

Empa Quarterly

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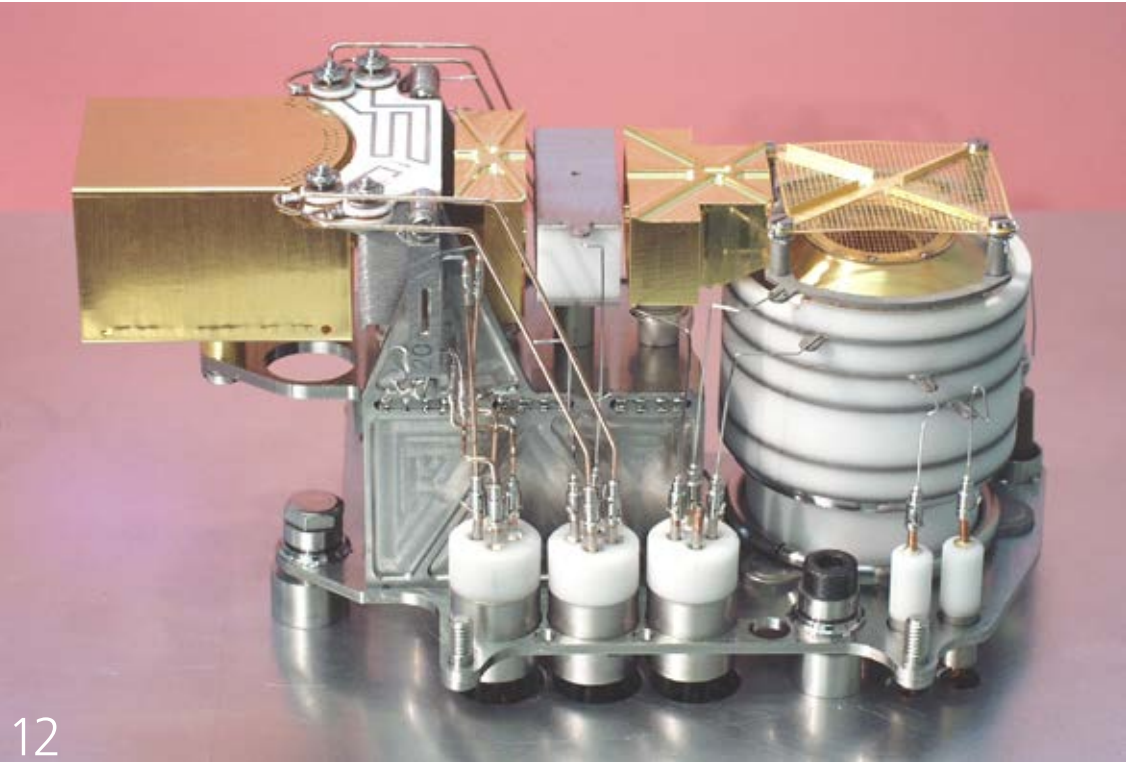
FOCUS: SPACE TECHNOLOGIES

THE FINAL FRONTIER

MATERIALS ON THE ISS
COMPONENTS FOR SPACE PROBES
EMISSIONS TRACKING FROM ORBIT

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Photos: Empa, NASA

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RESEARCH AT THE FINAL FRONTIER

Dear Reader,



Empa is conquering space. Well, at least our research is. Various space probes from the European Space Agency (ESA) with Empa technology aboard are currently on their long journey to their extraterrestrial destinations (p. 12). And on the International Space Station (ISS), astronauts are using microgravity to develop novel materials with unprecedented properties for Empa researchers (p. 16). Other satellites are directly being used by Empa researchers to locate the source regions of various pollutants, such as greenhouse gases, in Earth's orbit thanks to precise trace gas analysis – and thus monitor the progress (if any...) of international environmental agreements (p. 24).

Empa has recently expanded its partner network in order to focus its research activities in the field of space technologies. In addition to established collaborations, say, with ESA and the University of Bern, Empa has established new partnerships as a member of the Center for Space and Aviation Switzerland and Liechtenstein (CSA), for example with Space Florida, with which the CSA intends to set up a joint Space Hub at the Innovation Park in Dübendorf (p. 10).

The complex multilayer materials currently being optimized at Empa (p. 26) go to show that materials science for space applications also brings clearcut benefits down here. These materials can be used to shield the sensitive "inner workings" of satellites from extreme temperature fluctuations. They are also suitable for manufacturing flexible electronics for foldable electronic devices, smart textiles, and medical sensors.

Enjoy reading!
Your MICHAEL HAGMANN

[COVER]



Only a handful of satellites have ever returned to Earth in one piece. The European research satellite EURECA is one of them – photographed here during its recapture by the space shuttle Endeavour. Empa researchers have investigated the structure of the satellite using advanced X-ray methods (p. 22).

Photo: NASA

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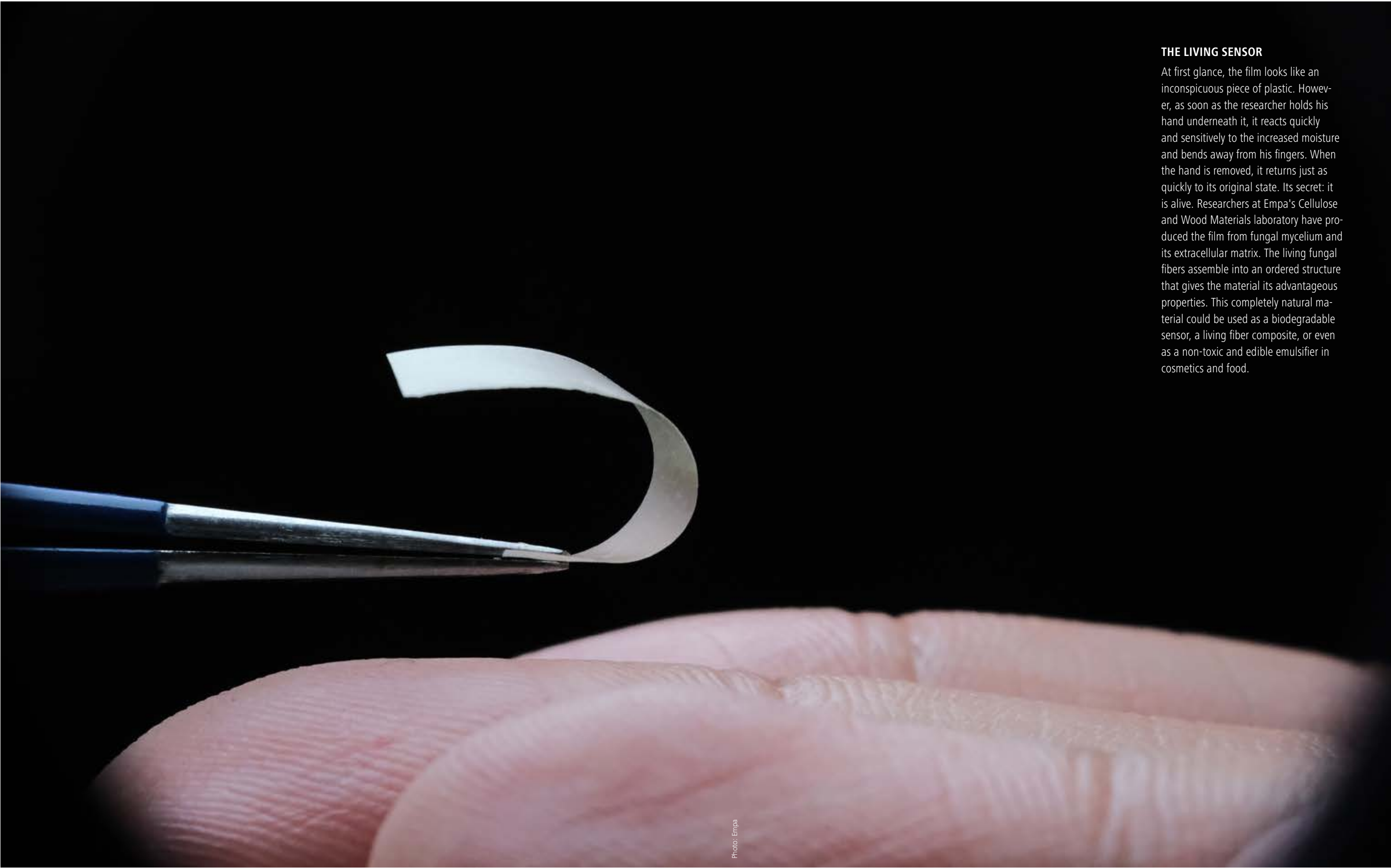
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THE LIVING SENSOR

At first glance, the film looks like an inconspicuous piece of plastic. However, as soon as the researcher holds his hand underneath it, it reacts quickly and sensitively to the increased moisture and bends away from his fingers. When the hand is removed, it returns just as quickly to its original state. Its secret: it is alive. Researchers at Empa's Cellulose and Wood Materials laboratory have produced the film from fungal mycelium and its extracellular matrix. The living fungal fibers assemble into an ordered structure that gives the material its advantageous properties. This completely natural material could be used as a biodegradable sensor, a living fiber composite, or even as a non-toxic and edible emulsifier in cosmetics and food.

Photo: Empa

COMPREHENSIVE “CATALOG” OF CHEMICALS OF CONCERN IN PLASTICS



PLASTOSPHERE
The study identifies 16,325 chemicals in plastics. At least 4,200 of these are harmful to health and the environment.



All plastics, from food packaging to car tires, contain hundreds of chemicals that can end up in food, living spaces, and the environment. A study published in the scientific journal *Nature*, with the participation of Empa and Eawag, provides the first comprehensive and systematic overview of all chemicals that may be contained in plastics, their properties, uses, and hazards. The study also offers a scientific approach to identifying chemicals of concern. This enables scientists and manufacturers to develop safer plastics and policy makers to promote a non-toxic circular economy.

CHILDREN'S BOOK WITH IDEAS FOR A PLANET-FRIENDLY FUTURE

What could sustainable living look like for everyone? Together with schoolchildren and the University of Teacher Education St. Gallen (PHSG), Empa researchers have published an illustrated children's book on circular economy called “Zukunft(K)reise” (Journeys into the Future), which aims to encourage reflection. It is aimed at children in grades 3 to 6 of primary school. The researchers at PHSG have developed comprehensive accompanying material for use in schools. The book is available as a free e-book and can be obtained as a high-quality printed edition from Empa and PHSG.



JOURNEYS INTO THE FUTURE
Children and researchers worked together to create the book.



Photos: Adobe Stock, Empa

Photos: Empa

SWISS ENGINEERING “OSCAR” FOR CLIMATE-SAVING CONCRETE

CLIMATE-FRIENDLY
Mateusz Wyrzykowski (left) and Nikolajs Toropovs with their CO₂-storing concrete.

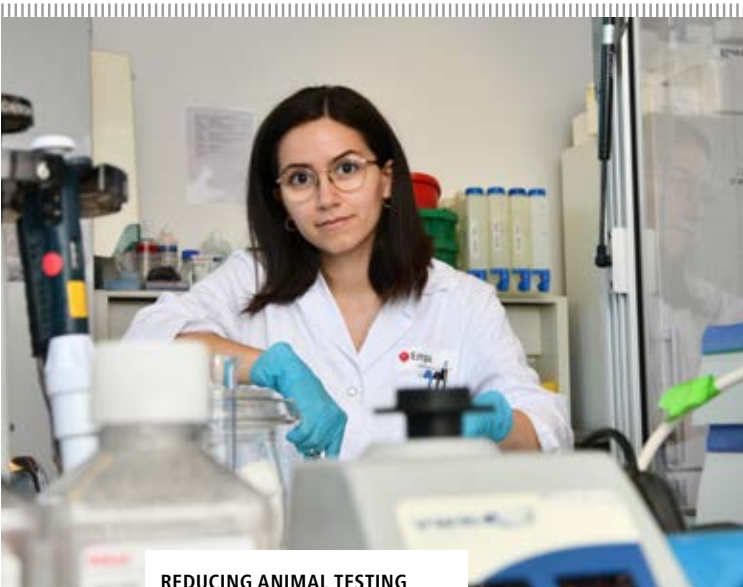


The Building Award recognizes outstanding engineering achievements in the Swiss construction industry – similar to the Oscars in the film world, it is awarded in several categories. This year, Empa was honored in the category Research, Development, Start-ups for its CO₂-storing concrete containing carbon pellets. Empa researchers Pietro Lura, Mateusz Wyrzykowski, Nikolajs Toropovs, Daniel Grossegger, and Frank Winnefeld from the Concrete and Asphalt lab developed the innovative concrete as a carbon sink – a promising approach to significantly reducing emissions in the construction industry.



YOUNG 3R INVESTIGATOR AWARD FOR EMPA RESEARCHER

The Swiss 3R Competence Center (3RCC) has awarded Manon Murdeu, a doctoral student at Empa's Particles-Biology Interactions lab, the Young 3R Investigator Award. The young researcher has developed a placenta-embryo chip that can be used to assess the toxic effects of chemicals, drugs, and nanoparticles during pregnancy without the use of animal testing. Her work fills a major gap in health research: the lack of safety data on how substances affect pregnant women and developing embryos.



REDUCING ANIMAL TESTING
Empa researcher Manon Murdeu has developed a placenta-embryo chip.



THIS MACHINE MAKES METHANE

This summer, Empa inaugurated its novel methanation plant. The move-MEGA research project is the first to demonstrate so-called sorption-enhanced methanation at pilot scale – a technology developed at Empa that makes the power-to-gas process more flexible and robust. The produced synthetic methane can serve as a renewable energy carrier, replacing fossil natural gas. In combination with methane pyrolysis, it is also possible to produce green hydrogen from it.

Text: Annina Schneider

Empa's new methanation plant, move-MEGA, brings together central components of the energy transition: It produces methane from renewable hydrogen and CO₂, with a deliberate focus on increasing the load flexibility of the process – a crucial advantage for utilizing fluctuating renewable electricity sources. The innovative demonstration plant shows how renewable solar power can be converted directly into hydrogen via electrolysis and then, together with CO₂ captured from ambient air, processed into synthetic methane – ready to be fed into the gas grid. The direct integration of these processes at a single site is unique.

A NEW APPROACH:

LOAD FLEXIBILITY AND EFFICIENCY

At the heart of the new plant is a process termed sorption-enhanced methanation, where zeolite pellets with defined pore sizes serve as catalyst carrier. These pellets adsorb the water produced as a by-product during methanation, shifting the chemical equilibrium in favor of methane formation. As a result, the process can be operated at lower pressures and temperatures, and the methane produced can be used directly or injected into the gas grid without elaborate post-treatment.

A key aspect of developing this new process was thermal management:

to ensure continuous operation, at least two reactors are required, alternating between methane production and regeneration/drying. For this drying step, a sophisticated thermal management is essential, allowing waste heat from methanation to be either removed from the reactor or stored in the catalyst bed. The Empa team led by Florian Kiefer and Andreas Borgschulte spent over five years developing this technology from fundamental research, through lab scale facilities to a functional demonstrator.

"Thanks to sorption-enhanced methanation and advanced thermal management, we achieve high conversion rates and significantly greater load

flexibility than with conventional methods. This makes the technology especially attractive for direct coupling with photovoltaic or wind power plants," explains move-MEGA project leader Florian Kiefer.

NEW PATHS IN CLIMATE PROTECTION

The power-to-gas demonstrator also integrates a Direct-Air-Capture (DAC) unit, enabling the CO₂ needed for methanation to be sourced directly from ambient air. This creates the precondition for negative CO₂ emissions: In a subsequent step, the methane can be split via methane pyrolysis into solid carbon and hydrogen, as shown in current Empa research projects. Solid carbon

MOVE-MEGA

With the inauguration of the demonstration plant, the move-MEGA project, dedicated to producing synthetic methane from sustainable hydrogen and CO₂ from ambient air, was successfully completed. At its core is the sorption-enhanced methanation technology developed at Empa, used here for the first time in a demonstration facility within Empa's mobility demonstrator move. Alongside sorption-enhanced methanation, special focus is placed on the efficient use of process waste heat, which is integrated into existing system components. The project was supported by the ETH Board, the Canton of Zurich, Glattwerk, Avenegy Suisse, Migros, Lidl Switzerland, Armasuisse, and Swisspower.

then serves as a long-term CO₂ sink and can be used in building materials such as concrete or asphalt. Hydrogen can be used as an energy carrier for industrial high-temperature applications that are currently dependent on fossil fuels and are difficult to electrify. A demonstration project is currently underway in collaboration with the Association for the Decarbonization of Industry (VzDI) in Zug.

FROM VISION TO REALITY

The brains behind Empa's innovative methanation plant move-MEGA, from left: Florian Kiefer, Jürg Arduser, and Christian Bach.

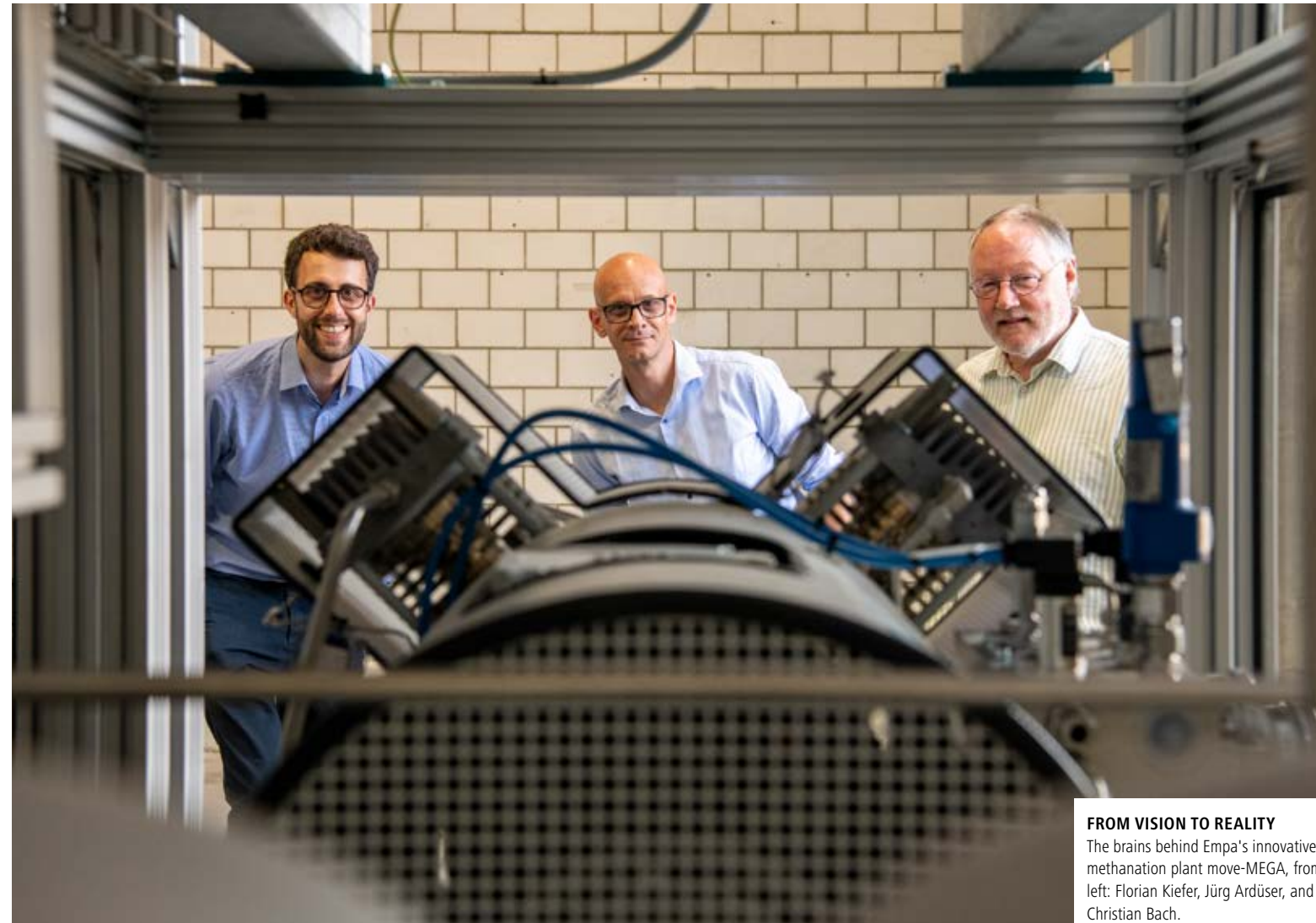


Photo: Marion Nitsch



"WE NEED A CERTAIN CRITICAL MASS"

From environmental monitoring to future moon bases: innovative materials, processes, and models are essential for space travel. Lorenz Herrmann, member of Empa's Directorate and Head of the Advanced Materials and Surfaces department, explains how Empa's strengths can benefit the Swiss space industry and why collaborative networks remain key.

Interview: Michael Hagmann

What is Empa, a materials research institute, doing in space?

Firstly, we have long been leaders in environmental modeling and analysis. In other words, we combine the observation, measurement and analysis of certain gases from space, such as greenhouse gases or air pollutants, with highly sensitive environmental analysis and atmospheric modeling (p. 24).

And secondly, Empa naturally stands for novel materials and innovative production technologies – in this context, for the application field of space equipment, such as satellites, components for space stations, and research equipment for scientific missions. And all of this must, of course, function maintenance-free under extreme conditions for years on end. This would simply be unthinkable without an enormous expertise in materials science.

Linked to this, but going a step further, so to speak, is materials science and development in zero gravity, i.e., on the International Space Station (ISS) or in the context of parabolic flights (p. 16). This is very fundamental but has always been a core area of Empa's work.

And last but not least, a look into the future: so-called in-space manufacturing, i.e., the idea of providing production capacities in space with the hope of being able to produce completely different materials with specific structures and unique properties under these very special conditions in space, for example for quantum computers or chip manufacturing.

"We have a thorough understanding of how to translate scientific findings into practical applications."

And perhaps another step ahead: Space agencies are once again pursuing the vision of building a station on the moon. To do this, you have to use what is available up there. And, of course, this requires an extremely circular approach – precisely a field of research that Empa is currently advancing in our NEST building laboratory, for instance. That would then be circular construction on an entirely different level.

As you can see, there are quite a few points of contact ...

"Space technologies" is a broad field. Where specifically can Empa's research make a difference?

First and foremost, of course, through our enormous expertise in materials, as already mentioned, but also because at Empa, we have a very thorough understanding of technology transfer, i.e., how to translate the latest scientific findings into practical applications. Take in-space manufacturing, for example: As soon as the first ideas for specific applications are available, we could develop appropriate materials and production processes that work under these very special conditions.

Empa has been a member of the Center for Space and Aviation Switzerland and Liechtenstein (CSA) since June. What do you expect from this partnership?

Our primary goal is to gain access to this new market – space technologies and applications. Swiss companies will be developing numerous new products and applications in this area in future, and at Empa we want to be part of this alliance. And then, of course, a certain visibility vis-à-vis the "big players" in the field, ESA and NASA. This requires a certain critical mass, which we hope



Photo: Marion Nitsch

to achieve through this partnership. Another advantage for us is the proximity to the Innovation Park just around the corner here in Dübendorf.

Good point: at the end of July, CSA, Switzerland Innovation, and Space Florida agreed to establish a joint hub for research and innovation in the field of space technology at the Innovation Park. There seems to be a kind of gold rush atmosphere when it comes to space at the moment ...

That's definitely the case, particularly in the field of satellite-based communica-

tion technologies. This area will become even more important globally in the future than it already is, especially since it is also of geostrategic significance. We will almost certainly see growth and a corresponding boom here in the future. What will also continue – probably on the same scale as today – are scientific space missions for Earth and space observation. These are enormously important for better understanding climate phenomena, for example. As for the more visionary areas, we are still looking for real "killer applications." We will definitely continue to follow this closely.

LORENZ HERRMANN

CAREER: Lorenz Herrmann studied physics and earned his doctorate at the University of Regensburg and the Ecole Normale Supérieure in Paris. In 2010, he joined the ABB Research Center in Dättwil, where he most recently headed the Energy Technologies department. Since 2022, he has been head of Empa's Advanced Materials & Surfaces department, and since 2023, he has also led the Nanoscale Materials & Manufacturing Technologies research focus area.

How is the collaboration with the "big players," such as ESA?

We are involved in numerous ESA projects through our long-standing partnership with the University of Bern (p. 12). Since May, there has been another connection via the new European Space Deep-Tech Innovation Center Switzerland (ESDI), which was opened by ESA in collaboration with the Paul Scherrer Institute (PSI) at Park Innovaare and on whose advisory board I am. The aim here is to strengthen our research collaboration with ESA. ■



FROM DÜBENDORF AD ASTRA

Engineers from Empa's Joining Technologies and Corrosion laboratory have been working in partnership with the University of Bern for over 20 years, manufacturing components for scientific instruments used in various space missions run by the European Space Agency (ESA). One mission carrying parts from Dübendorf has already been successfully completed, three are currently in space, and two more are in preparation.

Text: Anna Ettlin

1

BEPICOLOMBO
Space probe
Launch: 2018
Goal: orbit of the planet Mercury



2

PLATO
Space telescope
Scheduled launch: 2026
Goal: studying Earth-like exoplanets from Earth's orbit



3

CHEOPS
Space telescope
Launch: 2019
Goal: studying exoplanets from Earth's orbit



4

COMET INTERCEPTOR
Space probe
Scheduled launch: 2029
Goal: newly discovered comet or interstellar object



5

ROSETTA
Space probe
Launch: 2004
Goal: following and landing on comet "67P/Churyumov-Gerasimenko"



6

JUICE
Space probe
Launch: 2023
Goal: Jupiter and its icy moons Ganymede, Callisto, and Europa



Uncrewed space probes represent the pinnacle of engineering. They must be lightweight and compact, withstand the shocks of rocket launch, and then function for years without any maintenance – under extreme conditions such as vacuum, harsh radiation, and large temperature fluctuations. Every component of these highly complex devices must meet the highest standards.

Hans Rudolf Elsener from Empa's Joining Technologies and Corrosion lab is well aware of this responsibility. For around 25 years, he and his colleagues have been supplying various components for scientific instruments for space probes in collaboration with the University of Bern. This often involves the high-precision soldering of metal and ceramics in high vacuum. Some European Space Agency (ESA) missions have already flown with Empa components on board, others are in preparation. ■

2
PLATO:
EARTH'S
DISTANT
COUSINS

Plato will use its 26 cameras to search for Earth-like exoplanets – planets in other solar systems – that orbit particularly bright stars. Empa carried out heat treatments on components of the telescope's optical unit, which serve as carriers for camera lenses. The heat treatment protects the parts from damage caused by temperature fluctuations due to solar radiation. Plato will launch at the end of 2026.



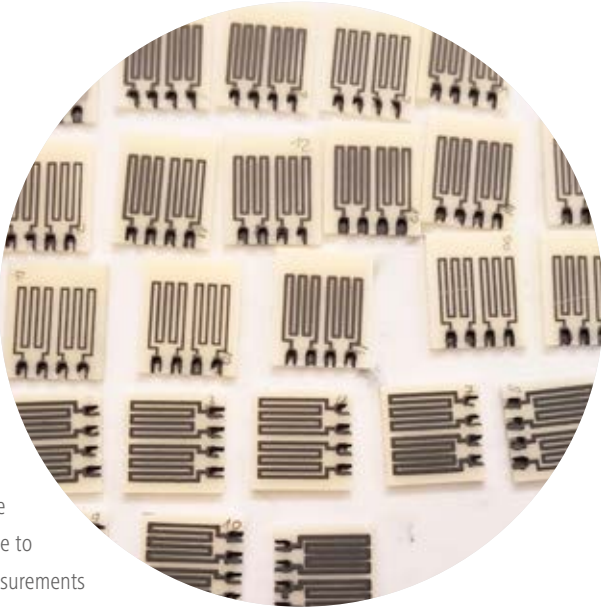
1
BEPICOLOMBO: FLYING
CLOSE TO THE SUN

BepiColombo, a joint mission between ESA and the Japan Aerospace Exploration Agency (JAXA), is only the third probe to ever fly to Mercury. Empa manufactured ion optics and heating structures for instruments that will study particles in the thin exosphere of the innermost planet of the solar system. BepiColombo will reach Mercury's orbit in November 2026.



3
CHEOPS:
EXOPLANETS
IN THE SPOT-
LIGHT

Cheops is a compact space telescope that will continue to gather more accurate measurements of known exoplanets until 2026 in order to learn more about their size and possible composition. Empa engineers equipped the telescope's powerful photometer with various heaters to ensure that the instrument functions reliably in the cold depths of space.



Photos: Empa



4
COMET INTERCEPTOR: INTO
THE GREAT UNKNOWN

The Comet Interceptor mission, once again in collaboration with JAXA, aims to fly to, track, and investigate a comet or interstellar object that is yet to be discovered. Empa supplied a fine protective grid for the pressure and environmental sensor of the probe, which is currently under construction. The delicate instrument will investigate the coma – the diffuse cloud of dust and gas surrounding the comet's nucleus.



5
ROSETTA: RENDEZVOUS
WITH A COMET

The Rosetta mission was the first to fly to a comet and land a probe – a compact instrument package called Philae – on its surface. Empa supplied ion mirrors, ion sources, and zoom optics for the two mass spectrometers of the ROSINA instrument group on Rosetta, which examined the comet's coma.



6
JUICE: LOOKING FOR
LIFE UNDER THE ICE

Juice, short for Jupiter Icy Moons Explorer, aims to take a closer look at Jupiter's ice-covered moons to see if they could harbor life. Empa supplied components for the ion optical system of the NIM mass spectrometer, which will study the outermost layer of Jupiter's atmosphere and its moons. Juice will reach Jupiter in the summer of 2031.



MATERIALS FROM SPACE

Metallic glasses are novel materials with applications in space technology, but also in medicine and the watch industry. To better understand their properties and improve their production, Empa researchers are conducting various experiments on board the International Space Station (ISS) in collaboration with the European Space Agency (ESA).

Text: Anna Ettlin

Metals are versatile materials that surround us everywhere, whether as large structural elements or tiny components in our electronic devices, as robust tools or elegant jewelry. In most applications, they show an ordered crystalline structure, which they almost always adopt when solidifying from the melt. But what happens when metal atoms do not arrange themselves in clear patterns? If certain alloys are cooled very quickly, they solidify into a “disordered” – amorphous – structure similar to that of glass. This is why such amorphous metals are also referred to as “metallic glasses”.

Metallic glasses are something like the Holy Grail of metallurgy. They are as hard as quartz glass and their smooth surface is particularly resistant to scratches and corrosion. Unlike glass, however, metallic glasses are elastic and return to their original shape after deformation more readily than ordinary metals. This makes

them a sought-after material for applications in medicine and space technology.

The crux of the matter, however, is the production of metallic glasses, because most metals are “eager” to assume their natural crystalline form. “It is particularly difficult to maintain the amorphous structure when manufacturing larger components,” says Empa researcher Damien Terebenec, who conducts research on metallic glasses at Empa’s Center for X-ray Analytics.

ELIMINATING GRAVITY

Materials scientists such as Terebenec work with complex alloys and precise processes to produce amorphous metals. This requires a thorough understanding of the physical properties of the material, especially in its molten liquid form. This presents a challenge: “The metallic liquid droplet must be levitated to avoid crystallization induced by contact with the crucible, which could otherwise compromise the entire



IN ORBIT
NASA astronaut Suni Williams prepares material samples for installation on the exterior of the Columbus module of the ISS.



ON EARTH
Empa researcher Damien Terebenec analyzes the structure of metallic glasses using an X-ray diffractometer.

Photos: NASA, Empa

experiment” explains Terebenec. To this aim, strong electromagnetic fields can be used to levitate droplets of liquid metal in suspension – but the gravity of the Earth deforms the spherical droplets and distorts the measurements.

For this reason, Terebenec and other researchers at the Center for X-ray Analytics, headed by Antonia Neels, are using a unique research platform: the International Space Station (ISS). As part of the European Space Agency's (ESA) THERMOPROP research project, led by Neels, the researchers are investigating the physical properties of metallic glasses in microgravity – the near-weightlessness of Earth's low orbit. At the same time, experiments are also being conducted at Empa in Dübendorf, where Neels, Terebenec, and their colleagues are characterizing the structure of metallic glasses using various X-ray techniques.

“The data from the experiments on the ISS is fed into materials simulations, which in turn can be used to develop and optimize industrial processes,” says Antonia Neels. Despite the lofty heights at which some of the experiments are taking place, the project is grounded in practice: Besides researchers from Empa and EPFL, an industrial partner has been involved from the outset. The Swiss company PX Group from La Chaux-de-Fonds manufactures metallic glasses for the watch industry, where the hard, flexible materials are used for precise mechanisms and robust cases. “Our partner has already been able to incorporate our findings from the project into improved manufacturing processes,” says Neels.

RELIABLE MECHANISMS FOR SATELLITES

The knowledge gained on board the ISS and at Empa is also being fed back into space. In addition to their terrestrial applications, metallic glasses are well-suited for use in spacecrafts and



AMORPHOUS METAL
The twin of this sample is currently installed on the outside of the ISS as part of the SESAME experiment.

satellites. Their elasticity and resistance enable the construction of reliable mechanisms that function maintenance-free over long periods of time. In a second project with ESA, Empa researchers are exposing samples of the material to the harsh conditions of space.

The corresponding experiment, called SESAME, flew to the ISS in November 2024 and was installed on the outside of the European laboratory module Columbus in December. It comprises numerous material samples from 15 European research institutions. After about a year in space, the samples will return to Earth and be analyzed – including the metallic glass provided by Empa researchers. “We can simulate individual space conditions on Earth, such as temperature fluctuations, vacuum, or radiation – but not all of them together,” explains Neels. “We want to know whether a prolonged exposure to space conditions changes the structure of the material, because in the end, the structure defines the properties”, adds Terebenec.

The experiments on the space station are not one-offs but are carried out in batches. Further experiments with Empa's liquid metallic glasses on board the ISS are scheduled to take place next year. “Both projects will probably run until the end of the ISS in 2030,” says Neels. There is still a lot to learn in and for space. ■

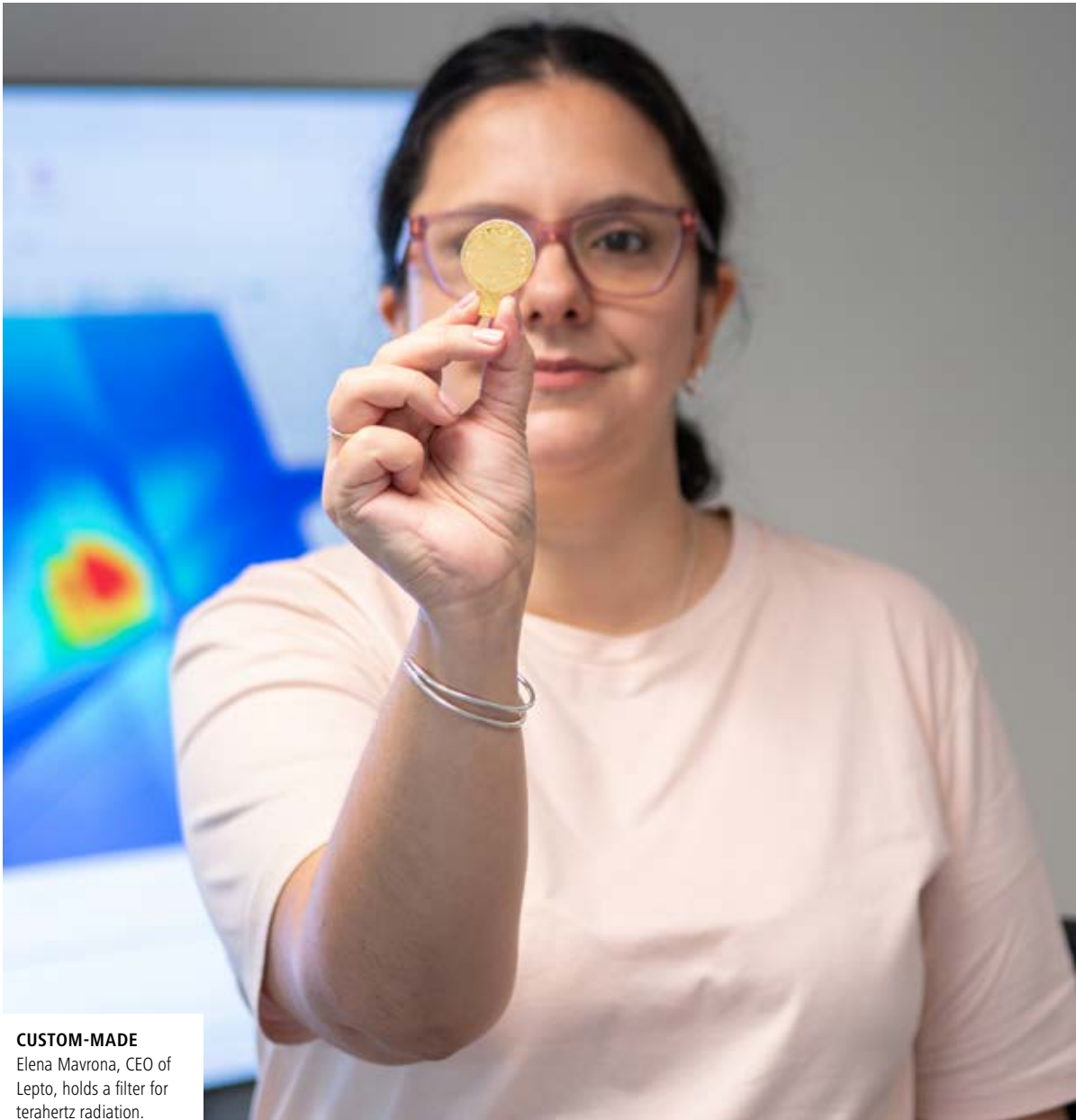


Photo: Empa

RIDING THE TERAHERTZ WAVE

Terahertz radiation is a promising part of the electromagnetic spectrum that has so far been underutilized. Empa researchers Elena Mavrona and Erwin Hack want to help close the so-called terahertz gap. With their spin-off company Lepto, they manufacture filters and other devices for terahertz radiation, enabling a wide range of applications both in space and on Earth.

Text: Anna Ettlin



CUSTOM-MADE
Elena Mavrona, CEO of Lepto, holds a filter for terahertz radiation.

Photo: Empa

The ultrathin foil stretches over its ring-shaped polymer frame. Depending on the angle of view, it appears almost transparent at times, then shimmers in gold, red, and green. This rainbow of colors is caused by the metallic microstructure on the surface of the film: highly precise microscopic patterns made of pure gold. As beautiful as it may appear, the foil is not a decorative object, but a high-tech filter for terahertz radiation, and the first product from the Empa spin-off Lepto GmbH.

Lepto, Greek for thin, is a fitting name, as the filter is just one micrometer – one thousandth of a millimeter – thick. The young company was founded in April 2025 in Dübendorf by Empa researchers Elena Mavrona and Erwin Hack. The scientists had been working together on terahertz radiation at Empa's Transport at Nanoscale Interfaces laboratory for the past six years.

"With wavelengths between 0.03 and 3 millimeters, terahertz radiation lies at the boundary between optics and electronics," explains Elena Mavrona, now CEO of Lepto. In the electromagnetic spectrum, the terahertz range fits in between the shorter-wave area of visible and infrared light and the longer micro- or gigahertz waves that we use for most of our wireless communication technologies, from Bluetooth to Wi-Fi.

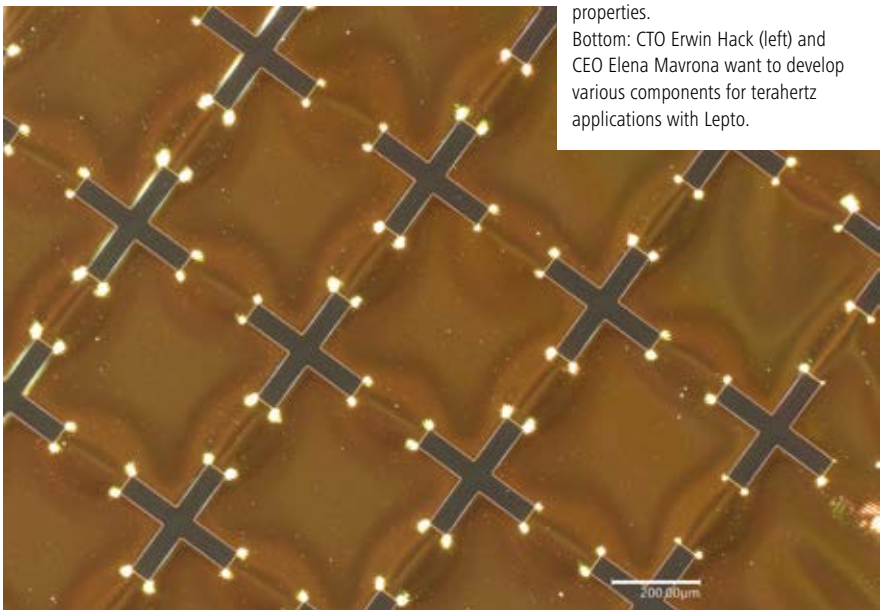
CLOSING THE GAP

Compared to its spectral "neighbors", the terahertz band has long been largely unexplored; technologies for generating and measuring terahertz radiation were few and far between. It is only in the last 30 years or so that this so-called terahertz gap has begun to close. This is because terahertz radiation promises versatile applications in medicine, communication, and materials



A GOLDEN GRID

Top: A Lepto terahertz filter.
Center: The microscopic structure of the gold coating gives the filter its properties.
Bottom: CTO Erwin Hack (left) and CEO Elena Mavrona want to develop various components for terahertz applications with Lepto.



research. Lepto aims to enable precisely such applications with its products: components that allow the emission and detection of terahertz rays.

The spin-off has its roots in a research project in which Hack, Mavrona, and their colleagues succeeded in developing a particularly thin structure for highly effective terahertz filters. They filed a patent for the production technology. "We never actually planned to start a company," says Erwin Hack, CTO of Lepto. "But we received many inquiries from other research institutions, and they were very satisfied with our filters' performance. That's when we realized there was a market for them."

The filters are just the start. "We are also working on other components for terahertz radiation, such as polarizers," says Mavrona. What sets Lepto products apart from the competition is their thinness. The polymer film that serves as the substrate for the gold microstructure of the actual filter is extremely thin and highly transparent across all areas of the electromagnetic spectrum. This makes the resulting filters particularly effective – but also very light and compact.

"Terahertz radiation is ideal for communication between satellites."

FOR SATELLITES AND SKIN SCANS

For this reason, the spin-off founders see an important market for their products in the field of space technologies, where the weight of components plays a key role – and terahertz rays have several areas of application. "On the one hand, terahertz spectroscopy is an excellent method for investigating many phenomena in astrophysics and geophysics,"

ABOUT LEPTO GMBH

Lepto GmbH is an Empa spin-off and is supported by glatec, the Empa business incubator. The founders receive coaching through glatec as well as Initial Coaching supported by Innosuisse. Lepto is backed by additional members of the Transport at Nanoscale Interfaces laboratory, including co-inventor Ivan Shorubalko and advisors Rolf Brönnimann, Tero Kulmala, and Jonas Gartmann. The spin-off is currently seeking pre-seed funding. Elena Mavrona has received the Empa Entrepreneur Fellowship for the spin-off.

explains Mavrona. "On the other hand, terahertz is also ideal for communication between satellites, as well as satellite-to-ground communication." According to Hack, the higher frequency of terahertz radiation compared to conventional communication technologies enables faster data transmission. Because the radiation has shorter wavelengths than its "big brother" gigahertz, it does not travel quite as far – an advantage that makes terahertz-based communication technologies more secure.

Space is by no means the only area of application for terahertz radiation and Lepto components. In the atmosphere, the radiation is scattered relatively quickly and only extends over short distances. Nevertheless, it is considered one of the key technologies for 6G, the next standard for mobile communications, which is set to be even faster and more energy-efficient than the current 5G standard.

There is also great potential for terahertz waves in medicine, as they can penetrate superficial tissue layers. Similar to its neighbors in the electromagnetic spectrum, terahertz waves are

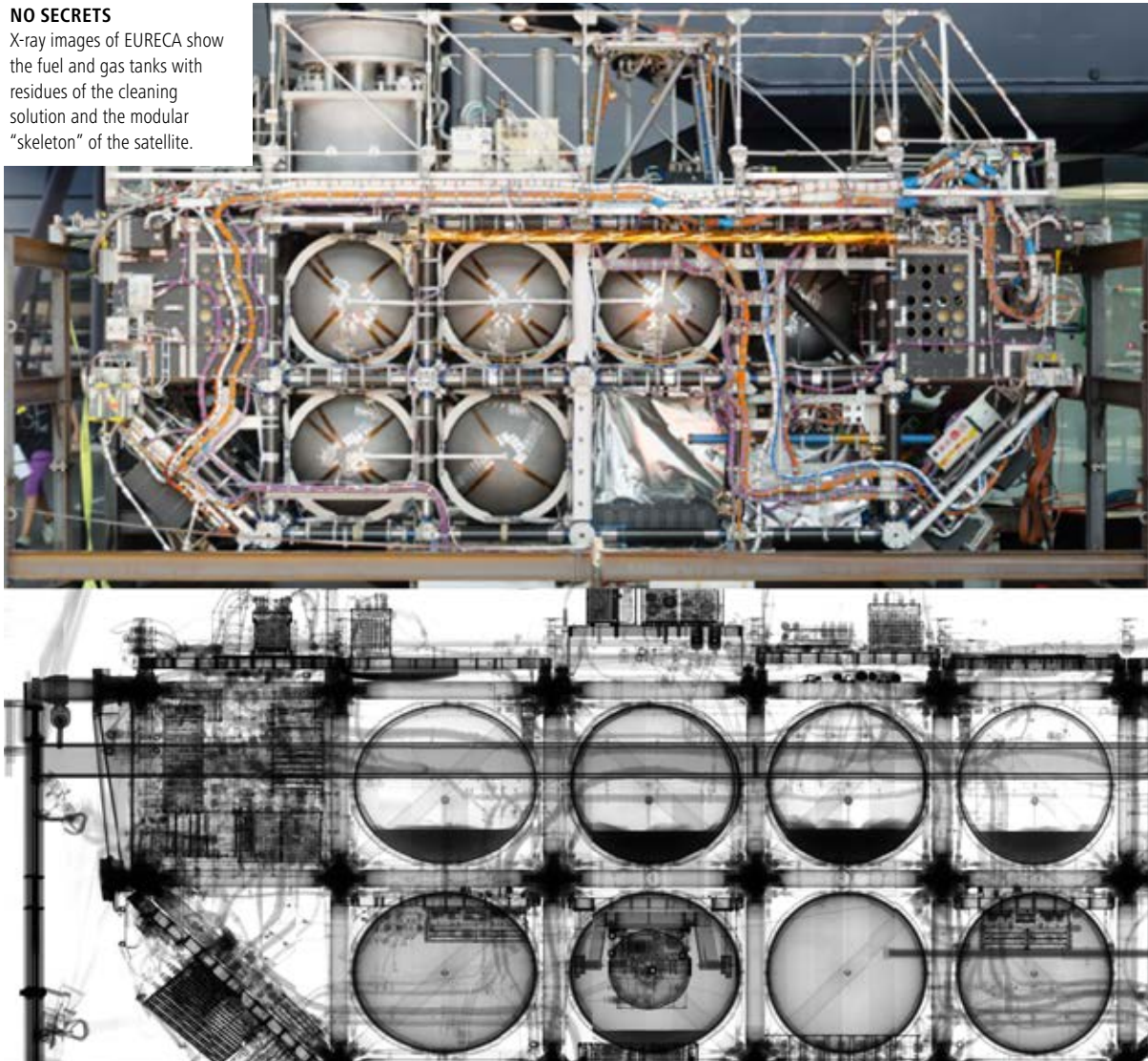
non-ionizing and therefore safer than X-rays. Since they are surface-sensitive, they are primarily being developed for applications on the skin, such as cancer diagnosis or the examination of superficial blood vessels or wounds. Another field of application is security, for example in body scanners at airports.

Currently, demand for Lepto's terahertz filters and polarizers comes mainly from the research sector. In addition to applications in spectroscopy for characterizing materials, research is also being conducted into terahertz-based quantum computers. "Our filters are very thin, and we manufacture the frames for them to order using 3D printing," explains Mavrona. This allows the young company to produce complex, yet compact filter systems precisely tailored to customer requirements. "We look forward to bringing our products to market soon," say the two founders. ■



NO SECRETS

X-ray images of EURECA show the fuel and gas tanks with residues of the cleaning solution and the modular "skeleton" of the satellite.



HOW TO X-RAY A SATELLITE

It is rare for satellites to return to Earth intact after their mission in space – one example is the European satellite EURECA. Empa researchers have studied the satellite using various non-destructive X-ray methods. These could be used in future in the development of reusable space technologies, as well as in aviation and the automotive industry.

Text: Anna Ettlin

Photo: Empa

Photo: NASA

Whether it's a sprained ankle or a backpack at the

airport, X-ray images are an everyday occurrence in many areas. Empa researchers at the Center for X-Ray Analytics have succeeded in taking images that are far less commonplace: In collaboration with the Swiss Space Center (now Space Innovation at EPFL) and the Swiss Museum of Transport, they have X-rayed an entire satellite. The imaged satellite is called EURECA – short for EUropean REtrievable CArrier – and is one of a kind. It was launched into space in 1992 aboard the Space Shuttle Atlantis. Swiss astronaut Claude Nicollier deployed EURECA into orbit. There, the 4.5-ton satellite remained for the next eleven months – until it was captured by the crew of the Space Shuttle Endeavour on July 1, 1993, and brought back to Earth. This makes EURECA one of the very few satellites to have returned from its mission in space intact.

The European Space Agency (ESA) originally planned several missions for the reusable satellite. EURECA carried 15 interchangeable instruments for scientific experiments ranging from biology to astrophysics. However, the budget for the program was cut, and EURECA's first flight was also its last. At the end of 2000, the satellite was put on exhibit at the Swiss Museum of Transport in Lucerne. From there, the journey to Dübendorf and Empa was a short one. Examining a flown satellite was not an opportunity Empa researchers were willing to miss.

**EN ROUTE**

Swiss astronaut Claude Nicollier with EURECA, ready for launch, aboard the Space Shuttle Atlantis.

A DEEP LOOK INSIDE

EURECA was first X-rayed in 2016. The complete results of the investigation were published in 2025 in the journal *Acta Astronautica*. Using the high-energy X-ray facility, the researchers were able to X-ray the five-meter-long, three-meter-high, and two-and-a-half-meter-wide satellite in one piece. They also used other X-ray techniques for parts of the satellite and for the two scientific instruments that remained on board.

The big advantage of X-ray imaging is the same for satellites as it is for ankles in hospitals and hand luggage at airports: It allows a non-destructive view of the interior. "Our analysis covers several orders of magnitude, from the entire carrier structure of the satellite to investigations of materials at nanometer scale," says Empa researcher Robert Zboray,

lead author of the publication. The researchers found several defects, such as cracks in EURECA's composite struts and fractures and deformations in the scientific instruments.

"Satellites are exposed to strong radiation, large temperature fluctuations, and collisions with particles from meteorites and space debris," says Zboray. "Our methods enable us to identify weak points, especially in reusable satellites." Damage can also occur during launch and landing. According to Zboray, further experiments would be necessary to pinpoint the exact event that caused the damage. "Ideally, such satellites should be X-rayed both before launch and after landing," says the scientist.

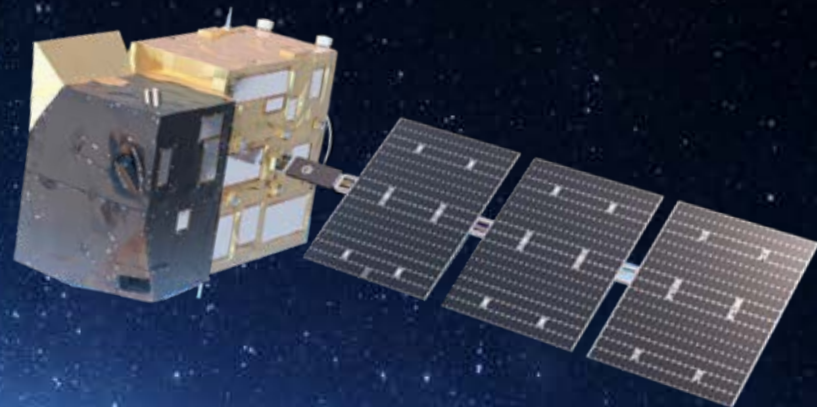
Although these days, EURECA only unfolds its solar panels at the Swiss Museum of Transport, the topic of reusable space technologies is more relevant today than ever before. By 2025, there will be over 10,000 satellites in Earth's orbit – and the number is growing every year. The issue is compounded by countless rocket stages, fragments of old satellites, and other space debris that pose a danger to active satellites and manned spaceflight. Reusable satellites could help reduce this flood of space junk – and Zboray is convinced that X-ray techniques could be used to optimize their design. However, high-energy X-ray imaging also has terrestrial applications, such as examining components for the aviation and automotive industries, or even in forensics. ■



SNIFFING OUT EMISSIONS FROM ORBIT

Space offers a new perspective on greenhouse gases and air pollutants: in future, European satellites will for the first time provide detailed emission maps, all the way down to the contributions of individual power plants and industrial facilities. The necessary methods and technologies were developed by Empa researchers within international research partnerships.

Text: Manuel Martin



THE OBSERVER ABOVE
The new CO2M satellites will provide the EU with an independent data basis for reviewing climate policy and demonstrating progress in the decarbonization of Europe.

Photos: ESA, Adobe Stock

As of 2027, new satellites for CO₂ measurement (CO2M) will be launched into orbit. Originally, only two were planned – but simulations by Empa convinced the European Commission to have a third satellite built. This will significantly improve coverage on a global scale: Instead of every five days, the greenhouse gases carbon dioxide (CO₂) and methane (CH₄) can now be measured around the globe every 3.5 days. The new instruments will provide comprehensive greenhouse gas images with a resolution of two kilometers, covering entire regions rather than just narrow measurement strips as previous satellites have done. This will allow the emissions of individual countries, cities, or even individual power plants to be determined in spatial detail. The CO2M mission is part of the EU's Copernicus Earth observation program. It is being developed by the European Space Agency (ESA) and will then be handed over to the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) for operation. Its goal is to monitor human-caused CO₂ emissions worldwide.

NITROGEN DIOXIDE MEASUREMENTS MAKE THE DIFFERENCE

"Satellites measure the concentrations of greenhouse gases and air pollutants in the atmosphere – but only with the help of complex dispersion simulations can we calculate the emissions of a power plant, a city, or even an entire country," explains Gerrit Kuhlmann from Empa's Air Pollutants / Environmental Technology lab. In order to find out which technologies are suitable for such analyses, Empa researchers simulated the CO₂ measurement data of a future satellite some years ago. These computer simulations, commissioned by ESA, were decisive

in ensuring that the CO2M satellites will measure not only CO₂, but also nitrogen dioxide (NO₂). This combination is crucial because it allows man-made emissions to be distinguished from natural sources: The combustion of coal, oil, and gas always produces NO₂ in addition to CO₂, in contrast to natural CO₂ emissions of the biosphere.

Today, Empa researchers are applying their models to real satellite data. Measurements from the European Copernicus satellite Sentinel-5P demonstrate how reliable the method is. Its TROPOMI instrument detects nitrogen oxides emissions from large power plants in the US, for instance. "We were able to clearly identify the exhaust plumes of several power plants and determine their nitrogen oxides emissions," says Kuhlmann. "Power plants in the US have to report their emissions daily – and our calculations correspond very well with these reports." This goes to show that satellites are a reliable tool not only for observing emissions, but also for quantifying them with a spatial resolution of just a few square kilometers.

TRACKING DOWN MAJOR EMITTERS

Empa researchers are not only focusing on regions with good data coverage such as Europe and North America. As part of the European CORSO project, a global dataset is currently being compiled on major emitters such as coal, gas, and oil power plants, cement plants, and iron and steel factories. Comparing nitrogen oxides emission estimates based on public and commercial databases with actual TROPOMI measurements has already yielded some surprises: Some of the listed plants do not even exist, while others were missing from the emissions databases. In many countries, the assumptions about the fuels used

were also incorrect – for example, in the case of so-called dual-fuel power plants, which can be operated with both oil and gas. "We were able to show that gas is mainly used in many places, which leads to significantly lower nitrogen oxides emissions than assumed," explains Kuhlmann.

The methods and technologies developed are also to be applied to greenhouse gases such as CO₂ in the future. "Today, we can already reliably quantify air pollutants such as nitrogen oxides using satellite data. In a few years, we will also be able to accurately and continuously monitor major greenhouse gas sources worldwide with the CO2M satellites," says Kuhlmann. This opens up a new perspective from space that shows in detail whether the world is really making progress in climate mitigation. ■



ULTIMATE FINESSE

IN A VACUUM

Empa doctoral student Johanna Byloff prepares the samples on the coating machine of the Empa spin-off Swiss Cluster.



Ultra-light, super-flexible, highly insulating: an aluminum-coated polymer film is used to shield satellites from temperature extremes. Researchers at Empa have succeeded in making the material even more resistant by implementing an ultra-thin intermediate layer. The technology could in future also be used to improve flexible electronics and medical sensors.

Text: Anna Ettlin

The picture that pops up before our inner eye when we hear the word “satellite” is probably this: two extended solar “wings” and a compact body wrapped in foil with a golden or silvery shimmer. Researchers at Empa’s Mechanics of Materials and Nanostructures laboratory in Thun are now working to improve precisely this foil. As its widespread use indicates, the material is crucial for satellites and space probes. It is known as multilayer insulation or superinsulation and consists of several layers of a robust polymer coated with a thin layer of metal, usually aluminum. The coated film can also be encountered on Earth, for example in the form of survival blankets.

Photo: Roland Richter, Empa

Aboard spacecraft, superinsulation protects the electronics from temperature fluctuations. “For satellites in low Earth orbit, the temperature difference between the sun-facing side and the side facing away is around 200 degrees. A similar temperature difference also occurs when a satellite flies into the Earth’s shadow or out of the shadow back to the sunlit side of the planet – and this happens 16 times a day,” says Empa researcher Barbara Putz. “Electronics work best at room temperature, though.” And since it is directly exposed to space conditions, the superinsulation itself must also be resistant to extreme conditions.

An extremely resistant polymer, polyimide, is most often used as the base for the thin-film structure. In addition to its temperature and vacuum resistance, this material is also characterized by the fact that the aluminum layer adheres to it particularly well. “The reason for this is an intermediate layer, just a few nanometers thin, that forms at the interface between the polymer and the aluminum during the coating process,” explains Putz. The researcher now wants to investigate this interface in more detail – and use the intermediate layer in a targeted way. It should not only enable better superinsulation for future satellites but also accelerate the development of flexible electronics back on Earth. She received an Ambizione Grant from the Swiss National Science Foundation (SNSF) for this research project.

FIVE NANOMETERS MAKE ALL THE DIFFERENCE

To better understand the intermediate layer and its effects on material properties, Putz and her doctoral student Johanna Byloff opted for a simple model system: a 50-micrometer-thick polyimide film coated with 150 nanometers of aluminum. Between the metal and the plastic, the researchers apply a

coating of aluminum oxide measuring just five nanometers. Working with such a thin intermediate layer is challenging. To ensure clean processing, the researchers use a coating machine from the Empa spin-off Swiss Cluster AG, which was founded in 2020 by researchers from the Mechanics of Materials and Nanostructures laboratory. The device makes it possible to apply different coating processes to the same workpiece one after the other without removing it from the vacuum chamber.

“We use the same combination of materials that is used for space applications, such as the European Mercury probe BepiColombo or the sunshield of NASA’s James Webb Space Telescope,” says Byloff. “The difference is that the thin intermediate layer forms naturally in those applications, whereas we manufacture it specifically, which allows us to adjust its properties.” The space telescope’s 21-by-14-meter sunshield also illustrates the demands placed on the composite material in space. In addition to the large temperature differences, the insulating layers are exposed to mechanical stress. “On the one hand, the sunshield was stowed away during transport of the telescope and had to unfold at its destination without the layers tearing or separating from each other,” explains Byloff. “On the other hand, particles and space debris can damage the film. It is important that the damage remains localized and does not spread as long cracks across the entire surface.”

FROM SATELLITES TO MEDICAL SENSORS

The researchers put their model film through its paces, subjecting it to tensile experiments and temperature shocks and characterizing it chemically and physically. The result: The new intermediate layer makes the material more elastic and significantly more resistant to cracks and flaking. Next, the

researchers want to vary the thickness of the interlayer and apply it to other polymer substrates. “The natural interlayer can only form on a few polymers and only to a thickness of around five nanometers, which limits its usefulness,” says Barbara Putz. “We expect that our artificial interlayer will enable multilayer systems on other polymers that were previously out of the question due to poor coating adhesion.”

Satellite insulation is not the only area in which flexible multilayer systems are in demand. Putz and Byloff also see a major field of application for their research in flexible electronics, which are also based on metal-coated polymer substrates. Thin-film components for electronic devices usually have several layers made of different materials. But here, too, the mechanical properties could be improved through the targeted use of thin intermediate layers. This could advance the manufacturing of foldable or rollable devices, smart textiles, and flexible medical sensors, for example. ■



IMPLANTABLE “EYE PATCH”

Damage to the cornea affects millions of people worldwide. Empa researchers are working on a transparent, biocompatible implant from the 3D printer. This allows defects to be repaired seamlessly and permanently. The project could now be started thanks to a generous donation from a foundation.

Text: Andrea Six



SEEING CLEARLY
Empa researcher Hien Le is working on an artificial cornea made of hydrogel for people with visual impairments.

Like a windowpane, the transparent cornea is the outermost layer of tissue that protects our eyes. If this 500 to 600 micrometer-thin tissue is damaged by infections, injuries or malformations, vision impairment or even blindness can occur. Millions of people worldwide are affected by corneal damage, but only around 100,000 of them each year can be treated with a corneal transplant. The reason: Demand for donated tissue is significantly higher than its availability.

A team of researchers from Empa, the University of Zurich, the Zurich Veterinary Hospital and Radboud University

in the Netherlands is therefore developing a self-adhesive implant that is not dependent on tissue donations and does not cause a rejection reaction. “The basis for the implant is a biocompatible hydrogel made of collagen and hyaluronic acid,” says Markus Rottmar from Empa’s Biointerfaces lab in St. Gallen.

ARTIFICIAL CORNEA SUPPORTS HEALING
The transparent implant also contains additives to ensure optimum biomechanical stability. The artificial cornea will be produced by 3D printing. “3D extrusion bioprinting makes it possible to tailor the implant to the patient’s individual corneal curvature,” says Rottmar.

ZUKUNFTSFONDS
Private support that makes a difference: the project was fully financed thanks to a generous donation from a foundation. Empa’s Zukunftsfonds raises private third-party funds for such pioneering research projects that are not yet supported otherwise. Would you also like to give our research an additional boost? Further information including a link to our donation form can be found at:



In a later step, the researchers will load the hydrogel with human stem cells from the eye so that the artificial cornea can support tissue regeneration. And because the self-adhesive transplant does not require surgical sutures, longer operating times and post-operative complications such as infection, scarring or inflammation can also be avoided. ■

Photo: Empa

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THE WOODEN MOUSE

Modern printed circuit boards are made from petroleum-based materials and are difficult to recycle. Empa researchers have developed a biodegradable version – an important step toward sustainable electronics. Their novel material is based entirely on wood and can be processed into functional circuit boards for electronic devices.

Text: Anna Ettlin

They are the “heart” of every electronic device, from laptops to electric toothbrushes: printed circuit boards, also known as PCBs. These rigid boards are covered with copper traces and soldered electronic components and are usually of a tell-tale green color. They are, however, not exactly environmentally friendly.

The substrate generally used for the traces and components is a laminate made of fiber-reinforced epoxy resin. This composite material is based on petroleum and cannot be recycled. Proper disposal is costly, for example in a special pyrolysis furnace with exhaust air purification – a challenge, given the large quantities of discarded circuit boards that accumulate for disposal each year.

Researchers led by Thomas Geiger from Empa's Cellulose and Wood Materials laboratory are working on a “green”, i.e., sustainable option – which is actually brown. As part of the EU research project HyPELignum (see box), they developed a wood-based substrate for PCBs that can compete with conventional epoxy resin – and is also completely biodegradable. The researchers have incorporated the boards made from this material into functioning computer mice.

DREAM TEAM OF FIBRILS AND LIGNIN

The source for the carrier material is a natural mixture of cellulose with a small amount of lignin. Strictly speaking, it is a waste product. “Our partners at the TNO research institute in the Netherlands have developed a process for extracting the raw materials lignin and hemicellulose from wood,” explains Geiger. “What remains is brownish lignocellulose, for which there has been no use so far.” Geiger, who has a long track record of research into electronics made from cellulose, saw the potential of the raw material.

HYPELIGNUM

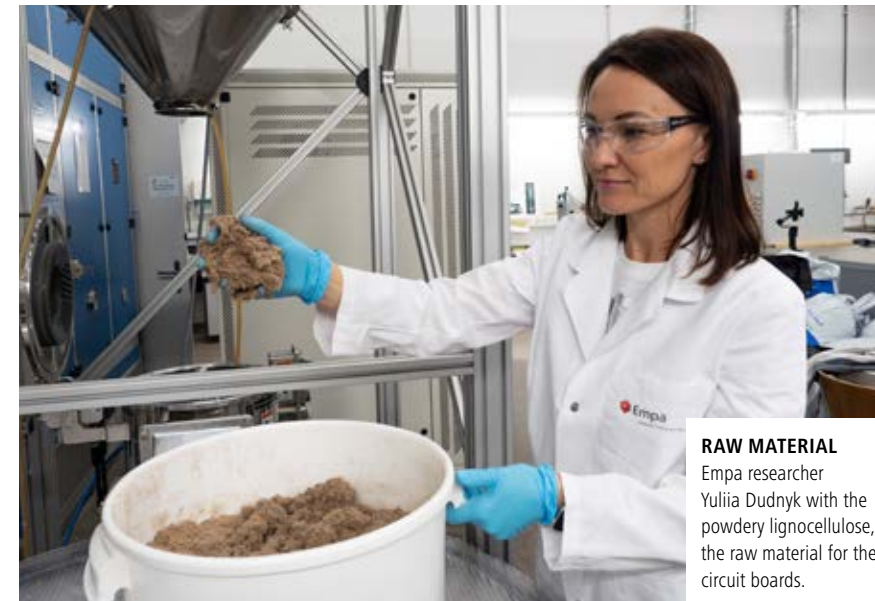
The EU research project HyPELignum aims to develop a holistic approach to functional, CO₂-neutral electronics. The international project partners from research and industry are combining wood-based raw materials and transition metals that are as non-critical as possible with additive manufacturing and advanced sustainability analyses. The project is funded under the Horizon Europe program and by the State Secretariat for Education, Research, and Innovation (SERI) and will run from October 2022 to September 2026. Researchers at Empa are involved in the development of sustainable printed circuit boards and in life cycle analysis.

In order for the flaky lignocellulose to become a high-tech product such as a PCB, it must first be ground by adding water to break down the relatively thick cellulose fibers into thinner fibrils. This creates a fine network of slender fibrils that are interconnected. In a next step, the water is squeezed out of the mixture under high pressure. The fibrils move closer together and dry to form a solid mass. The researchers call this process hornification. “The lignin contained in the material serves as an additional binding agent,” says the Geiger.

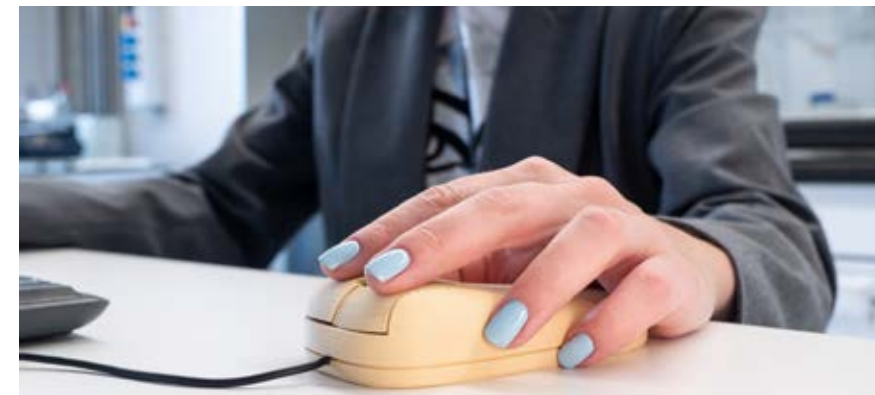
The resulting hornified board is almost as resistant as a conventional circuit board made of fiber-reinforced epoxy – almost. This is because the compostable board is still sensitive to water and high humidity. But water is needed because, “if no water can penetrate the carrier material at all, microorganisms such as fungi can no longer grow in it – and it would thus not be biodegradable,” explains Geiger.

A COMPOSTABLE COMPUTER MOUSE

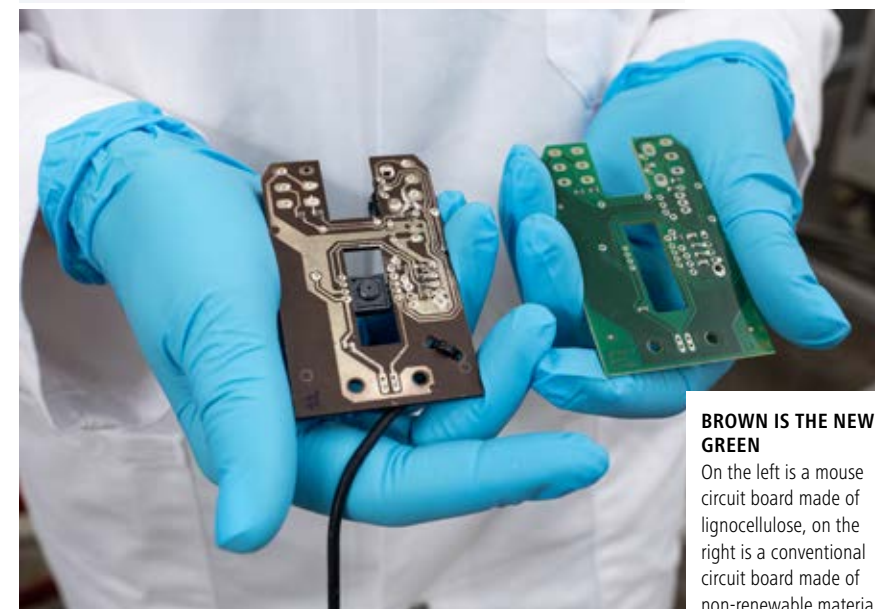
Nevertheless, the researchers are confident that the resistance of lignocellulose-based biomaterials can be further improved with suitable processing methods. “For certain applications, however, we also need to rethink our relationship with electronics,” says Thomas Geiger.



RAW MATERIAL
Empa researcher Yuliia Dudnyk with the powdery lignocellulose, the raw material for the circuit boards.



FUNCTIONAL AND BIODEGRADABLE
Researchers produced the 3D-printed casing from a mixture of biodegradable plastic and wood fibers.



BROWN IS THE NEW GREEN
On the left is a mouse circuit board made of lignocellulose, on the right is a conventional circuit board made of non-renewable materials.

“Many electronic devices are only in use for a few years before they become obsolete – so it doesn't make sense to manufacture them from materials that can last for hundreds of years.”

In collaboration with their industrial partner PROFACTOR GmbH in Austria, the researchers have printed conductive traces on their sustainable circuit boards and fitted them with components to produce functioning electronic devices, such as a computer mouse or an RFID card. At the end of its service life, such a device could be composted given the right conditions. Once the carrier material has decomposed, the metallic and electronic components can be removed from the compost and recycled.

Next, the researchers want to make their biomaterial for circuit boards more resistant without compromising its biodegradability. The project partners also plan to produce further demonstration devices with lignocellulose plates at the end of the HyPELignum project in 2026. Transfer to industry is also a must: “Together with Swiss and European companies, we want to develop further applications for the lignocellulose material,” says Geiger.



AFFORDABLE OR SUSTAINABLE? WHY NOT BOTH!

Electric cars are indispensable for climate-friendly mobility. They are most effective when e-vehicles are shared and charged intelligently. Real-time information on electricity prices and CO₂ emissions is crucial for this. This is demonstrated by a study based on extensive car-sharing usage data conducted by researchers at Empa and the University of Geneva.

Text: Manuel Martin



CAR-SHARING
Empa researchers analyzed the emissions-based charging of shared electric cars.

More electric drives systems and fewer cars – this is how emissions from traffic can be significantly reduced. Electric vehicles offer particularly great potential with car sharing. However, not all electricity is created equal: Depending on the time of day, both the energy mix (and thus the resulting CO₂ emissions) and the price for electricity vary. Using data from around 1.5 million users of the car-sharing provider Mobility, Empa researchers analyzed the emission-

dependent charging of electric cars. Their result: Low electricity prices – i.e. cost-savings – and low emissions can rarely be achieved simultaneously. Those who look for the cheapest tariff over the course of the year can save an average of 21% of the costs. On the other hand, those who charge in the most climate-friendly way can reduce their emissions by up to 82 percent. “A key challenge is to combine cost and emission targets,” says study author Sven Eggimann. “Ideally, it should also pay off financially to charge electric vehicles in a climate-friendly way.”

Photo: Mobility Cooperative

REAL-TIME TARIFF MODELS IN HIGH DEMAND

The study's calculations are based on hourly electricity price fluctuations. However, if only rough tariff models with day-night differences are offered, smart charging becomes tricky. “Most people in Switzerland don't know what the actual electricity price or

Appropriate incentive systems – such as a CO₂ price or corresponding electricity tariffs – are also needed to make charging during low-emission periods worthwhile. Simulations by the Empa team show that with a CO₂ price of around 30 cents per kilogram of CO₂ equivalent, climate-friendly and price-optimized charging can indeed be combined – but only with dynamic tariffs that reflect the real emissions of electricity consumption. “Ideally, charging should be based on voluntary measures supported by incentives,” says Romano. “These include, for example, cheaper electricity tariffs or reserved parking spaces during low-emission periods.” Otherwise, charging access could be restricted or inflexible charging behavior could be subject to additional fees.

DRIVEN MORE FREQUENTLY DURING THE DAY, YET STILL ENVIRONMENTALLY FRIENDLY

Shared vehicles are on the road more frequently and more often during the day – and therefore need to be charged more overnight, when the electricity mix tends to be less climate-friendly. Nevertheless, according to Eggimann, the total emissions and costs differ only slightly compared to private vehicles. “Although shared cars are used more intensively, short charging breaks and increasingly available fast-charging infrastructure leave enough leeway for low-emission charging.”

Car sharing promises to significantly reduce the number of vehicles on the road. With 25 percent fewer cars in Swiss cities, the strain on the electricity supply in winter could be noticeably reduced. “Car sharing requires less energy overall because there are fewer vehicles on the road,” explains Romano. “Even if the number of kilometers driven annually remains similar to that of privately used cars, other means of

transport are increasingly being used in addition to shared vehicles. This relieves the burden on the system as a whole.”

THE CRUX OF THE MATTER: WINTERTIME

For a sustainable transport revolution, electric vehicles should therefore not be viewed in isolation from optimized electric charging. “This requires further developments at the regulatory and technical level,” says Eggimann. “In the long term, however, the goal is clear: a charging infrastructure that automatically guides its users to low-emission and cost-effective charging times – without them having to constantly make decisions themselves.” If Switzerland is to focus more on electric cars in the future, the energy system will have to be adapted accordingly. Even with optimized charging times and a reduced vehicle fleet due to car sharing, the additional electricity demand resulting from the electrification of private mobility remains considerable – with a simulated winter deficit of around one terawatt hour per month in 2050. “This seasonal supply deficit cannot easily be remedied with additional batteries or shifting charging times,” explains Romano. “Electrification is therefore only part of the solution. If you really want to do something for the climate, you should rely on car sharing, public transport – and drive less overall.” ■



DISCOVERING ENERGY FUTURES THROUGH PLAY



CLIMATE CHALLENGE

In this simulation game, young people design a climate-neutral Switzerland.

Make decisions and change the future: Since August 2025, schoolchildren have been able to do just that at the Swiss Museum of Transport. In collaboration with Empa and Ulrich Creative Simulations GmbH, the Swiss Museum of Transport has developed an interactive simulation game called "Klima Challenge". In a two-hour workshop for school classes, students from the 8th grade onwards take on the role of decision-makers and shape Switzerland to become climate-neutral. The game was developed as part of the Joint Initiative Energy Science for Tomorrow (ES4T) of the ETH Domain.



"WISSEN2GO": PFAS, THE FOREVER CHEMICALS

PFAS chemicals are a hot topic – substances from this huge class of compounds end up in the environment, some even in the human body, and pollute it for generations. At Empa, Eawag, and the Ecotoxicology Center, researchers are working on a variety of approaches to protect both the environment and our natural resources such as drinking water, as well as to transform industry in a sustainable way. In the upcoming issue of "wissen2go," experts will answer key questions such as: What exactly are PFAS? Why are PFAS a problem? What can we do about them? And where and for how long will this problem affect us? Register today for the online event on November 25, 2025, at:



(UN)CANNY ALL-ROUNDERS

PFAS pollute the environment for generations. "wissen2go" provides answers to the most important questions about these forever chemicals.



"MINING THE ATMOSPHERE" AT THE WORLD EXPO IN OSAKA



HEIDI IN JAPAN

The mascot of the Swiss Pavilion at Expo 2025 visits the Empa exhibit.

From August 13 to October 13, Empa was represented at the Swiss Pavilion at Expo 2025 in Osaka. As part of the Swissnex exhibition Anticipation, Empa presented its interdisciplinary research initiative Mining the Atmosphere. Visitors were able to immerse themselves in the "atmospheric mine" by interacting with various objects – an aerogel sample, a cube made of CO₂-negative concrete, and a plastic figure of Heidi – and learn how CO₂-capturing materials work, how buildings can become carbon sinks, and why industrial processes will no longer have to rely on fossil fuels in the future.



EVENTS
(IN GERMAN AND ENGLISH)

28. OKTOBER 2025

Course: Laser Micromachining

Zielpublikum: Industrie und Wirtschaft

www.empa-akademie.ch/laser

Empa, Dübendorf

10. – 12. NOVEMBER 2025

SSbD25 – Safe and Sustainable by Design

Chemicals and Materials

Zielpublikum: Wissenschaft und Industrie

www.empa-akademie.ch/ssbd25

Empa, Dübendorf

17. NOVEMBER 2025

Course: Energy-autonomous embedded systems and the Internet-of-Things

Zielpublikum: Industrie und Wirtschaft

www.empa-akademie.ch/energy

Empa, Dübendorf

14. JANUAR 2026

Klebebewehrungen für die Verstärkung bestehender Tragwerke

Zielpublikum: Industrie und Wirtschaft

www.empa-akademie.ch/sia166

Empa, Dübendorf

10. – 12. FEBRUAR 2026

1st International Conference on Mg-based cements

Zielpublikum: Wissenschaft

www.empa.ch/web/MgQ2026

Centre Loewenberg, Murten

You can find all our current events here:



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Materials Science and Technology