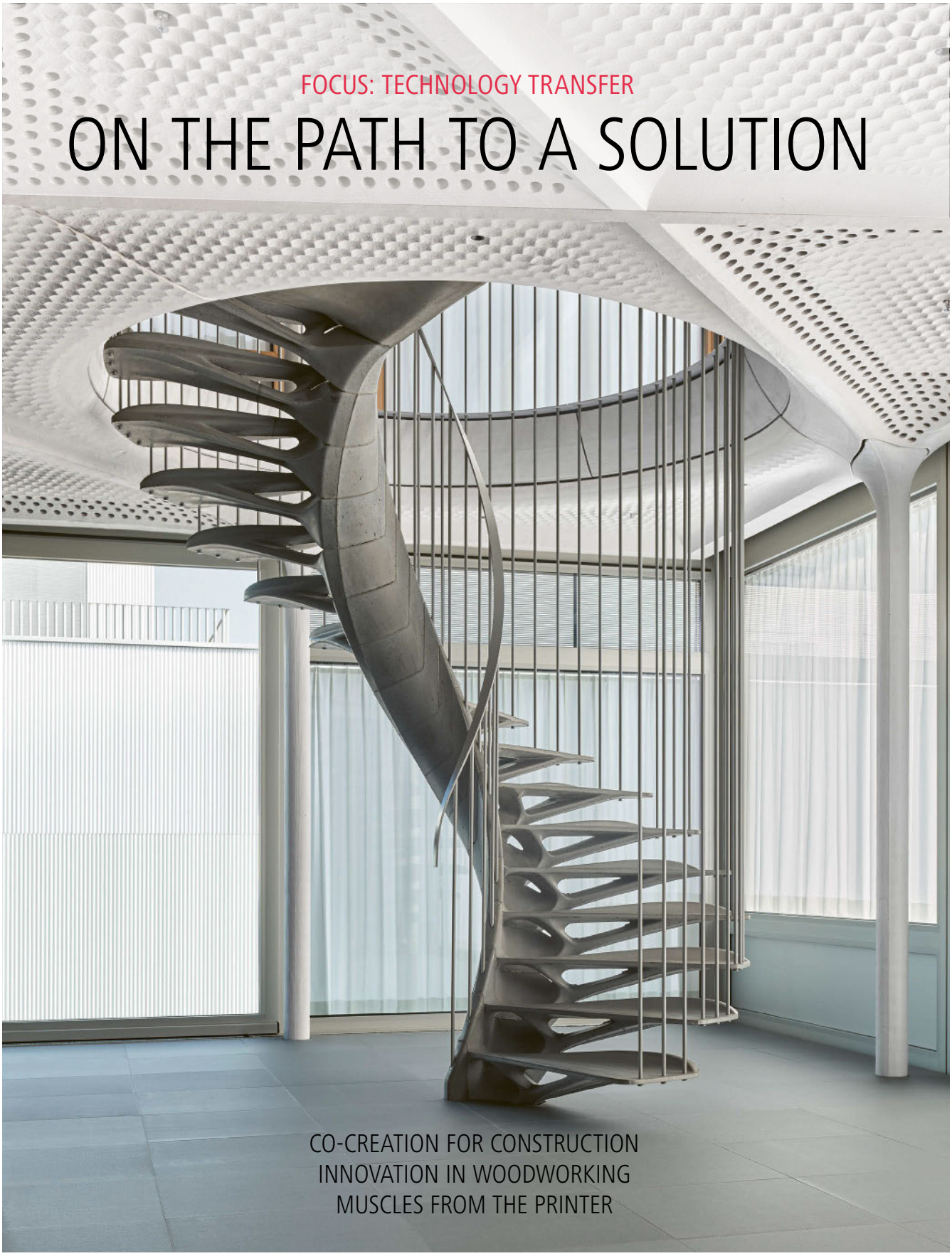
Empa Quarterly

RESEARCH & INNOVATION II #85 II OCTOBER 2024

FOCUS: TECHNOLOGY TRANSFER

ON THE PATH TO A SOLUTION



CO-CREATION FOR CONSTRUCTION
INNOVATION IN WOODWORKING
MUSCLES FROM THE PRINTER

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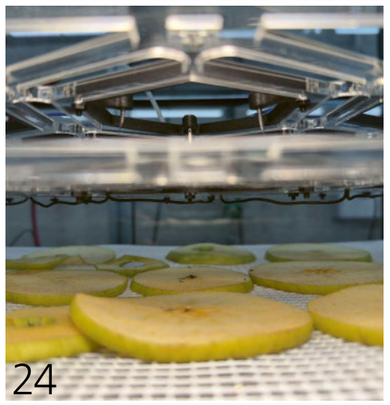
[CONTENT]

[FOCUS: TECHNOLOGY TRANSFER]


32


12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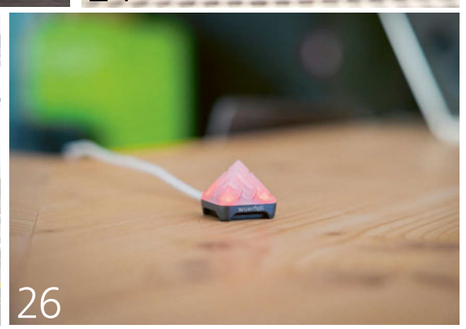
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Photos: Nicolas Zonvi, Zooey Braun, Empa, Wuerfeli by QE

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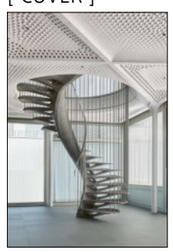

The path from an idea to a finished product is not always straight, as symbolized by the spiral staircase in the new NEST unit STEP2. At the same time, this new unit shows that true innovation can be achieved when industry and science work together. Thanks to digital design methods and 3D-printed formwork, the staircase not only looks elegant, but also saves material (p. 12). Photo: Zooey Braun

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MAKING A DIFFERENCE IN THE REAL WORLD

Dear Readers

If you pride yourself as one of Switzerland’s hotbeds of innovation – as Empa usually does – then the grandiose words should be followed by action. After all, it is often not smart ideas that are lacking, but their implementation in practice, i.e. the transfer of technologies from the laboratory to the real world. And this is precisely one of our core concerns, combined with the aim of giving Swiss companies an innovative edge in the increasingly tough global competition.

At Empa, this technology transfer takes many different forms – be it through direct industry cooperation, Innosuisse-funded projects or by founding start-ups and supporting them in our business incubators (p. 10). If these endeavours are ultimately successful, they result in innovative products, such as a credit card made of wood, an optimized sports bra or a significantly improved luminescent material that makes the timepiece on your wrist easy to read even in the dark (p. 26). Our partners range from typical Swiss SMEs (p. 15) to large global corporations (p. 12). What they have in common (like us) is a desire for innovative solutions that make our world a wee bit better.

We also showcased some of these innovations from our laboratories at our Open Lab Day in mid-September on our new research campus, co-operate, in Dübendorf. The reactions to this and the encounters and discussions were overwhelmingly positive – many thanks again from this side to all our visitors!

Enjoy reading!

Your MICHAEL HAGMANN

LIVING LUNAR LANDSCAPE
If a tooth falls out, a dental implant can be inserted into the jaw. One of the crucial factors for success is the surface structure of the material, which must be attractive to bone cells so that the implant grows stably into the jawbone. While the majority of these artificial tooth roots integrate successfully into the jawbone and last for years, some implants fail. Together with partners from industry, Empa researchers have now succeeded in structuring titanium alloys with particular precision using pulsed laser light. Using the new technology, the Innosuisse-funded team was able to shape the material surface in a way that resembles natural bone. The femtosecond flashes of laser light create a structure with depressions and elevations in the micro- and nanometer range on which the precursors of bone cells (light blue) feel comfortable, which promotes stable ingrowth of the implant (red: red blood cells).

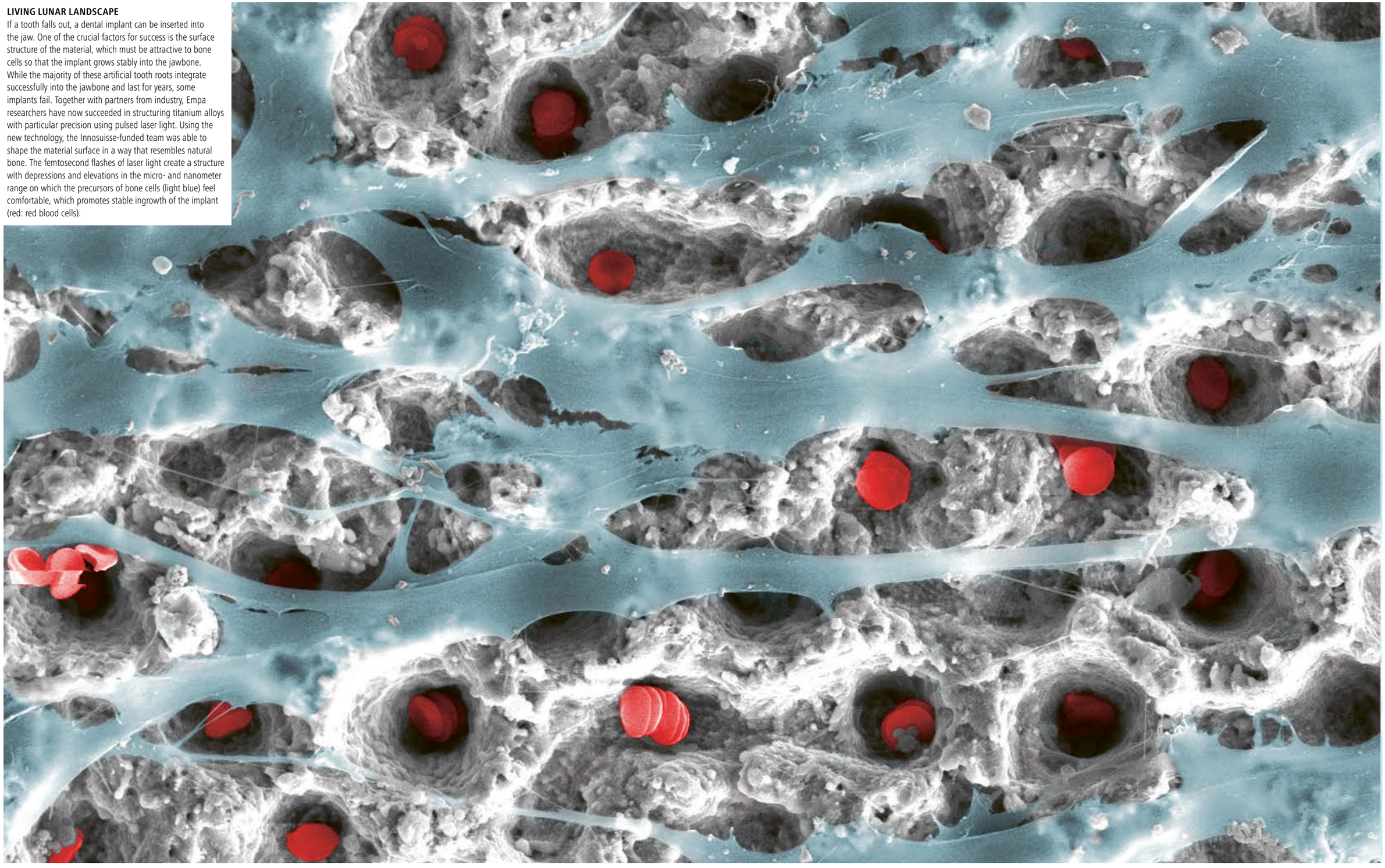


Photo: colored electron microscopy, Empa

SUCCESS
Winners, jury members and members of the organization team on stage.

AEROGEL ARCHITECTURE AWARD 2024

On July 12, the Aerogel Architecture Award was presented for the fourth time on the Empa campus in Dübendorf. A total of six projects were awarded in two categories, Realized Solutions and Student Projects. They all demonstrate innovative applications of aerogel materials in architecture and construction projects that enable major savings in terms of heat loss and energy consumption mitigation through minimal intervention in the building fabric and appearance. The winners are a renovated social housing building from Italy and a student project from Brazil.

30 YEARS OF EMPA IN THUN

On January 1, 1994, Empa opened its Materials Technology lab at the new site in Thun. Almost 30 employees from the former Materials and Testing Technology section of the Group for Armaments Services (GRD) moved from the Federal Military Department to Empa and thus to a civilian employer. Recently, the Thun campus celebrated its 30th anniversary. In the last 30 years, Empa's Thun campus has developed into an internationally renowned center for materials technology with a unique research infrastructure. Currently, around 90 people work here in two research labs, Advanced Materials Processing and Mechanics of Materials and Nanostructures.

HAPPY BIRTHDAY
Recently, Empa's Thun campus celebrated its 30th anniversary.

Photos: Empa

MATTHIAS SULZER NEW DEPARTMENT HEAD

NEW LEADERSHIP
Matthias Sulzer will take over Empa's Engineering Sciences department.

Energy and building technology expert Matthias Sulzer will take over as Head of Empa's Engineering Sciences department as of January 1, 2025. He succeeds Peter Richner, who will retire at the end of March 2025. Sulzer will also take over the co-lead of Empa's Research Focus Area Built Environment and the scientific management of NEST. Currently, he is a senior scientist at Empa's Urban Energy System lab and lectures at ETH Zurich. He also holds a visiting faculty appointment at the Lawrence Berkeley National Laboratory in the US.

ROBOTICS INNOVATIONS FOR A SUSTAINABLE FUTURE

LOFTY QUARTERS
The steel frame forms the basis for the robot aviary.

Construction work on the latest NEST unit, the DroneHub, started in early July. The open-air laboratory will serve as a bridge between the built and the natural environment. Here, the international team led by Mirko Kovac wants to investigate the extent to which drones and other autonomous robots can be used in building inspection, maintenance and repair. They also want to develop a diverse portfolio of robots and drones to collect environmental data in forests and wetlands. The DroneHub will go into operation in November 2024.

Photos: Empa

EMISSION POSSIBLE

Researchers from Empa, the University of Bristol and the Netherlands Organization for Applied Scientific Research (TNO) have investigated the emissions of the potent greenhouse gas HFC-23 from the production of Teflon and coolants. Their study shows: Abatement measures work – but are not being implemented everywhere.

Text: Anna Ettlin

BAD FOR THE CLIMATE
HFC-23 is a greenhouse gas that is produced as a by-product during the manufacturing of Teflon and coolants.

Photo: Adobe Stock

Hydrofluorocarbons (HFCs) are potent greenhouse gases (GHGs). The most potent of these compounds is trifluoromethane, also known as HFC-23. One kilogram of HFC-23 in the atmosphere contributes as much to the greenhouse effect as 12,000 kilograms of CO_2. It takes around 200 years for the gas to break down in the atmosphere. For this reason, more than 150 countries have committed to significantly reducing their emissions of HFC-23 as part of the Kigali Amendment to the Montreal Protocol.

The main source of HFC-23 is the industrial production of certain coolants and of polytetrafluoroethylene (PTFE), better known as Teflon. HFC-23 is a by-product of the synthesis of a precursor to Teflon. Since 2020, all Teflon manufacturers are obligated to destroy the climate-damaging gas. According to the reports of the individual countries, this is happening: On paper, global emissions of HFC-23 for the year 2020 were only 2,000 tons. The actual global emissions, which have been determined in numerous studies, show a different picture: In 2020 alone, around 16,000 tons of the GHG were released into the atmosphere.

ACCURATE MEASUREMENTS THANKS TO TRACER GAS

Why this discrepancy? To answer this question, researchers from Empa, the University of Bristol and the Netherlands Organization for Applied Scientific Research (TNO) took a close look at HFC-23 emissions from a Teflon factory in the Netherlands. They have just published their latest findings in the journal Nature.

In order to record the factory's emissions as comprehensively and accurately as possible, the researchers used a novel method. They released a tracer gas right next to the factory: a non-toxic gas that does not occur in the atmosphere and decomposes within just a few weeks. At a distance of around 25 kilometers, they measured the concentrations of HFC-23 and other by-products of Teflon manufacture – and also the concentration of the tracer. "Since we knew exactly how much tracer we had released and how much of it arrived at the measuring point, we were able to calculate the emissions of HFC-23 and other gases," says first author Dominique Rust, who worked on the project as part of her doctorate at Empa.

The factory utilizes abatement measures to curb its HFC-23 emissions; the gas is burned off before it can escape. But the new study shows: "The emissions we measured were higher than the ones the factory reported", explains Empa researcher Martin Vollmer. "However, the amount emitted is still low, showing that the abatement measures work well." Co-author Kieran Stanley from the University of Bristol agrees: "These results are really encouraging. They show that abatement measures for plants producing fluoropolymers like Teflon can significantly reduce emissions of this highly potent GHG." And Empa researcher Stefan Reimann adds: "If all factories had emissions similar to the one we measured, we could prevent global HFC-23 emissions corresponding to almost 20 % of CO_2 emissions from global air traffic."

VERIFICATION AND COMPLIANCE

So if the abatement measures are effective, how can the high readings in the atmosphere be explained? "We must assume that the measures reported by the countries do not correspond to reality everywhere," says Martin Vollmer. The authors of the study call on countries to have their Teflon factories independently audited. "Such independent verification of GHG emissions from the production of fluoropolymers and coolants are needed to help close the gaps in our understanding of emission sources and check that countries are fully compliant under different international climate and environment agreements," adds Stanley. "The collaboration with the Teflon manufacturer and the Dutch authorities was key to the success of our study," says Rust, who is now a research associate at the University of Bristol.

The tracer method developed by the researchers would be suitable for independent audits of factories and industrial areas – also for other gases, the scientists are convinced. Empa researchers are already planning another study in South Korea in October, in which they want to use the tracer method to determine the emissions of halogenated substances in the South Korean capital Seoul. "At the Cabauw measuring station, TNO will extend the monitoring of the GHG's in the context of the European ICOS infrastructure with continuous monitoring of halogenated substances. This allows us to track the location and determine the emission of the sources of halogenated substances that were found to pass by the station during this experiment," adds TNO researcher Arnoud Frumau. ■

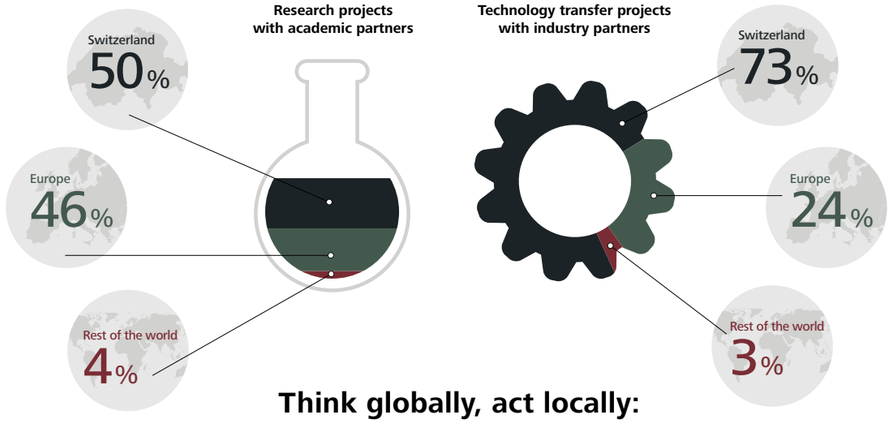
MEASURING TOWER
The measurements were carried out on the 213-meter-high mast of the Dutch Cabauw measuring station.

Photo: ICOS RI / Tom Oudijk, Sander Karsen, Dennis Manda

FROM SCIENCE TO INDUSTRY

How do innovations get out of the lab and into the wider world? There are different ways, summarized under the term technology transfer. In this interview, Marlen Müller, Head of Knowledge and Technology Transfer at Empa, explains why collaboration with industry is in Empa's DNA, what got Switzerland to the top of international innovation rankings and how researchers benefit from projects with partners from industry.

Interview: Anna Ettlin



Think globally, act locally:
research and technology transfer at Empa

Marlen Müller, what exactly is technology transfer?
Applied to Empa, technology transfer means bringing research results from our laboratories to industry. At Empa, this happens primarily through direct cooperation with companies or through the founding of spin-offs by our researchers. From a holistic perspective, however, technology transfer also involves the transfer of "brains": When our researchers take up positions in industry or in public administration, they bring the knowledge they acquired at Empa into society.

How important is technology transfer at Empa?
Technology transfer is one of the pillars of Empa, alongside research and teaching. We see ourselves as a bridge between research on the one hand and industry and society on the other. Cooperation with industry is in our DNA: Empa was founded as a materials testing institute. Even back then, the focus was on the benefits for society and the economy. Since then, Empa has evolved into a renowned research institute, but we have always maintained and even expanded our close ties with Swiss industry in particular.

Photo: Empa

Does this set Empa apart from other research institutions?
Most universities and research institutes now have technology transfer offices. As a materials science institute, however, we have a lot to offer, because practically everything industry does has to do with materials or processes. And this is precisely where Empa has its core competencies: We conduct research on the whole range of materials, from wood and ceramics to nano and quantum materials, thin films and composites. Our researchers have extensive experience with interdisciplinary and transdisciplinary collaboration, and it is quite common for several research groups with different areas of expertise to jointly develop new solutions in industrial projects, thus creating real added value for our partners. Moreover, our demonstrators NEST, ehub and move offer unique platforms to industry to test their innovations under real-world conditions.

Which type of technology transfer is most important for Empa?
Our most important channel for technology transfer to industry is direct collaboration with our industrial partners. We have around 130 Innosuisse projects every year (p. 20). These result in products, patents, software and technologies. We contractually regulate the conditions of cooperation as well as the ownership and use of the research results with our project partners. Sometimes, the project ideas come from our researchers, in other cases they arise from a direct need in industry, for example when a company wants to replace a material with an environmentally friendly alternative or optimize a manufacturing process to save energy.

How do companies benefit from such a cooperation?
Our implementation partners are often Swiss SMEs that are too small to operate their own R&D sections. Personnel, time and resources are also often scarce. However, many Swiss SMEs are global players, where they must assert themselves against international competition. Joint Innosuisse projects with Empa strengthen their innovative edge and thus the Swiss economy as a whole. But cooperation with us is also attractive for large companies. Even if they conduct their own research and development, they can venture closer to basic research with us. In Empa's demonstrators, they can test new technologies and materials in a real-world environment. A prime example of this is the brand new NEST unit, STEP2, which focuses on new digital design and production technologies with innovative materials and a comprehensive energy and comfort concept. The unit was planned and built together with BASF and other industrial partners. (See p. 12)

Graphic: Empa

And what do the researchers get out of it?
During industrial projects, our researchers can still publish their results after consultation with our partners. This is contractually regulated, as academic work is extremely important for our researchers, especially our doctoral students. At the same time, collaboration with industry is a valuable experience for young researchers. It is not uncommon for them to find jobs in industry through Innosuisse projects.

Switzerland is considered an extremely innovative country. Do we also have a well-established technology transfer to thank for this?
Switzerland is a knowledge society. We have few natural resources, so we have always had to secure our prosperity through innovation. We are particularly strong when it comes to the number of patent applications, which has earned us first place in the Global Innovation Index (GII) and similar rankings. However, we must not rest on our laurels: Great ideas alone are not enough; innovation is about actually bringing these ideas to market, i.e. introducing new or improved products, services or processes. Not to forget, countries such as China are catching up fast.

What does the future of technology transfer at Empa look like?
In future, we want to support our industry partners more closely once the project has been completed. Before the new process is implemented or the new product is launched on the market, the partner still needs to take a few important steps. This can be a challenge for SMEs in particular. In the longer term, we are currently observing a trend towards open source in research: More and more research funding agencies such as the EU are demanding open source approaches and open access to research data as a prerequisite to obtain funding. This has a huge impact on technology transfer. If a partner can no longer obtain exclusive rights to use a certain technology, they may be less willing to invest in research. We may be able to find a middle ground here and make results from the early phases of the project freely available, while the later findings are more likely to be patented. A balance between open source approaches and the protection of intellectual property will be crucial. ■

DIGITAL PRODUCTION
Digital design and construction processes help save material.

THE NEXT STEP

A digitally manufactured staircase that winds its way up to the second floor. A wafer-thin, perforated concrete ceiling that absorbs sound. Floor and wall materials made from recycled waste. The latest module in the NEST research and innovation building is a beacon for material-saving and energy-efficient construction technologies – and was created thanks to intensive collaboration between research and industry.

Text: Stephan Kälin

In Switzerland, the construction sector consumes by far the most raw materials, generates the largest amount of waste and is responsible for a third of all CO_2 emissions. With the modular research and innovation building NEST, Empa, together with more than 150 partners from research, industry and the public sector, has been working for over eight years to ensure that new technologies and materials for resource-efficient construction are developed to the point where they can make the leap into the market.

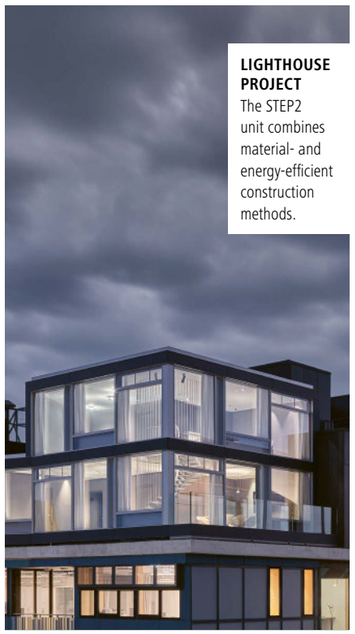
The most recent example of this is the STEP2 unit, which opened at the end of August. The two-story module combines a range of innovations, all of which are aimed at reducing material and energy consumption and promoting the circular use of our resources. “At the same time, it was crucial for us that to be able to develop solutions that are marketable and actually have a future in the construction industry,” says Enrico Marchesi, Innovation Manager at NEST. In a three-way team with main partner BASF and the architecture firm ROK, the NEST team at Empa has therefore carefully examined every idea for market relevance and developed real business cases with the numerous other partners. “For us as the main partner, the STEP2 unit serves to incorporate BASF’s broad chemical expertise into tangible, new and sustainable solutions for the construction sector in collaboration with the other partners,” says Olivier Enger, Senior Innovation Manager at BASF.

CO-CREATION IN THE CONSTRUCTION PROCESS

Accordingly, the team pursued a co-creation approach from the outset – which is rather unusual for a construction project. The results of this approach are functionally and aesthetically unique building innovations. These include, for instance, a multi-functional ceiling system or a curved concrete staircase whose material requirements were reduced to a minimum thanks to digital design methods and 3D-printed formwork. The building envelope consists of a new double skin façade, which is an important part of the energy concept, and several upcycling materials are being used for the first time in the interior fittings. ■

RESEARCH AND INDUSTRY PARTNERS

Empa
BASF
ROK Architekten GmbH
Digital Building Technologies – ETH Zurich
Aepli Metallbau AG
Stahlton Bauteile AG
SW Umwelttechnik Stoiser & Wolschner AG
WaltGalmarini AG
Bartenbach GmbH
Forward AM Technologies GmbH
Hilti AG
New Digital Craft GmbH
re-fer AG



LIGHTHOUSE PROJECT
The STEP2 unit combines material- and energy-efficient construction methods.

Photos: Andrei Jipa DBT ETH Zürich; Zooey Braun

PARTNERSHIP EYE TO EYE

In addition to individual research projects with companies, Empa also enters into strategic, long-term industrial partnerships. The cooperation with BASF is an excellent example of this: Starting with a project on the production of graphene nanostructures in 2011, numerous other topics have been worked on jointly with various Empa research teams over the years. And since 2017, BASF's Scouting & Academic Collaborations team has been based at Empa with its own offices. In this interview, Alice Glättli, Senior Vice President Group Research at BASF, gives an insight into the reasons that led to this strategic partnership.

Interview: Stephan Kälin

Alice Glättli, BASF is represented in almost 100 countries with its own laboratories and production sites. How did the partnership with Empa come about?
We are convinced that the pressing issues of the future can only be solved with innovations from the world of chemistry. This motivates us every day to develop solutions for the greatest challenges of our time – so that we can make a contribution to better protecting the climate, making optimum use of limited resources and supplying a rapidly growing world population with food, energy and clean water. Among other things, we rely on the strength of co-creation, the joint development of solutions. After all, innovations are often not created in individual companies or research laboratories, but through the exchange of knowledge and experience. Partnerships are therefore the key to our success. BASF has a research unit whose task is to evaluate technology trends worldwide and identify future technologies. This unit links external and internal networks. The Swiss team of this Scouting & Academic Collaborations unit focuses on the scouting and incubation of technologies that enable the sparing use of resources and energy, improve the quality of life in terms of acoustics, light, air and other aspects relevant to health, and contribute to the circular economy. In the search for excellent partners in these areas, one inevitably ends up at Empa, ETH Zurich and EPFL.

STRATEGIC PARTNER
Olivier Enger, Senior Innovation Manager, BASF; Alice Glättli, Senior Vice President Group Research, BASF; Tanja Zimmermann, Director of Empa; Matthias Halusa, Managing Director BASF Switzerland (from left)

What were BASF's motivations for having a team of its own based at Empa?
Developing solutions for our customers' sustainability requirements is generally a step-by-step process. This involves developing ideas together, exchanging information frequently and promptly, and working closely together. The best way to do this is to work at a common location. The Empa campus offers an ideal platform for bringing together the know-how of BASF experts with the top class of Swiss research institutions as well as innovative start-ups and other industrial partners.

BASF is the main partner of the NEST unit STEP2. What concrete insights does BASF now gain from the realization of this unit?
During the construction phase of STEP2, we used the unique, collaborative approach of NEST for several pioneering innovation projects. For example, we worked with other partners to develop an innovative acoustic box that can be integrated into the ceiling. The 3D printing process used makes it possible to easily adapt the box to the shape of the ceiling, optimize the geometry and performance of the box and improve its acoustic properties. A recyclable clay foam from BASF is used inside the box, which ensures pleasant room acoustics – and delivers an amazing insulation result with minimal use of materials. We have also developed processes and materials based on the principles of upcycling to create high-performance surface coverings from waste materials. Thanks to innovative binding agents, old denim fibers can be recycled and used for the production of floor tiles. A similar process enables the production of durable and high-quality furniture surfaces from coffee grounds. The real-life implementation of these technologies in NEST is of enormous importance to us and therefore also to our customers, so we are delighted that we will be able to continue using STEP2 as a co-creation platform and innovation workshop in the future. ■

Photo: Marion Nitsch

Photo: Empa

SIGNED BY FUNGI

Local and yet exclusive, natural and yet high-tech: Spalted wood combines contradictions. This very special wood is characterized by patterns of fine black lines, which it owes to a fungus. What used to be a rare chance find in the forest is now a standardized manufacturing process – thanks to the collaboration between Koster AG Holzwelten and Empa.

Text: Anna Ettlin

SPALTED WOOD
The pattern does not remain on the surface, but runs through the entire thickness of the spalted board.

What do you expect from a wood-working business? Precise work and beautiful products, perhaps furniture or a fine parquet floor. Large machines, but also a good deal of manual craftsmanship. Koster Holzwelten, a family business in Arnegg near St. Gallen, offers all of this. In an outbuilding, however, the company shows a completely different, rather unexpected side. Here, in a time-honored, listed building, there are stainless steel containers, laboratories and climate and vacuum chambers. Sterility is a top priority here, and both humidity and temperature are strictly controlled. This is where a unique product is born: spalted wood, which the company developed in collaboration with Empa.

It all started with a few wavy black lines that Jakob Koster, CEO at the time, discovered on a piece of wood from his workshop. Koster showed the piece to Empa researcher Francis Schwarze. The expert in fungi immediately recognized the drawing as a trace of a sac fungus. This inconspicuous fungus is primarily known as a hard-to-detect pest on deciduous trees. However, due to its ability to produce the dark pigment melanin, it has also always been known as a wood refiner. “In the past, tree trunks were left in the forest for several months in the hope that they would be colonized by the right fungus,” says Schwarze. That wasn’t good enough for Jakob Koster. What if we could produce the coveted spalted wood in a controlled manner, the entrepreneur asked himself?

The idea turned into an Innosuisse project. Together, Koster AG Holzwelten and Empa developed a standardized, scalable process for the production of spalted wood. “I would never have thought that we as an SME could develop something so innovative with a research institute like Empa,” says Koster. The great commitment on both sides has borne fruit: Now, around seven years later, the unique product is on the market.

A CONTROLLED INFECTION

Nothing is left to chance in the production of spalted wood. The boards, which can be up to two and a half meters long, are brought to the correct humidity in a vacuum chamber, sterilized and inoculated with the fungus. They then spend several weeks in a climate chamber while the fungus etches its markings into the wood. With the know-how gained during the project in the Empa laboratories, Koster AG Holzwelten can control and refine the appearance of the melanin pattern.

Once the fungus has completed its work, the wood undergoes a technical drying process, which simultaneously kills the fungus. “The special thing about this particular fungus is that it does not break down the heavily lignified areas of the cell wall; the wood thus retains a high degree of flexural strength,” explains Schwarze. The resulting spalted wood with its dancing lines is particularly suitable for decorative applications, for example for furniture, interior design, musical instruments and even jewelry. Inquiries are already piling up, reveals Jakob Koster, who has now handed over the management of the company to his son and is devoting himself entirely to sales and innovation.

Numerous hardwood species are suitable for the production of spalted wood. Koster AG Holzwelten relies on native species such as maple, beech, ash, linden and poplar. Today, these types of wood are mainly used for heating, since they are not considered attractive enough for other applications. “Wood is an important CO_2 sink – as long as you don’t burn it,” says Empa researcher Schwarze. Refining locally produced wood is also a sustainable alternative to exotic import timber. “We have to learn to develop innovative products with our local resources in Switzerland,” summarizes Koster.

PATTERNED
Numerous native hardwood species can be processed into spalted wood, such as ash (above) and maple (below).

Photo: Empa

HARD WORK, INVENTIVENESS – AND A BIT OF LUCK

Innovation needs more than just a clever idea: It takes a lot of hard work to turn promising laboratory results into marketable products. No one knows this better than Lewis Douls, who has accompanied the spalted wood project through this transition. The chemist originally came to Empa on a civil service placement. However, he was so enthusiastic about the work in the fungal laboratory that he stayed at the research institute – until he moved to Koster AG Holzwelten two years ago to take over the upscaling of the spalted wood production.

No easy task: Cultivating fungi in a controlled manner is a high-tech undertaking. The conditions that the melanin-producing sac fungus needs to grow are also ideal for countless other types of fungi, and fungal spores are everywhere. “Sterility was the biggest challenge,” recalls Douls. Another challenge was cost-effectiveness: A fully equipped biotechnology laboratory does not simply spring up like a mushroom. Expensive equipment, such as autoclaves for sterilization or vacuum chambers for wood humidification, were needed. Here, however, Koster AG Holzwelten was helped by its inventive spirit – and a good dose of luck. The company was able to take over a large part of the climate chambers from a retired mushroom grower. The laboratory equipment came from ETH Zurich, which had commissioned the company with a renovation. What’s more, Douls was able to optimize certain process steps, such as the sterilization of the boards, so that a large autoclave was no longer required.

Francis Schwarze is impressed by the effort his project partners have put into the facility. “It’s not a matter of course for an SME to acquire so much knowledge and to set up its own laboratory,” says the researcher. Schwarze and Douls agree that the company is now even better equipped for cultivating the wood fungus than the Empa laboratory where the project started.

With the challenges overcome, the production line is up and running, and the fungi are doing their decorative work in the air-conditioned chambers. The next step, as Jakob Koster knows, is sales. After the long development period, the new product must become commercially viable. However, the project partners already have new ideas for the future. For now, they are willing to reveal just this: The perfect combination of wood and fungus can do so much more … ■

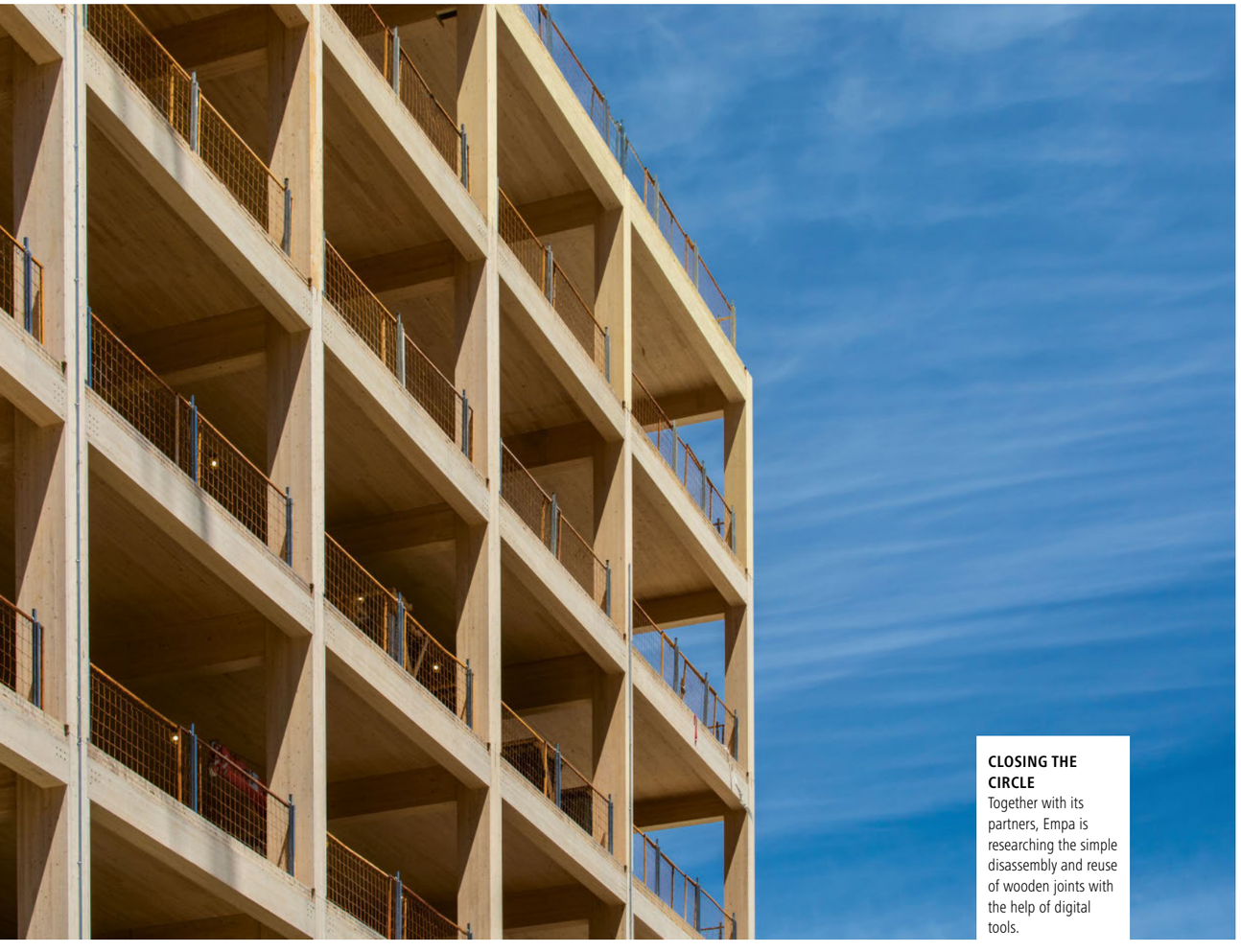
MUSHROOM COMPUTER
A special computer controls the climate in the cultivation chamber.

Photo: Empa

BACK TO THE FUTURE WITH WOOD AND CLAY

Traditional building materials such as wood and clay are climate-friendly and perfectly complement each other. To ensure they can also be used on a large scale in the construction industry in the future, Empa is teaming up with Swiss universities and industrial partners in an Innosuisse-funded Flagship project called Think Earth – Regenerative Building.

Text: Manuel Martin



CLOSING THE CIRCLE
Together with its partners, Empa is researching the simple disassembly and reuse of wooden joints with the help of digital tools.

Photo: Adobe Stock

It is well known that the construction industry contributes significantly to climate change with its massive greenhouse gas emissions. However, it is less clear how CO_2 emissions can best be reduced. The Innosuisse Flagship project (see box) Think Earth – Regenerative Building is taking a promising approach. Here, a large consortium is focusing on modern construction techniques using timber and clay to reduce the environmental impact of the construction industry.

The combination of these environmentally friendly materials enhances their individual advantages: Timber provides the necessary load-carrying capacity and stiffness, while clay adds additional load-carrying capacity and mass, which contributes to heat regulation, vibration damping and fire safety. By 2029, efficient and scalable construction methods are to be developed in various sub-projects in order to advance climate-neutral construction and living.

FLEXIBLE TIMBER CONNECTIONS IN DEMAND

Although wood is a renewable natural resource, it must be reused if it is to be used sustainably in the construction industry. Currently, the reuse rate of wood is only 10 percent – as part of the Flagship project, this is to be increased to 90 percent with the help of other renewable materials such as earth-based building materials. Timber connections play an important role here. In contrast to concrete structures, which are cast as monolithic structures, timber structures rely on the connection of individual components. According to Empa researcher Pedro Palma, these are just as important as the timber components themselves and are often more critical from a structural point of view. "The connections ensure continuity and improve the structural behavior through various properties, such as the ability to deform and dissipate energy, that the wooden components themselves cannot offer." In a sub-project, Empa's Structural Engineering Laboratory is working with researchers from ETH Zurich, Bern University of Applied Sciences BFH and 13 industrial partners on the disassembly and reuse of timber connections. At the same time, they are developing digital tools to support this process, thus strengthening circular economy.

PREVENTING SHRINKAGE

Earth-based building materials have a good carbon footprint, and raw earth is available in almost unlimited quantities. However, they are often only used for smaller applications such as bricks, as their structure shrinks and cracks as they dry. According to Pietro Lura, Head of Empa's Concrete and Asphalt Laboratory and Professor at ETH Zurich, suitable additives are crucial to avoid this. "Clay can always be reused as long as it remains unchanged. However, as soon as a mineral stabilizer is added, the energy balance and recyclability deteriorate." To solve this problem, researchers from ETH Zurich and Lura's team are working together with industrial partners BASF Schweiz AG and Eberhard Bau AG on bio-based and biodegradable additives. The researchers are testing their ability to reduce shrinkage while maintaining recyclability and hydroscopic capability. "The big challenge is to find functional additives that are both made from natural raw materials and biodegradable," says Yi Du, researcher at Empa and ETH Zurich. The most promising additives are being tested on a large scale in order to use green chemistry to produce crack-free clay-based building materials and reduce the amount of excavated earth. ■

FLAGSHIP INITIATIVE: BIG QUESTIONS, BROAD NETWORK

With its Flagship initiative, the Swiss Innovation Agency Innosuisse promotes systemic and transdisciplinary innovations that are of central importance for the economic and social challenges in Switzerland. Unlike other Innosuisse projects, which usually solve specific problems of individual SMEs or start-ups, researchers from various institutions work together with numerous industry partners on an overarching issue. The Flagship project Think Earth – Regenerative Building comprises ten sub-projects ranging from materials science and process engineering to prototypes for building construction as well as case studies and standards for architecture. The aim is to lay the foundations for climate-neutral construction with hybrid elements made of timber and clay.

INNOVATION IS TEAMWORK

Innosuisse, the Swiss innovation promotion agency, supports research-based innovation in order to strengthen the competitiveness of the Swiss economy. As part of Innosuisse projects, companies work together with universities or research institutes such as Empa to bring innovative ideas to the market. Empa is currently involved in around 80 running projects of this kind. Here are four of them.

Text: Anna Ettlin, Andrea Six

COMFYPAS: CRYSTAL PROTECTION FOR SATELLITES

On their journey from the Earth's surface into orbit, satellites are exposed to enormous forces – a challenge for the high-tech devices, which often contain highly sensitive instruments. The biggest

issues are not caused by the strong acceleration during the rocket launch, but by dynamic loads. These occur primarily during separation events, when spent fuel tanks or the payload fairing are jettisoned via a controlled detonation of small explosive devices. The structure to which the satellite is attached, the so-called payload adapter, transmits the vibrations to the satellite itself. Together with the Swiss space company Beyond Gravity, Empa researchers Marco Ravasi and Andrea Bergamini are working on a new type of payload adapter designed to reduce hazardous vibrations. They are using so-called phononic crystals for this purpose. "Depending on their structure, crystals can reflect, scatter or diffract light in very different ways," explains Bergamini, research group leader in Empa's Acoustics / Noise Control laboratory. Phononic crystals use this particular property of crystal structures – just for sound waves instead of light. With the right structure, the harmful vibrations can be reflected or attenuated in such a way that they no longer pose a threat to the sensitive payload.

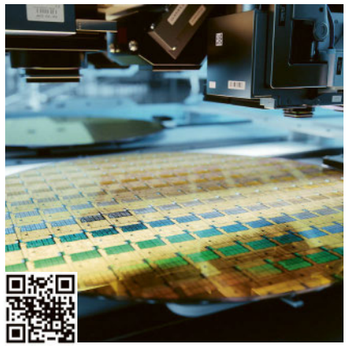
GREENPEEL 2.0: TURNING WOOD INTO LEATHER

Vegan leather alternatives often rely on polyurethane, a plastic typically made from petroleum – not exactly the most environmentally friendly solution. Although some renewable alternatives exist, they are not yet fully convincing. Together with the Swiss start-up BINOVA AG, Empa researchers are working on a sustainable vegan leather that can match the original. It should

Photos: Adobe Stock

be robust and hard-wearing, have an elegant look and feel and be based on renewable materials as much as possible. To achieve this, the project partners utilize two natural polymers: cellulose and lignin. Cellulose, the basic building block of plant cell walls, is the most abundant biomolecule on Earth. Lignin, one of the main components of wood, is also available in large quantities: It is a by-product of paper production, which is largely incinerated today. Empa researchers led by Gustav Nyström, head of Empa's Cellulose & Wood Materials laboratory, in collaboration with their industrial partners, now want to use these abundant, renewable raw materials to develop a leather alternative that emits up to 80% less CO_2 and uses up to 90% less water than real leather.

THREE FREE: NO LEAD, NO CRY



Photos: Adobe Stock

Few fields demand such high precision as the semiconductor industry. The tiny computer chips and other components are manufactured under extreme conditions. Depending on the process step, temperature extremes, vacuum or strong acids are involved. To ensure proper conditions at all times, they are monitored by various sensors, which in turn have to withstand the adverse environments. This is a challenge for suppliers to the semiconductor industry, such as the Swiss company Inficon AG, which manufactures highly sensitive vacuum sensors, among other things. The manufacturer uses a particularly resistant glass to connect the sensor components. However, with increasing EU regulations restricting dangerous substances, the lead-containing glass was suddenly no longer available. The search for alternatives on the market was unsuccessful, so Inficon approached Empa. In cooperation with the company, Empa researchers led by Gurdial Blugan from the Laboratory for High Performance Ceramics succeeded in developing a lead-free glass that fully meets the high demands. At the same time, the researchers have devised new methods to precisely characterize the new lead-free glass. Following the successful completion of the first project, the partners have already started a follow-up to make the high-tech glass even better.

MALCOFIL: A MOSQUITO NET WITH ANTI-MALARIA EFFECT

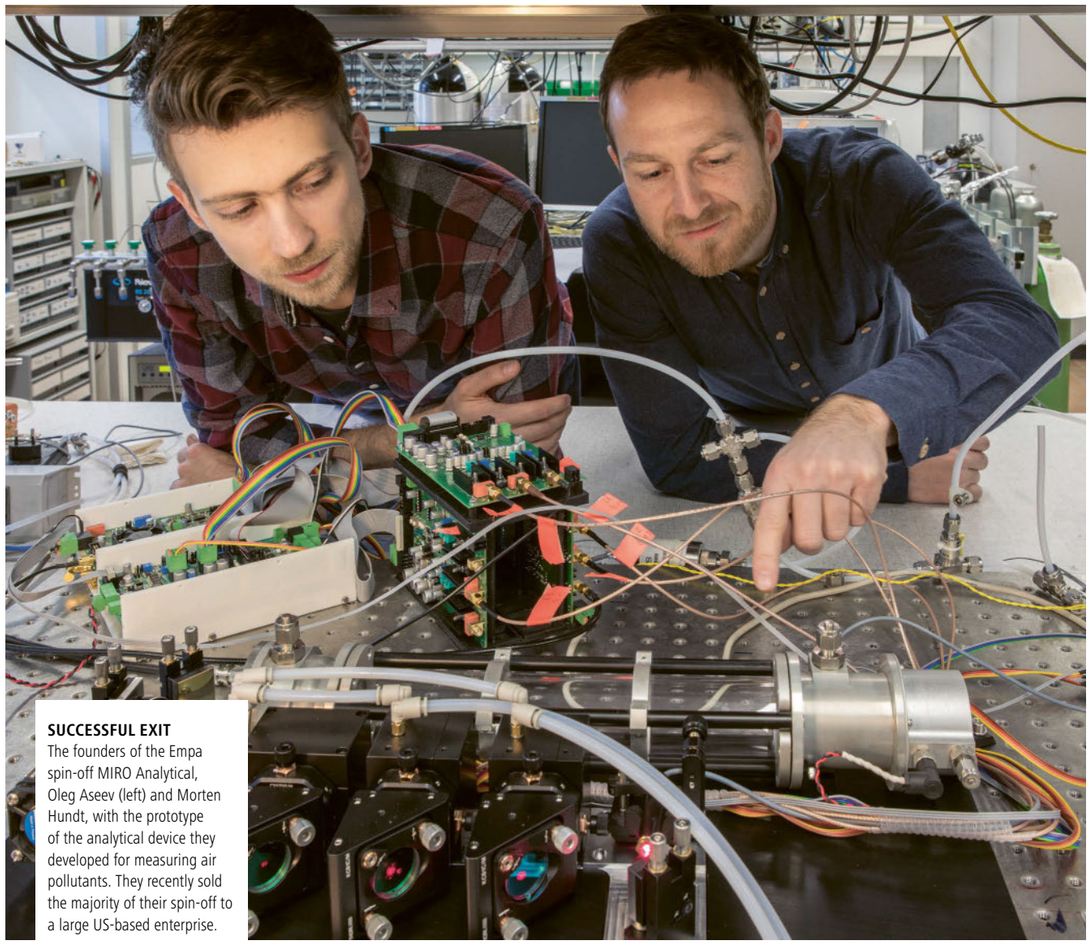
The mosquito is the deadliest creature on earth. Every year, over 600,000 people worldwide die from malaria alone, which is transmitted by mosquitoes. The best protection against infection is provided by impregnated mosquito nets. However, the dangerous Anopheles mosquito is now resistant to many common insecticides. Empa researchers are therefore working together with Swiss companies Vestergaard Sàrl and Monosuisse AG on new types of mosquito nets that effectively kill mosquitoes. In future, the nets should retain their insecticidal effectiveness for years and thus decimate the mosquitoes particularly efficiently. This is achieved using innovative core-sheath fibers which, due to their composition and manufacture, contain new effective insecticides inside them. Empa researcher Edith Perret from the Advanced Fibers laboratory in St. Gallen is confident: "The two-component fibers will enable the production of a

new generation of mosquito nets with effective malaria protection." First field studies in Africa with the new netting materials are planned for next year.

WHERE YOUNG COMPANIES TAKE OFF

For years, start-ups have been able to count on the support of the business incubators glatec and Startfeld. They accompany Empa's young companies on their path to independence – and do so extremely successfully, as the 37 spin-offs founded to date show.

Text: Manuel Martin



SUCCESSFUL EXIT
The founders of the Empa spin-off MIRO Analytical, Oleg Aseev (left) and Morten Hundt, with the prototype of the analytical device they developed for measuring air pollutants. They recently sold the majority of their spin-off to a large US-based enterprise.

Photo: Empa

Instruments for measuring air pollutants are usually complex, expensive and consume a lot of energy, as each gas is measured using a different method. The multi-gas analyzers from MIRO Analytical are completely different: They analyze up to ten greenhouse gases and pollutants quickly and precisely at the same time with just one device. When the Empa spin-off from Wallisellen was founded, the aim was to make air quality and greenhouse gas measurements simpler, more accurate and cheaper – and it succeeded big time: Since last fall, MIRO Analytical has been majority-owned by the Bruker Corporation, a group of companies in the field of instrumental analysis headquartered in Massachusetts. After IRsweep and CTSystems, another Empa spin-off has thus been taken over by a market leader.

START-UP SUPPORT FOR YOUNG COMPANIES

"A successful exit, i.e. the sale of a start-up, is rather rare for high-tech niche products, as they usually grow slowly and almost never change hands," says Mario Jenni, Managing Director of glatec. The support association glatec has been successfully operating a business incubator in Dübendorf since 2009 for Empa, Eawag and now also for WSL in order to facilitate and promote start-ups in the fields of materials science, environmental science and technology. On average, around ten young companies are housed at glatec, which require a wide range of support – from premises and market clarification to coaching for discussions with potential investors.

Every year, around four new spin-offs are added – usually two from Empa, one from Eawag and another external one, for example from ETH Zurich. Start-up funding has received an additional boost through the Empa Entrepreneur Fellowship, which supports young researchers for a year in setting up a company. For example, Empa researcher Abdessalem Aribia and Moritz Futscher founded the Empa spin-off BTRY in 2023, which was immediately accepted by the Business Innovation Center Switzerland of the European Space Agency ESA. Their thin-film batteries are safer, more durable and more environmentally friendly to manufacture than conventional lithium-ion batteries.

THE MAKING OF NEO-ENTREPRENEURS

The counterpart to glatec in Dübendorf is Startfeld in St. Gallen. The support association was founded in 2010 by Empa together with the University of St. Gallen, the University of Applied Sciences East and the City of St. Gallen and took over the activities of Empa's former business incubator TEBO. Startfeld was recently awarded the prestigious Financial Times Award for the first time, making it one of Europe's leading Start-up Hubs in 2024. Another success story that is also reflected in the cross-location figures: The 37 Empa spin-offs founded so far, together with the other start-ups in the two business incubators, employ a total of more than 1100 people – which roughly corresponds to a doubling of the number of jobs, relative to Empa.

So what does it take to be successful as a start-up? According to Peter Frischknecht, Head of Startfeld since 2011, the questions are significantly different in science than in business – so neo-entrepreneurs need a certain amount of rethinking. "Startfeld therefore helps to transform researchers into company founders." He supported and developed Empa's start-up support in St. Gallen for years as part of the technology transfer team until it was integrated into the then new Switzerland Innovation Park East in 2022. In future, start-ups will receive even more targeted support at the beginning of their growth phase. "There are many good ideas and patents in Switzerland, but there is also a noticeable reluctance to scale up. Unfortunately, this means that some of the potential can only be partially exploited," says Frischknecht, explaining the challenge. The HSG START Accelerator is currently being set up in cooperation with the University of St. Gallen and the student initiative START Global.

FLEXIBILITY IS KEY – AND A STRONG TEAM

"Young entrepreneurs know their technology down to the last detail, but they often lack a view of the market," adds Mario Jenni. However, an invention will only be successful if it solves or at least alleviates a real problem. Entrepreneurial flexibility is crucial here: If things get stuck, there should be a willingness to adapt the business model, the technological focus or the team. "However, it is often difficult for company founders to detach themselves from their original idea and perhaps focus on a scientifically less interesting but marketable by-product." Ultimately, the team also plays a decisive role: Promising technologies often fail on the market due to a lack of flexibility and market orientation. On the other hand, strong teams can succeed even with less convincing products. ■

CLEVER START-UP IDEAS

If no industrial partner can be found for a promising new technology, researchers frequently become entrepreneurs themselves. Spin-offs are young companies that emerge directly from Empa's research. They develop products and services that do not yet exist – as these four examples show.

Text: Andrea Six, Anna Ettlin, Manuel Martin

BTRY: THINNER, FASTER, BETTER

Lithium-ion batteries are currently our most advanced battery technology, but they do have some weaknesses. They lose capacity with every cycle, charge relatively slowly and only work well in a narrow temperature range. Moritz Futscher and Abdessalem Aribia are convinced they can do better. Together, the two former Empa researchers have

founded the spin-off BTRY, which is developing a completely new type of thin-film battery. Not only is it safer and more durable than conventional lithium-ion batteries, it is also much more environmentally friendly to manufacture and can be charged and discharged in just one minute. Their vision has been well received: Since its founding last year, BTRY has already completed a successful financing round and made it to the third stage of the Venture Kick program, as well as earning a place among the Top 100 Swiss Start-ups. What began with prototypes of just a few millimeters is now a cell measuring around ten by ten centimeters that is still as thin as a hair. The long-lasting and fast thin-film batteries are in particular demand in the fields of medical technology, sensor technology and consumer electronics.

ANAVO MEDICAL: IMPROVED WOUND HEALING WITH NANOPARTICLES

Poorly healing wounds are a major burden for those affected and an increasing cost factor for the healthcare system. The start-up anavo medical aims to remedy this with innovative materials based on nanoparticles. The healing nanoparticles are to be used, for example, as a spray for chronic wounds caused by diabetes or as an aqueous solution for wound healing disorders after operations. The metal oxide nanoparticles work by reducing inflammation and killing bacteria. "What's more, the nanoparticles also stimulate the body's own healing processes by promoting the formation of healthy tissue," says

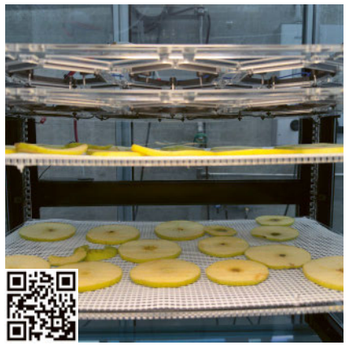
Photos: Empa

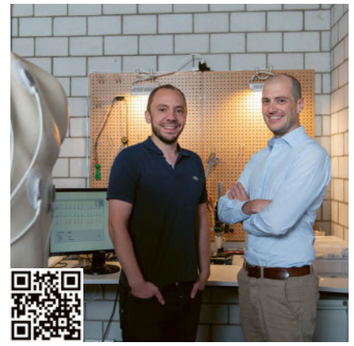
anavo co-founder Tino Matter. Another advantage of the technology developed by researchers at Empa's Particles-Biology Interactions laboratory in St. Gallen in collaboration with the Nanoparticle Systems Engineering Lab at ETH Zurich is that it is based on inexpensive materials that can be produced on a large scale. For this innovative achievement in technology transfer, anavo received the Empa Innovation Award and the Best Swiss Nanotech Startup Award, among others. Following promising laboratory results, the first clinical trials with patients are planned for the near future.

IONIC WIND TECHNOLOGIES: ENERGY-EFFICIENT COOLING THANKS TO IONIC WIND

Data centers consume vast amounts of energy – around 40 percent of it for cooling microprocessors alone. Novel cooling methods using ionic wind could drastically reduce this. These devices use electrostatic fields to convert electrical current directly and efficiently into a stream of air. The low speeds of the generated airflow have so far prevented widespread use. Now the multi-award-winning Empa spin-off Ionic Wind Technologies has achieved a breakthrough: Their novel airflow amplifier accelerates ionic wind much more strongly than before – thanks to new types of electrodes combined with a flow-optimized housing shape. If, for instance, conventional fans in data centers were replaced by their patented technology, up to 60 percent of cooling energy could be saved. According to spin-off founder Donato Rubinetti, the technology developed is suitable for industries that rely on cooling systems, drying processes and air purification. "I see potential wherever air needs to be moved with a small pressure difference, for example in the drying of food, which we have already done and know very well. In future, however, it will also be used primarily for cooling computers, servers and data centers."

Photos: Empa





NAHTLOS: COOL CLOTHING

Summer heat is particularly hard on people whose body's own temperature regulation is limited, for instance people with paraplegia, who are unable to sweat in the affected areas of their body. This is where the developers of the St. Gallen medtech start-up Nahtlos come in with their cooling garments: Equipped with a semi-permeable textile layer with a water reservoir, the clothing uses the cooling effect of evaporating water. "The cooling vest draws heat from the skin in this process, which provides relief from overheating," says José Näf, co-founder of the Empa spin-off. "There is great demand for products of this kind – also for use in heat-intensive working environments, such as road construction or production facilities," says the neo-entrepreneur. The team led by founding partner and former Empa researcher Michel Schmid is also working on further developing the textile ECG electrodes "Duratrode", which have already been successfully launched on the market, for high-volume production.

PRODUCTS WITH "EMPA INSIDE"

Technology transfer is a long and complex, sometimes tedious process. Not all research projects lead to a market-ready product – but some do. Here you will find a selection of products in whose development Empa has played a significant role. Some have been on the market for some time, others hit the shelves only recently. What they all have in common: They contain a piece of Empa.

Text: Anna Ettlin, Andrea Six

AMPHIBIOUS ATHLETIC WEAR

Skin wounds, connective tissue damage, muscle tension: Suboptimal sports bras can have unpleasant consequences. The Swiss TechTex start-up Swijin has therefore launched new sportswear on the market to change this: Swijin products are sets consisting of a sports bra and bottom that work as both swimwear and running gear and dry at lightning speed – up to five times faster than conventional swimwear or sportswear. The products were developed together with Empa researchers in an Innosuisse project. The resulting new textile technologies for sports bras are already patent pending.

A PYRAMID FOR BETTER AIR QUALITY

The Wuerfeli makes the air quality visible in an elegant way. The compact gas sensor changes color as soon as it is time to let fresh air into the room. It measures the concentration of stale breathing air indoors and thus offers an easy way to monitor the indoor climate. Developed in collaboration with Empa as part of a comprehensive study on air quality in 150 classrooms, the sensor is a reliable and proven measuring device for healthy air. Produced in Landquart (GR) by the start-up Quanta Elusio (QE), the Wuerfeli is now also available on Galaxus.

EMPA SHINING FROM YOUR WRIST

Empa research helps Swiss watches glow in the dark, including the MoonSwatch collection, a cooperation between Swatch and Omega. Both the hands and hour markers of these watches are coated with the luminescent material Swiss Super-LumiNova Grade X1. From 2013 to 2015, it was jointly improved by the Appenzell-based company RC Tritec AG, Empa and the University of Geneva as part of a CTI-funded project (Commission for Technology and Innovation, now Innosuisse). The luminescent material is based on strontium aluminate. Through a complex mechanism, the material stores incoming light and emits it later. By refining the process steps, the partners made the substance glow even longer and brighter.

WOOD IN THE WALLET

Where conventional credit and debit cards are made of plastic, the Empa spin-off Swiss Wood Solutions relies on wood. The company has developed a credit card made from native wood species such as cherry, oak or spruce. The highlight: Unlike other wooden cards, the card from Swiss Wood Solutions does not need a plastic core. The card body consists of just four layers of veneer and one layer of paper. At the end of its service life, the high-quality card can therefore be composted – only the built-in chip, the antenna and the magnetic strip, which is currently still mandatory, are left behind. The technology is not limited to bank cards: Membership cards, access cards, business cards and company ID cards are also possible.

Photos: Wuerfeli by QE, Swiss wood Solutions

Photos: Swijin, Empa, Tisca

SPORTS TURF FOR THE STARS

The best drama is played out on this theater stage: The large green parquet for 22 stars and a single prop, the football. When artificial turf comes into play, its durability and sure-footedness are in demand. The Swiss textile company Tisca in Bühler (AR) has joined forces with Empa researchers from the Advanced Fibers laboratory to develop core-sheath fibers consisting of two polymer components. To prevent abrasions in the event of a tackling and fall, the surface of the fibers is soft, while the hard core provides stability. The product is already in use on international pitches, for example at the London football club Arsenal.

ARE NANOPLASTICS DANGEROUS FOR BABIES?

Allergies and asthma are widespread diseases that could arise during embryonal development. A team led by Empa researcher Tina Bürki is investigating nanoplastic particles, which could lead to the development of a hypersensitive immune system in the child. The project is supported by the Eduard Aeberhardt Foundation and another foundation.

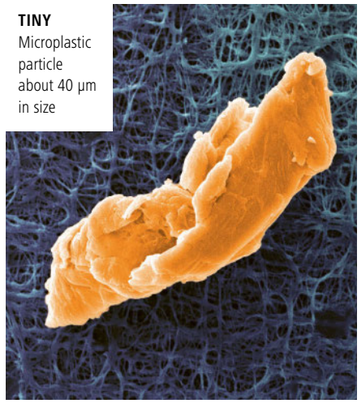
Text: Andrea Six

Asthma, hay fever or chronic skin conditions: The occurrence of allergic reactions is on the rise. Environmental factors during the early development in the womb are suspected, which lay the foundation for later illnesses. A team of researchers from Empa, ETH Zurich, EPFL, the University of Zurich and the Cantonal Hospital of St. Gallen is now focusing on micro- and nanoplastics. It is known that the tiny plastic particles enter the body via drinking water, food and air and find their way to the unborn child. Here they could affect the immune system of mother and child. Moreover, they are able to transport other pollutants, allergens and pathogens.

The research project now aims to provide a holistic view of the significance of plastic particles during pregnancy. To achieve this, experts from the fields of materials science, cell biology and allergy research are working together with clinical experts. The project is funded by the Eduard Aeberhardt Foundation and another foundation.

CORRECTLY ASSESSING RISK

The team led by Tina Bürki and Sina Ruhstaller from Empa's Particles-Biology Interactions laboratory are particularly interested in the placenta. The organ forms exclusively during pregnancy and supplies the child with nutrients and messenger substances. The placenta could therefore play a decisive role when it comes to the immune response to foreign substances.



TINY Microplastic particle about 40 µm in size

It is already clear that nanoparticles can disrupt the communication between the placenta and the child. However, the effect of micro- and nanoplastics on the immunological function of the placenta and the effects on the fetal immune system have not yet been elucidated. "There is an urgent need for a correct risk assessments of environmental pollutants for pregnant women," says Bürki.

In order to analyze the process of nanoparticle exposure, the researchers will examine the micro- and nano-abrasion of everyday plastic products and evaluate the interactions with allergy-causing substances and pollutants. Using cell cultures of the human placenta and fetal blood cells, the transport in the body and the reaction to the particles can be mapped realistically. "By releasing hormones and mediators, the placenta could contribute to abnormal developments in the child's immune system," says Tina Bürki. For the sustainable use of safe plastic products, it is therefore essential to know whether and which polymers have an increased potential to trigger allergies. ■

PRIVATE SUPPORT THAT MAKES THE DIFFERENCE

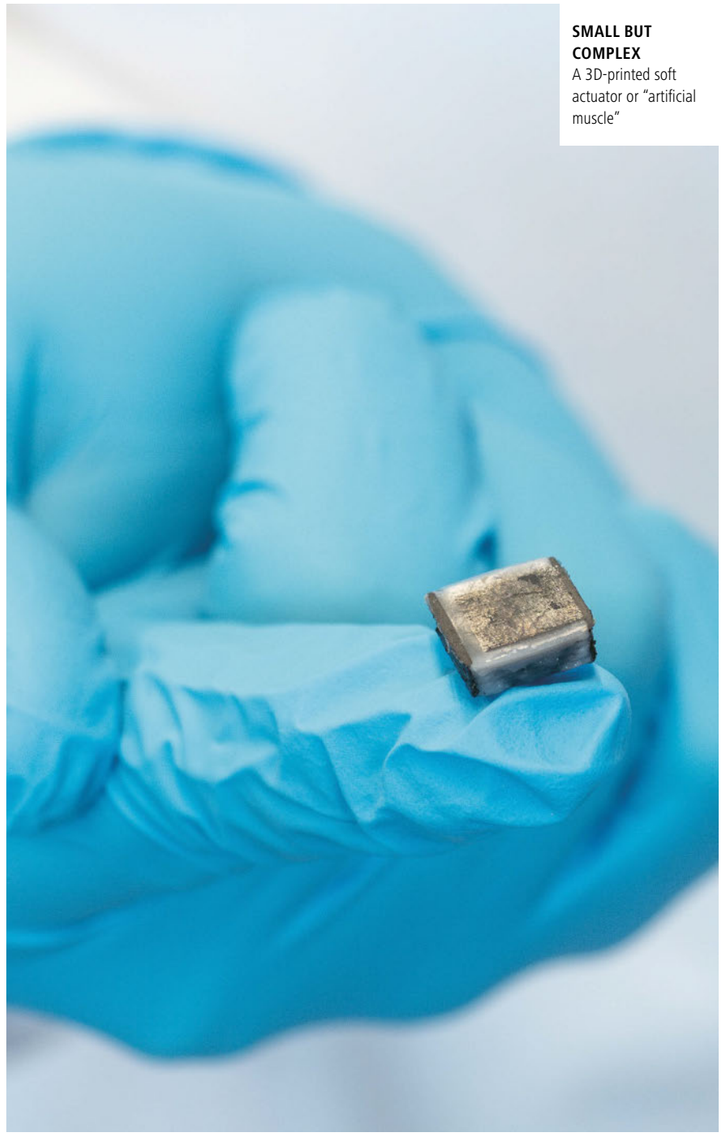
Thanks to generous donations from the Eduard Aeberhardt Foundation and another foundation, the project could get started. However, further funds are still being sought. The Empa Zukunftsfonds is looking for private funding for pioneering research projects that are not yet (fully) supported. If you would also like to make a contribution to the project, you can find our donation form here:

Photo: Martin Pivokonský / The Czech Academy of Sciences / Empa

MUSCLES FROM THE PRINTER

Empa researchers are working on artificial muscles that can keep up with the real thing. They have now developed a method of producing the soft and elastic, yet powerful structures using 3D printing. One day, these could be used in medicine or robotics – and anywhere else where things need to move at the touch of a button.

Text: Anna Ettlin



SMALL BUT COMPLEX
A 3D-printed soft actuator or "artificial muscle"

Photo: Empa

Artificial muscles don't just get robots moving: One day, they could support people at work or when walking, or replace injured muscle tissue. However, developing artificial muscles that can compare to the real thing is a major technical challenge. In order to keep up with their biological counterparts, artificial muscles must not only be powerful, but also elastic and soft. At their core, artificial muscles are so-called actuators: Components that convert electrical impulses into movement. Actuators are used wherever something moves at the push of a button, whether at home, in a car engine or in highly developed industrial plants. However, these hard mechanical components do not have much in common with muscles just yet.

RECONCILING CONTRADICTIONS

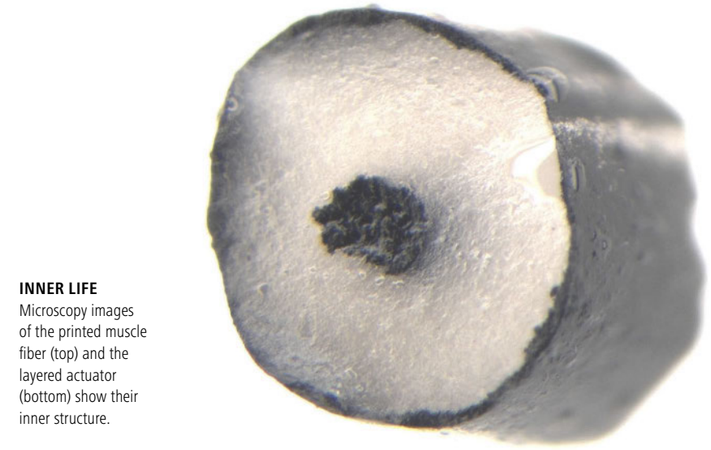
A team of researchers from Empa's Laboratory for Functional Polymers is working on actuators made of soft materials. Now, for the first time, they have developed a method for producing such complex components using a 3D printer. The so-called dielectric elastic actuators (DEA) consist of two different silicone-based materials: a conductive electrode material and a non-conductive dielectric. These materials interlock in layers. "It's a bit like interlacing your fingers," explains Empa researcher Patrick Danner. If an electrical voltage is applied to the electrodes, the actuator contracts like a muscle. When the voltage is switched off, it relaxes to its original position.

3D printing such a structure is not trivial, Danner knows. Despite their very different electrical properties, the two soft materials should behave very similarly during the printing process. They should not mix but must still hold together in the finished actuator. The printed "muscles" must be as soft as possible so that an electrical stimulus can cause the required deformation. Added to this are the requirements that all 3D printable materials must fulfill: They must liquefy under pressure so that they can be extruded out of the printer nozzle. Immediately thereafter, however, they should be viscous enough to retain the printed shape. "These properties are often in direct contradiction," says Danner. "If you optimize one of them, three others change… usually for the worse."

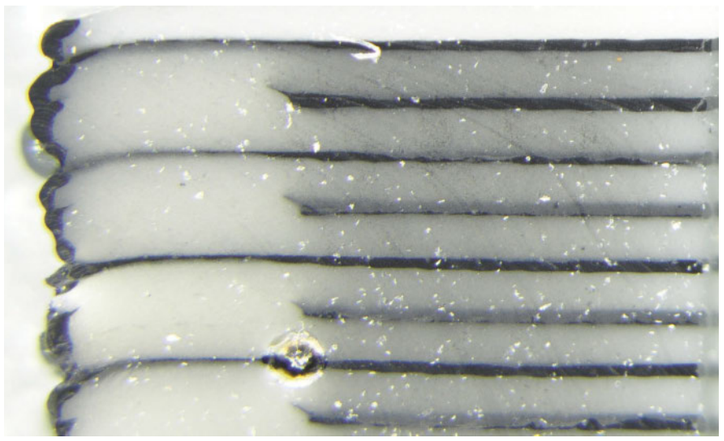
FROM A VR GLOVE TO A BEATING HEART

In collaboration with researchers from ETH Zurich, Danner and Dorina Opris, who leads the research group Functional Polymeric Materials, have succeeded in reconciling many of these contradictory properties. Two special inks, developed at Empa, are printed into functioning soft actuators using a nozzle developed by ETH researchers Tazio Pleij and Jan Vermant. The collaboration is part of the large-scale project Manufhaptics, which is part of the ETH Domain's strategic area Advanced Manufacturing. The aim of the project is to develop a glove that makes virtual worlds tangible. The artificial muscles are designed to simulate the gripping of objects through resistance.

However, there are far more potential applications for soft actuators. They are light, noiseless and, thanks to the new 3D printing process, can be shaped as required. They could replace conventional actuators in cars, machinery and robotics. If they are developed even further, they could also be used for medical applications. Dorina Opris and Patrick Danner are already working on it. Their new process can be used to print not only complex shapes, but also long elastic fibers. "If we manage to make them just a little thinner, we can get pretty close to how real muscle fibers work," says Opris. The researcher believes that in future it may be possible to print an entire heart from these fibers. However, there is still a lot to do before such a dream becomes a reality. ■



INNER LIFE
Microscopy images of the printed muscle fiber (top) and the layered actuator (bottom) show their inner structure.



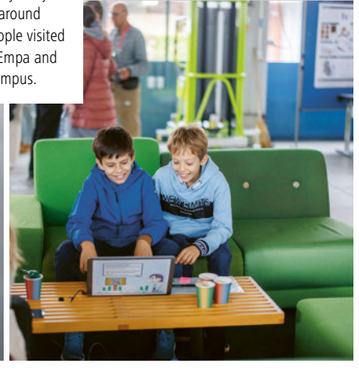
Photos: Empa

A DAY OF ENGAGING ENCOUNTERS

In mid-September, Empa and Eawag opened their doors to the public. Around 7,000 guests visited the campus in Dübendorf, exchanged ideas with the researchers and learned how the research of today is shaping the world of tomorrow.

Text: Anna Ettlin

WELCOME
Despite the cool and occasionally rainy weather, around 7,000 people visited the joint Empa and Eawag campus.



Photos: Nicolas Zonvi

On Saturday, September 14, Empa held an Open Lab Day in Dübendorf. Despite the cool and occasionally rainy weather, almost 7,000 visitors flocked to the Empa campus. Young and old alike learned about Empa's research at around 70 stations as well as during guided tours, workshops and lectures. The partner institute Eawag, one of the world's leading water research institutes, also opened its doors on this day.

One of the highlights of the day was the new research campus co-operate, which Empa and Eawag completed and put into operation this summer. During guided tours, visitors experienced the modern laboratories and offices, the newly designed outdoor space and the innovations from the Empa laboratories that were used in the construction of the three new buildings, such as the geothermal probe field, which stores summer heat for the winter.

MATERIALS AS DRIVERS OF INNOVATION

There was even more educational and interesting information on the topic of energy transition at the booths: Do-it-yourself solar cells, audible batteries and advanced smart energy systems delighted visitors. In the theme world Climate Change, visitors learned about the greenhouse effect and how CO_2 can be captured from the air and processed into innovative, sustainable materials and products. At the Open Lab Day, young people – future decision-makers – were able to familiarize themselves with the technologies that will shape their future.

The Healthy Life, Healthy Environment theme world also attracted a great deal of interest. Here, research literally went under the skin with 3D-printed joints, innovative surgical instruments and nanoparticles for medicine. Older visitors were particularly interested in this subject area, which aims to make our lives healthy and worth living well into old age. Empa researchers also shed light on environmental factors that can affect our health, such as noise and the ubiquitous microplastics.

In the Dwindling Resources section, everything revolved around valuable raw materials: How can we use them wisely? What does it take to recycle asphalt, concrete or batteries efficiently? Can we produce renewable plastic? These topics were by no means reserved for adults: Children were also able to actively contribute their ideas on the circular economy and a future worth living. But even this did not exhaust the full diversity of materials science. The theme world Fascinating Materials offered a colorful kaleidoscope of unusual and "crazy" materials and technologies. There were robots and magnets, molecules and satellites, liquid air, artificial earthquakes and much more to discover. In addition, a number of Empa spin-offs showed how innovations from the laboratory make their way into the real world. And for young people who wanted to get hands-on themselves, Empa presented its exciting apprenticeships.

BEHIND THE SCENES AND CENTER STAGE

Well over 300 Empa employees and around 100 colleagues from Eawag worked during the Open Lab Day. In addition, many more contributed to making the day an unforgettable experience for the guests in the months and weeks beforehand. Empa would like to thank them warmly for their efforts. A big thank you also goes to all the visitors who explored the campus in Dübendorf on Saturday full of curiosity and a thirst for knowledge. ■

YOUNG AND OLD
Visitors of all ages were able to experience Empa research up close during the Open Lab Day.

Photos: Nicolas Zonvi

BATTERY CONFERENCE WITH A NOBEL LAUREATE

ILLUSTRIOUS GUEST
Nobel Laureate Stanley Whittingham (3rd from left) and other guest speakers with the conference organizers David Reber (2nd from right) and Corsin Battaglia (1st from left) on the Empa campus

The Swiss Battery Days took place for the sixth time from August 26 to 28. The international conference, organized by Empa, PSI and the Swiss Battery Association iBAT, brings together battery researchers and industry experts. What began as a small event six years ago welcomed around 250 participants from all over Europe this year. Among them was a special guest: Stanley Whittingham, professor at Binghamton University and Nobel Prize laureate. Together with John Goodenough and Akira Yoshino, Whittingham was awarded the Nobel Prize in Chemistry in 2019 for the development of lithium-ion batteries. At the Swiss Battery Days, he spoke about current trends in battery research in the US.

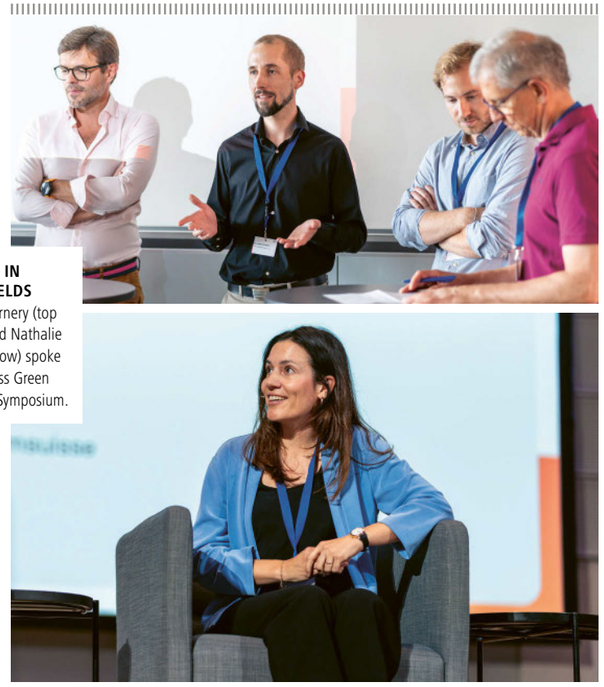
wissen2go

WONDERFUL VARIETY: BATTERIES FOR ALL OCCASIONS

Whether for electric cars, cell phones or in the basement as stationary power storage – batteries are a key element of the energy transition. However, batteries need very different properties depending on the application: be compact and lightweight, store as much energy as possible, or charge and discharge quickly. Last but not least, batteries should also be sustainable – and cost-efficient. Quite a lot of requirements ... but also an enormous opportunity for Swiss industry. Empa researchers are working on a wide variety of battery technologies for different applications. They will be presenting the latest battery trends at Wissen2go on October 29. The free event will take place at the Empa-Akademie in Dübendorf as well as online (in German).

Photos: Empa

SWISS GREEN ECONOMY SYMPOSIUM: ECONOMY MEETS SUSTAINABILITY



EXPERTS IN THEIR FIELDS
Jannis Wernery (top center) and Nathalie Casas (below) spoke at the Swiss Green Economy Symposium.

From August 27 to 29, the Swiss Green Economy Symposium took place in Winterthur. The conference on business and sustainability focused on the topic of "Solving conflicts together" and brought together business, politics, science and NGOs to discuss urgent challenges such as circular economy, climate protection, sustainable construction and carbon capture technologies. Among the 280 speakers and forum participants were Nathalie Casas, member of Empa's Directorate and Head of the Energy, Mobility and Environment department, and Empa researcher Jannis Wernery from the Building Energy Materials and Components laboratory.

Photos: Thomas Oehrli / Visual Craft

EVENTS
(IN GERMAN AND ENGLISH)

28. OKTOBER 2024
Kurs: Energy Harvesting
Zielpublikum: Industrie und Wissenschaft
www.empa-akademie.ch/harvesting
Empa, Dübendorf

29. OKTOBER 2024
wissen2go: Batterien im Fokus
Zielpublikum: Öffentlichkeit
www.empa.ch/web/w2go/batterien
Empa, Dübendorf, und online via Zoom

05. NOVEMBER 2024
RFA Seminar Built Environment
Zielpublikum: Industrie und Wissenschaft
www.empa-akademie.ch/rfaseminar
Empa, Dübendorf

29. NOVEMBER 2024
Kurs: Tribologie
Zielpublikum: IngenieurInnen, ProduktentwicklerInnen, KonstrukteurInnen
www.empa-akademie.ch/tribologie
Empa, Dübendorf

THE PLACE WHERE INNOVATION STARTS.