Empa Quarterly

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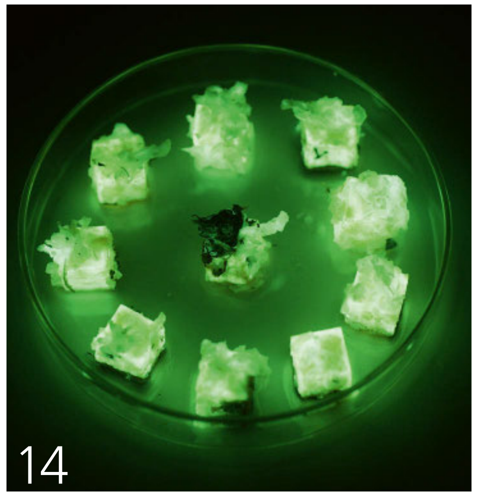
FOCUS: GREEN TECHNOLOGY

OUT OF THE WOODS

GLOWING WOOD
LIVING BATTERIES
SMART MATERIALS

[CONTENT]

[FOCUS: GREEN TECHNOLOGY]



Photos: Empa

[COVER]

This green glow was created in an Empa laboratory. Nevertheless, it is a natural phenomenon that was already known to the Greek philosopher Aristotle. Under the right conditions, wood infused with fungal filaments can glow. It could, for example, serve as an energy-efficient, heat-free and biodegradable light source.

Photo: Empa

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www.empa.ch
EDITORIAL Empa Kommunikation
LAYOUT PAUL AND CAT.
www.paul-and-cat.com
CONTACT Phone +41 58 765 47 33
redaktion@empa.ch
www.empaquarterly.ch
PUBLISHING SEQUENCE
quarterly
PRODUCTION
anna.ettlin@empa.ch

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Dear Readers

Switzerland is not exactly blessed with raw materials. However, one natural resource that is quite abundant is wood. Around a third of Switzerland is forested, with slightly rising trend. The ingenious thing about it is that the material grows back, binding CO_2 at the same time. And it is much more versatile than you might think. There is almost nothing that cannot be done with wood and the materials obtained from it.

Did you know, for instance, that wood can glow in the dark? Or that cellulose fibers can be used to produce green electronics, for example sensors that indicate environmental changes? All this and much more is possible when resource 1 (wood) is combined with resource 2 (bright minds), as this Quartely impressively shows. Incidentally, the latter also investigated how Swiss wood should be best used in order to generate high added value on the one hand and to bind the CO_2 it contains for as long as possible on the other. Their conclusion: It should only be used for energy, i.e. burnt, after as long a lifespan as possible in various incarnations – as building material, furniture or some such. This is known as cascading use.

Besides wood, our forest also offers another source of new materials – fungi. In fact, these are what make the wood mentioned at the beginning of this article glow in the dark. They can also be used to make mini-batteries, for example to power sensors in agriculture or environmental research. Once their work is done, they simply turn to dust.

Have fun reading – and all the best for the New Year!

Your MICHAEL HAGMANN

Photo: Empa

AIRY CELLULOSE FROM A 3D PRINTER

Ultralight, thermally insulating, biodegradable: aerogel made from cellulose is extremely versatile. In an SNSF project, Empa researchers from the Building Energy Materials and Components laboratory have succeeded in 3D printing the natural material into complex shapes. Although the original focus was on thermal insulation – for precision insulation in microelectronics, for instance – the researchers see great potential in medicine. As the printable aerogel consists of pure cellulose, it is biocompatible and, owing to its porous structure, is capable of releasing drugs in the body over time. And 3D printing offers the possibility of producing various shapes, for example as a scaffold for cell growth or for personalized implants.

A LOOK BEHIND THE SCENES: BECOME A FRIEND OF EMPA

COMMUNITY
Friends of Empa is a platform for everyone interested in Empa's research and the people behind it.

Empa wants to further expand its dialog with the interested public. To this end, it has launched a new initiative called Friends of Empa. The aim of the initiative is to create a community of people who are interested in Empa and its research. Friends have access to exclusive events, lectures and lab tours. In this way, they learn first-hand from the researchers what they are currently working on and get a look behind the scenes, which is hardly possible in normal circumstances. The community is open to everyone. Empa is looking forward to welcoming many Friends to its campuses in the coming years. Would you also like to be a Friend of Empa? Register at:

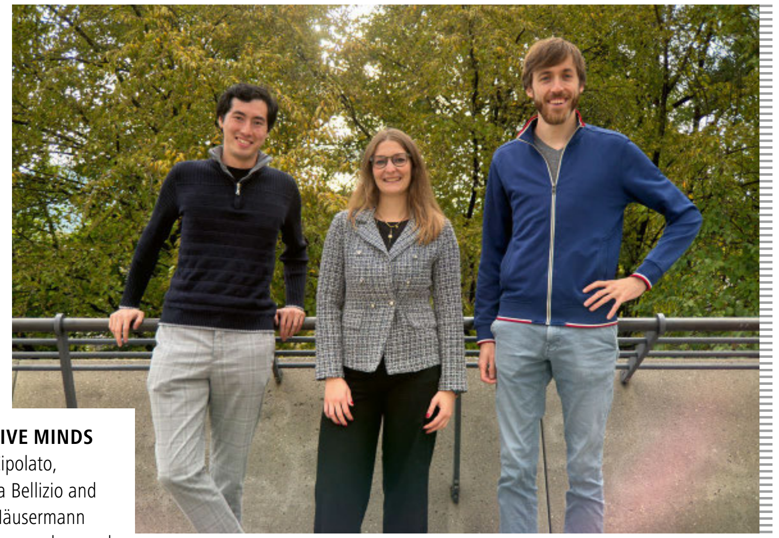
AWARD FOR INNOVATION AGAINST SURGICAL COMPLICATIONS

The Empa Innovation Award recognizes outstanding projects bridging the gap between the laboratory and industry. This year, a team from Empa and ETH Zurich led by Alexander Jessernig, Alexandre Anthis and Inge Herrmann was honored for their SensAL technology. SensAL warns quickly and precisely of life-threatening complications after abdominal surgery. The principle is cost-effective, convincingly simple and easy to integrate into everyday clinical practice, which also impressed the jury. Shortly after the prize was awarded, SensAL was also honored at the Falling Walls Switzerland science event.

AWARD WINNER
Alexander Jessernig with the SensAL technology.

Photos: Empa; ETH Zurich

EMPA ENTREPRENEUR FELLOWSHIP FOR TOMORROW'S START-UPS



CREATIVE MINDS
Oscar Cipolato, Federica Bellizio and David Häusermann (f.l.t.r.) are each awarded an Empa Entrepreneur Fellowship.

Empa's promotion of its start-ups has received a boost through the Empa Entrepreneur Fellowship. 2024 marks the third time this fellowship was awarded to young researchers who want to turn applications-oriented research into innovative products or services. Three winners have been selected this year: Oscar Cipolato is pushing forward laser tissue soldering with robots, Federica Bellizio is developing a platform for energy suppliers, and David Häusermann is researching drones to help firefighters and industrial inspectors.

SCIENCE BREAKTHROUGH OF THE YEAR GOES TO INGE HERRMANN

Empa researcher Inge Herrmann was awarded the Global Women's Impact Award and the Science Breakthrough of the Year 2024 in the Women's Impact category by the Falling Walls Foundation. Herrmann presented her research in November on the Falling Walls Main Stage and as part of the Kavli Dialog. In addition, Alexander Jessernig, a doctoral student in Herrmann's team and winner of Falling Walls Switzerland, presented his sensor for the early detection of post-operative bowel leaks. Inge Herrmann heads a research group in Empa's Particles-Biology Interactions laboratory and the Ingenuity Lab at the University of Zurich and Balgrist University Hospital. She is also an accredited professor in the Department of Mechanical Engineering at ETH Zurich. In one of her research projects, her team has developed a reversible hydrogel implant that could be used to prevent the widespread female disease endometriosis and at the same time act as contraceptive.

OUTSTANDING
Inge Herrmann was honored for her work on women's health.

Photos: Empa

CARBON-BASED QUANTUM LEGO

Quantum technologies promise breakthroughs in communication, computing, sensors and much more. However, quantum states are fragile, and their effects are difficult to grasp, making research into real-world applications challenging. Empa researchers and their partners have now achieved a breakthrough: using a kind of "quantum Lego", they have been able to accurately realize a well-known theoretical quantum physics model in a synthetic material.

Text: Anna Ettlin

WITH UTMOST PRECISION
Using special nanographene molecules, the researchers were able to realize a theoretical model from quantum physics.

Graphic: Empa

The smallest unit of information in a computer is the bit: on or off, 1 or 0. Today, the world's entire computing power is built on the combination and interconnection of countless ones and zeros. Quantum computers have their own version of the bit: the qubit. It, too, has two basic states. The main difference: Quantum effects allow a superposition of the two states, so that the qubit is not either 1 or 0, but both at the same time. With different proportions of 0 and 1, the qubit can theoretically assume an infinite number of states.

This ambiguity should give quantum computers true "superpowers". At least in theory, quantum-based computers can perform calculations in fractions of a second that stump today's best supercomputers. However, quantum computing is not yet fully developed. One of the biggest challenges is linking the qubits – since one single (qu)bit is not much of a computer.

One way to realize the 0 and the 1 of the qubit is via the alignment of the so-called electron spin. The spin is a fundamental quantum mechanical property of electrons and other particles, a kind of torque that, put simply, can point "up" (1) or "down" (0). When two or more spins are quantum-mechanically linked, they influence each other's states: Change the orientation of one, and it will also change for all the others. This is therefore a good way to make qubits "talk" to each other. However, like so much in quantum physics, this "language", i.e. the interaction between the spins, is enormously complex. Although it can be described mathematically, the relevant equations can hardly be solved exactly even for relatively simple chains of a just few spins. Not exactly the best conditions for putting theory into practice.

A MODEL BECOMES REALITY

Researchers at Empa's nanotech@surfaces laboratory have now developed a method that allows many spins to "talk" to each other in a controlled manner – and that also enables the researchers to "listen" to them, i.e. to understand their interactions. Together with scientists from the International Iberian Nanotechnology Laboratory and the Technical University of Dresden, they were able to precisely create an archetypal chain of electron spins and measure its properties in detail. Their results have now been published in the renowned journal Nature Nanotechnology.

The theory behind the chain is familiar to all physics students: Take a linear chain of spins in which each spin interacts strongly with one of its neighbors and weakly with the other. This so-called one-dimensional alternating Heisenberg model was described almost 100 years ago by physicist and later Nobel Prize laureate Werner Heisenberg, one of the founders of quantum mechanics. Although there are materials in nature that contain such spin chains, it has not yet been possible to deliberately incorporate the chains into a material. "Real materials are always much more complex than a theoretical model," explains Roman Fasel, head of Empa's nanotech@surfaces laboratory and co-author of the study.

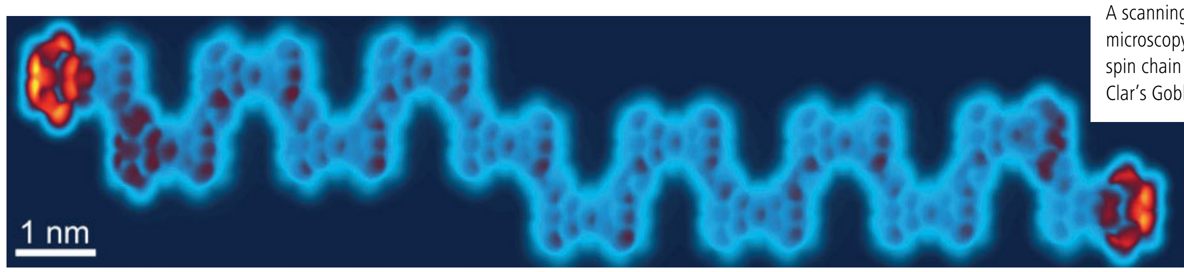
A "GOBLET" MADE OF CARBON

To create such an artificial quantum material, the Empa researchers used tiny pieces of the two-dimensional carbon material graphene. The shape of these nanographene molecules influences their physical properties, in particular their spin – a kind of nano-sized quantum Lego brick from which the scientists can assemble longer chains.

For their Heisenberg model, the researchers used the so-called Clar's Goblet molecule. This special nanographene molecule consists of eleven carbon rings arranged in an hourglass-like shape. Due to this shape, there is an unpaired electron at each end – each with an associated spin. Although predicted by chemist Erich Clar as early as 1972, Clar's Goblet was only produced in 2019 by Fasel's team at the nanotech@surfaces laboratory.

The researchers have now linked the goblets on a gold surface to form chains. The two spins within a molecule are weakly linked, while the spins from molecule to molecule are strongly linked – a perfect realization of the alternating Heisenberg chain. The researchers were

Photo: Empa



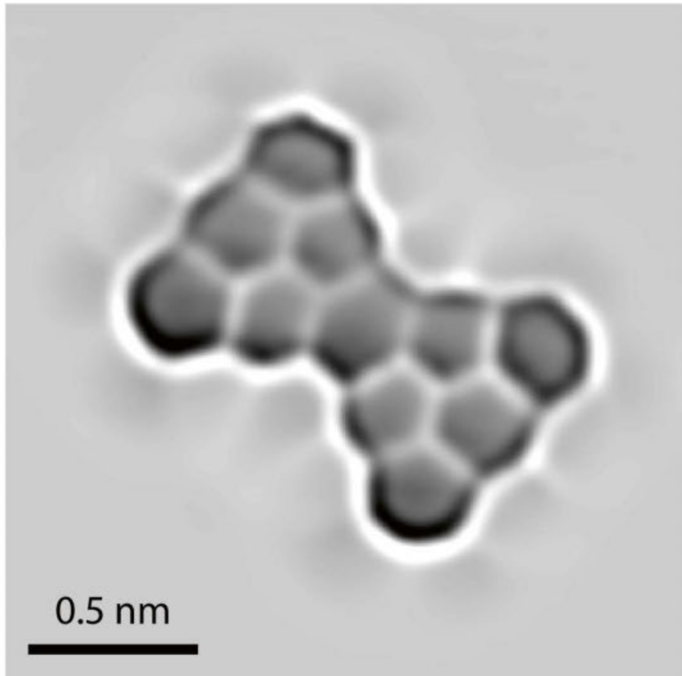
CONNECTED
A scanning tunneling microscopy image shows the spin chain made of individual Clar's Goblets.

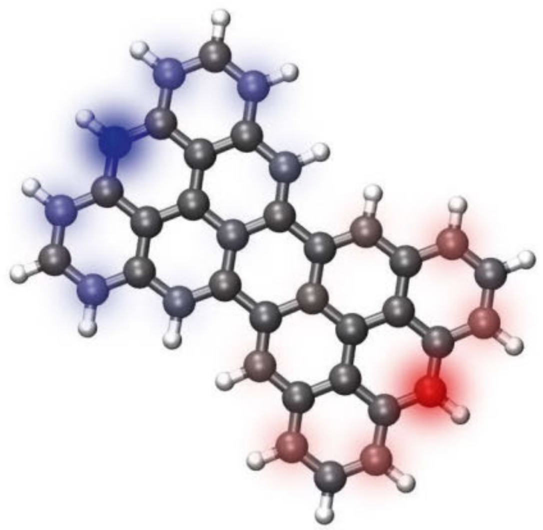
able to precisely manipulate the length of the chains, selectively switch individual spins on and off and "flip" them from one state to another, allowing them to investigate the complex physics of this novel quantum material in great detail.

FROM THEORY TO PRACTICE

Fasel is convinced that, just as the synthesis of Clar's Goblet enabled the production of Heisenberg chains, this study will in turn open new doors in quantum research. "We have shown that theoretical models of quantum physics can be realized with nanographenes in order to test their predictions experimentally," says the researcher. "Nanographenes with other spin configurations can be linked to form other types of chains or even more complex systems." The Empa researchers are leading by example: In a second study, which is about to be published, they were able to recreate a different type of Heisenberg chain in which all spins are equally linked.

To be at the forefront of applied quantum physics, theoretical and experimental scientists from different disciplines need to work together. Chemists at Dresden University of Technology provided Empa researchers with the starting molecules for their synthesis of Clar's Goblets. And researchers from the International Iberian Nanotechnology Laboratory in Portugal contributed their theoretical expertise to the project. The theory needed for such breakthroughs is not (just) what you find in physics textbooks, Fasel emphasizes, but a sophisticated transfer between the quantum physics model and the experimental measurements. ■





UNIQUE MOLECULE
Left: High-resolution scanning tunneling microscopy image of Clar's Goblet. Right: Structural model of Clar's Goblet (blue: spin up, red: spin down).

Photo/Graphic: Empa

Photo: Empa

ELECTRIC FUNGI

A battery that needs feeding instead of charging? This is exactly what Empa researchers have achieved with their 3D-printed, biodegradable fungal battery. The living battery could supply power to sensors for agriculture or research in remote regions. Once the work is done, it digests itself from the inside.

Text: Anna Ettlin

BIOTECH EXPERT
Empa researcher Carolina Reyes with one of the fungus strains used to make the battery.

▶

Fungi are a source of fascination. This kingdom of life – more closely related to animals than to plants – encompasses an enormous variety. Everything can be found here: from edible mushrooms to molds, from single-celled life to the largest organism on Earth, from disease-causing pathogens to superheroes that produce medicines. Now, Empa researchers have coaxed another ability out of fungi: generating electricity.

As part of a three-year research project, supported by the Gebert Rüf Stiftung as part of their Microbials funding program, researchers from Empa's Cellulose and Wood Materials laboratory have developed a functioning fungal battery. The living cells do not produce a whole lot of electricity – but enough to power a temperature sensor for several days, for example. Such sensors are used in agriculture or in environmental research. The biggest advantage of the fungal battery: Unlike conventional batteries, it is not only completely non-toxic but also biodegradable.

FUNGI FROM THE PRINTER

Strictly speaking, the cell is not a battery, but a so-called microbial fuel cell. Like all living things, microorganisms convert nutrients into energy. Microbial fuel cells make use of this metabolism and capture part of the energy as electricity. Until now, they have mostly been powered by bacteria. "For the first time, we have combined two types of fungi to create a functioning fuel cell," says Empa researcher Carolina Reyes. The metabolisms of the two species of fungi complement each other: On the anode side there is a yeast fungus whose metabolism releases electrons. The cathode is colonized by a white rot fungus, which produces a special enzyme, allowing the electrons to be captured and conducted out of the cell.

The fungi are not "planted" into the battery but are an integral part of the cell from the outset. The components of the fungal battery are manufactured using 3D printing. This allows the researchers to structure the electrodes in such a way that the microorganisms can access the nutrients as easily as possible. To do this, the fungal cells are mixed into the printing ink. Easier said than done: "It is challenging enough to find a material in which the fungi grow well," says Gustav Nyström, Head of the Cellulose and Wood Materials lab. "But the ink also has to be easy to extrude without killing the cells – and of course we want it to be electrically conductive and biodegradable."

> "Fungi are still under-researched in the field of materials science."

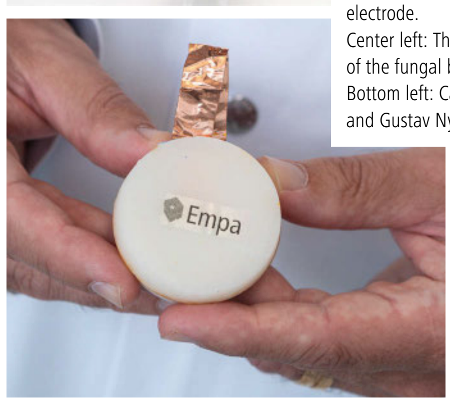
MICROBIOLOGY MEETS ELECTRICAL ENGINEERING

Thanks to their laboratory's extensive experience in 3D printing of soft, bio-based materials, the researchers were able to produce a suitable ink based on cellulose. The fungal cells can even use the cellulose as a nutrient and thus help to break down the battery after use. However, their preferred nutrient source is simple sugars, which are added to the battery cells. "You can store the fungal batteries in a dried state and activate them on location by simply adding water and nutrients," says Reyes.

Although the robust fungi survive such dry phases, working with the living materials posed a number of challenges for the researchers. The interdisciplinary project combines microbiology, materials science and electrical engineering. In order to characterize the fungal batteries, trained microbiologist Reyes not only had to learn electrochemistry techniques, but also to adapt them to 3D-printing inks.

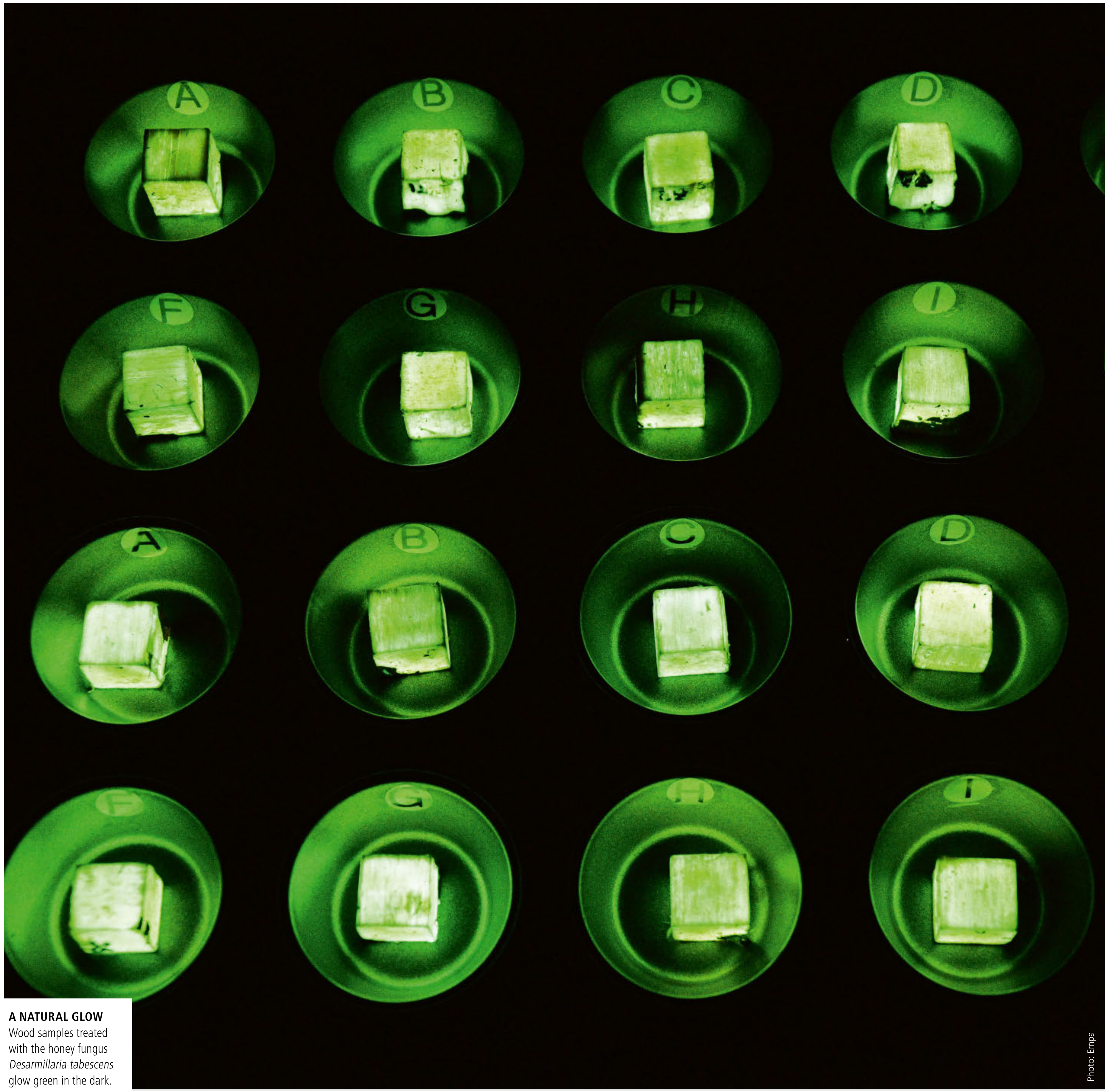
The researchers now plan to make the fungal battery more powerful and longer-lasting – and to look for other kinds of fungi that would be suitable for supplying electricity.

"Fungi are still under-researched and under-utilized, especially in the field of materials science," Reyes and Nyström agree. ■



LIVING ELECTRICITY
Right: Gustav Nyström with one of the fungal cultures.
Top left: The 3D-printed electrode.
Center left: The wax casing of the fungal biobattery.
Bottom left: Carolina Reyes and Gustav Nyström.

Photos: Empa



A NATURAL GLOW
Wood samples treated with the honey fungus *Desarmillaria tabescens* glow green in the dark.

Photo: Empa

LET IT SHINE!

Since more and more deciduous trees are being planted in Swiss forests, whose wood is often burned directly, innovative ideas for alternative uses are in high demand in order to utilize Swiss hardwood more sustainably. Empa researchers are therefore equipping wood with new functionalities. Their latest coup: wood that can glow in the dark.

Text: Andrea Six

In order to defy climate change and the bark beetle, more deciduous trees are being planted in Swiss forests. If possible, their wood should be used several times before it ends up as firewood, thus releasing the previously bound CO_2 back into the atmosphere. At present, however, hardwood is still too often used directly for heating. Innovative ideas for a more sustainable use are therefore needed. One possibility is to equip the natural material with new properties – in technical terms: functionalities – and transform it into magnetic, waterproof or electricity-generating wood, for instance.

A team led by fungal researcher Francis Schwarze from Empa's Cellulose & Wood Materials lab in St. Gallen is currently pursuing another idea for a new type of composite material based on hardwood: luminous wood. In addition to applications in technical fields, the luminous wood could be processed into designer furniture or jewelry.

ENTANGLED LIVING MATERIALS

This has been achieved thanks to a parasite: The honey fungus is a pathogen that causes white rot in trees and is therefore actually a wood pest. Some species produce the natural substance luciferin, which is stimulated to glow in a two-stage enzymatic process. Wood permeated by fungal threads therefore emits a green light.

"Naturally luminous wood was first described around 2,400 years ago by the Greek philosopher Aristotle," says Schwarze. Strictly speaking, the interwoven structure of fungus and wood can be described as a natural biohybrid, a combination of living materials. "Artificially produced composite materials of this kind would be interesting for many types of application," says the Empa researcher. But what nature seems to achieve effortlessly has so far been (too) challenging for biotechnology. Now, for the first time, the Empa team has succeeded in inducing and controlling the process in the laboratory.

FROM THE WOODS TO THE LAB

Biotechnologist Francis Schwarze has tracked down the glowing mushrooms in nature, analyzed them in the laboratory and deciphered their genetic code. The ringless honey fungus (*Desarmillaria tabescens*) turned out to be particularly powerful. After preliminary tests with different types of wood, Schwarze started with balsa wood (*Ochroma pyramidale*), a wood with a particularly low density. Using spectroscopy, the researchers observed how the fungus degrades lignin in the balsa wood samples, which is responsible for stiffness and compressive strength. However, X-ray diffraction analyses showed that the stability of the wood does not diminish as a result: The cellulose, which provides tensile strength in the wood, remained intact.

WANTED: A MOIST ENVIRONMENT

The biohybrid of fungus and wood develops its maximum luminosity when incubated for three months. *Desarmillaria* likes it particularly moist: The balsa wood samples absorbed eight times their weight in moisture during this time. The enzyme reaction in the wood finally gets triggered when in contact with air.

The glow unfolds its full splendor after about ten hours, emitting green light with a wavelength of 560 nanometers, as Empa researcher Giorgia Giovannini from the Biomimetic Membranes and Textiles lab determined during fluorescence spectroscopy analyses. The fascinating process currently lasts around ten days. "We are now optimizing the laboratory parameters in order to further increase the luminosity in the future," says the Empa researcher.

MUSHROOM HUNTER
Francis Schwarze in his treasure trove: mushroom cultures that glow, produce marbled wood or make wood sound better are his specialty.

Photo: Empa

NATURAL BIOLUMINESCENCE

In nature, bioluminescence occurs in a wide variety of organisms. The light is produced thanks to chemical processes that release energy in the form of both light and heat. If one compares the light-generating reactions in nature on the basis of their so-called quantum yield, the firefly is the winner with a value of 40%, luminous jellyfish achieve 17%, and luminous mushrooms reach 2%.

LUMINESCENT MUSHROOMS

Over 70 species of fungi show bioluminescence. They produce a glow known as "foxfire" in rotting wood. The term is a French-English hybrid of "faux" and "fire" for "false fire". The purpose of bioluminescence in fungi is not entirely clear. It may be to attract insects to spread fungal spores.

It is difficult to find luminescent wood in nature because ubiquitous artificial light sources at night make it difficult to spot. Empa researcher Francis Schwarze advises looking for dead wood under moist autumn leaves on a moonless fall night in a mixed beech forest. With a bit of luck, the mushroom and its glowing wood supper can be discovered.

LUMINOUS SQUID

The small squid *Watasenia scintillans* measures just eight centimeters, but it's big on camouflage: Light-emitting cells are scattered across its underside. These photophores confuse predatory fish that live on the seabed. When looking up towards the surface of the water, the luminous squid cannot be spotted by predators.

FIREFLIES

These insects, which are up to two centimeters in size, find each other for mating thanks to their light. Fireflies not only have a translucent abdomen, they also have a reflective layer on the inside. This "built-in mirror" also reflects the bioluminescence outwards. This makes *Lampyris noctiluca* the shining star among the bioluminescent creatures.

GIANT HONEY FUNGUS

It is called the honey fungus and is one of the most amazing creatures on Earth. It may sprout inconspicuously on the forest floor in the classic mushroom shape, adorned only with a decorative strip around the stipe, like a bracelet, which gives it the Latin name *Armillaria*.

Much more impressive, however, is its web of black strands that it draws over wood and ground. The fungal threads form thick, meter-long bundles, surrounded by a black melanin-containing protective layer. These so-called rhizomorphs search for new habitats and food sources.

The largest living organism in the world, a 2400-year-old honey fungus network, covers an area of several square kilometers in the US state of Oregon. The largest mushroom in Europe can be found in Switzerland on the Ofen Pass. This 1000-year-old honey fungus covers an area the size of 50 football pitches. ■

Photos: Empa; Adobe Stock; Benjamin Derge

PLEASE WAIT BEFORE BURNING

Sustainable, renewable and good for the climate: wood is the material of the future. But how much of it do we actually have and how do we make best use of it? Researchers from Empa and WSL have now analyzed the material flows of wood in Switzerland in detail – and discovered untapped opportunities.

Text: Anna Ettlin

Switzerland has set itself a goal that is as ambitious as it is necessary: net zero by 2050. One of the most important raw materials on the road to a climate-neutral future is wood. This renewable natural resource binds CO_2 from the atmosphere as it grows. Both as a material and as an energy source, wood and its numerous components offer alternatives to fossil fuels and materials. It is therefore hardly surprising that many sectors of industry plan to rely more on wood in future, whether in construction, in textile manufacturing or even in sectors such as electronics, chemicals and pharmaceuticals.

Little is known, however, about how much wood is available for all these desired applications and in what form. In order to shed some light on the matter, researchers from Empa and WSL have now comprehensively analyzed all documented material flows of wood in Switzerland. Their study, which was recently published in the journal Industrial Ecology, was carried out as part of SCENE, a joint initiative of the ETH Domain (see box).

EXTENSIVE DATA FOR AN ACCURATE ASSESSMENT

For their analysis, the researchers used data for the year 2020 from 21 different sources – a methodological challenge, as the figures in the various sources did not always match. Wood is a diverse raw material that can take many forms on its way from harvest to use, often differing in volume and moisture content: raw timber, sawn wood, wood chips, wood pulp for the paper industry and much more. Harmonizing the different material flows was therefore a Herculean task.

> **SCENE – A JOINT INITIATIVE OF THE ETH DOMAIN**
>
> The Swiss Center of Excellence on Net-Zero Emissions (SCENE) is a joint initiative of all six institutions of the ETH Domain, which is partly funded by the ETH Board. Together, the partners conduct interdisciplinary research to support Switzerland in achieving the net zero target by 2050. The two Empa laboratories Technology and Society and Cellulose and Wood Materials are working together with PSI and WSL in the work package Biomass Carbon Cycle.

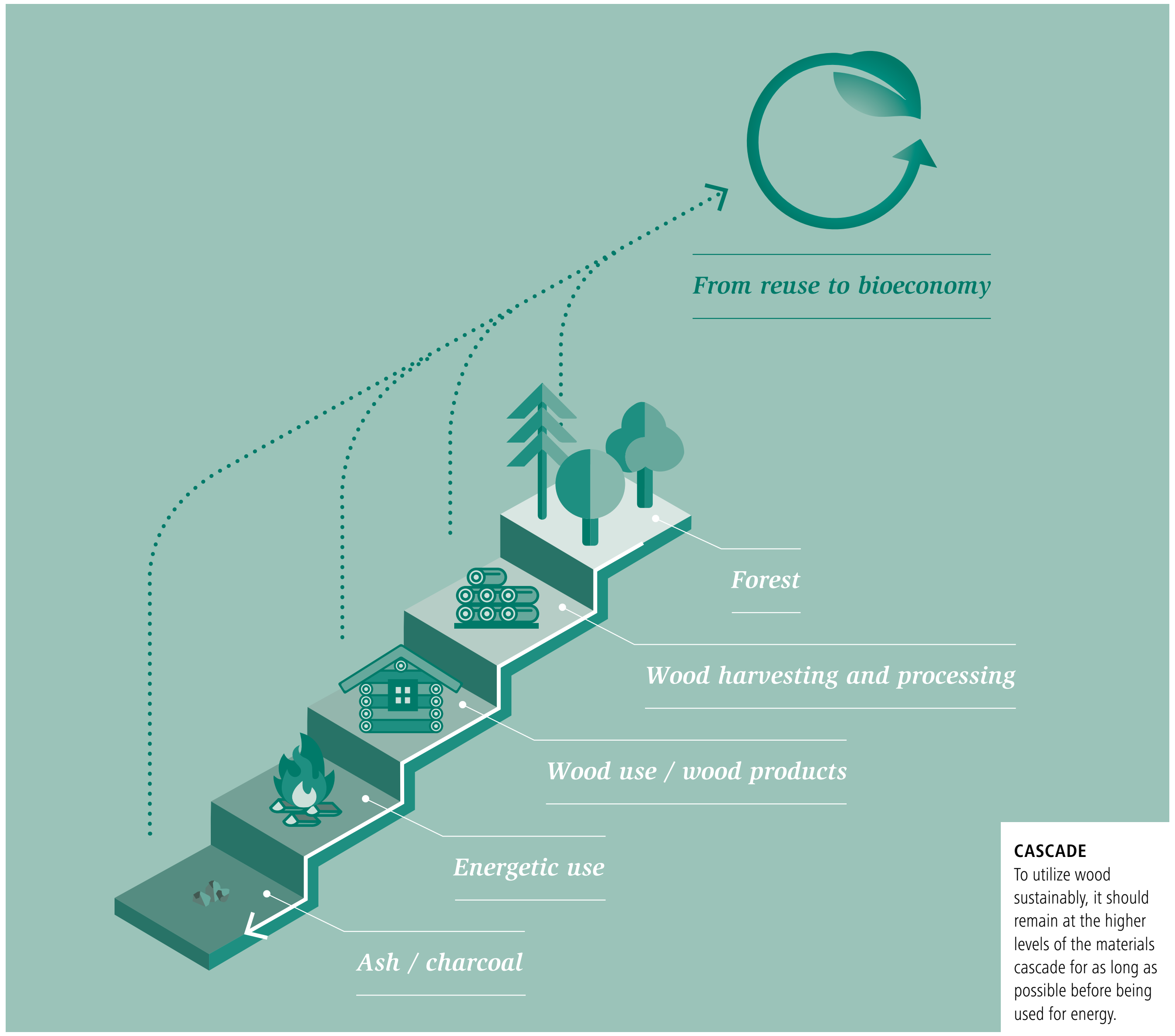
But the effort was worth it. "Comparable studies from abroad rely heavily on modeling. They have data on how much wood is harvested in the forest, and they use this to calculate the subsequent material flows," explains Nadia Malinverno from Empa's Technology and Society laboratory, the lead author of the study. The Empa team, on the other hand, used "real" data almost throughout, from timber harvesting and import/export to processing, recycling and disposal. This results in a much more accurate picture – albeit not a perfect one, emphasizes Malinverno. "We have to thank our colleagues at WSL and the Federal Office for the Environment (FOEN) for the good data that is available in Switzerland," adds co-author and Empa researcher Claudia Som.

WOOD SHOULD STAY WOOD FOR AS LONG AS POSSIBLE

The conclusion: Switzerland still has considerable potential when it comes to sustainable use of wood. For example, the recycling rate for wood is just under eight percent, compared to around 70 percent for paper. What's more: "Of the five to seven million cubic meters of wood that we harvest in Switzerland every year, around 40 percent is used directly for energy – in other words, it is burned," says Malinverno. The researchers agree that this is far from ideal. Because: "For wood to fulfill its function as a long-term CO_2 sink, it should remain in the technosphere as a material for as long as possible," explains Som.

The vision of the researchers and of the SCENE initiative is a so-called cascading use of wood. In this approach, a harvested tree would first be processed into the largest possible high-quality product – such as beams and boards for construction. This wood should then be (re-)used in this function for as long as possible. Only when reuse is no longer feasible would the wood be broken down into the next material stage, for example as smaller boards, wood chips or wood-based materials. It should only go into the furnace when it can no longer be used as a material.

This is just one possible example of a wood cascade. As part of SCENE, the researchers want to investigate in more detail which uses of wood make the most sense, both from an ecological and economic perspective. One of their goals is to take a closer look at selected material flows: In what form is wood present in a particular flow? Where exactly is it produced? How is it treated? And how else could it be used? Nadia Malinverno, Claudia Som and their fellow researchers will be looking into these questions in the coming years. ■



Graphic: Empa

CASCADE
To utilize wood sustainably, it should remain at the higher levels of the materials cascade for as long as possible before being used for energy.

ALPINE CRAFTSMANSHIP INSPIRES NEW MATERIALS

Traditional shingle production has inspired researchers at Empa and ETH Zurich to develop new types of wood-based panels made from split wooden sticks. Thanks to an AI-optimized process, these panels should be suitable for load-bearing components in the future – even if produced from lower-quality wood and tree trunks.

Text: Manuel Martin

INSPIRATION
Traditional wooden shingles serve as a blueprint for innovative wood-based materials.

Photo: Adobe Stock

Wooden shingles characterize the appearance of roofs and facades in the Alpine region – and have been hand-crafted for generations. This centuries-old craft inspired researchers at Empa and ETH Zurich to use this very efficient wood separation method to produce new types of wood-based materials. "In view of the growing impact of climate change on our forests and the construction sector, the production of panels from split sticks is an obvious choice. This means that they can be produced from wood of varying quality and from hardwood species, generate less material loss and should come close to solid wood products in terms of strength," says Ingo Burgert, Professor at ETH Zurich and leader of a research team at Empa. In Central Europe, spruce in particular is coming under increasing pressure due to longer periods of drought. More drought-resistant deciduous tree species will therefore play a more important role in the future. At the same time, the majority of hardwood in this country is currently burned to generate energy – despite the fact that more and more buildings are being built with wood, not least because as a renewable resource it binds CO_2 in the building material for longer periods.

SPLITTING FOR MAXIMUM MATERIAL YIELD

Traditionally, shingles are split by hand from log segments, while industrial processes rely on pneumatic splitting tools. "Shingle production shows us how wood can be processed in an energy-efficient and material-efficient way," explains Burgert. "Wood can be split parallel to the fibers with minimal energy and almost no losses." This chipless wood processing considerably increases the sawn timber yield, which, at around 60%, is significantly lower in Swiss sawmills.

In traditional shingle production, however, only selected high-quality softwood is usually used. In order to adapt the process for lower-quality hardwood species and to split longer sticks, the researchers rely on a two-stage splitting process. First, flat elements are separated, which are then further processed into wooden sticks of the desired dimensions. On a laboratory scale, the researchers adapted an apparatus for splitting firewood for this purpose. Thanks to a multi-bladed splitting head, several boards or sticks can be produced at the same time during one splitting process.

SELECTION THANKS TO AI

The splitting process produces wooden sticks in the direction of the grain without cutting the stiff and strong fibers. However, the irregular shape of the sticks poses a challenge. To overcome this, Burgert and his team are relying on artificial intelligence (AI). An automated camera system captures high-resolution images of each wooden bar, which are fed into a neural network. "With AI, we can determine important wood properties such as stiffness for each stick, regardless of shape, size or type of wood," explains Empa researcher Mark Schubert. "If we use different types of wood of different qualities in the future, wood sorting will play a crucial role. With our machine learning algorithms, we therefore generate as much data as possible about each individual piece of wood in order to use it optimally for wood-based materials with defined properties."

The team has pressed the first panels without sorting the wooden sticks beforehand. Even so, the potential of the manufactured demonstrators is already apparent: The panels can be produced in a highly resource-efficient manner and have mechanical properties that make them ideal for load-bearing components in the future. Despite challenges in terms of production processes, bonding, scalability and the predictability of material properties, Burgert is optimistic: "Our process has the potential to offer a sustainable alternative for the use of wood in times of accelerating climate change." ■

NEW CENTER FOR WOOD RESEARCH IN THE PLANNING

The project "Split wood rods for innovative wood-based panels in construction" is part of the Mainstreaming Wood Construction (MainWood) initiative. This initiative, which is supported by the ETH Board, promotes the increased use of wood in the construction industry. In addition, a Center for Wood Materials and Structures is currently being planned, which will bundle wood research at Empa and ETH Zurich and increase its visibility. As a central point of contact, the center will initiate innovative projects together with the wood industry in order to make better use of wood along the entire value chain. By developing new types of wood-based materials and technologies, the diverse application possibilities of the renewable and CO_2-storing resource wood are to be made even more accessible.

SMART AND SENSITIVE

Researchers from Empa, EPFL and CSEM have developed a green smart sensing tag that measures temperature and humidity in real time – and can also detect whether a temperature threshold has been exceeded. In future, this could be used to monitor sensitive shipments such as medicines or food. The sensor tag itself is completely biodegradable.

Text: Anna Ettlin

Vast flows of goods circle the globe every day. They include particularly delicate shipments, such as certain vaccines, medicines and food products. To ensure that these products arrive safely at their destination, they must remain within a certain temperature and humidity range throughout the entire supply chain. But how do we ensure this? It is costly and unsustainable to equip every single shipment with silicon-based sensors and chips. And measurements at nodes in the supply chain tell you nothing about what has already happened to the delicate goods on their way thus far.

Researchers from Empa, EPFL and CSEM have taken up this challenge in a four-year project called Greenspack. Together, they have developed a smart sensor tag that measures the temperature and relative humidity, and can "remember" when a certain temperature threshold has been exceeded. The small sticker is not only silicon-free, but also completely biodegradable. The project was funded by the Swiss National Science Foundation (SNSF) and Innosuisse as part of the BRIDGE Discovery program.

ELECTRICAL CIRCUITS WITH A MEMORY

To do its job, the smart tag needs neither a battery nor a transmitter. Instead, it works in a similar way to an RFID chip. It contains printed paths of conductive materials that form electrical circuits with resistive and capacitive elements. If these circuits are exposed to an electromagnetic field, for example from a tag reader, a resonance is created that can be decoded by the tag reader. The ingenious part: The conductivity and capacitance of the individual circuits changes depending on the ambient temperature or humidity, also changing their resonance. This alteration provides information about the current temperature and humidity – without any complicated measurement technology.

But that's not all – the researchers also wanted to give the label a kind of "memory". If the temperature of 25° Celsius is exceeded, a tiny element in one of the circuits melts, irreparably interrupting the circuit. The next time the label is read, it shows: This shipment was once too warm. "Talking about vaccinations, for example, this could mean that the shipment can no longer be used or that the expiry date is invalid," explains Gustav Nyström, head of Empa's Cellulose and Wood Materials laboratory, who led the research project.

This technology reduces the burden on the supply chain and lowers its carbon footprint: Potentially damaged goods are detected earlier and do not have to be shipped any further. If the goods have simply become less durable due to the temperature exposure, the shipment can be redirected to a closer location if necessary. "Depending on the materials we use, we can set different temperature thresholds," adds Nyström. Labels for frozen goods, for example, would be conceivable.

BIODEGRADABLE AND SUSTAINABLE

Once the shipment has reached its destination, the tag is envisioned to be composted or included with the cardboard recycling, as it is completely biodegradable. The Empa researchers have developed a dedicated material for the substrate, which consists of a biopolymer and cellulose fibers. The researchers at Empa and EPFL then used a customized ink containing the bioabsorbable metal zinc to print the conductive sensing elements. Meanwhile, the CSEM researchers worked on the tag design and readout technology.

Working with biodegradable materials is always a challenge – they should only decompose once their work is done. In addition, the individual components of the sensor tag only had to respond very selectively to the environmental conditions: "We didn't want the temperature sensor to react to moisture and vice versa," says Nyström. Together, the project partners succeeded in solving these problems. Two EPFL researchers are now working on commercializing the findings from Greenspack with a start-up called Circelec. The Empa researchers around Gustav Nyström want to delve even deeper into the field of green electronics and explore the potential of smart labels as sensors for agriculture and environmental monitoring. ■

Photo: Empa

STRESSED? GO GREEN!

It is hardly surprising that green spaces in noisy cities offer people respite from stress. However, a comprehensive study by Empa and WSL shows for the first time for Switzerland how much these recreational spaces actually affect physical and mental stress management.

Text: Manuel Martin

CAPTURED
The Irchelpark was recorded audio-visually for the study.

Photo: Adobe Stock

More and more people are moving to cities, which means more traffic, denser living and less space for parks or other green areas. As a result, the urban population is exposed to more and more noise and has fewer opportunities to relax in natural environments. A study by Empa and the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), funded by the Swiss National Science Foundation (SNSF), now shows how great the potential of urban green spaces for stress management actually is. "Noise-stricken city dwellers can recover much better if they live near green spaces or in green environments. This effect can be seen on both a physical and mental level – and is even demonstrable in the long term," says Empa researcher Beat Schäffer, summarizing the main findings. "The negative impact of noise on people can therefore be compensated to a certain extent by green spaces."

STRESS TEST IN THE LAB

So far, a lot of research has been done on the negative effects of noise, but hardly any on the positive influence of green spaces. In order to investigate the short-term effect on stress management, the researchers used the audio-visual environment of Empa's auralization laboratory ("AuraLab"). The test subjects were stressed – in the laboratory, they had to solve tasks under time pressure while being exposed to traffic noise at three different volumes (35 to 75 dBA, comparable to the background noise of a reading room through to loud road traffic).

After the stress phase, they were immersed in a virtual world using VR goggles: either in an urban environment with quiet city noises or in a landscape in the countryside with a natural background noise (44 dBA in each case, similar to the noise in a living room). The researchers created these audiovisual scenarios using a 360-degree camera and a so-called ambisonic microphone – at various locations in the city of Zurich with varying degrees of greenery and different background noises.

After immersing themselves in the virtual green space, the test subjects felt calmer, more relaxed and more focused than in the urban scenario. "At the beginning, there was a relaxation effect during both VR scenarios, but ultimately the physical stress decreased significantly more in the green environment," explains Empa researcher Claudia Kawai. The physiological stress level was measured by the sweat production on the fingers and the cortisol concentration in the saliva. The researchers were able to prove the negative effect of stress on the body through increased skin conductivity due to increased sweat secretion. However, these physical stress symptoms only occurred when the test subjects were not only exposed to noise in the stressful situation, but also had to solve tasks at the same time. Traffic noise, on the other hand, was always perceived as annoying, regardless of the additional cognitive stress.

VISIT AT HOME

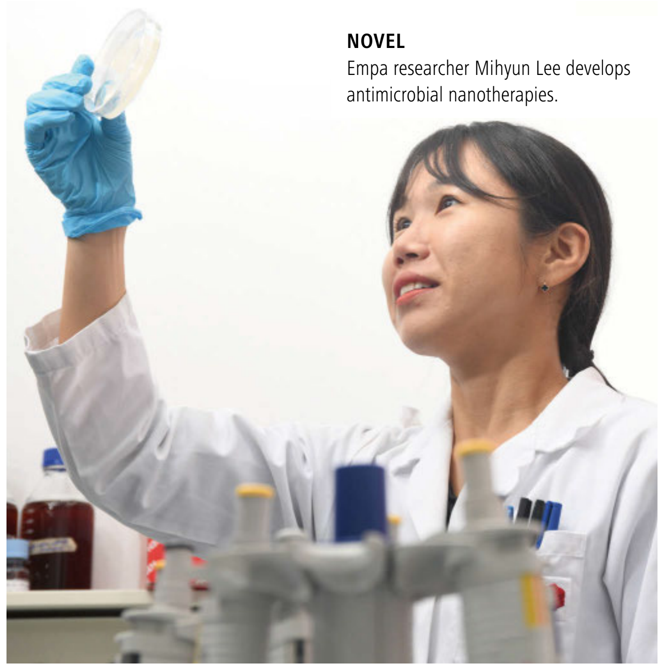
The results from the laboratory were then confirmed in a field study. Empa researchers visited more than 230 volunteers in the city of Zurich who live in environments with varying degrees of noise pollution and greenery. They documented the participants' surroundings with photos, took hair samples to measure the stress hormone cortisol and asked them how they felt. "Both the interviews and the laboratory analyses of the hair samples showed that green spaces in the neighborhood actually promote relaxation," says Beat Schäffer. The restorative effect of green spaces is therefore not only short-term, but can also help to reduce long-term stress.

In addition, WSL researchers conducted a representative survey to determine how well the Swiss population can relax in the green spaces in their neighborhoods and what role noise pollution is playing. On accompanied walks, they also investigated which audiovisual features are particularly conducive to relaxation. The results of the four sub-studies are now being combined to determine the recreational potential of green spaces. According to Empa researcher Schäffer, this RESTORE project (Restorative green spaces in noise-polluted areas) is unique and addresses a relevant topic that affects three quarters of the urban population in Europe. "It will provide important information for legislators and spatial planners and influence Swiss noise legislation and the implementation of the revised Spatial Planning Act." ■

NANOTHERAPY FOR THE EYE

Bacteria can cause dangerous infections after surgery on the eye. Particularly feared are antibiotic-resistant germs, which are almost impossible to treat and can lead to the loss of the eye. In the Nanovision project, researchers at Empa and the Cantonal Hospital of St. Gallen are developing novel nanocomplexes that kill resistant germs and protect the eye tissue at the same time. The project is supported by the Heinz A. Oertli Fund for Ophthalmology.

Text: Andrea Six



NOVEL
Empa researcher Mihyun Lee develops antimicrobial nanotherapies.

In cataracts, a clouding of the eye lens leads to a progressive loss of visual acuity. Around 17 million people worldwide are blind due to this eye condition. Cataract surgery provides a remedy and is therefore one of the most common surgical procedures performed on the eye. Complications such as an infection inside the eye occur in less than one percent of the patients. However, as the surgery is performed millions of times, the group of people affected is correspondingly large. Such an infection is particularly feared when antibiotic-resistant bacteria are involved, and conventional medication is no longer effective. Researchers at Empa and the Cantonal Hospital of St. Gallen are therefore developing nanocomplexes that kill resistant germs and protect the eye tissue. The Nanovision project was made possible by funding from Empa's Heinz A. Oertli Fund.

BLOCKING BACTERIAL TOXINS

If left untreated, the infection inside the eye, so-called endophthalmitis, leads to severe pain and even loss of the affected eye. Bacterial toxins and tissue-damaging defense reactions of the body's immune system are to blame. High-dose antibiotics injected into the eyeball can help – but only if the germs causing the infection are not resistant to the active ingredients. And this is where the problem lies: The typical endophthalmitis bacteria, staphylococci and enterococci, are among the pathogens for which antibiotics are currently becoming increasingly ineffective.

"We want to combat this problem with novel nanocomplexes," says Empa researcher Mihyun Lee from the Biointerfaces laboratory in St. Gallen. The nanocomplexes are being developed on the basis of tannin, a plant polyphenol with antibacterial and anti-inflammatory properties. In addition, the nanocomplexes are equipped with toxin blockers and antimicrobial peptides (AMP), which kill bacteria. The combination results in a multifunctional nanotherapeutic that protects the eye tissue by blocking bacterial toxin production and eliminates the germs. The Nanovision team will then use an ex vivo eye infection model to analyze how efficiently the nanocomplexes work. ■

HEINZ A. OERTLI FUND PROMOTES YOUNG TALENT

The Heinz A. Oertli Fund has supported a number of research teams at Empa. For example, Empa researchers are developing an intelligent valve for the treatment of glaucoma that regulates intraocular pressure. Another team from Empa and ETH Zurich is working on a soldering process that can be used to gently seal eye wounds. And in yet another project, young researchers are working on a nature-inspired tissue adhesive that uses the adhesive properties of marine mussels to seamlessly close corneal injuries. Empa's Zukunftsfonds is looking for private donations for outstanding research projects and talents that are not (yet) supported elsewhere. If you would also like to make a contribution, you can find our donation form here.

Photo: Empa

FAREWELL TO A FRIEND OF EMPA

Heinz A. Oertli, a friend and supporter of Empa and its researchers, has passed away. Thanks to his curiosity and financial support, Empa was able to build up competences in ophthalmology, and with his generous legacy this research area will now receive a solid funding for years to come.

Text: Martin Gubser

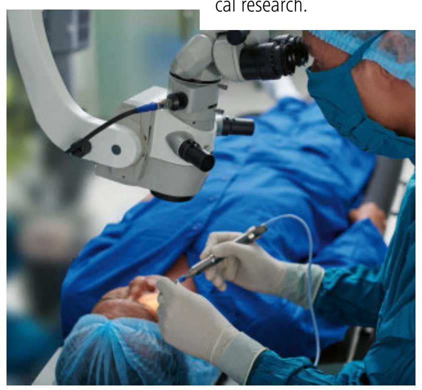
In November 2021, a certain Heinz A. Oertli contacted the Empa "Zukunftsfonds". He informed Empa's fundraising team via his trustee that he was interested in research at Empa in the field of ophthalmology. As it turned out during a subsequent visit, the founder of Oertli Instrumente AG, based in Berneck, had visited Empa in St. Gallen a few years earlier at the Open Lab Day – and had been closely following Empa's research activities ever since.

In May 2022, just six months after the initial contact, Oertli, then 92 years old and almost blind himself due to macular degeneration, established the Heinz A. Oertli Fund at Empa. Over the past three years, Empa has been able to carry out innovative research projects with these funds, enabling three doctoral students and one postdoc to embark on their scientific careers.

In the meantime, Heinz A. Oertli had moved into a retirement home in Teufen, where he had lived for many years, and was very happy about the regular exchange with Empa. As Empa Director Tanja Zimmermann recalls: "In January 2023, I had the pleasure of meeting Heinz A. Oertli in person over lunch. Mr. Oertli proved to be an extremely modest, charming and highly interested person who radiated a deep sense of gratitude for what he was able to achieve in his life. I was deeply impressed by him." During this and similar visits, Heinz A. Oertli always inquired about updates on the projects he was supporting, including from the researchers themselves. Due to his visual impairment, this always had to be done verbally and entirely without PowerPoint presentations.

Heinz A. Oertli passed away on June 18, 2024 at the age of 95. He left Empa a legacy that will enable the Heinz A. Oertli Fund for ophthalmological research to be continued for at least ten more years. ■

EYE TREATMENTS
The Heinz A. Oertli Fund supports ophthalmological research.



Photos: Oertli Instruments; unsplash; Adobe Stock

MAKING PERFECT SeNSE

In a four-year EU project led by Empa, eleven collaborators from research and industry succeeded in significantly improving batteries for electric cars. One of the main objectives of the project was to scale up the new materials and technologies so that they can be brought to market as fast as possible.

Text: Anna Ettlin

POWERFUL
The new battery cells have a higher energy density and are safer than conventional electric car batteries.

Photo: SeNSE Consortium

No new cars with combustion engines are to be sold in Europe after 2035. To achieve this ambitious goal, one thing is needed above all: better batteries so that electric cars can charge faster, travel longer distances and have a smaller ecological footprint. A large number of major research projects are supporting the battery and automotive industry in developing the batteries of the future. One of these, a Horizon 2020 project called SeNSE, came to a successful conclusion in early 2024.

The four-year EU project with an overall budget of more than 10 million Euros was initiated and led by researchers from Empa's Materials for Energy Conversion laboratory. At the time of the call for proposals, the relatively new laboratory was barely known in the field of battery research. Laboratory head Corsin Battaglia knew that in order to be part of a European battery project, he and his team would have to launch one themselves. And this they did: Battaglia and his colleague Ruben-Simon Kühnel were able to persuade academic institutions and industrial companies from around the world to join them, and together, they secured the funding.

TECHNOLOGIES FOR TODAY

The aim of SeNSE was both pragmatic and ambitious. The eleven collaborators wanted to develop solutions for the next generation of lithium-ion batteries – the next, emphasizes Battaglia, and not the one after that. In other words: At the end of the project, the developed materials and technologies should be as close as possible to industrial-scale production, and therefore to being used in electric cars. "We are also researching battery technologies that are potentially worlds better than lithium-ion batteries – more sustainable, safer and with a higher energy density," says Battaglia. "But it will still be a few years before they can be produced industrially. In SeNSE, we wanted to develop technologies that can be installed in market-ready electric cars within a few years."

> **SeNSE**
> The Horizon 2020 project SeNSE aimed to develop the next generation of lithium-ion batteries and strengthen the European battery industry. The four-year project was led by Empa and supported by the EU with 10 million Euros. The academic collaborators involved were the University of Münster, the Helmholtz Institute Münster, Coventry University in the UK, the AIT Austrian Institute of Technology and the Center for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW), as well as several industrial partners: the Swedish battery manufacturer Northvolt, the Swiss company FPT Motorenforschung AG, the French start-ups Solvionic and Enwires and the chemical company Huntsman, which operates a research site in Basel.

To achieve this, the teams involved worked through almost the entire battery production value chain in just four years: from developing new materials and scaling them up to installing them in battery cells. The pouch cells, which are roughly the size of a smartphone, were manufactured by the Austrian Institute of Technology (AIT). FPT Motorenforschung AG, a subsidiary of Iveco, was then able to install the cells in a ready-to-use module like the ones used in electric vehicles – including the associated electronics and software.

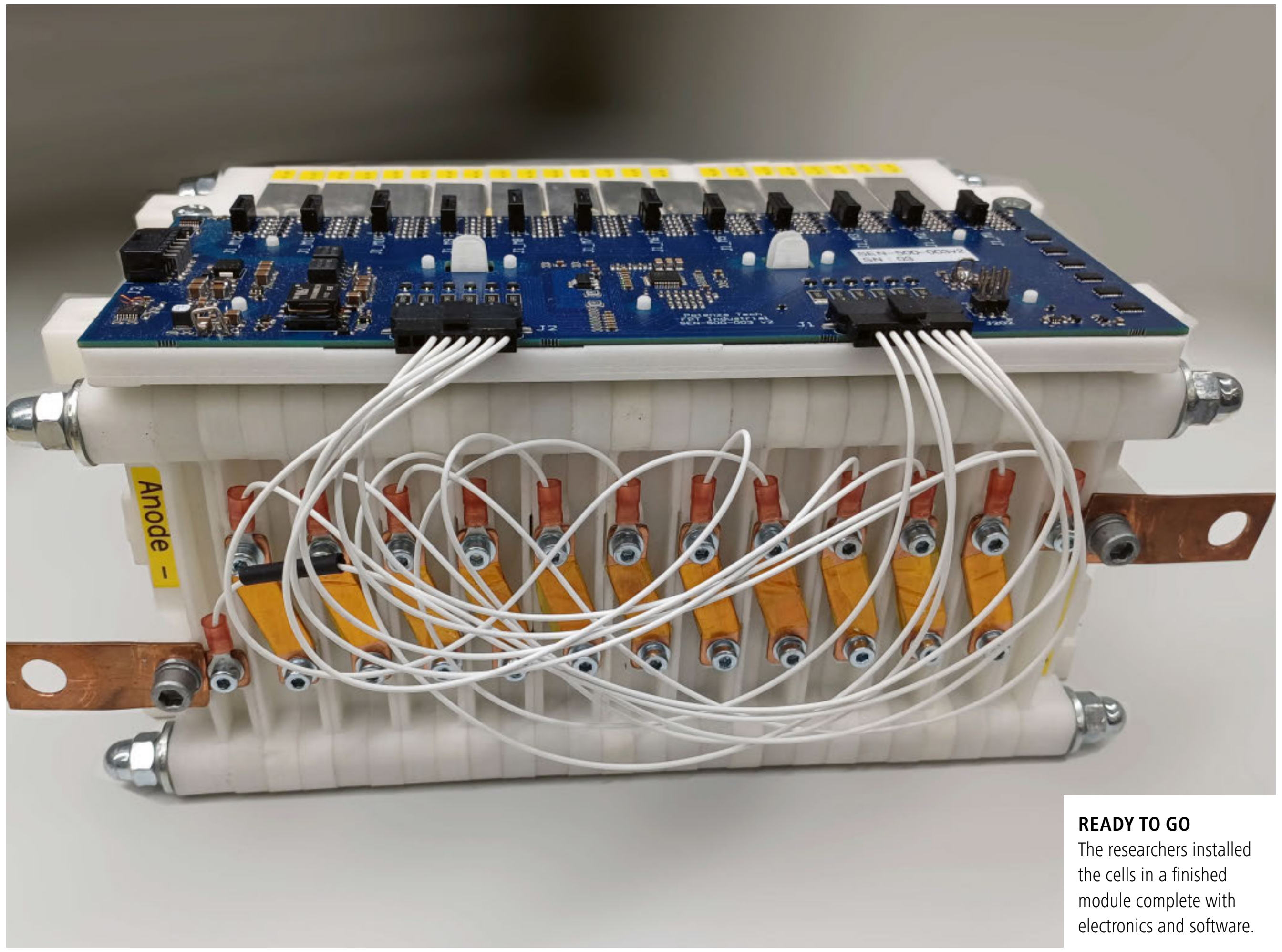
ALL COMPONENTS IMPROVED

The SeNSE module has several improvements over today's batteries: a higher energy density and a more favorable environmental balance, fast-charging capability and increased fire safety – and, of course, cost-effectiveness. All core components of the battery were further developed in the project. The cathode contains only half as much of the critical raw material cobalt as today's batteries. In the anode, the collaborators were able to replace some of the graphite – also classified as critical precisely because of battery production – with silicon, one of the most common elements in the Earth's crust.

The electrolyte – the liquid that transfers ions between the electrodes and thus enables the battery to be charged and discharged – has also been improved. Here, Empa researchers led the development efforts. "Conventional electrolytes are flammable," explains Empa researcher Kühnel. "We were able to greatly reduce the flammability by using certain additives without impairing the conductivity, which is key for fast charging and discharging." In order to further improve the fast-charging capability, Coventry University and FPT Motorenforschung AG also developed a sophisticated temperature management system for the pilot module. Sensors embedded directly in the cells monitor the temperature inside the battery in real time. A specially developed algorithm can then charge the cell just quickly enough to prevent damage from overheating.

> "We wanted to develop technologies that can be market-ready within a few years."

Battaglia and Kühnel see the scalability and the direct transfer to industry as the project's greatest successes. The industrial teams have already been able to register several patents for the new developments resulting from SeNSE, build pilot plants and secure financing, as well as incorporate their new knowledge into other battery technologies.



READY TO GO
The researchers installed the cells in a finished module complete with electronics and software.

Photo: SeNSE Consortium

The chemical company Huntsman has already launched the conductive additive which was used in the SeNSE electrodes on the market, where it is now available to battery manufacturers.

THE NEXT STEP

The path to success was not without its hurdles, though. In addition to the major organizational challenges posed by the pandemic, unstable supply chains and rising raw material and energy prices, there were also technical difficulties. For example, the prototype cells are not yet as stable as the project team would like them to be. Scaling, although successful, is also far from complete. "We have scaled up all new developments from laboratory to pilot scale," says Battaglia. "For production in a so-called gigafactory, of, e.g., project partner Northvolt, producing multiple gigawatt hours of batteries per year, the entire material production process would have to be scaled up once more, say, by a factor of 1000." This will require the commitment of industry.

Meanwhile, the Empa researchers are already turning their attention to the next European battery project. SeNSE had three sister projects that were funded in the same call for proposals. "We have founded a joint cluster for battery research, and we regularly exchange ideas and results," says Kühnel. The coordinators of the four projects have now launched a joint Horizon Europe research project called IntelLiGent. The aim is to develop cobalt-free high-voltage cells for electric cars. ■

PRECISE CANCER DIAGNOSIS IN 3D

Empa researchers have developed a new 3D tissue analysis for thyroid tumors. This special X-ray method uses AI to enable fast and more precise diagnoses without damaging the tissue samples. In future, this method could also be used for other types of cancer and replace more complex procedures with simpler imaging methods.

Text: Manuel Martin

The new 3D tissue analysis of thyroid tumors is still unfamiliar to pathologists. Instead of cutting the removed tissue into thin slices and examining them two-dimensionally under the microscope as before, they can now examine the entire tissue sample virtually on the computer screen and even rotate it as required to identify pathological changes. This has been made possible by so-called non-invasive histopathological 3D imaging. "The special thing about this method is that it can analyze complete biopsy blocks of a tumor in three dimensions in a short time without changing or destroying the tissue. This means that the sample can still be used for further molecular biological diagnostics," says Robert Zboray, group leader at Empa's Center for X-ray Analytics, who developed the technology.

PERSONALIZED TREATMENT

Together with pathologists from the University of Bern, Zboray was able to demonstrate that his new method can detect clinically relevant tissue characteristics in thyroid tumors. X-ray phase-contrast micro-computed tomography (micro-CT) can visualize even the smallest differences in soft tissue. These 3D images of tissue samples are then analyzed using machine learning. The Empa researcher hopes that this will enable pathologists to make more precise diagnoses and prognoses. The greatest challenge is to treat patients as individually as possible – in other words, to avoid overtreatment of low-risk tumors and at the same time to treat and monitor patients with a higher risk appropriately.

Around 300 million people worldwide are affected by thyroid cancer. However, tumor characteristics often differ greatly from patient to patient. These measurable biochemical and molecular characteristics of a tumor are known as biomarkers. They help to detect cancer at an early stage and indicate how aggressively a tumor can grow and which therapy it may respond to.

ZUKUNFTSFONDS

Empa's Zukunftsfonds is looking for private donations for outstanding research projects, such as the retrospective study mentioned above. If you would also like to support Empa's research, you can find further information here:

EXAMINING TISSUE FROM THE PAST

A major advantage of 3D analysis is that it also detects tumor characteristics in the deeper tissue layers that may be overlooked by conventional methods. "When encapsulated thyroid tumors grow aggressively and quickly, they often break into the surrounding healthy tissue and even invade blood vessels. Such vascular invasions are therefore often an indication of the malignancy and severity of the tumor," explains Zboray. An early and more precise diagnosis enables doctors to act more quickly and in a more targeted manner, thus improving the patient's prognosis.

In collaboration with the University and Inselspital Bern, Zboray and his team examined a thyroid tumor sample from a patient who died recently. This patient had been hospitalized in 2011 for a tumor that was classified as benign but later recurred in a malignant form. "Conventional sectional analysis missed capsular hernias deep in the tissue, which we were able to identify retrospectively using our new method," says Zboray. Based on this finding, a retrospective study of such recurrence cases is now being carried out, in which samples from patients across Europe are being examined who, despite initially harmless findings, later developed serious tumors. The study has so far been supported by the Mirto Foundation and the Bank Vontobel Donation Foundation. However, further funding is currently being sought.

INSIGHTS
Kiarash Tajbakhsh and Robert Zboray (right) take a close look at the tissue samples.

Photo: Empa

AN IDEAL ADDITION

According to Zboray, the new 3D tissue analysis can be seamlessly integrated into the clinical workflow and ideally complements conventional sectional analysis. "Established procedures are firmly anchored in everyday medical practice. Our technology is not intended to disrupt these processes, but to offer additional benefits." The development of new technologies for personalized medicine is also the goal of Personalized Health and Related Technologies (PHRT), a strategic research focus of the institutions of the ETH Domain, in which the project is embedded.

What's more, the technology also appears to be promising for other tumor types such as prostate cancer or lung cancer. Thanks to funding from the Swiss National Science Foundation (SNSF), Zboray can now test his 3D histology technique in the metastasis of colorectal cancer. He would also like to replace complex molecular analyses with simpler imaging methods. "If we succeed in correlating the molecular fingerprints of the pathologically altered cell functions in the tumor tissues with imaging texture features in the micrometer range, we could directly link our technology to the underlying genetic changes in the future," says Zboray, formulating his vision. ■

GREENHOUSE GAS MEASUREMENTS: TRAINING IN THE ASIA-PACIFIC REGION

INTERNATIONAL
Participants from 14 countries took part in the course.

In fall 2024, researchers from Empa's Air Pollutants / Environmental Technology laboratory conducted a training course for those responsible for greenhouse gas measurements in the Asia-Pacific region. The course, which took place partly online and partly on the Indonesian island of Sumatra, was attended by participants from 14 countries. It was organized by the World Meteorological Organization (WMO) and the Indonesian weather service as part of the WMO's Global Atmosphere Watch (GAW) program. One of the purposes of the program is to operate a global infrastructure for measuring greenhouse gas concentrations in the atmosphere. Empa has been supporting it through training and quality control since 1996.

E-WASTE RECYCLING IN SOUTH AFRICA

In summer 2024, the South African government published a strategy paper on the management of e-waste, which was developed in collaboration with Empa and the World Resources Forum (WRF). This is the first time the country has issued standardized guidelines for the proper and safe handling of e-waste. An important basis for this strategy was provided by the Sustainable Recycling Industries (SRI) program, financed by the Swiss State Secretariat for Economic Affairs (SECO) and implemented by Empa and the WRF, an international non-profit organization that emerged from Empa.

GREEN STRATEGY
South Africa is improving its e-waste management with support from Empa.

Photos: BMKG; Empa

Photo: Swiss Museum of Transport

EMPA AT THE SWISS MUSEUM OF TRANSPORT: EXPERIENCE THE ENERGY TRANSITION

CO_2 BALLOON
The Emission Explorer exhibit helps visitors to determine their CO_2 footprint.

An Empa exhibit has been on display at the Swiss Museum of Transport in Lucerne since the end of October. The Emission Explorer was developed as part of the ETH Domain's joint initiative Energy Science for Tomorrow (ES4T). Depending on their individual habits in various areas such as housing, nutrition and consumer behavior, visitors can use the Emission Explorer to find out where they stand in a nationwide comparison and what they can do to live more sustainably. The exhibit is part of the Experience Energy! exhibition, which will be on display at the Swiss Museum of Transport for another three years.

EVENTS
(IN GERMAN AND ENGLISH)

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