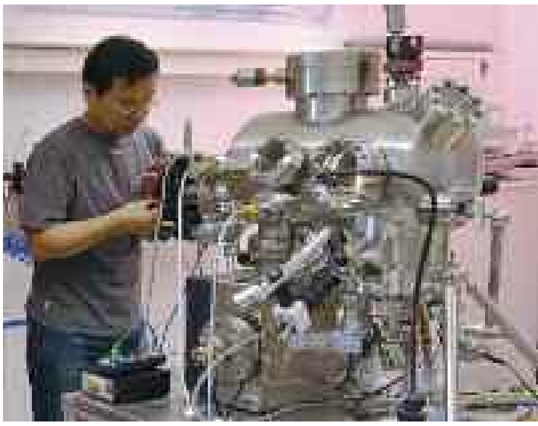
EmpaNews

Magazine for Research, Innovation and Technology Transfer
Volume 9 / Issue 32 / February 2011

Artificial turf with upstanding qualities 16



Microscopes & Nobel Prizes
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There's no such thing as "zero risk"

Nanotechnology – or, to be precise, nanotechnologies – have good cause to celebrate. This year marks the 30th anniversary of the scanning tunnelling microscope. This instrument and others like it enable us to peer into the world of atoms and molecules and thus make it accessible to us. Meanwhile, thanks to nanoeffects, numerous materials and products have been developed – and even brought to market – with new, very promising properties.

As always, when humankind is confronted with new technologies, some people see the glass as half full while others see it as half empty. When navigating these technological crosscurrents, we must deal with "nano" in a responsible manner. We do so by recognising and minimising possible risks at an early stage, without at the same time squandering the enormous opportunities it presents such as in the areas of energy or the environment.

The demand for "risk free" actions, arising time and again out of a mindset which pretends we can protect ourselves against every possible eventuality, is of little help here. Risks have simply belonged to our very existence from time immemorial. They're an essential part of the "background noise" that accompanies every change, because anyone who dares to chart a new and unknown course takes on risk.

New technologies can turn our lives completely upside down in a positive way. Just think about the introduction of the automobile or the Internet. In such situations, we must weigh the costs – in this context, the potential risks – against the expected benefits, and do so rationally while considering all the facts available to us.

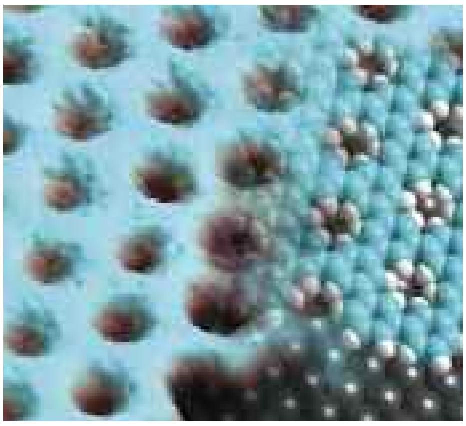
In the area of nanotechnologies, things are moving fast in Switzerland at the moment. For instance, the National Research Programme "Opportunities and Risks of Nanomaterials" has just started up, and Empa researchers are heavily involved in it. Further, the Swiss NanoConvention, with Empa as one of its organisers, will take place in May in Baden, and its goal is to intensify and expand the interdisciplinary dialogue on the topic of all things "nano".

Enjoy your reading!

Michael Hagmann
Head Communications

Cover

Empa researchers, together with the Swiss company TISCA TIARA, have developed a bi-component fibre for a novel type of artificial turf, one which thanks to its hardened core always returns to an upright position and because of its soft sheath avoids abrasions and grass burns. (Photo: TISCA TIARA)



Imprint

Publisher
Empa
Überlandstrasse 129
CH-8600 Dübendorf
Switzerland
www.empa.ch

Text & Design
Communication section

Contact
Phone +41 44 823 47 33
empanews@empa.ch
www.empanews.ch

Published quarterly

ISSN 1662-7768

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The art of insulating

New technologies such as vacuum insulation panels, vacuum glazing and aerogels are the future of building insulation. Empa is investigating opportunities and optimising materials in order to minimise heat losses in buildings.

TEXT: Peter Merz

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A building turns to art: in summer 1995, the artist couple Christo and Jeanne-Claude wrapped the Reichstag in Berlin. Efficient and elegant insulation can also be considered an art in some ways, even if based primarily on know-how. (Photo: txmx2, Flickr)

2
Modern high-performance insulating systems such as vacuum insulation panels offer excellent insulation even at low thickness. (Photo: Empa)

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Aerogels consist of more than 90 per cent air, which is enclosed in pores with sizes in the nanometre range; as a result, these materials are excellent thermal insulators. In addition, they allow light to pass through and thus make it possible to have natural lighting, for example in a gym. (Photo: Scobalit AG, Empa)

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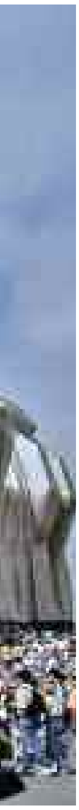
Vacuum glazing can achieve superior thermal insulation performance. The challenge consists in sealing the panes of glass in such a way that the vacuum in the space between can be maintained over decades. Empa researchers have patented a method whereby the two panes are sealed with a tin-based alloy and an electric potential. The ultrasonic image of a laboratory experiment (right) shows that the bonding with the tin was successful throughout. The air-tightness was confirmed with leak test measurements. (Photo: Empa)

During winter, many poorly insulated houses make it easy for energy and thus money to literally “walk out the door”. There are a variety of approaches to renovating buildings and to making them more energy efficient. Empa is particularly interested in high-performance systems which dramatically increase insulation ratings while reducing the overall material thickness. The Laboratory of Building Science and Technology researches and improves various systems of this type, some of which are still in development and some of which are commercially available.

“Empty space” insulates

Vacuum insulation panels (VIPs) have been used in Swiss construction projects for roughly a decade. Here, core materials with pores in the submicrometre range are wrapped in a protective envelope. This bag is then sealed at a pressure of roughly one millibar. Because the inside pressure is only a thousandth of the ambient air pressure, VIPs are excellent insulators; for panels straight from the factory, their thermal conductivity (lambda value, λ) is measured at 4 mW/m·K and thus is eight times better than conventional insulating materials. Because of their higher prices, VIPs are used primarily in specialty applications such as terrace or interior insulation. If a balcony were to be insulated with conventional materials, its floor would be higher than the floor of the adjacent living area.

The primary question about VIPs being addressed by Empa researchers for quite some time deals with their durability. Can they maintain their performance for 25 years, the minimum service lifetime needed to meet the requirements of the Swiss construction industry? “The panels available in Switzerland are of high quality, and market leaders are thus very interested in maintaining these standards. This includes rigorous control and surveillance of their service lifetimes,” comments Empa researcher and VIP expert Samuel Brunner. He and his colleagues have developed test methods for VIPs to determine their decrease in insulating capability over the years. For this, the panels are stored for roughly six months in an environ-



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mental chamber, and afterwards the researchers measure the increase in internal pressure and other ageing-related parameters.

"At this time, VIPs have the highest performance of any commercially available insulating system and make it possible to insulate buildings with a thin layer," adds Brunner. "Our measurements have shown that the latest available VIPs will still have a relatively low λ value of 6 mW/m·K even after 25 years. According to the requirements of standards common in the insulation industry, still 90 per cent of the panels must be below the stated value after 25 years. There is no other insulating material anywhere which can compete with this and exhibit such a low λ value after that many years." For instance, polyurethane insulating panels have a λ value between 22 and 28 mW/m·K depending on whether they are covered with a diffusion barrier, generally made of aluminium foil.

A solid material made of 90 per cent air

If the size of the pores is made even smaller, insulating materials can be manufactured without a vacuum which can still achieve λ values below 15 mW/m·K. Such materials, named aerogels, have nanometre-sized pores and consist of up to 90 per cent air. For quite some time, the Laboratory of Building Science and Technology has been researching aerogel-based materials as well as aerogel systems. For example, starting with commercial aerogel granules, Empa researchers have developed an insulating render which offers an elegant way to renovate historic buildings without changing their outward appearance. Initial field trials are planned for this year.

Matthias Koebel and his team are developing novel aerogel-based materials which are intended to be used primarily as insulating materials but which can also manipulate light. Using this type of translucent aerogels, roofs have already been insulated effectively, at the same time allowing for passive illumination of the interior spaces by natural daylight. Aerogels also offer great promise for artificial lighting. With this aspect in mind, Empa experts are investigating application possibilities in LED lighting technology.

Potential improvements with vacuum glazing

Well-insulated roofs and walls are of little use if the windows are the actual weak points. Vacuum glazing is the second main research area for Koebel's team. "It is true that today's double and triple-glazed windows already exhibit quite acceptable insulating values. However, there is only limited availability of the rare gases krypton and xenon which are used to fill these windows," explains Koebel. "The alternative is a vacuum glazing, which in theory achieves even better insulating values than a state-of-the-art triple glazing." In addition, such a window would be thinner, lighter and yet allow for more light to pass through.

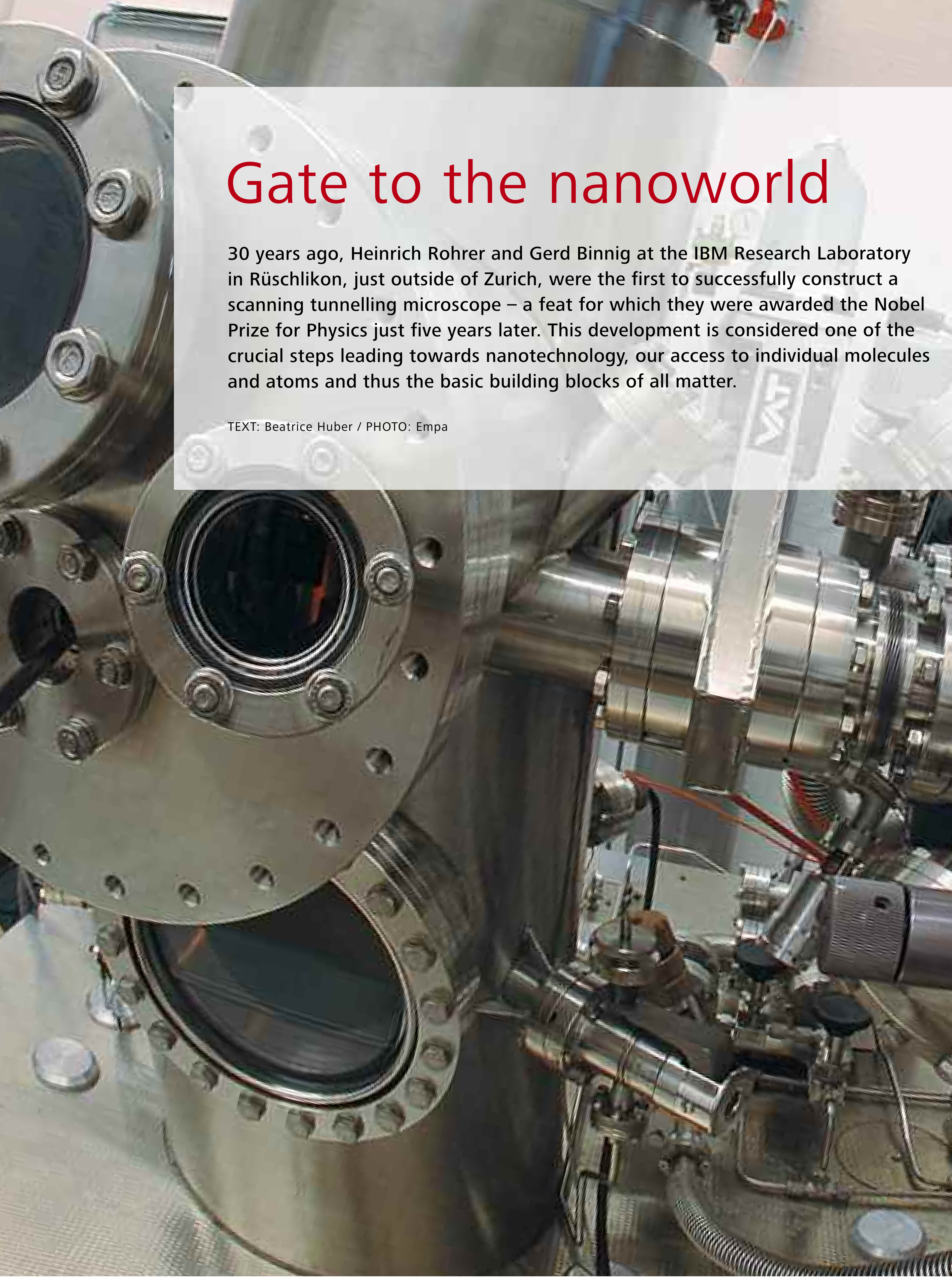
Today's commercial vacuum glazing products are made by sealing two panes along their perimeter followed by evacuation of the cavity space in between them through a pump-out port. The critical problems associated with this type of manufacturing are the high temperatures and the pump-out tube itself, which must be separately sealed off after pumping. This method, common especially in Asia, is able to produce vacuum glazing but only with insufficient insulating performance. In order to make a big breakthrough in European markets, the fabrication process and product performance must be improved and a longer service life guaranteed.

Koebel and his colleagues are following a new approach to sealing the two glass panes. For this, they are investigating vacuum compatible technologies for edge sealing. In one method that has proven successful in the laboratory, the panes are sealed in a high vacuum environment, in other words at a pressure between 10^{-3} to 10^{-4} millibar, using a special tin-based alloy. The pump-out tube is no longer required because the sealing takes place directly in the vacuum, meaning that after the process is done, there is no air left between the two panes. The solder-based sealing technology is patent pending. In addition, the Empa experts have also developed mathematical models to understand the ageing process of vacuum glazing, and can now estimate the magnitude of various contributions to the total pressure increase and ageing using computational tools alone. //

Gate to the nanoworld

30 years ago, Heinrich Rohrer and Gerd Binnig at the IBM Research Laboratory in Rüschlikon, just outside of Zurich, were the first to successfully construct a scanning tunnelling microscope – a feat for which they were awarded the Nobel Prize for Physics just five years later. This development is considered one of the crucial steps leading towards nanotechnology, our access to individual molecules and atoms and thus the basic building blocks of all matter.

TEXT: Beatrice Huber / PHOTO: Empa



This year, the scanning tunnelling microscope – the photo shows one set up at the Empa site in Thun – is celebrating its 30th birthday.

Nanotechnology as we know it today would not even exist without the instruments that allow us to peer into the world of the infinitesimal so we can analyse and manipulate it. Scientists at Empa use equipment such as electron microscopes, scanning tunnelling microscopes and atomic force microscopes for their research, and are also expanding the areas in which these tools can be used, as the articles on the following pages illustrate. This year, the scanning tunnelling microscope is celebrating its 30th birthday. In 1981, Heinrich Rohrer and Gerd Binnig at the IBM Research Laboratory in Rüschlikon developed the first instrument of this type which had the necessary precision and stability. Just a few years later in 1986, their work was honoured with the Nobel Prize in Physics.

A microscope which scans the surface

The scanning tunnelling microscope isn't a "real" microscope because it doesn't generate a direct optical image of the object being examined. Instead, the instrument examines the profile of a surface with a scanning tip whereby there's always a tiny distance between the tip and the surface. This prevents anything from being damaged during the scanning process. For its measurements, the microscope uses what is known as the quantum tunnelling effect. This quantum-mechanical effect, which gives the microscope its name, allows an electron (or some other particle) to drill a tunnel through a potential barrier which, according to classical physics, would be impenetrable. This movement of electrons creates a measurable current despite the fact that the scanning tip and the surface don't make contact. Flash memories, such as the chips in USB sticks, are also based on the tunnelling effect.

In 1986, Rohrer and Binnig shared the Nobel Prize in Physics with the German electrical engineer Ernst Ruska, who had already developed the electron microscope in the 1930s. Instead of normal light, that instrument uses an electron beam and with it achieves considerably higher resolution. Traditional optical microscopes have a resolution of approximately 200 nanometres, whereas these days electron microscopes have increased this to approximately 0.1 nanometre. Just like scanning tunnelling microscopes, electron microscopes have also long since become indispensable tools in nanotechnology. //

Research Programme set into motion

What opportunities do nanomaterials offer, and which risks do they entail? The National Research Programme NRP 64 intends to fill in existing gaps in knowledge and in this way contribute to the long-term success of nanomaterials. Empa is participating in four of the 17 sponsored projects.

TEXT: Beatrice Huber

Information technology, electronics, construction materials, environmental technology, energy technology, household appliances, textiles, cosmetics, foodstuffs, medicine – there's practically no limit to where nanomaterials can be put to use. Around the world there are already more than a thousand products on the market which contain nanomaterials. In the area of nanosciences, Swiss research institutes, including Empa, are among the world leaders. Nanomaterials offer enormous opportunities for Switzerland as a location for research and industrial applications. Their economic success, however, can only be long-term if possible risks can also be evaluated in a reliable manner.

Exploring opportunities and risks

The projects which are part of the recently initiated National Research Programme "Opportunities and Risks of Nanomaterials" (NRP 64) should therefore not only explore the opportunities which nanomaterials offer towards improving our health, environment and use of natural resources but also possible risks. Within an NRP, researchers from various disciplines collaborate on projects which are intended to contribute to the solutions of key present-day problems. The Swiss Federal Council sets the focus; the NRPs are carried out by the Swiss National Science Foundation (SNSF).

NRP 64 places its focus on synthetically manufactured nanomaterials. A "nanomaterial" is considered one which has structural components with at least one dimension of less than 100 nanometres. In this programme, especially those materials will be examined where there is a high probability of human or environmental exposure. One of the goals of NRP 64 is also to create the basis for developing tools to monitor and evaluate the effects of nanomaterials on people and the environment.

At the end of November 2010, the SNSF approved 17 project proposals from the 44 which were submitted, and is financing them for the first three years with CHF 6.3 million. Empa researchers are heading up three of these projects and are participating in yet another. //

Is nano sustainable in the long run?

In order to master challenges such as climate change or shortages of natural resources, we need long-term solutions. Nanotechnologies and nanomaterials can provide new approaches. The Swiss Academy of Engineering Sciences (SATW), along with leading Swiss nano experts such as Pierangelo Gröning, a member of Empa's Board of Directors, has published a brochure addressing long-term sustainability and nanotechnology. It also calls for a public discussion about the associated opportunities and risks. That's because nanotechnologies will enjoy success over the long term and make a contribution to sustainable development only if they do not entail any major risks. This brochure (in German) can be downloaded in PDF format at *www.satw.ch/nano*.

Photo: IBM

Empa as junior partner at the new IBM nanocentre

In May 2011, the new Centre for Nanotechnology will be opened on the grounds of the IBM Research Laboratory in Rüschlikon, in other words in the very location where the scanning tunnelling microscope was developed 30 years ago. The centre, which cost roughly CHF 90 million and will be operated jointly by IBM and ETH Zurich, is a further milestone for Switzerland as a key location for nanotechnology. Empa will also conduct research there as a junior partner.

Overall, it provides a 1000 square metre cleanroom along with six "noise-free" laboratories. These were constructed eight metres below ground level on a massive foundation and are completely shielded from external influences. This is necessary because work at the nanometre scale must be done very precisely, and even the smallest fluctuations in temperature as well as any noise, vibrations or electronic fields can be disruptive.

How nanotechnologies will impact our future

In order to develop innovative technologies efficiently, as well as to finance and regulate them, sound decisions must be taken which are based on the latest knowledge and findings. This is also the case with nanotechnology. The Swiss NanoConvention 2011 supports decision-makers in this role. It offers a platform where leaders from research and industry, key figures in innovation and technology, entrepreneurs, investors as well as administrators and politicians can gather to discuss ideas and exchange viewpoints – or even develop new ones. The participants will receive in-depth information about one of the most important emerging technologies of the 21st century and its potential for innovative approaches, products and services. In parallel to the Swiss NanoConvention, the NanoPubli event is inviting the general public to become informed about the world of the extremely small, first-hand at an exhibition and during lectures.

swiss nano convention

The central topics of the event are the major challenges of our time such as securing a sustainable energy supply and a clean environment along with the future of medicine with nano-therapeutics and diagnostics plus the development of innovative functional materials and their numerous industrial applications. Another focus will be the potential risks associated with free nanoparticles along with how society sees and addresses these issues.

In short, the Swiss NanoConvention is the showplace for nanotechnology in Switzerland. Because it is being organised jointly by the "who's who" of the Swiss nano community, it's the ideal place to get to know the leading minds and foremost proponents of nanotechnology.

Further information, including the programme and registration, is available at *www.swissnanoconvention.ch*

Happy Birthday!

Thirty years after the first successful experiments, it's hard to imagine industry and research without the scanning tunnelling microscope (STM). This and its further development, the atomic force microscope (AFM), not only display individual atoms but can also manipulate them. And if that's not enough, by combining these with other measurement methods, we'll soon be able to draw three-dimensional "chemical maps" which show how materials are built up, nanometre by nanometre.

TEXT: Martina Peter / PHOTOS: Empa

When it comes to small dimensions, we're "blind" – the resolution of the human eye is only 0.2 millimetre. In other words, people can only distinguish between two points if they're separated by a distance of at least 0.2 millimetre. For anything smaller we need visual aids – magnifying glasses and microscopes.

Optical microscopes can see approximately 1000 times "better" than the human eye and thus have a resolution of roughly 0.2 micrometre. But because the diameter of an individual atom is approximately 0.2 nanometre, that's not sufficient. What are the options when we can no longer see anything and orientation becomes difficult? Quite simply, touching and feeling the surrounding environment. It's exactly this principle which makes the scanning tunnelling microscope and atomic force microscope useful for creating images with resolutions at the atomic level.

"Magnifying glass" for the nanoworld

In STM, an extremely small electrically conductive needle, whose tip consists of a single atom, is brought close to the sample to be examined (which also must be electrically conductive). If the distance is only a few atomic diameters and if voltage is then applied, an electric current (the tunnelling current) starts flowing without the need for the needle and sample to touch each other. At a constant tunnelling current, a high-precision mechanism pushes the tip over the sample's surface thousands of times so it scans line by line. In this way, the tip "feels" the sample's electron density, which normally correlates with the position of the atoms. The up and down movement which is carried out in order to keep the tunnelling current constant is recorded by a computer and converted into a three-dimensional image of the surface.

In the last 30 years, STM and further developments of it have become a dominant fixture in research institutes around the world. Today's equipment, however, delivers far more than fascinating images of surfaces; it can manipulate atoms and molecules, such as pushing them around, arranging them in patterns and even more.

The scanning tunnelling microscope as a tool

At Empa, for instance, the chemist Karl-Heinz Ernst uses an STM to set molecules in motion. He heads up the Molecular Surface Science group and specialises in phenomena such as molecular self-assembly and crystallisation. For this, he uses an ultra-high vacuum unit which works at temperatures near four Kelvin, in other words, near absolute zero. "I'm interested in how molecules jump around when you tickle them," jokes Ernst, who is also a professor at the University of Zurich. "If we start molecules vibrating with tunnelling electrons, they sometimes break down and sometimes not. We want to understand better why they sometimes 'survive' for a longer or shorter time." This knowledge should help explain complex chemical processes, for instance what happens on catalyst surfaces.

Research in tandem

Surface molecules have also attracted the attention of Marco Bieri and Stephan Blankenburg of the nanotech@surfaces Laboratory. These two physicists have developed a very special way to collaborate. While Bieri carries out his experiments with an ultra-high vacuum STM at the Empa site in Thun, Blankenburg reserves time on the computing cluster Ipazia in Dübendorf so he can simulate the experiments. When Bieri takes actual molecules – monomers functionalised with bromine atoms – and places them in the STM's ice-cold sample chamber, Blankenburg at the same time "prepares" the virtual surface on a computer and places the molecules on it. In the computer, the surface molecules begin to align themselves following the laws of quantum mechanics; in the STM in Thun, the "deep frozen" molecules begin to warm up slowly thanks to the initiation of a heating process, they become active and likewise only gradually start forming the first (actual) chemical bonds with each other.

Thanks to extensive know-how and much experience, Empa is in a position to develop new equipment and measurement techniques which push the state-of-the-art.

These chemical reactions are extremely difficult to observe with the STM because they occur almost instantaneously. It takes a great deal of experience and patience to get oriented on the surface and recognise how the patterns and supramolecular systems build up. Because the tip of the STM isn't constantly optimally sharp and sometimes unintentionally "picks up" molecules from the surface, the images don't always correspond to the actual conditions on the sample. One of Bieri's main tasks is to identify STM images with excessively monotonous symmetries without irregularities as spurious results, known to the researchers as artefacts.

Using a Skype video conference, Bieri receives support from his colleague at the high-performance computer. Blankenburg informs him what he should be observing according to the simulation. In return, Bieri reports about unexpected phenomena which Blankenburg then inputs into his computer model – for example, the highly original way in nature how a molecule twists around on itself during polymerisation.

Both scientists agree that by working together they are able to much more quickly interpret experimental data, and in the process generate new knowledge such as about the reaction mechanisms of complex chemical processes. For roughly a year, the team has been using this tandem method, the combination of experiments and computing

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power. And they have done so with great success. Among other things, a much cited article describing graphene nanoribbons, published this past summer in the renowned scientific magazine Nature, is based on this new method (see EmpaNews 31).

Twenty-five years of atomic force microscopy

A tip with a diameter of only a few nanometres also plays the key role in one of the most important further developments of the STM, the atomic force microscope. While the STM measures the tunnelling current, the AFM records the forces which arise when a tip placed on a cantilever is slid over the “mountains and valleys” of the sample surface. Depending on the shape of the tip and its condition, it becomes possible to investigate a variety of physical properties on the sample. Hans Josef Hug, head of the Nanoscale Materials Science Laboratory and professor of physics at the University of Basel, lists a whole “zoo” of forces which can be detected with the AFM: from electrostatic and magnetic forces, through van der Waals and Casimir forces, to those created by covalent and ionic bonds. “The principle of the AFM brings us much further along in many areas: frictional forces give us insight into tribology; magnetic forces help us optimise the storage of electronic data; while information about local hardness or local adhesion provide us with important findings concerning the micromechanical properties of materials,” explains Hug. “At Empa there’s hardly a single force which we can’t record,” he adds, with a wink.

Empa’s User Lab

Numerous AFM and STM experts are at work all across Empa, and they make their knowledge available to many others besides their own in-house colleagues. The doors to the Swiss Scanning Microscopy User Lab (SUL) are also open to external clients and partners. With an array of AFMs, they can investigate topologies and measure local friction, as well as do in-depth studies of the contact potential and local mechanical properties of their materials. Whether on their own or with assistance, for each there’s a tailor-made solution.

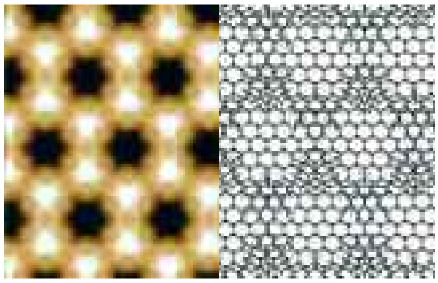
“This technical knowledge is nurtured by our research,” emphasises Hug. Empa is in an ideal position to develop new equipment and measurement techniques which push the state-of-the-art. He is convinced that “only in this way can we stay at the leading edge, fulfil users’ future requirements and be able to provide competent answers to their questions.”

Developing new instruments

To do so, some boundaries must be transcended. “AFM and STM aren’t really instruments for chemical analysis,” notes Hug. “If we deposit unknown atoms or molecules on a well-defined surface, AFM and STM by themselves won’t tell us exactly what they ‘see’ there.” In the NanoXAS project, Empa researchers working together with colleagues from the Paul Scherrer Institute thus want to overcome this deficiency. For this, they are combining two measurement techniques: X-ray absorption analysis shows which chemical elements are present in the region under investigation, while AFM determines the sample’s topography and other local properties. The result is a nearly nanometre-exact “chemical map” of the material. With it, the researchers hope to be able to selectively improve materials for future applications, such as developing more powerful digital cameras with a significantly increased amount of memory than is commonplace today.

Hug has numerous other ideas in mind, and when he starts talking about them, his pioneering spirit takes flight. “We’ve learned how to do imaging with STM and AFM and to perform manipulations at the atomic level. However, with this capability we should also advance into areas where until now we’ve not been able to conduct investigations,” he speculates. “In the nanoworld, for example, we ‘touch’ things without sensing how strongly we are handling them with our ‘nanohands’.” That’s a hurdle we must overcome.”

Thus, his next project within the EU Seventh Framework Programme, which goes by the name MDSPM (Multidimensional Scanning Probe Microscopy), has the goal of developing an AFM which can measure forces simultaneously vertically (perpendicular) and laterally (from side to side) with almost unbelievable precision. It recognises differences in the region of a millionth of a nano-Newton. Hug surmises that our understanding of how chemical reactions take place or how energy is lost through friction could possibly change radically. //



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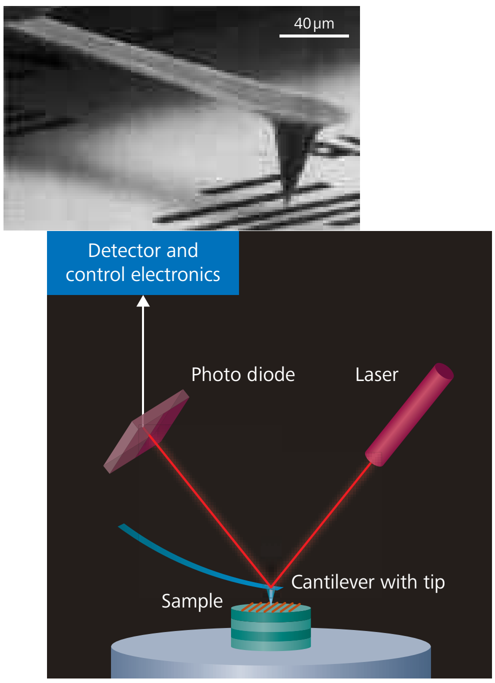
Bromine-containing polymer on a silver surface, as revealed by experiments using a scanning tunnelling microscope and computer simulations.



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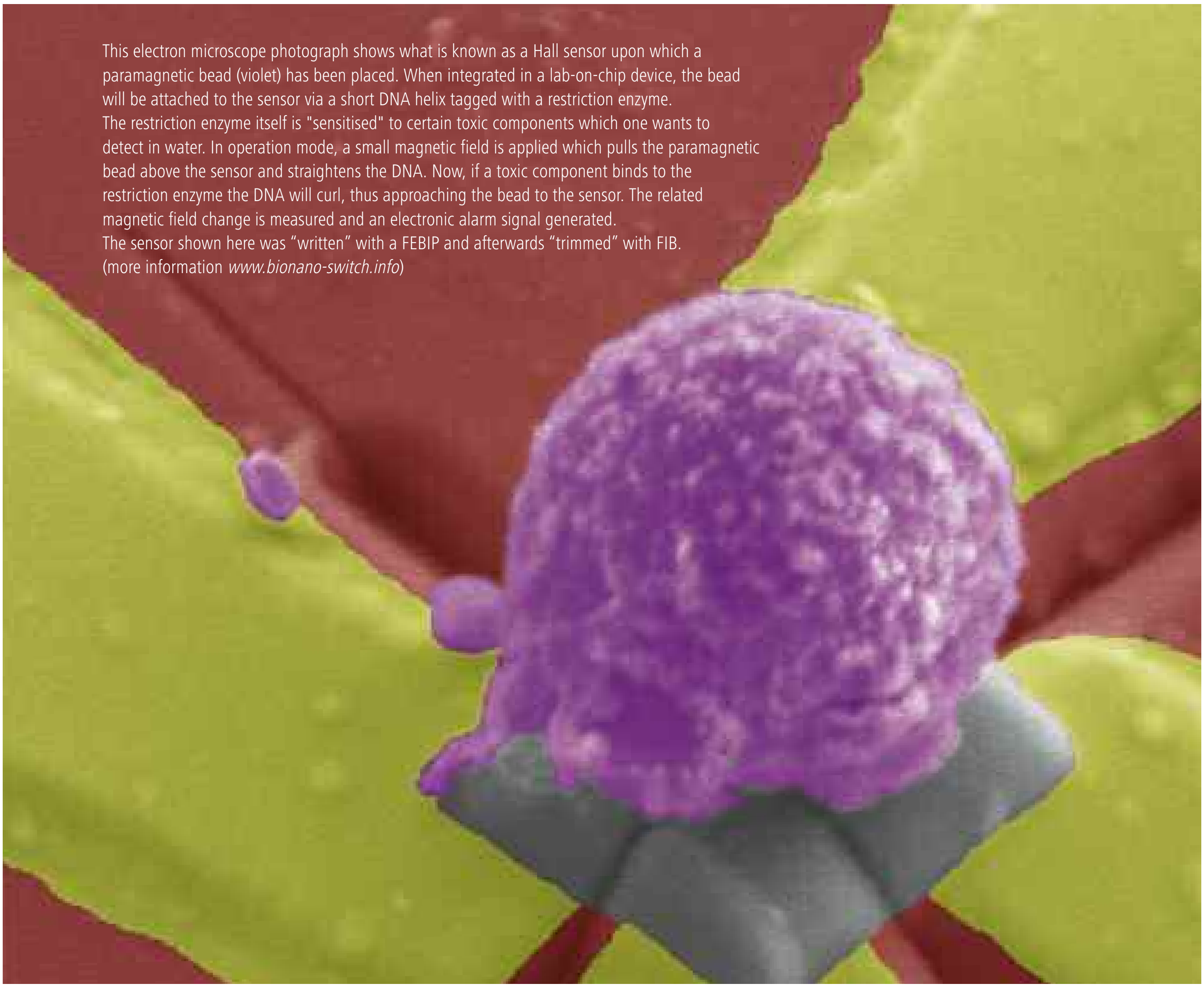
The image shows the inner workings of an atomic force microscope; a cantilever (see photo) scans the surface.



This electron microscope photograph shows what is known as a Hall sensor upon which a paramagnetic bead (violet) has been placed. When integrated in a lab-on-chip device, the bead will be attached to the sensor via a short DNA helix tagged with a restriction enzyme. The restriction enzyme itself is "sensitised" to certain toxic components which one wants to detect in water. In operation mode, a small magnetic field is applied which pulls the paramagnetic bead above the sensor and straightens the DNA. Now, if a toxic component binds to the restriction enzyme the DNA will curl, thus approaching the bead to the sensor. The related magnetic field change is measured and an electronic alarm signal generated.
The sensor shown here was “written” with a FEBIP and afterwards “trimmed” with FIB.
(more information *www.bionano-switch.info*)

Chemistry with electron beams

Focussed electron beams are used in electron microscopes to allow us to see extremely small objects, and today such investigations have become routine. More recently, however, electron beams are being used for chemical reactions. For example, surface structures measuring only nanometres across can be “written”. Empa researchers are perfecting this technology and are searching for completely new application areas.

TEXT: Beatrice Huber / PHOTOS: Empa

Instruments such as electron microscopes, scanning tunnelling microscopes and atomic force microscopes have opened our eyes to the world of the infinitesimally small. They have for the first time made it possible for those working in research and industry to fabricate targeted structures with nanometre feature sizes. However, these instruments can do much more. For instance, the electron microscope can also be used for chemistry. In this case, suitable gas molecules are injected close to a sample which is already in the microscope’s vacuum chamber. These adsorb on the

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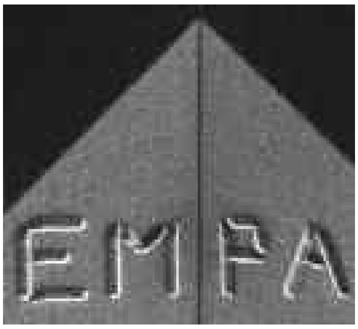

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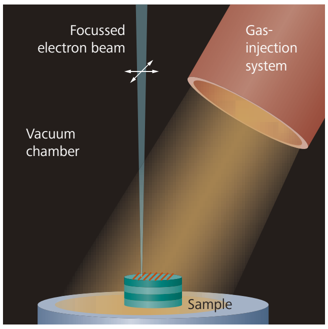

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sample in a reversible manner. The focussed electron beam, which normally serves to make objects visible, now instead induces chemical reactions of the adsorbed gas molecules, but only at the spot where the beam strikes the surface. The resulting non-volatile molecular fragments then remain permanently on the sample while the volatile fragments are removed by the vacuum system. By moving and holding in a programmed pattern, the electron beam can "write" a three-dimensional nanostructure.

Small, minimally invasive, direct

In technical jargon, this process is called FEBIP: focussed electron beam induced processing. A team led by Empa researcher Ivo Utke specialises in FEBIP, and uses it as an extremely flexible fabrication method for prototyping nanocomponents, in order to solve specific questions and problems in applied nanoelectronics, nanophotonics and nanobiology. The group is continually working to refine FEBIP and to open up new application areas. "With the help of a precisely positioned electron beam, it's possible to remove or apply surface structures with nanometre precision and in virtually any desired three-dimensional shapes," explains Utke. "FEBIP is especially attractive because it is minimally invasive."

FEBIP exhibits other decisive advantages. With it, structures can be placed, shaped and manufactured all in a single maskless step. That's not the case with other processes, which often need at least three steps. First a "mask" is fabricated on the probe, and then the material for the structure is deposited. Then, finally, the mask must be removed.

Nanostructures stabilise lasers

The vertical cavity surface emitting laser (VCSEL) is a semiconductor laser which is often used in data transmission for short-distance links like Gigabit Ethernet. These lasers are very popular in telecommunications because they consume little energy and can be simply fabricated in volumes of many tens of thousands on a single wafer.

However, long-wavelength VCSELs, those which work in the wavelength region above 1300 nanometres, can exhibit one weakness. Because of the cylindrical structure in which the lasers are built up on the wafer, the polarisation of the emitted light can sometimes change during operation. Polarisation is a property of certain waves, such as light waves, and it describes the direction of oscillation. A stable polarisation is necessary in order to reduce transmission errors and to use VCSELs in future silicon photonics. But thanks to FEBIP, Empa researchers, together with scientists from the Laboratory of Physics of Nanostructures at EPFL and its spin-off BeamExpress, can provide assistance. "We've written flat grating structures on the VCSELs with an electron beam," says Utke in describing their solution, "and the gratings were effective in stabilising the polarisation."

The search for the perfect composition

The scientists of Utke's team believe that beyond specific applications, it's just as important to refine and further develop FEBIP. Here a central aspect is to understand the physical-chemical processes in the vacuum chamber and with this to be able to exactly control the synthesis of material.

This was successful, for instance, in the case of a Hall sensor smaller than a micrometre in size. Hall sensors, named after the US physicist Edwin Hall, are used primarily to measure magnetic fields. In this particular application, the tiny sensor was used to measure the field produced by small (para)magnetic beads. These beads are functionalised, for example, with suitable biological substances so that they can react with other biological molecules such as antibodies. At the moment, this concept is being researched around the world, especially for diagnosing illnesses. Here the goal is to integrate a complete medical laboratory onto a chip the size of a finger, creating what is known as a Lab-on-Chip device. The research team, which also involves members of Empa's Electron Microscopy Centre, is examining how the performance of a Hall sensor changes if the applied surface structures are made up of cobalt and carbon in various combinations. To do this, they use a gas-injection system in the vacuum chamber to supply two gases, one for cobalt and one for carbon. Of course, the goal was to find the optimal ratio. This turned out to be a cobalt proportion of approximately 65 per cent. Almost as important, however, was the knowledge acquired about how this ratio could be controlled: by using a pulsed electron beam. Control was thus achieved with a simple physical parameter, specifically, time.

Different processes skilfully combined

The Empa researchers also tried to combine different methods in a single vacuum chamber. This has the advantage that the samples must not be reintroduced into or taken out of the vacuum chamber multiple times – both of these are time-intensive procedures.

Nanowires made of semiconductor materials such as silicon are intended for use in nanoelectronics – a further miniaturisation of microelectronics – in order to provide the interconnections between extremely tiny electronic components. However, it's not trivial to fabricate individual nanowires at predefined locations on structured substrates. Until now, bunches of nanowires without a preferred orientation frequently appeared from which individual wires then had to be selected. The Empa team, together with researchers from Germany's Max Planck Institute of Microstructure Physics, the Institute for Photonic Technologies and the Max Planck Institute for the Science of Light, have combined three methods: focussed ion beam (FIB), focussed electron beam induced processing (FEBIP) and the vapour-liquid-solid (VLS) method.

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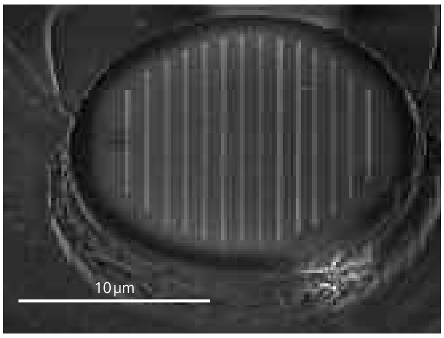

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The principle of the local deposition process which is induced with a focussed electron beam (in short, FEBIP): molecules from a gas-injection system are deposited on the sample surface in a reversible manner. The focussed electron beam dissociates adsorbed gas molecules. The resulting non-volatile compounds remain permanently on the sample. The result is a nanostructure – for example the lettering for Empa – which has been written by the movements of an electron beam.

3
Electron microscope photograph of a VCSEL (vertical cavity surface emitting laser) upon which a polarisation grating has been "written" with FEBIP. VCSELs are semiconductor lasers frequently used in optical data transmission.

4
A single nanowire growing on the cantilever of an atomic force microscope. To do this, three methods were combined: to start with, a focussed ion beam "drilled" a hole; then a tiny amount of catalyst was placed in the hole using FEBIP; and from this a nanowire was grown using the VLS (vapour-liquid-solid) method.

Focussed ion beams, in a way similar to focussed electron beams, can not only make objects visible but they can also mill structures into a surface. In contrast to FEBIP, no additional gas molecules are necessary for this process because the heavy ions can directly sputter atoms from the surface. VLS is a common method for fabricating nanowires. Here the precursor material of the wires is added in gaseous form and is dissolved in a small amount of catalyst, generally a "drop" of liquid metal such as gold. The dissolved molecules crystallise there and the wire begins to grow.

Scientists initially "milled" a hole at a suitable location with a focussed ion beam. In it, a focussed electron beam then "planted" a tiny amount of gold, which served as the VLS catalyst. In a third step, silane (a gaseous form of silicon) was added, and individual nanowires, made up of pure crystalline silicon, started to grow out of the holes. For this experiment, the final step took place in a separate growth chamber, but in theory it could also be integrated into an electron microscope with the help of a heated sample stage.

Utke is certain that chemistry with focussed electron beams has great potential. "FEBIP could soon become a true nanofabrication platform for rapid prototyping of nanostructures in a minimally invasive way, without necessitating the large investment of a clean room." //

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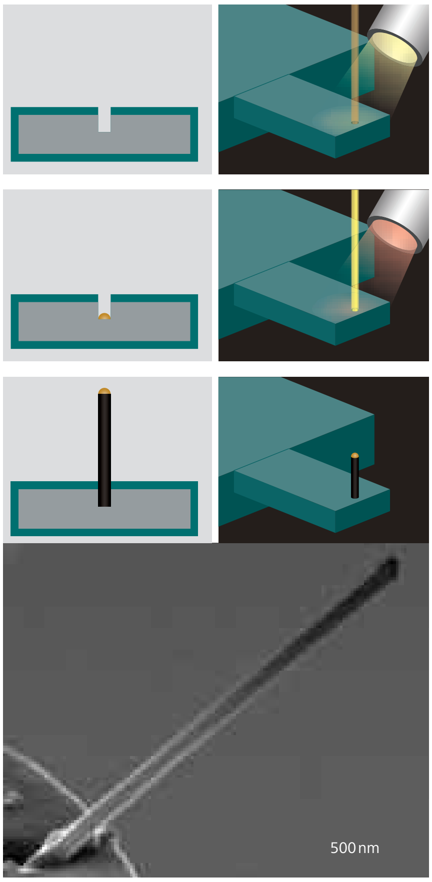

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Artificial turf with upstanding qualities

A "soft" shell and a "hard" core – for once, the reverse situation. Novel fibres enable the creation of artificial turf which meets the highest demands when playing football. Empa researchers, together with TISCA TIARA, a Swiss manufacturer of artificial turf, have developed a bi-component fibre with two impressive qualities: thanks to a hard core it returns to an upright position again and again, and because of a soft sheath it avoids abrasions and grass burns.

TEXT: Nadja Kröner / PHOTOS: Empa, TISCA TIARA

Maybe it's cold and wet outdoors, or perhaps it just snowed. It's not exactly the best time of year to play football, or is it? Thanks to artificial turf, for decades it's been possible to play during winter, too. The artificial grass is robust and stands up to any weather. Even so, a few of us might remember some painful injuries we got on artificial turf. The first generation of that material was manufactured using
4 polyamide fibres with excellent recovery properties and which always stood upright. But it's exactly these resistant fibres which frequently led to grass burns and abrasions whenever someone took a tumble.

That's why second-generation fibres consisted of polyethylene whose properties were much gentler to the skin. In practical use, however, these fibres also exhibited a serious defect: their resilience, or ability to stand upright after repeatedly being trampled upon, was very poor. Over time, the load on the fibres led to a downright flat pitch. That was not only visually unattractive, the "bent over" blades of artificial grass also changed how well the turf could be played on. As a result, an attempt was made to support the blades with sand or granulated material. Today, turf with a granulated infill is very common.

Modern artificial turfs such as SPORTISCA from TISCA TIARA, a manufacturer of textile-based floor coverings, meanwhile consist of three fibre layers which give them a relatively high degree of resiliency. Because the polyethylene fibres' lack of shape stability created problems even early during production, this firm, which is based in the Appenzell region of Switzerland, sought out Empa to help them find solutions. "The requirements on artificial turf are quite varied," notes Andreas Tischhauser, head of marketing at TISCA TIARA. "For instance, footballers want an especially soft grass surface while pitch operators want one with a long service lifetime. And, of course, it must also meet ecological requirements."

A development with many challenges

It was soon clear that a completely new fibre had to be developed. It should exhibit high resilience as well as optimal sliding friction behaviour. Two properties implies the need for two components, thought Rudolf Hufenus of Empa's Advanced Fibers Laboratory to himself. According to this idea, such a fibre should contain a hard polyamide core surrounded by a low-friction sheath of polyethylene.

With the support of Christian Affolter, a modelling expert in the Mechanical Systems Engineering Laboratory, they simulated a variety of cross-sections which would best fulfil the desired requirements.

However, the development of the new fibre was no easy task, as was discovered within the scope of a project financed by the Swiss Innovation Promotion Agency CTI. "At half-time, we were clearly behind our project plan," recalls Hufenus. The problem was that the modelling of all the various cross-sections was clearly more complex than had been assumed and took more time than anticipated. The input parameters for the models were the fibre's cross-section geometry along with the material properties of both polymers, which were determined through mechanical tests. In addition, the loading on the fibre, in other words how

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it should bend, was part of the model. All of this data finally resulted in a simulation of the fibre's stress-strain characteristics.

A further challenge arose because a new spinning head had to be developed for Empa's pilot spinning system in conjunction with the Institute for Rapid Product Development at ETH Zurich. The unusual aspect about this spinning head was that the two polymers could be processed at different temperatures. The basis for the construction was the assumption that the two polymers being used had to be extruded at different temperatures. In the course of the project it was determined that this isn't necessary.

The industrial production of the fibres also proved challenging because they need spinning systems designed specifically for fibres going into artificial turf, which are generally not two-component systems. "After we worked very hard to persuade him to do so, the fibre manufacturer we brought into this project told us he was prepared to modify his spinning systems as required," explains Hufenus. The time from planning to construction was a full year.

With trial and error to the optimum fibre

Even at the conclusion of the project, when the completed fibre was on hand, yet another difficulty arose – the fibres did not pass the Lisport test, which checks for long-term mechanical wear. The sheath of the two-component fibres separated from the core with time when placed under load. TISCA TIARA then further optimised the fibre after consultation with and support from Hufenus. "We proceeded according to the trial-and-error method in which we simply tried out various options until we found the best possible cross-section," says Tischhauser.

Finally everything was complete; with much patience they had succeeded in creating an optimal cross-section: instead of a thick core, the fibre consists of five thin ones. The fibre's resiliency qualities are guaranteed for years, as a new Lisport test was able to prove. "We're the first ones who have followed such a project through from the development of the fibre to the laying of the artificial turf," boasts Hufenus proudly. Tischhauser is also very pleased, saying, "We could hardly believe that all at once everything worked out."

The turf, which visually comes very close to the natural grass which it is intended to imitate, has already been laid on two football pitches, one in Ecublens near Lausanne and the other in Bürglen in the canton of Thurgau – and to the complete satisfaction of the footballers. "With this, we fulfilled the essential requirements of our industrial partner TISCA TIARA for a new fibre used in artificial turf," adds Hufenus.

A FIFA certification isn't anything to worry about, however, because at this time the standards are in fact trailing technological developments and effectively give a chance only to artificial turf with a granulated infill. Nevertheless, because of its clearly superior properties, the new artificial turf will surely be a market success because most football pitches don't require FIFA certification. In addition, it's more important for the teams that they can play, and more importantly train, in grey, wet weather and in snow than it is to be on certified turf. //

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A footballer's skin injuries caused by stiff polyamide fibres.

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Artificial turf made of polyethylene: continuous loading results in bent fibres, which besides degrading playability are a visual annoyance.

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The strips of turf are attached to an adhesive carrier with polyurethane glue so that the entire pitch can be laid in a floating manner.

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These fibres are stable due to their polyamide cores but are also gentle on the skin because of their polyethylene sheaths.

Adapted to industry

Clothing today must be able to do quite a lot – whether allowing moisture to wick away for improved comfort when worn or, in contrast, being watertight to protect against rain. In order to equip textiles with the desired properties, industry is always looking into new processes, one being plasma technology. Together with industry partners, Empa has made this technology industrially viable for the textile sector. The first products are already in development.

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TEXT: Beatrice Huber

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Textiles made of synthetic materials have the disadvantage that they generally are only partially wettable and thus still must be finished. Depending on the desired end use, the issue becomes one of making the textiles either more water permeable (more hydrophilic) or more water repellent (more hydrophobic). A hydrophilic treatment improves a textile's comfort when worn because perspiration can more easily make its way through clothing. If textiles are printed, they must be given this treatment ahead of time, otherwise the print doesn't adhere. Clothing intended to protect against water, such as rain, is given a hydrophobic treatment.

For decades, the textile industry has been looking for improved processes to make fabric either more hydrophilic or more hydrophobic. That's because the wet-chemical methods still common today are deficient in areas such as being resistant to wash and wear. In addition, they change the textile's properties, in particular its feel. Last but not least, they also consume large amounts of energy and water.

Plasma: moving from microelectronics to textiles

An alternative can be found in plasma technology which, for instance, has been long used in microelectronics for coating wafers. The key advantage is that it's dry and environmentally friendly. Low-pressure plasma processes have until now been considered too expensive for textiles, but this could soon change. Empa's Advanced Fibers Laboratory has been researching this technology for some time and is operating a pilot plant. Further, the lab has been collaborating with six textile companies as well as the Nano-Cluster Bodensee (NCB, see box), in a project financed by the Swiss Innovation Promotion Agency CTI to clarify more precisely the suitability and economic efficiency of plasma technology for the textile branch. "There's long been an interest in plasma technology in this branch. For instance, it was discussed intensively in a focus group at the Nano-Cluster Bodensee. Our project is a result of those discussions," reveals Sébastien Guimond, head of the project at Empa.

For plasma technology, gases serve as the raw materials. They are first activated to a plasma state in a vacuum chamber through the application of voltage. The activated molecules then collect on a substrate – such as a textile – in a thin layer consisting of only a few nanometres. This has the advantage that the properties of the textile, such as its feel, are not impaired.

1
Textiles should fulfil a wide range of tasks; one of these is protection against moisture. (Photo: iStock)

2
As a rule, synthetic textiles are only partially wettable, as shown here in the middle. Thus they must either be frequently given a hydrophilic (left) or a hydrophobic treatment (right). (Photo: Empa)

3
Together with six textile companies as well as the Nano-Cluster Bodensee, Empa's Advanced Fibers Laboratory has made plasma technology viable for industrial applications in the textile branch. Empa's pilot plant represents a decisive factor for the transfer of process knowledge from the laboratory to industrial scale. (Photo: Empa)

Multiple steps covered in the value-added chain

Together, the project partners cover multiple steps in the textile value-added chain. Empa's pilot plant is almost a perfect complement to the industrial plasma plant of the Austrian textile-finishing company Grabher Günter Textilveredelungs GmbH, which uses it to provide finished products for the participating Swiss firms (Christian Eschler AG, AG Cilander, Sefar AG, Bezema AG and Bischoff Textil AG). The NCB took over management of the project and worked out a cost model.

The established goals were all attained and the project was a complete success. All the plasma coatings newly developed by the Empa team, which includes Sébastien Guimond, Barbara Hanselmann and Dirk Hegemann, led to the textiles undergoing a hydrophilic treatment having a considerably longer lifetime and being more washable compared to results from existing methods as proven in laboratory lifetime tests. Two coating processes have already been successfully transferred from Empa's pilot plant to Grabher's industrial scale plant, and a further coating has been optimised there.

Robust processes developed for industry

Processes which are to stand the test of industrial use must be robust, in other words they must run day and night without any major disruptions. It's exactly concerning this point where many laboratory ideas have failed. One of the project's explicit goals was that the processes must also withstand harsh industrial environments. The results are quite impressive – the fabrics of interest can be processed reliably and reproducibly in both the pilot plant and the industrial system. Furthermore, the low-pressure plasma process can also hold its own as regards costs when compared with conventional processes.

Beside the "simple" transfer of the plasma technology to the textile sector, the project is also intended to help gain more detailed knowledge about this new technology in this branch. The Empa experts are therefore systematically investigating plasma treatments with various gaseous mixtures, textile materials and surface structures. "In this way, we can for the first time make definitive statements concerning the effectiveness of various plasma processes and set the plasma parameters accordingly," explains Guimond. The project led to results which met with great enthusiasm among the participants. Two of the participating companies have already started to treat textiles using plasma technology, and in the next few years would like to bring products based on it to market. The Swiss Innovation Promotion Agency CTI also labels this project as a success story. //

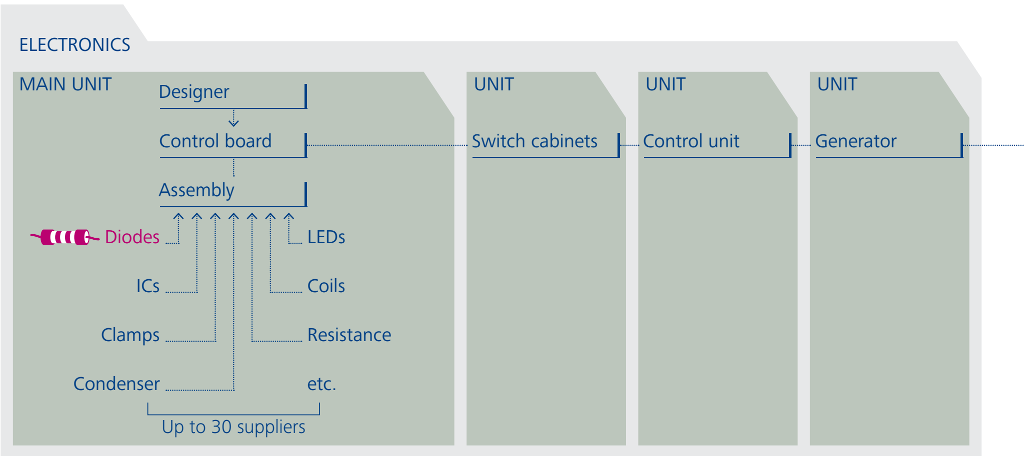
Nano-Cluster Bodensee (NCB)

The Nano-Cluster Bodensee is a network spanning all sectors of industry; it consists of more than 80 companies and R&D institutions in the Euregio Bodensee (Lake Constance European region), all of which develop micro and nanotechnologies for use in products and processes. Also participating as partners are the Swiss State Secretariat for Economic Affairs (SECO) and the cantons of St. Gallen, Appenzell Ausserrhoden, Thurgau, Schaffhausen, Grisons and Zurich. Empa is likewise a member, and in fact board member Xaver Edelmann serves as president of the organisation. www.ncb.ch

Debugging – successfully

Small but by no means unimportant: defective electronic components can lead to malfunctions, not only in computer systems but also in entire transportation systems or power plants, and as a result incur enormous expense. Troubleshooting is generally very difficult, especially if the components don't exhibit any manufacturing defects. Experts at Empa are playing the role of detective for industry and have taken causal research to the highest level.

TEXT: Martina Peter



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In a complex electronic system, thousands upon thousands of components and modules must work together smoothly. If there's a system outage, virtually an infinite number of errors could be responsible; for some individual microchips around 400 failure classes have already been defined. It's almost like trying to find the proverbial needle in a haystack when – as recently happened in a wind turbine – for no apparent reason, perfectly good diodes start failing on a regular basis.

That's a problem right up the alley of Empa researcher Peter Jacob, who joins with other experts in microelectronics, and together they use their skills as sleuths to investigate such failures as well as to uncover weaknesses in components, circuits and their applications. In the process they bring some surprising results to the light of day. The team from the Electronics/Metrology Laboratory operates as do specialised physicians in a group practice. The "patients" of Empa's Reliability Network are components and modules from power electronics, microelectronics and optoelectronics. "We receive enquiries from industrial customers who frequently expect the worst," according to Jacob. That's because many fear extremely high costs as a consequence of a system failure.

As would a doctor, the Empa experts first conduct a diagnosis meeting. They examine factors such as how the interconnections in the application are laid out, who delivered the modules or how long a component has been in use. In the case of the wind turbine, however, neither did the components exhibit manufacturing defects nor did the schematics reveal any defects. Nonetheless, small diodes were failing in the same location in a module with integrated rectifiers. Redundant systems – a type of replacement system which steps in if there is ever an operating malfunction – prevent higher level components, in this case the generator control system, from being affected. Even so, the continuous repair work proved extremely time-consuming and expensive in the remotely located wind turbines. It was thus the proper time to commission the Empa experts to search for the actual cause of the failure.

Painstakingly detailed detective work

Constructing a technical system such as a wind turbine is almost as complicated as the control systems it contains. One supplier erects the tower and turbine blades, while another develops the required control systems, which in turn contain countless electronic components from further manufacturers that are finally assembled into the overall control system by a further partner in the manufacturing chain. Having 30 or more suppliers involved is not unusual.

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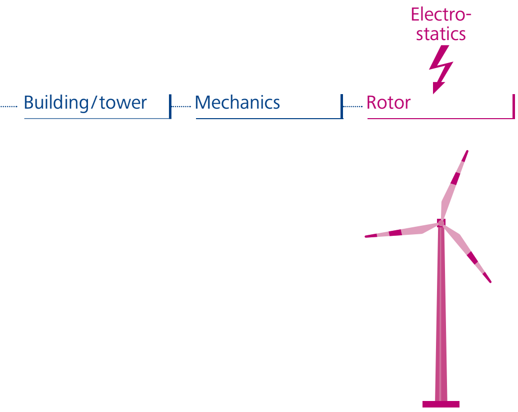

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In a complex electronic system, the search for the actual cause of the failure needs painstakingly detailed detective work. In the case of the wind turbine, it was the electrostatic charging of the rotor which led to the failure of the diodes.
(Illustration: André Niederer)

2
Especially in remote locations, the repair of failed electronic components can become time-consuming and expensive.
(Photo: Beatrice Huber)

This results in numerous interfaces, and errors can creep in at each one.

When Jacob or one of his colleagues want to physically analyse failed components and modules, they have at their disposal an arsenal of investigative equipment and manipulation processes for microstructures which is virtually unique in all of Switzerland. First they attempt to localise the failure in the component, which is generally a microchip the size of a fingernail and which has millions of transistors. If they are unsuccessful, they turn to a systems analysis. "Sometimes it's the apparently unimportant but instead rather random details which put us on the right track," explains Jacob.

In the case of the wind turbine, additional discussions with the responsible engineers led him to the solution of this puzzle. They reported to Jacob, among other things, an observation in the rotor's grounding system which in their eyes was of no real consequence, but by doing so they provided the Empa "investigators" with the missing piece of the puzzle. It was the electrostatic charging of the wind turbine which penetrated into the shaft and thus led indirectly to the failure of the diodes. A large rotor diameter creates large electrostatic voltages on the rotor axle. If this is not properly grounded, tiny sparks jump across, and they are coupled as voltage impulses into the electronics through the cabling conduits. These finally led to the diodes encountering an early demise.

The solution was to set up proper grounding, optimise the conduits to avoid interference with large impulses from neighbouring circuits and to add additional protective elements to the circuit at certain points – and with this, the mystery was solved. //

Empa's Reliability Network

At Empa, industry partners can find experts who can help them answer complex questions about quality and reliability regarding materials, components, equipment and systems. In doing so, the experts turn to equipment and methods such as focused ion beam (FIB) systems, scanning electron microscopes and transmission electron microscopes, special preparation and grinding machines as well as thermal laser stimulation and infrared thermography. Numerous corporate clients – especially small and mid-sized enterprises – have joined this "industry pool" whereby they can, as required, fall back on the assistance of the Reliability Network as well as a further Empa analysis centre, the ZZfP (Center for Non-Destructive Testing).
www.empa.ch/abt173

EmpaNews in e-paper format

Just recently, in addition to the printed edition of *EmpaNews*, it has become possible to receive the magazine in e-paper format and thus paper-free.

Simply go to the *EmpaNews* home page (*www.empanews.ch*) and click on the related icon in the right-hand column. Then you can instantly comb through past issues starting with #21, in other words, since the redesign of the research magazine in 2008. The web page also offers access to additional Empa publications as PDFs which you can flip through on your computer. Of course, it's also possible to store or print individual pages and articles.

Visit by the cantonal Government of St. Gallen

On 19 October, Empa in St.Gallen welcomed some distinguished guests: the entire cantonal Government paid a visit and the scientists at Empa gave a comprehensive view into their research activities. The members of the government were clearly impressed by what they saw.

Swiss Innovation Forum 2010

At the 5th Swiss Innovation Forum on 4 November in Basel, Empa presented its pilot's suit which was custom-made for Solar Impulse – an aircraft designed to pursue the goal of circumnavigating the globe using only solar energy. So that the pilots neither perspire nor freeze during the flight stages, which will last as long as five days and nights, special clothing systems are needed. When developing the pilot's suit, Empa reverted to an old, proven material; down, which has an extremely high level of thermal insulation and transports moisture quite well. During the first night flight of Solar Impulse at the beginning of July 2010, the suit passed its initial "acid test".

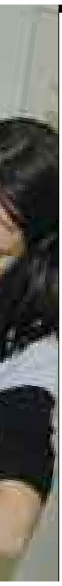
Prize awarded to Optotune

The Swiss Technology Award, which has been awarded since 2007 within the scope of the Swiss Innovation Forum, this year went to Optotune in the category "Start-up". Founded in 2008 as a spin-off of ETH Zurich, Optotune has its offices in Empa's glaTec technology centre in Dübendorf. Together with Empa researchers, the entrepreneurial company develops, among other things, optical systems which progressively vary the refractive power of a lens with the help of "artificial muscles" and in a way similar to the human eye. Meanwhile, the number of employees at Optotune has grown to 20.

Technology Days 2010

Mobility is an important pillar which supports the Swiss economy – but also a problem child on our way to a sustainable development. This raises the question as to how individual mobility can be guaranteed without putting an undue strain on people and the environment over the long term. To address this topic, the Technology Days 2010, sponsored by Swiss Engineering STV, SATW (Swiss Academy of Engineering Sciences) and Empa, delivered answers under the slogan, "Sustainable Mobility". An exhibition during the central event on 27 October at Empa in Dübendorf illustrated how multifaceted mobility already is today. Interested visitors were able to take a test drive in gas and electric vehicles.

Left: The Tesla Roadster, easily the best-known electric sports car, accelerates in only four seconds from zero to 100 km/hr – without making any noise. Right: Driving with natural gas, and especially biogas, significantly reduces CO_2 emissions.



Education week for young researchers

At the start of November, eleven young researchers – including three from Empa – spent a week travelling throughout Switzerland. They obtained insights into current research and development efforts as well as production requirements in the (bio)materials sector from a variety of companies as well as clinical and academic institutions. This "travelling lab workshop" is part of the educational activities of CCMX, the Competence Centre for Materials Science and Technology of the ETH Domain, in which Empa participates. Education plays a central role in the Competence Centre. During the workshop, participants were allowed to not only watch but were also required to take an active role in case studies and collaborate in practical problem-solving as well as introduce and discuss their own research projects. The workshop was organised by Katharina Maniura, co-head of Empa's Materials-Biology Interactions Laboratory and head of the CCMX MatLife Program; she accompanied the group throughout the week.

Let the wind flow…

Last year Empa constructed a new wind tunnel which the Laboratory of Building Science and Technology will use to study the behaviour of wind currents in cities. On 11 March, the official opening will take place with a symposium entitled Energy and Wind Research for Future Cities and Societies; it is targeted at architects, space planners, urban planners and scientists as well as interested members of the general public.

Take the train to Empa

Now it's possible – since the middle of December, the Glattalbahn metropolitan railway connects Empa in Dübendorf directly with the Zurich Airport and the Stettbach train station. At the opening festivities for the new Line 12, Empa displayed new drive technologies using test vehicles and prototypes which function with hydrogen, electricity or natural gas/biogas. In addition, the very numerous visitors were able to experience at first-hand research projects dealing with noise and fire protection in transportation. Further, on the Empa grounds they had the opportunity to inspect the new wind tunnel (see the item "Let the wind flow…") along with "Self", a living module for residential and working purposes, which is self-sufficient in energy and water consumption.

Opinion

Willi Haag

Willi Haag
President of the
cantonal Government, St. Gallen

> “We found the cooperation among the various branches of science and the latest achievements very impressive, as well as the interfaces between science and applications.”

Events

11 March 2011

Let the wind flow
Symposium to mark the opening of the wind tunnel at Empa
Empa, Dübendorf

16 March 2011

Earthquake-resistant multi-storey wooden buildings
For construction engineers and wood-frame specialists
Empa, Dübendorf

22 March 2011

Nanofabrication and nanoanalysis with focused electron and ion beams (FEB, FIB)
Empa/FSRM course
Empa, Dübendorf

25 March 2011

Challenges and opportunities of diesel particle filter technologies
For representatives in the particle-filter industry, government officials and members of the VERT Association
Empa, Dübendorf

5 April 2011

Aluminium alloys
Empa/FSRM course
Empa, Dübendorf

16 May 2011

Blended and alternative cements
For R&D professionals working with cement, mortar and concrete
Empa, Dübendorf

18 and 19 May 2011

Swiss NanoConvention 2011
For interested parties from science and industry
TRAFO Culture and Conference Centre, Baden

For details and further events:
www.empa-akademie.ch

Your way to access Empa’s know-how:

Portal

portal@empa.ch
Phone +41 44 823 44 44
www.empa.ch/portal