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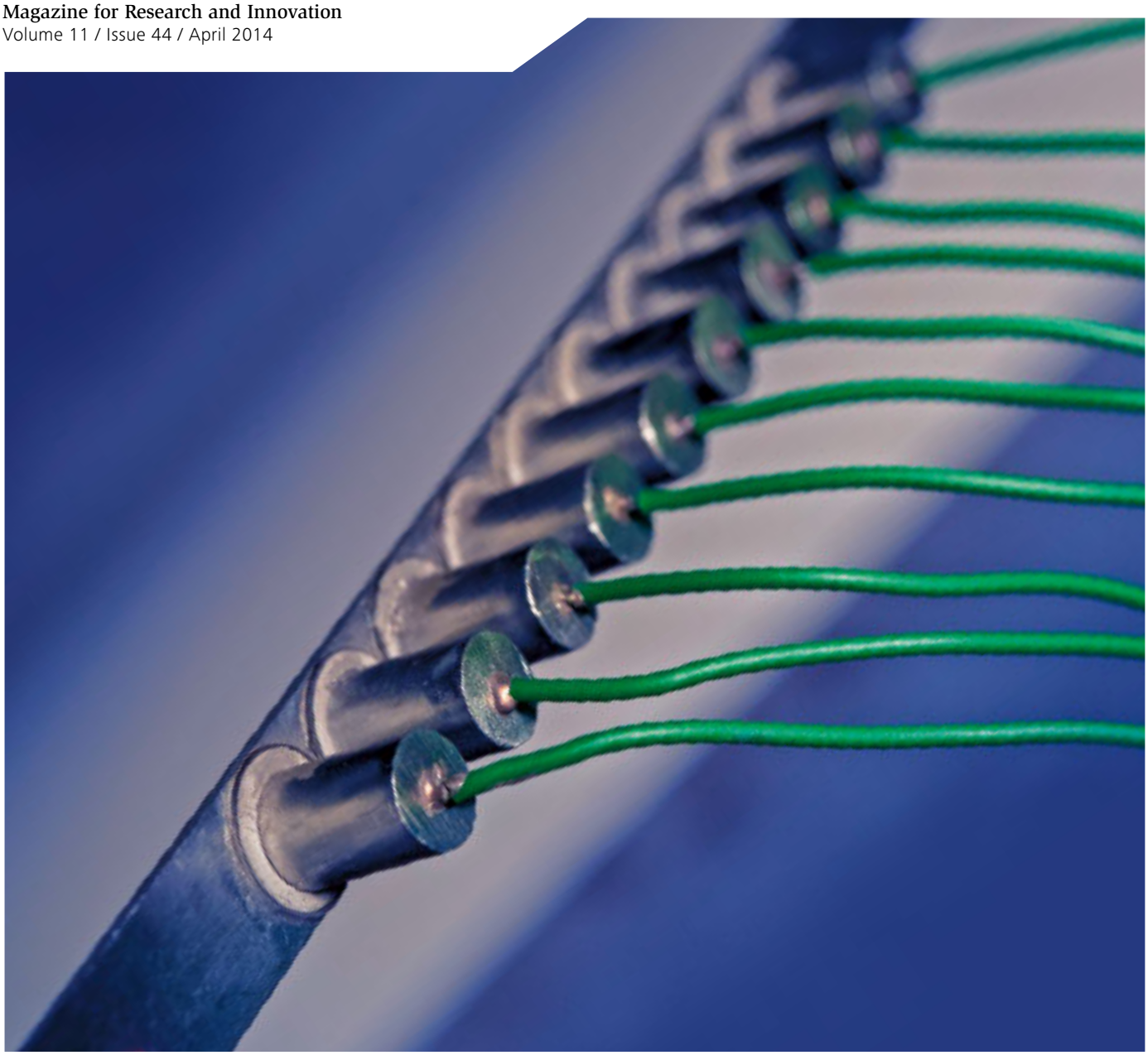

Programmable materials

EMPA
Materials Science & Technology

A source of knowhow for industry

Air cushions can save lives

Diamonds are poor kissers

Mikro- und Nanotechnologie

für die betriebliche Praxis – Weiterbildung zum MNT-Master in der EUREGIO Bodensee

In diesem Studiengang steht das Kleine und Winzige im Vordergrund: Mikro- und Nanotechnologie (MNT), die mittlerweile in Bereichen wie Sensorik, Beschichtungen, Medizin und Mikroelektronik eine herausragende Rolle spielen.

Zur effektiven Nutzung der Möglichkeiten der MNT ist es daher vorteilhaft, gut ausgebildete Mitarbeiter sowie ein entsprechendes Netzwerk zu haben, um den neuesten Stand der Technik für das eigene Unternehmen verfügbar zu machen. In der EUREGIO Bodensee besteht seit mehreren Jahren eine internationale Kooperation aus der FH Vorarlberg, Schloss Hofen, der Interstaatlichen Hochschule für Technik Buchs NTB, der Zürcher Hochschule für Angewandte Wissenschaften (ZHAW) und der Empa.

Unter der wissenschaftlichen Leitung des ETH-Professors und Empa-Direktors Gian-Luca Bona bieten diese Einrichtungen gemeinsam einen berufsbegleitenden Masterstudiengang MNT an, der auf die Bedürfnisse in der betrieblichen Praxis ausgerichtet ist. Er besteht aus den vier Modulen Technologie und Materialien der Mikrotechnik, Nanomaterialien und -werkzeuge, Materialien und Oberflächen sowie Bauteile, Systeme und Design für die Mikro- und Nanotechnologie.

Der Studiengang mit eng begrenzter Teilnehmerzahl von maximal 20 Studenten richtet sich dabei in erster Linie an Ingenieure in kleineren und mittleren Unternehmen, aber auch an technische Mitarbeiter. Die Studierenden erwerben nach erfolgreichem Abschluss den international anerkannten akademischen Grad Master of Science (Micro- and Nanotechnology) der FH Vorarlberg nach österreichischem Recht. Der MNT-Studiengang wurde in den Jahren 2011 und 2012 von den österreichischen Personalleitern zum besten technischen Studiengang gewählt (Quelle: Magazin Format, Ausgabe Juni 2012).

Sie können Ihre Masterarbeit im eigenen Berufsfeld durchführen und bekommen vielfältige neue Kontakte für einen gewinnbringenden Erfahrungsaustausch. Der Studiengang startet im September 2014 in der 5. Durchführung. Weitere Informationen finden sich unter **www.mnt.ch**

EMPA Materials Science & Technology

NTB INTERSTAATLICHE HOCHSCHULE FÜR TECHNIK BUCHS

Zurich University of Applied Sciences zh aw School of Engineering

Fachhochschule Vorarlberg

MICHAEL HAGMANN Head of Communications

Thinking beyond the ivory tower

Dear readers

Switzerland regularly fares extremely well in international university rankings, mainly thanks to the two ETHs in Zurich and Lausanne, but also to some of the cantonal universities, all of which conduct top-notch (basic) research. What's more, Switzerland is also a global frontrunner with regard to the number of patents registered per capita.

And although we have made a name for ourselves as "champions of innovation" in recent years, we could strive even harder to swiftly transform our research results into innovative products and technologies that succeed on global markets – thus giving Swiss industry a decisive competitive edge. It is precisely this so-called precompetitive research that often harbors imponderable risks. After all, not everything that seems ingenious in the lab can be upscaled industrially and smoothly put into practice. Incidentally, this is exactly why it is often tricky to find financial backers as the road to economic success can be (very) long and bumpy.

For some time, Empa has settled in this "no man's land" between university and the market and, together with its industrial partners, endeavored to get new technologies "on the road" – highly successfully, too, as the examples in the current issue of EmpaNews on the topic of technology transfer demonstrate.

Enjoy reading!

hy.muve, a hydrogen-powered street sweeper, is the result of a cooperation between Empa and the vehicle manufacturer Bucher-Schörling. A success story in 10 chapters. 12

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Cover
Prototype of a programmable metamaterial: this aluminum strip fitted with piezo elements can allow vibrations of different frequencies to pass through and block out other frequencies. One day, it could be used to create a material that automatically absorbs vibrations at lightning speed – a revolution in mechanical engineering. Page 16. Photo: Wolfram Raither, ETH Zürich

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Air cushions fight off fire and frost

Extreme situations require special clothing that provides protection and comfort – and, in extreme cases, guarantees survival. The air cushions between the fabric and the body plays a key role in this respect. Empa scientists are looking to develop reliable clothing that offers the wearer unprecedented protection against the heat and cold thanks to its insulating air layers.

TEXT: Antonia Fischer / PICTURES: Empa

Sometimes, physical sensations can be deceptive: if a fireman starts perspiring in a burning building or an extreme climber begins to feel cold on the steep face, it may already be too late to prevent injury or even death. Only accurately constructed clothing with guaranteed insulating properties can help in such situations.

Agnes Psikuta from Empa's Laboratory for Protection and Physiology has spent the last three years developing a computer model that can be used to produce garments that insulate the body in a precisely defined way. Thanks to her work, we will soon be able to predict how long an item of clothing will fulfil its function and protect a mountaineer from frostbite, for instance.

While the material is important for such functional clothing, it all boils down to the thickness of the air layers between fabric and body. "These air layers create the largest temperature difference provided that the air stays still," explains Psikuta. The thicker the air layer the better it insulates.

Psikuta and her team, Joanna Frackiewicz-Kaczmarek and Emel Mert, have devised a method to precisely determine the thickness of the air layers between body and fabric. The garments are sewn in the lab and tested on male and female manikins. A 3D scanner scans the manikins first undressed, then clad. The scans are then superimposed virtually on the computer. The result is a colour map image that displays the areas of the body where the clothing is in contact with skin, where there are air layers between the skin and clothing and how thick they are. In order to make the reading accurate enough, every scan is repeated six times. It is well worth the effort, Psikuta says: "Nobody else in the world has such an accurate method for determination of air gap thickness."

The scan results display where the clothing insulates well and where more insulation material needs to be incorporated. In poorly designed clothing, the wearer starts to feel cold quicker as there is not much of an air gap there and the clothing lies close to the body. When wearing more clothing layers, the more still air spaces will be formed, which will insulate the body better.

In recent years, Empa has been systematically investigating the behaviour of clothing on the body. The computer calculations should help industrial partners to design better protective clothing and functional sportswear. In doing so, there are two main questions: what does the design need to look like for clothing to have more or less contact surface and what do air gaps and contact surfaces achieve? The aim is to be able to predict exactly how long and to which extent a certain garment will provide the desired insulating or cooling effect.

Simulating firemen in action

The next step is to consider different postures. As firemen rarely stand up straight while in action, for instance, Psikuta and Mert will test a selection of garments on a flexible manikin. Movement is also a key factor. Wind or a person's movements alter the insulating air layers; also, movement warms the human body. Psikuta wants to monitor how the clothing behaves using a moving manikin and can also "work up a sweat" with the aid of built-in sweat nozzles.

Psikuta will then test whether the newly designed clothing can actually withstand really extreme conditions using several different manikins. Each manikin will be exposed to a different (more or less hostile) environment, including a manikin that has to walk through fire to assess the risk of burning.

The tests on manikins, clothing and air layers are expected to be completed in three years from now and will enable industry to develop high-performance clothing that is streets ahead of the current standard. Psikuta is convinced: "Small differences in clothing can make a world of difference to its performance, safety and comfort." //

Agnieszka Psikuta is installing the scanner and preparing a reading with her colleagues. The laser scans (below) depict the thickness of the air cushions between several layers of clothing and the skin. Air cushions offer protection against heat and cold.

Lasers make sewing a thing of the past

1

If you want to make a piece of clothing, you pick up a needle and thread – that's been the way for thousands of years. But sewing's not quite so handy, when the clothing has to be water- or even air-proof as the needles pinch tiny holes. Welding textiles together with a laser is an elegant way of getting round this problem. Empa scientists demonstrate how.

TEXT: Martina Peter / PICTURES: Empa

Fishbones or needles made of bone, horn or ivory used to be all the rage but today they have been replaced by high-precision metal industrial sewing machine needles for manufacturing garments. They can make up to 10,000 stitches a minute. But no matter how thin the needles, they all leave holes in the "textile surface structure". This means that, for instance, rain can penetrate the seam of an outdoor jacket. To prevent this, the seams are then glued together in a second step. A long-established joining technique from the metal and plastics industry – welding – now makes this lengthy two-step process a thing of the past. A diode laser welds textiles in a completely non-permeable manner, in just a single step.

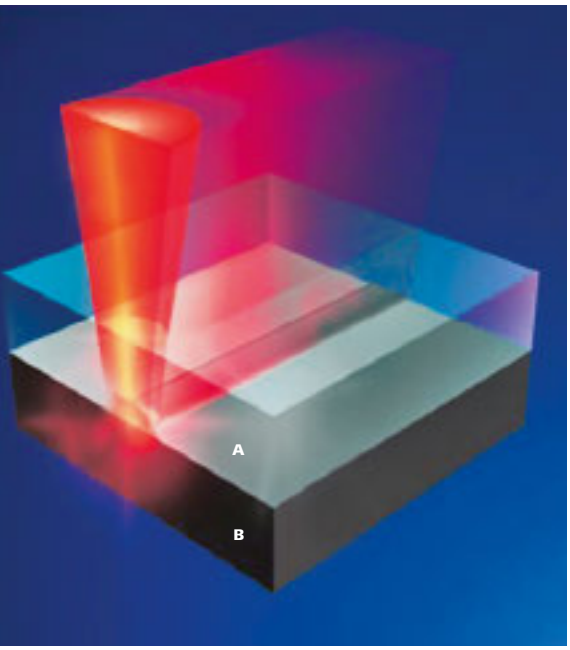
Laser welding – new for textiles too

The principle of laser welding is simple: a laser beam heats up the metal or thermoplastic so intensely that it melts in places and the materials become fused. A diode laser now does the same thing with textiles made of polymer fibers. A laser beam penetrates a transparent textile layer. The underlying layer absorbs the beam's energy and transmits it back to the transparent layer. The two layers then heat up along the seams for welding and the polymer chains of the textile layers melt together. "You just can't beat joins on the molecular level", says textile engineer and project leader Alexander Haag from Empa's Laboratory for Protection and Physiology about the advantages of welded textiles.

However, the researchers have yet to overcome some stumbling blocks. One of them is the nature of textiles. Textiles are "limp". Their form is unstable and they can form creases involuntarily. They are thin and can quickly become overheated by the laser and then damaged. Different "textile surfaces", as the expert calls them, also behave differently during processing: because of their stitches knitted and crocheted fabrics are trickier candidates than "smooth" fabrics.

1
This is how it works: the top layer of the material (**A**) must be transparent to the diode laser light, the lower layer (**B**) must absorb the laser light. This results in precision heating. The simultaneous application of pressure welds the textile layers together.

2
Project coordinator Alexander Haag working the research laser: the goal is to join micrometer-thin membranes is a lasting and compact manner.



2

A further challenge: the laser beam can't cope with some black materials. What the human eye sees as black, i.e. light-absorbing, is almost transparent for the laser which functions in the infrared part of the spectrum. Prior to welding it must be clear whether the textile surface is really suitable for laser welding in terms of its absorption, reflection and transmission properties.

Haag is currently modifying all the process parameters to identify the best techniques for welding various layers together. At the end of the year when the project financed by the Commission for Technology and Innovation (CTI) will be completed, a welding method should be available, which can join different thermoplastic polymer fabrics with up to 10 micrometer-thin membranes made of polyester or polyurethane in a lasting and tight manner. To this end, the Empa team is developing two different diode laser welding facilities together with their industrial partners Leister Technologies AG in Kägiswil, Unico Swiss Tex GmbH in Alpnachstad, Schips AG in Tübach, Schoeller Textil AG in Sevelen, Serge Ferrari Terrsuisse SA in Emmenbrücke and the Swiss Textile College Zurich: a laser sewing machine for quasi infinite joining and a facility for joining complex structures on one level in all directions.

According to the Empa textile expert the new joining technology opens up entirely new possibilities. "As laser welding is more closely related to computer-aided construction than to a conventional sewing machine, the action can be very precisely controlled just like in technical construction" comments Haag. "It lends itself not only to straight but also to complicated, curvy welded seams and even to 3D constructs". They are needed, for instance, when the design includes valves to introduce air between two structures. By means of simple control it is relatively easy to weld airtight and watertight seams for outdoor jackets and larger textile areas made from various superimposed ultra-thin layers of material using precision lasering. Another advantage of the welded seams: "They feel pleasant on the skin as they are very soft", says Haag.

Welding ultrathin films with textiles

Empa scientist Markus Weder and his team have already demonstrated in a number of projects that laser welding is particularly well-suited to combining textiles with ultrathin membranes. For instance the clothing developed for multiple sclerosis patients with Unico swiss tex GmbH is already established on the market. Cooling pads made from ultrathin polyester membranes are built into their shorts and T-shirts. Weder explains how this works, "The cooling clothing consists of three layers. Two 10 to 15 micrometer-thin polyester membranes make up the inner and outer layers. Between them there is a crocheted fabric, about 100 micrometers in thickness, that creates a cavity between the membranes. It can simply be filled with tap water". The winning argument according to Weder, "The membranes are watertight but permeable for water vapor. The water evaporates on the outside and the wearer has a pleasant cooling feeling on the skin."

Next the textile engineers want to present an ECG belt with welded-on, wettable elements for the long-term monitoring of cardiovascular patients, which they have developed in another CTI project. It has been especially designed for older people who don't perspire so much anymore. And finally the researchers are working together with industrial partners on medical support stockings that don't have to be tugged on with great difficulty but can be "pumped up" with air. The icing on the cake: the variable pressure in the (multi-ply) stockings can be used for monitoring purposes, too. A measurement device can provide information on how frequently the patients move around. //

A source of knowhow for industry

In a globalized economy, the competitive ability of a high-tech country lacking in n like Switzerland depends on its innovative strength. To guarantee prosperity, research results from the labs have to be passed on to Swiss companies quickly to help them succeed on the market. The current "Focus" outlines Empa's role in the Swiss technology transfer scene.

TEXT: Gabriele Dobenecker / PICTURE: Optotune

Two Optotune employees during tests on a beam path: the start-up company was given a helping hand in Empa's business incubator, glaTec.

As an application-oriented research institute for material science and technology, Empa is committed to bridging the gap between science and industry. Through individual collaborations and a broad range of services, Empa is able to offer its partners tailor-made solutions. Whether the idea is to develop new products, optimize existing technologies or solve specific problems – with 500-plus highly qualified scientists and engineers and its top-notch infrastructure, Empa is the number-one port of call.

100 research projects with industry launched every year

Last year alone, Empa initiated over 100 new R&D projects with various partners from industry, all supported by Empa's Technology Transfer Office, which was founded in 2005. Around the same time the institute also established the Empa Portal to facilitate the contact to potential customers and partners – a convenient drop-in center that enables interested companies to submit queries to Empa without having to go through the whole rigmarole of finding the "right" contact person first.

From researcher to entrepreneur

Economically speaking, spin-offs, i.e. new companies founded at Switzerland's universities and research institutes, are crucial. Empa helps its fledgling companies in the early stages by offering coaching, specialist advice, administrative support and infrastructure: Empa has been running the business incubator glaTec at its headquarters in Dübendorf for the last five years and is involved in Eastern Switzerland's STARTFELD initiative with its technology center

>>

Research Cooperation

With at least 100 new research projects every year, this is the most frequent form of cooperation with partners from industry. One example is the aerogel insulating plaster developed with the Fixit AG, a building materials company. This plaster combines the insulating properties of polystyrene (or styrofoam) with the easy application and water permeability of conventional mineral plaster. It is, therefore, particularly well suited for the energy refurbishment of historic buildings. The project was sponsored by the Commission for Technology and Innovation (CTI). After research spanning roughly two years, the insulating plaster was launched on the market in early 2013. In January 2014 the product won the Swiss Environment Award.

tebo in St. Gallen. The sale of the Tagblatt newspaper building right on Empa's doorsteps has opened up fresh prospects at the site: spearheaded by tebo, a technology park is currently under construction on the premises, where the idea is for companies that match Empa's competence profile to settle and create new possibilities for collaborative projects.

Expert knowledge for the real world

Together with partners from industry and research, Empa is constructing a Coating Competence Center aimed at offering training in the field of coating technologies and "handing over" the latest research results from the lab to industrial partners as quickly and directly as possible so that they can turn them into innovative products.

Finally, with its wide range of courses and information events, the Empa Academy provides a lively platform for knowledge transfer and an open dialog with experts from science, industry, public authorities and politics and, last but not least, for the interested public. Around 5,000 participants flocked to roughly 90 Academy events last year.

"Key to Switzerland's innovative success"

Empa's tech transfer activities do not go unnoticed; during one of his recent visits Federal Councilor Johann Schneider-Ammann, Head of the Federal Department of Economic Affairs, Education and Research, confirmed that Empa is on the right track: "As an entrepreneur, I have often looked to collaborate with Empa, having realized what extraordinary achievements the researchers record there. For me, Empa is the beating heart of Switzerland's knowledge and technology transfer network and a linchpin of our innovative success." //

The ABC

Strategic Cooperation

In select areas Empa enters into strategic partnerships with long-standing research partners, for instance in April 2010 with the company Hexis AG. The goal is to establish the solid oxide fuel cell (SOFC) on the market as a sustainable alternative to the overall energy supply of buildings. Partnerships of this kind extend beyond individual projects. The search is on for new project ideas, access to funding agencies in Switzerland and the EU, and broad interdisciplinary cooperation.

# of technology transfer

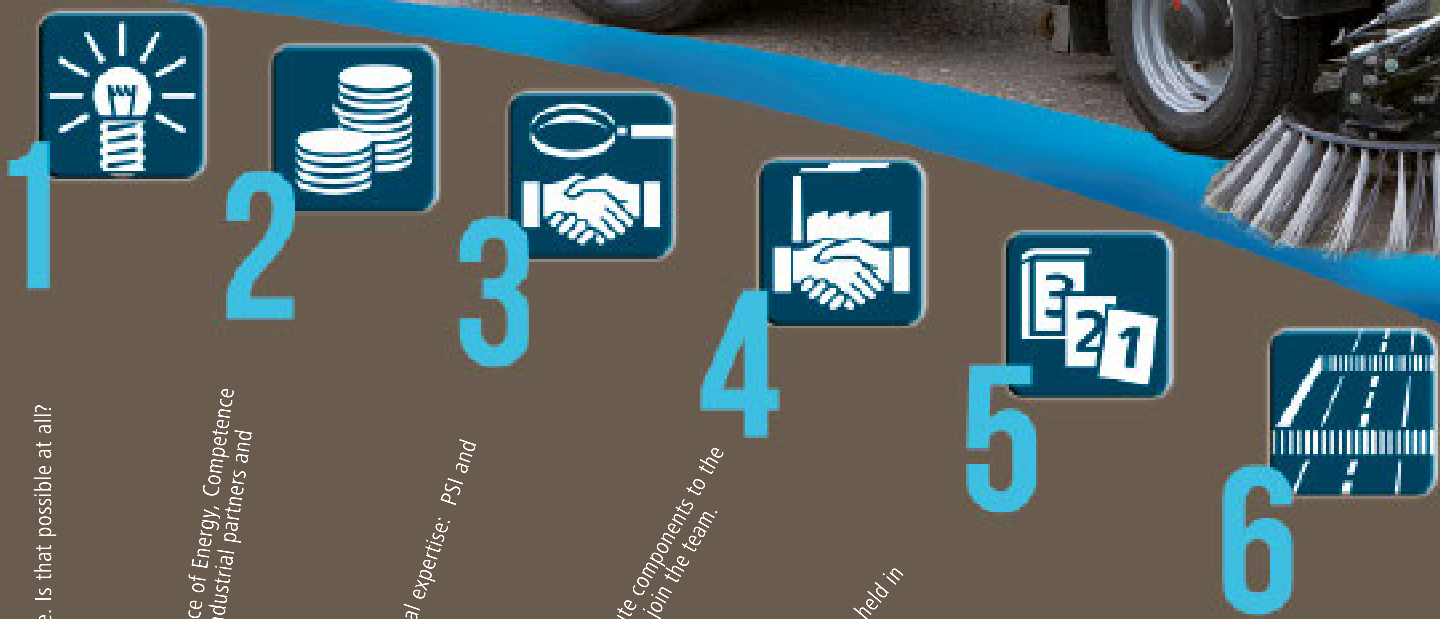
Technology Offers

Patents frequently emerge from research projects, which Empa then offers to industry partners for licensing. Two examples:

– Wood combustion produces large volumes of fine particles. Empa has developed an electrostatic particle separator that can be retrofitted to small wood-burning units like fireplaces. It captures up to 90 percent of fine particles. The German manufacturer Kutzner + Weber distributes the system under the brand name "Zumikron".

– Empa engine experts have come up with a novel hydraulic valve control that requires no camshafts or valve springs. The valves are, therefore, lighter and their kinetic energy is not converted into heat but recuperated. This reduces fuel consumption. The patent is currently available for licensing.

The latest offers can be accessed on www.empa.ch/technologieangebote
Further information: +41 58 765 4444, portal@empa.ch



1. Idea A municipal utility vehicle with a hydrogen fuel cell drive. Is that possible at all?

2. Funding Contractual negotiations with the Swiss Federal Office of Energy, Competence Centre for Energy and Mobility of the ETH Domain (CCEM), various industrial partners and potential pilot regions.

3. Research partners Empa draws together internal and external expertise: PSI and the CCEM competence center are now on board, too.

4. Industrial partners Who is interested and in a position to contribute components to the pilot vehicle? Bucher-Schörling, BRUSA Elektronik AG and Messer Schweiz AG join the team.

5. Time Research requires patience: The first exploratory talks about hy.muve were held in 2007. The vehicle was rolled out in 2009. It is now in its fifth year of test operation.

6. "Playground" A prototype is sensitive and not immediately viable. The municipal utilities in Basel had the space, competence and patience for the first six months of technical fine-tuning. They were followed by St. Gallen, Bern and Geneva, each for three months.

7. Optimization cycles hy.muve is constantly being technically refined and retrofitted with the help experience from practical operation is taken on board.

8. Market survey Visitors from several European cities inspect the prototype

9. Product development Based on hy.muve's technolo An eco-powered street sweeper tailored to customer

10. Marketable product ye

The road to success

It's a long haul from an idea to a marketable product. Longer than many people may think. Empa has experience in pushing this kind of pioneering technological project through. Care about an example? The fuel cell–powered street sweeper "hy.muve" nicely illustrates the key ingredients to success.

Springboard for neo-entrepreneurs

Optotune products are manufactured in the cleanroom (top). High-precision optical devices are essential for the development work.

Empa's business incubator glaTec has already helped a number of young companies to sprout wings and go it on their own. One of these is Optotune. A spin-off from ETH Zurich, the team joined Empa in 2008 and, after an incubation period of nearly three years, ventured the leap onto the free market – successfully, as we can see today.

TEXT: Cornelia Zogg / PICTURES: Optotune

Optotune CEO Manuel Aschwanden took advantage of Empa's infrastructure from 2008 to 2010.

Over 30 employees currently work at Optotune's "new" headquarters in Dietikon in the outskirts of Zurich. Since leaving glaTec, the company has not stopped growing and has made a name for itself on the market. It all began with a project funded by the Commission for Technology and Innovation (CTI) aimed at developing a flexible lens with a focal length that could be altered electrically in a matter of milliseconds. Initially, the team headed by Manuel Aschwanden, an ETH Zurich physicist fresh from his doctorate, set their sights on applica-tions for cell phones, cameras, scanners and lighting systems. From 2008 to 2010 the start-up took advantage of Empa's infrastructure. "Empa was a huge help. Its infrastructure is outstanding and the staff are very helpful," says Aschwanden. As Empa's own lab equipment was not always available and speed is crucial in industry, for instance, Optotune was often given priority.

Getting rid of the start-up label

Optotune has been in Dietikon for almost four years now. The time eventually came to leave the Empa nest when things started to get cramped as many other start-ups began to squeeze into glaTec. For the successful fledglings, it was high time they ventured out "into the big, wide world" – and not a moment too soon, either, as it transpired: a start-up should shed its image as quickly as possible if it wants to compete on the market. According to Aschwanden, customers were often hesitant as a start-up label is always associated with a certain degree of risk. Nevertheless, "it was the right decision to join Empa," the founder confirms.

The secret to success? It's the team, stupid

Meanwhile, the company has ballooned to over 30 employees – twice as many as when it left Empa four years ago. All the technical "glitches" have been ironed out – the lenses work as intended and the interest from indus-try is tremendous, as Aschwanden explains. However, the young entrepreneur has never forgotten one of the principles from the Empa days: the right team and the right partners are the key to setting up a successful com-pany. And this includes Empa with its business incubator.

Aschwanden also took another lesson to heart that does not solely apply to start-ups: "Everything takes twice as long as planned." For Optotune, the plan ultimately proved successful; business is flourishing. And other young companies that were given the opportunity to receive a kick-start from glaTec are about to "spread their wings", too. Nonetheless, Mario Jenni, glaTec's Managing Director, is confident that the coveted facilities at Empa will not stay empty for long: "The demand is huge – and unfortunately our space limited." //

glaTec

glaTec is a support organization backed by Empa, Eawag, the City of Dübendorf, the regional association glow.das Glatttal, the City of Zurich and Canton of Zurich's Business and Economic Development Division. Empa's business incubator currently hosts twelve young companies, which not only benefit from the facilities on campus, but also the contact with other researchers, help with market surveys and coaching. More information at *www.glatec.ch*

Knowledge hub

The Empa Academy, the institute's platform for knowledge transfer and public dialog, is turning 15. What can the Academy offer? What does the future hold? An interview with Academy Director Anja Pauling.

INTERVIEW: Rainer Klose / PICTURE: Empa

Ms. Pauling, the Empa Academy is supposed to disseminate the knowledge garnered here at Empa. How do you achieve this?

A central element is the academy building on the Dübendorf campus with its flexible event rooms and state-of-the-art infrastructure. This is where the majority of our meetings, conferences, courses and public events take place. It also provides space for exhibitions, which is being used frequently in the scientific arena, but also in the exchange with industry. This enables us to live up to our role as a "center for knowledge transfer".

You offer courses and other training events for science, industry and society. Where do the ideas for them come from? Is the Empa Academy also open to external input? Which wishes can be fulfilled?

The Empa Academy is a service for and by the scientists who work at Empa. Consequently, the topics are rooted in Empa's research areas, but absolutely from outside, too. If topics are "hot" or controversial – such as nano-technology or alternative energies at the moment – they surely will figure on our planning. However, new contents for courses also often spring from our events. We distribute questionnaires among our participants and fre-quently happen upon fresh themes.

The Academy is also responsible for bringing Empa scientists into contact with industrial partners. How do you go about this?

Empa is known for its applications-oriented research and collaborates intensively with external partners, espe-cially from industry. What many people don't know: our range of topics is vast. For instance Empa investigates water-resistant wood, new materials for wound healing or cutter blades made of ceramics and much more. Some-times not even all the companies involved in these very fields are aware of this. And that's where the Academy comes in: organizing suitable events for the exchange with industry such as the newly established series of "Technology Briefings".

Can people still use the Empa Academy even if they don't have much to do with materials science?

Actually, we have also been renting out the Academy to externals for a while now. This is particularly interest-ing for companies or associations that are involved in similar fields to Empa as we can "enrich" their events with lab visits, tours or talks, which always goes down really well. And the Dübendorf campus is easily reachable by plane, train, tram or car, too.

You have been heading the Academy since last fall. What are your plans? What programs and activities can we expect in the future?

Next year, the Empa Academy is celebrating its 15th anniversary. My predecessor, Anne Satir, put together a top-class program over the years. I intend to build on this and take it to the next level. I am currently hatching a couple of new ideas concerning event forms or the use of the premises in Dübendorf and St. Gallen to make Empa's activities even more visible. The realization of the lighthouse project NEST will enable us to expand our possibilities noticeably as we will also have seminar rooms in NEST – right next door to the Academy – that will be available to the public. I'm really looking forward to watching the Empa Academy develop further and hope that many EmpaNews readers will find their way to our events.

The Empa Academy's current program is available at www.empa-akademie.ch

1

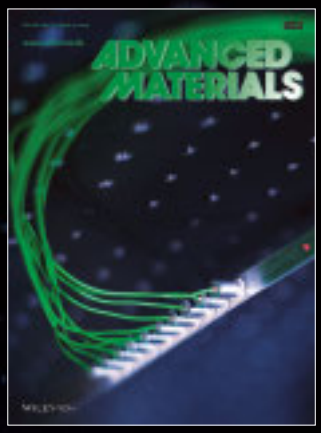
A sheet metal that never

Researchers from Empa and ETH Zurich have succeeded in producing a prototype of a vibration-damping material that could change the world of mechanics forever. The material of the future is not only able to damp vibrations completely; it can also specifically conduct certain frequencies further.

TEXT: Rainer Klose / PICTURES: Empa

1
Physicist Andrea Bergamini, who conducts research at Empa and ETH Zurich, holding the functional model of a "programmable material".

2
The cover of the international journal Advanced Materials from March 5, 2014, featuring Bergamini's invention.



2

rattles

Although the "programmable material" still only works in a one-dimensional model construction, it has already demonstrated it unusual capabilities: The research project entitled Phononic Crystal with Adaptive Connectivity has just been published in the journal Advanced Materials (www.advmat.de). The first step towards mechanical components with freely programmable properties has thus been achieved.

The working model used by the researchers consists of a one-meter by one-centimeter aluminum plate that is one millimeter thick. This sheet-metal strip can vibrate at different frequencies. In order to control the wave propagation, ten small aluminum cylinders (7 mm thick, 1 cm high) are attached to the metal. Between the sheet and the cylinders sit piezo discs, which can be stimulated electronically and change their thickness in a flash. This ultimately enables the team headed by project supervisor Andrea Bergamini to control exactly whether and how waves are allowed to propagate in the sheet-metal strip. The aluminum strip thus turns into a so-called adaptive phononic crystal – a material with adaptable properties.

Adaptation in fractions of a second

The piezo controls can now be set in such a way that waves are able to propagate through the sheet-metal strip "perfectly normally", i.e. as though no aluminum cylinders were attached to it. Another configuration enables a certain frequency spectrum of the waves to be absorbed. And this muffling is variable as the piezo elements can alter their elastic properties electronically in fractions of a second – from low to high stiffness. Bergamini explains what could develop from the research results: "Imagine you produce a sheet of metal, imprinted with an electronic circuit and small piezo elements at regular intervals. This sheet metal could be programmed electronically to block a certain vibration frequency. The interesting thing is that even if you cut off part of the sheet, the waves in the cropped section would largely spread in the same way as in the initial piece." This method could be used on three-dimensional components.

Such a "metamaterial" could fundamentally revolutionize mechanical engineering and plant construction. Until now, the vibration properties were already determined in the selection of material and the geometry of the part. In future, the material could react to current vibration readings and adapt its vibration properties at lightning speed.

Further research on "programmable materials"

During the Phononic Crystal with Adaptive Connectivity research project, Empa-researcher Bergamini collaborated with Paolo Ermanni's group at ETH Zurich and Massimo Ruzzene from Georgia Institute of Technology. In a follow-up project, the programmability of the prototype is to be expanded: "Until now, every piezo element has reacted to vibrations alone, independent of its neighbor," explains Bergamini. "As the next step, we want to interconnect the elements with each other to be able to control them jointly or in a coordinated fashion." //

CLEVER saving while driving

One of the world's first natural gas hybrid test vehicles made its maiden voyage at Empa. Two years later, Empa researchers now have the facts and figures to confirm the potential of the innovative concept: the combination of gas and electricity is worth it – both for the environment and the car owner's wallet. A glimpse into the power train engineering of the coming decade.

TEXT: Antonia Fischer / PICTURE: Empa

Video
Testfahrt: So funktioniert der CLEVER

http://www.youtube.com/watch?v=7L4NSldiSXI

Two years ago, the natural gas hybrid CLEVER rolled out of the garage on its maiden voyage. Since then, the one-off vehicle has repeatedly showcased its abilities on test drives and roller dynamometers.

In a six-year project in close collaboration with two institutes from ETH Zurich and industrial partners Volkswagen and Bosch, a team of researchers from Empa's Laboratory for Internal Combustion Engines developed CLEVER, a natural gas hybrid car, which runs on an electric and a natural gas engine. CLEVER uses its different energy sources in the most efficient way for the driving situation at hand – which gives it the edge over conventional natural gas vehicles.

With CLEVER, the scientists and engineers have built a hands-on model that can be test-driven. "Empa is the link between purely academic research and industry. Here we show what could also have been demonstrated with a computer simulation on a real car, which also enables its drivability and similar practical factors to be gauged," says project leader Patrik Soltic.

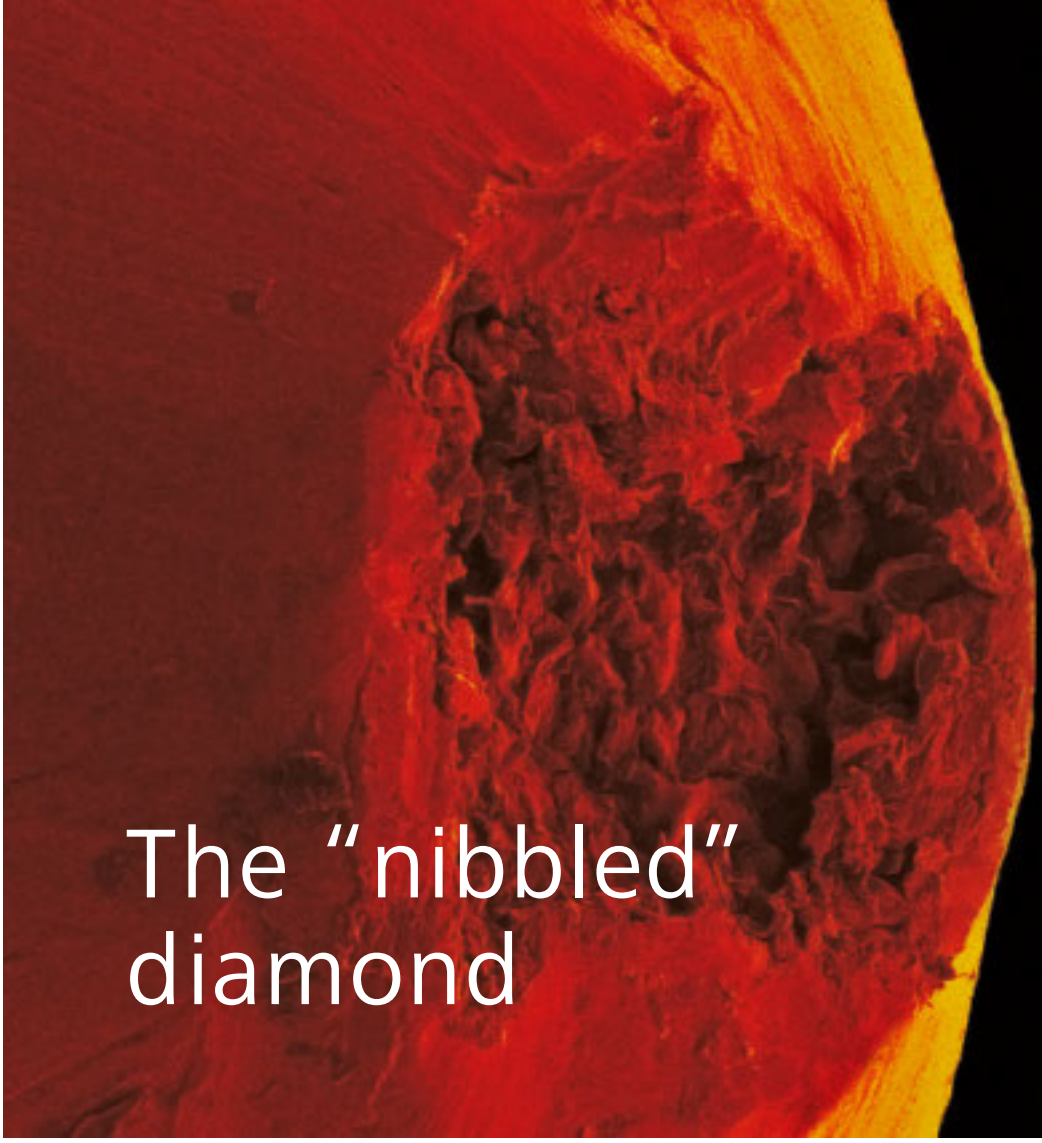
Same price tag – better for the environment

The maiden voyage took place in 2012. Since the rollout, CLEVER's drive engineering has demonstrated its functionality for over 2,000 kilometers at various test rigs and courses. The combination of a natural gas and an electric engine is worth it, the project reveals. Although a mid-range vehicle with a natural gas hybrid drive of the CLEVER type would cost around ten to 20 percent more than a gasoline-powered car, the operating costs throughout its service life would not be any more expensive due to its low consumption and cheaper fuel. What's more, it would emit up to 40 percent less CO_2. And if biogas is added to the natural gas, CO_2 emissions will drop even further. "These figures are especially exciting for companies that operate fleets," says Soltic.

With the new exhaust gas limits, the pressure on companies to curb CO_2 emissions is set to increase even further as of 2015. And for 2020 the EU has decided to slash the permitted CO_2 level by another 30 percent. "A current stat-of-the-art mid-range natural gas vehicle would no longer fulfill this requirement," says Soltic. Whether and when there will actually be natural gas hybrids for sale, however, depends on the strategies of the automobile industry. "We can't say for sure. In light of the increasingly strict CO_2 regulations in future I assume, however, that such hybrid concepts will gain popularity after 2020."

Green gas from surplus electricity

A natural gas hybrid would be especially environmentally friendly if it ran on renewable energies. "The renewable energy sector such as solar power is bound to expand massively in Switzerland," says Soltic. There will be times, such as in summertime, where so much electricity is produced that it cannot be stored at all (or insufficiently at the very least). The answer: the power-to-gas concept. Green surplus electricity can be used to split water to produce hydrogen and, in an additional step adding CO_2, methane. This "green" gas can then simply be bottled or fed into the gas network to power vehicles like CLEVER. Empa is currently working on a demonstration platform called "Future Mobility", which uses this new concept and tests it in everyday operations. //



The “nibbled” diamond

Building on enzymes

Empa researchers want to manufacture additives for building materials from renewable resources. In future, (waste) materials “refined” by enzymes are to do the job. Textiles and cleaning agents could likewise become less resource-consuming and more environmentally-friendly thanks to new biotechnological methods.

TEXT: Antonia Fischer / PICTURE: Empa

Even if large volumes of crude oil don’t flow into the sea like after a major spill, “black gold” is neither environmentally friendly nor sustainable. Extraction, transport and processing pollute air and water. What’s more, because of our huge appetite for energy and feedstocks, new deposits have to be constantly exploited. But there is only a limited amount of crude oil. Nonetheless, it is used today as the basis for the production of detergents, synthetic textiles, paints, foils and numerous other articles of daily use. The construction industry also places its bets on crude oil-based substances. Concrete plasticizers are frequently manufactured on a crude oil base. Without plasticizers concrete would be rigid and far larger volumes of water would have to be admixed. This, in turn, could be detrimental to concrete strength. Thanks to additives less water can be used whilst retaining the same degree of strength and ease of use.

“But the construction industry is on the look-out for solutions that build on cheap renewable resources”, says Michael Richter, a biocatalysis expert in Empa’s Laboratory for Biomaterials. Richter’s team is working on a project that aims to modify materials through enzymes and equip them with specific properties. The technical jargon for this is “functionalization”. Lignin, a by-product from paper production, is one such material (renewable resource). A project

What looks like a crater on Mars is, in fact, a damaged diamond viewed through an electron microscope. This "failed" experiment got as far as the title page of the journal "AIP, Review of Scientific Instruments", a mark of distinction for the researchers.

The valuable gemstone was the victim of a hardness test in a nanoindenter. This machine presses a tip made of diamond into hard materials in order to measure the penetration depth and, by extension, the degree of the material's hardness. Up to 400 degrees Celsius this can be done without any problem in air – the diamond won't oxidize. In a high vacuum (one billionth of normal air pressure) it even withstands up to 700 degrees. But caution: the hardest material in the world can no longer resist every opponent.

The diamond with the "frontal damage" lost its shape when it came into contact with an ordinary steel sample at 500 degrees. The carbon crystal – that's what a diamond really is – reacted chemically with the steel and formed iron carbide (Fe_3C). The far softer steel sample had actually "bitten off" a piece of the diamond.

Jeff Wheeler and Johann Michler, both Empa researchers in Thun, established what had gone wrong with this hardness test. They published their analysis in the journal "AIP, Review of Scientific Instruments" where it was immediately selected as the title story. Wheeler and Michler advise their colleagues to only undertake mechanical high temperature tests with materials that can "stand" each other. Steel, for instance, only likes opposing bodies made of wolfram carbide. This substance is hard but cheap. It is to be found in the tip of a hammer drill; chemically speaking almost nothing can upset it. But with the "wrong" combination nothing much is left after the first hot kiss, as the diamond example goes to show. //

http://scitation.aip.org/content/aip/journal/rsi/84/10

J.M. Wheeler and J. Michler (2013) Indenter materials for high-temperature nanoindentation, Rev. Sci. Instrum. 84, 10130

funded by the Commission for Technology and Innovation (CTI) aims to develop enzymatic processes to implement these very modifications. The goal is to produce effective concrete additives using enzymatic processes from sustainable sources and to replace crude oil-based additives. For concrete production this would mean for instance the admixture of cement, gravel, sand and water as well as a rather small amount of functionalized lignin. The mixture containing little water would then be almost as liquid as honey and easy to work with.

Enzymes are biocatalysts in metabolic processes. They catalyze reactions under physiological conditions in all living beings. The enzymes used to modify lignin naturally occur in bacteria and fungi. In the case of the latter they play an important role in nature in the constitution and decay of wood, which mainly consists of lignin. "Empa has a great deal of experience with wood and wood-decaying enzymes", says Richter. That's why the Laboratory for Applied Wood Materials as well as the one for Functional Polymers are involved in the project as well. Industrial project partner Sika Technology, a manufacturer of chemical building products, provides the practical expertise for the project.

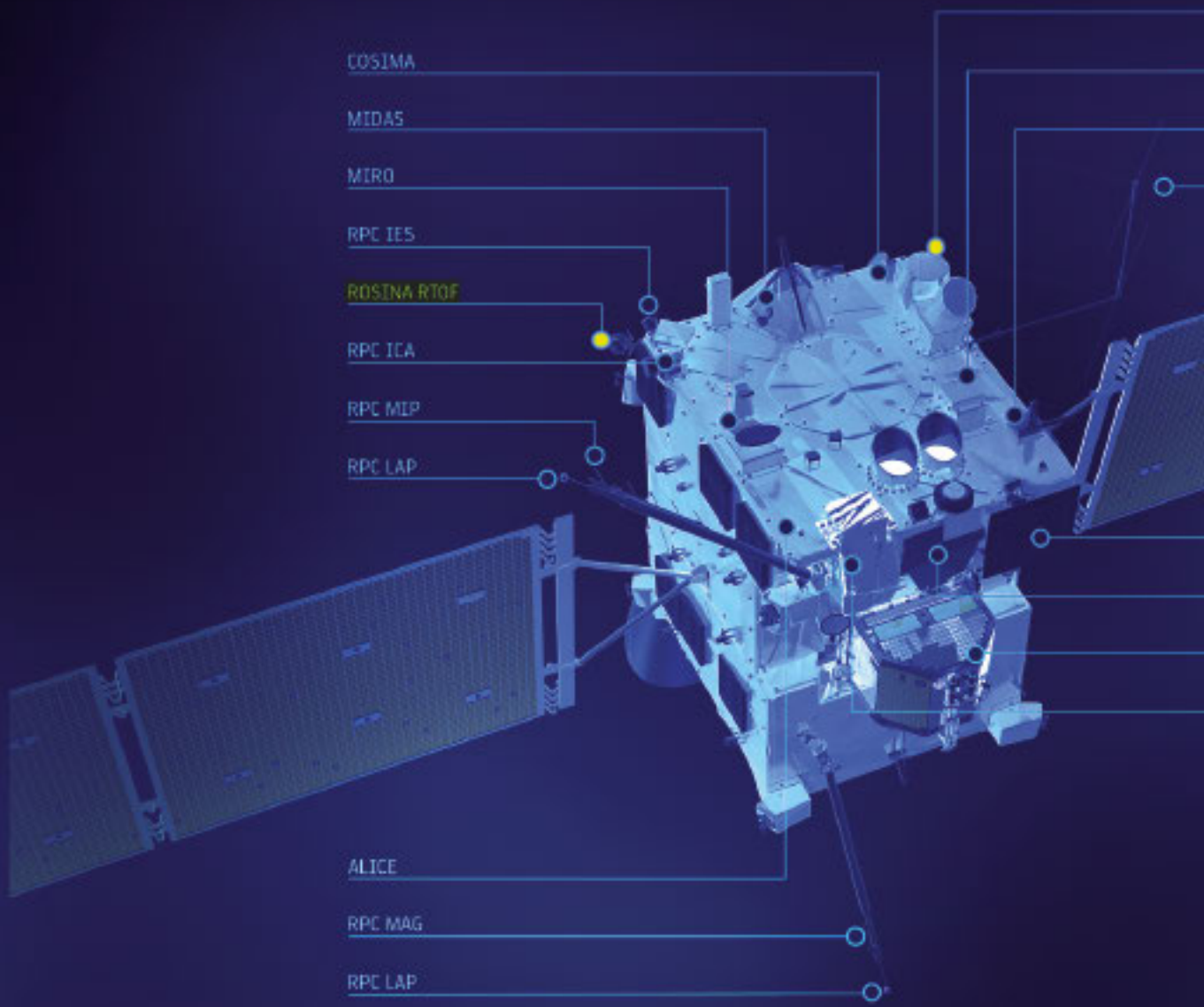
The production process for concrete additives developed by Empa is part of a larger alliance on polymer functionalization launched a year ago by four research institutes and five companies. It is coordinated by evocatal GmbH (Germany). Functionalized materials are also to be used in the textile industry and in the development of cleaning agents. In all cases the objective is to secure access to new, resource-saving processes: detergents are to function at lower temperatures thanks to the addition of enzymes and to be biodegradable. Textiles are to be more readily modifiable thanks to enzymes and suitable for longer wear.

The enzymatic functionalization of polymers is uncharted territory compared to other enzyme applications like in the food or pharmaceutical industry. "Very few others have embarked on the scale of research that Empa and its partners are now engaged in", says Richter. "In some instances, we are pursuing completely new approaches with enormous economic – and ecological – potential."

But enzymes are real all-rounders. Besides the "concrete project", the Empa biocatalysis group is also looking at biosensors based on immobilized proteins and novel wound dressings for the monitoring of wound-healing processes. "Enzymes lend themselves to highly diverse innovative solutions", comments Richter. "The added value in our case stems from the combination of materials and biology." //

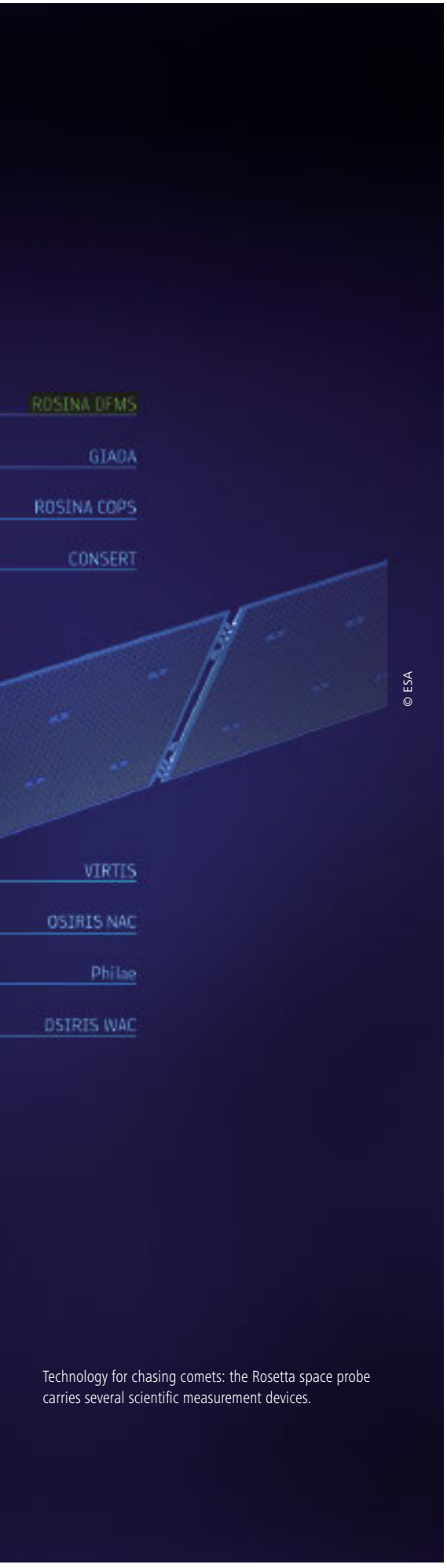
Chasing comets

For ten years now the space probe "Rosetta" has been hurtling towards its destination: the comet 67/Churyumov-Gerasimenko. On board sophisticated Empa metal-ceramic sensors have been integrated into two mass spectrometers, which go by the names of ROSINA RTOF and ROSINA DFMS. They are currently gearing up for their assignment of analyzing ions and gas particles in the comet's "atmosphere". The decisive moment is approaching fast: in May the critical approach maneuver will begin – the probe enters the comet's orbit. Once that step is completed, it will follow the comet for two years and collect data that will not only supply information about the comet itself but could also provide some insight into the origin of life on our planet. More about Rosetta's journey in the autumn issue of EmpaNews!



Animation
The ten-year journey of the Rosetta probe through our solar system

http://sci.esa.int/rosetta/52838-twelve-year-journey-in-space/



Technology for chasing comets: the Rosetta space probe carries several scientific measurement devices.

Mercury: energy-saving bulbs given green light

Empa has been investigating how much mercury energy-saving bulbs contain and whether manufacturers actually comply with the corresponding legal requirements. Of the 75 commercially available bulbs tested, every single one met the mercury-level requirements. What is new: while only the bound mercury in energy-saving bulbs was previously measured, Empa has now devised a method to gauge the gaseous – and considerably more dangerous – mercury in these bulbs. The technique involves dipping the bulb in a solution of potassium permanganate and opening the glass body with a tool. As there is negative pressure in the glass body, the potassium permanganate solution shoots in and binds all the mercury.

Empa and NIMS publish open-access journal

In January 2014 Empa and Japan's National Institute for Materials Science (NIMS) signed a five-year agreement for the publication of the open-access journal Science and Technology of Advanced Materials (STAM). As the first step, Empa opened a STAM editorial office in Switzerland, which acts as the European hub for the journal. STAM focuses on classic materials science topics and will increasingly tackle themes such as medical and bio-engineering applications thanks to the collaboration with Empa. Articles from Europe and the US should boost the journal's reputation and global reach even further. The journal can be accessed via the British Institute of Physics Publishing's open-access platform.

Environmental award for high-performance insulating plaster

Empa's mineral insulating plaster is fire-resistant.

Empa and Fixit AG won the Swiss Environmental Prize in the Innovation category, beating 75 other nominees to the award. In a four-year project, Empa researchers and Fixit product developers devised a high-performance in-sulating plaster and launched it on the market. Thanks to the development, it is now possible to insulate histori-cal buildings optimally from both an energetic and material-compliant perspective while retaining their external appearance. Within the scope of the research project, a rendering system with outstanding thermal properties was developed based on nanoporous aerogel. Since the insulating plaster was launched on the Swiss market in early 2013, over 5,000 m2 of wall in 35 buildings has been insulated with the novel product.

Swiss NanoConvention 2014

21 / 22 May 2014
Brugg Windisch

www.swissnanoconvention.ch/2014

swiss nano convention

Partners

Events
(in German)

28. April 2014

Chronische Wundbehandlung heute und morgen
Zielpublikum: Wissenschaft, Industrie, Kliniken
www.empa.ch/tbwund
Empa, St. Gallen

5. – 6. Mai 2014

C-A-S-H Workshop (Calcium Silicate Hydrates Containing Aluminium)
Zielpublikum: Industrie und Wissenschaft
www.empa.ch/cash
Empa, Dübendorf

8. Mai 2014

Neue Trends in der Flammschutzforschung
Zielpublikum: Industrie und COST-Mitglieder
www.empa.ch/flamat_deu
Empa, Dübendorf

22. Mai 2014

Empa-FSRM-Kurs: Die Welt der Stähle
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