Empa Quarterly

RESEARCH & INNOVATION II #73 II OCTOBER 2021

FOCUS

BUILDING SMARTER

EXPERIMENTAL HEAT STORAGE
GENTLER CANCER TREATMENT
TOXIC TRACES IN A NATIONAL PARK

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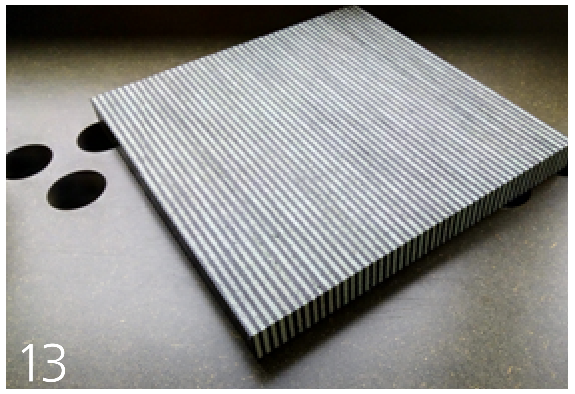
[FOCUS: BUILDING SMARTER]



Photos: Schweizerischer Nationalpark, Roman Keller, Nicolas Zonvi, Hochuli advanced, Wikimedia/ Extreme CCTV

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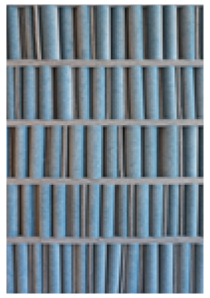

Old carpets as acoustic insulation material for partition walls of offices? It works! And it looks good. NEST's Sprint unit sets new standards for sustainable construction – and was built in just ten months (page 19).
Image: Martin Zeller

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myclimate.org/01-21-387731

[IMPRINT]

PUBLISHER Empa
Überlandstrasse 129
8600 Dübendorf,Schweiz
www.empa.ch
EDITORIAL Empa Kommunikation
LAYOUT PAUL AND CAT.
www.paul-and-cat.com
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ISSN 2297-7414
Empa Quarterly (English edition)

THINKING OUTSIDE OF THE BOX

Dear Reader,

If you know your material, you can make the most amazing things out of it: an adhesive from cellulose to restore old works of art, a cancer treatment with fewer side effects from metal oxides, or a low-cost thermal imaging camera from ultra-thin multi-layer coatings.

All these are clever ideas, developed in one of the 30+ Empa labs, which have one thing in common: Their inventors dared to venture outside their own disciplines and joined forces with colleagues with entirely different backgrounds. In short, they have thought outside the box – in the most literal sense. Because this is the only way to create something really new, i.e. what constitutes a true innovation at its (word) core.

Even if we "just" build, we try to gain insights for novel solutions. For instance, through an experimental borehole field as a sustainable seasonal heat storage system for the winter, which we are currently installing under our new laboratory building at a depth of around 100 meters (p. 22), or in the new NEST unit Sprint, which was created entirely from used and recycled materials (p. 19).

So much creativity often takes time, i.e. money. That is why we have decided to increasingly approach private donors. We will report regularly on how we use the funds we raise, starting with an article on a process for making concrete much more environmentally friendly (p. 24).

Enjoy reading and see you in the next issue!

Your MICHAEL HAGMANN

STICKY ART

Preserving historic wooden works of art for future generations is anything but trivial. The 19th century pyrography on a thin lime wood panel pictured here is completely broken apart; the thumbnail in the top left corner shows merely one half of the artifact. Researchers at Empa and the University of the Arts in Bern have developed a cellulose glue that joins the lime wood together in a stable and at the same time gentle way. This is because the wood-based adhesive does not damage the artwork and yet defies the often harsh environmental conditions of cultural assets in old castles or damp church cellars.

Information on the research project:
www.empa.ch/web/gei/wnb

Photo: Karolina Soppa, HKB

BIOTECH VIOLIN IS COMING HOME

A MUSICAL TREAT
Irina Pak from the Tonhalle Orchester Zurich played the Mycowood violin – with obvious enthusiasm.

PRECIOUS
Walter Fischli, president of the Walter Fischli Foundation (right), hands over a Mycowood violin to Empa researcher Francis Schwarze who invented the technology.

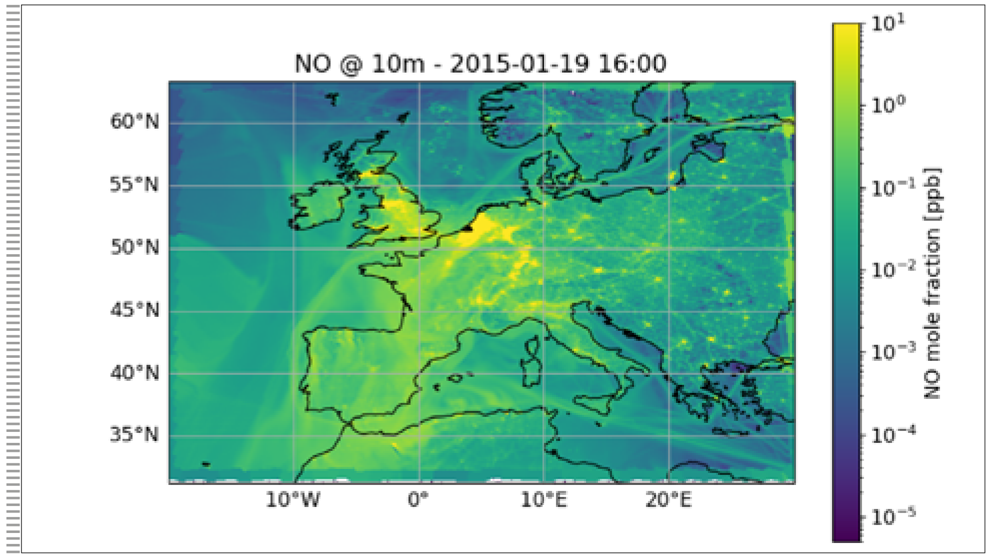
Walter Fischli, President of the Board of Trustees of the foundation of the same name in Allschwil (BL), recently handed over the "Caspar Hauser II" Mycowood violin to Empa representatives. The foundation supports a long-standing research project at Empa, in which biotech violins are being developed: With the help of a white rot fungus, the team led by Empa researcher Francis Schwarze has succeeded in developing a process, in which fungi break down wood cells in a very specific manner – and in the process changes the acoustic properties of the tonewood. In this way, the Empa scientists produced so-called Mycowood that gave the "Caspar Hauser II" its body. The instrument is an exact copy of a Guarneri master violin from 1724, and initial comparative acoustic analyses of the original and its biotech copy have already proved promising. Now the Mycowood instrument has been returned to its "birthplace". But only for a short time: In order for the "Caspar Hauser II" to develop a unique soul in addition to its extraordinary body, the instrument will be allowed to develop its sound through frequent performances in the coming years. To celebrate the handover, the virtuoso violinist Irina Pak from the Tonhalle Orchester Zurich played on the "Caspar Hauser II". The violinist elicited both contemporary sounds as well as baroque melodies from the time the original violin was built from the new violin.

www.empa.ch/web/s604/mycowood-violin

https://nph.onlinelibrary.wiley.com/doi/full/10.1002/ppp3.10097

Photos: Empa

BETTER CLIMATE MODELS THANKS TO SUPERCOMPUTERS

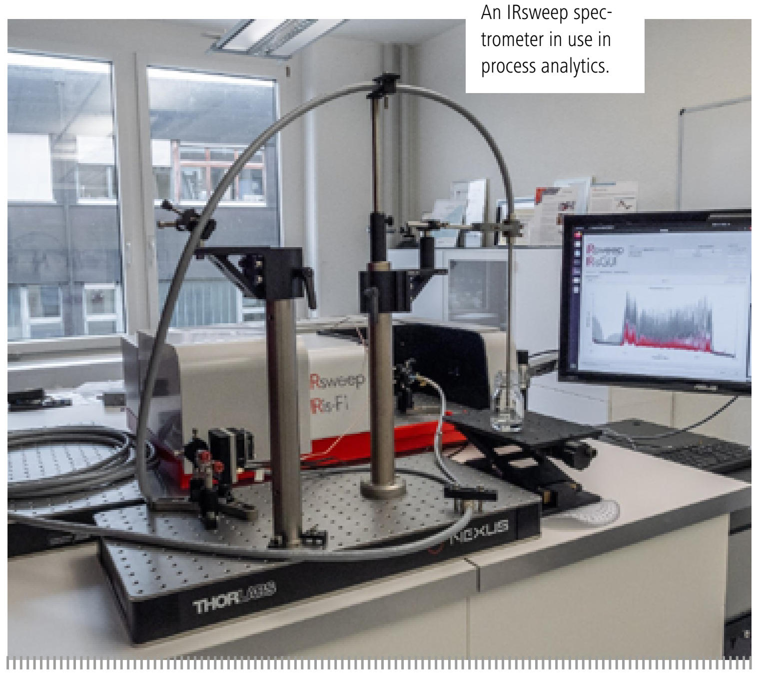


CALCULATED WITH ICON-ART
The map shows the distribution of nitrogen monoxide (NO) on 19 January 2015 at 4 pm. You can see cities and roads as an NO source. In the west, the distribution is smoother than in the east – due to chemical processes and because the sun has already set in the east.

Since July, the Swiss Platform for Advanced Scientific Computing has been funding a three-year project led by Empa researcher Dominik Brunner – on a major challenge for computational models: climate. Atmospheric processes with their interactions and consequences for global warming or air pollution have long since pushed conventional computers to their limits – and more powerful architectures into play. GPUs (Graphic Processing Units) with many processors calculate massively in parallel, but they require different programming. With the HAMAM project, the team aims to make two particularly computationally intensive extensions of the ICON weather and climate model fit for GPUs: the ART module for air quality simulations and HAM for the interactions between aerosols and climate. These models will be implemented and tested on the supercomputer Piz Daint at the Swiss National Supercomputing Center in Lugano.

www.empa.ch/web/s503/team-modelling

Photos: Empa, IRsweep AG



ON THE TRAIL OF FAST REACTIONS
An IRsweep spectrometer in use in process analytics.

SPIN-OFF ON THE ROAD TO SUCCESS

On track in just a few years: IRsweep was founded in 2014 – as a spin-off from Empa and ETH Zurich. In May, Sensirion, a manufacturer of digital microsensors and -systems, took over the young company with its eleven employees. Its laboratory spectrometers with frequency comb technology in the mid-infrared range are used in research and development to detect rapid chemical reactions in the shortest possible time. IRsweep instruments are already in use in Europe, North America and Asia. In the long run, this technology might be used to create low-cost sensors that can detect traces of gases in the environment, for instance.

https://irsweep.com/

GENTLER TUMOR TREATMENT

FIRE AND ICE
Empa researcher Lukas Gerken produces nanoparticles for cancer therapy using flame synthesis. To make the tiny metal particles visible, the electron microscope is cooled to freezing temperatures with liquid nitrogen.

Photo: Empa

Radiation therapy is one of the cornerstones of cancer therapy. However, some types of tumor respond little or hardly at all to radiation. If it were possible to make tumor cells more sensitive, treatment would be more effective and gentler. Empa researchers have now succeeded in using metal oxide nanoparticles as "radiosensitizers" – and in producing them on an industrial scale.

Text: Andrea Six

Today, various treatment methods are available for cancer that can complement each other. Radiation therapy is frequently used, and can be combined with surgery and chemotherapy, for example. Although treatment with ionizing radiation has been used in medicine for more than 100 years, even modern oncology is sometimes not satisfied with its effectiveness. The reason: Malignant tumors are not always sensitive enough to radiation. "If the sensitivity of the tumor cells could be increased, radiotherapy could be carried out more effectively and more gently," says Empa researcher Lukas Gerken.

In other words: A desired treatment outcome could be achieved with a lower dose of radiation than is currently the case, or particularly radiation-resistant tumors could finally become sensitive to radiation. The team led by Lukas Gerken and Inge Herrmann from the "Particles-Biology Interactions Laboratory" at Empa in St. Gallen and the "Nanoparticle Systems Engineering Laboratory" at ETH Zurich is therefore working with oncologists at the Cantonal Hospital in St. Gallen to find ways to sensitize tumor cells to radiation.

The researchers have set their sights on nanoparticles made of metal oxides that can act as so-called radiosensitizers. The team has now succeeded in producing these radiosensitizers in large quantities and analyzing their effect in more detail. The researchers recently published their results in the journal Chemistry of Materials.

CURED IN THE FIRE

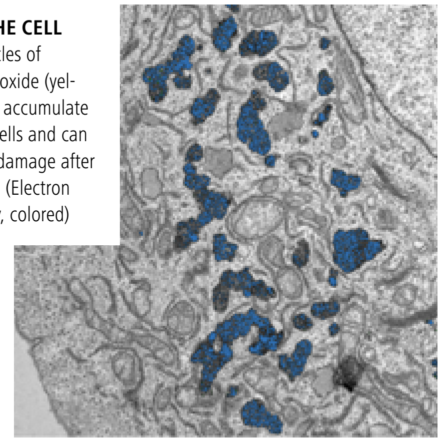
In cancer research, studies are currently underway with various classes of substances to make the irradiation of tumors more effective. Exactly how nanoparticles made of gold or more exotic metal oxides such as hafnium dioxide work in this context is not yet fully understood. What is known, though, is that a complex reaction cascade exerts oxidative stress in cancer cells. In this way, the repair mechanisms of the malignant cells may be overwhelmed.

In order for the nanoparticles to be made available for clinical use, two hurdles had to be overcome: Production via conventional wet chemistry methods makes it difficult to produce quantities on an industrial scale, and there is a lack of comparative analyses on the efficacy of different substances.

Empa researcher Gerken has now succeeded in producing metal oxide radiosensitizers using a method that is ideally suited to industrial applications: He relied on flame synthesis to obtain top-quality oxides of hafnium, zirconium and titanium. "Thanks to this production method, it is even possible – depending on the production facility – to synthesize several kilograms per day," explains Gerken. For the laboratory analyses at Empa, however, the scientist made do with just a few grams.

Photo: Empa

INSIDE THE CELL
Nanoparticles of hafnium dioxide (yellow-green) accumulate in cancer cells and can cause cell damage after irradiation. (Electron microscopy, colored)



BETTER THAN GOLD

Once the nanoparticles were available in suitable quantities, Lukas Gerken was able to screen the "gems" in detail, for example using X-ray spectroscopy and electron microscopy. His verdict: "We can produce sterile, high-quality metal oxide nanoparticles that appear harmless to healthy cells," the researcher explains. He proved this using cell cultures that he treated with different nanoparticle suspensions in the lab. The metal oxides accumulated in large quantities inside the cells. The front-runner was hafnium dioxide: Here, half a billion nanoparticles entered each individual cell without being toxic. Compared to the metal oxides, nanogold did much worse with the same particle size: About 10 to 30 times fewer gold particles made it into the cell.

As harmless as the substances initially are to healthy cells, they unfold their effects powerfully when used in radiation. The team was able to demonstrate this using cancer cell lines. If the cell cultures were treated with metal oxides and then bombarded with X-rays, the killing effect increased significantly. Hafnium dioxide turned out to be the most potent tool: Tumor cells treated with hafnium particles could be eliminated with less than half the radiation dose. This first comparative study also showed that hafnium dioxide is even four times more effective than nanogold and titanium dioxide. Healthy human cells (so-called fibroblasts), on the other hand, showed no negative radiation effects after nanoparticle treatment.

SHINY LITTLE HELPERS

The chemical element hafnium is named after the place it was discovered, Copenhagen (Hafnia in Latin). The chemist and Nobel Prize winner George de Hevesy and the physicist Dirk Coster were finally able to detect the element from the titanium group in 1923 by means of X-ray spectroscopy, after various scientists such as Nobel Prize winner Niels Bohr had long suspected its existence. Hafnium does not normally occur in the human body and is non-toxic. In oncology, it is hoped that hafnium will have a supporting effect in the treatment of cancer. First clinical trials have already been completed.

The results make Lukas Gerken confident: "We will continue on this path to explore the nanoparticles' mechanism of action and further optimize their efficiency." He hopes that his studies will thus advance the clinical application of nanoparticles in radiation therapy. ■

Further information on the topic is available at:
www.empa.ch/web/s403

SEEING THE WORLD THROUGH DIFFERENT EYES

Short-wave infrared light (SWIR) is useful for many things: It helps sort out damaged fruit and inspecting silicon chips, and it enables night vision devices with sharp images. But SWIR cameras have so far been based on expensive electronics. Researchers at Empa, EPFL, ETH Zurich and the University of Siena have now developed a SWIR screen consisting of just eight thin layers on a glass surface. This could make IR cameras useful everyday objects.

Text: Rainer Klose

FALSE COLORS
The world looks different in infrared: Landscape photos taken with a SWIR camera.

Photo: iStockfoto

Infrared (IR) light is invisible to humans. However, some animals, such as rattlesnakes or bloodsucking bats, can perceive IR radiation and use it to find food. But even for humans, the ability to see in the short-wave IR (SWIR) range would sometimes be useful. With the help of starlight alone, one could see quite sharply at night. Mechanics would be able to see the heat of a soldering tip at a glance. And fruit merchants could detect damaged produce even before the rotting process begins.

But IR light has a "problem": It is weaker than visible light and than UV light on the other side of the light spectrum. So while UV light makes white shirts and dancers' teeth glow blueish in a club – all it takes is a fluorescent dye in the laundry detergent – IR light is difficult to make visible for the human eye. This is because dyes can convert high-energy light directly into low-energy light, but not the other way around.

AN ENTIRE IR CAMERA ON A CHIP

So IR cameras require sophisticated electronics to capture IR light, an electronic amplifier, and finally a screen to display the artificially generated image. This is expensive. Today's standard SWIR cameras for industrial use cost around 7,000 Swiss francs.

Empa researchers Roland Hany, Karen Strassel, Wei-Hsu and Michael Bauer have now succeeded in capturing SWIR light – and making it visible – with a single component. The device developed at Empa is basically an OLED display with three additional layers (see graphic). IR light falls through an electrically conductive glass pane onto a dye layer in a photodetector. Therein, electrons begin to migrate, their motion being amplified by an electrical voltage. The electrical charges then migrate into the OLED layer, where they produce a green light spot. Electronic signal processing by a computer is not necessary: The incoming (invisible) SWIR light is amplified in an "analog" way, so to speak, and displayed directly on the screen. The color of the emitted visible light – blue, green, yellow or red – can be adjusted by selecting the dye in the OLED.

NIGHT VISION – AND SORTING BEANS

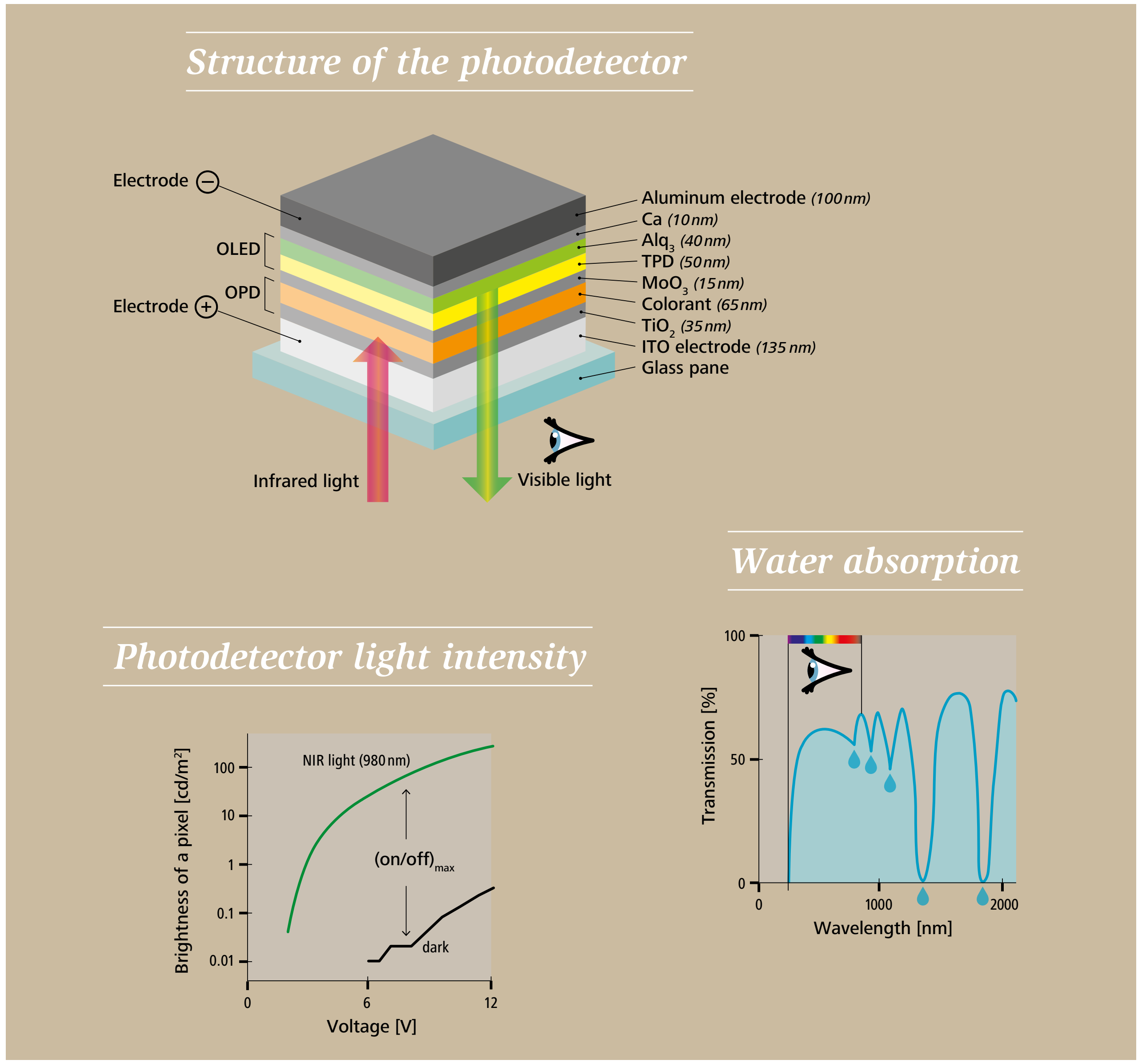
SWIR light is useful for many applications in the food industry, logistics or crafts. For example, one can visualize the temperature of soldering tips or monitor the cooling of newly manufactured jars and bottles. SWIR light makes moist objects appear darker, which is useful for sorting coffee beans or black olives: Stones and metal objects as impurities shine brightly among all the dark (moist) fruit on a conveyor belt.

The key to Roland Hany's SWIR screen is special dyes that he and his colleagues have been investigating for quite a while, so-called squaraines. The name comes from the basic structure of the chemical molecule, squaric acid. This class of dyes was first discovered in the 1960s and is characterized by deep colors and a high temperature stability. The researchers chemically modified the squaric acid so that it absorbs in the range of SWIR light. "Right now, we're working with dyes that absorb at just under 1000 nanometers," Hany says. "But we're already working on shifting the absorption to longer wavelengths, further into the IR range. If we succeed, our sensor will be able to detect water and moisture much better than it does now."

IN SEARCH OF AN INDUSTRIAL PARTNER

Hany likes to call the module he developed with his group OUC, or organic upconversion device. That's because it converts weak IR light into stronger, visible light ("upconversion") and works by using thin layers of dye made from carbon-based chemistry ("organic"). One problem is that the know-how to manufacture organic optoelectronic devices on an industrial scale is mainly located in Asia. Hany is confident, however, that his discovery will soon come to fruition: "Right now, we're working on increasing the sensitivity of the module and improving its long-term stability."

What can you do with such SWIR vision devices? A promotional film by camera manufacturer Sony shows it.
https://youtu.be/mS4EBbALAFM



Graphic: Empa

STRUCTURE OF THE PHOTODETECTOR

The Infrared (IR) photodetector resembles a sandwich of several layers. IR light is absorbed in the organic photodetector (OPD), creating electrical charges: electrons and holes. The electrons travel to the positive (and transparent) electrode (titanium dioxide, TiO_2/indium tin oxide, ITO); the holes travel through a transport layer (molybdenum oxide, MoO_3) into the organic light-emitting diode (OLED). There, they combine with electrons injected via the negative electrode (aluminum, Al/calcium, Ca). In the process, they emit visible light. Abbreviations: TBD = N,N'-Bis(3-methylphenyl)-N,N'-diphenylbenzidin; Alq3 = Tris(8-hydroxyquinolin)aluminium

PHOTODETECTOR LIGHT INTENSITY

A variable voltage is applied between the two electrodes. The higher the voltage, the more easily the charges generated by the IR light migrate into the OLED and recombine there, emitting visible light. The intensity of the visible light is expressed in units of candela per square meter (cd/m²). For high voltages – here between six and twelve volts – however, even in the absence of IR light ("dark"), a small leakage current already flows, which weakly emits visible light. To obtain the highest possible image contrast, the difference in the intensity of the emitted visible light with and without IR rays should be as large as possible: "$(on/off)_{max}$".

WATER ABSORPTION

Water does not absorb light in the visible range, so it is "colorless". However, it does have some prominent absorption bands between 760 nm and 2000 nm. If, for example, an apple is irradiated with IR light at 1450 nm, the water in the apple absorbs these IR rays, while the non-water components of the apple reflect the IR light. This makes, say, internal bruising of apples immediately visible as dark spots. It is thus easy to sort out damaged apples for a direct processing into apple juice.

Further information on the topic is available at:
www.empa.ch/web/s209

INSULATION FROM EMPTY BOTTLES

Insulation webs are essential in aluminum window profiles and facades for good thermal insulation. Empa researchers and their partners have been working for some time on a novel "sandwich" product with an environmentally friendly filling: recycled material from PET bottles. Now the market launch is approaching – with good prospects of success.

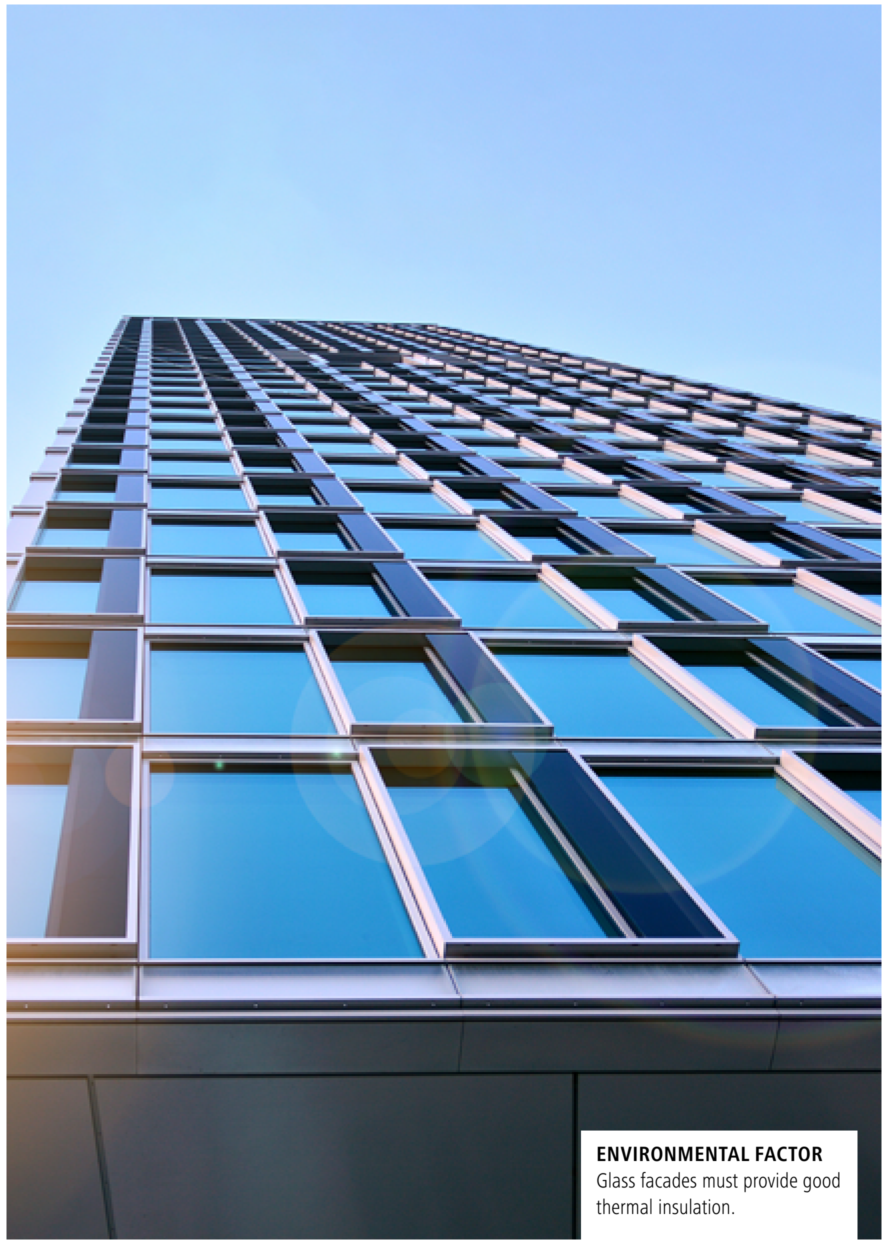
Text: Norbert Raabe

They are better hidden than screws, of which you can at least still see the heads. But they are just as ubiquitous: Insulation webs are stuck inside aluminum and metal profiles for windows and facade glazing – as thermal separators between the outside and inside, because otherwise cold or heat would flow unchecked through the metal frames. An inconspicuous component, then, that is becoming even more important with global warming and the need to reduce CO_2 emissions.

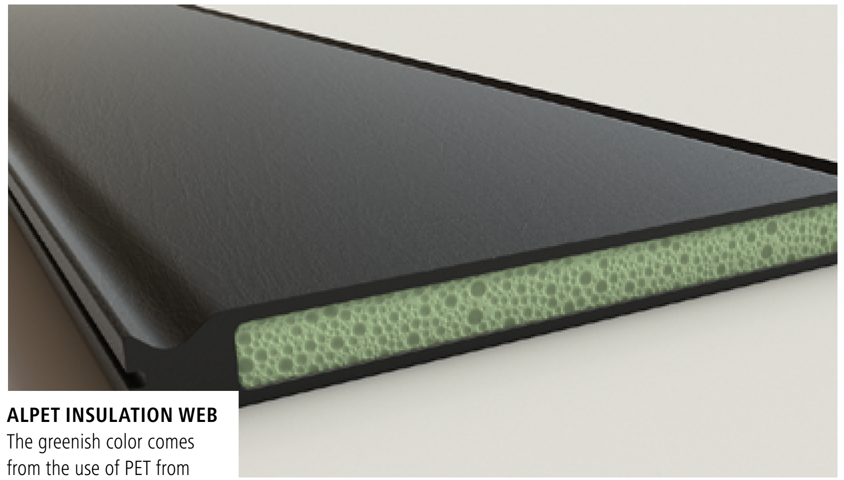
But although it has been established for more than four decades, the insulation web has potential for improvement. An Empa team led by Michel Barbezat and Giovanni Terrasi from the Mechanical Systems Engineering lab is working on a new type of product – together with experts from the metal construction company Hochuli in Wigoltingen, which has founded its own spin-off – hochuli advanced – to commercialize the new developments.

The highlight of the "Alpet" insulation web: Inside the glass-fiber-reinforced plastic is a foam strip made of polyethylene terephthalate – PET, in other words, from recycled bottles. Numer- ▶

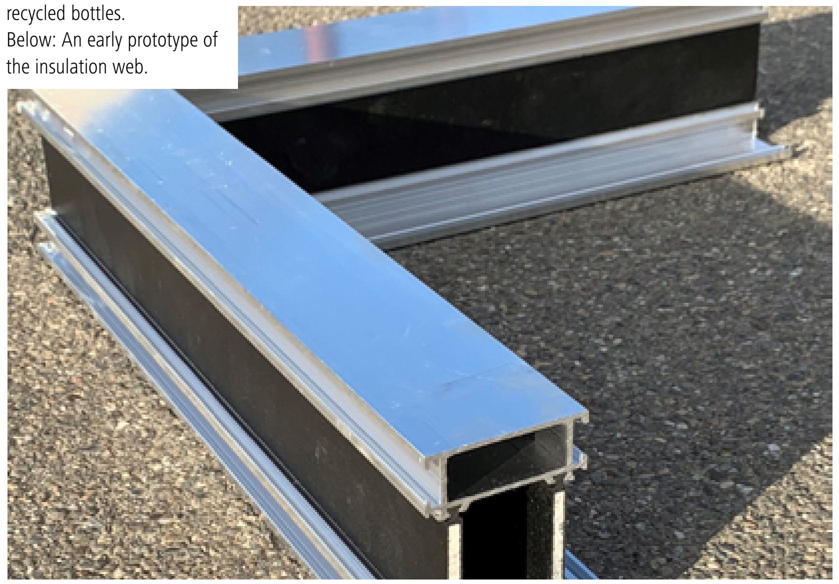
Photo: Shutterstock



ENVIRONMENTAL FACTOR
Glass facades must provide good thermal insulation.



ALPET INSULATION WEB
The greenish color comes from the use of PET from recycled bottles.
Below: An early prototype of the insulation web.



Photos: Hochuli advanced

THE STEPPED ISOSTRESS METHOD

How does a plastic component deform over a period of 30 or more years – under continuous load and large temperature differences? Common creep tests in the laboratory over 1,000 hours under combined thermal-mechanical loads do not allow any serious statements to be made. In order to be able to make long-term predictions, however, new methods have been developed and refined in recent years, including the Stepped Isostress Method (SSM), which Empa experts applied to the new insulating web. In simple terms, the deformations from numerous individual tests with increasing loads are added up to form a master curve that provides information about longer periods of time. This procedure can also be carried out with a single measurement performed with gradually increasing loads – which makes it easier to investigate critical temperature ranges at the same time.

ous air pores within this layer insulate efficiently: The thermal conductivity of the prototypes averages around 0.1 W/mK, depending on the web width – far less than a standard insulation web made of another polymer, polyamide (around 0.25 W/mK), and also significantly lower than high-end products available today.

FINE-TUNING MANY DETAILS

A simple approach, as it seems at first glance – but to turn this seemingly simple idea into a viable product, a lot of conceptual work was required as part of an Innosuisse-funded project. Take the production method, for instance: After testing different processes, the experts decided on so-called extrusion, in which heated, molten plastic is pressed through a slot as a soft dough and shaped in this way – around the strip of PET. But that in turn raised questions, for example about the proportion of air voids in this "filling".

"As many as possible" is the answer, in order to achieve a high insulating effect. Only: "Too many" would have jeopardized the stability of the prepared PET strand, because its encasement with the black plastic takes place at temperatures of up to 300 degrees and under high pressure. The researchers also adapted the thickness of this "sheath" to the necessities: as thin as possible for a good insulating effect – but thick enough so that the web would later also withstand mechanical loads, including the post-treatment of the finished overall profile, such as powder coating or anodizing.

From numerous samples, the developers distilled seven variants for testing – altogether an insulation web about 1,000 meters in length – and from these the final prototype as the basis for the finished products. An important step in the production process was also achieved along the way: The web welds virtually by itself due to the heat – without the need for another "seam" to be glued. "This is already a big advantage," says metal construction engineer Frank Hochuli from Empa's industrial partner. "There are no local weak spots where material could come off. And the fewer steps, the cheaper the product."

A lengthy process that paid off in the end, as Empa's Michel Barbezat confirms. "Technically, we certainly have a very good chance," he says. The measured values and the product, which can be easily recycled despite the use of two different materials, are already convincing. And the experts are also confident about the necessary long-term stability over many years, which his team tried to estimate with experiments using the innovative Stepped Isostress Method (see box).

INDEPENDENT TESTING IN GERMANY

Barbezat admittedly sees a challenge in convincing a large manufacturer of window profiles to cooperate, which produces and sells profiles for installation companies for windows and facades. "After all, compared to large companies, we are ‚nobodies,'" he says. So to win customers, the team also needed an independent blessing from above – so the partners sent their "Alpet" insulation web to the ift testing institute in Rosenheim, Bavaria, which has been a reference in the industry for decades.

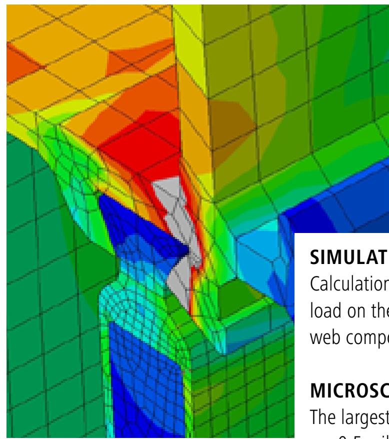
The German experts not only repeated the Swiss tests, but also subjected the prototypes to fire and fracture tests as well as other stresses – for example, to invisible microcracks after 1,000 hours of storage in oil or light acid, or to strong tension in the transverse direction. According to Frank Hochuli, official certifications for fire behavior, static load-bearing capacity and for thermal insulation have already been issued.

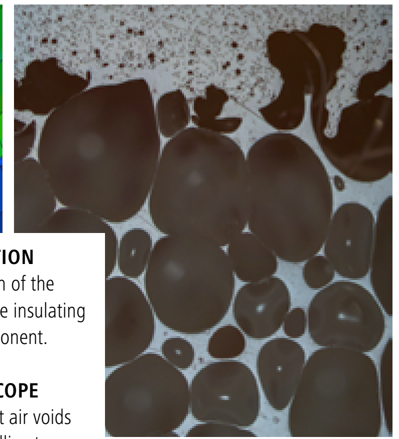
MORE ENVIRONMENTALLY FRIENDLY WITH LITTLE EFFORT

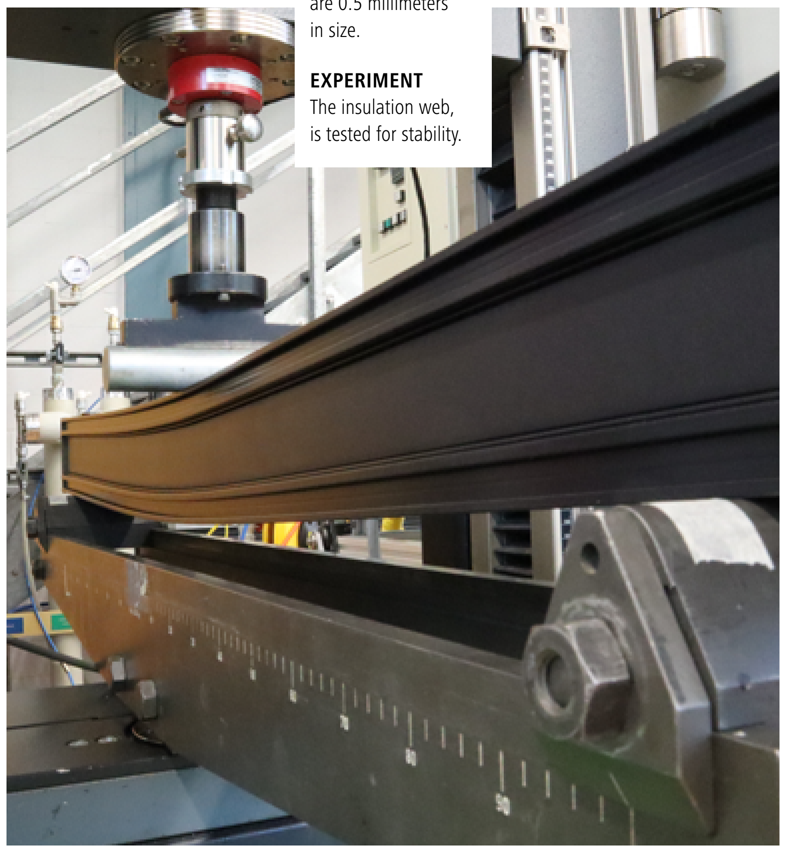
What would be the effect of the new insulation web in an entire window, including glass panes, aluminum profiles, seals and all the other components and details? Compared with today's high-end designs, Hochuli estimates that the thermal insulation in a new office building, for example, could be improved by up to twenty percent. And because the web with its "dovetail" as a mounting connection is compatible with all common systems, existing solutions can be upgraded relatively easily – for example, for the rather high requirements according to passive house standards. "It takes a lot of effort to do that with aluminum profiles these days," he says, "our system would certainly make it easier."

Detailed tests are then also carried out by the manufacturers themselves, in their own laboratories with their own profile systems. Talks on this have taken place; the first customers are already starting trials. "I am definitely optimistic!" says Hochuli. "Otherwise, I would hardly have founded a new company to bring our idea to the market." Nevertheless, the future path will not be a solo effort: Empa's experts will continue to support the insulation web with their know-how. ■

Further information on the topic is available at: https://www.empa.ch/web/s304







SIMULATION
Calculation of the load on the insulating web component.

MICROSCOPE
The largest air voids are 0.5 millimeters in size.

EXPERIMENT
The insulation web, is tested for stability.

Photos: Hochuli advanced, Empa

CONCRETE CONSTRUCTION – THE LIGHTWEIGHT WAY

ON TOP
The HiLo unit sits on the upper southwest corner of the research building NEST.

Photo: Roman Keller

At the beginning of October, the latest unit was opened in the NEST research and innovation building – HiLo. HiLo is an example of how attractive architecture can be when combining emission- and resource-saving construction and operation. The unit combines innovative design and construction methods for concrete structures with integrated and adaptive building technologies. The two-story module was developed and realized by two research groups at ETH Zurich in close cooperation with numerous partners from industry.

Text: Stephan Kälin

In the latest NEST unit HiLo, building principles from the Middle Ages meet construction methods of the future: The two-story building module with the telltale double-curved concrete roof was planned and built using state-of-the-art design and fabrication methods. However, the ETH Zurich researchers were inspired not least by the ancient cathedral builders who knew a thing or two about how to create self-supporting structures.

HiLo is an office environment that will soon be operational. Its name stands for "High Performance – Low Emissions": The unit is testing how the construction and operation of buildings can be designed to be as energy- and resource-efficient as possible – while at the same time ensuring an attractive architecture and a high level of comfort for the building's users.

NEW CONCEPTS TURNED INTO REALITY

To realize HiLo – now the eighth module in NEST – the two ETH research groups led by Philippe Block, Professor of Architecture and Structures, and Arno Schlüter, Professor of Architecture ▸

PIONEERING
The special concrete ceilings of HiLo save around 70 percent in material.
Top: A window with adaptive solar panels regulates the heat transfer from the outside.

Photos: Roman Kellers

and Building Systems, joined forces. In several years of research, they developed groundbreaking new concepts and technologies, built prototypes in close cooperation with industrial partners and further developed their ideas before these innovations were finally implemented for the first time in a real building project – in HiLo.

RESOURCE-EFFICIENT CONCRETE STRUCTURES

The double-curved roof is particularly striking, gaining its stability primarily from its geometry. It consists of two concrete layers connected by a network of concrete ribs and steel anchors. It was built using flexible formwork consisting of a tensioned cable net and a membrane, onto which the concrete was sprayed. This construction method can do with much less concrete and formwork material.

The researchers also set themselves the goal of using as little material as possible for the floors in the two-story unit. HiLo's lightweight floor design saves more than 70% of material compared to conventional concrete floors. This is achieved by the floor's thin, funicular structure. Digital manufacturing methods make it possible to integrate ventilation, cooling and low-temperature heating into the rib structure, thus saving even more material (and volume).

SELF-LEARNING BUILDING TECHNOLOGIES

With regard to the integration of building technologies, the façade is also becoming increasingly important. An adaptive solar façade developed by Arno Schlüter's group is implemented in HiLo. It consists of 30 photovoltaic modules that can align themselves with the sun. The flexible modules can also be used to control the incidence of sunlight into the room in order to provide passive heating or – on the contrary, to increase shading and thus reduce the need for cooling.

The adaptive solar façade is part of a series of innovative building technology components for the efficient regulation of the indoor climate. During operation, the researchers will be constantly optimizing the interaction of the individual technologies with the unit's users using machine learning to investigate how comfortable indoor conditions can be achieved with as little energy and emissions as possible. ■

AIRY AND LIGHT
The self-supporting, curved roof was created by spraying concrete onto a strained membrane.

Further information on the topic is available at: www.empa.ch/web/nest/hilo

Photo: Roman Keller

DEMOLITION AND BREAKTHROUGH

The new NEST unit Sprint sets standards for circular construction: In just ten months, flexible, COVID-19-compliant office spaces were built using mostly reused materials and components. Sprint demonstrates: The „stockpile" of reusable materials and the re-use potential in the construction industry is enormous – you just have to use it.

Text: Annina Schneider

RE-USE
The façade of the Sprint unit consists of wooden slats that were previously attached to NEST's „backbone." The PV modules come from past projects.

Photo: Martin Zeller

With Sprint, a new office unit made largely of reused materials and components was recently put into operation at NEST. Flexible demountable partition walls made of reused materials divide the office unit into twelve COVID-19 compliant individual offices and give the unit a unique character. The entire unit follows the design for disassembly approach (see box page 20), so that when needed, for example, the flexible partition walls can be removed and thus the individual offices can be converted into an open-plan office.

Sprint demonstrates what today is still met with skepticism in the construction industry: Building with reused materials and components is a true alternative to building with virgin materials and meets market demands for flexible and fast construction. "In a world where resources are constantly becoming scarcer, circular construction is more ▸

„DESIGN FOR DISASSEMBLY"

The design for disassembly approach takes dismantling into account right from the start, and the construction method facilitates future modifications and disassembly for the recovery of systems, components and materials, thus ensuring that, at the end of their regular life span, buildings can be transferred to another use cycle – a second life, if you wish – as efficiently as possible.

urgent than ever and forms the basis for achieving our CO_2 targets," emphasizes Enrico Marchesi, NEST innovation and project manager. "With the Sprint unit, we have therefore set ourselves the goal of finding solutions that are as universally applicable as possible and thus simplify the reuse of building materials."

RETHINKING PLANNING, EXECUTION AND ECONOMICS

Building with reused materials is an iterative process, in which the question of available materials runs through the entire construction process. In order for such a project to be implemented in the shortest possible time, it requires, among other things, a rethinking of planning and execution, as well as a flexible schedule. "The time factor is a big challenge in reuse, as the reused material must be found and also be available exactly when needed. Contrary to our initial concerns about the tight schedule, though, we were able to find the re-use materials even faster than new materials. This is mainly due to the current scarcity of resources – but also shows that re-use has no impact on construction time," explains Kerstin Müller, architect and member of the management team at baubüro in situ, which planned the Sprint unit.

Building with reused materials also requires a different mindset when it comes to defining economic efficiency. The added value of re-use clearly lies in the fact that the material is given the necessary respect. Hans Emmenegger, head of the carpentry division at HUSNER Holzbau, sees great opportunities in this: "In my opinion wood, for instance, is a very grateful raw material. It can be processed well, which in turn makes it easy to reuse. If wood is installed in a healthy way, i.e. dry, it does not lose value. On the contrary, it actually gains value because of its characteristic aesthetics."

REUSE AS A BOOSTER FOR INNOVATION

Building with reused materials requires not only flexible planning and execution, but also more flexibility in design. For instance, planners must be aware that the material they find will partly determine the final design. "Sprint impressively demonstrates that reused material is by no means a hurdle to design, but that creativity can be used to achieve design elements that one would not have thought of initially. The different partition walls in Sprint are a great example of this: We built some from scrap bricks, others from old books, and still others from old carpet," says Oliver Seidel, architect and member of the management team at baubüro in situ.

The carpet partition for Sprint, for example, was developed by Jonas Schafer, component hunter at baubüro in situ. It can be completely dismantled after use. Empa researchers tested the wall for airborne sound insulation in the acoustics lab. The carpet partition has proven itself in terms of its building acoustics properties and is now being put to the test in the Sprint offices (see box).

EXPLOITING OPPORTUNITIES AND ACCEPTING LIMITS

However, Sprint shows that reuse is not per se cheaper in today's market situation. Nevertheless, Oliver Seidel is convinced: "As soon as a competitive market with reused materials and components has established itself, cost advantages will also accrue for reuse. Moreover, I believe that there is a need for CO2 taxes, for example, which would increase the prize of new materials and relieve the costs for used materials, so that their ecological benefit can be quantified."

Reuse also offers new opportunities. For example, certain reused materials such as natural stone or automatic fire protection doors suddenly can become affordable, as opposed to the same components, brand-new. What's more, the materials can be evaluated in terms of the CO_2 savings they enable.

In the case of technical components such as pumps or valves, however, the question arises as to whether reuse is worthwhile in terms of warranty and service life. It is quite possible that it makes more sense to procure these components anew. Verifying the service life of such engineered components is feasible, but time-consuming and costly. "The challenge in building with reused materials is to strike a balance between what is technically feasible and what makes sense," says Maike Stroetmann, BIM CAD department manager at Bouygues Energies & Services. ■

BEST SOUND INSULATION FROM OLD CARPETS

Empa researchers tested the airborne sound insulation of the carpet partition specially designed for Sprint in the acoustics lab. For this purpose, the partition wall was set up in an adapter between two test rooms and the airborne sound transmission was measured. The weighted sound reduction index (Rw) was calculated from the frequency-dependent measurement data.

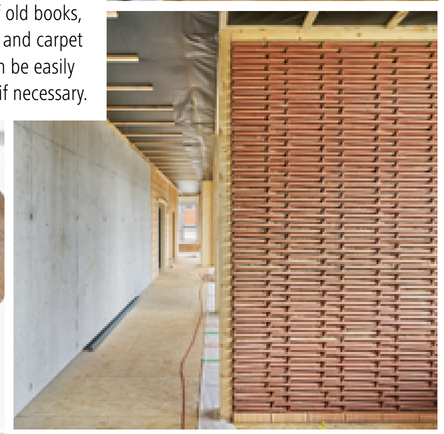
With several measurements, the researchers investigated how the carpet tiles must be folded for optimal sound insulation. In the best case, the researchers achieved a sound insulation of 26dB. This means that, as a room divider, the carpet wall achieves much better acoustic insulation than, for example, mobile movable walls in open-plan offices.

This innovative and cycle-compatible partition wall therefore has potential wherever buildings are designed to be flexible or even temporary, such as for interim uses.

> "A CO_2 tax is needed that makes new materials more expensive and relieves the burden on used materials."

Further information on the topic is available at: www.empa.ch/web/nest/sprint

Photos: Martin Zeller



OLD AND FLEXIBLE
The partition walls between the offices are made of old books, scrap bricks and carpet tiles and can be easily dismantled if necessary.

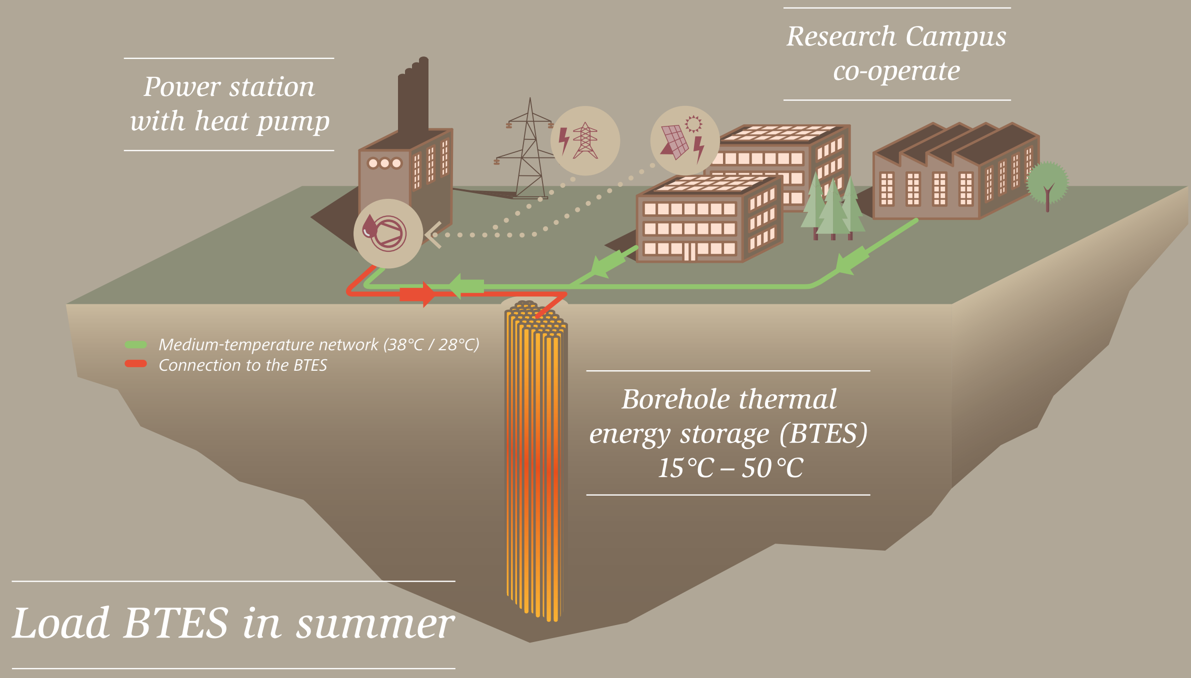
HEAT STORAGE IN THE DEEP

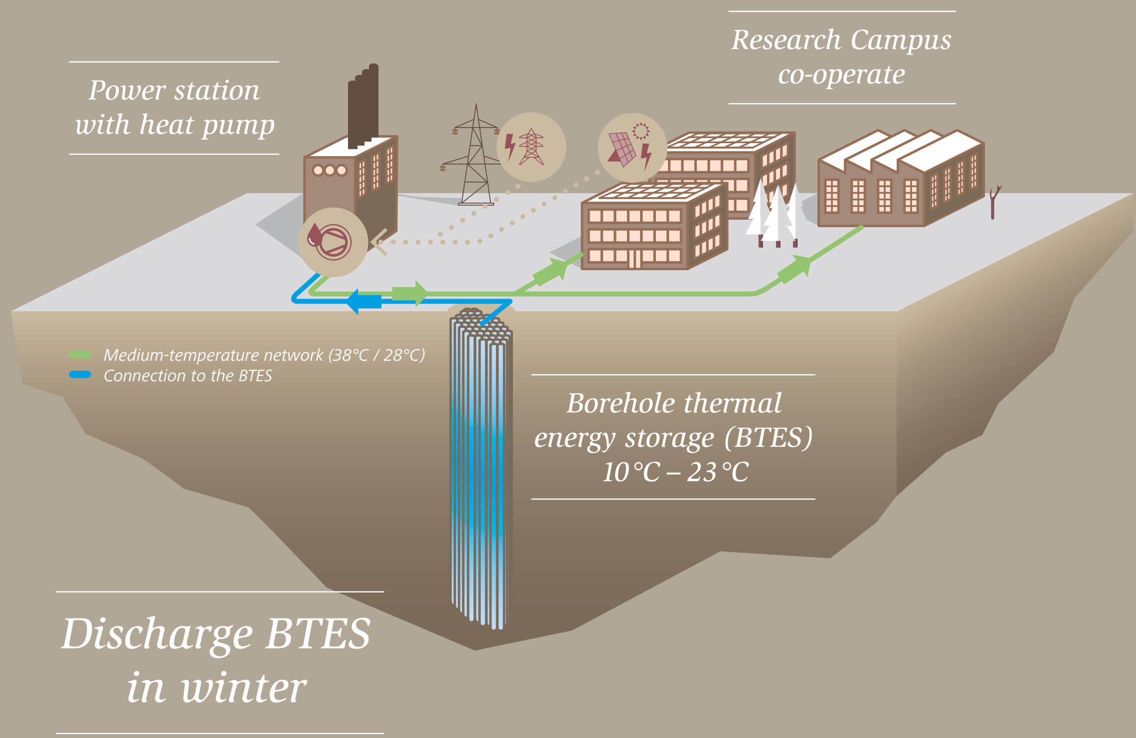
In Dübendorf, Empa is currently building a new, future-oriented research campus, co-operate, where groundbreaking research is conducted – and which is itself an object of research. This is because an experimental, seasonal energy storage facility is being built under the site, which will supply energy not only to the new buildings but to the entire Empa campus. In summer, for example, the waste heat from ventilation systems and laboratory equipment will be stored to be used in winter for heating or for the production of domestic hot water.

The aim is to either use around 90% of waste heat directly or to store it temporarily in the ground storage facility. In this way, Empa aims to reduce the CO_2 emissions of its buildings to a minimum and thus make a huge step towards a sustainable energy future.

Empa will be able to use the heat storage facility for research purposes for a period of ten years. The heat reservoir – a field of geothermal probes with a temperature gradient – comprises 144 probes extending up to 100 meters deep into the ground. At this depth, the storage unit works particularly effectively, losing only a small proportion of the stored heat to the environment. In the center of the geothermal probe field, the maximum temperatures can reach 50°C, at the edge the values are around 10°C. A tube system makes it possible to control each tube of the geothermal probe individually or to control defined areas and thus achieve the optimum mix between temperature, efficiency and energy storage.

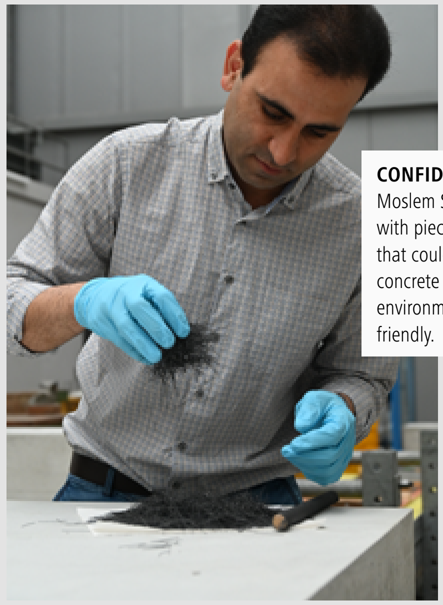
Although such an earth storage system is very effective, it is also sluggish due to its large mass. The Empa researchers assume that the final operating temperature will be reached after about three to four years.





Graphic: Empa

BUILDING MATERIALS HELP PROTECT THE CLIMATE



CONFIDENT
Moslem Shahverdi with pieces of wire that could make concrete more environmentally friendly.

Scientists are visionaries. Sometimes their ideas go much further than an industrial partner is willing to go. The Empa Zukunftsfonds aims at supporting such visionary projects, where, despite high risks – or precisely because of them –, breakthrough successes are to be expected. The latest example is a research project on prestressed high-performance concrete, which can now be started thanks to funding from the Ernst Göhner Foundation.

Text: Rainer Klose

The production of concrete contributes around nine percent of global CO_2 emissions. If we want to combat climate change, we therefore need new types of concrete that last longer, produce fewer greenhouse gases and are so stable that it is possible to build slimmer – i.e. more material-efficient – structures. Empa researchers came up with an idea: Could a self-prestressing concrete be the solution?

Researchers are already experimenting with reinforced concrete elements that are prestressed by heat rather than hydraulically. Moslem Shahverdi from Empa's Structural Engineering lab would like to go one step further: Small pieces of wire, just two to three centimeters long, are distributed in the concrete. If these wires, which are made of a special alloy known as shape memory alloys (SMA), are heated, they contract. This could produce concrete that prestresses itself in all spatial directions at the push of a button, as it were. And the material would be much stronger and more durable than conventional reinforced concrete we have been using for 140 years.

Researchers from two other Empa labs are supporting Shahverdi: Experts from the Concrete and Asphalt lab are developing concrete mixtures with a lower carbon footprint. And colleagues from the Mechanical Systems Engineering lab, who specialize in calculating the strength of small and large building components, can suggest particularly promising experimental setups to Shahverdi using so-called finite element simulations. This significantly reduces the number of actual experiments and helps researchers reach their goals faster.

THE COURAGE TO TAKE RISKS – ALSO ON THE PART OF SUPPORTERS

„It's a classic high-risk, high-gain project," says Masoud Motavalli, who heads the Structural Engineering lab. „The risk of failure is high, but there's also a lot to gain." Motavalli has repeatedly approached funding agencies and industrial partners with this idea since 2008, for a long time without success.

Now the Empa Zukunftsfonds has succeeded in securing funding from the Ernst Göhner Foundation. This means that the ambitious project can finally get off the ground. „We are very happy and grateful that, thanks to this generous and courageous start-up financing from the Ernst Göhner Foundation, we can now set our sights on a major goal: protecting the climate with the help of intelligent building materials of the future," says Gabriele Dobeneck-er from Empa's fundraising team. Support from foundations, but also private donations to the Empa Zukunftsfonds, would make such visionary projects possible in the first place and are therefore of great importance to Empa. ■

More information can be found at:
www.empa.ch/web/zukunftsfonds

Photos: Empa

AN EYE FOR THE SMALLEST THINGS

As head of Empa's Electron Microscopy Center, Rolf Erni has to balance many tasks: negotiating industrial contracts, promoting young scientists, teaching, supporting researchers at other Empa labs. And fascinating fundamental research, for which he is now being honored as one of the very few Distinguished Senior Researchers at Empa.

Text: Norbert Raabe

If you google what Rolf Erni actually does, you have to be prepared for polysyllabic words. "We employ atomic-resolution imaging, mostly in STEM mode, combined with local electron energy-loss spectroscopy (EELS), energy-dispersive X-ray (EDX) spectroscopy, as well as off-axis electron holography" – food for thought from the Electron Microscopy Center's website, at which even trained researchers are likely to frown.

"This is not rocket science," Rolf Erni likes to say then, as he did recently at a talk about his work – a reassuring understatement that probably stems from his research stint in the US. In other words, this is not highly sophisticated research for a select few, nor is it an impossibility for the normally gifted. Instead, it is the everyday work of "microscopists," as Erni calls the guild, to which he has belonged for about 20 years – with curiosity, diligence, and highly cited publications in journals and books. In short: with a lot of success.

Quite unplanned, is how Erni describes his career. After receiving his PhD in materials science from ETH Zurich, Erni initially wanted to go straight into industry – but then "drifted off," as he says. First, he spent a postdoc year at the National Center for Electron Microscopy in California; then, in 2004, he joined FEI, a leading manufacturer of electron microscopes. His job was to assist in the development of a new type of instrument, including its introduction to the market.

This microscope was to be "super-stable" and – just like optical devices – reduce even minimal "shakes" to enable a higher resolution. This also required solutions for inconspicuous details. For instance, the ring-shaped electromagnetic lenses that focus the electron beam – corresponding to the light beam of an optical microscope – contain a copper wire that heats up under continuous current. "These have to be cooled with water," Erni explains, "and just the vibrations caused by water running through the instrument could have been critical for the instrument's stability."

SUCCESS? STAYING ON THE BALL

So he got to know his tool over the years – inside and out – and experienced the rapid development over two decades as an insider: from aberration corrections that eliminated "blurring" caused by excessively deflected electrons to the first CCD cameras in the 1990s. As in photography, they replaced films that had recorded electrons after they had penetrated the ultra-thin sample. And from advancing to atomic resolution of less than a tenth of a nanometer to new detectors that directly capture single electrons.

"There's always something new", says Rolf Erni, "so it's really true that if you don't keep up, you rust." And these small and big steps paved the way for today's projects like "Cluster", supported by the EU's Horizon2020 framework program – with a fascinating question: How is solid matter formed? Or more precisely, how do the first "nuclei" of solids like crystals form?

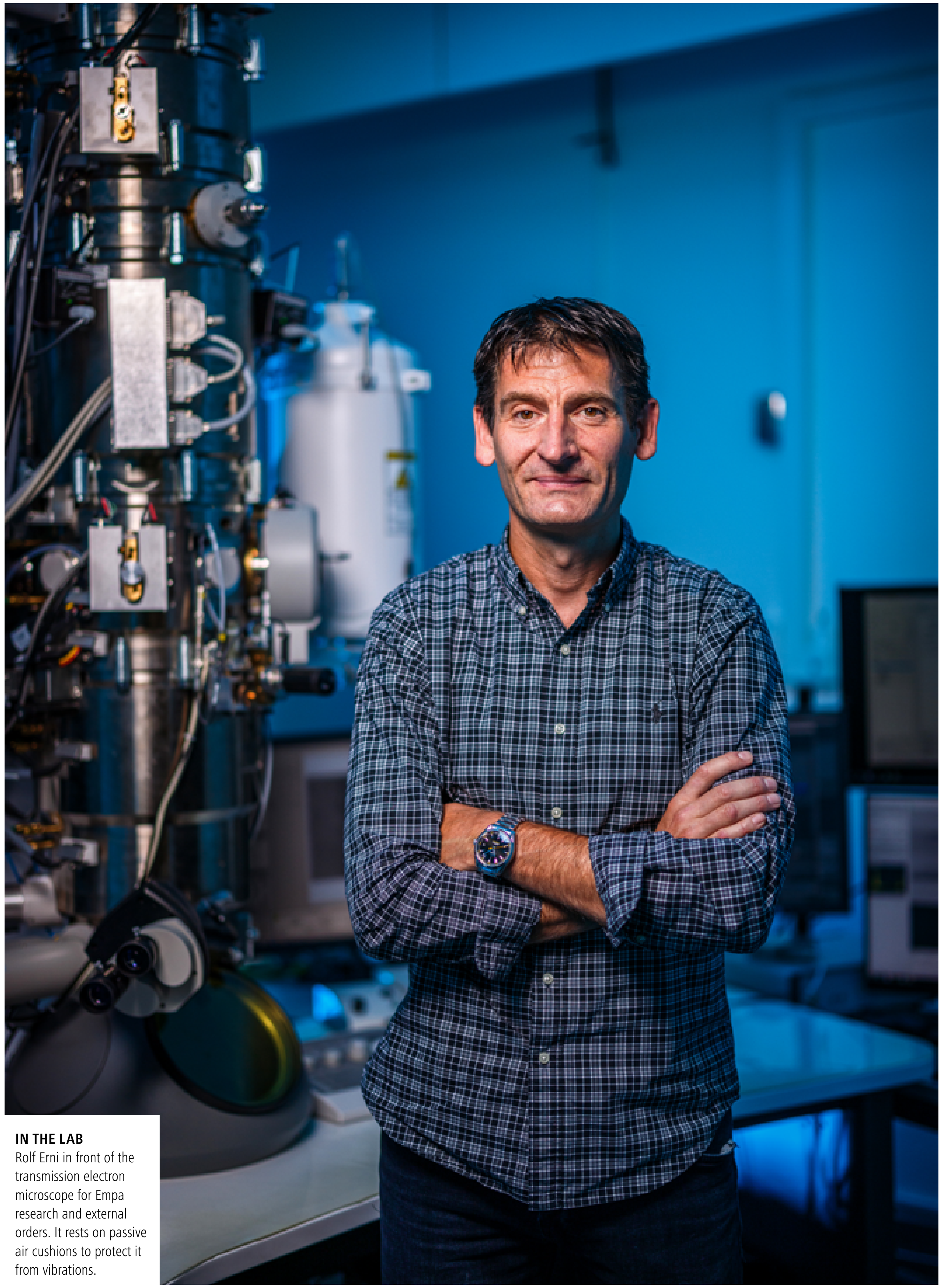
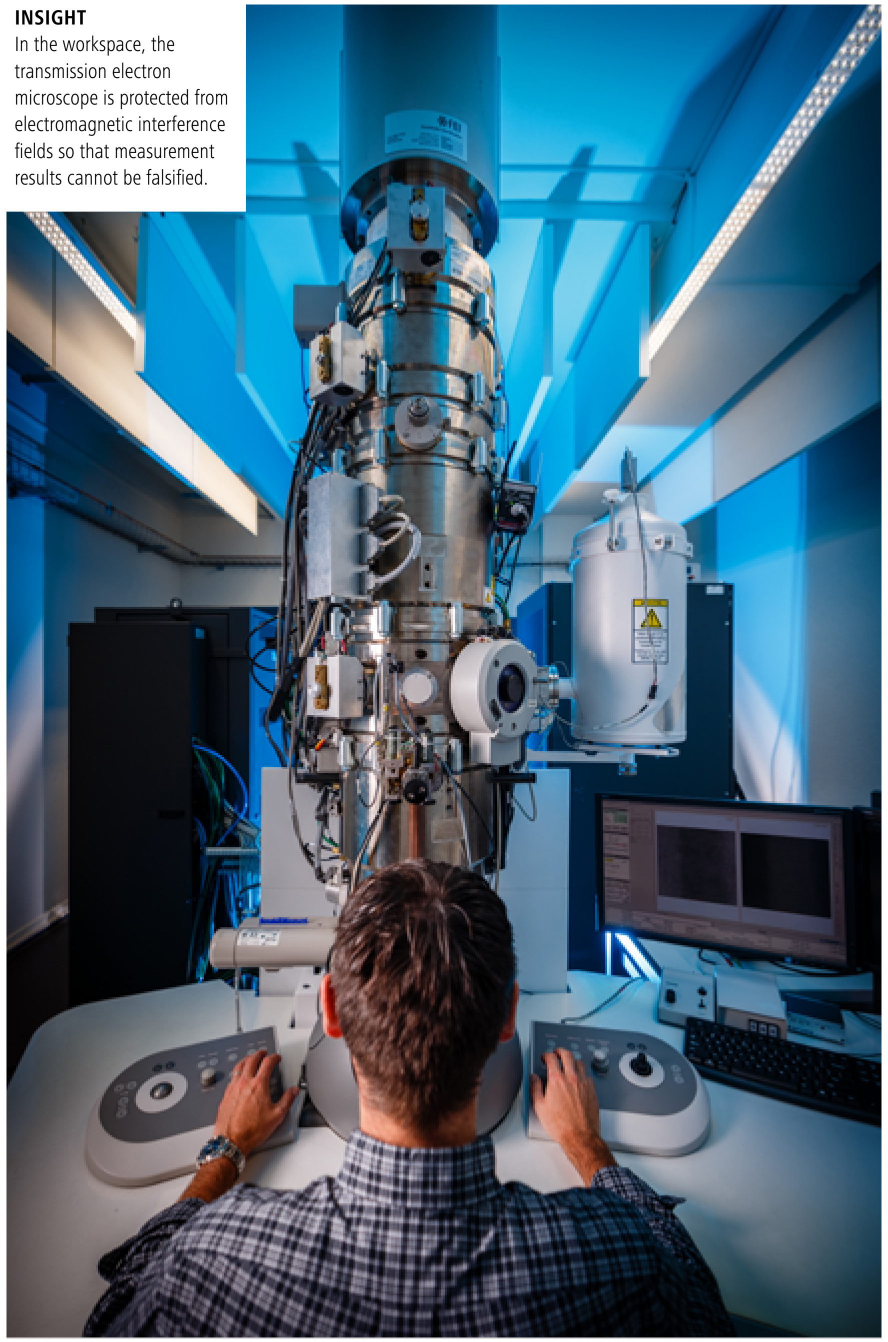


Photo: Nicolas Zonvi

IN THE LAB
Rolf Erni in front of the transmission electron microscope for Empa research and external orders. It rests on passive air cushions to protect it from vibrations.



INSIGHT
In the workspace, the transmission electron microscope is protected from electromagnetic interference fields so that measurement results cannot be falsified.

ROLF ERNI

CAREER: After graduation, postdoc at the National Center for Electron Microscopy, California, then as an expert at the manufacturer FEI in Eindhoven. As researcher at the University of Antwerp and again in California. Since 2009, head of the Center for Electron Microscopy at Empa.
SCIENCE: Training in materials science at ETH Zurich, diverse research in electron microscopy, publication of technical papers and books, lectureships at ETH Zurich, member of technical committees.

A blind spot in research – and a perfect opportunity for the Empa team. “If you understood these processes, you might be able to control them,” the researcher says, enthused. “And then it might also be possible to grow materials with favorable properties in a targeted manner. Or even those that don’t occur in nature at all.” There is still a long way to go, of course, he adds. And it leads ove…– fundamental research.

ONE WHO EXPLAINS WELL

The team took its first steps in the lab with platinum atoms, because heavy metals appear more high-contrast in the electron microscope, i.e., they are easy to “see”. How would Erni explain this to his eight-year-old son, who has already visited the lab with his class? “We put platinum atoms on a bed of carbon, and then we observe: What happens to them when you heat them up or bombard them with electrons?”

He does so by means of STEM (scanning transmission electron microscopy), that is, by scanning the beam over the platinum samples – at up to 150 frames per second, so that every molecular movement is captured and no phase is missed. “It’s actually not that complicated; it’s just no one has done it before,” says Erni. “And no one has dared to do this superfast scanning.”

The team has assembled their individual recordings into short video sequences. They show how different platinum structures form: ordered clusters of between six and 25 atoms – often including a very densely packed structure that platinum also adopts in its solid state. In the next step, the experts tried it in a more complex environment of a liquid, where similar phenomena could be observed: Atoms formed in what the experts call a “quasi-molten, crystalline state.”

How would Rolf Erni explain this observation to his son? That matter in this state “wobbles” in different forms? “Yes, exactly,” he nods – and quickly comes up with a more precise image. “Or like deforming a bunch of magnetic beads in your hand. And in the process, highly orderly structures emerge from time to time.”

Photo: Nicolas Zonvi

Photos: Empa, Nicolas Zonvi

DIVERSITY AS A RESEARCHER’S VIRTUE

Pondering over such fundamentals, signing industrial contracts, training dozens of Empa researchers from other labs so they can use the electron microscopes for their own research: Being a researcher and a service provider at the same time – isn’t that too much of a good thing? No, says Erni; on the contrary, he considers diverse insights highly valuable for his team, which he started building up in 2009 – at the time a key incentive to join Empa.

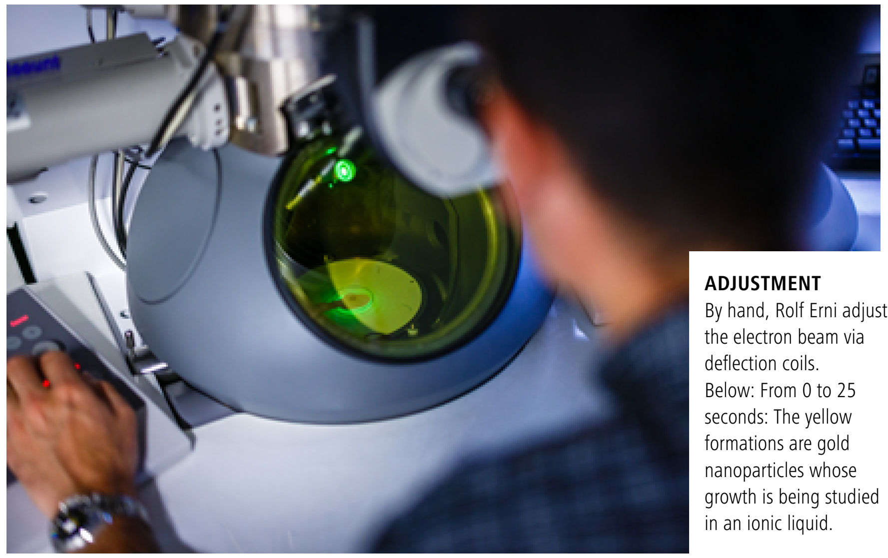
> “Like deforming a bunch of magnetic beads in your hand”.

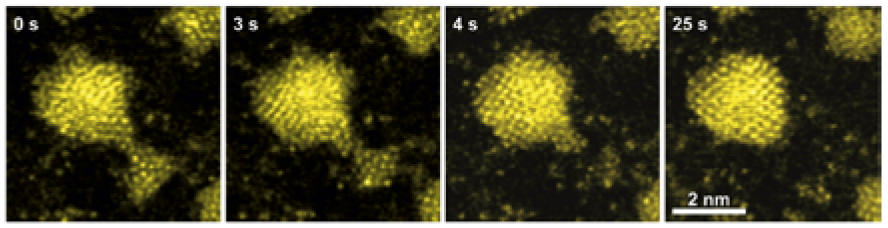
The center started with 2.5 full-time positions, today it has around ten. Whether for high-performance batteries, novel alloys or CO_2-neutral cements of the future, the need for microscopists’ expertise will continue to grow – and in discussions among experts about future service centers, Rolf Erni also advocates independent research. Of course, it’s important to host and equip these centers so that people can have their measurements taken, he says – but it’s equally important to be able to try out something new, he says, “and to have the freedom not to have to charge for every hour the microscope is running.”

In electron microscopy, the tool itself, with all its opportunities and pitfalls, is also a research object. Tinkering with new procedures is an inseparable part of it – and talented young scientists with creativity and the perfectionism it takes to succeed are as valuable as in any other scientific field. “In the end, you have extremely well-educated folks in your team – and all they do is service?” says Rolf Erni. “That can’t be it.” ■

ELECTRON MICROSCOPY AT EMPA

Four devices are currently in use at Empa. Firstly, there are two scanning electron microscopes, which scan the object under investigation with an electron beam; the interaction of the electrons with the sample is processed into an image. These instruments are primarily used for the analysis of materials. The two transmission electron microscopes work on a different basic principle: The electrons penetrate the wafer-thin samples, as if one were shining through a foil, and produce an image underneath – depending on the method, up to atomic resolution. These devices are used primarily in research. In addition to the EU-funded Cluster project on the formation and growth of crystals, which is significant for catalysts, for example, the Empa team is also working on complex oxides, which play an important role in technologies such as novel electronic components and data storage media.





ADJUSTMENT
By hand, Rolf Erni adjusts the electron beam via deflection coils.
Below: From 0 to 25 seconds: The yellow formations are gold nanoparticles whose growth is being studied in an ionic liquid.

Further information on the topic is available at: www.empa.ch/web/s299

POISON SOURCE IN THE IDYLL

Sediments in the Spöl, a small river in the very south of the canton Graubünden, are contaminated with PCBs. The chemicals originate from a 50-year-old anti-corrosion coating of a hydroelectric power plant in an upstream dam; they are transported and distributed with the waters of the Spöl – all the way to the Black Sea. Now the river has to be remediated. What is disputed, though, is the extent to which this must be done – and who will pay for it. Analyses by Empa scientists play a central role in this: They show just how much PCB is hidden in which areas of the riverbed.

Text: Rainer Klose

PUNT DA GALL DAM
The Punt da Gall dam on Lago di Livigno was completed in 1970. Some of the water-bearing pipes are protected with rust-proofing paint containing PCBs – which was still permissible at the time.

Photo: Schweizerischer Nationalpark

Luck and misfortune often lie close together in the wilderness of a national park. On 20 September 2020, a park ranger in the Swiss National Park found a dead eagle owl on the edge of a hiking trail next to the little river Spöl. The bird certainly had an unhappy ending: One wing was broken, and the eagle owl was emaciated to 1.3 kilograms, less than half its normal weight, as later examination revealed. That the bird was found at all, on the other hand, was shere luck. Normally, dead animals in the wild are carried off and eaten within hours by foxes or birds of prey.

Now the ball was rolling. The carcass was examined at the Center for Fish and Wildlife Medicine at the University of Bern. To detect any poisonous residues in the bird's body, the specialists sent the eagle owl's entrails to Empa. "The sample material was not exactly fresh anymore," recalls Markus Zennegg, a chemist in Empa's Advanced Analytical Technologies lab. But when Zennegg examined the first samples in the mass spectrometer, he was quite surprised. "The instrument showed concentrations that I would not have thought possible. The load of particularly toxic polychlorinated biphenyls (PCBs) in this bird was 20 micrograms per kilogram of body fat – that's thousands of times above normal levels for wild animals." Zennegg had to dilute the samples and run them through his instrument one more time to determine the concentration correctly.

POLLUTANTS FROM A POWER PLANT

The PCB concentrations in the eagle owl from the national park were not entirely unexpected, however. The Spöl, where the bird was found, draws its water from the "Lago di Livigno". The lake is dammed by the "Punt da Gall" dam. And that's where the problem lies: When the dam was built in the late 1960s, anti-corrosion paint containing PCBs was used, which has since been slowly worn away and contaminates the water at the Spöl. Here again, luck and misfortune lie close together: In 1970, the dam including the power plant was put into operation. Only two years later, in 1972, Switzerland banned PCB-containing substances in "open systems". But by then, the dam was already finished – and, to a certain extent, brand new. For 50 years, the dam water carried the pollutant slowly downstream and deposited it in sandbanks and floodplains. In some places, PCB pollution reaches as deep as half a meter into the sediment.It is possible that a first, larger wave of PCBs was distributed in the sediments as early as 2013 during a mud flood in the Spöl.

A second incident occurred in 2016: A remediation company stored waste from sandblasting work in the dam wall, which was blown away by a storm and carried into the Spöl. The owner of the dam, the power plant company Engadiner Kraftwerke AG (EKW), reported this accident to the environmental authority.

Since then, Empa has been monitoring the case. Markus Zennegg analyzes for instance fish and has developed special, highly sensitive passive samplers that can measure the PCB content in the water of the reservoir. Since 2017, the consumption of fish from the Spöl has been banned: Fish in the Swiss National Park exceed the PCB level permitted for food by a factor of four.

TOP OF THE FOOD CHAIN

Of course, the eagle owl had no way of knowing this. Like other predators, such as otters, foxes and bears, it is at the top of the food chain. PCBs are fat-soluble pollutants that accumulate in the fatty tissue of fish. If the eagle owl feeds mainly on fish from the Spöl, it becomes a candidate for chronic PCB poisoning.

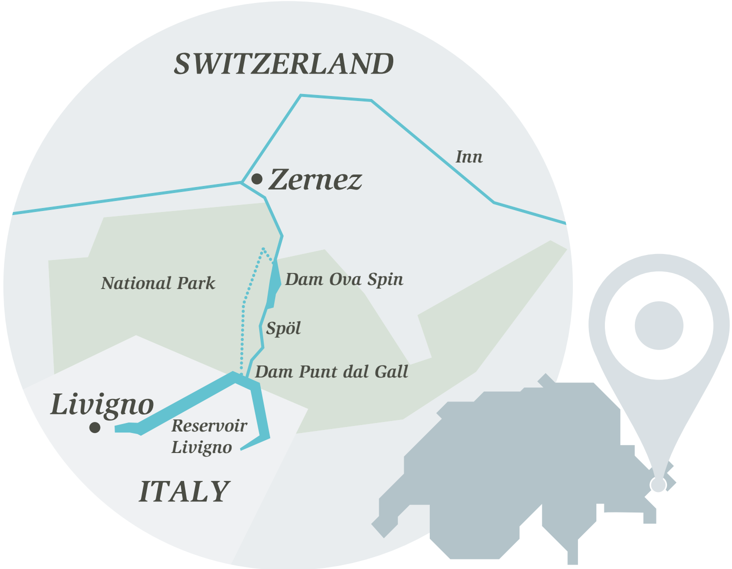
There are various substances in the group of PCBs. In the dead eagle owl from the Spöl valley, Zennegg detected above all PCB 126, a substance that is only about ten times less toxic than notorious Seveso dioxin TCDD. The substance weakens the immune system and hormone metabolism, damages reproductive organs and can cause cancer.

Humans are also affected by PCB exposure. The chemical virtually does not degrade in the environment and stays there for centuries. The European Food Safety Agency (EFSA) believes that a person should ingest a maximum of two picograms of such dioxin-like PCBs per kilogram of body weight per week. The value is calculated from the sperm quality. Swiss citizens already consume 14 picograms of PCBs per week – seven times above the EFSA recommendation.

REMEDIATION SUCCESSFULLY REHEARSED

So what is to be done? Opinions are divided. All those involved – the power plant company EKW, the environmental office of the canton of Graubünden and the administration of the Swiss National Park – agree that the PCB time bomb in the upper reaches of the Spöl should be defused as soon as possible. After all, the water runs from there into the Inn, then past Innsbruck, Kufstein, Rosenheim and Passau into the Danube – and from there into the Black Sea.

The first 60 meters behind the dam, the so-called Tos basin, had already ▶



TOSBECKEN
The first river basin, just behind the dam wall, was already rehabilitated on a trial basis in 2017: Fine sand grains were filtered out, burned out in a gravel plant and reinstalled in the basin.

been rehabilitated in a pilot project in 2016. "They filtered out the fine sand with grain sizes of less than 3 millimeters, burned it out in a gravel plant and then reinstalled it in the basin," explains Ruedi Haller, director of the Swiss National Park. "This method successfully removes about 90 percent of the PCB contamination."

The question remains how many kilometers of the Spöl will have to be remediated in this way. In February 2021, the environmental authority of the canton of Graubünden ordered the remediation of the upper reaches of the Spöl over a length of 2.9 kilometers. The National Park Authority, on the other hand, is demanding remediation of the entire river course over 5.8 kilometers (see info box). Further downstream, the PCB contamination is no longer as serious as in the upper reaches, but still clearly too high for a national park.

National Park Director Haller, in calling for total cleanup, is thinking not only about the water in the rivers, but specifically about wildlife that accumulate the toxin in their bodies. "If animals die, their territories are occupied from other areas, the population is thinning out, and the Spöl valley acts as a population sink. The poisoned Spöl can thus have far-reaching effects if migrating animals carry the PCB over wide areas." But that, he said, is exactly the opposite of what a national park is supposed to be by law: a place where rare species can find an intact habitat and positively impact other populations outside the national park.

LEGAL SITUATION UNCLEAR

A legal dispute has arisen between the power plant company EKW, the Swiss National Park and the environmental office of the canton of Graubünden. EKW had already offered to finance the remediation in advance and settle the dispute over the costs later. Many things are unclear, however: Will the remediation company have to pay for the 2016 accident? Will the case be treated as an industrial contaminated site or under water protection laws? Michael Roth, the director of EKW, sees it this way: "The Spöl case is hardly comparable to any other known environmental pollution incident. Accordingly, authorities cannot refer to other cases, which has a negative impact on legal certainty. It will be inevitable that one or the other question will have to be clarified by the courts."

A VISIT IS WORTHWHILE – AS SOON AS POSSIBLE

Empa scientists will continue to monitor the stress on fish and wildlife in the national park with their chemical analyses. A visit to the river is worthwhile sooner rather than later: As soon as the remediation begins, the Spöl will turn into a construction site for two to three years, says National Park Director Haller. "We will stay in the riverbed itself as much as possible with excavators and dumpers to destroy as little of the surrounding area as possible. A mobile gravel plant will travel with the site, filtering out the fine sand from the polluted sediments and burning it out on site so we can put it right back in."

Photos: Schweizerischer Nationalpark / Graphik: Empa

Eventually, the riverbed will be purposefully flooded several times with water from the reservoir to redistribute the clean sand and erase the traces of construction. "A few years later, nature will have reclaimed the landscape – without PCB pollution," says Ruedi Haller. "Then we can pass the national park on to the next generations with a clear conscience." ■

Further information on the topic is available at: www.empa.ch/web/s502

Photos: Schweizerischer Nationalpark

WARNING SIGN
On a hiking trail near the river Spöl a park ranger found this dead eagle owl.

REMEDIATION
After the end of the construction work nature is allowed to reclaim the the riverbed. The picture was taken during the test cleanup in 2017.

FUELING UP WITH HYDROGEN – AT OLMA

What will the fueling station of the future look like? With an increasing expansion of photovoltaic systems, there will be a surplus of renewable energy in summers that can be converted into hydrogen – a fuel that is particularly suitable for trucks and other heavy vehicles. Together with partners, Empa will be demonstrating how hydrogen can be produced and refueled at a stand at the OLMA in St. Gallen from 7 to 17 October. Besides information worth knowing about sustainable fuels and answers to frequent questions, visitors will also have the opportunity to try their hand at it themselves – with the model of a fueling station and the Hyundai NEXO Fuel Cell car. In addition, an e-bike from Linde that runs on H2 will also be on display.

www.empa.ch/web/move

PROMISING
Hydrogen is still rarely used today; in future, however, it could contribute a great deal to sustainable mobility.

SWISS GREEN ECONOMY SYMPOSIUM WITH EMPA EXPERTISE

HIGHLY ATTENTIVE
As a „Changemaker", Gian-Luca Bona gave an interested audience new impulses for a sustainable energy supply.

„Sustainability needs ingenious minds": Such was the motto of the Swiss Green Economy Symposium held in Winterthur in early September with experts from business, research and politics. Empa CEO Gian-Luca Bona brought the institute's perspective to an event on sustainable energy production and the procurement of mineral resources. In his „Changemaker Impulse" talk, he outlined the need for more – and different – materials for renewable energy production, along with the need to harvest, store and use energy in an environmentally friendly way for the sustainable development of our society. Through specific examples such as printed, biodegradable batteries, the audience learned first-hand what Empa researchers are contributing to this filed. Anna Krutikov, Head of Sustainability at Glencore, Christoph Wiedmer, Co-Managing Director of the Society for Threatened Peoples Switzerland, and Monica Rubiolo, Head of Trade Promotion at the State Secretariat for Economic Affairs (SECO), then joined Bona for a panel discussion.

https://sges.ch/

Photos: Quade & Zurfluh AG / Lifefair, Swiss Green Economy Symposium

TINY GLOBE MADE OF CERAMIC

AWARD WINNING
The globe picture by Empa researcher Evgeniia Gilshtein.

At the Swiss NanoConvention last June, not only posters and a startup company received awards, but also pictures: a tribute to successful presentations of nano research. The jury awarded second place to Empa researcher Evgeniia Gilshtein – for a colored globe one-tenth of a millimeter in diameter. The sphere's irregular grain structure is achieved by a flash lamp annealing process, which lasts only about two milliseconds. The material of the sintered sphere is initially comprised of micron-sized alumina particles and nanometer-sized iron oxide particles mixed in water. The result inspired Gilshtein to use image processing to turn it into our blue planet – fitting for 2021, which the UN has declared the „International Year of Peace and Trust". First place went to Nadine Leisgang from the University of Basel, third place went to Filippos Kapsalidis from ETH Zurich.

www.empa.ch/web/s207

Photo: Empa

EVENTS

(IN GERMAN AND ENGLISH)

27. OKTOBER 2021
Forum: Future of Industries 2021
Zielpublikum: Industrie und Wirtschaft
www.fuw-forum.ch/future-of-industries-2021
Gottlieb Duttweiler Institut, Rüschlikon

5. NOVEMBER 2021
Kurs: Tribologie
Zielpublikum: Industrie und Wirtschaft
www.empa-akademie.ch/tribologie
Empa, Dübendorf

17. NOVEMBER 2021
Kurs: Neue Trends in der Fügetechnologie
Zielpublikum: Industrie und Wirtschaft
www.empa-akademie.ch/fuegetech
Empa, Dübendorf

25. NOVEMBER 2021
Technology Briefing: Advanced Manufacturing
Zielpublikum: Forschung und Industrie
www.empa.ch/web/tb/am
Paul Scherrer Institut, Villigen

25. NOVEMBER 2021
Seminar: Kohlenstofffaserverstärkte Kunststoffe im Bauwesen
Zielpublikum: Baufachleute, ArchitektInnen
www.empa-akademie.ch/rfa
Empa, Dübendorf

30. NOVEMBER 2021
Workshop: Analytik als Antwort auf materialspezifische Fragen
Zielpublikum: Industrie und Forschung
www.empa-akademie.ch/solserv
Empa, St. Gallen

Details and further events at
www.empa-akademie.ch

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