Empa Quarterly

RESEARCH & INNOVATION II #84 II JULY 2024

FOCUS: OPEN LAB DAY

EXPERIENCE SCIENCE

OPEN LAB DAY
Empa Dübendorf
14 September 2024

CERAMICS THAT FEEL
EARTHQUAKES IN THE LAB
CONSTRUCTION FOR THE CLIMATE

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[CONTENT]

[FOCUS: OPEN LAB DAY]


20


28


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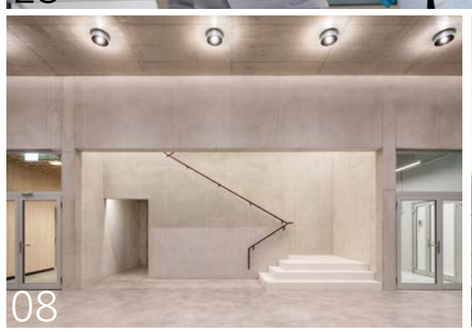
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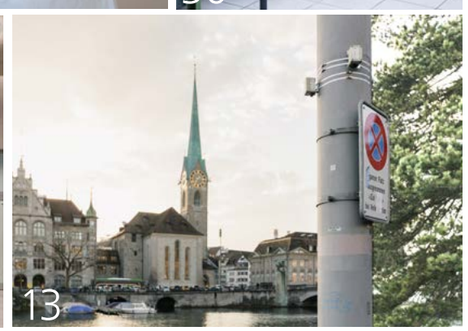
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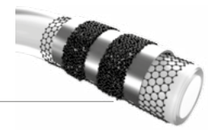

[COVER]

This is where we create the future: Young scientists from Empa's Cellulose & Wood Materials laboratory in their new space on the research campus co-operate, where they are researching sustainable and biodegradable replacements for plastic. From left: Carolina Reyes, Jorge Sanchez, Enrico Boschi, Luana Amoroso and (hidden) Ash Sinha. Photo: Marion Nitsch

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SETTING THE COURSE TOGETHER

Dear Readers

Energy shortages, the climate crisis, mountains of waste on the one hand – dwindling resources on the other, an ageing society: highly complex challenges that lie ahead of us. Research can (and must!) play its part and develop new technological approaches, for instance for a sustainable, secure energy supply or ways to a truly circular economy.

Whether society will, by and large, embrace these, is, of course, another matter. At the heart of the matter is the question: What drawbacks are we prepared to accept in order to "buy" certain advantages? Even if these are "merely" changes in our behavior or high costs, such as those admittedly incurred when cleaning the atmosphere of excess man-made CO_2 according to the new Empa initiative, Mining the Atmosphere. After all, the latter are nothing other than our unpaid "recycling fees" when we blow CO_2 into the air while burning fossil fuels.

This discourse must include all societal stakeholders, i.e. it must be transdisciplinary, and not just take place within the scientific and technological bubble. The pandemic has clearly demonstrated this.

To find broadly acceptable solutions together requires first and foremost a trusting and open dialog. Our open day in mid-September at the new "co-operate" research campus offers an opportunity for this. The current issue of Empa Quarterly offers a first glimpse in our program.

I would be delighted to meet one or the other of you in person at this occasion.
Until then, enjoy reading!

Yours MICHAEL HAGMANN

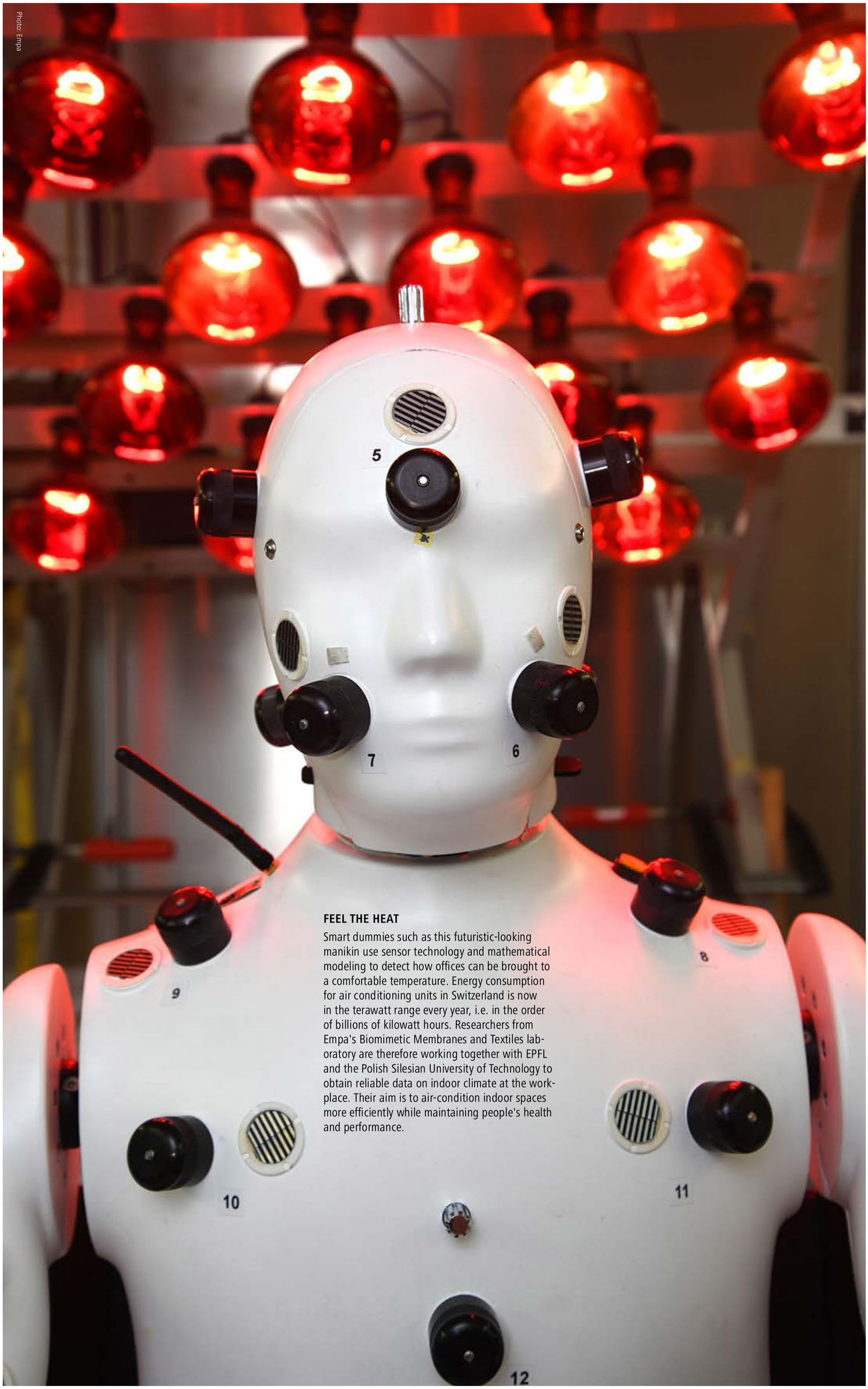


Photo: Empa

FEEL THE HEAT

Smart dummies such as this futuristic-looking manikin use sensor technology and mathematical modeling to detect how offices can be brought to a comfortable temperature. Energy consumption for air conditioning units in Switzerland is now in the terawatt range every year, i.e. in the order of billions of kilowatt hours. Researchers from Empa's Biomimetic Membranes and Textiles laboratory are therefore working together with EPFL and the Polish Silesian University of Technology to obtain reliable data on indoor climate at the workplace. Their aim is to air-condition indoor spaces more efficiently while maintaining people's health and performance.

BETTER CALIBRATION FOR FASTER DIAGNOSTICS

FLUORESCENCE
This card, known as a calibration target, can be used to calibrate medical devices with high precision.

DNA sequencing and fluorescence microscopy are important procedures in medicine and research. They can be used to accurately diagnose diseases, to screen cells and genes and to develop personalized therapies. However, the highly sensitive devices required for this only work reliably if they are precisely adjusted and calibrated. Empa researchers from the Surface Science & Coating Technologies laboratory, in collaboration with the company IMT AG from Greifensee, have developed special calibration targets for DNA sequencers and fluorescence microscopes, which allow the systems to work more quickly and reliably.

RESEARCH FOR KIDS: WHAT ICE CAN TELL US ABOUT THE CLIMATE

Ice cores are a unique climate archive. Empa researchers from the Air Pollutants / Environmental Technology laboratory are working on methods to accurately determine greenhouse gas concentrations in such frozen samples. For this purpose, they have even been to Antarctica. During one such expedition, Bernhard Bereiter, then a postdoctoral researcher at Empa, photographed an ice core in sunlight. Now, his picture adorns the cover of the book, Frozen in Time, by American author Carmella Van Vleet, which uses ice cores to teach schoolchildren about climate research.

ILLUMINATING ICE CORES
The cover photo of the children's book was taken by an Empa researcher in the Antarctic.

Photos: Empa

HIGH-TECH SYSTEM FOR INTRICATE METAL STRUCTURES

WIRE-ARC WELDING
The WAAM system enables Empa researchers to produce large yet complex metal structures.

Intricate bridges, lightweight beams and supports made of metal: A new system makes all this possible. The Wire-Arc Additive Manufacturing (WAAM) technology combines robotic 3D-printing and arc welding in order to melt and deposit metal wires layer by layer, orchestrated by robot-controlled precision. Using its own WAAM system, Empa researches the load-bearing capacity and fatigue behavior of WAAM components and explores innovative applications previously thought impossible, such as component reuse and multi-metal components.

EMPA DATA FOR THE SRF CLIMATE MONITOR

REAL-TIME CO_2 READINGS
The research station on Jungfraujoch monitors the CO_2 concentration in the atmosphere.

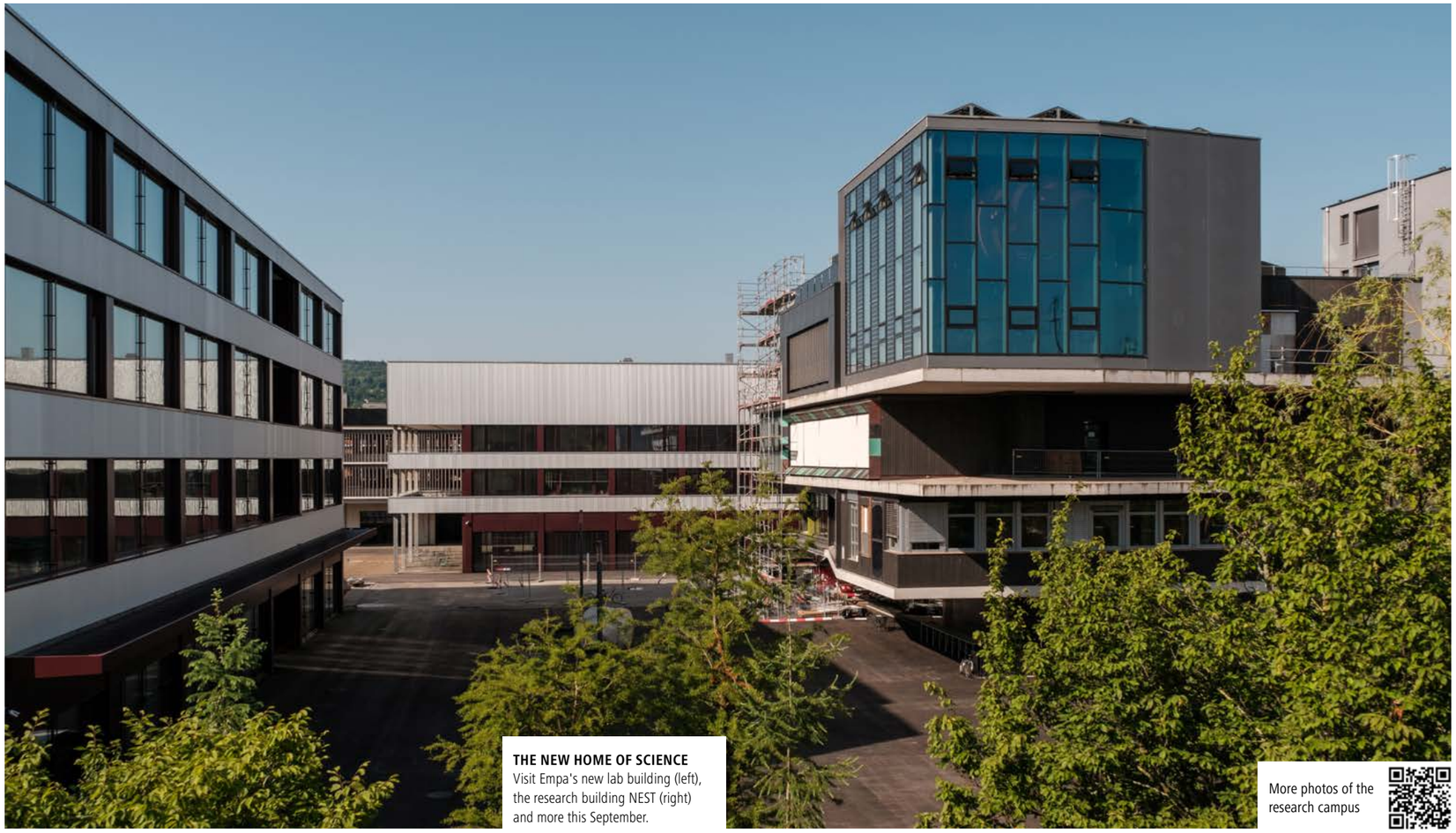
"On the pulse of the planet – daily facts and figures on climate" is how the Swiss Radio and Television SRF website advertises its Climate Monitor. Some of the data published online, namely the CO_2 concentrations measured on Jungfraujoch, are supplied by researchers from Empa's Air Pollutants/Environmental Technology laboratory. The data is collected as part of the National Air Pollution Monitoring Network (NABEL) and the European research infrastructure Integrated Carbon Observation System (ICOS, p. 13) at the research station on the Jungfraujoch.

Photos: Empa, Konsta Punkka

BEWARE: SCIENTISTS AT WORK!

How does this actually work – research? What are scientists developing in their labs? And what is it like to be a researcher, scientist or engineer? If you are looking for answers to these questions join us at Empa's Open Lab Day on 14 September!

Text: Tanja Zimmermann



THE NEW HOME OF SCIENCE
Visit Empa's new lab building (left), the research building NEST (right) and more this September.

More photos of the research campus

Although we regularly (and happily) report on all the exciting innovations from our laboratories – for instance, in our research magazine Empa Quarterly, which you're holding in hands as you read this – the people behind our research often remain merely "instruments in the service of progress", to put it somewhat academically. Yet it is precisely these people, our researchers and engineers, whose clever ideas pave the path to a sustainable future in the first place.

How much more exciting would it be to be able to watch the innovation makers at work, to experience research live in practice – instead of only reading in the newspaper or watching in the news about a new battery technology or CO_2-neutral concrete being developed?

A BRAND NEW RESEARCH CAMPUS

This is exactly what we want to offer all interested, curious visitors with an Open Lab Day. And we have the perfect reason to do so: This summer, we completed and opened our new research campus, co-operate. This is now literally "The Place where Innovation Starts".

Photo: Empa

And an impressive one at that: Ultra-modern and equipped with all kinds of technological innovations, co-operate symbolizes our goal of operating our entire campus in a CO_2-neutral way in the mid-term, for example by means of a large field of geothermal probes with which we want to store heat from the summer for the winter season.

On 14 September 2024, we will be showcasing around 70 of our research projects around NEST and, of course, in the new co-operate buildings, as well as all kinds of exciting things to try out and participate in. Thematically, everything will revolve around our research focus areas and the major challenges we are currently facing as a society: How can we achieve the energy transition – as quickly as possible? The net zero target is a must for all of us – but is that enough? And what about so-called negative emission technologies? What does a genuine circular economy look like? And how do new materials and technologies enable personalized treatment of various diseases?

A LOOK BEHIND THE SCENES

Questions to which we urgently need answers. This is what our researchers are working on day in, day out. On 14 September, you can peek over their shoulders and experience research up close and personal. I look forward to welcoming you on our campus! ■

OPEN LAB DAY
14 SEPTEMBER
EMPA DÜBENDORF

BEYOND ZERO: CONSTRUCTION FOR THE CLIMATE

With its new research initiative Mining the Atmosphere, Empa is proposing nothing less than a paradigm shift: from a CO_2-emitting to a CO_2-binding society. The greenhouse gas is to be used as a valuable material – for example, as a carbon-based aggregate for concrete or as a thermal insulation material – and stored for the long term. In the NEST unit Beyond Zero, materials like these are being used and tested for the first time. Research, industry and planning are working hand in hand. In this interview, Nathalie Casas (Empa), Corinne Reimann (Implenia) and Christoph Kellenberger (OOS) shed light on the pioneering project from different perspectives.

Interview: Annina Schneider

Photo: Marion Nitsch

IN CONVERSATION WITH (from left to right): Corinne Reimann, Head of Warranty at Implenia Switzerland Ltd., Nathalie Casas, Head of Empa's Energy, Mobility and Environment Department and member of the Directorate, and Christoph Kellenberger, co-founder and member of the Executive Board at OOS.

Nathalie Casas, why do we need to take action? What is the purpose of negative emissions technologies (NET)?
Nathalie Casas: The level of CO_2 emissions is increasing rapidly, making it impossible to achieve the 1.5-degree target. Thus, we need to take action. Negative emissions technologies (NET) can effectively remove excess CO_2 from the atmosphere, allowing us to retrospectively clean it up. However, in addition to historical emissions, there are also future emissions that are difficult to avoid, such as those from aviation or agriculture. These emissions will require compensatory measures using NET.

> "We need to move beyond just talking about climate change and start implementing solutions."
>
> Nathalie Casas, Empa

The Mining the Atmosphere initiative was recently launched. The construction of the Beyond Zero unit in the NEST research and innovation building at Empa is currently being planned. What is needed next?
Nathalie Casas: There are many things to consider, but the most important is taking action. We need to move beyond just talking about climate change and start implementing solutions. This involves making new technologies, which are still on a laboratory scale,

ready for the market, and adopting those, which are already available. We try to accelerate this for the construction sector with the planned NEST unit, Beyond Zero. The unit will test and install new materials that can reduce CO_2 or are even CO_2-negative. These innovative materials have shown promise in the laboratory, and we are now working to scale them up and prepare them for the market. This raises questions such as how the materials are produced and whether there are appropriate guidelines. It is crucial to collaborate with the right partners in this endeavor.

Why is it crucial to get planners on board when developing new building materials, Christoph Kellenberger?
Christoph Kellenberger: When designing a building, architects play a key role in determining the construction principles and choosing the building materials. It's important to involve planners early in the process of developing new building materials, so that practical knowledge can contribute to the innovation process. Additionally, architects can introduce new knowledge to the planning and construction industry and explain the benefits of using new CO_2-neutral or CO_2-negative building materials. Ultimately, the goal is to increase the carbon store in our building stock.

How do you evaluate the economic potential of NET in the construction industry, Corinne Reimann?
Corinne Reimann: NETs are a great opportunity for the construction industry as they enable the industry to make a significant contribution to sustainability. This is achieved through the use of CO_2-neutral or CO_2-negative materials such as concrete. Currently, the industry is perceived to be lagging behind in the area of sustainability, but it has significant potential, especially with the use of such materials.

NEST UNIT BEYOND ZERO

The NEST unit Beyond Zero promotes promising CO_2-reduced and CO_2-negative innovations in the building sector and shows whether and how buildings can act as carbon sinks. The unit uses innovative building materials developed at Empa, such as concrete or insulation material, which can bind carbon. The project also analyzes the global feasibility of such technologies and shows how the transformation of the construction industry could be achieved. Beyond Zero is currently in the planning stage. More information on nest.empa.ch/beyondzero

What are the main challenges in this project?
Corinne Reimann: If the new concrete performs reliably and has the same functionality as traditional concrete, its potential usage is significant. The main challenge I foresee is its cost-effectiveness, specifically the price of the new concrete. This is a significant hurdle that should not be underestimated, as there seems to be a reluctance to bear additional costs. This is already evident on a small scale, for example with water-saving taps: If the investment pays off, everyone is on board; but if it becomes more expensive, people are less willing, unfortunately. I believe that we can only initiate this transformation with the help of subsidies because ultimately, the construction industry needs to act economically.

Christoph Kellenberger: Exactly. However, as I mentioned earlier, I see another crucial point in the transfer of knowledge – in addition to market-driven building materials, products, and construction principles, of course. It must be made transparent and comprehensible how these can be used and what effect can be achieved with them. Widespread use can be achieved most easily if the new materials are "significantly better" than what is currently on the market, motivating new suppliers to adopt these products. Regarding knowledge transfer, it is important to raise awareness in the planning and construction industries, which account for around 40% of current emissions from construction and operation, to the fact that they have a significant influence in reducing CO_2 emissions. Additionally, simple and practical new construction solutions are needed for the use of materials that can store carbon in the building stock, and this knowledge must be put into practice. ■

Read the complete interview here and discover more about the potential opportunities and risks, and who needs to contribute to this paradigm shift.

OPEN LAB DAY
NEST

HOW MUCH CO_2 DOES ZURICH EMIT?

To achieve net zero, we need to reduce our CO_2 emissions quickly and efficiently. An EU project involving Empa has selected Zurich as one of three pilot cities in Europe to accurately measure and model their carbon dioxide emissions. The findings will help cities to achieve their climate targets.

Text: Anna Ettlin

UNOBTRUSIVE
Two ICOS Cities CO_2 sensors attached to a lamp post in Zurich.

Photo: Pekka Pelkonen, ICOS RI

Cities are the largest source of greenhouse gases in the world. Around 70% of all anthropogenic emissions are produced in, around and by cities. At the same time, they have great scope for action to reduce these emissions. Many urban areas have more ambitious climate targets than their countries – including the city of Zurich, which aims to achieve net zero by 2040, ten years before Switzerland. Reducing greenhouse gas emissions in such a short space of time requires reliable data. They show progress, reflect the effectiveness of measures and create incentives by making emissions more visible and tangible. "No diet can be successful without a scale," summarizes Lukas Emmenegger, Head of Empa's Laboratory for Air Pollutants / Environmental Technology.

But how can we measure the emissions of an entire city? This question is being addressed by the EU project ICOS Cities, in which Zurich is one of three pilot cities, together with Paris and Munich. As part of ICOS Cities, scientists want to work with city administrations to develop methods for measuring and modeling emissions in cities. It is no coincidence ▶

that Zurich is one of the three "chosen" cities. "The city already has high-quality data on its emissions, has a 'digital twin' and is very open with these resources," explains Emmenegger. Empa has also contributed to this: "When ICOS Cities was launched, we already had a CO_2 measurement network throughout Switzerland, including in Zurich," says Empa researcher Dominik Brunner.

MEASURING EMISSIONS...

As part of ICOS Cities, Empa researchers have expanded this network to 60 locations throughout the city. The inexpensive, small measuring devices cling inconspicuously to street lamps and trees from Uetliberg to Irchel. This low-cost sensor network is supplemented by a mid-cost network. In collaboration with Swisscom, Empa researchers were able to install around 20 more complex instruments on mobile phone antennas in the city. A measuring tower on the roof of a high-rise building in Hardau rounds off the measurement palette. There, high-precision measurements were carried out at certain times under the direction of the University of Basel in order to record other greenhouse gases such as methane and nitrous oxide and to understand the complex CO_2 fluxes above the city.

Photo: Pekka Pelkonen, ICOS RI

SCIENCE WITH A VIEW
On the roof of a high-rise building in Hardau, intermittent high-precision measurements record the concentration of various greenhouse gases and their complex flows over the city, as part of the multi-modal approach of the ICOS Cities project.

This complexity is needed because selective measurements of CO_2 concentrations do not reveal much about emissions. The complex topography of the city, especially that of Zurich, creates air currents that are difficult to predict and can quickly transport the greenhouse gas away from its source. "Another challenge is to distinguish anthropogenic emissions from the natural CO_2 cycle in the atmosphere," says Brunner. The forests around the city breathe in and breathe out large quantities of carbon dioxide every day. The University of Basel also measures and studies these natural fluctuations caused by plants.

... AND UNDERSTANDING THEM

The Empa researchers incorporate this and all other data from the project – and there is a lot of it – into their models. Modeling is the final and most important step in understanding the city's emissions. Where does the measured CO_2 originate? What influence does the weather have on the concentrations? Which part is natural and which is anthropogenic?

The team led by modeling expert Brunner is looking for answers to these questions together with partners abroad. To this end, they are developing two models: One shows how the city releases carbon dioxide to an accuracy of around one kilometer. The second model "sees" individual buildings. "We compare these models with the city's emissions estimates, known as the CO_2 inventory," explains Brunner. The work, especially on the complex high-resolution model, is not quite done yet. But the results are promising. For example, the researchers were able to measure and model a noticeable reduction for the winter of 2022/23: The city had significantly reduced its energy consumption at that time due to the energy crisis. The models work.

A RECIPE FOR SUSTAINABILITY

This modeling expertise is another reason why Zurich, of all places, was chosen as the pilot city. "Empa is one of the few institutes in the world that combines both measurements and modeling under one roof," says Emmenegger. As a founding partner of the National Air Pollution Monitoring Network (NABEL), which has been in operation since 1979, Empa can look back on a long "career" in the determination of (trace) gases in the air.

While in the 1970s the focus was exclusively on pollutants, today, researchers are also looking at carbon dioxide and other greenhouse gases. By developing and comparing different measurement methods and models in ICOS Cities, they want to develop a kind of cookbook for Zurich and other cities, with different recipes for monitoring their CO_2 emissions. The project will run until 2025, after which it will be the cities' turn: what they "cook" with the recipes from the project is up to them. "The city of Zurich is an important and committed partner in the project," says Emmenegger. "We hope our findings will help them achieve their climate targets." ■

ICOS

The Integrated Carbon Observation System (ICOS) is a European research infrastructure that investigates the global carbon cycle and how it is influenced by human activities. ICOS currently collects standardized, freely accessible data from more than 180 measuring stations in 16 countries. Switzerland participates with stations on the Jungfraujoch and in Davos. With the ICOS Cities project, ICOS aims to lay the foundations for expanding its three existing focal points – atmosphere, oceans and ecosystems – to include cities as important CO_2 emitters. ICOS Switzerland consists of the institutions ETH Zurich, Empa and WSL, the Universities of Bern and Basel and MeteoSwiss.

OPEN LAB DAY
CLIMATE CHANGE

SENSITIVE CERAMICS

Robots that can sense touch and perceive temperature differences? An unexpected material might just make this a reality. At Empa's Laboratory for High-Performance Ceramics, researchers are developing soft and intelligent sensor materials based on ceramic particles.

Text: Anna Ettlin

FLEXIBLE
Empa researcher Christopher Bascucci demonstrates a soft material which can be enhanced with ceramic sensors.

Photo: Empa

Most people think of coffee cups, bathroom tiles or flower pots when they hear the word "ceramic". Not so Frank Clemens. For the research group leader in Empa's Laboratory for High-Performance Ceramics, ceramics can conduct electricity, be intelligent, and even feel. Together with his team, Clemens is developing soft sensor materials based on ceramics. Such sensors can "feel" temperature, strain, pressure or humidity, for instance, which makes them interesting for use in medicine, but also in the field of soft robotics.

Soft ceramics – how is that supposed to work? Materials scientists like Clemens define ceramics as an inorganic, non-metallic material that is produced from a collection of loose particles in a high-temperature process known as sintering.

The composition of ceramics can vary – and their properties change as a result. But earthenware and porcelain are nowhere to be seen in Clemens' lab. The researchers work with materials such as potassium sodium niobate and zinc oxide, but also with carbon particles.

None of these materials are soft. In order to fashion them into flexible sensors, the researchers embed ceramic particles in stretchable plastics. "We work with so-called highly filled systems," says Clemens. "We take a matrix made of a thermoplastic and fill it with as many ceramic particles as possible without compromising the elasticity of the matrix." If this highly filled matrix is then stretched, compressed or exposed to temperature fluctuations, the distance between the ceramic particles changes, and with it the electrical conductivity of the sensor. It's not necessary to fill the entire matrix with ceramic, emphasizes Clemens: Using 3D printing, the researchers can also embed the ceramic sensors as a kind of "nerves" in flexible components.

SELECTIVE AND INTELLIGENT

The production of soft ceramic sensors is not trivial. Usually, soft sensors are sensitive to different environmental influences at the same time, such as temperature, strain and humidity. "If you want to use them in practice, you need to know what you are measuring," says Clemens. His research group has succeeded in producing soft sensors that react very selectively only to pressure or only to temperature. The researchers integrated these sensors into a prosthetic hand. The prosthesis "senses" the flexion of its fingers and notices when it touches a hot surface. Such "sensitivity" would be an advantage both for robotic gripping tools and for human prostheses.

The Empa team even went one step further with the development of a soft "robot skin". Similar to human skin, the multi-layered plastic skin reacts to touch and temperature differences. In order to evaluate the complex data, the Empa researchers developed an AI model together with researchers from the University of Cambridge and trained it using data from around 4,500 measurements. This is also reminiscent of human perception, as the nerve impulses from our skin are evaluated and extrapolated in the brain.

SAFE COLLABORATION BETWEEN HUMANS AND MACHINES

The aim, says Frank Clemens, is for humans and machines to work together safely and harmoniously. "Today's robotic systems are big, clunky and very strong. They can be dangerous for humans," explains the researcher. If in future we are to increasingly share our workplaces with robots, they should react quickly and sensitively to touch. "If you accidentally touch another person, you automatically pull away," says Clemens. "We want to give robots the same reflex." The researchers are now looking for industrial partners in the field of robotic gripping systems. But soft sensors are also in demand in medicine – the team recently completed an Innosuisse project with the company IDUN Technologies, in which they produced flexible electrodes for brain wave measurements.

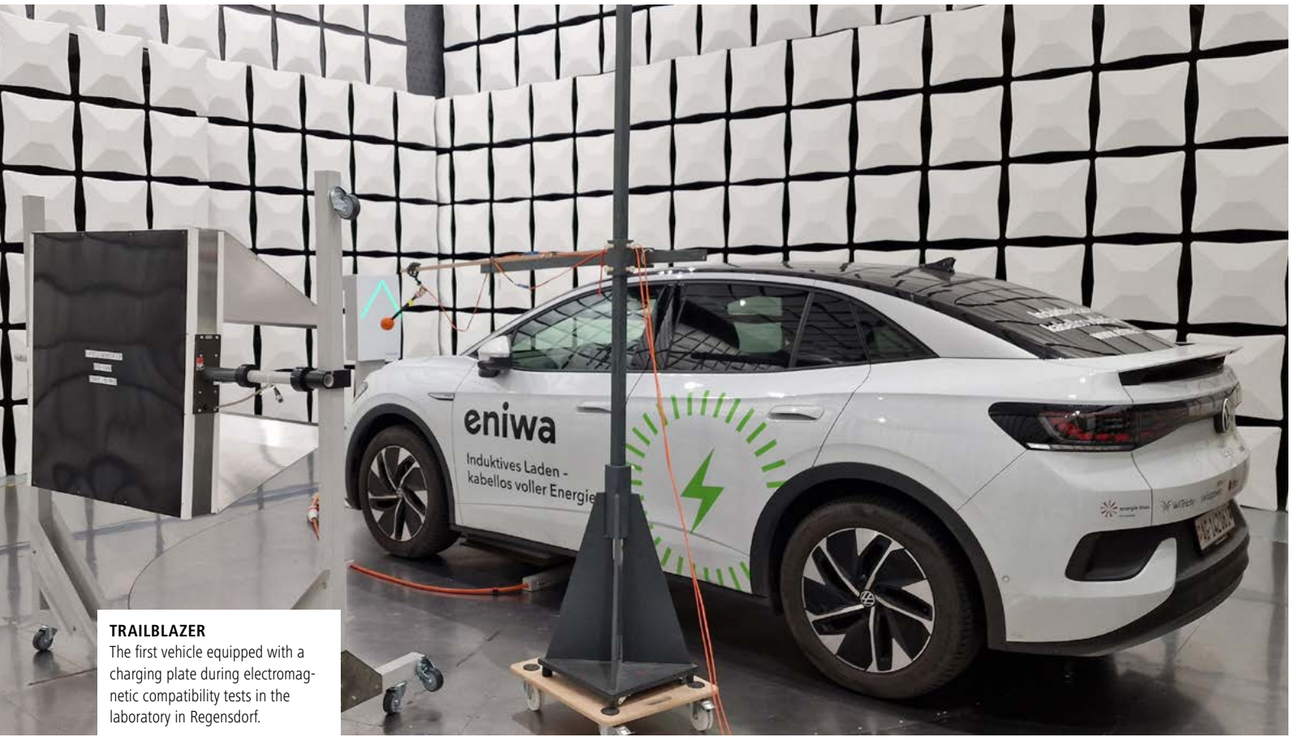
OPEN LAB DAY
HEALTHY LIFE & ENVIRONMENT

The work is far from over: The researchers want to make their soft ceramic sensors even more sensitive and intelligent. This involves combining new ceramic materials and soft polymers and optimizing their sensor properties. The secret to success lies in the interaction of these two components. ■

UNPLUGGED

What is already common practice for toothbrushes and cell phones will also be used for electric cars in the future: inductive charging without any cables. Together with partners, Empa is investigating the advantages and drawbacks of this technology in everyday life. One step has already been taken: The very first vehicle in Switzerland that has been converted for this purpose received road approval.

Text: Stephan Kälin



TRAILBLAZER
The first vehicle equipped with a charging plate during electromagnetic compatibility tests in the laboratory in Regensdorf.

Photo: Empa & Eniwa AG

It couldn't be more convenient: If you maneuver your electric car correctly onto the designated parking space, the charging process starts automatically. A base plate in the parking lot transmits energy via a magnetic field to a receiver plate on the vehicle's underside and then to the battery. The technology for inductive charging of electric cars already exists and is being developed by the US company WiTricity, for example, which also has a subsidiary in Switzerland. What is missing is the regulatory framework – and practical experience of the advantages and disadvantages of inductive charging compared to wired, conductive charging. This is precisely where the INLADE project comes in: "We want to find out how inductive charging proves itself in everyday life and what regulatory changes will be necessary for the concept to become established," explains Mathias Huber from Empa's Chemical Energy Carriers and Vehicle Systems laboratory.

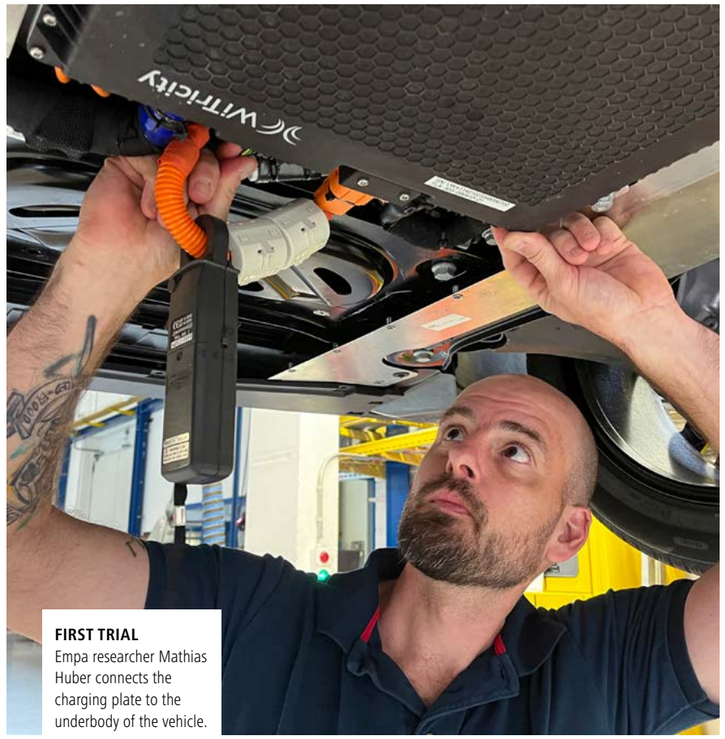
While the permissions for the charging stations are still pending, the first vehicle equipped with a charging plate has already received road approval. This required extensive electromagnetic compatibility (EMC) measurements and electrical safety tests. "The aim was to ensure that the magnetic field during inductive charging does not have any negative effects on other devices inside and outside the vehicle and, of course, on people," explains Huber. Together with representatives of project partner Eniwa AG, who operate this first vehicle, the Empa researcher accompanied the tests in the laboratory of the EMC Test Center in Regensdorf. Empa will soon be putting its own prototype vehicle and a corresponding charging station into operation. The aim is to be able to assess and evaluate the energy efficiency and reliability of the new system. "We are investigating the efficiency of both charging systems in different environmental conditions such as rain or snow," says Huber. According to the manufacturer, the efficiency of inductive charging should be around 91 percent. Huber: "These values are comparable with wired charging."

SIMPLIFY BIDIRECTIONAL CHARGING

While Empa is responsible for the technical analysis, researchers at the Zurich University of Applied Sciences (ZHAW) are investigating the experiences of vehicle users. The project is also evaluating potential use cases such as e-car sharing, electric buses, cabs and autonomous vehicles. INLADE is being led by the energy provider Eniwa AG from Buchs. Other partners are the municipal utility alliance Swisspower, Energie Thun AG and BRUGG eConnect AG.

Energy suppliers in particular see a great potential of the new technology for bidirectional charging, in addition to increased convenience for e-car owners. This involves using the car battery as a storage unit that feeds part of the energy back into the grid when it is not needed for driving. Vehicle batteries could therefore play a major role in stabilizing the electricity grid in the future – but only if they are connected to the grid. "When the batteries are virtually full, vehicles are generally not connected to the charging station, although in this state they would be predestined to temporarily make some of their energy available to the grid," explains Samuel Pfaffen, Head of Corporate Development at Eniwa. With inductive charging, there is no need to connect the vehicles manually via a cable, which makes it much easier to access the vehicles' battery.

The INLADE project was launched at the end of November 2023 and will run for two years. It is supported by the Swiss Federal Office of Energy (SFOE) and the cantons of Zurich and Aargau. ■



FIRST TRIAL
Empa researcher Mathias Huber connects the charging plate to the underbody of the vehicle.

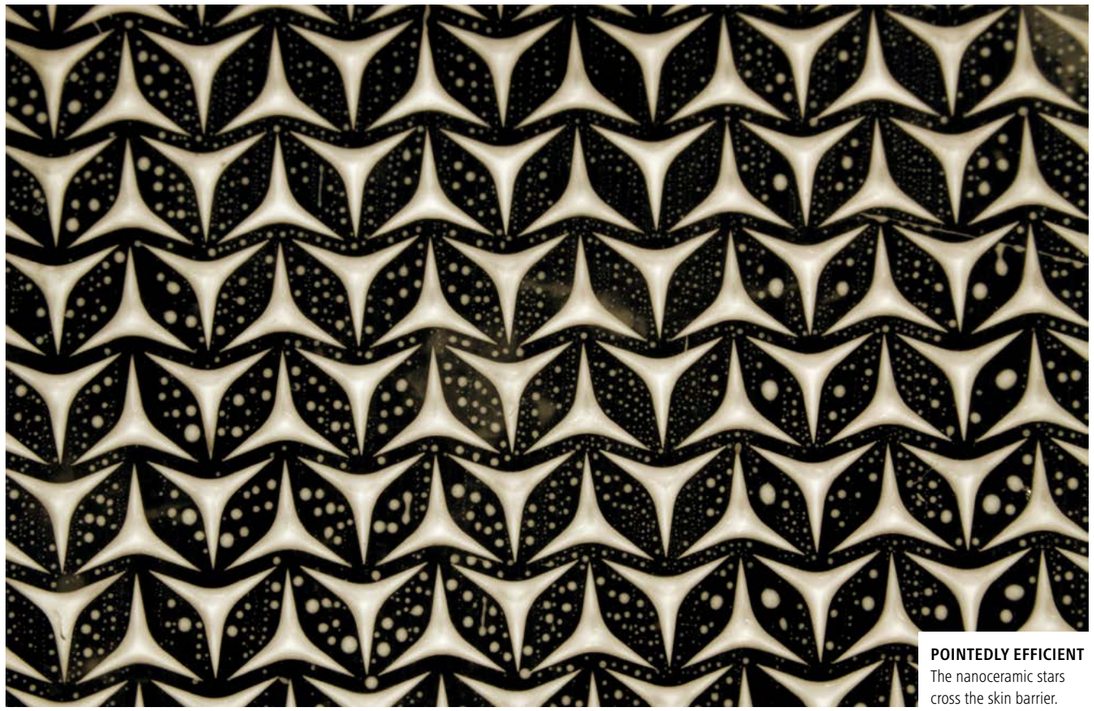
Photo: Empa

OPEN LAB DAY
MOVE

STARDUST IN THE BATHROOM

Widespread skin diseases such as psoriasis or neurodermatitis are difficult to treat. Together with an industrial partner, Empa researchers have found an innovative solution: Nanoceramic "stars" create tiny skin lesions and allow therapeutic molecules to reach their site of action.

Text: Andrea Six



POINTEDLY EFFICIENT
The nanoceramic stars cross the skin barrier.

When material scientists look into the stars, they may be able to recognize the future – namely when it comes to stars made of nanoceramics. Empa researchers in Dübendorf and Thun are working with industry partner Aldena Therapeutics to develop innovative treatment methods for widespread skin diseases.

The team is focusing on nanoceramic stars that "go through the skin". The project is funded by Innosuisse, the Swiss innovation promotion agency.

DELIVERING THERAPIES INTO THE SKIN

The problem is that modern active ingredients do not penetrate deep enough into affected skin layers if they are applied in conventional ointments or lotions. However, if the skin could be made permeable for a short time, the large therapeutically active molecules could be delivered to their target site. For instance, siRNA molecules, short for small interfering RNA, are being used for new therapies. These molecules can help regulate protein production through targeted interactions with the body's own messenger RNA (mRNA). As such, they can intervene in disease progression and block damaging processes. Drugs with this mode of action already exist for some metabolic disorders and hereditary diseases.

For the application of such siRNAs in modern therapies, Aldena Therapeutics, based in Boston, London and Lausanne, was looking for an effective method to deliver active ingredients into – or rather: under – the skin. Empa researchers Michael Stuer from the High Performance Ceramics laboratory and Patrick Hoffmann from the Advanced Materials Processing laboratory therefore used nanoceramics made of aluminum oxide particles to create a three-dimensional, sharp-edged shape. After sintering, three-armed stars with a diameter of around 0.8 millimeters were created, which can be used to temporarily open the skin barrier for the siRNA molecules. "The 3D stars with tapered arms create micro-wounds in the skin that quickly close on their own," explains Stuer. However, there is still enough time for the active ingredient to penetrate the skin.

SCALES
For the bearded dragon, scaly skin is both a trademark and a sign of good health. In humans, on the other hand, chronic skin conditions such as psoriasis or atopic dermatitis are the cause of scaly skin.

Photos: Empa, Adobe Stock

COST-EFFICIENT AND SUSTAINABLE

In the StarCURE project, the Empa team succeeded in producing the stars curved at a precise angle. In this way, the stars "roll" over the skin when applied, quickly tilting and thus creating more micro-openings in the skin than flat structures. The nanoceramic stars are applied in a gel. The excess is removed a few seconds after application. Michael Stuer, who has tested the star-containing gel himself, confirms the testimony of previous test subjects: "It feels like a skin scrub".

Another decisive factor for the stars' use as a therapy was a cost-efficient manufacturing process. If they had to be produced using a laser process, for example, the manufacturing price would not deliver a viable product. Without further ado, the Empa researchers developed polymer casting molds with which large quantities can be manufactured much more quickly and easily. With this upscaling to industrial scale, it is possible to significantly reduce manufacturing costs. The researchers recently filed a patent application for the process.

GENTLE APPLICATION

But the Empa team and Aldena Therapeutics want to go even further: In the next step, Stuer wants to change the recipe so that the nanoceramic stars become biodegradable or disintegrate after use. In the future, the current ceramic material could be bound to a biopolymer or replaced by a bioglass. This would significantly expand the field of application. "Patients could simply wash the stars off after application," says Stuer.

And finally, the field of application is not limited to skin diseases. One example: Up to 30 percent of all children and young adults suffer from injection phobia. Administering a drug by injection to those affected causes them great anxiety and even fainting. In everyday medical practice, this is a challenge for everyone involved. According to the Empa researcher, the nanoceramic stars could also be a good solution for these people to be supplied with the necessary medication or vaccines easily and without needles. ■

CHRONIC SKIN CONDITIONS

Widespread chronic skin diseases like psoriasis, eczema and atopic dermatitis, the pigmentation disorder vitiligo or white spot disease and circular hair loss (alopecia areata) are difficult to treat. The cause of these conditions is not always fully understood. In addition to hereditary predispositions, environmental exposures induce inflammatory processes in the skin, leading to the symptoms. Depending on the clinical picture, this leads to redness, scaling or loss of pigment or hair. Depending on the severity, the diseases can significantly reduce the quality of life of those affected.

OPEN LAB DAY
HEALTHY LIFE & ENVIRONMENT

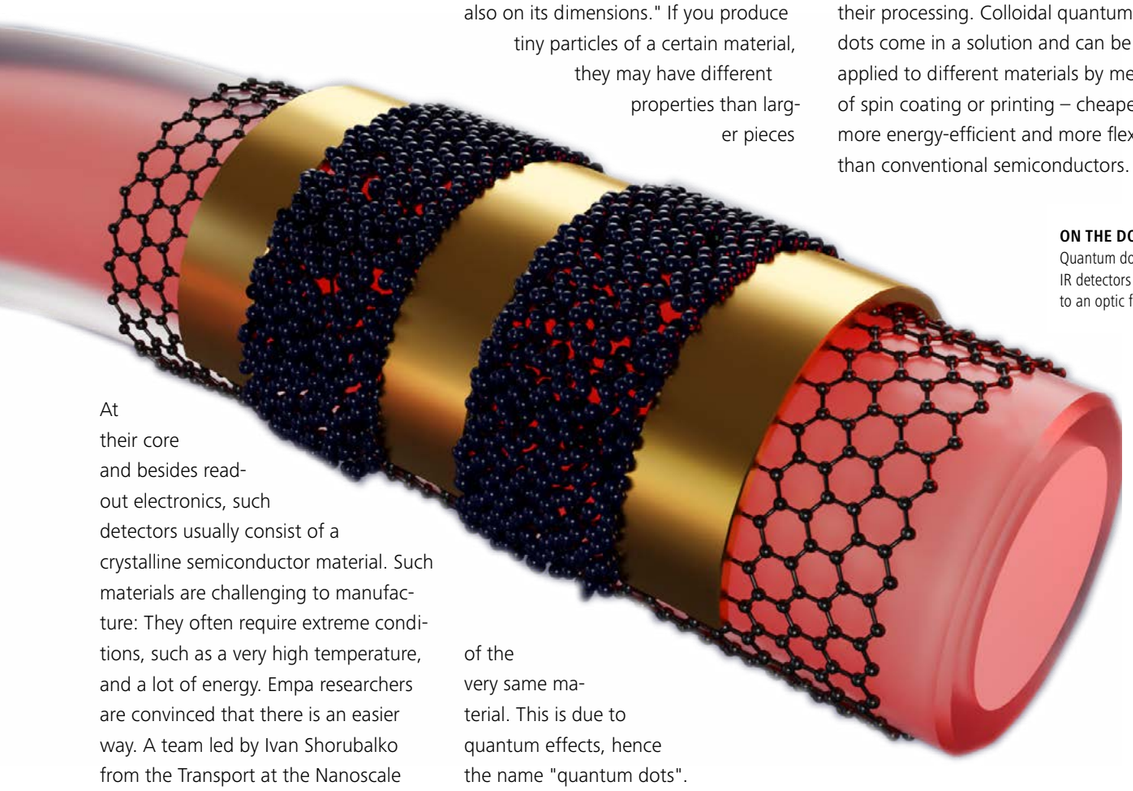
A KEENER EYE FOR THE INVISIBLE

From smart textiles to self-driving cars: Empa researchers are developing new types of detectors for infrared radiation that are more sustainable, flexible and cost-effective than conventional technologies. The key to success is not (only) the composition of the material, but also its size.

Text: Anna Ettlin

What do motion detectors, self-driving cars, chemical analyzers and satellites have in common? They all contain detectors for infrared (IR) light. At their core and besides readout electronics, such detectors usually consist of a crystalline semiconductor material. Such materials are challenging to manufacture: They often require extreme conditions, such as a very high temperature, and a lot of energy. Empa researchers are convinced that there is an easier way. A team led by Ivan Shorubalko from the Transport at the Nanoscale Interfaces laboratory is working on miniaturized IR detectors made of colloidal quantum dots. The words "quantum dots" do not sound like an easy concept to most people. Shorubalko explains: "The properties of a material depend not only on its chemical composition, but also on its dimensions." If you produce tiny particles of a certain material, they may have different properties than larger pieces of the very same material. This is due to quantum effects, hence the name "quantum dots".

For the discovery and synthesis of these fascinating tiny particles, Moungi Bawendi, Louis E. Brus and Alexey Ekimov were awarded the Nobel Prize in Chemistry in 2023. But while the science behind quantum dots is complex, the simplicity instead lies in their processing. Colloidal quantum dots come in a solution and can be applied to different materials by means of spin coating or printing – cheaper, more energy-efficient and more flexible than conventional semiconductors.



ON THE DOT
Quantum dot-based IR detectors applied to an optic fiber.

Graphic and photo: Empa

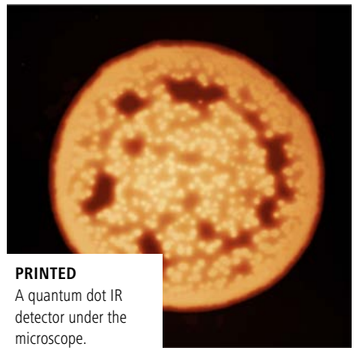
FROM MATERIAL TO PROCESS TO APPLICATION

Quantum dots already have a history at Empa. Maksym Kovalenko's research group in the Thin Films and Photovoltaics laboratory has been working on the synthesis of quantum dots from various materials for over ten years. Shorubalko and his team then integrate the quantum dots to produce functioning electronic components, so-called devices – for instance IR detectors. Together with other Empa experts, they are also researching processing methods and further applications for the quantum dots and the devices made from them.

One example: In 2023, Empa researchers succeeded in printing an IR detector made of quantum dots onto an optical polymer fiber – something that is not possible with conventional IR detectors. To achieve this, device specialist Shorubalko and his doctoral student Gökhan Kara worked not only with materials expert Kovalenko, but also with Yaroslav Romanyuk, an expert in printing from Empa's Thin Films and Photovoltaics laboratory, and with fiber specialist René Rossi from the Biomimetic Membranes and Textiles laboratory. The researchers published their findings in the journal Advanced Materials Technologies in 2023.

One possible application of this technology would be smart textiles. "The global textile market is bigger and faster-growing than the consumer electronics market," says Shorubalko. Specialized textiles in particular could benefit from the flexible IR detectors, for example functional clothing for firefighters or medical textiles for patient monitoring. However, Shorubalko also sees great potential in fashion: "If detectors and other electronic components are small, inexpensive and easy to manufacture, we can use them to functionalize our everyday clothing. Current technologies are simply not compatible with textiles."

Since each detector consists of numerous quantum dots only five nanometers in size, it is possible to manufacture very small IR detectors. In a recent publication in the journal ACS Photonics, Shorubalko, Kara and their peers at Empa and ETH Zurich describe a detector that is smaller than the wavelength of the light it measures. This enables the researchers to record additional properties of infrared light, such as phase or interference, which makes the detector even more versatile.



PRINTED
A quantum dot IR detector under the microscope.

UNMATCHED SPEED

Next, Shorubalko aims to improve the speed of the detector. Fast IR detectors are needed, for example, for lidar, the light-based distance detection technology that helps self-driving cars to find their way, among other things. "Today, lidars use silicon-based infrared detectors, which measure IR light with a wavelength of around 905 nanometers," says the researcher. The problem: Although this wavelength is invisible to the human eye, it is still harmful at high power. For this reason, the lidar's laser can only emit weak light, which limits the range of the entire system. Detectors for longer, safer wavelengths do exist, but they are too expensive to be used on a large scale. A fast detector based on quantum dots could provide an alternative and enable powerful, safe and cost-effective lidar systems.

So when will quantum dot-based IR detectors come onto the market? Unlike most novel technologies and materials, patience is not required in this case. "Qquantum dot IR detectors are already available, for example from the US manufacturer SWIR Vision Systems" says Shorubalko. "I've never seen a technology make the leap from the lab to the market so quickly." Nevertheless, the researchers' work continues. Their task now is to make this promising technology even faster, cost-effective, more flexible and more sustainable. ■

OPEN LAB DAY
FASCINATING MATERIALS

UNDERGROUND RESEARCH

In a recently launched project, the aquatic research institute Eawag is investigating, together with Empa on the joint campus in Dübendorf, how the use of borehole thermal energy storage (BTES) affects the surrounding soil, the groundwater and the microorganisms living in it.

Text: Cornelia Zogg, Eawag

In winter, conventional geothermal heat pumps draw heat from the ground to heat buildings. The borehole heat accumulators installed on the Empa and Eawag campus are geothermal probes that can not only draw heat to the surface in winter, but also store summer heat underground so that it is available in the colder season. Temperatures of up to 65 degrees Celsius are supplied to the storage system. As a result, temperatures of up to 50 degrees Celsius are reached locally in the ground.

So far, however, little is known about how the subsurface reacts to these high temperatures. The regular heating and cooling of the probes at depths of up to 100 meters can affect the chemical components in the groundwater as well as the microbial communities in soil and water. Exactly how and to what extent is now being investigated as part of the ARTS (Aquifer Reaction to Thermal Storage) research project at the aquatic research institute Eawag.

OPEN LAB DAY
ENERGY TRANSITION

A UNIQUE SETUP

144 geothermal probes were "sunk" on the Dübendorf campus. They run up to 100 meters deep and converge in a basement next to the new car park. The geothermal probe field is being used by Empa's ehub (Energy Hub) team to investigate experimental designs of such storage systems and the interaction with other heat sources. Initial results show that it can make a valuable contribution to the decarbonization of a local energy system.

Three new holes were recently drilled into the ground: ART's groundwater observation points. Over the next three years, water samples from underground will be pumped to the surface to provide information on how the microbiology of the environment reacts to the probes and to what extent the chemical composition of the groundwater is affected.

The researchers use five pumps to extract groundwater samples from the three boreholes before, during and after it comes into contact with the geothermal probes. In the first few years of the project, only two of the three monitoring stations will be relevant, as comparisons can be made just a few months after the probes are commissioned. However, it may take several years for the groundwater from the immediate vicinity of the probes to reach the third station further away – that's how slowly the groundwater flows through the subsurface.

MINIATURE MASS SPECTROMETER

The aim of the project is to gain insights into the reactions triggered by this type of heat storage in the groundwater. This includes not only hydrogeochemistry and microbiology, but also the analysis of gases such as oxygen, methane or carbon dioxide produced by the effects of heat in the ground. Such gases are mainly consumed and produced by bacteria underground – depending on the effects of heat and cold. For this purpose, the water in the pump flows into the GE-MIMS mass spectrometer (also known as miniRUEDI) developed at Eawag. "For the next three years, miniRUEDI devices will measure the dissolved gases in the groundwater every hour, while 2.4 liters of water are pumped through the mass spectrometer every minute," explains Joaquin Jimenez-Martinez, head of the project and researcher in Eawag's Water and Drinking Water Department.

The sampled water is also regularly analyzed in the laboratory by researchers from Eawag's Environmental Microbiology and Aquatic Ecology Departments. They focus on the question of how microbial diversity changes under the influence of temperatures of this magnitude. DNA traces (known as eDNA) can also be used to determine which organisms populate the groundwater and whether their numbers and distribution change as a result of the geothermal probes.

GREAT INTEREST FROM THE FEDERAL GOVERNMENT AND CANTONS

Switzerland already has the highest density of geothermal probes per unit area in the whole of Europe, which is why the project is attracting a great deal of interest from the cantons and the federal government. The demand for new possibilities for energy generation and seasonal storage has also increased as part of the energy transition. The effects of temperature input on the groundwater as an overall system are also of interest. ARTS is therefore supported by the Swiss Federal Office of Energy as well as the Cantons of Zurich, Aargau, Thurgau, Zug and Geneva and is run in cooperation with Empa and Eawag.

Employees from the environmental offices of Zurich and Thurgau also contribute to the understanding of hydrogeological questions. Collaboration at this scale is uncommon and the speed at which the project was developed is unprecedented. "It only took ten months from the initial idea in a corridor at Eawag to the drilling of the holes on campus for the sensors," says Jimenez-Martinez. This shows how urgent the issue is. ■

IN PROGRESS
View of the construction site of the new research campus, featuring a geothermal probe field with 144 geothermal probes, reaching down to a depth of 100 meters (left in the picture).

Photo: Empa

SHAKEN, NOT STIRRED

Multi-storey timber buildings are extremely popular. To prevent them from being damaged by strong winds or earthquakes, sufficient bracing must be provided in the supporting structure. Computer calculations provide the basis for this. To check these in practice and improve the computer models, Empa researchers use a two-ton "shaker".

Text: Remigius Nideröst

MINIATURE EARTHQUAKE
The "shaker" causes a structural model (right) to vibrate, as can occur during earthquakes.

In Empa's largest laboratory in Dübendorf, the Bauhalle, an impressive experiment will be set up for the Open Day on September 14, 2024. The centerpiece is the so-called "shaker". Instead of mixing cocktails for visitors, Empa's civil engineers René Steiger, Pedro Palma, and Robert Widmann from the "Structural Engineering" lab will utilize the shaker to demonstrate how a model of a building vibrates, as can occur during earthquakes. The researchers use the model to show how the weight and stiffness distribution in the structure influence the way it vibrates.

The background to this demonstration: timber buildings are becoming increasingly popular in Switzerland, also because of the sustainability potential of timber as a renewable building material. Timber buildings up to 75 meters in height and more than 20 storeys are now being built in Switzerland, but the majority of timber buildings are 4 to 5-storey timber-frame buildings. In order to ensure the structural rigidity of buildings made with prefabricated timber frame elements and nailed wood-based panels, and to prevent damage caused by strong wind gusts or earthquakes, structural engineers can follow different strategies: they can either provide additional load-bearing walls or increase the load-bearing resistance of the existing walls by using thicker components, stronger materials or more fasteners. The bottom line is that this means more material and more work, which results in higher costs. Added to this, stiffening is not the best solution in every case. In order to absorb earthquake shocks, it is sometimes even more advantageous if the structure is not too rigid, but can deform to a certain degree. This must also be taken into account in the computer calculations.

Photo and graphic: Empa

REALISTIC DATA SUPPORTS ARCHITECTS AND PLANNERS

The entire timber construction industry, as well as architects, engineers and building owners, are therefore interested in realistic data on stiffness, natural frequencies, and damping in multi-storey timber buildings in order to find the best solution for their project. This is the only way to ensure that exactly the right amount of material is used – and in the right places.

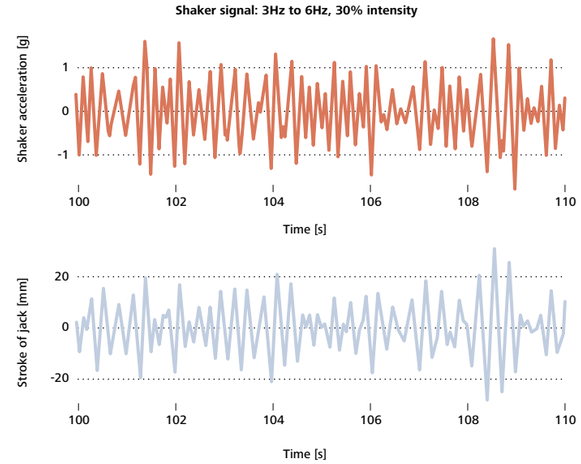
For a long time, there were only mathematical approximations, but no real data collected on typical multi-storey timber buildings. Although shake table tests on timber buildings were carried out in Japan and North America, the results are not easily transferable to the Swiss conditions, as they simulate strong earthquakes. In addition, the Japanese and North American construction methods and buildings differ significantly from those in Switzerland. This is, in part, due to different requirements for thermal insulation, sound insulation, and fire protection. Also missing is information on the rigidity of entire wall elements or walls that extend over several storeys, since in building standards engineers only find values for the properties of individual nailed, stapled or screwed connections, timber-frame parts and planking materials.

THE "SHAKER" THAT MAKES A HOUSE SWING

This is where Empa's "shaker" comes into play, the hydraulic horizontal oscillator that can set up to 1000 kg of oscillating masses in motion in a controlled manner. It had an important application for research into timber frame construction a few years ago when it was hoisted by crane to the top floor of a wooden apartment building under construction in Oberglatt in the canton of Zurich. The 1000 kg mass was then set in motion, thanks to the precise control of the servo-hydraulic cylinder, causing the wooden house to sway horizontally. Just as would be expected from gusts of wind or minor earthquakes in the Zurich lowlands. Meanwhile, acceleration sensors measured the horizontal movements of the building on three storeys and provided values of structural rigidity, natural frequency and damping. The measurements were taken during three different construction phases.

This allowed the researchers to observe directly how the building became increasingly rigid: in the first phase only the load-bearing walls acted as bracing, in the second phase the non-load-bearing planking of the walls was also installed, and in the third phase the windows were installed. "The first results already showed that the calculations on the model did not match the experiments," says Steiger. The supporting structure proved to be significantly stiffer than had been calculated based on the specifications in the standards and the models used.

Such experimental measurements, as well as the projects in the Empa laboratory, provide information on how the used building materials affect the stiffness, natural frequency and damping of buildings. With their work, the scientists help to supplement standards and computer models, and they support civil engineers and architects in optimizing their planning. They are also strengthening the competitiveness of timber as a sustainable building material for multi-storey buildings. ■



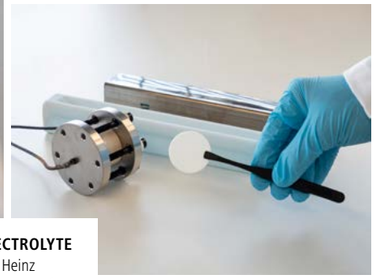
SIMULATED SHOCKWAVES
The shaker tests the building with a wide range of amplitudes and frequencies

OPEN LAB DAY
FASCINATING MATERIALS

THE FIREPROOF BATTERY

Originally developed for electric cars, nowadays they supply mobile phone antennas with electricity, and tomorrow perhaps entire districts: The salt battery is a safe and long-lasting battery technology with huge potential. Empa researchers are collaborating with an industrial partner to further develop these special batteries.

Text: Anna Ettlin



SOLID ELECTROLYTE
Left: Meike Heinz inspects a sample of the solid ceramic electrolyte used in the salt battery. Top right: In the back, a commercial salt cell with its electrolyte, in the front a lab cell. Bottom right: View inside the lab cell.

Photos: Empa

In 1997, the Mercedes-Benz A-Class famously tipped out of a bend during the elk test. One of the causes of the infamous incident: The car was originally designed to be electric. Switching to a combustion engine eliminated the heavy battery, resulting in the center of gravity shifting too far upwards.

The battery that should have been installed in the A-Class was a so-called salt battery. In contrast to most other batteries, in which the cathode and anode are immersed in a shared pool of liquid electrolyte, the electrolyte in a salt battery is a solid, namely a ceramic ion conductor based on sodium aluminum oxide. The solid electrolyte is non-flammable and allows the anode and cathode to be separated, which increases the service life of the battery. The cathode of a salt battery is based on granules of common salt and nickel powder; the sodium metal anode is only formed during charging.

For electromobility, this battery technology has not proven to be the best solution. Today's electric cars run on lithium-ion batteries, which are lighter and quicker to charge. However, for other applications, salt batteries are superior to their lithium-ion competitors. For this reason, they are the subject of ongoing research – at Empa, among others.

SAFE AND DURABLE

The research collaboration began in 2016 when the Ticino-based salt battery manufacturer HORIEN Salt Battery Solutions, formerly known as FZSoNick, approached Empa. The company wanted to improve the ceramic electrolyte consisting of sodium aluminum oxide, also known as beta-alumina, in its battery cells as part of an Innosuisse project. This led to further projects on the cell geometry and electrochemistry of the salt battery, as it differs greatly from other battery types. "The assembly of salt battery cells for research purposes is very complex and there are hardly any studies on their exact mechanisms of action. That's what makes these projects so interesting for us: We can learn a lot and develop our understanding together with our industrial partner," says Empa researcher Meike Heinz from the Materials for Energy Conversion laboratory, headed by Corsin Battaglia.

This different cell structure gives salt batteries some advantages over lithium-ion batteries. For example in terms of safety: Although salt batteries need an operating temperature of around 300° Celsius, they can neither burn nor explode. This is why they are also used in places where lithium-ion batteries are not even permitted, such as in mining and tunnel construction and on offshore oil and gas production platforms. Due to their high operating temperature, salt batteries are also much less sensitive to temperature than their lithium-ion counterparts. This makes them ideal emergency power storage systems for critical infrastructure, such as mobile phone antennas. Even in remote and exposed locations, the long-lasting and maintenance-free salt batteries can do their job reliably for decades.

However, the operating temperature is also a disadvantage of this battery technology: Salt batteries need active heating to be ready for use. How can a battery that needs electricity be at all cost-effective? "Depending on the application, it is more efficient to keep a battery warm than to cool it," explains Meike Heinz. "Heat is generated during charging and discharging due to the cell's resistance. In an optimal system, a large battery can heat itself," adds Empa researcher Enea Svaluto-Ferro.

CELL CHEMISTRY FOR THE FUTURE

As materials scientists, Meike Heinz and her team focus on cell chemistry. Most of the raw materials for salt batteries are inexpensive and available in large quantities. The architecture of the cell also makes it easy to recycle. However, as the cathode material, nickel, is increasingly being classified as critical, HORIEN and Empa set about reducing the nickel content of the cells as part of the project HiPerSoNick, which was funded by the Swiss Federal Office of Energy (SFOE). This was no easy task, as the composition and microstructure of the cell must be very precisely coordinated to ensure an efficient and long-lasting salt battery.

OPEN LAB DAY
ENERGY TRANSITION

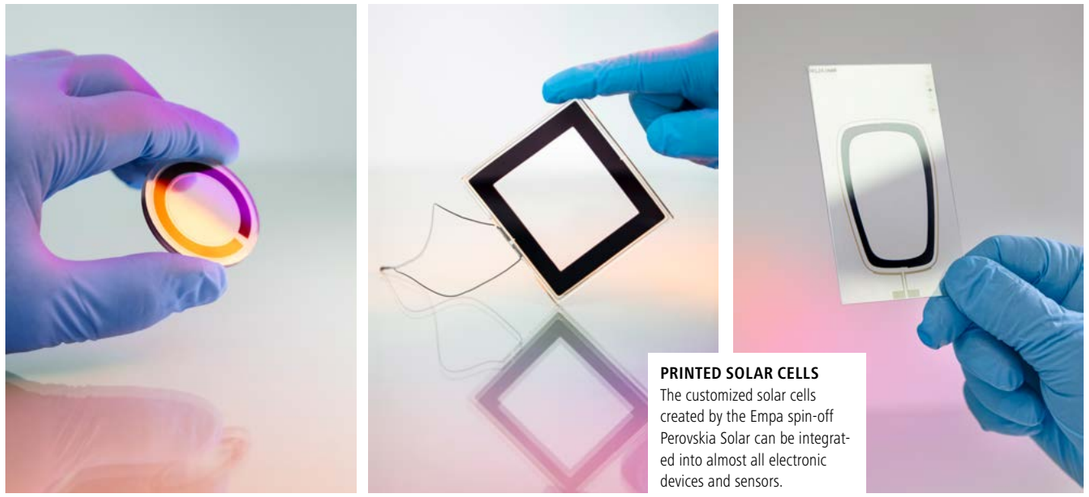
As part of the EU project SOLSTICE, which runs until mid-2025, HORIEN and Empa, together with other project partners, are investigating whether the nickel in molten salt batteries could be replaced entirely by zinc. "The low melting point of zinc is a challenge at the current operating temperature," says Meike Heinz. Nevertheless, the researchers have already found promising approaches to stabilize the cathode microstructure.

Follow-up projects in which the Empa team will attempt to further improve – and scale up – nickel-free salt batteries are already in planning. After all, their safety, long service life and avoidance of critical raw materials would make salt batteries ideal for stationary storage. If salt batteries can be produced cheaply and in large quantities, they could one day provide electricity not only to mobile phone antennas but to entire residential areas. ■

PRINTED SOLAR CELLS FOR EVERY DEVICE

Charging smartwatches, keyboards and the like could soon be a thing of the past. The Empa spin-off Perovskia Solar prints customized solar cells for almost any electronic device. These can be produced cost-effectively – and even work indoors.

Text: Manuel Martin



PRINTED SOLAR CELLS
The customized solar cells created by the Empa spin-off Perovskia Solar can be integrated into almost all electronic devices and sensors.

Photos: Perovskia Solar

Every person owns an average of seven electronic devices. There are several billion devices in use around the world – and with the upcoming Internet of Things (IoT), the number is growing all the time. These need to be regularly recharged or their batteries replaced. The Empa spin-off Perovskia Solar has therefore specialized in custom-made solar cells for every conceivable electronic device.

Conventional silicon solar cells, however, are complex and expensive to customize and inefficient under poor lighting conditions. "We can print new types of perovskite solar cells in any size – and at low cost. With their high efficiency, they can power almost any electronic device indoors in bright home and office lighting," says company founder Anand Verma.

A NEW FACTORY FOR CUSTOMIZED SOLAR CELLS

Perovskites have excellent properties: They absorb light particularly efficiently and are good at conducting the generated electricity. Until now, however, perovskite-based solar cells were neither stable nor durable enough for large-scale use. Verma therefore spent five years at Empa developing printing processes for perovskite solar cells before setting up his own company in 2020. The Empa spin-off is currently on the road to success: Perovskia Solar supplies over 25 international companies with customized solar cells for the IoT and for consumer electronics devices. The company recently set up a factory in Aubonne in the canton of Vaud. One million perovskite elements are to be printed there every year to equip electronic devices with solar cells that supply our digital lifestyle with electricity. ■

MUSIC AT HIGH VOLTAGE

A Tesla coil that makes music besides flashes of lightning? No problem for Silvio Müller and Yanis Strüby, apprentice physics laboratory technicians at Empa. With their singing Tesla coil, they won both the jury and the participant award at the "Züri-Oberland" apprentice competition.

Listen for yourself:
In the video, the apprentices show the production process of the coil – and what it sounds like when music is played on it.

Text: Anna Ettlin

Tesla coils are fascinating. These electrical transformers generate a high voltage – complete with lightning bolts and the smell of ozone. Due to their low power, however, the light show is usually harmless, and Tesla coils have become crowd pullers in museums and at science shows.

Yanis Strüby and Silvio Müller, who are in the third year of their apprenticeship as physics laboratory technicians at Empa, shared this fascination. They decided to build a Tesla coil for the "Züri-Oberland" apprentice competition (LWZO). But lightning alone was not enough for the Empa lab technicians-to-be: Their coil should also play music. Last November at the LWZO in Wetzikon, they not only impressed the expert jury, but also their fellow competitors, the other apprentices – and won both the jury and the participant award.

BOTH HANDMADE AND HIGH-TECH

The road to victory was anything but easy. The project had to be researched, planned, calculated, manufactured and tested. The apprentices wound the actual coil by hand: almost 2,000 turns, a total of around 350 meters of copper wire. "We had to be very careful because the wire was very thin and we didn't want it to break," recalls Müller. "It was the first big project of our own and certainly a test of our patience," adds Strüby. "But we made it – and we learned that we work very well together under pressure."

Their vocational trainer, Dominik Bachmann, research engineer in Empa's Transport at Nanoscale Interfaces laboratory, encouraged the apprentices to participate at the LWZO – but the idea of the singing Tesla coil, Bachmann stresses, was entirely theirs. "At times, I had to read up on it myself before I could answer their questions," he smiles.

The senior apprentices at Empa were also a source of inspiration to Strüby and Müller: Sofie Gnannt and Nick Cáceres won the LWZO as well as other competitions last year. "These competitions are a cool experience for the apprentices – and good preparation for their individual practical work, one of the requirements to complete their apprenticeship," says Bachmann. Strüby and Müller also enjoyed the exchange with apprentices from various professions. They have already warmly recommended participation in the competition to junior apprentices at Empa. ■

INVENTORS
Silvio Müller (left) and Yanis Strüby with their Tesla coil.

Photo: Empa

ON THE TRAIL OF SPINAL DISEASES

Many people suffer from spinal defects, which are often associated with degenerative diseases. The causes are still largely unknown. To change this, Empa researchers from the Center for X-Ray Analytics are investigating a stabilizing ligament in the spine in collaboration with Balgrist University Hospital in Zurich. The project was recently launched thanks to a number of private donations.

Text: Loris Pandiani

More and more people are suffering from problems with their spine – especially as they get older. One widespread spinal disorder is lumbar spinal stenosis, which puts pressure on the nerve cords in the spine. The consequences of this can range from severe pain to paralysis. To date, medicine does not know exactly what causes such degenerative diseases.

RESEARCHER Raluca Barna is studying a particular spinal ligament.

Initial studies indicate that a ligament between the vertebral arches, the so-called Ligamentum flavum, could play a decisive role in the degeneration of the spine. In a recently launched project, a research team led by Annapaola Parrilli from Empa's Center for X-Ray Analytics, in collaboration with Jonas Widmer from Balgrist University Hospital, wants to investigate this hypothesis in more detail. The project was launched thanks to funding from the Evi Diethelm-Winteler Foundation, the Philipp and Henny Bender Foundation, two other foundations and around 50 private donations.

ANALYSIS UNDER TENSION

"We are investigating the Ligamentum flavum using various imaging and biomechanical methods to gain a better understanding of how its structure and stability change over time," explains doctoral student Raluca Barna, who was recruited to Parrilli's team for this project. For this purpose, real Ligamenta flava donated for research purposes are put under tension in the laboratory. To precisely analyze the structure and composition of the ligament, high-resolution 3D images of the tissue samples are also taken using micro- and nano-computed tomography (CT).

"Our initial tests have already yielded promising data. We are very much looking forward to gaining a deeper understanding of spinal degeneration over the course of the project," says Annapaola Parrilli. Patients suffering from severe back problems can also look forward to this as the findings should lead to a faster selection of a suitable treatment in future. ■

RESEARCH FUNDING THROUGH EMPA'S "ZUKUNFTSFONDS"

Empa's "Zukunftsfonds" is seeking private donations for outstanding research projects that are not (yet) supported elsewhere. If you are interested in supporting innovative research, please visit the website of the "Zukunftsfonds": www.empa.ch/web/zukunftsfonds

Photo: Empa

GETTING MEDICAL RESEARCH TO THE PATIENTS

ENABLING PROGRESS
Aarau Cantonal Hospital is one of the hospitals set to benefit from the research collaboration.

Advances in medical research and innovation benefit from close collaboration between medical doctors on the one hand and researchers on the other. However, due to increasing time and cost pressures in everyday clinical practice, it is difficult for medical professionals to actively participate in research projects. The hospitals in the canton of Aargau as well as Empa, ETH Zurich and Paul Scherrer Institute (PSI) are now tackling this problem together. In future, medical doctors will be able to apply for research projects through the newly founded Association for Medical Research and Innovation in the Canton of Aargau. They will then work on joint projects with researchers from the three ETH Domain institutions for six to 24 months while still continuing their work at the hospitals.

BEYOND PAPER: SWISS EPRINT CONFERENCE AT EMPA

7th edition

Swiss-ePrint

The Swiss Conference on Printed Electronics and Functional Materials

September 25 – 26, 2024
Empa, Akademie

DIGITAL PRINTING
During the seventh edition of the Swiss ePrint conference, international experts on digital printing will meet at Empa.

Digital printing goes well beyond paper. In recent years, printing technologies have been developed for optoelectronics, biomedical applications, roll-to-roll processing – used in the manufacture of solar cells, among others – and more. On 25 – 26 September, Empa will host the 7th edition of the Swiss ePrint conference, which will bring together Swiss and international professionals in this emerging manufacturing discipline. The program includes a variety of talks by experts in the field, as well as a poster session and valuable networking opportunities. Registration is open, with Earlybird fees for those who register before 23 August 2024.

Photo: Kantonsspital Aarau, Graphic: Empa

EMPA RESEARCH IN SWEDISH SCIENCE MUSEUM

EXHIBIT
The Empa paper battery in the "Tekniska Museet" in Stockholm.

Visitors to the National Museum of Science and Technology in Stockholm, Sweden, can now also see a sample of Empa research. As part of the exhibition "Skogen" (Swedish for forest), the museum is exhibiting the paper battery developed by Empa researchers from the Cellulose and Wood Materials laboratory, headed by Gustav Nyström. The exhibition will run for the next three years – plenty of time to plan a trip to Sweden.

Photo: Tekniska Museet

EVENTS
(IN GERMAN AND ENGLISH)

20. AUGUST 2024
Konferenz: Biointerfaces International Conference
Zielpublikum: Wissenschaft und Industrie
biointerfaces.ch, FHNW Campus Muttenz

26. – 28. AUGUST 2024
Konferenz: Swiss Battery Days 2024
Zielpublikum: Wissenschaft & Industrie
swissbatterydays.empa.ch
ETH Zürich

04. – 05. SEPTEMBER 2024
SSB+M2024 Annual Meeting
Zielpublikum: Wissenschaft
ssbrm.ch/ssbrm2024
Empa, St. Gallen

05. SEPTEMBER 2024
MARVEL Industry Day
Zielpublikum: Wissenschaft & Industrie
nccr-marvel.ch/events/2024-industry-day-empa
Empa, Dübendorf

03. OKTOBER 2024
Tage der Technik 2024: Künstliche Intelligenz in der Industrie
Zielpublikum: Industrie und Wirtschaft
www.tage-der-technik.ch
Empa, Dübendorf

28. OKTOBER 2024
Kurs: Energy Harvesting (in English)
Zielpublikum: WissenschaftlerInnen, IngenieurInnen sowie technische Marketingverantwortliche
www.empa-akademie.ch/energyharvesting
Empa, Dübendorf

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