** Synthesis of carbon nanotubes over Fe catalyst on aluminium and suggested growth mechanism. Carbon 2003, 41(3), 539–547 ⋆ •

**Galli Marxer, C./Collaud Coen, M./Schlapbach, L.** Study of adsorption and viscoelastic properties with a quartz crystalmicrobalance by measuring the oscillation amplitude. Journal of colloid and interface science 2003, 261(2), 291–298 ⋆ •

**Galli Marxer, C./Collaud Coen, M./Schlapbach, L. et al.** Simultaneous measurement of the maximum oscillation amplitude and the transient decay time constant of the QCM reveals stiffness changes of the adlayer. Analytical and bioanalytical chemistry 2003, 377(3), 570–577 ⋆

**Galli Marxer, C./Collaud Coen, M./Schlapbach, L. et al.** Cell spreading on quartz crystal microbalance elicits positive frequency shifts indicative of viscosity changes. Analytical and bioanalytical chemistry 2003, 377(3), 578–586 ⋆

**Gröning, P./Ruffieux, P./Schlapbach, L./Gröning, O.** Carbon nanotubes for cold electron sources. Advanced engineering materials 2003, 5(8), 541–550 (second entry; for main entry, see under first author in Dept "Advanced Materials and Surfaces", Lab " nanotech@surfaces ") ⁎

**Hayoz, J./Koitzsch, C./Schlapbach, L. et al.** Electronic structure of the YH3 phase from angle-resolved photoemission spectroscopy. Physical review letters 2003, 90(19), 196804 ⋆ •

**Koitzsch, C./Bovet, M./Schlapbach, L. et al.** Growth of thin Bi films on W(110). Surface Science 2003, 527(1–3), 51–56 ⋆ •


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⁎ Science Citation Index Expanded SCIE (multiple entries)
• performed outside Empa

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|---|---|---|
| | Lupu, D./Biris, A.R./ Schlapbach, L. et al. | Cobalt-free over-stoichiometric Laves phase alloys for Ni-MH batteries. Journal of alloys and compounds 2003, 350(1–2), 319–323 ⋆ • |
| | Orimo, S.-I./Züttel, A./ Schlapbach, L. et al. | Hydrogen interaction with carbon nanostructures: current situation and future prospects. Journal of alloys and compounds 2003, 356, 716–719 ⋆ |
| | Ruffieux, P./Gröning, O./ Bielmann, M./Mauron, P./ Schlapbach, L./Gröning, P | Hydrogen adsorption on sp(2)-bonded carbon: Influence of the local curvature. Physical review B. 2002, 66(24), 245416 (second entry; for main entry, see under first author in Dept "Advanced Materials and Surfaces", Lab " nanotech@surfaces ") ⋆ |
| | Sudan, P./Züttel, A./ Schlapbach, L. et al. | Physisorption of hydrogen in single-walled carbon nanotubes. Carbon 2003, 41(12), 2377–2383 ⋆ • |
| Corrosion and Materials Integrity | Faller, M./Richner, P. | Material selection of safety-relevant components in indoor swimming pools. Materials and Corrosion 2003, 54(5), 331–338 ⋆ |
| | Faller, M./Richner, P. | Sicherheitsrelevante Bauteile in Hallenbädern – Werkstoffauswahl und Kontrollierbarkeit. In: Seminar RVS in zwembadtoepassingen, Made, Netherlands, November 14, 2002, Publ. in: Syllabus no. 61 of the Dutch corrosion centre, p. 109–131 |
| | Faller, M./Von Trzebiatowski, O. | Atmosphärische Korrosion – ein Problem für die Umwelt? VDI-Berichte Nr. 1765, 2003, p. 151–172. |
| | Gusev, A.A./Guseva, O. | Voltage breakdown in random composites. Advanced engineering materials 2003, 5(10), 713–715 ⁎ |
| | Guseva, O./Brunner, S./. Richner, P | Service life prediction for aircraft coatings. Polymer degradation and stability 2003, 82(1), 1–13 ⋆ |
| | Reiss, D./Faller, M./Guseva, O. | Results from the multipollutant programme: Corrosion attack on zinc after 1, 2 and 4 years of exposure (1997–2001), within the scope of the UN/ECE convention on long-range transboundary air pollution, an international co-operative programme on effects on materials, including historic and cultural monuments, Empa Dübendorf, June 2003, 56 p. Empa research report no. 136/43 |
| | Schmutz, P./Lips, K./Müller, Y./ Uggowitzer, P.J./Virtanen, S. | Corrosion mechanisms on Mg alloys as a function of Al composition, microstructure and protection strategies. In: 204th Electrochemical society meeting, Orlando, FL, USA, October 12–16, 2003, CD, 11 p. |
| | Trüllinger, S./Zgraggen, M. | Neues zu asiatischen Krisen: Ein Aufsatz zur Untersuchung an historischen Waffen. Helvetia archaeologica 2002, 33(131-132), 144-150 |
| | Von Trzebiatowski, O./ Schicker, M./Kürsteiner, J./ Sidler, Th./Schleuniger, J. | Arbeitstechnik – Qualitätssicherung bei Lackierarbeiten. JOT Journal für Oberflächentechnik Schweiz Spezial 2003, 43(10), VIII-X |
| Functional Polymers | Banerjee, D./Studer, B./ Rentsch, D./Furrer, G. | Acid–base chemistry of aqueous aluminium nanoclusters. In: 7th Int. conference on the biogeo chemistry of trace elements ( ICOBTE), Uppsala, Sweden, June 15–19, 2003, p. 496–497 |
| | Banerjee, D./Studer, B./ Rentsch, D./Furrer, G. | Chemical reactivity and stability of aluminium nanoclusters in aqueous environments. In: Int. workshop on biogeochemical controls on the mobility and bioavailability of metals in soil and groundwater, Ascona, Switzerland, March 2–7, 2003, p. 5 |
| | Crenshaw, B./Löwe, Ch./ Weder, Ch. | Photoluminescent Polymerblends. Polym. Mater. Sci. Eng. 88, 2003, p. 505 |
| | Flüeler, P./Böhni, H./Zwicky, P./ Löwe, Ch./Kramer, H./ Farshad, M. | Waterproofing systems for Swiss alpine base tunnels – Testing and evaluation. In: Plastics forum 2003, Brussels, Belgium, June 12–14, 2003, CD, 17 p. (second entry; for main entry, see under first author in Dept "Materials and Systems for Civil Engineering", Lab "Polymers/Composites") |
| | Flüeler, P./Farshad, M./ Löwe, Ch./Kramer, H. | New evaluation procedure of the waterproofing systems for the Swiss Alpine base tunnels. In: ITA world tunnelling congress, Amsterdam, Netherlands, April 12–17, 2003. Publ. in: (Re)claiming the underground space, ed.: J. Saveur, Lisse: Balkema, 2003, vol. 1, p. 441–447. ISBN 90-5809-542-8 (second entry; for main entry, see under first author in Dept "Materials and Systems for Civil Engineering", Lab "Polymers/Composites") |
| | Nagel, M./Frater, G./ Hansen, H.-J. | Synthesis of macrocyclic ketones by repeatable two-carbon ring expansion reactions. Chimia 2003, 57(4), 196–199 ⋆ |
| | Rentsch, D./Hany, R. et al. | Improved reproducibility of chemical reactions on purified polystyrene resins monitored by $^{31}$P MAS NMR. Tetrahedron letters 2003, 44(37), 6987–6990 ⋆ |



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**High Performance Ceramics**

**Rentsch, D./Hany, R. et al.** Quantitative determination of loadings and oxidation products of polystyrene-bound phosphines using $^{31}$P MAS NMR. Journal of combinatorial chemistry 2003, 5(5), 610-616 ⋆

**Rüedi, G./Nagel, M./ Hansen, H.-J.** Stereo- and regioselectivity in dynamic gas-phase thermoisomerization (DGTI): novel route to α-campholanic acid and derivates. Organic letters 2003, 5(15), 2691–2693 ⋆

**Rüedi, G./Nagel, M./ Hansen, H.-J.** Novel diradical-mediated ring opening reactions. Synlett 2003, (8), 1210–1212 ⋆

**Zimmermann, T./Pöhler, E./ Geiger, Th.** Cellulosefibrillen für die Polymerverstärkung. In: 4th Int. symposium über Werkstoffe aus nachwachsenden Rohstoffen (naro.tech) , Erfurt, Germany, September 11–12, 2003, CD, Sektion 4-05, 10 p. (second entry; for main entry, see under first author in Dept "Materials and Systems for Civil Engineering", Lab "Wood")

**Zinn, M./Weilenmann, H.-U./ Hany, R./Schmid, M./Egli. Th.** *Tailored synthesis* of poly([*R*]-3-hydroxybutyrate-*co*-3-hydroxyvalerate) (PHB/HV) in *Ralstonia eutropha* DSM 428. Acta biotechnologica 2003, 23(2–3), 309–316 (second entry; for main entry, see under first author in Dept "Materials and Systems for Protection and Wellbeing of the Human Body", Lab "Biocompatible Materials") ⋆

**Beffort, O./Kübler, J./ Cayron, C./Buffat, Ph.-A.** Einfluss von Legierungselementen auf mechanische Eigenschaften und Ausbildung der Grenzfläche in Al/SiC-Verbundwerkstoffen. In: 14. DGM-Symposium über Verbundwerkstoffe und Werkstoffverbunde, Vienna, Austria, July 2–4, 2003. Weinheim: Wiley-VCH, p. 61–66. ISBN 3-527-30762-1 (second entry; for main entry, see under first author in Dept "Advanced Materials and Surfaces", Lab "Materials Technology")

**Blugan, G./Kübler, J. et al.** Keramische Mehrschicht-Laminate aus Siliziumnitrid und einem Komposit aus Siliziumnitrid/ Titannitrid. In: 14. DGM-Symposium über Verbundwerkstoffe und Werkstoffverbunde, Vienna, Austria, July 2–4, 2003. Weinheim: Wiley-VCH, p. 337–342. ISBN 3-527-30762-1

**Clemens, F./Wegmann, M./ Graule, T.J. et al.** Computing fibers: a novel fiber for intelligent fabrics? Advanced engineering materials 2003, 5(9), 682–687 ⁎

**Herzog, A./Vogt, U.** Kurzfaserverstärktes reaktionsgebundenes Siliciumnitrid. In: 14. DGM-Symposium über Verbundwerkstoffe und Werkstoffverbunde, Vienna, Austria, July 2–4, 2003. Weinheim: Wiley-VCH, p. 411–416. ISBN 3-527-30762-1

**Herzog, A./Vogt, U./Graule, T.J.** Biomorphe SiC-Keramik mit orientierter Porenstruktur. In: 14. DGM-Symposium über Verbundwerkstoffe und Werkstoffverbunde, Vienna, Austria, July 2–4, 2003. Weinheim: Wiley-VCH, p. 779–784. ISBN 3-527-30762-1

**Holtappels, P./Stimming, U.** Solid oxide fuel cells (SOFC). In: Handbook of fuel cells – fundamentals, technology and applications, eds: W. Vielstich, A. Lamm and H.A. Gasteiger, vol. 1, part 4, p. 335–354. ISBN 0-471-49926-9.

**Holtappels, P./Graule, T.J./ Gut, B./Vogt, U. et al.** Fabrication and performance of anode supported solid oxide fuel cells. In: 8th Int. symposium on solid oxide fuel cells (SOFC VIII), Paris, France, April 27–May 2, 2003, Electrochemical society proceedings, vol. 2003-7, p. 1003 ff

**Hopfe, V./Sheel, D.W./ Vogt, U. et al.** In-situ monitoring for CVD processes. Thin solid films 2003, 442(1–2), 60–65 ⋆

**Klingner, R./Sell, J./ Zimmermann, T./Herzog, A./ Vogt, U./Graule, T.J./ Thurner,Ph. et al.** Wood-derived porous ceramics via infiltration of $SiO_2$-Sol and carbothermal reduction. Holzforschung 2003, 57(4), 440–446 ⋆

**Kübler, J./Lemster, K./ Graule, T.J. et al.** Eisenbasislegierung/Oxidkeramik – MMCs durch reaktive Schmelzinfiltration. In: 14. DGM-Symposium über Verbundwerkstoffe und Werkstoffverbunde, Vienna, Austria, July 2–4, 2003. Weinheim: Wiley-VCH, p. 73–78. ISBN 3-527-30762-1

**Trentini, E./Kübler, J./ Sglavo, V.M.** Comparison of the sandwiched beam (SB) and opposite roller loading (ORL) techniques for the pre-cracking of brittle materials. Journal of the european ceramic society 2003, 23(8), 1257-1262 ⋆

**Vaucher, S./Beffort, O./ Kübler, J. et al.** An orthotropic magnesium-carbon composite as a lightweight heat-guide material with high specific stiffness and radiation transparency. Advanced engineering materials 2003, 5(9), 669–672 (second entry; for main entry, see under first author in Dept "Advanced Materials and Surfaces", Lab "Materials Technology") ⁎

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# Publications

## Joining and Interface Technology

**Vital, A./Klotz, U.E./ Graule, T.J. et al.**
Synthesis of spherical, non-aggregated silica nanoparticles. In: Nato advanced research workshop on nanostructured materials and coatings in biomedical and sensor applications, Kyiv, Ukraine, August 4–8, 2002. Publ. in: Nato science series II: mathematics, physics and chemistry, vol. 102, p. 203-210. ISBN 1-4020-1320-5 and ISBN 1-4020-1321-3

**Wegmann, M./Clemens, F./ Graule, T.J./Hendry, A.**
Microextrusion of lanthanide-doped barium titanate for PTCR applications. American ceramic society bulletin 2003, 82(11), 9501–9508 ⋆

**Balitskii, A.I./Diener, M./ Harzenmoser, M. et al.**
Corrosion-mechanical resistance of high-nitrogen Cr-Mn austenitic steels welded joints. In: Michael Smialowski int. symposium on corrosion and hydrogen degradation: Advances in corrosion science and application ( MSCHS 2003), Zakopane, Poland, September 9–13, 2003, p. 163–168

**Burlet, H./Klotz, U.E./ Lüthi, Th. et al.**
Microstructural and mechanical performance assessment of diffusion bonded bimetallic model discs. In: 6th Int. Charles Parsons turbine conference on engineering issues in turbine machinery, power plant and renewables, Dublin, IE, September 16–18, 2003, 735–748

**Elsener, H.R./Janczak-Rusch, J./ Bissig, V./Klotz, U.E./Zigerlig, B.**
Partikelverstärkte Aktivlote: Grundlagen. In: 14. DGM-Symposium über Verbundwerkstoffe und Werkstoffverbunde, Vienna, Austria, July 2–4, 2003. Weinheim: Wiley-VCH, p. 738–743. ISBN 3-527-30762-1

**Harzenmoser, M.**
Welding of high nitrogen steels. In: Int. conference on high nitrogen steels (HNS 2003), Schaffhausen, Switzerland, March 26–28, 2003, p. 179–188

**Khalid, F.A./Beffort, O./ Klotz, U.E./Keller, B.A./ Gasser, P./Vaucher, S.**
Study of microstructure and interfaces in an aluminium-$C_{60}$ composite material. Acta materialia 2003, 51(15), 4575–4582 (second entry; for main entry, see under first author in Dept "Advanced Materials and Surfaces", Lab "Materials Technology") ⋆

**Klotz, U.E./Solenthaler, Ch.**
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**Holzer, L./Lothenbach, B./Winnefeld, F.** Der Einfluss der mikrostrukturellen Entwicklung und der Porenlösungschemie auf das Erstarrungsverhalten von Zementpasten. In: 4. Tagung Bauchemie, Weimar, Germany, September 30–October 1, 2002, GDCh-Monographien, vol. 25, p. 51–56

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Heinrich, C.A./Pettke, T./ Bleiner, D. et al. — Quantitative multi-element analysis of minerals, fluid and melt inclusions by laser-ablation inductively-coupled-plasma mass-spectrometry. Geochimica et cosmochimica acta 2003, 67(18), 3473–3497 ⋆

⋆ Science Citation Index SCI
⁎ Science Citation Index Expanded SCIE
⋆ Science Citation Index SCI (multiple entries)
⁎ Science Citation Index Expanded SCIE (multiple entries)
• performed outside Empa

# Publications


Mayer, A./Ulrich, A. et al. — Retention of fuel borne catalyst particles by diesel particle filter systems. In: SAE 2003 world congress & exhibition, Detroit, MI, USA, March 3–6, 2003, SAE technical paper series 2003-01-0287, 7 p., (also publ. in: SAE SP-1755/SP 1754CD).

Senn, M. — Wurden diese Nägel in Develier-Courtételle Ju geschmiedet? Helvetia archaeologica 2002, 33(131–132), 120–125

Senn, M./Devos, W. — Some news about the chemical composition of bloomery iron materials. In: Archaeometallurgy in Europe, Milan, Italy, September 24–26, 2003, vol. 1, p. 17–26

Ulrich, A./Wichser, A. — Analysis of additive metals in fuel and emission aerosols of diesel vehicles with and without particle traps. Analytical and bioanalytical chemistry 2003, 377(1), 71–81 ⋆


## Logistics, Controlling and Marketing

Technology Transfer and Knowledge Management


Hischier, R./Gilgen, P.W. — Neue Datenbank für Ökobilanz. Umwelt Focus 2003, (4), 13–16 (second entry; for main entry, see under first author in Dept "Information, Reliability and Simulation Technology", Lab "Technology and Society ")

Kläntschi, N./Peter, M. — Wissen ist mehr als Information. Neue Zürcher Zeitung 2003, 224(256), B 14

Madlener, R./Robledo, C./Muys, B./Hektor, B./Domac, J. — A sustainability framework for enhancing the long-term success of LULUCF projects. Zürich: CEPE, 2003, 26 p. (CEPE working paper; Nr. 29), auch: www.cepe.ethz.ch

Pasquerella, C./Pitzurra, O./Herren, T. et al. — Lack of influence of body exhaust gowns on aerobic bacterial surface counts in a mixed-ventilation operating theatre : a study of 62 hip arthroplasties. Journal of hospital infection 2003, 54(1), 2–9 ⋆




⋆ Science Citation Index SCI
⁎ Science Citation Index Expanded SCIE
⋆ Science Citation Index SCI (multiple entries)
⁎ Science Citation Index Expanded SCIE (multiple entries)
• performed outside Empa

# EMPA Activities 2003
## Conferences

### Special Topics

**Cetinkaya, N.** Mentoring an der Empa, Themenabend Donna Informatica und Schweizer Informatikergesellschaft, Zürich 06-02 ■ ◗

**Edelmann, X.** Lecture: Business Exzellenz in einer Forschungsinstitution des ETH-Bereichs, in Vorlesung «Business Excellence» von Prof. Dr. Fritz Fahrni, ITEM, Universität St. Gallen, 07-05 ■ ◗

**Schlapbach, L.** Lecture: Empa, von der Prüfungs- zur Forschungsanstalt, Jahresrapport des Bundesamtes für Waffensysteme und Munition, Gruppe Rüstung, Bern, 03-14 ■ ◗

**Schlapbach, L.** Lecture: Start or Stop Research Activities in National Labs, Excellence in Management in R & D and Testing Organisations, EARTO/eurolab, The Hague, Netherlands, 03-20 thru 21 ■ ◗

**Schlapbach, L.** Lecture: Empa 2003, on the Way to the Materials Science and Technology Insitution of the ETH-Domain, 1st BENEFRI Materials Day, University of Fribourg, Fribourg, 06-27 ■ ◗

**Schlapbach, L.** Lecture: Empa R&D-Activities, Quo Vadis Aero Industry Switzerland – SAIG Seminar / Workshop, SWISSMEM, Zürich, 09-24 ■ ◗

**Schlapbach, L.** Lecture: Die Empa 2003 und ihre Zukunft, Generalversammlung 2003, VKB, Sektion Zürich, Zürich, 12-03 ■ ◗

### Advanced Materials and Surfaces

**Muster, W. J.** Verbundwerkstoffe; 14. Symposium Verbundwerkstoffe und Werkstoffverbunde, Wien, Austria, 07-02 thru 04 ▲

**Muster, W. J.** EUROMAT 2003 Lausanne, European Congress and Exhibition on Advanced Materials and Processes, Lausanne, 09-01 thru 05 ▲

**Schlapbach, L.** Lecture: Nanoscience and Nanotechnology in Switzerland, the Nanotech 2003 + Future, International Congress and Exhibition on Nanotechnology, Makuhari Messe, Chiba, Japan, 02-22 thru 28 ■ ◗

**Schlapbach, L.** Lecture: Nanoscale Structures and Materials Science at Empa, 11th Annual Meeting of the Swiss Colloid Group (SGCIS), Nano- and Meso-Particle Assemblies, Ilford, Marly, 03-12 ■ ◗

**Schlapbach, L.** Lecture: Nanotechnologie an schweizerischen Forschungsinstitutionen, Workshop «Aufbau von Aus- und Weiterbildung im Bereich der Nanotechnologie in der Euregio Bodensee», Wirtschafts-, Innovations- und Technologie-Förderverein WIT e.V., Gottmadingen, Empa, St. Gallen, 03-25 ■ ◗

**Schlapbach, L.** Lecture: Hydrogen and ist storage, a challenge for material science, IEA Conference on Science and Energy Technology, Paris, France, 04-01 thru 02 ■ ◗

**Schlapbach, L.** Lecture: Hydrogen-storage materials for mobile applications, La Sfida dell'Energia, Scienza di Materiali, Universita di Torino/Unione Industriale Torino, Torino, Italy , 05-30 ■ ◗

**Schlapbach, L.** Lecture: The role of Hydrogen as a future energy carrier, Towards a Hydrogen Economy – Case Study Iceland, Prime New Energy AG, ETH Zürich, Zürich, 06-02 ■ ◗

■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# EMPA Activities 2003

## Conferences

### Corrosion and Materials Integrity

| | |
|---|---|
| **Schlapbach, L.** | Lecture: Nanotech@Empa, Conference on «Swiss Competences in Materials», SVMT, School of Engineering and Architecture, Burgdorf, 06-04 ■◗ |
| **Schlapbach, L.** | Lecture: Hydrogen Energy and its Storage, Idrogeno 2003, CNR-IFAC, Sesto Fiorentino, Italy, 06-13 ■◗ |
| **Schlapbach, L.** | Lecture: Nanotechnologie – Einführung und Perspektiven, Lernexpedition Nano: Zwischen Zweifel und Zuversicht, Stiftung Risiko-Dialog, Empa-Akademie, Dübendorf, 06-18 ■◗ |
| **Schlapbach, L.** | Lecture: Growth and characterization of nanotubes, 2003 MaNEP Topical Meeting «Materials: preparation, charaterization, and specific properties», Neuchâtel, 06-25 thru 26 ■◗ |
| **Schlapbach, L.** | Lecture: The energy economic based on hydrogen storage challenge, International Summer School «Towards a Hydrogen-based Society», Technical University of Denmark, Lyngby, Denmark, 08-14 ■◗ |
| **Schlapbach, L.** | Lecture: Nanostructure Research @ Empa: From Electron Sources to Functional Surfaces, Nanofair 2003, St. Gallen, 09-09 ■◗ |
| **Schlapbach, L.** | Lecture: Hydrogen as an Energy Carrier: Properties, Challenges, History, TOHOKU-Göttingen Forum on Advanced Materials Programme, University of Göttingen, Göttingen, Germany, 10-22 thru 23 ■◗ |
| **Schlapbach, L.** | Lecture: Light Weight Metal Hydrides, Solid and Liquid State Hydrogen Storage Materials, IEA Hydrogen Semiannual Workshop, Waikaloa, Big Island Hawai, USA, 11-17 thru 19 ■◗ |
| **Bartl, M./Werner, R.** | Lecture: Schadensbegrenzung in der Praxis oder wenn Schäden zur logistischen Herausforderung werden, Tagung Umgang mit brandbedingten Kontaminationen, Empa-Akademie, Dübendorf, 06-24 ▲■ |
| **Faller, M.** | Lecture invited: Atmosphärische Korrosion – Abschwemmverhalten, Seminar Metalle und Umwelt SIV BML, Münchenbuchsee, 01-30 ■●◗ |
| **Faller, M.** | Lecture: Korrosion metallischer Werkstoffe unter besonderer Berücksichtigung der nicht rostenden Stähle, Pestalozzi-Seminar «Vermeiden von Korrosionsschäden beim Einsatz nicht rostender Stähle», Dietikon, 04-14 ■● |
| **Faller, M.** | Lecture invited: Runoff behaviour of different materials used for roofing and facades – 5 years exposure study in Switzerland, Workshop on Release of Heavy Metals due to Corrosion of Materials, München, Germany, 05-09 ■●◗ |
| **Faller, M.** | Lecture: Runoff behaviour of metallic materials, Euromat, Lausanne, 09-04 ■● |
| **Guseva, O. A./Brunner, S./ v. Trzebiatowski, O./Richner, P.** | Lecture: Service life prediction for coatings concerning loss of gloss, Athens Conference on Coatings Science and Technology, Vouliagmeni, Athens, Greece , 07-07 thru 11 ■●◗ |
| **Guseva, O. A./Brunner, S./ v. Trzebiatowski, O./Richner, P.** | Lecture invited: Service life prediction for coatings concerning loss of gloss, 1st European Weathering Symposium, Prague, Czech Republic, 09-25 thru 26 ■●◗ |
| **Reiss, D.** | Lecture: Calculation of runoff data from corrosion data – dose response functions for runoff, Workshop on Release of heavy Metals due to Corrosion of Materials München, Germany, 05-09 ■● |
| **Reiss, D./Rihm, B.** | Lecture: Visualisation of Corrosion by Mapping, Euromat, Lausanne, 09-03 thru 04 ■● |
| **Schmutz, P.** | Symposium on «Characterization, Mechanistic Models and Transport Aspects of Cathodic and Anodic Processes» 204th Electrochemical Society Meeting (ECS), Orlando, USA , 10-12 thru 16 ▲ |
| **Schmutz, P.** | Lecture: Corrosion Mechanisms on Mg Alloys as a Function of Al Composition, Microstructure and Protection Strategies, 204th Meetin Electrochemical Society ECS, Orlando, Florida, USA, 10-12 thru 16 ■● |
| **Schmutz, P.** | Fachtagung Schweizerische Gesellschaft für Oberflächentechnik, Grenchen, 11-6 thru 07 ▲ |
| **Sidler, T.** | Lecture: Bedeutung der Untergrundvorbereitung, Empa-Akademie, Dübendorf, 02-20 ■ |
| **Tuchschmid, M.** | Lecture: Analytik und Beurteilung der Kontaminanten, Tagung Umgang mit brandbedingte Kontaminationen, Empa-Akademie, Dübendorf, 06-24 ▲■ |
| **v. Trzebiatowski, O.** | Lecture invited: Ausgewählte Schadensbeispiele, Technische Akademie Esslingen, Sarnen, 05-19 thru 23 ■◗ |



■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# EMPA Activities 2003

## Conferences

| | | |
|---|---|---|
| | v. Trzebiatowski, O. | Lecture invited: Zuordnung von Schäden an Polymerwerkstoffen mit dem Rasterelektronen-mikroskop, Technische Akademie Esslingen, Sarnen, 05-19 thru 23 ■◗ |
| | v. Trzebiatowski, O. | Lecture: Sind Korrosionsprodukte ein Problem für die Umwelt, Wissenschaftsapéro Empa-Akademie, Dübendorf, 08-25 ■ |
| | v. Trzebiatowski, O. | Lecture invited: Atmosphärische Korrosion – ein Problem für die Umwelt?, 29. VDI-Jahrestagung Schadensanalyse, Würzburg, Germany, 10-16 thru 17 ■◗ |
| | Winkler, R. | Lecture: Mikroanalytik mittels EMS, Technische Akademie Esslingen, Sarnen, 05-23 ■ |
| | Zgraggen, M. | Lecture: Lasergeschnittene Bauteile, eine Herausforderung für Verzinker, VSKF-Forum, Stahl-Korrosionsschutz, Empa-Akademie, Dübendorf, 03-20 ■ |
| | Zgraggen, M. | Lecture invited: Beurteilung von Brüchen an metallischen Bauteilen mit der Rasterelektronen-mikroskopie, TAE Weiterbildungszentrum Sarnen, 05-21 ■◗ |
| | Zgraggen, M. | Lecture invited: Beuteilung von Brüchen an metallischen Bauteilen mit der Rasterelektronen-mikroskopie, TAE Ostfildern, Germany, 10-08 ■◗ |
| | Zgraggen, M. | Lecture invited: Fraktographie an Keramik und Glas, Technische Akademie Esslingen, Ostfildern, Germany, 10-08 ■◗ |
| | Zgraggen, M. | Lecture invited: Zuordnung von Schäden an Polymerwerkstoffen mit der Rasterelektronen-mikroskopie, Technische Akademie Esslingen, Ostfildern, Germany, 10-08 ■◗ |
| | Zgraggen, M./ v. Trzebiatowski, O./ Haslinger, H. A. | Lecture: Probleme und Schäden in der Fertigungskette Laserschneiden, Schweissen und Feuerverzinken, SVMT-Tagung an der Empa, Dübendorf, 06-23 ■ |
| Functional Polymers | Geiger,T./Gasser, P./ Hany, R./Zinn M. | Poster: Functional Polymers from Polyhydroxyalkanoates Protection of Surfaces from Biofouling, Int. Conf. BIOSURF V, Zurich, 09-25 thru 26 ◆ |
| | Geiger, T./Michel, F./ Schleuniger, J.A. | Poster: Biopolymer to Consolidate Matte Paint European Congress on Advanced Materials and Processes, Lausanne, 09-01 thru 05 ◆ |
| | Hartmann, R. et al. | Poster: Polyhydroxyalkanoates Containing Aromatic Side Chains, Annual Assembly Swiss Society for Microbiology, Basel, 03-06 thru 07 ◆ |
| | Hartmann, R./Hany, R./ Egli, T./Witholot, B./Zinn,M. | Poster: Tailor Made Thermal Properties of Functionalized Polyhydroxyalkanoates PGS-Meeting, Fribourg, 05-09 ◆ |
| | Löwe, Ch./Weder, Ch. | Lecture: Photoluminescent Polymer Blends, Annual Meeting and PGS Meeting, Duebendorf, 11-28 ■◗ |
| | Nagel, M./Lippert, T. | Lecture: Polymeric Materials Designed for Laser Ablation Lithography (LAL) Based on Photosensitive Triazene Containing Building Blocks SCS Fall Meeting, Lausannne, 10-09 ■ |
| | Rentsch, D./Furrer, G. et al. | Poster: Al nanoclusters in ink-jet printer technology Nano Conference and TOP NANO 21 Annual Meeting, St. Gall, 09-09 thru 11 ◆ |
| | Zimmermann, T./Pöhler, E./ Geiger, T. | Poster: Cellulose Nanofibrils for Polymer Reinforcement Nano Conference and TOP NANO 21 Annual Meeting, St. Gall, 09-09 thru 11 ◆ |
| | Zinn, M./Geiger, T./Hany, R. | Poster: Tailor-made synthesis of bioplastic (polyhydroxyalkanoate) in Pseudomonas putida (oleovorans), Jahrestagung der Schweizerischen Gesellschaft für Mikrobiologie, Luzern, 02-20 thru 21 ◆ |
| Joining and Interface Technology | Elsener, H. R./ Janczak-Rusch, J./Bissig, V./ Klotz, U. E./Zigerlig, B. | Partikelverstärkte Aktivlote: Grundlagen. in 14. Symposium Verbundwerkstoffe und Werkstoffverbunde, Wien, Austria, 07-02 thru 07-04 ◆ |
| | Harzenmoser, M. | Work package 2 «Welding», 2nd Meeting EU-project»NanoRotor», Kassel, Germany, 03-14 ■ |
| | Harzenmoser, M. | 1) QM in der Schweisstechnik. 2) Schweissfehler: Erkennung und Bewertung. 3) Schadenfälle, Kurs Sichtprüfung, Winterthur, 01-21, 11-11 ■ |
| | Harzenmoser, M. | Welding of High Nitrogen Steels, International Conference on High Nitrogen Steels, Schaffhausen, 03-26 thru 28 ■◗ |

■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# EMPA Activities 2003

## Conferences

| | | |
|---|---|---|
| | Klotz, U.E.. | Austenitbildung und -stabilität in 9-12% Chromstählen – ein Anwendungsbeispiel für ThermoCalc. Thermo-Calc Anwendertreffen, Achen, Germany, 06-12/13 ■ |
| | Lehmann, H. | Bruchmechanische Versuche an hartgelöteten Stählen in Modus I, Modus II und Mixed-Mode, 27. Sitzung der SVMT-Fachgruppe «Strukturintegrität», Birr, 03-05 ■ |
| | Lehmann, H./Harzenmoser, M./ Schindler, H. J. | Characterization of Strength and Fracture Toughness of Martensitic Steel Brazed With Gold-Nickel Alloy, 9th International conference on The Mechanical Behaviour of Materials (ICM9), Genf, 05-25 thru 29 ■ |
| | Piazza, D./Klotz, U.E/Gasser, P./ Vital, A./Janczak-Rusch, J. | Nanopartikelverstärkte Lotwerkstoffe. Empa Forschungsmarktplatz, Dübendorf, 03-26 ◆ |
| | Piazza, D./Boccaccini, A.R./ Kaya, C./Janczak-Rusch, J. | Hochtemperatur-Löten von einem Mullit-Mullit Verbundwerkstoff. In: 14. DGM-Symposium über Verbundwerkstoffe und Werkstoffverbunde, Vienna, Austria, 07-02 thru 07-04 ■ |
| | Roth, M. | Praktische Beispiele III Schadensuntersuchungen mit Oberflächenanalytik, Fortbildungsseminar Systematische Beurteilung technischer Schadensfälle, Deutsche Gesellschaft für Materialkunde, Ermatingen, 04-03 ■◗ |
| | Roth, M. | Schadensuntersuchungen mit Oberflächenanalytik, Seminar Rasterelektronenmikroskopie und Analyse von Mikrobereichen und Oberflächenschichten, Technische Akademie Esslingen, Sarnen, 05-19 ■◗ |
| | Roth, M. | Zuordnung von Schäden an keramischen Bauteilen mit dem REM, Seminar Rastereleketronen-mikroskopie und Analyse von Mikrobereichen und Oberflächenschichten, Technische Akademie Esslingen, Sarnen, 05-19 ■◗ |
| High Performance Ceramics | Blugan, G./Kübler, J./Michler, J./ Orlovskaya, N./Lugovy, M. | Lecture: Microstructure and Properties of Silicon Nitride/ Titanium Nitride Composites and Multi-Layer Laminates, EUROMAT 2003, Lausanne, 9-1 thru 5 ■ |
| | Clemens, F./Wegmann, M./ Graule, T./Hendry, A. | Lecture: Herstellung von schnell ansprechenden PTCR $BaTiO_3$-Faserhalbzeugen über die Schmelzextrusion, 10. Keramik-Tag der BAM Symposium Folien- und Multilayertechnologie für funktionskeramische Anwendungen, Berlin, Germany, 04-10 thru 11 ■ |
| | Clemens, F./Mathewson, A. | Lecture: Computing Fibers – Substrates for Smart Textiles, EUROMAT 2003, Lausanne, 09-01 thru 04 ■ |
| | Fischer, K./Holtappels, P./ Rzepka, M./Stimming, U. | Lecture: Simulation of various fuel cell systems in mobile applications, Forum Echem, Wien, Austria, 02-03 ■● |
| | Graule, T. | Lecture: Nanopowders for high performance ceramics, Dept. Materials, Seminar, EPF Lausanne, 05-27 ■◗ |
| | Graule, T. | Lecture: Hochleistungskeramik, Seminar des Fachbereichs Maschinenbau der FH Konstanz, Germany, 10-23 ■ |
| | Heiber, J./Clemens, F./Graule, T./ Hülsenberg, D./Hecht-Mijic, S. | Lecture: $SiO_2$-Glasfaserherstellung über die Extrusion von $SiO_2$-Nanopulvern, 77. Glastechnische Tagung, Leipzig, Germany, 05-26 thru 28 ■ |
| | Heiber, J./Clemens, F./Graule, T./ Hülsenberg, D./ Hecht-Mijic, S. | Poster: Fabrication of amorphous $SiO_2$-fibres by extrusion, EUROMAT 2003, Lausanne, 09-01 thru 05 ◆ |
| | Heiber, J./Clemens, F./Graule, T./ Hülsenberg, D./Hecht-Mijic, S. | Poster: Fabrication of amorphous $SiO_2$-fibres by extrusion, Nanofair, St. Gallen, 09-09 thru 11 ◆ |
| | Heiber, J. | Lecture: Untersuchungen zur Herstellung von $SiO_2$-Glasfasern mit komplexer Geometrie, Jahrestagung der Deutschen Keramischen Gesellschaft (DKG), München, Germany, 09-15 thru 17 ▲■ |
| | Herzog, A./Vogt, U. | Poster: Kurzfaserverstärktes reaktionsgebundenes Siliciumnitrid, 14. Symp. Verbundwerkstoffe und Werkstoffverbunde, Wien, Austria, 07-02 thru 04 ◆ |
| | Holtappels, P. | Lecture: SOFC Activites at the Laboratory for High Performance Ceramics, University of Twente, Enschede, Netherlands, 03-19 ■◗ |
| | Holtappels, P. | Lecture: Review on SOFC Anodes, SOFCNET workshop, Espoo, Finland, 08-09 ■◗ |



■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# EMPA Activities 2003

## Conferences

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|---|---|
| **Holtappels, P./Gauckler, L./ Graule, T./Gut, B./Honegger, K./ Jorger, M./McEvoy, A.J./ Perednis, D./Rambert, S./ Robert, G./Vogt, U.** | Lecture: Fabrication and performance of anode supported Solid Oxide Fuel Cells, 8th Internat. Symp. On Solid Oxide Fuel Cells, Paris, France, 04-27 thru 05-02 ■● |
| **Holtappels, P./Vogt, U./Graule, T.** | Lecture: Brennstoffzellen: Mehrschichtverbunde der besonderen Art, Verbund 2003, Wien, Austria, 02-07 thru 04 ■● |
| **Holtappels, P./Gauckler, L./ Graule, T./Gut, B./Honegger, K./ Jorger, M./McEvoy, A.J./** | Lecture:Fabrication and performance of anode supported SOFCs, Swiss Fuel Cell Research Symposium, Yverdon-Les-Bains, 05-19 ■ |
| **Holtappels, P./Vogt, U./ Vaucher, S./Van herle, J./ Buffat, P./Bucheli, O./Sfeir, J.** | Poster: Ceramic nanopowder fabrication and application as an active and stable cathode material, Nanofair, St. Gallen, 09-09 ◆ |
| **Kübler, J./Orlovskaya, N./ Lugovy, M.** | Poster: Keramische Mehrschicht-Laminate aus Siliziumnitrid und einem Komposit aus Siliziumnitrid/ Titannitrid (= Multi-Layer $Si_3N_4$ and $Si_3N_4$ /TiN Ceramic Laminates) 14. Symp. Verbundwerkstoffe und Werkstoffverbunde, Wien, Austria, 07-02 thru 04 ◆ |
| **Kübler, J./Lemster, K./ Graule, T./Minghetti, T./ Schelle, C.** | Lecture: Eisenbasislegierung/Oxidkeramik – MMCs durch reaktive Schmelzinfiltration (= Iron base alloy/oxide ceramic – MMCs by reactive melt infiltration), 14. Symp. Verbundwerkstoffe und Werkstoffverbunde, Wien, Austria, 07-02 ■● |
| **Lemster, K./Klotz, U. E./ Fischer, S./Gasser, Ph./Kübler, J.** | Lecture: Titanium as an activator material for producing MMCs by pressureless melt infiltration, Ti-2003, 10th World Conference on Titanium, Hamburg, Germany, 07-13 thru 18 ■ |
| **Lemster, K./Kuzma, I./Kübler, J.** | Lecture: Metal Matrix Composites (MMCs) by Reactive Melt Infiltration, EUROMAT 2003, Lausanne, 09-02 thru 05 ■ |
| **Thünemann, M./Herzog, A./ Vogt, U./Beffort, O.** | Lecture: Porous SiC-Preforms by intergranular binding with preceramic polymer, EUROMAT 2003, Lausanne, 09-02 ■ |
| **Graule, T./Vital, A.** | Lecture: Transparente Nanodispersionen – Ein Werkstoff aus der Hochleistungskeramik, 141. GAT Nanotechnology Meeting, Uzwil, 06-12 ■◗ |
| **Vital, A./Zuercher, S./Graule, T./ Vonmont, H./Arnosti, G./ Stalder, B./Apel, E./Höland, W.** | Poster: Development of a ball mill for nano-comminution of glasses and glass ceramics, Nanofair, St. Gallen, 09-09 thru 11 ◆ |
| **Vogt, U./Herzog, A./Graule, T.** | Lecture: Modern Processing Routes for Biomorphic Based Materials, 105th Annual Meeting & Exposition of the American Ceramic Society, Nashville, Tennessee, USA, 04-27 thru 30 ▲■●◗ |
| **Vogt, U./Herzog, A.** | Lecture: Silicium Carbid- und Compositmaterialien von natürlichen Rohstoffen, Materials Week, München, Germany, 09-16 thru 18 ■◗ |
| **Vogt, U./Herzog, A.** | Lecture: Biomorphe SiC-Keramiken aus nachwachsenden Rohstoffen, Materialwissenschaftliches Kolloquium, Chemische Materialwissenschaften, Universität Konstanz, Germany, 12-02 ■◗ |
| **Vogt, U./Herzog, A./Graule, T.** | Lecture: Hochporöser Kohlenstoff durch Pyrolyse von natürlichen Rohstoffen, Seminar Festkörper-physik, UNI-Fribourg, 12-09 ■◗ |
| **Vogt, U./Herzog, A./Graule, T.** | Lecture: Biomorphe SiC-Keramik mit orientierter Porenstruktur, 14. Symposium für Verbund Werkstoffe und Werkstoffverbunde, Wien, Austria, 07-02 thru 04 ▲■● |
| **Vogt, U./Holtappels, P.** | Lecture: Tailored Perovskite Powders for SOFC Appliocations, Swiss Fuel Cell Research Symposium, Yverdon, 05-19 thru 20 ■◗ |
| **Wegmann, M./Clemens, F./ Graule, T./Hendry, A.** | Poster: Rapid-Response Ceramic Thermistor Fibers,The Second IEEE International Conference on Sensors (Sensors 2003), Toronto, Canada, 10-22 thru 24 ◆● |
| **Wegmann, M./Clemens, F./ T. Graule/Hendry, A.** | Extrusion of Rapid-Response BaTiO3 PTCR Thermistors, EUROMAT 2003, Lausanne, 09-01 thru 04 ◆ |
| **Zürcher, S./Graule, T.** | Lecture: Nanodispersions for Low Temperature Sintering of Thin Films SOFC Electrolyte, 11th Annual Meeting of the Swiss Colloid Group (SGCIS) Nano- and Meso-Particle Assemblies, Marly, 03-12 ■◗ |

■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# EMPA Activities 2003

## Conferences

### Materials Technologie

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|---|---|
| **Zürcher, S./Graule, T.** | Lecture: Nanodispersions for Low Temperature Sintering of Thin Films SOFC Electrolyte, EUROMAT 2003, Lausanne, 09-01 ■● |
| **Zürcher, S./Graule, T./Kaiser, A.** | Poster: Nanodispersions for low sintering of thin films SOFC electrolyte, TOP NANO 21 Annual Meeting 2003, St. Gallen, 09-09 ◆ |
| **Zürcher, S./Vital, A./Graule, T./ Arnosti, G./Stalder, B./Apel, E./ Höland, W.** | Poster: Development of a ball mill for nano comminution of glasses and glass ceramics, TOP NANO 21 Annual Meeting 2003, St. Gallen, 09-09 ◆ |
| **Ballif, Ch./ Pouvreau, C./Gassilloud, R./ Breguet, J.-M./Michler, J.** | Poster: Fundamentals of Nano-scaled Crack Propagation for Processing of Semiconductor Devices, 4th Topnano 21 Annual Meeting, St. Gallen, 09-09 thru 11 ◆ |
| **Ballif, Ch./ Pouvreau, C./Gassilloud, R./ Breguet, J.-M./Michler, J.** | Poster: Application for Robotics: A Study of Crack Propagation in Semiconductors, LEA (Laboratoires Européens associés) microtechniques, Arc et Senans, France, 09-29 thru 30 ◆ |
| **Beffort, O.** | Lecture: Einfluss von Legierungselementen auf mechanische Eigenschaften und Ausbildung der Grenzfläche in Al/SiC-Verbundwerkstoffen, DGM, Wien, Austria, 07-02 thru 04 ■● |
| **Beffort, O.** | Lecture: Porous SiC-Preforms by intergranular binding with preceramic polymer, EUROMAT 2003, Lausanne, 09-01 thru 04 ■● |
| **Beffort, O./Rohr, L./Roth, M.** | Poster: Development of a cookware with a Al/Si(C) base for high efficiency cooking systems, DGM-Tagung «Verbundwerkstoffe und Werkstoffverbunde» (14. Symposium), Wien, Austria, 06-02 thru 04 ◆ |
| **Beffort, O./Vaucher, S.** | Poster: Novel Al/carbon-based (nano)composites for thermal management applications, Forschungsmartkplatz, St. Gallen, 06-26 ◆ |
| **Beffort, O./Khalid, F.-A./ Keller, B./Klotz, U.E./Vaucher, S.** | Poster: About the thermal and chemical stability of diamond during processing of Al/diamond composites by liquid metal infiltration, EUROMAT 2003, Lausanne, 09-01 thru 04 ◆ |
| **Brandt O./Siegmann, S.** | Poster: Thermisch gespritzte Metal- und Keramikschichten kombinert mit Kunststoffen für Antihaftwirkung, 14. Symposium Verbundwerkstoffe und Werkstoffverbunde, Wien, Austria, 07-02 thru 04 ◆ |
| **Bucaille, J.-L.** | Lecture: A new technique to determine the elastoplastic properties of thin metallic films using sharp indenters, ICMCTF, San Diego, USA, 04-19 thru 23 ■● |
| **Bucaille, J.-L./Stauss, S./ Michler, J.** | Lecture: Determination of the stress-strain curves of metals using instrumented indentation with sharp indenters: Validation on polycrystalline copper, ICM – The 9th International Conference on the Mechanical Behaviour of Materials, Genf, 05-25 thru 29 ■● |
| **Bucaille, J.-L./Stauss, S./ Michler, J.** | Lecture: Détermination de la contrainte d'écoulement des métaux par indentation instrumentée: application au cuivre polycrystalling, 16éme Congrès Français de Mécanique, Nice, France, 09-01 thru 05 ■ |
| **Kern, Ph.** | Lecture: Electrochemical surface machining and structuring of metallic materials, Uhrentechnologie und Meterial – eine Kombination auf Zeit, Biel, 12-11 ■ |
| **Kern, Ph./Lerf, R.** | Lecture: Characterization of the Surface of Ti6Al7Nb modified by different industrial processes, 18th European Conference on Biomaterials, Stuttgart, Germany, 10-01 thru 04 ■ |
| **Kern, Ph./Chauvy, P.F./ Landolt, D.** | Lecture: Electrochemical micro-machining of metals thorugh an electrophoretically deposited epoxy mask, 204th International Meeting of the Electrochemical Society, Orlando, USA, 10-12 thru 16 ■● |
| **Kleiner, S./Uggowitzer, P.J.** | Lecture: Magnesium Forming – The Mechanical Anisotrophy, 1st International Conference on Light Metals Technology, Brisbane, Australia, 09-18 thru 20 ■◗ |
| **Leparoux, M.** | Lecture: Development of a filtration unit with a by-pass sampling system for nanoparticle collection, Filtech Europa 2003, Düsseldorf, Germany, 10-21 thru 23 ■● |
| **Leparoux, M./Schreuders, C./ Shin, J.W./Siegmann, S.** | Poster: Investigation of non-oxide nanoparticles by RF induction plasma processing – synthesis, modelling and in-situ monitoring, Empa, Dübendorf, ◆ |



■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# EMPA Activities 2003

## Conferences

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|---|---|
| **Margadant, N.** | Lecture: Insights to Spraying Conditions, Microstructure and Properties and Their Statistical Correlation for Different Thermal Spraying Processes Using Complementary Characterization Methods, ITSC 2003, Orlando, USA, 05-05 thru 08 ■ ● |
| **Margadant, N.** | Lecture: History of Tribology, LSSTs 10th Anniversary, ETH Zürich, 06-13 ■ ◗ |
| **Michler, J.** | Lecture: Depth profiling by GDOES: application of hydrogen and d.c. bias voltage corrections to the analysis of thin oxide films, ICMCTF, San Diego, USA, 04-19 thru 23 ■ ● |
| **Rabe, R./Stauss, S./Zenke, J./ Breguet, J.-M./Blank, E./ Michler, J.** | Lecture: Some Applications of a New in-Situ Indentation Apparatus for Use Inside a SEM, EUROMAT 2003, Lausanne, 09-01 thru 04 ■ ● |
| **Rohr, L.** | Lecture: Zukunftspotential Nanotechnologie, Veranstaltung des Arbeitgeberverbandes (AGV), Thun, 02-03 ■ |
| **Rohr, L.** | Lecture: A future of thermal spraying at the example of tribological requirements for wear resistant applications, International Conference MATRIB 2003, Vela Luka, Croatia, 06-26 thru 28 ■ ● ◗ |
| **Rohr, L.** | Organization: Smart Surfaces in Tribology: Advanced Additives and Structured Coatings, Zürich, 09-10 thru 12 ▲ |
| **Schneider, Ph./Siegmann, S./ Cannizzaro, D./Hitzek, R.** | Poster: Thermisch gespritzte Schichten als Hochtemperatur-Verschleissschutz, Empa, Dübendorf, ◆ |
| **Schwaller, P.** | Lecture: Mechanical properties of an icosahedral AlPdMn Quasicrystal studied by Nanoindentation experiments, Swiss Physical Society Meeting, Basel, 03-21 ■ |
| **Schwaller, P.** | Lecture: Vom Frontalunterricht zum WBT-Drehbuch: Erfahrungen eines Neueinsteigers, Fachhochschule Olten, 04-29 ■ |
| **Schwaller, P.** | Lecture: Microtribological studies of different TiC / a-C:H coatings using a modified Nanoindentation setup, Smart Surfaces in Tribolgy Conference, Zürich, 09-10 ■ ● |
| **Schwaller, P.** | Lecture: Introduction to Nanoindentation and Inverse Problems, Empa, Thun, 11-12 ■ |
| **Shin, J.W./Leparoux, M./ Siegmann, S./Dorrier, J.-L./ Hollenstein,Ch.** | Poster: In-situ monitoring of the synthesis of nano-powders by RF thermal plasma, Top Nano 21, St. Gallen, 09-09 thru 11 ◆ |
| **Siegmann, S.** | Lecture: Comparison of Particle In-Flight Characteristics and Coating Properties, ITSC 2003, Orlando, USA, 05-05 thru 08 ■ ● |
| **Siegmann, S.** | Lecture: Experimental Study of Substrate Thermal Conditions at APS and HVOF, ITSC 2003, Orlando, USA, 05-05 thru 08 ■ ● |
| **Siegmann, S.** | Lecture: Low Pressure Wire Arc and Vacuum Plasma Spraying of NiTi Shape Memory Alloys, ITSC 2003, Orlando, USA, 05-05 thru 08 ■ ● |
| **Siegmann, S.** | Lecture: Physically and chemically modified surfaces with designed sliding and wetting properties, Smart Surfaces in Tribology: Advanced Additives and Structured Coatings, Glattbrugg, 09-10 thru 12 ■ ● |
| **Siegmann, S.** | Lecture: Influence of Particles Velocity and Temperature on the Properties of Thermally Sprayed Coatings, Les Premières Rencontres Internationales sur la Projection Thermique, Lille, France, 12-04 thru 05 ■ ● ◗ |
| **Stark, W.J./Ernst, F.O./ Grunwaldt, J.D./Hannemann, St./ Schreuders, C./Strobel, R./ Wagner, K./Baiker, A./ Leparoux, M./ Pratsinis, S.E.** | Poster: Fundamental Research on Ceramic Nanoparticles – Nanoparticle Production, Nanofair, St. Gallen, 09-09 thru 11 ◆ |
| **Stauss, S./Bucaille, J.-L./ Blank, E./Michler, J.** | Lecture: Assessment of elasto-plastic properties of metallic materials and coatings by nanoindentation and inverse analysis, EUROMAT 2003, Lausanne, 09-01 thru 04 ■ ● |
| **Vaucher, S./Beffort, O./ Kübler, J./Lehner, F.** | Poster: Magnesium-graphite fibers composite tailored for High Energy Physics, DGM-Tagung «Verbundwerkstoffe und Werkstoffverbunde» (14. Symposium), Wien, Austria, 06-02 thru 04 ◆ |

■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# EMPA Activities 2003

## Conferences

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|---|---|---|
| | Vaucher, S./Beffort, O./ Herzog, A./Vogt, U. | Poster: Metal Matrix-Composites derived from Wood, EUROMAT 2003, Lausanne, 09-01 thru 04 ◆ |
| | Walther, J.H./Schreuders, C./ Tsantilis, S./Koumoutsakos, P./ Leparoux, M./Pratsinis, S.E. | Poster: Fundamental Research on Ceramic Nanoparticles – Understanding Nanoparticle Formation, Nanofair, St. Gallen, 09-04 thru 09 ◆ |
| | Zenke, J./Sill, A./Fatikow, S./ Michler, J./Büttgenbach, S. | Poster: Mechanical Materials Characterisation in a SEM, MICRO.tec 2003, München, Germany, 10-13 thru 14 ◆ |
| nanotech@surfaces | Fasel, R. | Determination of molecular orientation in adsorbate systems by means of angle-scanned x-ray photoelectron diffraction 19th Annual SAOG meeting, Fribourg, 01-24 ■● |
| | Fasel, R. | Chirality transfer from single molecules into self-assembled monolayers Symposium on Surface Science 3S'03, La Plagne, France, 04-03 ■● |
| | Fasel, R. | Probing Molecular Orientation at Surfaces via XPD, Surface Science Seminar, Empa, Dübendorf , 06-25 ■ |
| | Fasel, R. | Chirality transfer from single molecules into self-assembled monolayers, Seminar of the Surface Science Research Center at the University of Liverpool, Great Britain, 10-15 ■◗ |
| | Fasel, R. | Determination of the absolute chirality of adsorbed molecules via XPD, 7th International Conference on Atomically Controlled Surfaces, Interfaces and Nanostructures ACSIN-7, Nara, Japan, 11-18 ■● |
| | Fasel, R. | Chirality transfer from helical molecules into self-assembled monolayers, 7th International Conference on Atomically Controlled Surfaces, Interfaces and Nanostructures ACSIN-7, Nara, Japan, 11-19 ■● |
| | Gröning, O. | The role of nanocarbon electron emitter in field emission flat panel displays, Society of Information Display Mid Europe Spring Meeting, Neuchâtel, 03-06 ■●◗ |
| | Gröning, O. | Carbon Nanotubes: Prototype of a material for Nanotechnology», BENEFRI course :Recent Trends in Material Science, Bern, 04-25 ■◗ |
| | Gröning, O. | Current induced degradation of multiwalled carbon nanotube emitter, 203rd Meeting of the Electrochemical Society, Paris, France, 04-27 ■● |
| | Gröning, O. | Fabrication strategies for efficient carbon nanotube field electron emitter, 1st BENEFRI Materials Day, Fribourg, 06-27 ■◗ |
| | Gröning, O. | Field emission from Diamond and Nanotubes, Diamond 2003, Salzburg, Austria, 09-07 ■●◗ |
| | Gröning, P. | 19th Annual SAOG meeting, Fribourg, 01-24 ▲ |
| | Gröning, P. | Nanotechnologie: Eine Herausforderung für die interdisziplinäre Forschung, 4. Nanomat Szene, Forschungszentrum Karlsruhe, Germany, 04-10 ■●◗ |
| | Gröning, P. | Carbon: The Material for Future Microelectronics. Conference on «Swiss Competences in Materials", Burgdorf, 06-04 ◆ |
| | Gröning, P. | Metallized Polyimide for a New Generation of Flexible Printed Circuit Boards. International Symposium on Plasma Chemistry (ISPC-16), Taormina, Italy, 06-22 thru 27 ◆● |
| | Gröning, P. | Controlled Growth of Carbon Nanotubes in Chemical Vapor Deposition. Nano Conference 2003, Nanofair 2003, St. Gallen, 09-09 thru 11 ◆ |
| | Gröning, P. | Carbon Nanotubes for Cold Electron Sources. 3rd Swiss/US-Nanoforum, University of Basel, 10-13 thru 14 ■●◗ |
| | Ruffieux, P. | Interaction of hydrogen with sp2-bonded carbon: influence of local curvature and local electronic effects, Tagung der Schweizerischen Arbeitsgemeinschaft Oberflächen und Grenzflächen (SAOG), Freiburg, 01-12 ■● |
| | Ruffieux, P. | Supramolecular columns of hexabentocoronenes on copper and gold (111) surfaces, International winterschool on electronic properties of novel materials (IWEPNM), Kirchberg, Austria, 03-08 ▲● |
| | Ruffieux, P. | Domains with different electronic properties at the surface of 1T-TaSe2, Swiss Workshop on Materials with Novel Electronic Properties, Diablerets, 09-29 ▲● |



■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# EMPA Activities 2003

## Conferences

**Surfaces, Coatings, Magnetism**

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|---|---|
| **Ernst, K.-H.** | Welt im Spiegel: Chiralität ist überall II: Quantenmechanik und Paritätsverletzung, FU Berlin, Fachbereich Physik, Berlin, Germany , 02-04 ■◗ |
| **Ernst, K.-H.** | Welt im Spiegel: Chiralität ist überall I: Allgemeine Aspekte, FU Berlin, Fachbereich Physik, Berlin, Germany , 02-04 ■◗ |
| **Ernst, K.-H.** | Self-Assembly and Optical Switching of Chiral Molecules at Surfaces, Seminar Prof. Manz, Physikal. Chemie, FU Berlin, Berlin, Germany , 02-04 ■◗ |
| **Ernst, K.-H.** | Welt im Spiegel: Chiralität ist überall IV: Adsorption chiraler Moleküle, FU Berlin, Fachbereich Physik, Berlin, Germany , 02-05 ■◗ |
| **Ernst, K.-H.** | Welt im Spiegel: Chiralität ist überall III: Chirale Festkörperoberflächen, FU Berlin, Fachbereich Physik, Berlin, Germany , 02-05 ■◗ |
| **Ernst, K.-H.** | Welt im Spiegel: Chiralität ist überall VI: Summenfrequenzspektroskopie in chiralen Medien, FU Berlin, Fachbereich Physik, Berlin, Germany , 02-06 ■◗ |
| **Ernst, K.-H.** | Welt im Spiegel: Chiralität ist überall V: Optische Aktivität, FU Berlin, Fachbereich Physik, Berlin, Germany , 02-06 ■◗ |
| **Fasel, R./Wider, J./Greber, T./ Quitmann, C./Ernst, K.-H.** | Determination of the absolute chirality of adsorbed molecules via XPD, 4th internat. Symp. on Atomic Level Characterizations – ALC '03, Kauai, Hawaii , 10-05 thru 10 ■ |
| **Hauert, R.** | DLC coatings for biological applications, Jahrestagung SPS (Swiss Physical Society), Basel, 03-21 ■ |
| **Hauert, R.** | An overview of DLC coatings for biological applications, seventh applied diamond conference / third frontier, 08-18 thru 21 ◗ |
| **Hauert, R.** | An overview of DLC coatings for biological applications, NIMS, Tsukuba, Japan, 08-25 ■ |
| **Hauert, R.** | On the coefficient of static friction of diamond-like carbon coatings, Euromat conference, Lausanne, 09-01 thru 04 ■ |
| **Hauert, R.** | An overview on tailored tribological behavior of diamond-like carbon, Smart Surfaces in Tribology, Zürich, 09-10 thru 12 ■ |
| **Hauert, R.** | Moderne Analytische Methoden für die oberflächenbearbeitende Industrie, Technische Fachtagung der Schweizerischen Gesellschaft für Oberflächen (SGO), Grenchen, 11-06 thru 07 ■◗ |
| **Hauert, R.** | An overview of DLC coatings for biological applications, Dr. Robert Mathys Foundation, Bettlach, 12-02 ■◗ |
| **Haug, F.-J.** | Electrical Properties of the heterojunction in Cu(In,GA)Se2 Superstrate Solar Cells, Conference proceeding of 3rd World Conference of Photovoltaic Solar Energy Conversion, Osaka, Japan, 05-11 thru 18 ■●◗ |
| **Parschau, M./Fasel, R./ Ernst, K.-H.** | Modification of Metal Surfaces via Adsoption of Helical Aromatic Molecules, Gordon Research Conference «Chemical Reaction at Surfaces», Ventura, California, USA , 02-16 thru 21 ◆ |
| **Parschau, M./Fasel, R./ Ernst, K.-H.** | Chirality transfer from helical molecules into self-assembled monolayers, 4th Internat. Symp. on Atomic Level Characterizations – ALC '03, Kauai, Hawaii , 10-05 thru 10 ■ |
| **Patscheider, J.** | The role of substrate bias for TiC-a-C:H nanocomposite coatings, Int. Conf. Metall. Coatings Thin Films '03, San Diego, CA, USA, 04-29 ■ |
| **Patscheider, J.** | International Conference of Metallurgical Coatings and Thin Films '03, San Diego, CA, USA, 04-28 thru 05-02 ▲ |
| **Patscheider, J.** | International Conference of Metallurgical Coatings and Thin Films '03, San Diego, CA, USA, 04-28 thru 05-02 ■ |
| **Patscheider, J.** | Interfaces and Interphases: a Key to Understanding Nanostrutured Hard Coatings, Surface Analysis '03 (AVS), University of Illinois, Urbana-Champaign, USA, 06-04 ■◗ |
| **Patscheider, J.** | Nanostructured Hard Coatings: From Multilayers to Nanocomposites, Euromat '03, Lausanne, 09-01 ■◗ |

■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# Conferences

**Patscheider, J.** Wear Protection by Nanostrutured Hard Coatings: From Multilayers to Nanocomposites, Smart Surfaces in Tribology, Zürich, 09-10 ■◗

**Patscheider, J.** Structure and properties of Nanostructured Hard Coatings: From Multilayers to Nanocomposites, Int. Summer School on Vacuum, Electron and Ion Technologies VEIT 13, Varna, Bulgaria ■◗

**Patscheider, J.** Nanostrukturierte Hartstoffschichten, OTTI-Kolleg, Würzburg, Germany, 11-04 ■◗

**Patscheider, J.** Nanostructured Hard Coatings: From Multilayers to Nanocomposites, NATO-Workshop Nanostructured Materials, Moscow, Russia, 12-08 ■◗

## Materials and Systems for Civil Engineering

**Meier, U.** Bonding of carbon fibre reinforced plastic (CFRP) strips on concrete with stress gradients and process control / 21st International Symposium on Bonding Technology / New Munich Trade Fair Center, München, Germany, 01-13 ■◗

**Meier, U.** Prospective View of Adaptive Materials in Structural Systems, 82nd Annual Conference of US Transportation Research Board of the National Academies, Marriott Hotel, Washington D.C., USA, 01-14 ■◗

**Meier, U.** Multifunctional composites in construction: a prospective view, JEC Conference Heading for New Horizons, Paris Expo – France, Porte de Versailles, Paris, France, 04-01 ■◗

**Meier, U.** Strengthening and Stiffening of Historic Wooden Structures with CFRP, JEC Conference Heading for New Horizons, Paris Expo – France, Porte de Versailles, Paris, France, 04-02 ■◗

**Meier, U.** Adaptive material systems for civil structures, 12th International Techtextil Symposium, Congress Center Messe Frankfurt, 04-09 ■●◗

**Meier, U.** Werkstoffe der Luft- und Raumfahrt machen Karriere im Bauwesen, Rotary Club Zug, City Hotel Ochsen, Zug, 04-14 ■◗

**Meier, U.** CFK im Bauwesen, SACAC Fachtagung, Schloss Lenzburg, 05-20 ■◗

**Meier, U.** Advanced Materials: Transitioning from the Traditional to the New in Civil Engineering Technology, V Simposio EPUSP sobre Estruturas de Concreto, Escola Politécnica of the University of São Paulo, Brasil, 06-08 ■◗

**Meier, U.** Effiziente Nutzung von Faserverbundwerkstoffen bei Tragwerken, 14. Symposium Verbundwerkstoffe und Werkstoffverbunde der Deutschen Gesellschaft für Materialkunde DGM, Technische Universität Wien, Austria, 07-02 ■●◗

**Meier, U.** Strengthening of Historic Wooden Structures with Carbon Fiber Reinforced Polymers, Euromat 2003, EPF Lausanne, 09-04 ■●

**Meier, U.** Composites for Bridges and Civil Engineering, Composite Bridge Alliance Europe COBRAE Conference, Hotel Casa Branca, Porto, Portugal, 11-12 ■◗

**Stöcklin, I./Meier, U.** Strengthening of concrete structures with prestressed and gradually anchored CFRP strips, 6th International Symposium on Fibre Reinforced Polymer Reinforcement for Concrete Structures, National University of Singapore, 07-08 thru 10 ■●

**Ulaga, T./Meier, U.** Kohlenstofffaserverstärkte thermoplastische Lamellen für die Verstärkung von Betonbauwerken, Swiss Bonding 03, 17. Int. Symposium, HSR Rapperswil, 05-21 ■●◗

**Ulaga, T./Vogel, T./Meier, U.** The bilinear stress-slip bond model: theoretical background and significance, 6th International Symposium on Fibre Reinforced Polymer Reinforcement for Concrete Structures, National University of Singapore, 07-08 thru 10 ■●

Applied Physics in Building

**Affolter, Ch./Ghazi Wakili, K.** Die Anwendung der Finite Elemente Methode im Brandschutzingenieurwesen, VIB-Tagung, Basel, 05-20 ■◗

**Brunschweiler, U.** SBI-Testanlage: Messmethode, VKF Infoveranstaltung, Empa-Akademie, Dübendorf, 01-29 ▲■◗

**Büchli, R.** Algen an Fassaden, Stand der Kenntnisse, Abhilfemassnahmen, Vorlesungsreihe Spezialfragen Bauphysik, ETH Zürich, 01-17 ■◗



■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# EMPA Activities 2003

## Conferences

**Büchli, R.** Bauschäden – positiv betrachtet, Bauplatz – Jahresveranstaltung, Köppel AG, St. Gallen, 02-12 ■◗

**Büchli, R.** Bauschäden, Fachtagung, AH-MF, Basler Versicherung, Schlieren, 03-26 ■◗

**Büchli, R.** Bauschäden, Fachtagung, AH-MF, Basler Versicherung, Basel, 04-09 ■◗

**Büchli, R.** Microbiological growth on facades, 2. Internat. Symposium, CIB/W086, Lisbon, Portugal, 11-06 ■●

**Büchli, R.** Kirchen und Bauphysik, 1. Tagung Zentrum für Kulturgüteranalytik, Empa-Akademie, Dübendorf, 11-27 ■◗

**Bundi, R./Brunner, S.** Simulation of edge effects and steps in the development of service life, 6. Annual Vacuum Insulation Symposium, VIA, Washington DC, USA, 06-05 thru 06 ◆●

**Frank, Th.** SBI-Testanlage: Bedarfsanlyse, VKF Infoveranstaltung, Empa-Akademie, Dübendorf, 01-29 ▲■◗

**Frank, Th.** Fenster – Stand der Technik und neue Entwicklungen, AWEL Energie-Praxis Seminar, Zürich, 05-1 ■◗

**Frank, Th.** Fenster – Stand der Technik und neue Entwicklungen, AWEL Energie-Praxis Seminar, Uster, 05-19 ■◗

**Frank, Th.** Neuausgabe der SIA Norm 180, HSR/Empa Fortbildungskurs «Wärme und Feuchteschutz im Holzbau", Rapperswil, 05-27 ▲■◗

**Frank, Th.** Dynamische Nachweise für den sommerlichen Wärme-schutz, HSR/Empa Fortbildungskurs «Wärme und Feuchteschutz im Holzbau", Rapperswil, 05-27 ▲■◗

**Frank, Th.** Fenster – Stand der Technik und neue Entwicklungen, AWEL Energie-Praxis Seminar, Winterthur, 06-10 ■◗

**Frank, Th.** Temperaturverhalten von Leicht- und Massivbauten im Vergleich, Energie-Apéro, Kt. Thurgau, Weinfelden, 10-30 ■◗

**Frank, Th.** Temperaturverhalten von Leicht- und Massivbauten im Vergleich, Energie-Apéro, Kt. Schaffhausen, Schaffhausen, 11-06 ■◗

**Frank, Th./Binder, B.** Modelling of outdoor boundary conditions – Analysis of field measurements on windows, DAME-BC Conference, EU-JRC, Ispra, 10-14 ◆●◗

**Ghazi Wakili, K.** Feuchteschutz, Fortbildungskurs «Wärme und Feuchteschutz im Holzbau", HSR/Empa Fortbildungskurs «Wärme und Feuchteschutz im Holzbau", Rapperswil, 05-27 ■◗

**Ghazi Wakili, K./Bundi, R./ Frank, Th.** Vacuum Insulated Panels In Building Applications, CISBAT 2003, EPFL, Lausanne, 10-08 ■●

**Ghazi Wakili, K./Frank, Th.** Humidity dependent Water vapour retardes in light wooden constructions, INIVE/AIVC/BETEC Conference, Washington DC, USA, 10-13 thru 14 ■●

**Ghazi Wakili, K./Frank, Th.** Feuchteadaptive Dampfbremsen, Vorlesungsreihe Spezialfragen der Bauphysik, ETH Zürich, 12-12 ▲■

**Hugi, E.** Prüf- und Forschungsaktivitäten des Brandlabors – Ein Überblick, Vorlesungsreihe Spezialfragen der Bauphysik, ETH Zürich, 12-05 ■◗

**Manz, H.** Experimental and numerical study of a double envelope façade (Status report), Internat. Energy Agency, Solar Heating and Cooling Programme, Task 27: Performance of solar façade components, Project A3, Expert-Meeting, 2002, Lissabon, Portugal, 04-03 ■

**Manz, H.** Experimental and numerical study of a mechanically ventilated glass double façade with integrated shading device, 2. Int. Building Physics Conference, Leuven, Belgium, 04-14 ■●

**Manz, H.** Shading, Daylighting, Load interaction – Empirical Tests at Empa, IEA Task 34/43, Testing and Validation of Building Energiy Simulation Tools, Expert Meeting Empa, Dübendorf, 09-29 ■◗

**Meili, M.** Brandschutzfenster, Brandsicherheit im Holzbau, Lignum, Aarau, 05-22 ■◗

**Meili, M.** Brandlabor, Leistungsspektrum: Forschung, Entwicklung, EN-Versuche, Ausbildungskurs Brandspezialist, VSSM, Bürgenstock, 09-11 ■◗

■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# EMPA Activities 2003

## Conferences

| | | |
|---|---|---|
| | Meili, M. | Entwicklung von Brandschutzfenstern EI 30, Fensterforum, FFF, Wettingen, 09-18 ■◗ |
| | Meili, M. | Brandlabor, Leistungsspektrum: Forschung, Entwicklung, EN-Versuche, Ausbildungskurs Brandspezialist, VSSM, Bürgenstock, 10-15 ■◗ |
| | Moser, K./Schnewlin, P. | Wie schnell sind Schnelltrockner und Schnellzemente, Fachtagung, KBS, Lenzburg, 01-30 ■◗ |
| | Mühlebach, H. | Bedeutung der Luftdichtigkeit von Gebäudehüllen, HSR/Empa Fortbildungskurs «Wärme und Feuchteschutz im Holzbau", Rapperswil, 05-27 ■◗ |
| | Schnewlin, P. | Brandlabor, Leistungsspektrum: Forschung, Entwicklung, EN-Versuche, Ausbildungskurs Brandspezialist, VSSM, Bürgenstock, 09-11 ■◗ |
| | Simmler, H. | Deklaration von Wärmedämmstoffen, Weiterbildungskurs Energieberater, AFU, St.Gallen, 02-27 ■ |
| | Simmler, H. | Performance assessment of solar façade components, IEA SHC Task 27 Dissemination Workshop, Freiburg i.Br., Germany, 10-06 ■◗ |
| | Simmler, H./Brunner, S. | Service life prediction for vacuum insulation panels (VIP), CISBAT 2003, EPFL, Lausanne, 10-08 ■● |
| | Simmler, H./Binder, B. | Angular solar heat gain, DAME-BC Conference, EU-JRC, Ispra, 10-14 ■●◗ |
| | Tanner, Ch. | Grundlagen der Bauphysik, AWD-Kurs, smgv, Empa, Dübendorf, 01-08 ■ |
| | Tanner, Ch. | Empa-Stand an der Swissbau, Basel, 01-21 thru 25 ▲ |
| | Tanner, Ch. | Bauphysikalische Untersuchungen, Gastreferat bei HTA, Rapperswil, 02-10 ■◗ |
| | Tanner, Ch./Ghazi Wakili, K. | Wärmebrücken in Dämmstoffen, 29. Bausachverständigentage, AIBau, Aachen, 04-07 ■◗ |
| | Tanner, Ch. | VIP und ADB, Fachtagung Gebäudehülle 03, SVDW / SFHF, Interlaken, 04-09 ■◗ |
| Center for Energy and Sustainability in Buildings | Althaus, H-J./Classen M. | Ecoinvent 2000: Results of the Harmonisation, Uptate and Extension of LCA Data on Metals, Special LCA Discussion Forum, Lausanne, 12-05 ■◗ |
| | Bertschinger, H. | Luftregister: Lösungsbeispiele, Leistungsmöglichkeiten, Dimensionierung, Kosten und Nutzen, Forum-Energie-Zürich, ETH Zürich, 09-30 ■◗ |
| | Bertschinger, H. | Das Passivhaus punktet aktiv für die Umwelt, 15. Wissenschaftsapéro, Empa-Akademie, Dübendorf, 12-10 ■◗ |
| | Kellenberger, D./Althaus H-J. | Ecoinvent 2000: Results of the Harmonisation, Uptate and Extension of LCA Data on Construction Materials, Special LCA Discussion Forum, Lausanne, 12-05 ■◗ |
| | Zimmermann, M. | IEA Future Buildings Forum Workshop SUBURET «Advanced Concepts for Sustainable Building Retrofit», St. Moritz, 01-15 thru 17 ▲◗ |
| | Zimmermann, M. | Konzeption und Planung von erdverlegten Luftansaug-Kanälen und Luftansaug-Erdrefistern, Tagung «Energie aus dem Untergrund – Erdreichspeicher für moderne Gebäudetechnik», Empa-Akademie, Dübendorf, 05-06 ▲◗ |
| | Zimmermann, M. | Neue Entwicklungen im Fensterbereich, Energie-Praxis Seminar, Ziegelbrücke/Zürich, 05-14 and 06-04 ■◗ |
| Concrete/ Construction Chemistry | Hesselbarth, D./Kaufmann, J. | Lecture: Properties of short fiber reinforced cement paste for concrete tubes produced by centrifugation method, ACI Spring Convention, Vancouver, Canada, 03-30 thru 04-04 ■● |
| | Hoffmann, C. | Lecture: Besonderheiten des SCC in der Bauausführung, Firmenkolloquium, Weinfelden, 03-06 ■ |
| | Hoffmann, C./Leemann, A./ Olbrecht, Hp. | Organisation and Lectures: SCC – ein Beton mit Potential und Tücken, Kurszentrum des Kt. Baumeisterverbandes Zürich, Effretikon, 01-10 ▲■ |
| | Hoffmann, C./Leemann, A. | Lecture: Homogeneity of structures made with selfcompacting concrete and conventional concrete, 3rd International RILEM Symposium on Self-Compacting Concrete. Reykjavik, Iceland, 08-17 thru 20 ■● |
| | Holzer, L. | Lecture: Gefügeentwicklung während der Hydratation, 1. CEMNET@CH – workshop, Porosität von Zementmaterialien, Dübendorf, 04-10 ■● |



■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# Conferences

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|---|---|
| **Holzer, L./Winnefeld, F./ Lothenbach, B./Zampini, D.** | Lecture: The Early Cement Hydration: A Multi-Method Approach, 11th International Congress on the Chemistry of Cement (ICCC), Durban, South Africa, 05-11 thru 16 ■● |
| **Holzer, L./Kaufmann, J./ Indutnyi, F./Gasser, Ph./ Münch, B.** | Lecture: The 3D pore structure of cement paste investigated with DualBeam FIB (Focused Ion Beam), NSF-FWHA workshop on imaging and simulation of concrete microstructure (Nano- to Mesoscale), Evanston, USA, 07-29 thru 31 ■●◗ |
| **Holzer, L./ Kaufmann, J./ Indutnyi, F./Gasser, Ph./ Münch, B.** | Lecture: The 3D pore structure of cement paste investigated with DualBeam FIB (Focused Ion Beam), EUROMAT 2003 – European Congress and Exhibition on Advanced Materials and Processes, Lausanne, 09-01 thru 05 ■● |
| **Holzer, L./Kaufmann, J./ Indutnyi, F./Gasser, Ph./ Münch, B./Yang, T.** | Poster: The 3D pore structure of cement paste investigated with DualBeam FIB (Focused Ion Beam), 5. Tagung Bauchemie, (GDCh) Weimar, München, Germany, 10-09 thru 10 ◆● |
| **Jenni, A./Herwegh, M./ Zurbriggen, R./Holzer, L.** | Lecture: Quantitative Microfabric Analysis of Polymer-Modified High-Porous Mortars, 11th International Congress on the Chemistry of Cement (ICCC), Durban, South Africa, 05-11 thru 16 ■● |
| **Jenni, A./ Zurbriggen, R./ Holzer, L./ Herwegh, M.,** | Lecture: Entwicklung der Mikrostrukturen und physikalischen Eigenschaften von polymer-modifizierten Fliesenklebern während der Trocken- und Nasslagerung (Teil 2), Ibausil, 15. Internationale Bausstofftagung, Weimar, Germany, 09-24 thru 27 ■ |
| **Kaufmann, J.** | Lecture: Porosität und deren Charakterisierung, 1. CEMNET@CH – workshop, Porosität von Zementmaterialien, Dübendorf, 04-10 ■● |
| **Kaufmann, J./Hesselbarth, D./ Matschei, Th.** | Lecture: Effect of the Addition of Ultrafine Cement on the Properties of Fiber Reinforced Composites, 11th International Congress on the Chemistry of Cement (ICCC), Durban, South Africa, 05-11 thru 16 ■● |
| **Kaufmann, J./Matschei, Th.** | Lecture: Shrinkage behaviour of very dense cement pastes, 6th CANMET/ACI conference on Durability of Concrete, Thessaloniki, Greece, 06-01 thru 07 ■● |
| **Leemann, A.** | Lecture: Béton autocompactant: composition et caratéristiques, Journée d'information Holcim, EPF Lausanne, 10-08 ■◗ |
| **Leemann, A./Hoffmann, C.** | Lecture: Pressure of selfcompacting concrete on the formwork, 3rd International RILEM Symposium on Self-Compacting Concrete, Reykjavik, Iceland, 08-17 thru 20 ■● |
| **Leemann, A./Holzer, L.** | Lecture: Alkali-aggregate reactivity – identification of reactive silicates, 9th Euroseminar of Microscopy, Tronheim, Norway, 09-08 thru 12 ■● |
| **Lothenbach, B.** | Lecture: Modeling of Pore Solution in the Cement-Water System, Materials Modeling-Materials Day, ETH, Zürich, 01-24 ■● |
| **Lothenbach, B.** | Organization: Tagungsorganisation: 1. CEMNET@CH – workshop, Porosität von Zementmaterialien, Dübendorf, 04-10 ▲ |
| **Lothenbach, B./Holzer, L./ Winnefeld, F.** | Lecture: Thermodynamische Modellierung der Hydratation von OPC, Ibausil, 15. Internationale Bausstofftagung, Weimar, Germany, 09-24 thru 27 ■● |
| **Moser, K.** | Lecture: Wie schnell sind Schnelltrockner und Schnellzemente? 15. KBS Unterlagsboden-Fachtagung, Lenzburg, 01-30 ■ |
| **Moser, K.** | Lecture: Presyn a-plus Entwicklungsarbeiten an der Empa, Faserbeton-Fachtagung der Presyn-Lizenznehmer, Nottwil, 03-13 ■ |
| **Moser, K.** | Lecture: Engineering Design Methods for Service Life Planning: State of the Art, MDBP 2003 Management of Durability in the Building Process, International Workshop Milan, Italy, 06-25 thru 26 ■● |
| **Romer, M.** | Lecture: Detachment of Shotcrete Linings due to Long Term Interaction with Ground Water, International Seminar on The Thaumasite Form of Sulfate Attack on Concrete, Sheffield, Great Britain, 06-24 ■●◗ |
| **Romer, M./Holzer, L.** | Lecture: What Triggers Concrete Deterioration in Aqueous Environments ? 11th International Congress on the Chemistry of Cement (ICCC), Durban, South Africa, 05-11 thru 16 ■● |
| **Winnefeld, F.** | Lecture: Historische Kalkmörtel, Kurszentrum des Kt. Baumeisterverbandes Zürich, Effretikon, 02-05 ■ |

■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# EMPA Activities 2003

## Conferences

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|---|---|---|
| | Winnefeld, F./Holzer, L. | Lecture: Monitoring Early Cement Hydration by Rheological Measurements, 11th International Congress on the Chemistry of Cement (ICCC), Durban, South Africa, 05-11 thru 16 ■● |
| | Winnefeld, F./Böttger, K.G./ Knöfel, D. | Lecture: Restoration mortars for historical masonry, EUROMAT 2003 – European Congress and Exhibition on Advanced Materials and Processes, Lausanne, 09-01 thru 05 ■● |
| | Winnefeld, F./Lothenbach, B./ Holzer, L./Plötze, M./Rytz, G. | Lecture: Einfluss verschiedener Sulfatträger auf die Hydratation von Portlandzement, Ibausil, 15. Internationale Bausstofftagung, Weimar, Germany, 09-24 thru 27 ■● |
| | Winnefeld, F./Peters, A. | Poster: Einfluss von Fliessmitteln auf die Rheologie und den Hydratationswärmefluss von Zementleimen, 5. Tagung Bauchemie (GDCh) Weimar, München, Germany, 10-09 thru 10 ◆● |
| | Yang, T./Holzer, L./ Keller, B./Magyari, E. | Poster: AFM Study of Water adsorption and transport in cement on a molecular scale, international Nano Conference 2003 in the context of 4. Annual Meeting TOP NANO 21, St. Gallen, 09-09 thru 11 ◆● |
| | Zurbriggen, R./ Jenni, A./ Herwegh, M./ Holzer, L., | Lecture: Mikrostrukturentwicklung in polymer-modifizierten Fliesenklebern während der Applikation (Teil1), Ibausil, 15. Internationale Bausstofftagung, Weimar, Germany, 09-24 thru 27 ■ |
| **Energy Systems/ Building Equipment** | Dorer, V./Haas, A. | Lecture: Aspects of air and heat distribution in low energy residential buildings, 24th AIVC/BETEC Conference, Washington DC, USA, 10-12 thru 14 ■● |
| | Haas, A./Dorer, V. | Lecture: Aspekte der Wärme- und Luftverteilung im Passivhaus, 7. Internationale Passivhaustagung 2003, Passivhaus Institut Darmstadt, Hamburg, Germany, 02-21 ■● |
| | Koschenz, M./Lehmann, B. | Lecture: Thermoaktive Bauteilsysteme tabs: Kühlen mit Energie aus dem Erdreich, Energie aus dem Untergrund: Erdspeicher für moderne Gebäudetechnik, Empa, Zentrum für Energie und Nach haltigkeit im Bauwesen, Dübendorf, 05-06 ▲■ |
| | Lehmann, B./Koschenz, M. | Lecture: tabs mit Phasenwechselmaterial: Auf der Suche nach thermischer Speichermasse für Leichtbauten und Renovationen, 25. Internationaler velta-Kongress 2003, Wirsbo-VELTA GmbH, Arlberg Hospiz, Austria, 04-05 thru 12 ■◗ |
| | Moser, A./Rüegg,T. | Lecture: Design Guide for Enhanced Local Exhausts with Jets – Summary of Swiss COST G3 Contribution, 7th int. Symposium on Ventilation for Contaminant Control 2003, SHASE, Sapporo, Japan, 08-05 thru 08 ■● |
| | Pfeiffer, A. | Lecture: Neuentwicklung Kühldeckenmodell in Type 56 – TRNSYS 16, TRNSYS-Usertag 2003, TRANSSOLAR GmbH, Stuttgart, Germany, 03-21 ■◗ |
| | Weber, A. | Lecture: TRNFLOW, the air flow multizone model within TRNSYS type 56, TRNSYS-Usertag 2003, TRANSSOLAR GmbH, Stuttgart, Germany, 03-21 ■ |
| | Weber, A. | Lecture: TRNFLOW, a new tool for the modelling of heat, air and pollutant transport in buildings within TRNSYS, Building Simulation 2003, IBPSA International Building Performance Simulation Association, Eindhoven, Netherlands, 08-11 thru 14 ■● |
| **Polymers/Composites** | Brunner, A.J. | Lecture: Vorhersage des Bruchverhaltens von Composite-Bauteilen: Welche Informationen kann die Schallemissionsanalyse liefern?, 27. Sitzung der Fachgruppe Strukturintegrität des SVMT, Alstom (Schweiz) AG, Birr, 03-05 ■ |
| | Brunner, A.J. | Lecture: Active Fiber Composites as Piezo Sensor, SAMPE Spring Meeting, Empa-Akademie, Dübendorf, 03-12 ■ |
| | Brunner, A.J. | Lecture: Fracture Mechanics of Composite Laminates: ESIS TC4 Developments and Prospects, Conference Prospects in Fracture, Imperial College, London, UK, 07-08 ■◗ |
| | Brunner, A.J. | Lecture: Fracture Mechanics Research in Continuous Fiber-Reinforced Composites, International Conference on Advanced Technology in Experimental Mechanics ATEM'03, Nagoya, Japan, 09-10 ■◗ |
| | Brunner, A.J. | Lecture: A Comparison Between Active and Passive Piezoelectric Elements for Damage Detection in Fiber-Reinforced Composites Laminates, International Conference on Advanced Technology in Experimental Mechanics ATEM'03, Nagoya, Japan, 09-10 ■● |
| | Brunner, A.J. | Organised Session OS9 Composite Structures – Damage Detection and Smart Monitoring (session organisers A.J. Brunner, C.-G. Kim, M. Hojo, A. Todoroki), International Conference on Advanced Technology in Experimental Mechanics ATEM'03, September 10-12, 2003, Nagoya, Japan, 09-10 thru 12 ▲ |



■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# EMPA Activities 2003

## Conferences

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|---|---|
| **Brunner, A.J.** | Lecture: Acoustic Emission of Fiber Reinforced Composites, Tokyo Institute of Technology (TIT), Tokyo, Japan, 09-12 ■● |
| **Brunner, A.J.** | Lecture: Fracture Mechanics of Composite Laminates: Selected Developments, Kyoto University, Kyoto, Japan, 09-16 ■● |
| **Brunner, A.J.** | Lecture: Schallemissionsanalyse von Faserverbundwerkstoffen, Zertifizierungskurs für Schallemissionsanalyse Stufe 3 nach EN473 Z-AT-2 der Deutschen Gesellschaft für Zerstörungsfreie Prüfung (DGZfP), Puchberg a. Schneeberg, Austria, 10-24 ■ |
| **Brunner, A.J.** | Lecture: Vergleichende Charakterisierung von Schallemissionssensoren, DACH-Seminar AT3-Erfahrungsaustausch, Puchberg a. Schneeberg, Austria, 10-27 ■ |
| **Brunner, A.J.** | Lecture: Schallemissionsanalyse an Bauteilen aus Faserverbundwerkstoffen, Institut für Leichtbau und Flugzeugbau Technische Universität Wien, Wien, Austria , 10-28 ■● |
| **Brunner, A.J.** | Lecture: Schallemissionsanalyse an Bauteilen aus Faserverbundwerkstoffen, Institut für Werkstoffkunde und -prüfung der Kunststoffe, Montanuniversität Leoben, Leoben, Austria, 10-29 ■ |
| **Brunner, A.J./ Blackman, B.R.K./ Williams, J.G.** | Lecture: Deducing Bridging Stresses and Damage from GIC Tests on Fibre Composites, Workshop Advances in the Statics and Dynamics of Delamination, Ecole Normale Supérieure (ENS), Cachan, France, 09-15 ■● |
| **Farshad, M.** | Lecture: Magnetoactive Polymer Composites. SAMPE Spring Meeting, Empa-Akademie, Dübendorf, 03-12 ■ |
| **Farshad, M.** | Lecture: Diagnose von Rohrleitungen – Neues Expertensystem für Schadenanalysen,. Empa-Akademie, Dübendorf, 03-14 ■ |
| **Farshad, M.** | Lecture: Berechnung der Steifigkeit. Kunststoffrohre richtig planen, berechnen und verlegen. 3. Seminar für IngenieurInnen und PlanerInnen von Versorgungsleitungen. Empa-Akademie/VKR, Thun, 04-01 ■● |
| **Farshad, M.** | Lecture: Statische Berechnung von Kunststoff-Rohrleitungen. Kunststoffrohre richtig planen, berechnen und verlegen. 3. Seminar für IngenieurInnen und PlanerInnen von Versorgungsleitungen. Empa-Akademie/VKR, Thun, 04-01 ◗■ |
| **Farshad, M.** | Lecture: Waterproofing systems in Swiss Alpine Base Tunnels – Testing and Evaluation, Plastics Forum 2003 European Parliament, Brussels, Belgium, 06-13 ■● |
| **Farshad, M.** | Lecture: Berechnung der Steifigkeit. Kunststoffrohre richtig planen, berechnen und verlegen. 4. Seminar für IngenieurInnen und PlanerInnen von Versorgungsleitungen. Empa-Akademie/VKR, Buochs, 11-27 thru 28 ■● |
| **Farshad, M.** | Lecture: Statische Berechnung von Kunststoff-Rohrleitungen. Kunststoffrohre richtig planen, berechnen und verlegen. 4. Seminar für IngenieurInnen und PlanerInnen von Versorgungsleitungen. Empa-Akademie/VKR, Buochs, 11-27 thru 28 ■● |
| **Farshad, M./Benine, A.** | Lecture: Magnetoactive Elastomer Composites, EUROMAT Conference 2003, Lausanne, 09-01 thru 05 ■● |
| **Flüeler, P.** | Lecture: The Sealing of Deep-seated Swiss Alpine Railway Tunnels – New Evaluation Procedure for Waterproofing Systems, National Institute for Standards and Technology (NIST), Gaithersburg, USA, 03-05 ■● |
| **Flüeler, P.** | Lecture: Zeitabhängigkeit der Kunststoffrohr-Eigenschaften. Kunststoffrohre richtig planen, berechnen und verlegen 3. Seminar für IngenieurInnen und PlanerInnen von Versorgungsleitungen, Empa-Akademie/VKR, Thun, 04-01■ |
| **Flüeler, P.** | Lecture: Werkstoffkunde und Rohreigenschaften. Kunststoffrohre richtig planen, berechnen und verlegen. 3. Seminar für IngenieurInnen und PlanerInnen von Versorgungsleitungen. Empa-Akademie/VKR, Thun, 04-01 ■ |
| **Flüeler, P.** | 3. Seminar für IngenieurInnen und PlanerInnen von Versorgungsleitungen. Empa-Akademie/VKR, Thun, 04-01 thru 02 ▲ |
| **Flüeler, P.** | Lecture: New Evaluation Procedure of the Waterproofing Systems for the Swiss Alpine Base Tunnels, International Tunnelling Association (ITA) World Tunnel Congress, Amsterdam, Netherlands, 04-12 thru 17 ■● |

■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# Conferences

**Road Engineering/ Sealing Components**

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| **Flüeler, P.** | Lecture: Sealing and Drainage System for the new Railway Tunnels Crossing the Swiss Alps, Seminar at Parsons Brinkerhoff MTA, New York, USA, 09-03 ■ ● |
| **Flüeler, P.** | Lecture: Which are the best sealing and drainage systems for the new Swiss railway AlpTransit projects?, Massachusetts Institute of Technology (MIT), Cambridge, USA, 09-17 ■ ● |
| **Flüeler, P.** | Lecture: Zeitabhängigkeit der Kunststoffrohr-Eigenschaften. Kunststoffrohre richtig planen, berechnen und verlegen. 4. Seminar für IngenieurInnen und PlanerInnen von Versorgungsleitungen. Empa-Akademie/VKR, Buochs, 11-27 thru 28 ■ |
| **Flüeler, P.** | Lecture: Werkstoffkunde und Rohreigenschaften. Kunststoffrohre richtig planen, berechnen und verlegen. 4. Seminar für IngenieurInnen und PlanerInnen von Versorgungsleitungen. Empa-Akademie/VKR, Buochs, 11-27 thru 28 ■ |
| **Flüeler, P.** | 4. Seminar für IngenieurInnen und PlanerInnen von Versorgungsleitungen. Empa-Akademie/VKR, Buochs, 11-27 thru 28 ▲ |
| **Huber, Ch.** | Lecture: Active Fiber Composites, Veranstaltung: SAMPE Spring Meeting, Empa-Akademie, Dübendorf, 03-12 ■ |
| **Kormann, X.** | Lecture: Piezoelectric ceramic fibers for active fiber composites: a comparative study, SPIE Conference Smart Structures and Materials 2003, San Diego, USA, 03-02 thru 06 ■ ● |
| **Kornmann, X.** | Matériaux utlisés dans les structures adaptives, Centredoc, Neuchâtel, 11-14 ■ ● |
| **Kornmann, X.** | Lecture: Active Fiber Composites (AFCs): Sensors and Actuators for Adaptive Materials Systems, Materials Science Seminar ETH Zürich, Zürich, 12-03 ■ |
| **Snedeker, J.G./Farshad, M./ Schmidlin, F.R./Niederer, P.** | Lecture: The kidney capsular membrane: mechanical properties and role during traumatic impact, Gemeinsame Jahrestagung der Österreichischen, Deutschen und Schweizerischen Gesellschaft für Biomedizinische Technik, Salzburg, Austria, 07-21 thru 24 ■ |
| **Snedeker, J.G./Rogelj, J./ Farshad, M/Schmidlin, F.R./ Niederer, P** | Lecture: Finite Element Models of Abdominal Organs for Use in Trauma Research, World Congress of Biomechanics, Calgary, Canada, 08-04 thru 09 ■ ● |
| **Snedeker, J.G./Voide, R./ Farshad, M./Schmidlin, P./ Niederer, P.** | Poster: Time-Dependent Material Properties of the Porcine Kidney Capsular Membrane, World Congress of Biomechanics, Calgary, Canada, 08-04 thru 09 ◆ |
| **Snedeker, J.G./Farshad, M./ Schmidlin, F.R./Niederer, P.** | Lecture: The importance of the kidney capsular membrane during trauma, The 7th Conference of the European Society for Engineering and Medicine (ESEM) and the European Society for Artificial Organs (ESAO), Halle, Germany, 09-18 thru 21 ■ ● |
| **Hugenschmidt, J.** | Non-destructive-testing of traffic-infrastructure using GPR, Int Syposium Non-Destructive Testing in Civil Engineering, NTD-CE, Berlin, Germany, 09-18 ■ ● |
| **Partl, M.N.** | Innovations in Swiss Asphalt Pavement Research, Seminar Politcnico di Torino, Italy, 02-12 ■ |
| **Partl, M.N.** | 6th Int. RILEM Symposium on Performance Testing and Evaluation of Bituminous Materials PTEBM03, Zürich, 04-14 thru 04-16 ▲ |
| **Partl, M.N.** | Recent Research Achievements in Asphalt Road Research in Switzerland, NARC Symposium, Nottingham, Great Britain, 05-08 ■ ● |
| **Partl, M.N.** | Conclusions of the RILEM Symposium PTEBM03: Binder Testing, European BitSpec Seminar, Brussels, Belgium, 06-12 ■ ● |
| **Partl, M.N.** | Innovative Developments of Research on Asphalt Pavement Materials Pavement Materials: SIIV Summer School «Le Pavimentazioni Stradali Flessibile" Università Politecnica delle Marche Ancona, Italy, 09-08 ■ |
| **Partl, M.N.** | RILEM TC 182 PEB Working Program and Achievements, RILEM-AAPA Workshop, Melbourne, Australia, 10-03 ■ ● |
| **Partl, M.N.** | Conclusions of the 6th RILEM Symposium on Performance Testing and Evaluation of Bituminous Materials. Proceedings of 12th Int. Flexible Pavements Conference, Melbourne, Australia, 10-05 thru 10-08 ■ ● |



■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# EMPA Activities 2003

## Conferences

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|---|---|---|
| | Partl, M.N./Stimolo, M./ Hugenschmidt J. | Nondestructive Testing of Asphalt Pavements, Seminar Politecnico di Torino, Italy, 02-13 ■ |
| | Partl, M.N /Anderegg, P./ Brönnimann, R./Raab, C. | Langzeitüberwachung des Belagverhaltens einer Autobahn. Proceedings of GESA-Symposium 2003, 12.-13. June 2003, Braunschweig, Germany, 06-12 thru 06-13 ■● |
| | Partl, M.N./Gubler, R./ Hugener, M. | Nano-Science and –Technology for Asphalt Pavements. 1st Internat. Symposium on Nanotechnology in Construction, Paisley, Great Britain, 06-23 ■● |
| | Partl, M.N./Hean, S: | Mastic Asphalt and Waterproofing Components for Bridge and Tunnel Construction. Proceedings of 12th Int. Flexible Pavements Conference, Melbourne, Australia, 10-05 thru 10-09 ■● |
| | Piber, H./Partl, M.N. | RILEM – Interlaboratory Tests on Performance Prediction of Pavements. Proceedings of 12th Int. Flexible Pavements Conference, Melbourne, Australia, 10-05 thru 10-10 ■● |
| | Poulikakos, L./Raab, C./ Partl, M.N./Anderegg, P./ Heutschi, K. | Swiss Contribution to Eureka Logchain Footprint E!2486. Swiss Transport Research Conference 03, Monte Verità (Ascona), 04-14 ■● |
| | Raab, C./Partl, M.N./ Anderegg, P./Brönnimann, R. | Two Years Experience with a New Long-Term Pavement Performance Monitoring Station on a Swiss Motorway. 3rd International Symposium on Maintenance and Rehabilitation of Pavements and Technological Control, Minho University, Guimarães, Portugal, 07-09 ■● |
| | Raab, C. | FWD, RSD and MDD Deflection Comparison, Workshop CSIR, 3 Dec., Pretoria, South Africa, 12-03 ■◗ |
| | Stimolo, M. | Visualization of the Sliding friction Heat during the Skid resistance Test through Infrared (IR) Thermography, Int Syposium Non-Destructive Testing in Civil Engineering, NTD-CE, Berlin, Germany, 09-18 ◆ |
| | Stimolo, M./Mastrangelo, R | Passive Infrared Thermography as Inspection and Observation Tool in Bridge and Road Construction, Int Syposium Non-Destructive Testing in Civil Engineering, NTD-CE, Berlin, Germany, 09-18 ■◗ |
| | Takahashi, S./Poulikakos, L./ Partl, M.N. | Evaluation of Improved Porous Asphalt by Various Test Methods. 6th Int. RILEM Symposium on Performance Testing and Evaluation of Bituminous Materials PTEBM03, Zürich, 04-14 thru 04-16 ■● |
| Strength and Technology | Affolter, Ch. | Thermomechanische Modellierung von Lötverbindungen mit angepasstem Kriechgesetz für bleifreie Lote; DGM-Tagung (Deutsche Gesellschaft für Materialkunde), Session «Anwendung in der Elektro- und Energietechnik», Wien, Austria, 07-02 thru 07 ■● |
| | Kieselbach, R. | Optimized Design of Adhesive Lap-Shear Joints for Fatigue Loading, SWISSBONDING, International Congress of Bonding Technology at HSR Rapperswil, 05-20 thru 22 ■● |
| | Kieselbach, R. | Limit Strains for Severe Accident Conditions to Nuclear Power Plants, 5th Euromech Solid Mechanics Conference ESMC-5, Thessaloniki, Greece, 08-17 thru 22 ■● |
| | Michel, S. | Fatigue Resistance of Carbon Fiber Reinforced Polymers up to the Gigacycle Regime; Int. Conf. on Aeronautical Fatigue ICAF 2003, Luzern, 05-05 thru 09 ■● |
| | Michel, S. | Fatigue Resistance of Carbon Fiber Composites at Very High Numbers of Fatigue Cycles; Int. Conf. on the Mechanical Behaviour of Materials ICM9), Genf, 05-26 thru 29 ■● |
| | Michel, S. | Effect of Environmental Condition and Frequency Variations on the Fatigue Crack Path in Aluminium Alloys; Int. Conf. on Fatigue Crack Path (FCP2003), Parma, Italy, 09-18 thru 19 ■● |
| | Weisse, B. | Optimierung einer Klebverbindung; DGM-Tagung (Deutsche Gesellschaft für Materialkunde), Session «Strukturelles Kleben», Wien, Austria, 07-02 thru 07 ■● |
| | Zhang, R. | Novel Actuators for Haptic Displays based on Elektroactive Polymers, Virtual Reality Software and Technology 2003, Osaka, Japan, 10-01 thru 03 ■● |
| Structural Engineering | Bergamini, A. | A simple Approach to the Localization of Flaws in Large Diameter Steel Cables, SPIE Conference, San Diego, USA, 03-03 ■● |
| | Bergamini, A./Christen, R. | SWISSBAU, Ausstellung, Demonstration: Damage Detection in Cables, Basel, 01-22 ■◗ |
| | Bergamini, A./Christen, R. | SAMCO Summer Academy in Cambridge UK, Damage Detection in Cables, Cambridge, Great Britain, 06-14 ■◗ |

■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# EMPA Activities 2003

## Conferences

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|---|---|---|
| | Christen, R./Bergamini, A. | Intern. Symposium NDT-CE 2003 Berlin, A simple approach to the automatic recognition of flaws in large diameter steel cables, Berlin, Germany, 09-16 ◆ |
| | Feltrin, G. | SAH Tagung Weinfelden Messung, Auswertung und Dämpfung von Schwingungen, Weinfelden, 11-04 ■◗ |
| | Feltrin, G./Vanomsen, P. | International Conference Wind Effects on Trees, 09-18 ◆ |
| | Feltrin, G./Weber, F. | D-A-CH Tagung, Geregelte Schwingungsdämpfung von Seilen, ETH Zürich, 09-18 ■◗ |
| | Feltrin. G./Wenk, Th. | D-A-CH Tagung, ETH Zürich , 09-18 ▲ |
| | Gsell, D./Motavalli, M./ Feltrin, G./Weber, F. | 6. Symposium Bauwerksdynamik, Adaptives Brückenmodell an der Empa, Empa-Akademie, Dübendorf, 06-13 ■◗ |
| | Huth, O./Feltrin, G./ Ulfkjaer, J.P./Kilic, N. | IMAC XXI Kissimee FL, Model Update and Damage Identification on a Prestressed Concrete Bridge Using Modal Parameters and Projective Input Residuals, Kissimee, Finland, 02-03 ■● |
| | Huth, O./Feltrin, G. | D-A-CH Tagung, Schadensdiagnose mit modalen Parametern: Erfahrungen an einer Spannbetonbrücke, ETH Zürich, 09-18 ■◗ |
| | Motavalli, M. | AIPCR – Tagung, Durban, South Africa, 10-15 ◆◗ |
| | Weber, F./Feltrin, G. | SPIE Conference 2003 San Diego Theoretical comparison of different controlled damping devices for cable vibration mitigation, San Diego, USA, 03-03 ■● |
| | Weber, F./Feltrin, G. | 5th Symposium on Cable Dynamics, Influence of the offset friction of rheological fluid dampers on the ivbration mitigation performance, Santa Margherita Ligure, Italy, 09-15 ■● |
| Wood | Arnold, M. | Lecture: Properties and utilisation of native wood species, A review of activities at the Empa Wood Laboratory, Wood research, Knowledge and concepts for future demands, A tribute to Prof. Dr. Jürgen Sell, Empa, Dübendorf, 01-17 ■◗ |
| | Arnold, M. | Lecture: Compression failures in wind-damaged spruce trees, International Conference «Wind Effects on Trees», University of Karlsruhe, Germany, 09-16 thru 18 ■● |
| | Graf. E. | Lecture: Durability of wood against wood inhabiting organisms – A review of activities at the Empa Wood Laboratory, Wood research, Knowledge and concepts for future demands, A tribute to Prof Dr Jürgen Sell, Empa Akademie, Dübendorf, 01-17 ■◗ |
| | Klingner, R. | Lecture: Holzabgeleitete hochporöse SIC-Keramik, Forstwisschenschaftliches Kolloquium ETH Zürich, 01-20 ■◗ |
| | Klingner, R. | Lecture: Innovative Strukturkeramik aus Holz, Vorlesungsreihe «Aktuelle Probleme aus der Materialwissenschaft II», Universität für Bodenkultur, Wien, Austria, 06-16 ■◗ |
| | Klingner, R. | Lecture: Thermodynamik im Hornissennest, Jahresversammlung der Schweizerischen Entomologischen Gesellschaft 2003, ETH Zürich, 03-07 ■ |
| | Meili, M. | Lecture: Sicherstellen des Baulichen Brandschutzes durch Feuerwiderstandsprüfungen an Bauteilen. SFS Zimmererhöck, Arbon, 05-08 ■ |
| | Meili, M. | Lecture: Ablauf und Sinn und Zweck von Feuerwiderstandsprüfungen an Bauteilen. Brandschutzspezialistenkurs VSSM, Bürgenstock, 05-12 ■ |
| | Meili, M. | Lecture: Ziele und Resultate von Feuerwiderstandsprüfungen an Brandschutzfenstern. Lignum Brandschutztagung, Aarau, 05-22 ■ |
| | Meili, M. | Lecture: Oberflächenbehandlung von Holz und Holzwerkstoffen im Aussenbereich. Fortbildungskurs Lignum, Brig, 05-23 ■ |
| | Meili, M. | Lecture: Prüfprogramm und Einsatz von Brandschutzfenstern. FFF Forum, Wettingen, 09-18 ■ |
| | Meili, M. | Lecture: Ablauf und Sinn und Zweck von Feuerwiderstandsprüfungen an Bauteilen. Brandschutzspezialistenkurs VSSM, Bürgenstock, 10-15 ■ |
| | Meili, M. | Organization: Tagungsleitung Spezielle Bemessungssituationen im mehrgeschossigen Holzbau. 35. SAH Fortbildungskurs, Weinfelden, 11-04 thru 05 ▲ |



■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# EMPA Activities 2003

## Conferences

**Meili, M.** Organization: Kursleitung Planung, Ausführung und Visionen des mehrgeschossigen Holzbaus. Minergiemesse, Bern, 11-27 ▲

**Meili, M.** Lecture: Einführung in die Thematik das Brandschutzes. Hochschule für Technik, Wirtschaft und Verwaltung, Zürich, 12-17 ■◗

**Nay, M.** Lecture: Algen und Pilze an Fassaden, Forschung an der Empa St. Gallen, 4. Dahlberg-Kolloquium «Algen an Fassadenbaustoffen, Ursachen,Schadensausmass, Lösungsansätze», Hochschule Wismar, Germany, 05-08■◗

**Nay, M.** Lecture: Biofilme auf Fassaden, Tecat-Seminar, Empa, Dübendorf, 06-02 ■◗

**Nay, M.** Lecture: Woher kommen, wie leben, und was verursachen Algen, Flechten, Pilze an Fassaden, Weiterbildungsveranstaltung des Gipsermeister-Verbandes der Ostschweiz, Balgach, 06-24 ■

**Nay, M.** Lecture: Das KTI-Projekt Algen und Pilze an Fassaden an der Empa St. Gallen, Jahrestagung internat. Fachverband Kunstharzputze, Brienz, 10-24 ■

**Pöhler, E./Zimmermann, T./ Geiger, T.** Lecture: Cellulosefibrillen für die Polymerverstärkung, naro.tech, 4. Internationales Symposium «Werkstoffe aus Nachwachsenden Rohstoffen», Erfurt, Germany, 09-11 ■●

**Raschle, P.** Lecture: Die Lebensansprüche der Mikroorganismen. Mikroorganismen als Schadensverursacher. ETH-Vorlesung ausgewählte Kapitel der Bauphysik, 01-17 ■◗

**Raschle, P.** Lecture: Algen und Pilze an Fassaden: Die Lebensansprüche dieser Mikroorganismen und deren Folgen, ISK Internationaler Sachverständigenkreis, Tagung 2003, Ausbau und Fassade D-A-CH, Luzern, 01-30 thru 31 ■◗

**Raschle, P.** Lecture: Algen und Pilze an Fassaden: Die Lebensansprüche der Mikroorganismen als Ursache für Schäden, Seminar des Amts für Hochbauten der Stadt Zürich und der Immobilienbewirtschaftung der Stadt Zürich gemeinsam mit Keim Farben Schweiz, Helferei Grossmünster, Zürich, 03-25 ■

**Raschle, P.** Lecture: Algen und Pilze an Fassaden. Seminar des Amts für Hochbauten der Stadt Zürich und der Immobilienbewitrtschaftung der Stadt Zürich. Helferei Grossmünster Zürich, 05-08 ■

**Raschle, P.** Lecture: Schimmel und Schädlinge im Depot und Museum erkennen und bekämpfen. Fortbildungstagung der Vereinigung Schweizer Museumsverbände VMS/ICOM, Naturhistorisches Museum Bern, 06-02 ■

**Raschle, P.** Lecture:Algen und Pilze. Problem an hochwärmegedämmten Fassaden. Energiefachstelle des Kantons Thurgau, Weinfelden, 10-30 ■◗

**Raschle, P.** Lecture: Algen und Pilze. Problem an hochwärmegedämmten Fassaden. Energiefachstelle des Kantons Schaffhausen, Schaffhausen, 11-06 ■

**Raschle, P.** Lecture: Nachweis der Bioaktivität am Textil. Bühler AR, 11-19 ■

**Raschle, P.** Lecture: «Tätigkeiten im Bereich Archtekturausstattung von historischen Bauten». Beiratssitzung des Zentrums Kulturgüteranalytik der Empa, Dübendorf, 11-26 ■

**Raschle, P.** Lecture: Mikrobiologische Analytik am Beispiel der Klosterkirche Müstair GR. Tagung «Analytik und Massnahmen an Baudenkmälern und Kulturgütern», Empa, Dübendorf, 11-27 ■◗

**Raschle, P.** Lecture: Mikrobiologie im Bauwesen und Kulturgütererhaltung. Mikrobiologie-Kurs der PHS St. Gallen, Empa, Dübendorf, 12-16 ■◗

**Richter, K.** Lecture: $CO_2$-Neutralität von Holz im Dienste der Wald- und Holzwirtschaftspolitik. Grundlagen der Bilanzierung. Forstwissenschaftliches Kolloquium ETH Zürich, 01-13 ■◗

**Richter, K.** Organization: Wood research – Knowledge and concepts for future demands, A tribute to Prof Dr Jürgen Sell, Empa Akademie, Dübendorf, 01-17 ▲

**Richter, K.** Lecture: Comparative LCA of forest products – A review of activities at the Empa Wood Laboratory, Wood research – Knowledge and concepts for future demands, A tribute to Prof Dr Jürgen Sell, Empa Akademie, Dübendorf, 01-17 ■◗

**Richter, K.** Lecture: Holzprodukte als CO2-Senken und ihre CO2-Substitutionseffekte in der Schweiz, Fachtagung Holz-Wald- Nachhaltigkeit, Fachhochschule Kuchl, Austria,04-15 ■◗

■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# EMPA Activities 2003

## Conferences

**Richter, K.** Lecture: Umweltanalysen über den Lebenszyklus. Folgen für die Holzwirtschaft, Statusseminar der Schweizerischen Arbeitsgemeinschaft für Holzforschung SAH und Hochschule für Architektur, Bau und Holz, Biel, 06-20 ■◗

**Richter, K.** Lecture: Oberflächenbeschichtung bei Holzfenstern: Ansätze zur Systemoptimierung, Produktionsoptimierung im Fensterbereich, Weiterbildungsseminar MGB Holzschutz, Wangen a.A, 06-24 ■

**Richter, K.** Lecture: Oberflächenbeschichtung bei Holzfenstern: Ansätze zur Systemoptimierung, Produktionsoptimierung im Fensterbereich, Weiterbildungsseminar MGB Holzschutz, Münchwilen, 06-26 ■

**Richter, K.** Lecture: Beiträge der Holzwirtschaft zur Reduktion der Klimaerwärmung: Verantwortung der Ausgebildeten. Diplomfeier Hochschule für Architektur, Bau und Holz, Biel, 11-07 ■◗

**Richter, K.** Lecture: Neue Trends in der Oberflächenbehandlung witterungsbeanspruchter Holzbauteile. Prolog Internationales Holzbau-Forum, Hochschule für Architektur, Bau und Holz, Biel, Garmisch Partenkirchen, Germany, 12-10 thru 12 ■◗

**Robledo, C./Werner, F.** Lecture: Renewable materials and climate change: political technical and social implications, Wood research – Knowledge and concepts for future demands, A tribute to Prof Dr Jürgen Sell, Empa Akademie, Dübendorf, 01-17 ■◗

**Sell, J.** Lecture: Beschichtungen an Holzfassaden – ein Überblick. Anforderungen an Beschichtungen, Leistung, neue Trends, Holzschutztagung 2003, Deutsche Gesellschaft für Holzforschung DGfH, Augsburg, Germany, 03-28 ■◗

**Steiger, R.** Lecture: Improved efficiency of timber structures, A review of activities at the Empa Wood Laboratory, Wood research, Knowledge and concepts for future demands, A tribute to Prof. Dr. Jürgen Sell, Empa, Dübendorf, 01-17 ■◗

**Steiger, R.** Lecture: Wärme- und Feuchteschutz im Holzbau, 16. Empa/HSR-Fortbildungskurs «Holzbau», Hochschule Rapperswil, 05-27 ■◗

**Steiger, R.** Organization: Organisation und Leitung des 16. Empa/HSR-Fortbildungskurses «Holzbau» zum Thema «Wärme- und Feuchteschutz im Holzbau», Hochschule Rapperswil, 05-27 ▲

**Steiger, R.** Lecture: Tragsicherheit, Bemessungskonzept und Baustoffe, Einführungskurs zur neuen Norm SIA 265 Holzbau, ETH Zürich, 07-14 ■◗

**Steiger, R.** Lecture: Tragsicherheit, Bemessungskonzept und Baustoffe, Einführungskurs zur neuen Norm SIA 265 Holzbau, ETH Zürich, 09-09 ■◗

**Steiger, R.** Lecture: Erdbeben: Seismologische Grundlagen – Risiko in der Schweiz, Erfassung in den SIA-Normen, 35. Fortbildungskurs der Schweizerischen Arbeitsgemeinschaft für Holzforschung SAH, Spezielle Bemessungssituationen im mehrgeschossigen Holzbau: Schall, Brand, Schwingungen, Logistik, Weinfelden, 11-04 thru 05 ■◗

**Steiger, R.** Lecture: Die neuen SIA-Tragwerksnormen, SWISSCODES, Änderungen gegenüber den Vorgängernormen mit Einfluss auf den Holzbau, GV der Schweizerischen Fachgemeinschaft Holzleimbau SFH, Pratteln, 11-28 ■

**Werner, F.** Lecture: Mechanismen und Effekte der Materialsubstitution im Gebäudepark mit Holz hinsichtlich des Treibhauseffektes. Forstwissenschaftliches Kolloquium ETH Zürich, 01-13 ■◗

**Werner, F.** Lecture: Wood products as carbon sinks and their substitution effects in Switzerland, 5. Plenaary Meeting of COST E21: The role of forest for mitigating greenhouse gas emissions, Thessaloniki, Greece, 11-28 ■●

**Widmann, R.** Lecture: Einsatz von zugelassenen Bauprodukten im Schweizer Holzhausbau, Weiterbildungsveranstaltung des Schweizerischen Verbandes für geprüfte Qualitätshäuser VGQ, Goldach, 10-24 ■

**Widmann, R.** Lecture: Einführung in die Schwingungslehre – Schwingungen im Holzhausbau als Komfortproblem. 35. Fortbildungskurs der Schweizerischen Arbeitsgemeinschaft für Holzforschung SAH, Spezielle Bemessungssituationen im mehrgeschossigen Holzbau: Schall, Brand, Schwingungen, Logistik, Weinfelden, 11-04 thru 05 ■◗



■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# Conferences

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|---|---|---|
| | Widmann, R. | Lecture: Qualitätssicherung im Holzhausbau heute – unterschiedliche Ansätze im internationalen Vergleich, Seminar Qualität im Holzhausbau, SH-Holz Schweizerische Hochschule für die Holzwirtschaft, Biel, 05-06 ■ |
| | Widmann, R. | Lecture: Winterlicher Wärmeschutz, 16. Empa/HSR-Fortbildungskurs «Holzbau», Hochschule Rapperswil, 05-27 ■◗ |
| | Zimmermann, T. | Lecture: The fine structure of the cell wall of soft- and hardwoods, A review of activities at the Empa Wood Laboratory, Wood research, Knowledge and concepts for future demands, A tribute to Prof. Dr. Jürgen Sell, Empa, Dübendorf, 01-17 ■◗ |
| | Zimmermann, T. | Lecture: Die Strukturen der Holzzellwand als Vorbild für technische Anwendungen, Forstwissenschaftliches Kolloquium ETH Zürich, 01-20 ■◗ |
| | Zimmermann, T. | Lecture: Die Holzzellwand als Vorbild für technische Anwendungen, Vorlesungsreihe «Aktuelle Probleme aus der Materialwissenschaft II», Universität für Bodenkultur, Wien, Austria, 06-16 ■◗ |
| | Zimmermann, T. | Lecture: Structural and fractographic study on chemically end enzymatically treated wood, 4th International Plant Biomechanics Conference, Michigan State University, East Lansing, USA, 09-18 ■● |
| | Zimmermann, T./ Pöhler, E./ Geiger, T. | Poster: Cellulose-nanofibrils for polymer reinforcement, Nanofair 2003, St. Gallen, 09-09 thru 11 ◆ |
| | Zimmermann, T./ Pöhler, E./ Geiger, T. | Poster: Cellulose-nanofibrils for polymer reinforcement, PGS-Annual Meeting, Functional optical polymers, Dübendorf, 11-28 ◆ |

## Materials and Systems for Protection and Wellbeing of the Human Body

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| Biocompatible Materials | Bruinink, A. | Lecture: Umgebungsbedingte Einflussgrössen der Zellentwicklung einschliesslich Zellmigration, Bremen, Germany, 11-18 ■◗ |
| | Bruinink, A. | Lecture+Workshop: Bio-aktive Oberflächenmodifikation durch Mikrostrukturierung, Bremen, Germany, 11-18 ■◗ |
| | Bruinink, A./Jaschko, A./ Sener, B./Augello, M./Ruffieux, K./Schug, J. | Poster: Effects of human dentin isolates on human bone cell performance, 35th USGEB Meeting, Davos, 03-19 thru 21 ◆ |
| | Bruinink, A./Kaiser, J.-P./ Baumgartner, F./Manser P./ Scharnweber, D./Worch, H. | Effects of surface topography on cell performance including motility, 8th Euromat Meeting, Lausanne, 09-01 thru 04 ■● |
| | Bruinink, A./Hälg, M./Wick, P./ Tobler, U./Manser, P./Grünert, J. | The choice of serum and ist pretreatment determines human bone marrow cell performance, 18th ESB meetiong, Stuttgart, Germany, 10-01 thru 04 ■● |
| | Bruinink, A./Hofstetter, L./ Kaiser, J.-P./Manser, P./ Osterwalder, Th. | Lecture: Approaching the approach: To elucidate cell-material interactions, BAG Bern, 10-27 ■ |
| | Bruinink, A./Meyer, D.C./Hälg, M. | Lecture: Adult human and rat bone and bone marrow cell performance: Effects of tissue culture conditions, 2nd Japanese-Swiss Workshop on Biomaterials, 11-05 thru 07 ■● |
| | Chai-Gao, H./Crevoisier, F./ Sigrist, H./Zimmermann, H./ Hauert, R./Bruinink, A./ Raschle, P./Bischoff, B./Bilia, M./ Bischoff, K. | Poster: BioPad: Bioactive Tissupor wound pads, KTI MedTech meeting 2003, Bern, 08-26 ◆ |
| | Denk, E./Walcyzk, T./ Davidsson, L./Zimmermann, M./ Hurrell, R./Synal, A./ Fortunato, G./Wendt, K./ Geppert, C./Häuselmann, H.J. | Evaluation of 41Ca and 84 Sr as novel isotopic tools in bone research, 5th Int. Symp. Nutr. Asp. Osteoporosis, Lausanne, 06 ◆ |
| | Fortunato, G./Wunderli, S. | Poster: Combined measurement uncertainty in isotope dilution MC-ICP-MS, European Winterconf. Plasma Spectrochem., Garmisch-Partenkirchen, Germany, 01-12 thru 17 ◆● |

■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# EMPA Activities 2003

## Conferences

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| **Fortunato, G./Fabian, D./ Ritter, A./Wunderli, S.** | Lecture: Assessing the origin of lead white pigments from the 17th century using lead isotope ratios and trace analyis, Int. Conf. ICP-MS, Venedig, Italy, 10-24 thru 25 ■● |
| **Frei, B./Wampfler, B.** | Eurachem General Assembly, St. Gallen, 05-20 thru 24 ▲◗ |
| **Geiger, T./Schleuniger, J./ Trottmann, M./Gasser, P./ Delavy, R./Hany, R./Zinn, M.** | Poster: Functional Polymers from Poly(3-hydroxyalkanoates): Protection of Surfaces from Biofouling, Biosurf V, Functional Polymeric Sufaces in Biotechnology, Zürich, 09-25 thru 26 ◆ |
| **Hälg, M./Wick, P./Tobler, U./ Schug, J./Bruinink, A.** | Poster: Effects of culture conditions on human bone (marrow) cell performance, International Symposium Interface Biology of implants, Rostock. Germany, 05-15 thru 16 ◆● |
| **Hartmann, R./Hany, R./Egli, T./ Witholt, B./Zinn, M.** | Poster: Polyhydroxyalkanoate (PHA) containing aromatic side chains, Annual Meeting of Swiss Society for Microbiology, Basel, 03-06 thru 07 ◆ |
| **Hartmann, R./Hany, R./Egli, T./ Witholt, B./Zinn, M.** | Poster: Tailor-made thermal properties of functionalized polyhydroxyalkanoates, Polymer Group of Switzerland, Spring Meeting Formulating Polymers for Product Design, Fribourg, 05-09 ◆ |
| **Hedinger, R.** | Lecture: Ermitteln der Unsicherheit mit Software, Messunsicherheit und Fähigkeit in der Analytik, Seminar am Haus der Technik, München, Germany, 11-11 ■ |
| **Hedinger, R.** | Lecture: Fallbeispiele – Unsicherheit analytischer Verfahren, Messunsicherheit und Fähigkeit in der Analytik, Seminar am Haus der Technik, München, Germany, 11-11 ■ |
| **Kaiser, J.-P./Bruinink, A.** | Poster: Monitoring of cell migration on structured surfaces, 10th Swiss Soc. Biomat. Meeting, Neuchâtel, 05-14 ◆● |
| **Kaiser, J.-P./Bruinink, A.** | Poster: Monitoring of cell migration on structured surfaces, 10th General meeting of the Swiss Society for Biomaterials (SSB), Neuchâtel, 05-14 ◆● |
| **Kaiser, J.-P./Bruinink, A.** | Monitoring of cell migration on structured surfaces, 18th ESB meeting, Stuttgart, Germany, 10-01 thru 04 ■● |
| **Meyer, V.R.** | Lecture: Fallstricke in der HPLC, 30. InfoExpo, Basel, 09-16 ■◗ |
| **Meyer, V.R.** | Lecture: Messunsicherheit – kein Schreckgespenst im Labor, Merck, Darmstadt, Germany, 11-20 ■◗ |
| **Pritzkow, W./Vogl, J./ Ostermann, M./Wunderli, S./ Fortunato, G.** | Poster: Neue, verbesserte und SI-rückgeführte Atomgewichtsbestimmung von Cd, 6. Symp. «Massenspektrometrische Verfahren der Elementspurenanalyse» und 18. ICP-MS Anwendertreffen, Berlin, Germany, 10-0 thru 09 ◆ |
| **Schmid, M.** | Lecture: Interlaboratory Tests on polymers by DSC: Determination and Comparison of OIT and OIT*, Standardisation, Measurement and Testing (SMT) of polymer materials for better quality of life, Warschau, Poland, 10-10 ■● |
| **Schmid, M.** | Lecture: Ringversuche an polymeren Werkstoffen, Thermoanalytische Methoden in der Kunststoffprüfung, Universität Erlangen, Germany, 10-30 ■◗ |
| **Weber, M.** | Lecture: Elementanalytik auf metrologischem Niveau, Conference of Ion Analysis CIA, Berlin, Germany, 02-25 ■●◗ |
| **Weber, M.** | Lecture: Messunsicherheit in der Spurenanalytik, APPLICA, Olten, 05-06 ■◗ |
| **Weber, M.** | Lecture: Ion analysis at the highest stage – the metrological approach by NMI's, Inorganic Working Group Meeting of CCQM, St.Gallen, 10-14 ■ |
| **Weber, M.** | Lecture: Transfer of analytical standards in Switzerland, IAWG/EAWG workshop (Consultative commitee of amount of substance, CCQM), St.Gallen, 10-15 ■◗ |
| **Wunderli, S./Fortunato, G./ Reichmuth, A./Richard, Ph.** | Poster: Uncertainty budget for mass values determined by electronic balances in analytical chemistry – new method for air buoyancy, European Winterconf. Plasma Spectrochem., Garmisch-Partenkirchen, Germany, 01-12 thru 17 ◆● |
| **Wunderli, S./Pritzkow, W./ Vogl, J./Fortunato, G.** | Lecture: Preparation of high purity enriched cadmium isotopes for a new atomic weight and metrological applications using MC-ICP-MS, BCEIA 2003, Beijing, China, 10-15 ■●◗ |



■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# EMPA Activities 2003

## Conferences

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| | Wunderli, S./Fortunato, G. | Lecture: An improved atomic weight for natural abundance cadmium by use of seven enriched isotopes and MC-ICP-MS, Seminary of institute of analytical chemistry for radiotrace elements, Chinese Institute of Atomic Energy CIAE, Beijing, China, 10-21 ■◗ |
| | Wunderli, S./Fortunato, G. | Lecture: Preparation steps for a new atomic weight for cadmium and IDMS application by MC-ICP-MS, Chulalongkorn University, Bangkok, Faculty of Science, Department of Chemistry, Bangkok, Thailand, 11-11 ■◗ |
| | Zinn, M. | Bioprocess design for the tailored biosynthesis of bioplastic (poyhydroxyalkanoates), ETH Zürich, 11-25 ■◗ |
| | Zinn, M | Biofilm formation in aquaqueous systems and its control, CIBA Spezialitätenchemie Grenzach GmbH, Grenzach-Wyhlen, Germany, 12-16 ■◗ |
| | Zinn, M. | Lecture: Tailor-made synthesis of polyhydroxyalkanoate, Swiss Society of Biomaterials, General Meeting, Neuchâtel, 05-14 ■ |
| | Zinn, M./Dejung, S./Egli, T. | Poster: Screeining for aromatic polyhydroxyalkanoates produced by Pseudomonas putida GPo1, Annual meeting of Swiss Society for Microbiology, Basel, 03-06 thru 07 ◆ |
| | Zinn, M./Geiger, T./Hany, R. | Lecture: Green polymers: new leads from nature, Polymer Group of Switzerland, Spring Meeting Formulating Polymers for Product Design, Fribourg, 05-09 ■◗ |
| | Zinn, M./Witholt, B./Egli, T. | Lecture: Multiple-nutrient-limited growth as a means to produce tailor-made bioplastic (PHA), 11th European Congress on Biotechnology, Basel, 08-24 thru 29 ■● |
| **Functional Fibers and Textiles** | Fischer, A. | Plasmatechnik in der Textilindustrie, 3. GR-Symposium, Bern, 01-29 ■ |
| | Fischer, A. | Reactive DC-Pulsed Sputtering of a (PbO)Zr22.8Ti22.8 (at%) Target – PZT film preparation and properties, 11. BFPT Plasmatechnologie, Ilmenau, Germany, 03-10 thru 12 ■ |
| | Fischer, A. | Oberflächenfunktionalisierung von Fasern und textilen Geweben mit Plasmatechnologie, Seminar TOP NANO21, Dübendorf, 07-04 ■ |
| | Fischer, A. | Forschung und Anwendung der Nanotechnologie im Textilbereich, Churfirsten-Kurs SVTC, Unterwasser, 09-12 thru 13 ■ |
| | Fischer, A./Hegemann, D. | Seminar TOP NANO21, Dübendorf, 07-04 ▲ |
| | Furrer, P./Herzig, U./Hufenus, R. | 7. Schadenfall-Meeting, St. Gallen, 11-28 ▲ |
| | Halbeisen, M. | Optimierung von funktioneller Bekleidung durch Anwendung der TRIZ-Methode, Europäischer TRIZ Kongress, Zürich, 03-20 thru 21 ■◗ |
| | Hegemann, D. | Design of Functional Plasma Coatings, AVS 50, Baltimore, USA, 11-02 thru 07 ■● |
| | Hegemann, D./Müller, M. | Nanoanalytik an Textilien, Seminar TOP NANO21, Dübendorf, 07-04 ■ |
| | Hufenus, R. | Verstärken von Fundationsschichten auf weichem Untergrund, 8. Tagung «Kunststoffe in der Geotechnik», TU München, Germany, 02-18 thru 19 ■ |
| | Reifler, F. | SMOG – eine Methode zur Erfassung der Antismell-Wirksamkeit textiler Ausrüstungen, 3. GR-Symposium, Bern, 01-29 ■ |
| | Reifler, F. | Water distribution and movement in wet aramid-based ballistic body armour panels detected with neutron radiography, 2nd European Conference on Protective Clothing (ECPC) nd NOKOBETEF 7, Montreux, 05-21 thru 24 ■● |
| | Ritter, A. | Quantitative Bestimmung von Schwermetallen in Kunststoffen, Applica, Fachseminar Spuren- und Mikroanalytik, Olten, 05-06 ■ |
| | Ritter, A. | Bestimmungen des Antioxydantiengehalts in Polyolefinen – Ringversuche an polymeren Werkstoffen, 6.Würzburger Tage der Instrumentellen Analytik in der Polymertechnik, Würzburg, Germany, 12-11 ■◗ |
| | Ritter, A./Fortunato, G. | Sophisticated analysis of cultural heritage, Euromat 2003, Lausanne, 09-03 ■◗ |

■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# Conferences

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|---|---|---|
| | Ritter, A./Fortunato,G. | Instrumentelle Analytik an Kulturgütern, Tagung zur Kulturgüteranalytik, Dübendorf, 11-27 ■ |
| | Schmid, H.R. | Comment vérifier les propriétés antidérapantes des revêtements de sols? Modifications du revêtement en cours d'usage, Congrès «Revêtements de sol surs», Lausanne, 04-10 ■ |
| Protection and Physiology | Brühwiler, P. | Poster: Study of Bicycle Helmets Using the Heated, Perspiring Manikin headform «ALEX», 2nd European Conference on Protective Clothing (ECPC) and NOKOBETEF 7, Montreux, 05-21 thru 24 ◆ |
| | Brühwiler, P. | Angle Dependence of Bicycle Helmet Ventilation and Comfort, 5IMMM, 5th International Conference on Thermal Manikins and Modelling, Strassbourg, France, 09-29 ■ |
| | Brühwiler, P. | Helmet Retention and Physiology, Workshop on Future Motorcyle Helmets and Visors, London, UK, 11-21 ■ |
| | Camenzind, M. | Lecture: Breathability versus protection, Functional Forum – Outdoor Traid Fair Friedrichshafen, Friedrichshafen, Germany, 07-25 ■◗ |
| | Derler, S. | Lecture: Developement of a mechanical hip model for the testing of hip protectors, Meeting of the hip protector standards working party, University of Teesside, Middlesbrough, Great Britain, 04-01 ■◗ |
| | Derler, S. | Lecture: Veränderung der Gleitfestigkeit durch die Benutzung, bfu Fachtagung «Sichere Bodenbeläge», bfu, Bern, 04-02 ■◗ |
| | Derler, S. | Lecture: Veränderung der Gleitfestigkeit durch die Benutzung, bfu Fachtagung «Sichere Bodenbeläge», Empa, St. Gallen, 04-03 ■◗ |
| | Richards, M. | Poster: Validation and measurement techniques of SAM, 2nd European Conference on Protective Clothing (ECPC) and NOKOBETEF 7, Montreux, 05-21 thru 24 ◆ |
| | Richards, M. | Modelling fire-fighter responses to exercise and asymetric IR-radiation using a dynamic multi-mode model of human physiology and results from SAM, 5IMMM, 5th International Conference on Thermal Manikins and Modelling, Strassbourg, France, 09-29 ■ |
| | Rossi, R. | Lecture: Sweat Management, Stand des Projektes, 3. GR-Symposium, Bern, 01-29 ■◗ |
| | Rossi, R. | Lecture: Wie praxisrelevant sind die Anforderungen der Brennbarkeitsverordnung?, Wissenschaftsapero, Empa, Dübendorf, 02-10 ■ |
| | Rossi, R. | Lecture: Brennbarkeit von Bekleidungstextilien – Erörterung der Brennbarkeitsverordnung in der Schweiz, Dialog Textil – Bekleidung, München, Germany, 05-06 ■◗ |
| | Rossi, R. | Lecture: Hot steam transfer through heat protective clothing layers, 2nd European Conference on Protective Clothing (ECPC) and NOKOBETEF 7, Montreux, 05-21 thru 24 ■◗ |
| | Rossi, R | Lecture: Use of Hydrophilic Fibers and Fabrics for Improved Physiological Properties of Cold Protecctive Clothing, The Fiber Society 2003 Spring Symposium, Loughborough, Great Britain, 06-30 thru 07-02 ■◗ |
| | Rossi, R. | Kurs: Kleider- und Stoffbrände, Grundkurs Brandschutzermittlung, Schweizerliches Polizei-Institut, Zürich, 09-12 ■◗ |
| | Rossi, R./Metzger, Y. | Tagung: 2nd European Conference on Protective Clothing (ECPC) and NOKOBETEF 7, Montreux, 05-21 thru 24 ▲ |
| | Weder, M. | Lecture: Atmungsaktivität versus Regenschutz, Funktionsforum – Outdoor-Messe Friedrichshafen, Friedrichshafen, Germany, 07-24 ■◗ |

## Information, Reliability and Simulation Technology

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|---|---|---|
| Acoustics | Baschnagel, K. | Prinzipien der Bauakustik. Lärmschutz-Seminar. Institut für Rechtswissenschaft und Rechtspraxis. Universität St.Gallen, Olten, 03-25 ■ |
| | Baschnagel, K. | Einführung in die Bauakustik. 35. Fortbildungskurs , Schweizerische Arbeitsgemeinschaft für Holzforschung, Weinfelden, 11-04 ■ |
| | Baschnagel, K. | Grundlagen der Bauakuktik. Lärmschutz-Seminar. Institut für Rechtswissenschaft und Rechtspraxis. Universität St. Gallen, Luzern, 11-11 ■ |



■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# EMPA Activities 2003

## Conferences

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|---|---|
| **Eggenschwiler, K.** | Was ist Lärm? Wie wird Lärm gemessen? Öffentliche Informationsveranstaltung Fluglärm, Egg, 01-27 ■ |
| **Eggenschwiler, K.** | Anforderungen an Beschallungsanlagen für Sprache. EOTEC-Fachseminar Muttenz, 01-31 ■ |
| **Eggenschwiler, K.** | Was ist Lärm? Wie wird Lärm gemessen? Öffentliche Informationsveranstaltung Fluglärm, Zürich Witikon, 02-02 ■ |
| **Eggenschwiler, K.** | Was ist Lärm? Wie wird Lärm gemessen? Öffentliche Informationsveranstaltung Fluglärm, Zürich Schwamendingen, 03-31 ■ |
| **Eggenschwiler, K.** | Raumakustik – Vom Schulzimmer zum Konzertsaal. Hautpversammlung Naturforschende Gesellschaft Zürich, Dübendorf, 05-10 ■ |
| **Eggenschwiler, K.** | Was ist Lärm? Wie wird Lärm gemessen? Öffentliche Informationsveranstaltung Fluglärm, Dübendorf, 05-19 ■ |
| **Eggenschwiler, K./ Baschnagel K.** | Anforderungen an Beschallungsanlagen für Hörsäle. DAGA'03, 29. Jahrestagung für Akustik, Aachen, Germany, 03-20 ■◗ |
| **Emrich, F.** | Die neue SIA-Norm 181. Frühlingstagung der Schweizerischen Gesellschaft für Akustik, Genf, 06-06 ■ |
| **Emrich, F.** | In situ Messungen an Schallschutzschirmen mit dem Adrienne-Verfahren. Technische Kommission VSS, .c/o. FALS, Glattbrugg, 06-19 ■ |
| **Emrich, F.** | Schallschutz im Hochbau – Revision der SIA181 und deren Bedeutung für den Holzbau. 35. Fortbildungskurs , Schweizerische Arbeitsgemeinschaft für Holzforschung, Weinfelden, 11-04 ■ |
| **Emrich, F.** | Entwicklungen in der Normung zur Bauakustik. im Rahmen der Vorlesungsreihe B. Keller / Th. Frank, Spezialfragen der Bauphysik an der ETH, Zürich, 11-21 ■ |
| **Hofmann, R./ Emrich, F.** | Die gesetzlichen Grundlagen. Lärmschutz-Seminar. Institut für Rechtswissenschaft und Rechtspraxis. Universität St. Gallen, Luzern, 11-11 ■ |
| **Nguyen, C.H. /Pietrzko, S.** | Analyse und Modellierung elektro-mechanisch-akustischer Kopplungen zwischen piezoelektrischen Kraftaktuatoren und vibroakustischen Strukturen. Empa- 2. Forschungsmarktplatz, St. Gallen, 03-26 ■ |
| **Nguyen C.H./Pietrzko S./ Buetikofer R.** | Actuation Transfer in a PZT-actuated Beam under Effective Working Conditions. ICSV10, Stockholm, Sweden, 07-07 ■● |
| **Poulikakos, L.D./Raab, Ch./ Partl, M./Heutschi, K./ Anderegg, P.** | Swiss contribution to Eureka Logchain Footprint E!2486. 3rd Swiss transport research conference (STRC), Ascona, 03-29 ■ |
| **Thomann, G.** | Möglichkeiten und Grenzen der akustischen Fluglärmsimulation. Wissenschaftsapero «Krach am Himmel – wie sehr belastet uns der Fluglärm», Empa-Akademie, Dübendorf, 03-07 ■ |
| **Thomann, G.** | Fluglärm – Grundlagen und Beispiele von Fluglärmsimulationen. Gesetzliche Grundlagen und Grenzwerte. Projektwoche Flughafen- und Raumentwicklung, Nachdiplomstudium in Raumplanung ETH Zürich, 04-08 ■ |
| **Thomann, G.** | Fluglärmsimulation. Gastvortrag Vorlesung Prof. Wiedmer, ETH Zürich, 06-13 ■ |
| **Walk, M.** | Schalldämmeigenschaften von Wänden und Decken im Holzbau – ein Überblick. 35. Fortbildungskurs, Schweizerische Arbeitsgemeinschaft für Holzforschung, Weinfelden, 11-04 ■ |
| **Walk, M./Emrich, F./Leuthardt F.** | Entwicklung von Simulationsmethoden für haustechnische Benutzungsgeräusche. DAGA'03, 29. Jahrestagung für Akustik, Aachen, Germany, 03-20 ◆ |
| **Walk, M./Emrich, F.** | Kostenfolgen von Schallschutz-Verbesserungen im Hochbau der Schweiz in Hinblick auf die Revision der Norm sia 181. BUWAL-Seminar, Bern, 06-25 ■ |

**Electronics/Metrology**

| | |
|---|---|
| **Anderegg, P./Brönnimann, R./ Raab, C./Partl, M.N.** | Langzeitüberwachung des Belagsverhalten einer Autobahn, GESA-Symposium, Braunschweig, Germany, VDI/VDE Gesellschaft, Düsseldorf, Germany, 06-12 thru 13 ■ |
| **Brönnimann, R.** | Structural Health Monitoring, Astra – Informationstag, Empa, Dübendorf, 11-12 ■ |
| **Brönnimann, R.** | Dimensionelle Messungen, metas-Besuch, Empa, Dübendorf, 11-26 ■ |

■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# EMPA Activities 2003

## Conferences

**Brönnimann, R./Anderegg, P./Nellen, P.M./Sennhauser, U.** RELIABLE LONG-TERM HEALTH MONITORING OF CFRP WIRES, Meeting of International Working Group on Structural Health Monitoring, Empa, Dübendorf, 07-24 ■

**Campi, D./Blau, B./Christin, R./Curé, B./Grillet, JP./Mezin, N./Neuenschwander, J./Riboni, P./Sequeira Tavares, S./Sgobba, S./Vittet, M.** Manufacturing of the CMS solenoid conductor at Techmeta, 8th International Conference on Advanced Technology and Particle Physics, Como, Italy, 10-06 ■ ●

**Dias-Lalcaca, P./Hack, E./Sennhauser, U.** Evaluation of coherent fibre-bundle characteristics for use in an ESPI-based instrument for measuring strain in electronic packages, TEST 2003 Kongress, Nuremberg, Germany, 05-15 ■

**Flisch, A./Hofmann, J./Obrist, A.** Efficient Volume Digitizing with Adaptive Computerized Tomography. Intern. Symposium on Computed Tomography and Image Processing for Industrial Radiology, Berlin, Germany, 06-23 thru 25 ■ ●

**Flisch, A./Hofmann, J./Obrist, A.** Volumendigitalisierung mit adaptiver 2D-Computertomographie. Anwenderforum Rapid Product Development, Fraunhofer IPA, Stuttgart, Germany, 09-17 ■ ◗

**Flisch, A./Hofmann, J./Obrist, A.** Tomographic Data Acquisition for Rapid Product Development Applications. Empa Workshop Materiali moderni, Manno, 10-17 ■ ◗

**Flisch, A./Piazza, D.** Prototipazione all'Empa: Dal «reverse engineering» alla realizzazione di componenti «high-tech» per applicazioni spaziali. Workshop Empa / SUPSI «Materiali moderni», Manno, 10-17 ■ ◗

**Grossmann, G.** Simultane Lötverfahren, Prozessparameter und Lötstellen. Tagung Bleifreies Löten, Empa-Akademie, Dübendorf, 03-28 ■

**Grossmann, G.** Anlagentechnik des bleifreien Reflowlötens. Tagung Bleifreies Löten, Empa-Akademie, Dübendorf, 03-28 ■

**Grossmann, G.** 6. Europäisches Elektronik-Kolleg. 49. Sitzung der Zuverlässigkeitstechnik, Empa, Dübendorf, 05-06 ■

**Grossmann, G.** Bleifreies Löten, Tagung an der Empa. 50. Sitzng der Zuverlässigkeitstechnik, Empa, Dübendorf, 09-04 ■

**Grossmann, G.** Neue F&E-Projekte, Weiterführung Lead-free. 51. Sitzung Zuverlässigkeitstechnik, Empa, Dübendorf, 12-10 ■

**Hack, E./Dias, P./Sennhauser, U.** Characteristics of imaging fibre-bundles for use in a ESPI-based instrument for distributed high-resolution measurements. Speckle Metrology, Trondheim, Norway, 06-15 thru 18 ■ ● ◗

**Held, M./Wosinska, L.** Reliability of Optical Components and Devices in Communications Systems and Networks; Activities of COST270 WG1. 7th International Conference on Telecommunications, Workshop on All Optical Networks, Zagreb, Croatia, 06-06 ■ ◗

**Held, M./Nellen, Ph.M./Wosinska, L.** Availability optimization by sensitivity analysis of fiber optical network systems. ESREL 2003, Maastricht, The Netherlands, 06-15 thru 18 ■

**Held, M./Wosinska, L./Nellen, P. M./Mauz, C.** Consideration of connection availability optimization in optical networks. 4th International workshop on the Design of Reliable Communication Networks DRCN, Banff, Canada, 10-19 thru 22 ■ ●

**Hofmann, J.** Smartscan. 51. Sitzung der Zuverlässigkeitstechnik, Empa, Dübendorf, 12-10 ■

**Jacob, P.** Grundlagen der Rasterelektronenmikroskopie. TU München, Limnolog. Station Iffeldorf, Germany, 03-17 thru 19 ■ ◗

**Jacob, P.** RFID auch für KMUs – eine Technologie die sich durchsetzt? 49. Sitzung der Zuverlässigkeitstechnik, Empa, Dübendorf, 05-06 ■

**Jacob, P.** RFID. EAN-Tagung, Basel, 05-07 ■

**Jacob, P.** ESD-Einträge durch die Chip-Passivierung bei post-Wafer-Prozessen: Fehlermechanismen, elektrische Ausfallverhalten und Analysen. ITG Diskussionssitzung, Grainau, Germany, 05-27 thru 28 ■

**Jacob, P.** Polymer Residues After Metal Etch On CMOS Semiconductors: Mechanisms, Functional- and Reliability Risks. EUROMAT 2003, Lausanne, 09-01 thru 05 ■



■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# EMPA Activities 2003

## Conferences

**Jacob, P./Thiemann, U.** (Latente ESD-Schädigungen von Bauelementen durch post-Wafer-Prozesse: Eine Gefahr auch für Leistungshalbleiter? 32. Kolloquium Halbleiter-Leistungsbauelemente und ihre systemtechnische Anwendung, Freiburg, Germany, 10-27 thru 28 ■ ◗

**Jacob, P./Gärtner, R.** Vorbeugende Massnahmen in der Fertigung gegen ESD-Schädigungen in Mikrostrukturen. 8. ESD-Forum, München, Germany, 12-09 thru 10 ■

**Jacob, P./Thiemann, U.** Electrostatical Discharge Related Impacts Directly to Device Surfaces by Processing and Their Effects on Reliability and Field Return Failures. 8. ESD-Forum, München, Germany, 12-09 thru 10 ■ ●

**Jud, P.** Materialverhalten und Degradation bleifreier Lote. Tagung Bleifreies Löten, Empa-Akademie, Dübendorf, 03-28 ■

**Jud, P.** Leadfree: Probenherstellung für Zeit-Dehnungsversuche. 49. Sitzung der Zuverlässigkeitstechnik, Empa, Dübendorf, 05-06 ■

**Lüthi, Th./Neuenschwander, J.** Quality Monitoring of Co-Extruded and Welded Aluminium Stabilised Superconducting Cables using Ultrasonics. ETH Zurich and Superconductor Manufacture for High Energy Physics, ETH, Zürich, 04-16 ■ ◗

**Nellen, P.** Projects in Telecommunication, Visit of Nokia Miniaturization Team Empa, Dübendorf, 01-22 ■

**Nellen, P.** ESREL-Tagunsbericht, 50. Sitzung der Zuverlässigkeitstechnik, Empa, Dübendorf, 09-04 ■

**Nellen, P.** Überwachung und Frühwarnung dank zuverlässiger faseroptischer Sensoren, Kursvortrag, Schweizerische Zentralstelle für die Weiterbildung der Mittelschullehrpersonen «wbz cps», Winterthur, 11-13 ■ ◗

**Nellen, P./Sennhauser, U./ Reiner, J.** Nanoreliability. EuroNanoForum 2003 Trieste, Italy, 12-09 thru 12 ◆

**Nellen, P./Wyss, P.** MEMS related activities at the Laboratory Electronics/Metrology, Colibrys SA, Neuchâtel, 11-04 ◗

**Neuenschwander, J.** Bildgebende Ultraschallanalyse von Elektronikkomponenten, 51. Sitzung der Zuverlässigkeitstechnik, Empa, Dübendorf, 12-10 ■

**Neuenschwander, J./Blau, B./ Christin, R./Lüthi, Th./Rössler, G.** Quality Monitoring of the Electron Beam Welding of the CMS Conductor Using Ultrasonics. The 18th International Conference on Magnet Technology (MT-18), Morioka, Japan, 10-22 ◆ ●

**Obrist, A./Hofmann, J./Flisch, A.** Efficient Volume Digitizing with Adaptive Computerised Tomography. Numerisation 3D 2003, Paris, France, 04-23 thru 24 ■ ◗

**Reiner, J.** Systematische Untersuchung von Leckstromfluktuationen bei elektrischer Belastung dünner Gateoxidschichten (< 7 nm), 21. Diskussionssitzung der ITG «Fehlermechanismen bei kleinen Geometrien», Grainau, Germany, 05-28 ■

**Reiner, J./Gasser, P./Nicoletti, G.** Gallium-Contamination of FIB-prepared TEM-Lamella, European FIB User Group Meeting (EFUG), Archachon, France, 10-06 ■

**Reiner, J.** Leakage current behavior of thin gate oxide under electrical stress, 14th European Symposium on the Reliability of Electron Devices, Failure Physics and Analysis (ESREF), Archachon, France, 10-07 thru 10 ◆ ●

**Reiner, J.** Pre-breakdown leakage current fluctuations of thin gate oxide, IRW Internat. Reliability Workshop, Lake Tahoe, Canada, 10-20 thru 23 ◆ ●

**Rössler, G./Lüthi, Th./ Neuenschwander, J./Flisch, A.** Prüfung der Fügezone von bi-metallischen Turbinenscheiben aus zwei optimiert angepassten Nickelbasis-Legierungen (dual-alloy). Jahrestagung 2003, DGZfP, Mainz, Germany, 05-27 ■ ●

**Sennhauser, U.** 6. EU-Rahmenprogramm, 49. Sitzung der Zuverlässigkeitstechnik, Empa, Dübendorf, 05-06 ▲

**Sennhauser, U.** Anwendung der FIB in Materialwissenschaft und Fehleranalyse. Workshop des DGM Arbeitskreises «Präparative Aspekte der TEM». Max Planck Institut für Metallforschung, Stuttgart, Germany, 05-21 ■ ◗

**Sennhauser, U.** 50. Sitzung der Zuverlässigkeitstechnik, Empa, Dübendorf, 09-04 ▲

■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# EMPA Activities 2003

## Conferences

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|---|---|---|
| | Sennhauser, U. | 51. Sitzung der Zuverlässigkeitstechnik, Empa, Dübendorf, 12-10 ▲ |
| | Sennhauser, U. | Neue F&E-Projekte ESD, RFID. 51. Sitzung Zuverlässigkeitstechnik Empa, Dübendorf, 12-10 ■ |
| | Thurner, Ph. | Image Guided Fatigue Assessment of Bovine Trabecular Bone using Synchrotron Radiation (SR). 13th Annual Meeting of the European Orthopedic Research Society, Helsinki, Finland, 06-04 thru 07 ■ |
| | Thurner, Ph. | Tomography of Biological Cells on Polymer Scaffolds. International Conference of Materials for Advanced Technologies ICMAT, Singapore, 12-07 thru 12 ■◗ |
| | Wyss, P. | X-ray Tomographic and Laminographic Microscopy (XTM, XLM) using Synchrotron Radiation. Intern. Symposium on Computed Tomography and Imaging Processing for Industrial Radiology, Berlin, Germany, 06-23 thru 25 ■ |
| | Wyss, P. | Tomographische und radiographische Mikroskopie an der SLS und an der Empa. 51. Sitzung der Zuverlässigkeitstechnik, Empa, Dübendorf, 12-10 ■ |
| | Wyss, P./Thurner, Ph./ Hofmann, J./Lüthi, Th./ Obrist, A./ | Morphologic Investigations with X-ray Tomographic Microscopy (XTM) Using Synchrotron Radiation. TEST 2003 Kongress, Nuremberg, Germany, 05-13 thru 15 ■ |
| Mathematics, Imaging and Materials | Simon, K./Trachsler B. | A Random Walk Approach for Light Scattering in Material, Discrete Random Walks, DRW 03, Paris, France, 09-01 thru 06 ■● |
| | Steiger, W. | Offset-Druck Symposium, Zagreb, Croatia, 10-26 thru 29 ■● |
| Technology and Society | Hilty, L. | Gesundheit und Umwelt in einer Welt von smarten Gegenständen. Museum für Kommunikation, Bern, 09-23 ■◗ |
| | Hilty, L. | Das Vorsorgeprinzip in der Informationsgesellschaft. Internationales Symposium «Das Vorsorgeprinzip – Seine Renaissance im Risikomanagement», Winterthur, 10-02 ■◗ |
| | Hilty, L. | Pervasive Computing – Risiken der Durchdringung des Alltags mit ICT. Academia Engelberg, 10-15 ■◗ |
| | Hilty, L. | Informationsgesellschaft und nachhaltige Entwicklung – zwei Visionen ohne Zusammenhang? Tagung Informationsgesellschaft und Verantwortung, Schweizerische Botschaft und Wissenschaftsforum Berlin, Berlin, Germany, 10-22 ■◗ |
| | Hilty, L. | The Future of E-Waste. Engineering and Technology for the Information Society, WFEO Contribution to the World Summit on the Information Society (WSIS), Genf, 11-12 ■ |
| | Hilty, L. | Auswirkungen der ICT auf Gesundheit und Umwelt. 4. Ladenburger Kolleg der Gottlieb Daimler- und Karl Benz-Stiftung zum Thema Living in a Smart Environment, 11-18 ■◗ |
| | Hilty, L. | The Precautionary Principle in the Information Society – Technology Assessment for Pervasive Computing. Café Scientifique, Fribourg, 11-20 ■◗ |
| | Hilty, L. | Is there a driver in the car? Our everyday life caught in a network of smart objects. SIS-Forum, CERN Contribution to the World Summit on the Information Society (WSIS), Genf, 12-09, 12-11, 12-13 ■◗ |
| | Hilty, L. | The e-Waste Handbook: a Contribution to a Sustainable Information Society. The Changing Marketplace: Putting «e» To Work. Interactive Workshops organized jointly by the International Trade Centre (ITC) and the State Secretariat for Economic Affairs (seco), Switzerland at the ICT4D Platform Palexpo, Genf, 12-11 thru 12 ■◗ |
| | Hischier, R | European LCA Data on Paper and Board within the Framework of the Swiss database ecoinvent. 28th EUCEPA Conference Lisbon, Portugal, 04-02 ■● |
| | Hischier, R. | COST Action 530 – Working Group «Data Base», a European coordination platform for LCI activities. International Workshop on Quality of LCI Data, 10-20 ■● |
| | Hischier, R. | How compatible are the Swiss EcoSpold and the Swedish Sirii-SPINE formats for data doc umentation and exchange? International Workshop on Quality of LCI Data, 10-21 ■● |
| | Hischier, R./Wäger, P./ Gauglhofer, J. | Environmental Impact of the Recycling of ICT equipment – a case study of Swiss SWICO Recycling Guarantee System Presentation at SETAC/ISIE/Swiss Discussion Forum, Lausanne, 12-03 ■● |



■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# Conferences

**Köhler, A.** — Vortrag «Wenn Visionen realisiert warden – Chancen und Risiken des Pervasive Computing". Workshop «Mobil in die intelligenten Welten», Uni Stuttgart, Germany, 12-11 thru 12 ■◗

**Kräuchi, Ph.** — Kurzpräsentation von BENIGN, Workshop on IST for Risk Management, Environment and Humanitarian Demining in the 6th Framework Programm of the European Commission, 03-25 ■

**Ossés, M./Zah, R./Dinkel, F./ Noger, D./Grether, T./Saha, G.** — Managing the jute value chain with a Geographic Information System (GIS): threats and benefits. Oral Presentation at SETAC/ISIE/Swiss Discussion Forum, Lausanne, 12-03 thru 04 ■●

**Ruddy, T. F.** — Reducing Society'n Need for Material Input. In: Proceedings of the World Congress on the Digital Divide (WCDD) held by the World Federation of Engineering Organizations in Tunis, Tunesia, ■◗

**Ruddy, T. F.** — Improving Regulatory Consistency in the Information Society. In: Proceedings of the Side Event Held by the International Research Foundation for Development at the World Summit on the Information Society (WSIS), Genf, ■◗

**Ruddy, T. F.** — Regime Conflicts at the World Summit on the Information Society. In: Proceedings of the International Conference on Politics and Information Systems: Technologies and Applications (PISTA), Orlando FL, USA, 07-30 thru 08-02 ■●

**Ruddy, T. F.** — Open WSIS Networkshop, Genf, 12-12 ▲

**Ruddy, T. F.** — The Changing Marketplace: Putting «e» to Work for the Environment, 12-12 ■◗

**Ruddy, T. F.** — Lectures: «The Challenges of Multilateral and Bilateral Diplomacy» im Fache International Relations der Webster University, Genf, 09-01 and 15 ■

**Ruddy, T. F.** — Lectures: «International Affairs: Current Events» an der Webster University, Genf, 09-02 and 16 ■

**Ruddy, T. F./ Blankart, Franz** — Lecture: «International Political Economy, Economic and Monetary Integration» an der Webster University, Genf, ■

**Scharnhorst, W.** — Environmental assessment of the end-of-life phase of prinet wiring board assemblies used in antenna racks of 2G and 3G mobile phone networks, 12-02 thru 04 ◆●

**Zah, R./Ossés, M.** — The West-Bengal Jute Project. Forschungsseminar. University of Zurich, Department of Geography, Remote Sensing Lavoratories, Uni Zürich, 12-11 ■●

## Mobility, Energy and Environment

### Air Pollution/ Environmental Technology

**Buchmann, B.** — Added value of space-born data for an ambient air monitoring network, TEMIS user workshop, ESA-ESRIN, Frascati, Italy, 05-15 thru 16 ■

**Buchmann, B.** — Den Quellen Anthropogener Luftfremdstoffe auf der Spur, IAP, Universität Bern, 06-20 ■◗

**Emmenegger, L.** — Ammoniakmessungen im Gubristtunnel, Emissionen aus dem Verkehr, TECAT-Informationstag, Empa-Akademie, Dübendorf, 11-07 ■●

**Emmenegger, L.** — Planen von Emissionsmessungen, Emissionsmessungen an stationären Anlagen, Empa, Dübendorf, 09-02 thru 03 ■

**Emmenegger, L.** — Messen von physikalischen Parametern, Emissionsmessungen an stationären Anlagen, Empa, Dübendorf, 09-02 thru 03 ■

**Emmenegger, L.** — Qualitätssicherung bei Emissionsmessungen, Emissionsmessungen an stationären Anlagen, Empa, Dübendorf, 09-02 thru 03 ■

**Emmenegger, L./Mohn, J./ Gisi, D./Samardzic, B.** — Process Gas Analysis by Infrared Spectroscopy in the Semiconductor Industry, Tunable Diode Laser Spectroscopy Conference, Zermatt, 07-14 thru 18 ■●

**Emmenegger, L./Poulleau, J.** — Uncertainty of NOx and SO2 Emission Measurements, Chimia 7/8, 10-09 ◆●

**Folini, D.** — Identification of potential source regions; SOGE, third annual meeting, Urbino, Italy, 10-06 thru 07 ■◗

**Folini, D./Ubl, S./Kaufmann, P./ Schaub, D./Weiss, A.K./ Buchmann, B.** — Poster: Numerical models to locate sources of measured air pollution; CSCS Users Day, ETH Zürich, 11-25 ◆

■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# EMPA Activities 2003

## Conferences

**Gehrig, R.** Auswertung von Emissionsmessungen, Emissionsmessungen an stationären Anlagen, Empa, Dübendorf, 09-02 thru 03 ■

**Gehrig, R.** Zusammenhang zwischen PM10 und PM2.5. Wo machen parallele Messungen Sinn?, Österreichische Messtechnikertagung, Umweltinstitut des Landes Vorarlberg, Bregenz, Austria, 10-28 ■◗

**Gehrig, R.** PM10-Emissionen des Strassenverkehrs aus Abriebs- und Aufwirbelungsprozessen; Symposium Particulate Matter; Österreichische Akademie der Wissenschaften, Wien, Austria, 12-15 thru 16 ■◗

**Gehrig, R./Hill, M./Buchmann, B./ Imhof, D./Baltensperger, U./ Weingartner, E.** In-field measurements of road traffic related particle emissions, 7. ETH-Conference on Combustion Generated Particles, Zürich , 08-18 thru 20 ◆●

**Gehrig, R./Hill, M.** Feldmessungen von verkehrsbedingten Partikelemissionen, SANW/ACP-Workshop «Strassenverkehr und Luftqualität», ETH Zürich, 09-11 ■◗

**Gehrig, R./Hill, M.** Feinstaubemissionen des Strassenverkehrs durch Abrieb und Aufwirbelung, TECAT-Informationstag, Empa-Akademie, Dübendorf, 11-07 ■●

**Honegger, P.** Messen von Feststoffkonzentrationen, Metallen, Halbmetallen und ihren Verbindungen, Emissionsmessungen an stationären Anlagen, Empa, Dübendorf, 09-02 thru 03 ■

**Hüglin, Ch.** NABEL- Das Nationale Beobachtungsnetz für Luftfremdstoffe, Forschungskolloquium der MeteoSchweiz, 03-26 ■

**Hüglin, Ch./Marti A./ Ruckstuhl A.** Uncovering the dependence of maximum particulate and gaseous air pollutant concentrations on wind directions by nonparametric regression, European Aerosol Conference, Madrid, Spain, 09-01 thru 05 ■◆●

**Imhof, D./Baltensperger, U./ Weingartner, E./Gehrig, R./ Hill, M./Buchmann, B.,** In-field verification of PM10 emission factors of road traffic, 7. ETH-Conference on Combustion Generated Particles, Zürich , 08-18 thru 20 ◆●

**Kägi, R.** Specimen damage of secondary inorganic aerosols in the ESEM, EAC (European Aerosol Conference), Madrid, Spain, 09-01 thru 05 ◆●

**Kägi, R.** Minerals in the Air, Colloquium of the University Fribourg, Dept. of Earth Sciences, Fribourg, 11-04 ■◗

**Kägi, R./Mavrocordatos, D./ Schmatloch, V./Hug, P./ Hauert, R./Reimann, S.** Morphology and Chemistry of Oil Combustion Particles Revealed by a Combination of Single Particle Analysis and Bulk Analytical Methods, AAAR (American Association of Aerosol Science), 10-20 thru 24 ◆●

**Klausen, J.** The WMO Global Atmosphere Watch Program – An Overview, Journées d'étude sur la veille de l'atmosphère globale, Tamanrasset, Algeria, 02-02 thru 05 ■◗

**Klausen, J.** The GAW Station Information System (GAWSIS), CAS Working Group Meeting, WMO, Genf, 03-1 ■◗

**Klausen, J.** QA/SAC Switzerland, CAS Working Group Meeting, WMO, Genf, 03-18 ■◗

**Klausen, J.** QA/SAC Switzerland and WCC for Surface Ozone, Carbon Monoxide and Methane. GAWTEC V training course, Schneefernerhaus, Germany, 06-24 thru 27 ■

**Klausen, J.** Carbon Monoxide: An Overview GAWTEC V training course, Schneefernerhaus, Germany, 06-24 thru 27 ■

**Klausen, J.** Quality Control, Data Analysis, Data Handling, GAWTEC V training course, Schneefernerhaus, Germany, 06-24 thru 27 ■

**Klausen, J.** GAWSIS: Status and Challenges, WMO GAW World Data Centre Managers Meeting, Albany, New York, USA, 09-09 thru 11 ■◗

**Mohn, J.** Messen von organischen Stoffen, Emissionsmessungen an stationären Anlagen, Empa, Dübendorf, 09-02 thru 03 ■

**Mohn, J.** Gasanalytik mittels FTIR, Emissionsmessungen an stationären Anlagen, Empa, Dübendorf, 09-02 thru 03 ■



■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# EMPA Activities 2003

## Conferences

**I.C. Engines/Furnaces**

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|---|---|
| Petritoli, A./Bonasoni, P./ Weiss, A. K./Schaub, D./ Fortezza, F. | Nitrogen dioxide pollution in the Po Basin: a quantitative analysis based on ground-based and satellite measurements, EGS-AGU-EUG Joint Assembly 2003, Nice, France, 04-06 thru 11 ◆ ● |
| Poulleau, J./Raventos C./ Blank F./Emmenegger. L./ Gould, R./Kassman H./ Reynaud, S./Rokkjaer, J./ Waeber, M. | Uncertainty of emission measurements for manual and automatic reference methods: Comparison between uncertainty budget approach and inter-laboratory field test approach, QA/QC in the field of emission and air quality measurements, Prague, Czech Republic, 05-21 thru 24 ■ ● |
| Reimann, S./Schaub, D./ Stemmler, K./Simmonds, P./ O'Doherty, S./Greall, B./ Stordal, F. | On-line measurements of halogenated greenhouse gases for allocation of European sources, EGS-AGU-EUG Joint Assembly 2003, Nice, France, 04-06 thru 11 ■ ● |
| Schaub, D. | Air Pollution Monitoring from Space – Activities at Empa, 16th ESA Symposium on European Rocket and Balloon Programmes and Related Research, St. Gallen, 06-02 thru 05 ■ ● |
| Schaub, D. | Unsere Erdatmosphäre und ihre Verschmutzung, Wissenschaftsapéro, Empa-Akademie, Dübendorf, 10-21 ■ ◗ |
| Schaub, D./Weiss, A./ Richter, K./Buchmann, B. | Space-borne detection of mesoscale NO2 transport, Forschungsmarktplatz Empa, St. Gallen, 03-26 ◆ |
| Schaub, D./Weiss, A./ Richter, K./Buchmann, B. | Frontal transport of NO2 as observed from GOME, 4th Swiss Global Change Day, Bern, 04-04 ◆ |
| Schaub, D./Weiss, A./ Richter, K./Buchmann, B. | Frontal transport influencing the NO2 distribution over Europe as observed from GOME, EGS-AGU-EUG Joint Assembly 2003, Nice, France, 04-06 thru 11 ◆ ● |
| Schaub, D./Weiss, A./ Petritoli, A. | The Use of Space-borne Measurements and the Ground-based Swiss Monitoring System for Tracing Atmospheric Pollution, 7th TROPOSAT workshop, ESA-ESRIN, Frascati, Italy, 05-08 thru 09 ■ ◗ |
| Schaub, D./Weiss, A. | Regional Monitoring of NO2, TEMIS user workshop, ESA-ESRIN, Frascati, Italy, 05-15 thru 16 ■ |
| Stemmler, K. | VOC Chemie in der Atmosphäre, Kolloquium Atmosphärenwissenschatt, PSI, Würenlingen, 10-20 ■ ◗ |
| Stéphane S./Thévenaz, L/ Rober, P./Niklès, M./ Emmenegger, L. | Photoacoustic Spectroscopy in Industrial Applications, Tunable Diode Laser Spectroscopy Conference, Zermatt, 07-14 thru 18 ■ ● |
| Ubl, S. | Synoptic transport of pollution plumes modelled with a LPDM, Forschungsmarktplatz Empa, St. Gallen, 03-26 ■ |
| Ubl, S./Kaufmann, P./ Weiss, A. K./Buchmann, B. | Synoptic transport pf pollution plimes modelled with an LPDM, EGS-AGU-EUG Joint Assembly 2003, Nice, France, 04-06 thru 11 ◆ ● |
| Zellweger, C. | The GWA world calibration centre for surface ozone, carbon monoxide, and methane, Journées d'étude sur la veille de l'atmosphère globale, Tammanrasset, Algeria, 02-02 thru 05 ◗ |
| Zellweger, C. | Carbon monoxide measurement techniques. GAWTEC V training course, Schneefernerhaus, Germany, 06-24 thru 27 ■ |
| Zeyer, K. | Messen von anorganischen, gasförmigen Stoffen, Emissionsmessungen an stationären Anlagen, Empa, Dübendorf, 09-02 thru 03 ■ |
| Zeyer, K. | Auswertung und Berichterstattung bei Emissionsmessungen, Emissionsmessungen an stationären Anlagen, Empa, Dübendorf, 09-02 thru 03 ■ |
| Zeyer, K./Emmenegger, L./ Mohn J. | Flexible Gasanalytik mittels extraktiver Fourier-Transform Infrarotspektroskopie, VDI, München, Germany, 05-27 ■ ◗ |
| Zeyer, K./Berry, N./Keck, M./ Emmenegger, L. | SF6 method to quantify air exchange rates in open exercise yards for pigs, international symposium: control of gaseous and odour emissions from animal production facilities, Horsens, Denmark, 06-01 thru 04 ■ ● |
| Ajtay, D./Weilenmann, M. | Lecture: Describing and Compensating Gas Transport Dynamics for Accurate Instantaneous Emission Measurement, DECADE- Workshop, VITO Research Institute, Mol, Belgium, 05-07 ■ ◗ |

■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# EMPA Activities 2003

## Conferences

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|---|---|
| **Ajtay, D./Weilenmann, M./ Soltic, P.** | Lecture: Towards accurate instantaneous emission models, 12th International Transport and Air Pollution Symposium, Avignon, France, 06-16 thru 18 ■ ● |
| **Ajtay, D./Weilenmann, M.** | Lecture: Static and Dynamic Instantaneous Emission Modelling, TECAT-Tag 2003: Emissionen des Strassenverkehrs. Symposium, Empa-Akademie, Dübendorf, 11-07 ■ ◗ |
| **Bach, Ch.** | Lecture: Das Clean Engine Vehicle-Projekt, 6. Int. Tagung «Motorische Verbrennung» Haus der Technik, München, Germany, 03-18 thru 19 ■ |
| **Bach, Ch.** | Lecture: Das Emissionsverhalten eines modernen Erdgasfahrzeuges, 12. Int. Automobiltechnisches Symposium, Empa-Akademie, Dübendorf, 05-16 ▲ ■ |
| **Bill, R.** | Lecture: Potentiale alternativer Antriebskonzepte, Atmospheric Chemistry Physics Workshop, ETH Zürich, 11-09 ■ ◗ |
| **Lämmle, Ch.** | Lecture: Prozesssimulation in der Erdgasmotorenentwicklung, 6. Int. Tagung «Motorische Verbrennung» Haus der Technik, München, Germany, 03-18 thru 19 ■ |
| **Lehmann, U./Mohr, M.** | Lecture: «Contribution to PMP: Comparison study of a wide range of Measurement systems for particles in vehicle exhaust», International Conference on Future Worldwide Emission Requirements for Passenger Cars and Light Duty Vehicles and EURO V, Milan, Italy, 12-10 thru 11 ■ ● |
| **Mathis, U.** | Lecture: Effect of organic vapour in diesel exhaust on nanoparticle formation, 7th International ETH-Conference on Combustion Generated Nanoparticles, Zürich, 08-18 thru 20 ■ ● |
| **Mathis, U./Mohr, M.** | Poster: Effect of methanol and toluene vapour in diesel exhaust on nanoparticle formation, European Aerosol Conference (EAC), Madrid, Spain, 08-31 thru 09-05 ◆ |
| **Mohr, M.** | Lecture: Comparison study of a wide range of particle measurement systems; Cambridge Particle Meeting; University of Cambridge, Great Britain, 04-04 ■ ◗ |
| **Mohr, M.** | Lecture: Konventionelle und neue Verfahren der Partikelmesstechnik; Seminar: Minimierung der Partikelemissionen von Verbrennungsmotoren, Haus der Technik, München, Germany, 04-08 ■ ◗ |
| **Mohr, M.** | Lecture: PMP comparison study of particle measurement systems; 7th int. ETH-Conference on combustion generated nanoparticles, Zurich, 08-12 ■ |
| **Mohr, M./Lehmann, U.** | Lecture: PMP comparison study of particle measurement systems, 7th International ETH-Conference on Combustion Generated Nanoparticles, Zürich, 08-18 thru 20 ■ ● |
| **Mohr, M./Lehmann, U.** | Poster: Comparison of a wide range of measurement systems for particles in vehicle exhaust, European Aerosol Conference (EAC), Madrid, Spain, 08-31 thru 09-05 ◆ |
| **Soltic, P.** | Lecture: Comparison of Different Engine Types and Fuels Regarding their Ozone Forming Potential, ERFCOFTAC joint annual meeting, PSI, Villigen, 05-26 ■ ◗ |
| **Soltic, P.** | Lecture: On-Road Heavy Duty Emission Measurement, CITA Conference, Dublin, Ireland, 09-16 thru 19 ■ ◗ |
| **Soltic, P./Bach, Ch.** | Poster: Comparison of Different Engine Types and Fuels Regarding their Ozone Forming Potential, 12th International Symposium Transport and Air Pollution, Avignon, France, 06-16 thru 18 ◆ |
| **Soltic, P./Rütter, J.** | Poster: Comparison of the NO2/NOx Emissions of Heavy-Duty Euro-3 Diesel Engines with and without a CRT(TM) System, 12th International Symposium Transport and Air Pollution, Avignon, France, 06-16 thru 18 ◆ |
| **Soltic, P./Weilenmann, M.** | Lecture: Emissionsentwicklung der Personenwagen, TECAT-Tag 2003: Emissionen des Strassenverkehrs, Symposium, Empa-Akademie, Dübendorf, 11-07 ■ |
| **Soltic, P./Rütter, J.** | Lecture: On-Road and Engine Dynamometer Measurement of Heavy Duty Engine Emissions, International Conference on Future Worldwide Emission Requirements for Passenger Cars, Light Duty Vehicles and EURO V, Milano, Italy, 12-10 thru 11 ■ ● |
| **Weilenmann, M.** | Lecture: The ARTEMIS project of 5th EU-FP, DECADE-Symposium, Bruxelles, Belgium, 09-18 ■ ◗ |
| **Weilenmann, M.** | Organisation: TECAT-Tag 2003: Emissionen des Strassenverkehrs. Symposium, Empa-Akademie, Dübendorf, 11-07 ▲ |



■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# Conferences

## Organic Chemistry

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|---|---|
| Weilenmann, M. | Lecture: Kaltstartemissionen von Euro-0 bis Euro-3, Automotive Day, HTI (Fachhochschule), Biel, 11-12 ■◗ |
| Weilenmann, M./Soltic, P./ Saxer, Ch./Forss, A.-M./Heeb, N. | Lecture: Regulated and Nonregulated Diesel and Gasoline Cold Start Emissions at different Temperatures, 12th International Transport and Air Pollution Symposium, Avignon, France, 06-16 thru 18 ■● |
| Beffort, O./Khalid, F.A./ Keller, B.A./Klotz, U./Vaucher, S. | Poster: About the thermal and chemical stability of diamond during processing of Al/diamont composites by liquid metal infiltration, EUROMAT03, Lausanne ◆ |
| Beffort, O./Khalid, F.A./ Keller, B.A./Klotz, U./Vaucher, S. | Poster: About the thermal and chemical stability of diamond during processing of Al/diamont composites by liquid metal infiltration, EUROMAT03, Lausanne, 10-01 thru 05 ◆ |
| Keller, B.A. | Lecture: Nanoparticles Hybrid Systems: Interactions, Local Structure and Mobility, Besuch Degussa, Empa, Dübendorf, 08-29 ■◗ |
| Bommer, B./Keller, B.A./ Graule, Th./Klotz, U. | Poster: Nanoparticle Size Characterization by Light Scattering, TOPNANO21-Meeting 2003, St. Gallen, 09-09 thru 11 ◆ |
| Brühlmann, S./Forss, A.-M./ Novak, P./Lienemann, P./ Trottmann, M./Saxer, C.J./ Weilenmann, M./Heeb, N.V. | Poster: TWC-induced benzene formation under fuel rich combustion, Europacat 6, European Federation of Catalysis Societies, Innsbruck, Austria, 09-01 thru 04 ◆ |
| Crockett, R. | Organisation: Smart Surfaces in Tribology: Advanced Additives and Structured Coatings, Zürich-Glattbrugg, 09-10 thru 12 ▲ |
| Dietsch, H./Keller, B.A. | Lecture: Organic-Inorganic Hybrid Materials at Empa: Concepts, Problems, Solutions, $TiO_2$-Workshop, Empa, Dübendorf, 10-29 ■◗ |
| Gerecke, A.C. | Lecture: Brominated flame retardants and their transformation products: Occurrence in the environment and correlation with endocrine effects in fish, NRP 50 – «Endocrine Disruptors: Relevance to Humans, Animals and Ecosystems»-Workshop 2003, Swiss National Science Foundation, Zermatt, 10-16 thru 17 ■◗ |
| Gerecke, A.C. | Lecture: Detection of α-isomer dominated HBCD (hexabromocyclododecane) in Swiss fish at levels comparable to PBDEs (polybrominated diphenyl ehters), Workshop on brominated flame retardants in the environment, Center for Disease Control, Atlanta, USA, Boston USA, 08-22 thru 23 ■● |
| Gerecke, A.C. | Lecture: Increasing concentrations of decabromodiphenylether (DecaBDE) in Swiss sewage sludge since 1993, Workshop on brominated flame retardants in the environment, Center for Disease Control, Atlanta and Boston USA, 08-22 thru 23 ■◆ |
| Gerecke, A.C. | Lecture: Spurenanalytik und Umweltverhalten von bromierten Flammschutzmitteln, 30. Infoexpo, Infoexpo Organisations-Büro, Basel, 09-16 ■◗ |
| Gerecke, A.C./Kohler, M./ Zennegg, M./Schmid, P./ | Poster: Detection of α-isomer dominated HBCD (hexabromocyclododecane) in Swiss fish at levels comparable to PBDEs (polybrominated diphenyl ehters), Dioxin 2003, Garry Hunt TRC ◆ |
| Heeb, N.V. | Environmental Conference Chair Lowell, MA, US, Boston, USA, 08-25 thru 29 ◆ |
| Gerecke, A.C./Kohler, M./ Zennegg, M./Schmid, P./ Heeb, N.V. | Poster: Detection of α-isomer dominated HBCD (hexabromocyclododecane) in Swiss fish at levels comparable to PBDEs (polybrominated diphenyl ehters), SACh Conference 2003, SACh, Zürich, 09-03 thru 05 ◆ |
| Heeb, N.V. | Lecture: Das Benzol-Problem – Was hat der Katalysator gebracht?, TECAT-Informationstag «Emissionen des Strassenverkehrs", Empa Akademie, Dübendorf, 11-07 ■◗ |
| Heeb, N.V. | Lecture: Zeitaufgelöste Abgasanalytik mittels Chemischer Ionisations-Massenspektrometrie, CEAC-Seminar, ETHZ, Zürich, 07-03 ■◗ |
| Heeb, N.V. | Lecture: Sekundäremissionen durch Abgasnachbehandlung, HdT-Tagung «Minimierung der Partikelemissionen von Verbrennungsmotoren", Forum der Technik, München, Germany, 05-20 thru 21 ■◗ |
| Keller, B.A. | Lecture: Flugzeit-Sekundärionen-Massenspektrometrie (TOF-SIMS): Probleme und Lösungen bei der Akkreditierung im Prüflabor, SOFA'03 Technische Aspekte der Akkreditierung nach ISO/IEC 17025, EUROLAB-Deutschland, BAM, Berlin, Germany, 01-24 ■◗ |

■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# Conferences

**Keller, B.A.** — Lecture: Nanoparticles Hybrid Systems: Interactions, Local Structure and Mobility, Besuch Degussa, Empa Dübendorf, 08-29 ■ ◗

**Kohler, M.** — Lecture: PBDE Flame Retardants, Concentrations in Swiss Sewage Sludge in 1993 and 2002, SEA Fachtagung, ETH Lausanne, 03-06 ■ ◗

**Kohler, M.** — Lecture: Umweltverhalten von bromierten Flammschutzmitteln, PEAK-Praxisorientierte EAWAG Kurse, Dübendorf, 08-29 ■ ◗

**Kohler, M./Schmid, P.** — Lecture: Current research activities of Empa on brominated flame retardants, OECD Clearinghouse meeting on brominated flame retardants, BUWAL, Bern, 05-12 thru 13 ■ ◗

**Kohler, M./Zennegg, M./ Gerecke, A.C./Schmid, P./ Heeb, N.V.** — Poster: Increasing concentrations of decabromodiphenylether (DecaBDE) in Swiss sewage sludge since 1993, SACh Conference 2003, SACh, Zürich, 09-03 thru 05 ◆

**Kohler, M./Zennegg, M./. Gerecke, A.C./Schmid, P./ Heeb, N.V** — Poster: Increasing concentrations of decabromodiphenylether (DecaBDE) in Swiss sewage sludge since 1993, Dioxin 2003, Garry Hunt TRC Environmental Conference Chair Lowell, MA, US, Boston, USA, 08-25 thru 29 ◆

**Mattrel, P.** — Lecture: Das Ozonbildungspotential des Abgases von Motorrädern, TECAT-Informationstag «Emissionen des Strassenverkehrs", Empa Akademie, Dübendorf, 11-07 ■ ◗

**Muller, F./Saric, M./ Schurtenberger, P./Dietsch, H./ Keller, B.A./Diez, S./Stoll, S.** — Poster: Nanoparticles Hybrid Systems: Interactions, Local Structure and Mobility, EUROMAT03, Lausanne, 10-01 thru 05 ◆

**Muller, F./Shalkevich, A./ Keller, B./Osman, M./Diez, S./ Stoll, S./Schurtenberger, P** — Poster: Design of ionorganic-organic hybrid materials by small angle scattering methods, 2nd PSI Summer School on Structure and Dynamics of Soft Condensed Matter, Zuoz, 08-09 thru 16 ◆

**Muller, F./Keller, B.A./Diez, S./ Stoll, S./Schurtenberger, P.** — Poster: Nanoparticles Hybrid Systems: Interactions, Local Structure and Mobility, TOPNANO21-Meeting 2003, St. Gallen, 09-09 thru 11 ◆

**Muller, F./Keller, B.A./Diez, S./ Stoll, S./Schurtenberger, P.** — Poster: Nanoparticles Hybrid Systems: Interactions, Local Structure and Mobility, TOPNANO21-Meeting 2003, St. Gallen, 09-09 thru 11 ◆

**Muller, F./Saric, M./ Schurtenberger, P./Dietsch, H./ Keller, B.A./Diez, S./Stoll, S.** — Poster: Nanoparticles Hybrid Systems: Interactions, Local Structure and Mobility, EUROMAT03, Lausanne, 10-01 thru 05 ◆

**Saxer, Ch./Forss, A.-M./ Weilenmann, M./Heeb, N.V.** — Poster: Benzene Emission Factors of the latest Diesel- and Gasoline-fueled Passenger Cars within the Common Artemis Driving Cycle, 12th international Symposium of Transport and Air pollution, INRETS, TUG, Avignon, France, 06-16 thru 18 ◆

**Tang, C.S./Vörös, J./Schmutz, P./ Keller, B./Textor, M.** — Poster: A Feasibility Study on Locally Addressable Electrochemical Patterning (LAEP) using Poly (L-lysine)-g-Poly (Ethylene Glycol), SAOG Meeting, Universität Fribourg, 01-24 ◆

**Tang, C.S./Vörös, J./ Schmutz, P./Petronis, S./ Textor, M./Keller, B.A./ Zennegg, M.** — Poster: Locally Addressable Electrochemical Patterning (LAEPT) using Poly (L-lysine)-graft-Poly(ethylene glycol), EUROMAT03, Lausanne, 10-01 thru 05 ◆
Lecture: Analytik und Beurteilung der organischen Kontaminanten, Umgang mit brandbedingten Kontaminationen, Belfor (Suisse) AG, Gisikon, Empa Akademie, Dübendorf, 06-24 ■ ◗

**Zennegg, M.** — Lecture: Polybromierte Diphentylether (PBDE) in Seefischen und zeitliche Trends in Klärschlamm, Chemische Problemstoffe, Workshop Flammschutzmittel, EAWAG, Dübendorf, 08-27 thru 29 ■ ◗

**Zennegg, M.** — Lecture: Toxikologie organischer Schadstoffe nach Brandereignissen, Umgang mit brandbedingten Kontaminationen, Belfor (Suisse) AG, Gisikon, Empa Akademie, Dübendorf, 06-24 ◗

## Solid State Chemistry and Analyses

**Barrelet, T.** — Lecture and Poster: Measurements of _34S values in a peat profile and determination of the sulfur content in Norway spruce, NCCR Climate Summer School, Grindelwald, 08-30 thru 09-06 ■ ◆

**Bleiner, D.** — Lecture: Laser sampling of tricky matrices for plasma mass spectrometry, 49th Conference on Analytical Sciences and Spectroskopy ICASS, Ottawa, Canada, 06-03 ■ ◗

**Bleiner, D.** — Lecture: Cells tubes gases and valves in LA-ICPMS, Conferenc Memorial Universität, St. John's, Canada, 06-17 ■ ◗



■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# EMPA Activities 2003

## Conferences

**Bleiner, D.** — Lecture: Nanoparticle differentiation in Laser-Ablation-induced aerosols, Conference on Laser Ablation, Heraklion, Greece, 10-06 thru 10 ■ ◆

**Bleiner, D.** — Organization: What can lasers do for the materials scientist? Las-Mat Seminar Empa-Akademie, Dübendorf, 12-04 ▲

**Bleiner, D./Ulrich, A./ Vonmont, H.** — Poster: Characterization of functionaly graded elements of Solid Oxide Fuel Cells by Laser-Ablation-ICPMS, European Winter Conference on Plasma Spectrochemistry, Garmisch-Partenkirchen, Germany, 01-12 thru 17 ◆

**Bleiner, D./Trottmann, M./ Ulrich, A.** — Lecture: Differenzierung von Nanopartikeln beim Laserbeschuss: Auswirkungen auf die Elementanalytik von epitaktischen Schichten vin Silicium Wafern, Tagung Festkörperanalytik, Wien, Austria, 09-21 thru 24 ■ ●

**Figi, R.** — Chairman: 2nd Conference Ion Analysis, Berlin, Germany, 02-24 thru 26 ◗

**Figi, R.** — Two Lectures: Analytik und Beurteilung der Kontaminanten – Anorganische Schadstoffe and Toxikologie anorganischer Schadstoffe nach Brandereignissen, Fachtagung Umgang mit brandbedingten Kontaminationen, Dübendorf, 06-24 ■

**Figi, R.** — Lecture: Analytische Fallgruben bei der Analyse metallischer Werkstoffe – zwei Beispiele aus der Praxis der Materialprüfung und -forschung, 23. Spektrometertagung, Linz, Austria, 10-07 thru 08 ■ ◗

**Figi, R./Nagel, O./Schreiner, C.** — Poster: RESH – ein Algorithmus für moderne Probenaufbereitung und Analytik, 23. Spektrometertagung, Linz, Austria, 10-07 thru 08 ◆

**Lienemann, P.** — Lecture: Probleme bei der Analyse von CuNi-Werkstoffen mit der Röntgenfluoreszenzspektrometrie, Gesellschaft für Bergbau, Metallurgie, Rohstoff- und Umwelttechnik, Eisenbach, Germany, 11-04 thru 06 ■

**Senn, M.** — Lecture: Die Entwicklung der Schwertfegerei von der Eisenzeit bis ins Frühmittelalter – archäologische Untersuchungen, Seminar Uni Bern, Bern, 06-02 ■ ◗

**Senn, M.** — Lecture: Ein Spurenelement-Fingerprint zwischem Schweizerischem Rennfeuereisen und Eisenerzen, EUROMAT, Lausanne, 09-01 thru 09-05 ■

**Senn, M.** — Organization and Lecture: Analytik und Massnahmen an Baudenkmälern und Kulturgütern, 1. Tagung Zentrum für Kulturgüteranalytik, Empa-Akademie, Dübendorf, 11-27 ▲ ■

**Senn, M./Devos, W.** — Lecture: Some news about the chemical composition of bloomery iron metals, Archaeometallurgy in Europe, Milano, Italy, 09-23 thru 26 ■

**Ulrich, A.** — Poster: Ein neuer Ultraschallzerstäöuber für die Analyse von Lösungen mit hoher Matrixkonzentration, Colloquium Analytical Atomic Spectroscopy CANAS, Konstanz, Germany, 03-24 thru 27 ◆

**Ulrich, A.** — Poster: Ultra trace analysis of high purity piping system components, Colloquium Analytical Atomic Spectroscopy CANAS, Konstanz, Germany, 03-24 thru 27 ◆

**Ulrich, A.** — Lecture: Analyse von Additivelementen in Treibstoffen und Emissionen von Dieselfahrzeugen mit Partikelfiltersystemen, Anwenderseminar Moderne Methoden und Applikationen in der Probenvorbereitung und ICP-OES, Idstein, Germany, 04-01 ■

**Ulrich, A.** — Lecture: Bestimmung von Additivelementen in Treibstoffen und Emissionen mit ICP-OES und ICP-MS, Fachtagung Varian Massenspektrometrie, Empa-Akademie, Dübendorf, 08-27 ■

**Ulrich, A./Figi, R./Schreiner, C.** — Poster: Comparison of Lab Quality De-Ionized Water Polymer Piping Materials, Colloquium Analytical Atomic Spectroscopy CANAS, Konstanz, Germany, 03-24 thru 27 ◆

**Ulrich, A./Hassler, S.** — Poster: Alternate solvents for the direct analysis of organic samples by ICP-OES, European Winter Conference on Plasma Spectrochemistry, Garmisch-Partenkirchen, Germany, 01-12 thru 17 ◆

**Ulrich, A./Wichser, A.** — Poster: Analysis of additive metals in fuel and emission aerosols of diesel vehicles with and without particle traps, European Winter Conference on Plasma Spectrochemistry, Garmisch-Partenkirchen, Germany, 01-12 thru 17 ◆

**Ulrich, A./Vonmont, H.** — Poster: ICP-MS Trace Element Analysis as a Forensic Tool, Colloquium Analytical Atomic Spectroscopy CANAS, Konstanz, Germany, 03-24 thru 27 ◆

■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# Conferences

**Ulrich, A./Wichser, A./ Figi, R./Schreiner, C.** Poster: Comparison of Piping Materials for Industrial Application, 6. Symposium Massenspektrometrie und Verfahren der Elementspurenanalyse und 18. ICP-MS Anwendertreffen, Berlin, Germany, 10-06 thru 10 ◆

**Weidenkaff, A.** Lecture: Design und Funktionalität nanostrukturierter Metalloxide, 7. Deutsche Physikerinnen Tagung, Augsburg, Germany, 11-07 ■ ◗

**Weidenkaff, A.** Lecture: Realstruktur, Redoxaktivität und physikalische Eigenschaften von perowskitartigen Übergangsmetalloxiden: laufende Aktivitäten, Klausurtagung kooperative Phänomene im Festkörper, Irsee, Germany, 11-21 thru 23 ■

**Weidenkaff, A.** Lecture: Einsatz perowskitartiger Metalloxide als Redoxkatalysatoren, physikalisches Kolloquium Universität Freiburg, Freiburg, 12-02 ■ ◗

**Weidenkaff, A.** Lecture: Design und Funktionalität nanostrukturierter Perowskitphase, Empa-Akademie, Dübendorf, 12-03 ■

**Wichser, A.** Lecture: Contamination risk due to gloves, 4th International Conference on High Resolution Sector Field ICPMS, Venedig, Italy, 10-14 thru 17 ■

**Zwicky, Ch.** Poster: Quantitative or Semi-quantitative? Lab-based WD-XRF versus mobile ED-XRF Investigations on Nickel-base alloys, APPLICA, Olten, 05-06 thru 07 ◆

**Zwicky, Ch.** Poster: Quantitative or Semi-quantitative? Lab-based WD-XRF versus mobile ED-XRF Investigations on Nickel-base alloys, Tagung Festkörperanalytik, Wien, Austria, 09-21 thru 24 ◆

## Logistics, Controlling and Marketing

Technology Transfer and Knowledge Management

**Eugster, M.** Gestión y Valorizaciòn de Residuos, CNPMLTA Medellín, Colombia, ■ ◗

**Gauch, M.** Gestión y Valorización de Residuos, CNPMLTA Medellín, Colombia, ■ ◗

**Gauch, M.** SESEC II, A case study for Cleaner Production in the textile industry in Colombia, seco/EPFL/ IMD/ Granit, Lausanne, 01-29 ■ ◗

**Gauch, M.** OIKOS-Tagung, Cleaner Production Centers in der Praxis, OIKOS/Universität SG, St.Gallen, ■ ◗

**Harzenmoser, M.** ISO14000 e PML, Mesa Redonda de PML, São Paolo, Brasil, 10-27 ■ ◗

**Kläntschi, N.** Lecture/Workshop: Weiterentwicklung Wissensmanagement Best Practice Empa, ZfU-International Business School, Zürich, 03-14 ■

**Kläntschi, N.** Lecture/Workshop: Wissensmanagement. SKP Executives, Konolfingen, 05-09 ■

**Kläntschi, N.** Lecture: Wissensnetzwerke als Element eines ganzheitlichen, praxisbezogenen Wissensmanagement-Ansatzes. Kongress Wissensnetzwerke, Panhans, Semmering, Austria, 05-13 thru 14 ■ ◗

**Robledo, C.** El rol de los Bosques en la Convención Marco de NU sobre el Cambio Climático; Un vistazo general. Conference on Biodiversity; organized by the University of Antioquia. Medellín, Colombia, 03-21 ■ ◗

**Robledo, C.** The role of forests in the UN convention on Climate change. Prepared ft the 34th meeting of the ITTC, Ciudad de Panamá, Panamá, 05-14 ■ ◗

**Robledo, C.** Alternative financing model for sustainable management in San Nicolás for the meeting on eosystem services organized by SwissRe and the Katoomba Grup, Rüschlikon, 10-29 ■ ◗

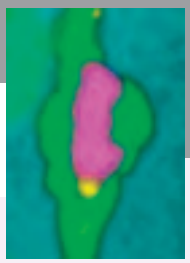
**Robledo, C.** For the Latin American Meeting on Climate change and Forests organized by FaO, UNEP, and IUCN: Intorucción al cambio climático, Modelo de financiación alternativo para los bosques de San Nicolás, Gobernancia, cambio climático y el sector forestal, Adaptación al cambio climático y el sector forestal, La rehabilitación del territorio forestal y la construcción del territorio forestal y la construcción de la resiliencia en la comunidad de Khuluyu, 11-11 thru 15 ■ ◗

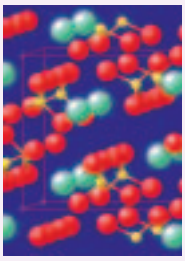
**Robledo, C./Fehse, J.** «Alternative financing model for sustainable management in San Nicolás» in 19th meeting of the SBSTA (UNFCCC), organized by the Secretary of the UNFCCC, Bonn, Germany, 06-07 ■ ◗



■ Lecture ◗ invited ● selected
◆ Poster ▲ Organisation

# Organizational Chart 2004





EMPA

# Organizational Chart 2004

## General Management

**Director-General**
Prof. Dr Louis Schlapbach

**Deputy**
Prof. Urs Meier

**Research Commission**
Paul W. Gilgen, Assistant

**Consultative Commission**
Dr Peter Loew, President

### Advanced Materials and Surfaces
Walter Muster, Department Head

#### Laboratories

- **High Performance Ceramics**
  Dr Thomas Graule
- **Functional Polymers**
  a.i. Dr Christiane Löwe
  (Dr Frank Nüesch, from April 1)
- **nanotech@surfaces**
  Dr Pierangelo Gröning
- **Surfaces, Coatings, Magnetism**
  Prof. Dr Hans Josef Hug
- **Materials Technology**
  Dr Lukas Rohr
- **Joining and Interface Technology**
  Dr Manfred Roth
- **Corrosion and Materials Integrity**
  Oliver von Trzebiatowski

### Materials and Systems for Civil Engineering
Dr Peter Richner, Department Head

#### Laboratories

- **Structural Engineering**
  Dr Masoud Motavalli
- **Concrete/Construction Chemistry**
  Dr Michael Romer
- **Wood**
  Dr Klaus Richter
- **Polymers/Composites**
  Peter Flüeler
  **Strength and Technology**
  a.i. Dr Gabor Kovacs
- Building Technologies
  - **Energy Systems/Building Equipment**
    Markus Koschenz
    **Applied Physics in Building**
    Thomas Frank
    **Center for Energy and Sustainability in Buildings**
    Mark Zimmermann
- **Road Engineering/Sealing Components**
  Dr Manfred Partl

### Materials and Systems for Protection and Wellbeing of the Human Body
Markus Rüedi, Department Head

#### Laboratories

- **Protection and Physiology**
  Dr René Rossi
- **Functional Fibers and Textiles**
  a.i. Rudolf Hufenus
- **Biocompatible Materials**
  Dr Helene Felber

## Research Programs

| Nanotechnology | Adaptive Material Systems | The Healthy Human | Technosphere – Atmosphere | Materials for Energy Technologies |
|---|---|---|---|---|
| Walter Muster | Prof. Urs Meier | Markus Rüedi | Dr Peter Hofer | Dr Xaver Edelmann |

**Information, Reliability and Simulation Technology**
Dr Xaver Edelmann, Department Head

Laboratories

- **Mathematics, Imaging and Materials**
  Dr Klaus Simon
- **Technology and Society**
  Prof. Dr Lorenz Hilty
- **Electronics/Metrology**
  Dr Urs Sennhauser
- **Acoustics**
  Kurt Eggenschwiler

**Mobility, Energy and Environment**
Dr Peter Hofer, Department Head

Laboratories

- **Internal Combustion Engines**
  Christian Bach
- **Air Pollution/Environmental Technology**
  Dr Brigitte Buchmann
- **Organic Chemistry**
  Dr Max Wolfensberger
- **Solid State Chemistry and Analyses**
  Dr Heinz Vonmont

**Logistics, Controlling and Marketing**
Roland Knechtle, Department Head

Sections

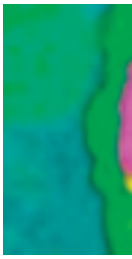
- **Human Resources**
  Madeleine Heim
- **Finances/Controlling/Purchasing**
  Heidi Leutwyler
- **Communication/Marketing**
  Robert Helmy
- **Construction/Infrastructure**
  Paul-André Dupuis
- **Mechanical Engineering/Workshop**
  Stefan Hösli
- **Informatics**
  Dr Christoph Bucher
- **Technology Transfer and Knowledge Management**
  Paul W. Gilgen

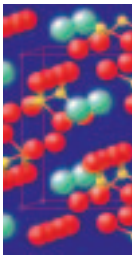
**EMPA Academy**
Dr Anne Satir

**Legal Services**
Marlen Müller

**Technology Center for the Region of Lake Constance TEBO**
Peter Frischknecht

**Center for Technology and Start-ups**
Dr Lukas Rohr





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