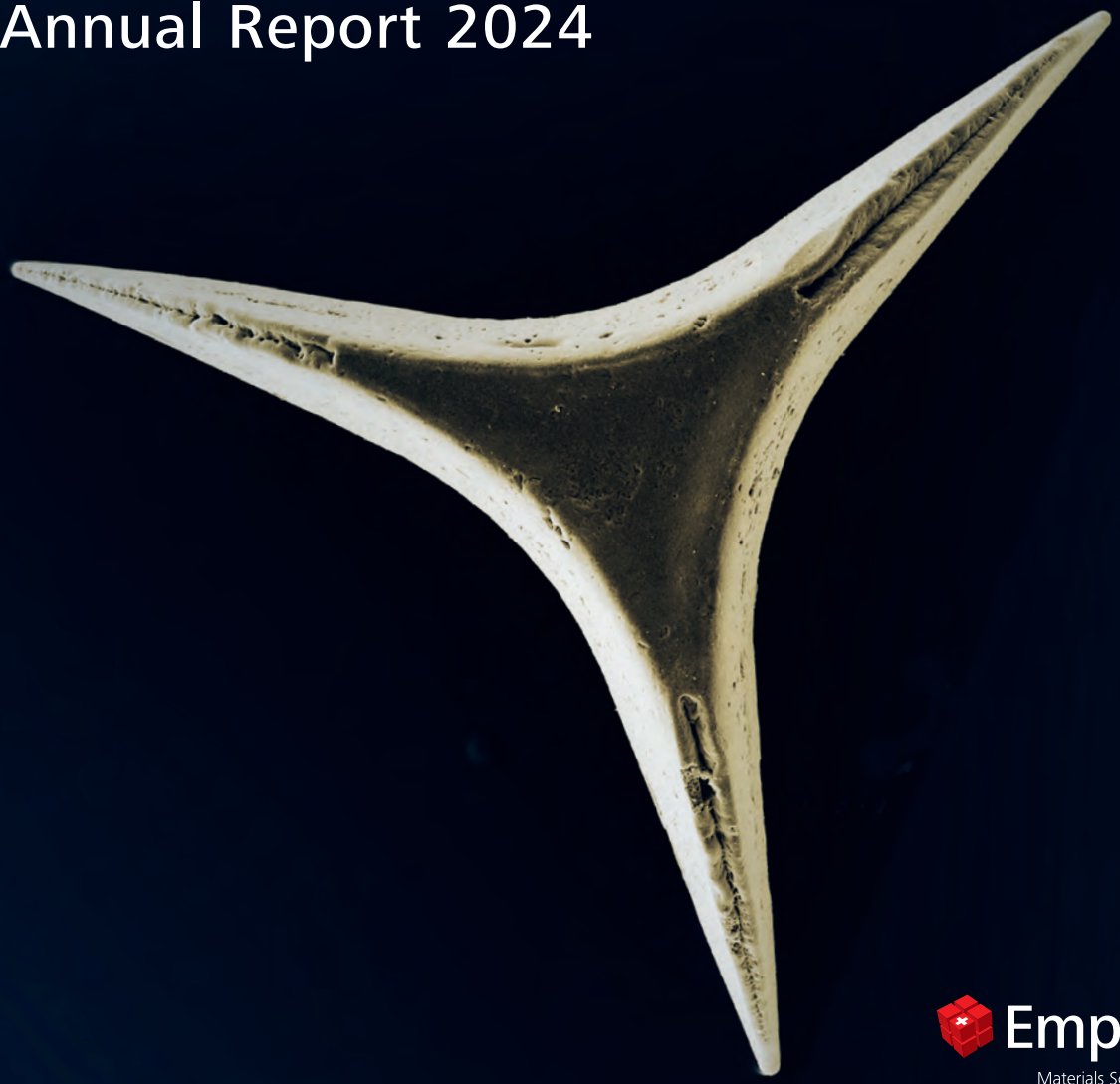
Annual Report 2024



Empa
Materials Science and Technology

Our Vision.
Materials and Technologies for a Sustainable Future.

Cover image:
Therapies that "get under the skin": Widespread skin diseases such as psoriasis and neurodermatitis are difficult to treat. Empa researchers have found an innovative solution together with an industrial partner in the "StarCURE" project. Stars made of nanoceramics cause tiny skin wounds and thus allow the active ingredients to reach their site of action.

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Resilience – the key to innovation

When we look back on the past year, one characteristic emerges as crucial: resilience. In a world full of uncertainties and challenges, it is essential to remain flexible, overcome obstacles and develop sustainable solutions – without losing sight of the big picture. This applies to politics, society and especially research, where setbacks are often the starting point for real progress.

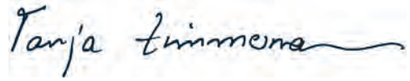
After all, innovation does not come about through the mere confirmation of previous knowledge, but through critical questioning, courageous rethinking and visionary developments. Successful research thrives on open exchange, interdisciplinary perspectives and the constructive competition of ideas.

This dynamism and intellectual agility also characterize Empa's work, be it in the development of new materials and technologies, in cooperation with our partners or in the outstanding commitment of our staff. Their commitment has made the past year a particularly successful one for Empa – a year that has shown us once again how important it is to tackle the challenges of the future with determination, creativity and team spirit.

One of last year's highlights was certainly the open lab day in Dübendorf for the opening of our new research campus co-operate, a name that epitomizes the spirit and culture of Empa. What's more, we were also able to open two new NEST units in 2024: STEP2 with our main partner BASF and the Drone-Hub together with Imperial College London and EPFL. And, last but not least, the brand new CarboQuant laboratory, where completely new carbon-based quantum materials are being developed for the electronics and computers of tomorrow thanks to financial support from the Werner Siemens Stiftung (WSS) and the Swiss National Science Foundation (SNSF), also went into operation.

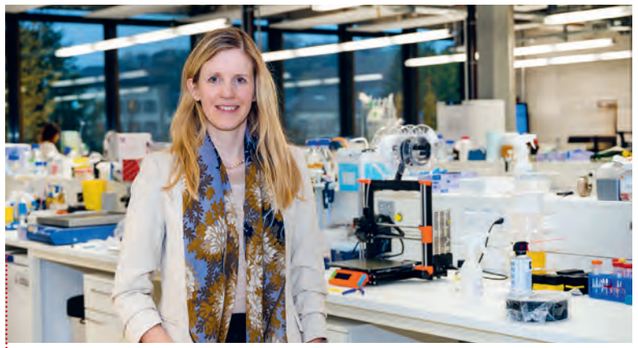
Our research initiative Mining the Atmosphere has been launched with no less than 15 projects, and around half of all Empa laboratories are tackling the urgent but Herculean task of removing the CO_2 we have emitted over the last 100 years from the atmosphere and developing valuable materials such as CO_2-negative concrete from it. Together with our sister institute Eawag and other partners, we are developing practical answers to climate change in the Climate Solutions initiative. And in the health sector, thanks to generous private support, we have now been able to launch another interdisciplinary initiative involving seven Empa laboratories and external hospital partners to improve the diagnosis, treatment and prevention of infections with antibiotic-resistant germs, a “silent pandemic” that will – unfortunately – continue to occupy us considerably in the future.

As I said, these wonderful successes would not have been possible without our great team at Empa. Managing such a large number of major events – without neglecting daily business – requires a good deal of resilience, tenacity and team spirit, as well as the will to assert oneself and shape the future – qualities that we at Empa promote and foster together.



***Prof. Dr Tanja Zimmermann**, Director*

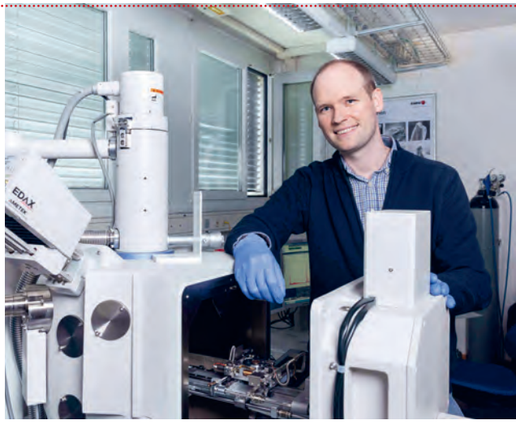
Year at a Glance

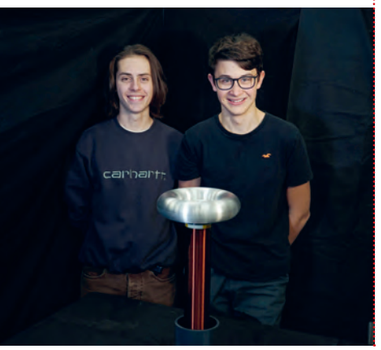


Innovation partnership in orthopaedic research
Balgrist University Hospital and the University of Zurich appointed Empa researcher Inge Herrmann, a leading expert in the field of medical technology, to their academic team. She was previously a professor at ETH Zurich and Empa, where she will continue to perform research and teaching duties. At Balgrist, Herrmann established the new Ingenuity Lab specializing in innovative developments in the fields of medical materials and technologies with the aim of applications in orthopaedic soft tissue research. Image: Balgrist

30 years of Empa in Thun
In 1994, Empa opened the Materials Technology Laboratory at its new site in Thun. Almost 30 employees from the former Materials and Testing Technology section transferred from the Federal Military Department to Empa and thus to a civilian employer. Since then, Empa's third site has developed into an internationally renowned center for materials technology with a unique research infrastructure. Almost 90 people now work in the two research labs Advanced Materials Processing and Mechanics of Materials and Nanostructures.
Image: Marc Weiler Photography

High Performance Ceramics lab under new leadership
On 1 August 2024, Jakob Schwiedrzik took over as head of the High Performance Ceramics laboratory in Dübendorf, following Thomas Graule, who retired. Schwiedrzik studied mechanical engineering at the Vienna University of Technology and obtained his doctorate in biomedical engineering at the University of Bern. He joined Empa as a postdoc and worked at the Thun site for ten years as a scientist and group leader. In addition to his scientific work at Empa, Schwiedrzik is also a lecturer at ETH Zurich, EPFL and the University of Bern.
Image: Marc Weiler Photography





The singing Tesla coil – 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. Lightning alone was not enough for the Empa lab technicians-to-be; their coil should also play music. They not only impressed the experts at the Züri-Oberland apprentice competition in Wetzikon, but also the other apprentices – and won both the jury and the participant prize.

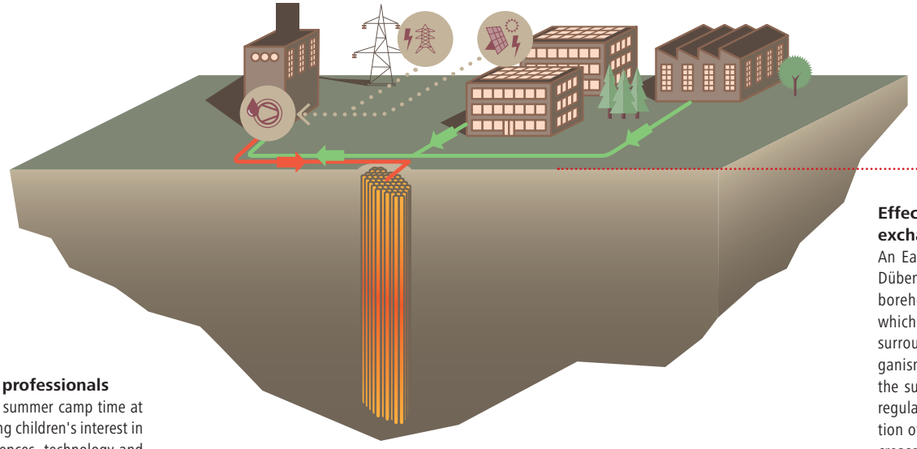
Moving X-ray images of the musculoskeletal system
In 2024, the Dynamic Imaging Center was put into operation at sitem-insel, the Swiss Institute for Translational Medicine and Entrepreneurship. For the first time, X-ray images of a moving person can be taken simultaneously from two different directions. This enables clinical research that is unique in Europe and represents a milestone in the investigation of diseases of the musculoskeletal system. The new center is the result of a close collaboration between Inselspital and Empa. The infrastructure and operation of the center are jointly financed.
Image: sitem

Matthias Sulzer new Head of Department
Energy and building technology expert Matthias Sulzer succeeded Peter Richner as Head of the Department of Engineering Sciences on 1 January 2025. Sulzer was previously a senior scientist at Empa's Urban Energy System Lab and teaches at ETH Zurich. He also holds a research position at the Lawrence Berkeley National Laboratory in the US. Sulzer studied building technology at the Lucerne University of Applied Sciences and Arts, which he completed with a Master's degree at the Universities of New South Wales and Sydney, specializing in energy management. On his return to Switzerland, he, together with two partners, founded a group of companies in the energy and building technology sector, which he successfully floated on the stock market.

Joint professorship for robotics between EPFL and Empa
In September, Empa researcher Mirko Kovac was appointed Professor of Sustainability Robotics at EPFL's School of Architecture, Civil and Environmental Engineering. The professorship and the associated laboratory, which are jointly supported by EPFL and Empa, combine Empa's expertise in materials, engineering and the flight arena – including the DroneHub at NEST, which opened in November – and EPFL's expertise in environmental monitoring, giving researchers and students the opportunity to work at both institutions.

Sustainable fuels and base chemicals for Switzerland
The aim of the reFuel.ch consortium is to develop robust supply paths for sustainable fuels and base chemicals for Switzerland. This is financed by the Swiss Federal Office of Energy (SFOE) as part of the SWEET funding program. Nine Swiss universities and research institutes from various disciplines as well as one industrial partner are involved. Since time is of the essence for climate-friendly solutions, political decision-makers are also involved.
Image: AdobeStock

Empa's apprenticeship training receives award
Empa not only conducts first-class research, but is also an outstanding training company. Ten different apprenticeships are offered and trained at Empa – and at a high level. For the fourth time in a row, Empa was awarded the Great Start! Certified Training Company quality label from the Great Place to Work consultancy, making it one of the best training companies in Switzerland. The award stands for special achievements in the development of trusting working relationships and the creation of attractive and supportive working conditions. Companies from all over Switzerland take part in the certification process and are evaluated by their own apprentices.



Effect of high-temperature borehole heat exchangers on groundwater
An Eawag and Empa project on the joint campus in Dübendorf is investigating how the high-temperature borehole heat exchangers under the new campus, which reach down to a depth of 100 meters, affect the surrounding soil, the groundwater and the microorganisms living in it. Pumps bring the groundwater to the surface at three different spots; the samples are regularly analyzed in the lab. The focus is on the question of how microbial diversity changes under the increased temperatures. DNA analyses can also be used to determine which organisms populate the groundwater and whether their numbers and distribution change as a result of the increased temperatures. As Switzerland has the highest density of geothermal probes in Europe, the project is attracting a great deal of interest from the federal government and the cantons.

Research adventure for future STEM professionals
The first week of summer vacation in Zurich is summer camp time at Empa! With this initiative, Empa aims at arousing children's interest in STEM topics such as computer and natural sciences, technology and mathematics. While their parents worked in their labs and offices, 24 children of primary school age spent a week trying their hand at being up-and-coming engineers and materials scientists. The camp was once again highly popular and quickly booked out. The children immersed themselves in the professional world of their parents in various workshops. In addition to the "work" in the laboratory, there was of course also plenty of fun and excursions.

Knowledge transfer between continents
South Africa is facing similar challenges in e-waste recycling as many other emerging countries: The quantities of e-waste are increasing, but disposal and recycling are often inadequate or unsafe. In summer 2024, the country's government published a strategy paper on the management of e-waste, which was developed in collaboration with Empa. This is the first time the country has issued standardized guidelines for the proper and safe handling of e-waste. The collaboration is part of a program funded by the State Secretariat for Economic Affairs (SECO).

Selected Projects

Investigating new materials and accelerating the development of innovative technologies; supplying the stimulus for the sustainable development of our society; providing the scientific basis for political and societal decisions – these are Empa's core objectives, which it pursues through research and development, cooperation, networks and partnerships as well as services, expertise and consulting activities. The following snapshots from the institute's laboratories give an insight into Empa's multifaceted research activities.

Fundamental quantum model recreated from nanographenes

Prof. Dr Roman Fasel, roman.fasel@empa.ch

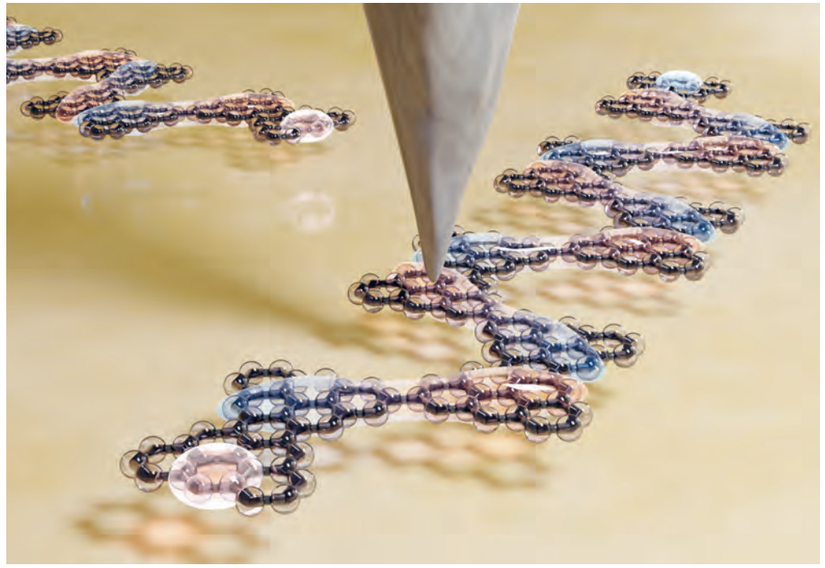
Quantum technologies utilize the unusual properties of the fundamental building blocks of matter. They promise breakthroughs in communication, computing power, measurement technology and much more. However, quantum states are fragile and their effects are difficult to grasp. Research into real applications is correspondingly challenging. Empa researchers from the "nanotech@surfaces" laboratory have now achieved a breakthrough: Using a kind of "quantum Lego", they have been able to precisely recreate a long-known theoretical quantum model in a synthetic material. Together with partners from other institutions, they were able to create an archetypal chain of electron spins and investigate their properties in detail.

A "chalice" made of carbon

In order to produce 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-quantum Lego brick from which the scientists can "plug together" longer chains. For their Heisenberg model, the researchers used a molecule called "Clar's Goblet". This nanographene molecule consists of eleven carbon rings arranged in an hourglass-like shape. Due to this special 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 at Empa in 2019.

Building blocks for the future

The researchers have now connected the goblets on a gold surface to form long chains. The two spins within a molecule are weakly linked, while the spins from molecule to molecule are strongly linked together – a perfect realization of the alternating Heisenberg chain. The researchers were able to precisely manipulate the length of the chains, selectively switch individual spins on and off and "flip" them from one state to another, thereby investigating the complex physics of this novel quantum material in more detail. The method is not limited to one model: Nanographene molecules with other spin configurations can be linked to form other types of chains or more complex systems. They thus form a new type of "building block" for investigating quantum states in more detail. //



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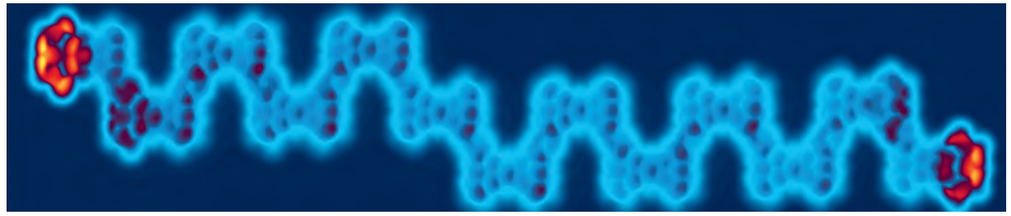

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1
Precision work:
Using special nanographene molecules, the researchers were able to realize a theoretical model from quantum physics.

2
A scanning tunneling microscopy image shows the spin chain made of individual "Clar's goblets".

Back to the future with wood and clay

Dr Pedro Palma, pedro.palma@empa.ch
Prof. Dr Pietro Lura, pietro.lura@empa.ch

The construction industry contributes significantly to climate change with its enormous greenhouse gas emissions. What is the best way to reduce these CO_2 emissions? The "Think Earth – Regenerative Construction" flagship project of the Swiss Innovation Agency Innosuisse is pursuing a promising approach. A consortium is using modern building techniques with wood and clay to reduce the environmental impact of construction. The combination of these environmentally friendly materials enhances their respective advantages: Wood provides the necessary load-bearing capacity and rigidity, while clay adds additional load-bearing capacity and mass, which helps to regulate temperature and humidity, dampen vibrations and ensure fire safety. Efficient and scalable construction methods are to be developed by 2029 in order to advance climate-neutral construction and living.

Flexible timber connections in demand

Although timber is a renewable natural resource, it needs to be reused more often if it is to be used more sustainably in the construction industry. The "Flagship" project aims to increase the reuse rate of timber with the help of other renewable materials such as earth-based building materials. Timber connections play an important role in this. In contrast to concrete structures, which are usually cast as monolithic structures, timber structures rely on the connection of individual components. These are just as important as the timber components themselves – and often even more critical from a structural point of view. The connections ensure continuity and improve structural behavior through properties such as the ability to deform and dissipate energy that the timber components themselves cannot provide. In a sub-project, Empa researchers are working together with ETH Zurich, Bern University of Applied Sciences BFH and 13 industrial partners on the disassembly and reuse of wood joints. At the same time, they are developing digital tools to support this process and thus strengthen the circular economy.

Preventing shrinkage

Earth-based building materials have a good carbon footprint and raw earth is available in almost unlimited quantities. However, raw earth is rarely used for load-bearing elements, as it shrinks excessively when it dries, causing cracks to form. To avoid this and increase strength, mineral binders such as cement are often used. However, clay can only be reused as long as it remains unchanged. However, as soon as mineral binders are added, the energy balance and recyclability deteriorate. To solve this problem, researchers at ETH Zurich and Empa are working together with industrial partners BASF Schweiz AG and Eberhard Bau AG on bio-based and biodegradable additives. The researchers are testing their ability to reduce shrinkage while maintaining recyclability and moisture regulation. //

Together with Swiss universities and industrial partners, Empa is researching the simple disassembly and reuse of wooden joints with the help of digital tools. Image: AdobeStock

Environmentally friendly at last: PFAS-free textiles

Dr Dirk Hegemann, dirk.hegemann@empa.ch

Rain jackets, swimming trunks or upholstery fabrics: Textiles with water-repellent properties require chemical impregnation. Fluorine-containing PFAS chemicals are effective, but harmful to health and the environment. Empa researchers have therefore developed a process with alternative substances that can be used to produce environmentally friendly water-repellent textile fibers without PFAS.

PFAS are synthetic chemicals that have a wide range of applications due to their ability to repel water, oil and grease. They have been used since the 1970s in the production of functional clothing, fire extinguishers and frying pans. As fluorine-containing substances do not degrade but accumulate in the environment and in the human body, they are known as "Forever Chemicals". The substances are suspected of causing health problems in humans and animals, such as cancer, cardiovascular diseases, obesity and developmental disorders.

The new, more environmentally friendly process was developed by Empa researchers together with Swiss textile companies to give textile fibers a water-repellent finish. In the Innosuisse-funded project, the team used organosilicon substances, which produce glass-like, hydrophobic layers and – unlike fluorine-containing PFAS – are harmless. Initial analyses show: The PFAS-free fibers repel water more strongly and dry faster than those of conventional products.

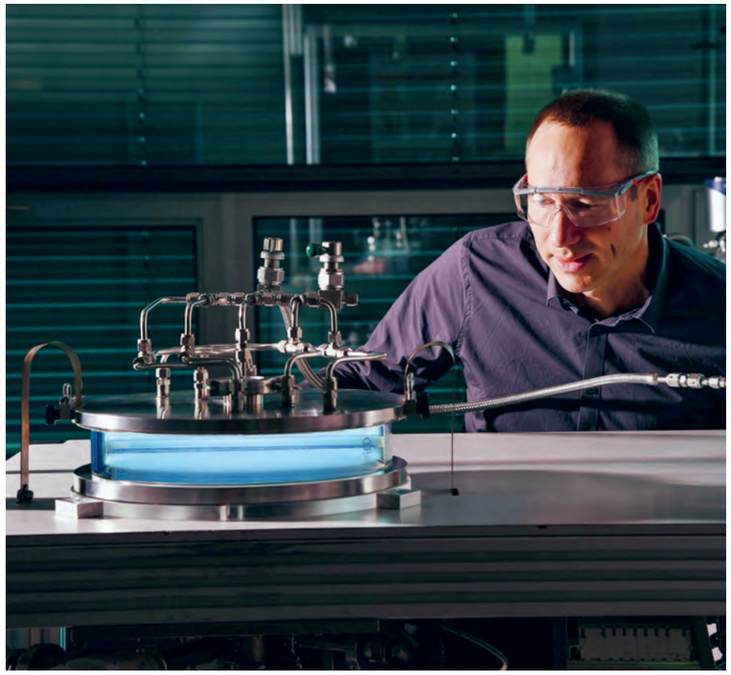
Sophisticated elastic fibers

Certain fibers in functional clothing proved to be particularly challenging. If swimming trunks are to retain their shape after swimming and dry quickly, they must combine two properties: They must be elastic and must not soak up water. Until now, it has not been possible to coat complex textiles with elastic fibers without gaps (and in an environmentally friendly way). The researchers finally succeeded in doing this using a plasma coating process. This is a significant step forward, as even a tiny wettable area would be enough for water to penetrate into the depths of a pair of swimming trunks, preventing the garment from drying quickly.

In Empa's plasma coating plant, the fluorine-free starting compounds are fragmented and activated in a reactive gas. In this way, they retain their functional properties and enclose the textile fibers in a water-repellent coating that is only 30 nanometers thick. Threads coated in this way can then be processed into water-repellent textiles of all kinds, for example garments or technical textiles such as upholstery fabrics.

Great interest from industry

The researchers are now working on scaling up the fluorine-free laboratory process to efficient and economically viable industrial processes, as the textile industry is very interested in sustainable alternatives for fluorine-free textiles. A successful collaboration that combines materials, fiber technology and plasma coating and leads to an innovative, sustainable and effective solution. //



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1
Empa researcher Dirk Hegemann is developing plasma coating processes for environmentally friendly textiles. The plasma system fragments fluorine-free starting compounds into a cloud that can coat textile fibers with nanometer precision.

2
Textile fibers (blue) can be given a uniform water-repellent finish using plasma coating. Even more demanding elastic fibers (red) remain permanently impregnated thanks to the new process. (Scanning electron microscopy, colored).

Experimenting ten times faster

Prof. Dr Corsin Battaglia, corsin.battaglia@empa.ch

Why do just one experiment when you can do ten at once? Empa researchers have developed a system with which catalysts, electrodes and reaction conditions for the electrolysis of carbon dioxide (CO_2) can be researched up to ten times faster. The system is supplemented by open source software for data evaluation.

The system was developed as part of the "SynFuels" joint initiative funded by the ETH Board. Researchers at Empa and the Paul Scherrer Institute (PSI) spent three years looking for ways to produce synthetic fuels – known as synfuels – from CO_2 in a targeted and economical way. This reaction poses a number of challenges. The electrolysis of CO_2 can produce more than 20 different products at the same time, which are difficult to separate from one another.

Accelerating research

The composition of these products can be controlled in different ways, for example by the reaction conditions, by the catalyst used and by the microstructure of the electrodes. The number of possible combinations is enormous, and investigating each of them individually would take far too long. This is why researchers from Empa's "Materials for Energy Conversion" department have developed a system with which up to ten different reaction conditions as well as catalyst and electrode materials can be investigated simultaneously.

The system consists of ten "reactors", i.e. small chambers with catalysts and electrodes in which the actual reaction takes place. The individual reactors are connected via hundreds of meters of tubing to several supply and discharge lines for gases and liquids as well as to various measuring instruments. Numerous parameters are recorded fully automatically, such as pressure, temperature, gas flows and the liquid and gaseous reaction products – all with a high temporal resolution. It is the first system of its kind for CO_2 electrolysis – such a novelty that not all the instruments required were even available on the market during the development phase. In collaboration with the company "Agilent Technologies", the Empa researchers co-developed the world's first online liquid chromatography device for their system.

Sharing research data

Conducting experiments ten times faster also generates ten times as much data. The researchers developed their own software for the analysis, which they are now making available to scientists at other institutions. This also applies to the National Center of Competence in Research "NCCR Catalysis", which focuses on the sustainable production of chemicals. The new parallel system for CO_2 electrolysis is set to play an important role in the second phase of this major national project. Both the data generated and the know-how will be made available to other Swiss research institutions. //

1
Ten experiments in parallel: Empa's new facility can accelerate research into CO_2 electrolysis up to ten times.

2
Alessandro Senocrate assembles the system in Empa's new laboratory building.
Image: Marion Nitsch

3
Corsin Battaglia inspects one of the ten reactors.
Image: Marion Nitsch

Cutting-edge technology opens up new dimensions

Dr Lars Sommerhäuser, lars.sommerhaeuser@empa.ch

In its “Coating Competence Center” (CCC), Empa enters into partnerships with innovative equipment manufacturers in order to further develop new coating and printing technologies and make them more widely applicable in industry. In addition to Oerlikon, Evatec, Optomec and Norbert Schäfli Maschinen AG, Scrona is now also one of these partner companies.

The finest droplets significantly increase the resolution

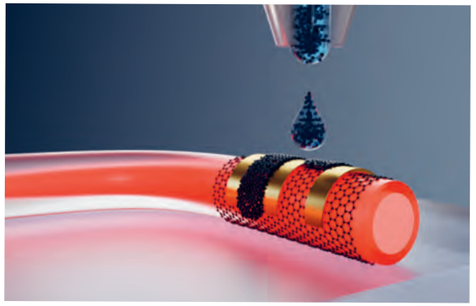
The Scrona founders researched electrohydrodynamic printing (EHD Printing) at ETH Zurich and then developed a printer as a spin-off that can print structures with a resolution of one micrometer (µm). This is around 50 times higher resolution than the widely used method of inkjet printing. In contrast to inkjet printing, in which up to 100,000 tiny ink droplets are “jetted” per second from channels only 20 to 30 µm wide, electrohydrodynamic printing works by shooting the ink from the tip of a needle in the form of tiny droplets through an electric field onto the printing substrate.

The printheads for both technologies are complex micro-electromechanical systems, so-called MEMS, which are manufactured using modern nanofabrication methods similar to computer chips. While leading manufacturers of inkjet printheads now combine over 2,000 nozzles in one printhead, Scrona has just introduced its latest generation of printheads with 128 nozzles, and even 1,000 nozzles in one printhead seem to be within reach.

This “cutting-edge technology” not only makes it possible to produce smaller ink droplets and thus increase the resolution of the printed structures – Empa's research platform is currently printing structures 20 nanometers in size, which literally represents a leap into new dimensions. In addition, the use of tips instead of channels also makes it possible to print inks with a higher viscosity and a higher solids content. This in turn makes it possible to print not only two-dimensional but also three-dimensional structures, such as columns just a few micrometers wide.

A printer for research and industry

The areas of application for EHD printing are diverse and range from sensors to displays in the field of printed electronics. At Empa, for example, researchers are using this technology to develop miniaturized infrared photodetectors that are smaller than the wavelength of the detected light. To do this, they use the Scrona printer to apply colloidal nanocrystals or quantum dots to a graphene-based field-effect transistor that encases an optical fiber. The colloidal quantum dots, which consist of lead sulphite or mercury telluride, were developed in Maksym Kovalenko's research group; Ivan Shorubalko's research group developed the inks, the printing process and the photodetector. This shows the potential for further applications from the field of optoelectronics is huge. //



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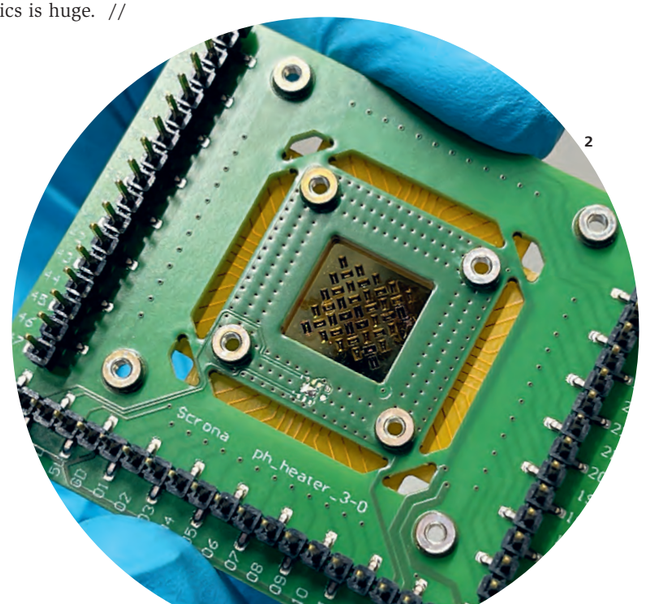

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1
Miniaturized photodetector: Quantum dots are printed on an optical fiber encased in a graphene-based field-effect transistor.

2
Print head of the Scrona printer, made from a silicon chip.

3
Empa researcher Ivan Shorubalko at the Scrona printer in the “Coating Competence Center”.

A year full of milestones

Reto Largo, reto.largo@empa.ch

With groundbreaking innovations, two new units and around 10,000 visitors to NEST, the year 2024 was all about progress and exchange. NEST, the modular innovation and research building of Empa and Eawag, once again proved its role as a creative hub and test platform for a sustainable future in the building sector.

Actively reducing emissions

The year kicked off with a visionary presentation by Peter Richner, Deputy Director of Empa, at Swissbau 2024. Under the title “Mining the Atmosphere – CO_2-negative building materials”, he presented a sustainable vision of how we can transform from a CO_2-emitting society to a CO_2-binding society. At its core, the concept aims to create buildings that are not only climate-neutral, but also actively remove CO_2 from the atmosphere and store it in the long term. Whether and how buildings can act as carbon sinks will be the central research topic of the new NEST unit “Beyond Zero”, which is expected to be realized in 2027.

New units opened: “STEP2” and “DroneHub”

STEP2, a flagship project for material-saving and energy-efficient construction technologies, was opened in August 2024. This unit demonstrates how buildings can be constructed in a way that conserves resources and energy, while making use of recyclable materials. The unit was designed using a co-creation approach, which is rather unusual for a construction project. “STEP2” not only stands for sustainable construction, but also for intensive cooperation between research and industry.

November marked another milestone with the opening of the “DroneHub”. For the first time, this unit offers a specially designed test area for drones that can be used for construction and maintenance work. In the style of a large aviary, the “DroneHub” enables tests under realistic conditions – without being subject to official airspace restrictions. This platform sets new standards for research into autonomous drones in the construction industry and beyond.

Technology brought to life: Empa opens its doors

Empa opened its (laboratory) doors on September 14, 2024: Around 7,000 interested visitors took the opportunity to experience research at first hand and innovative technologies up close. The fully booked NEST tours on the open day once again demonstrated the interest of visitors in the NEST research and innovation building. From 3D printing in construction to drone technology and sustainable building materials – the enthusiasm for the current topics at NEST was palpable.

“Beyond Zero” – a glimpse into the future

Meanwhile, the planning of the next NEST unit “Beyond Zero” continued to progress. The unit is focusing on how buildings can become CO_2 sinks in the future. A paradigm shift in the construction industry is to be initiated through the use of CO_2-negative materials. The research questions that are being tackled in “Beyond Zero” are closely linked to the research initiative "Mining the Atmosphere" and the project demonstrates how scientific research and practical realization can go hand in hand to overcome the challenges of climate change. //

1
Exterior view of the “STEP2” unit at dawn. In “STEP2”, technologies for resource-saving construction were developed into marketable products.
Image: Zooey Braun

2
Opening event “DroneHub” on November 20, 2024: The open-air space inside a building structure enables researchers to test drone systems under real conditions such as wind, weather and the turbulence that results.
Image: Marion Nitsch

Groundbreaking progress for sustainable energy sources

Christian Bach, christian.bach@empa.ch

2024 was all about sustainable fuels with important milestones in the further development of the Empa mobility demonstrator "move" for producing synthetic methane. Simultaneously, the kick-off of the "reFuel.ch" consortium took place, which is developing robust supply paths for sustainable fuels and basic chemicals to support Switzerland on the path to decarbonization.

"reFuel.ch" – Sustainable fuels and basic chemicals for Switzerland

Time is pressing to achieve net zero by 2050. Fuels, energy sources and basic chemicals for Swiss industry must become sustainable as quickly as possible. The "reFuel.ch" research consortium is conducting research into sustainable production processes and robust supply routes. This involves fundamental questions such as: How and where can such energy sources ideally be produced – and how can they be transported to Switzerland and integrated into the market? What political, legal and social framework conditions are necessary to ensure Switzerland's supply? How can domestic raw and waste materials such as liquid manure be increasingly used for energy? With Empa as the "lead institution" and with the support of the Swiss Federal Office of Energy (SFOE), "reFuel.ch" was successfully launched in 2024, accompanied by events and the launch of the official website www.sweet-refuel.ch.

Synthetic energy sources as a substitute for fossil fuels

The sustainable production of synthetic methane is being tested in a demonstration plant inside the mobility demonstrator "move". The hydrogen required for this is obtained using renewable electricity, while the CO_2 is extracted directly from the air. The core technology is a catalyst for sorption-enhanced methane synthesis, which was developed by Empa and previously successfully tested in the laboratory. Construction of the demonstration plant began in 2024 – it marks an important milestone in the implementation of this innovative technology.

A crucial step in this process was the commissioning of the direct air capture (DAC) system, which filters CO_2 from the atmosphere and stores it in a balloon. In addition, a waste heat utilization system was implemented that provides half of the process heat required for the DAC plant using waste heat from the electrolysis plant. These advances create the basis for putting the methanation demonstrator into operation by mid-2025. The partners in the project are the ETH Board, the Canton of Zurich, Migros, Glattwerk, Avenergy Suisse, Lidl Switzerland, Armasuisse and Swisspower.

In addition, AMAG Classic, Motorex and Empa have jointly conducted a detailed and scientifically sound study on the compatibility of synthetic petrol in classic cars. The result: Even Oldtimers can be operated in a climate-friendly manner in the future, as synthetic gasoline can be used in older engines without hesitation.

Additionally, the "H_2 districts" project, supported by the SFOE and led by H_2 Energy, was launched at "move" to investigate how hydrogen and fuel cells can supply buildings with energy in a grid-friendly way and support the power grid on cold days. //

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1
The research work of the "reFuel.ch" consortium has begun in the Empa laboratories of the "Chemical Energy Sources and Vehicle Systems" department. The picture shows Alessia Cesarini (left) and Ali Saadun.

2
Construction of the demonstration plant, which uses sorption-enhanced catalysis to produce methane from CO_2 and hydrogen, began in "move" in 2024. The plant should be ready to go into operation in mid-2025.

The foundation for tomorrow's energy supply

Philipp Heer, philipp.heer@empa.ch

Since opening in 2016, the “Energy Hub” (ehub for short) has been an important platform for evaluating and further developing energy storage solutions, conversion technologies and the control of energy flows in a real-life environment. The ehub connects NEST and “move” – and thus also links the building sector with the mobility sector. One of the most important drivers of innovation for the ehub is increasing digitalization, as it provides large-scale data on energy use and at the same time offers possibilities for optimizing use. This requires more and more computing capacity, whether in the context of a single building, communication applications with the power grid or the collection of data at the level of entire neighborhoods and cities. The hardware can be located either in central data centers or in small, decentralized hubs. The advantage in the latter case is that waste heat from computers can be used relatively easily in the district for heating and to provide domestic hot water.

Innovative use of waste heat and hydrogen technology

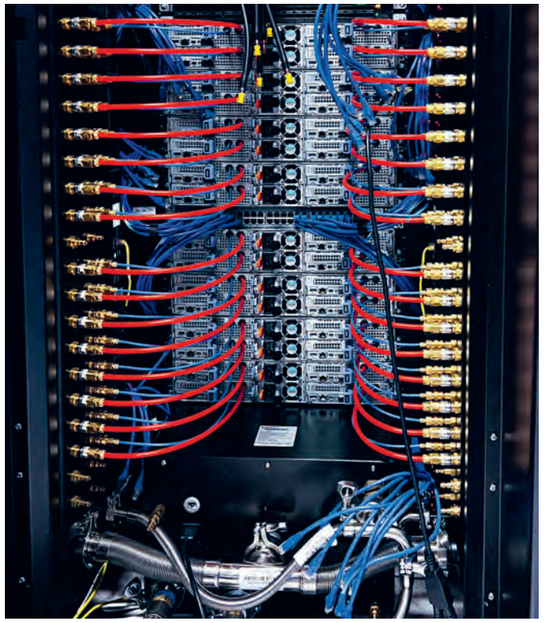
In the European “HEATWISE” project, researchers are investigating how waste heat from the IT infrastructure can be reused at different temperatures. To this end, NEST's data center was expanded with liquid-cooled servers, which enables a new form of heat recovery: The cooling liquid is heated to around 70 degrees Celsius within the computers and can be fed into NEST's high-temperature network, where it is used as shower water, for example. The experience and operational optimizations will be transferred to other data centers in Denmark, Turkey and Poland.

In addition, the demonstrators were expanded to include a hydrogen fuel cell, which was integrated into the ehub. A prototype was put into operation that can provide up to 60 kW of electrical and 60 kW of thermal power very dynamically. The interaction of this fuel cell with the existing heat pumps and battery storage systems is to be analyzed and optimized based on NEST's energy demands. The aim is to ensure that sufficient heat is always available, while at the same time reducing grid load peaks and maximizing electrical self-consumption.

Focus on energy data

In addition to the technical research priorities, the role of energy users was also examined. As part of the SWEET-Lantern consortium supported by the Swiss Federal Office of Energy (SFOE), various usage profiles were developed and enriched with real measurement data from smart meters. The resulting clusters of qualitative and quantitative data provide an insight into our behavior when using electrical and thermal energy. Surveys and data collection in various regions of Switzerland further enriched this data set.

Thanks to the extensions to the demonstrators, over 11,000 data points are now collected, stored and processed for researchers by the ehub platform every minute. To ensure that access to this data remains up-to-date, the previous interfaces for reading the data points have been expanded so that data can now be retrieved via common interfaces such as MQTT or a REST API. Part of the data set has already been published in “Nature Scientific Data” to illustrate the applicability of the collected data. //



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Not wasting heat: This was the goal set by a dozen European research institutions, including Empa, and industrial partners in the EU project “HEATWISE”: A newly developed “on-chip liquid cooling system” ensures optimal heat recovery in data centers. Image: ZutaCore

2
The H_2-districts research project is investigating the extent to which the use of fuel cells that heat buildings with renewable hydrogen makes sense at district level.

2

Concrete as a carbon sink

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Dr Peter Richner, peter.richner@empa.ch

The "Mining the Atmosphere" research initiative aims to capture excess CO_2 and store it in building materials such as concrete. Empa researchers have now demonstrated the potential of this idea for the first time: Five to ten billion tons of carbon could be used annually as concrete aggregates – enough to permanently store the excess CO_2 within 100 years after the energy transition and thus bring the CO_2 content of the atmosphere back to a climate-friendly level.

Building materials are crucial

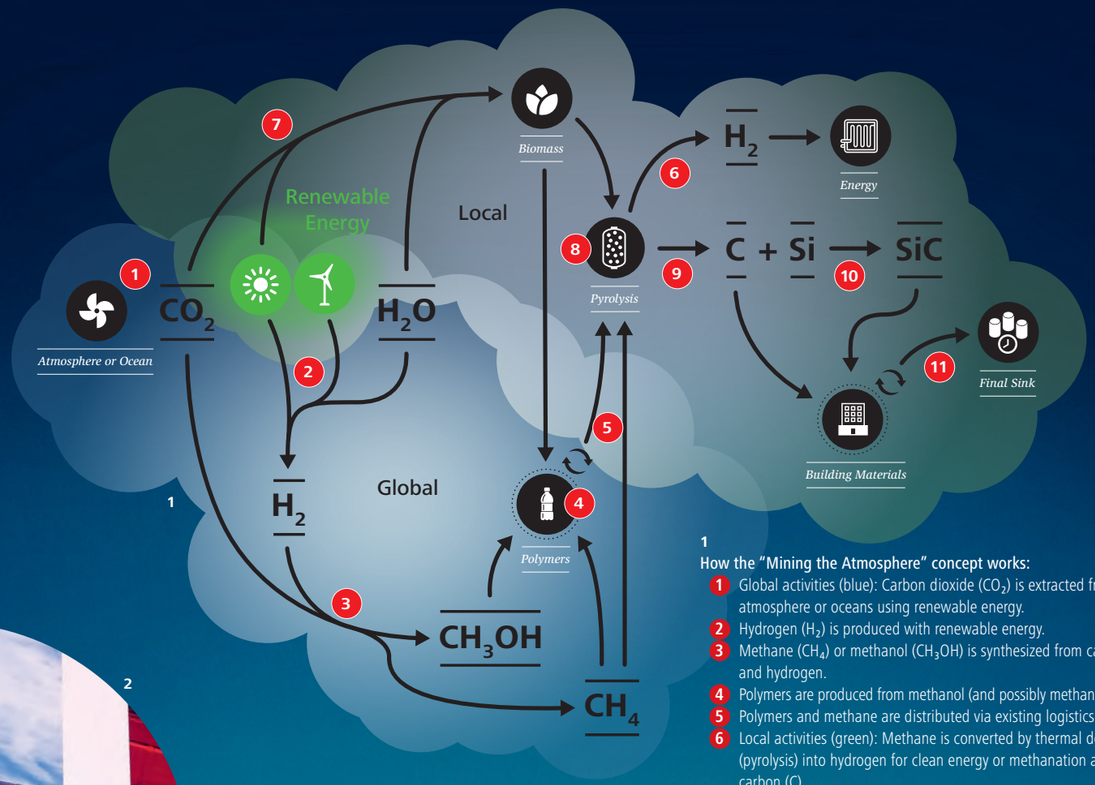
Compared to other CO_2 reduction measures such as underground storage methods, the "mining the atmosphere" approach offers several advantages: It ensures long-term stability as well as a high storage density of carbon and enables decentralized implementation. At the same time, conventional CO_2-emitting building materials can be replaced. Carbon from the atmosphere can be used, for example, to produce polymers, bitumen for asphalt or ceramic materials such as silicon carbide. In addition, other high-quality materials such as carbon fibers, carbon nanotubes and graphene could make the entire process economically viable – with concrete clearly accounting for the largest share of carbon storage.

In an optimal scenario, building materials such as concrete could bind up to ten gigatons of carbon per year. However, this potential would only be fully exploited from 2050 onwards, as sufficient renewable energy will only be available after the energy transition. In addition to the surplus 400 gigatons of carbon, at least an additional 80 gigatons would have to be removed from emissions that are difficult to avoid by 2100. According to various scenarios, the excess CO_2 could be completely incorporated into building materials within 50 to 150 years – this would bring the atmospheric CO_2 concentration back to the target level of 350 ppm ("parts per million").

Research initiative "Mining the Atmosphere"

The aim is to create a completely new global economic model and an associated industrial sector that uses CO_2 as the raw material of the future. CO_2 is first converted into basic chemicals such as methane or methanol. These are then further processed to replace conventional building materials and petrochemical products. At the end of their life cycle, these carbon-rich materials will be stored in special landfills to permanently bind the carbon. Thanks to synthetic methane (from CO_2 and solar hydrogen), energy can also be transported from sunny regions of the world to countries with an energy gap in winter.

Implementation requires further progress in materials research and process development. In 2024, Empa launched over ten new projects that complement existing research into carbon capture, conversion and utilization as well as system development. Among other things, researchers are developing innovative CO_2 adsorbents for the capture of CO_2 from the air, researching the electricity-based conversion of gaseous CO_2 into solid carbon and testing ways to maximize carbon storage density in concrete and asphalt using carbon-rich additives. Promising CO_2-negative building materials developed at Empa, such as concrete or insulation materials, will be used in the planned NEST unit "Beyond Zero", which will serve as a test platform for the transition from a CO_2-emitting to a CO_2-binding society. //



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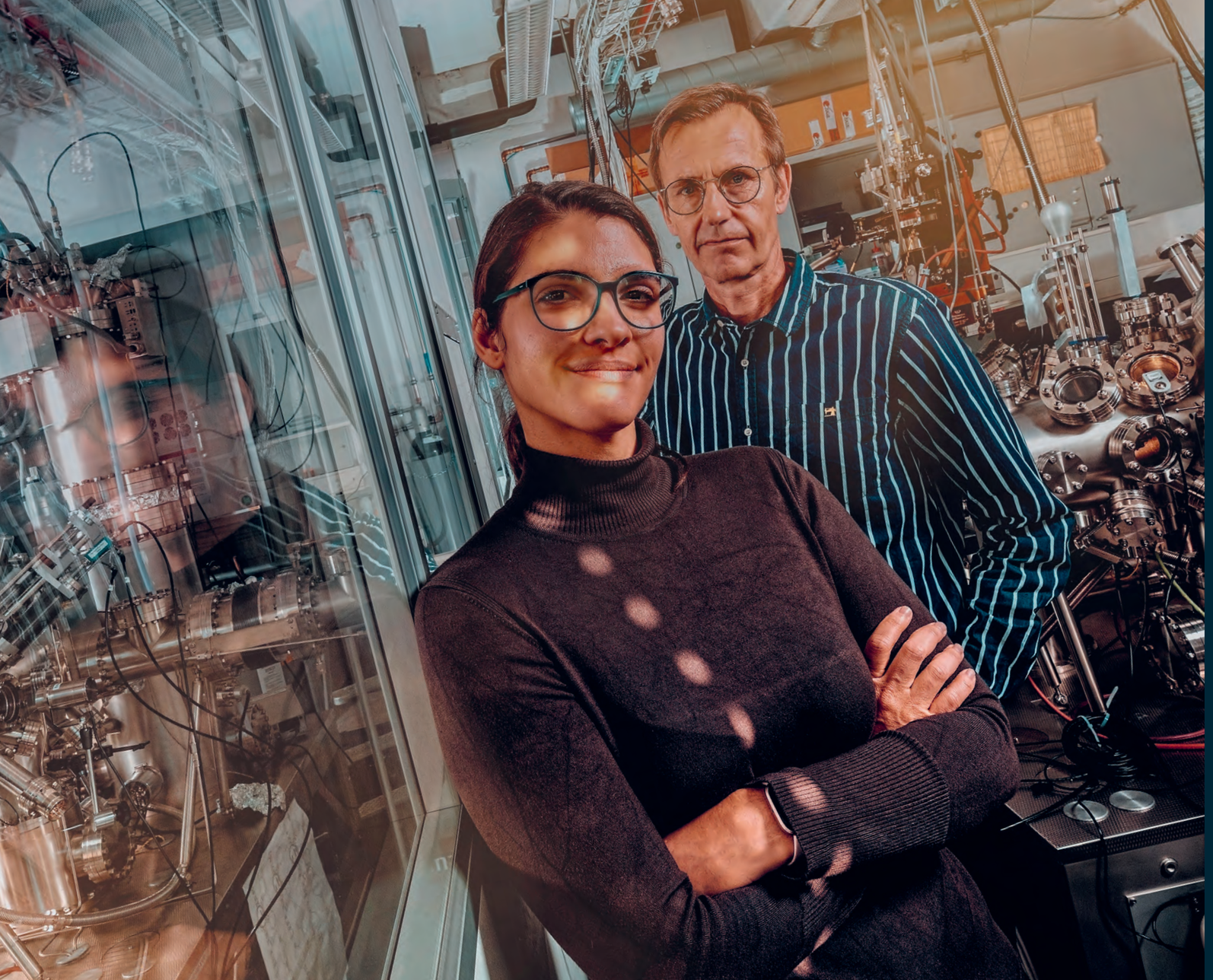
How the "Mining the Atmosphere" concept works:

1. Global activities (blue): Carbon dioxide (CO_2) is extracted from the atmosphere or oceans using renewable energy.
2. Hydrogen (H_2) is produced with renewable energy.
3. Methane (CH_4) or methanol (CH_3OH) is synthesized from carbon dioxide and hydrogen.
4. Polymers are produced from methanol (and possibly methane).
5. Polymers and methane are distributed via existing logistics chain.
6. Local activities (green): Methane is converted by thermal decomposition (pyrolysis) into hydrogen for clean energy or methanation and solid carbon (C).
7. Carbon dioxide is converted by photosynthesis into biomass, which is then pyrolyzed.
8. Waste polymers are pyrolyzed.
9. Carbon from all these sources is incorporated into building materials.
10. Carbon is combined with silicon (Si) to form silicon carbide (SiC), which is also used in building materials.
11. Finally, used building materials end up in landfills, which serve as final carbon sinks and bind the carbon dioxide permanently.

2
The deputy director of Empa, Peter Richner, presented the Empa initiative "Mining the Atmosphere" at Swissbau.

3
NEST Managing Director Reto Largo discusses the Empa initiative "Mining the Atmosphere" with a visitor at the Swiss Energy Days.



Research Focus Areas

Where do the major challenges of our time lie? Undoubtedly in the fields of human health and well-being, climate and the environment, dwindling raw materials, a safe and sustainable energy supply and the renovation of our infrastructure. In its four research focus areas, Empa pools the expertise of its 30-plus research labs and centers and develops practical solutions for industry and society.

How thin-film technology is paving the way for solid-state batteries

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Storing electrical energy has become an integral part of our lives. Whether in cell phones, tools and, in recent years, increasingly in mobility, batteries are becoming more and more central.

It is actually not entirely correct to simply speak of “batteries”, as there are many different types of batteries – depending on whether the focus is on mobile or stationary applications. Lithium-ion batteries have proven themselves for the examples mentioned at the beginning, but even in this sub-category there is a wide variety with many different cell chemistries. In addition to the service life (i.e. as many charging and discharging cycles as possible), high energy density, fast charging (the so-called C-rate) and safety (keyword: fire hazard) are of great importance.

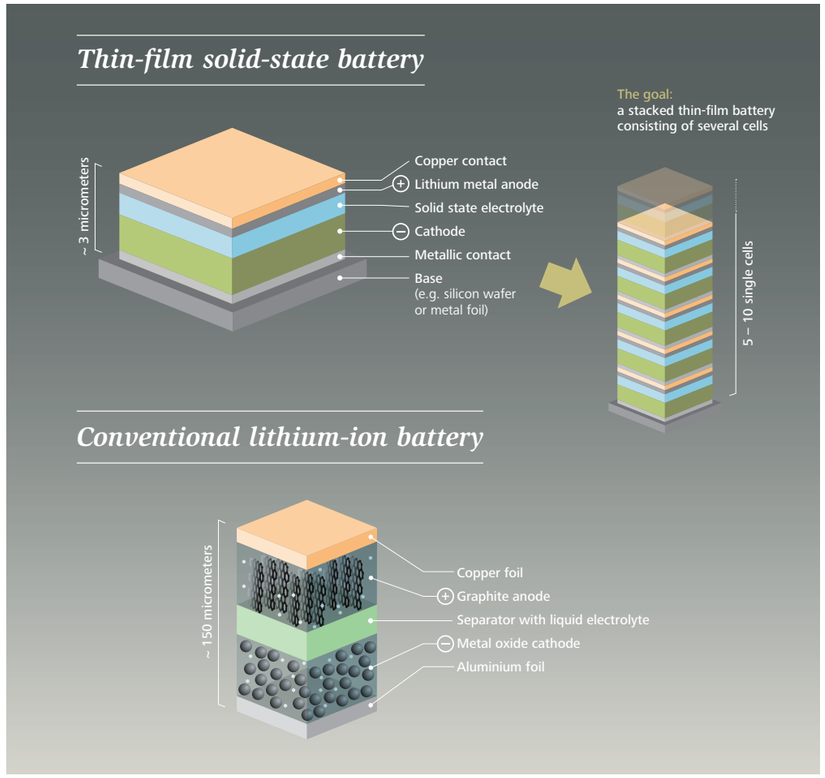
The risk of fire is due in particular to the battery's liquid electrolyte, which enables particularly high mobility of the Li-ions. This means that they can easily move back and forth between the electrodes during charging and discharging. In addition, the electrolyte is toxic when burned. The obvious solution is therefore to replace the liquid electrolyte with a solid. The challenge here is that the charge transport of the Li-ions must now take place in the solid, which is much more complex. At the same time, the interfaces between solid components and the mechanical properties are of great importance, as the “buffer function” of a liquid between the electrodes is no longer required. This can lead to thermal stresses.

The idea of Empa's “Thin Films and Photovoltaics” laboratory, headed by Yaroslav Romanyuk, is to make the solid-state electrolyte as thin as possible, which brings both electrical (fast charging) and mechanical advantages (lower thermal stresses). This requires thin films of excellent quality, a core competence of both the department and Empa as a whole.

In addition, “stacking”, i.e. connecting several thin-film batteries in series, enables a higher energy density. As fast charging and high energy density are normally mutually exclusive in one and the same battery, the thin-film battery is positioned in precisely this niche and is therefore aimed at applications between supercapacitors – which can be charged and discharged quickly – and conventional Li-ion batteries with high energy density. The Empa start-up BTRY, founded by Moritz Futscher and Abdessalem Aribia, will be responsible for marketing this new idea in the future.

The next step: in situ characterization

With their modified geometry, thin-film batteries also enable the scientific investigation of interfaces during operation. A current project funded by the Swiss National Science Foundation (SNSF) is focusing on the interface of the solid-state electrolyte. Empa researcher Marta Rossell will operate a solid-state battery “in situ” under a transmission electron microscope. The knowledge gained from this will provide scientifically significant findings and at the same time be of great commercial benefit. This is fully in line with Empa's mission to promote the technology transfer of disruptive material science innovations into practical applications. //



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1
Connecting several thin-film solid-state batteries in series (top) enables a higher energy density than with conventional lithium-ion batteries (bottom).

2
The successful BTRY founders: Moritz Futscher (left) and Abdessalem Aribia.

Improving circularity and reducing the environmental burden of the construction sector

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Dr Peter Richner, peter.richner@empa.ch

Among different construction materials, concrete is the material with by far the largest production volumes, both in Switzerland and globally. While a lot of effort focuses on reducing the environmental footprint at the material level, different groups at Empa work at addressing the sustainability challenges at the structural level. Here, novel reinforcement strategies enter the picture. In fact, the use of steel in reinforced concrete significantly worsens the environmental impact, in particular the energy consumption and greenhouse gas emissions. Moreover, construction steel is prone to corrosion, the main deterioration process in infrastructure made of reinforced concrete.

Protecting steel from corrosion places additional demands on concrete, the barrier that protects steel from the elements. The barrier is obtained at the expense of extra cement and by increasing the thickness of concrete cover and thus the overall volume of concrete members. Empa researchers work on alternative reinforcement strategies that help to address this conundrum. The overarching goal is to develop new materials for buildings and infrastructure that not only outperform the current solutions but also improve the circularity and reduce the environmental footprint of the built environment.

Various options: basalt fiber-reinforced polymers or …

Basalt fiber-reinforced polymers (basalt FRP), the newcomer among fiber-based composites, is particularly attractive for up-scaling due to a low price and wide availability of raw materials in Switzerland and globally. A potential of this technology for infrastructure applications has been shown in a research project carried out by Empa's Structural Engineering laboratory together with Swiss road authorities (FEDRO). Currently, the team is conducting an Innosuisse project in collaboration with the Swiss company SME Plüss Mechanics & Composites. The goal is to establish basalt FRP reinforcing bar production in Switzerland. The mechanical properties of the bars are being investigated, and their surface finishing is being optimized to enhance the bond with the surrounding concrete. The long-term durability of the developed bars in the concrete alkaline condition and reduction of the tensile strength was studied in creep tests. In the next step, the developed basalt bars will be implemented in a pilot project at the new NEST unit, Beyond Zero, and design strategies will be proposed to promote their use in the construction industry.

… carbon fiber-reinforced polymers

Carbon fiber-reinforced polymers (CFRP) are widely used in various strengthening applications for concrete and masonry structures. In particular, externally bonded reinforcement (EBR) using CFRP was first introduced by Urs Meier at Empa in the 1980s. After the first applications and successful commercialization in Switzerland in the early 1990s, EBR became a worldwide applied standard technology for the strengthening of structures. Carbon fiber production is currently based on petroleum-derivative precursors and is very energy- and cost-intensive. Empa's Mechanical Systems Engineering laboratory proposed a strategy to address this issue. The researchers developed methods to reclaim the CFRP strengthening strips from end-of-life buildings before demolition by controlled debonding, followed by reuse as internal prestressing reinforcement in precast concrete elements. This becomes feasible thanks to the exceptional properties of the CFRP composite, mainly excellent durability that spans beyond that of a typical building lifespan.

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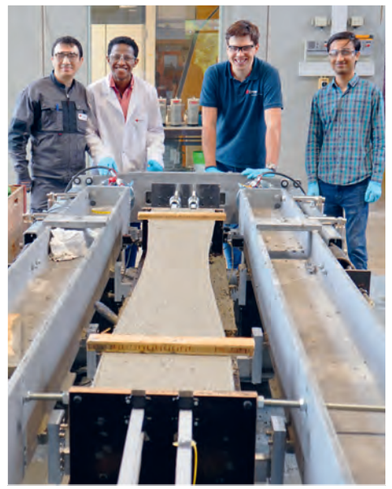

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Scientists from the Mechanical Systems Engineering lab with a freshly cast circular concrete-CFRP railway sleeper placed in a prestressing bed.

2
Flax yarn polymer strip developed at Empa – a prototype of a novel, bio-based concrete reinforcement.

The team produced several prototypes of circular concrete railway sleepers reinforced with reclaimed and processed CFRP EBR strip tendons. These sleepers were made of a novel recycled aggregate concrete mix developed by researchers at Empa's Concrete and Asphalt laboratory.

Combining bio-based fibers and recycled plastic for circular reinforcement

Moreover, three Empa laboratories – Structural Engineering, Mechanical Systems Engineering, and Advanced Fibers – currently collaborate in the framework of an Innocheck project on novel, circular FRP bars combining bio-based and recycled materials. They propose to obtain fibers from locally sourced flax yarns. These fibers are then embedded in a matrix made of recycled polyethylene, replacing the conventional synthetic resins and significantly reducing the environmental footprint. //

Challenging research for better health and personalized medical care

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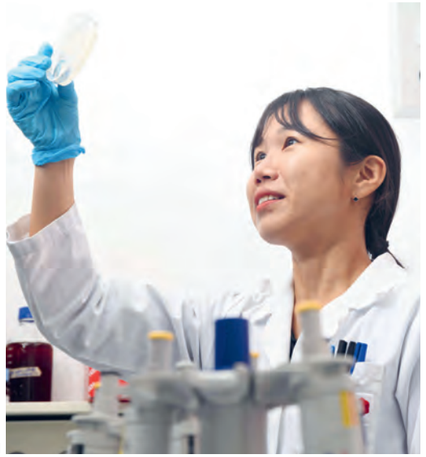
Prof. Dr René Rossi, rene.rossi@empa.ch

Projects in the Research Focus Area Health are targeting the three main pillars of health care: prevention, diagnostics and therapy. In close collaboration with hospital partners, this allows a comprehensive and transdisciplinary approach to improve public health and personalized medical care. The Research Focus Area Health is organized in a matrix structure to create the greatest possible impact. Research on novel materials and technologies is structured in the materials streams delivery, biointerfaces, wearables, imaging, and environment & health, and the translation to clinics is shown in different health clusters addressing urgent medical needs in oncology, infectious and cardiovascular diseases as well as dementia. To set priorities and accelerate innovations, different Booster programs spanning several elements of the matrix were launched recently. After the start of the Wound Booster and the Musculoskeletal Biodynamics Booster in 2023, another Booster addressing the challenges of antimicrobial resistance could be launched in 2024.

Antimicrobial resistance (AMR)

The continuously escalating prevalence of antimicrobial-resistant bacteria (AMR) presents a huge threat to humanity and places an enormous burden on society. Novel treatments to combat infections and address this need before our current antibiotics become ineffective and outdated are urgently needed. A special threat is linked to microbial biofilms related to device-associated infections and chronic wounds, both of which are associated with considerable morbidity and mortality and are particularly affecting the elderly.

An interdisciplinary Empa team proposes a nature-inspired and hybrid material-based solution to tackle the problem of AMR in chronic wounds and device-associated infections. Novel material systems for the delivery of beneficial bacteria, probiotics and/or bacteriophages to fight pathogenic bacteria are effectively living therapeutic materials or living medicines. As natural biological regulators of infections, bacteriophages and probiotics represent an ideal fit with the WHO's One Health strategy for animals, humans and the environment. Moreover, novel antibacterial coatings are being developed to reduce infections linked to dental implants or to reduce the potential transfer of microbes via high-touch surfaces in public spaces such as hospitals. Nanomaterials with antibacterial functions for the treatment of infections are specifically designed to meet the individual medical and physiological challenges linked to infectious diseases such as endophthalmitis, caused by an intraocular bacterial colonization in the eye, or dental root infections.



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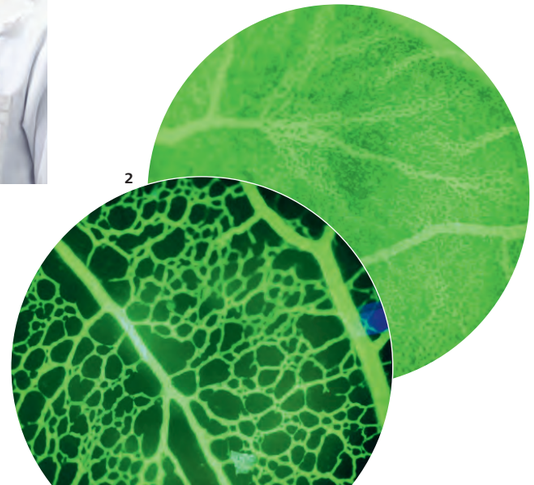

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Empa researcher Mihyun Lee from the Biointerfaces lab in St. Gallen develops antimicrobial nanotherapies.

2
If nanoparticles enter the placenta during pregnancy, the formation of blood vessels is suppressed. Fluorescence microscopy visualizes the consequences in the chicken egg model: The veins (green) only form a perforated, coarse-meshed network when they are treated with messenger substances from a nanoparticle-contaminated placenta (bottom). In comparison, a control chicken egg (top) displays a dense network of very fine blood vessels.

Impact of pollution on health

The effects on human health of many chemical substances such as nanoparticles and PFAS, which are almost indestructible, are not yet well understood. Such substances can be found in drinking water or in food and tend to accumulate in the body over time, which can increase the risk of health problems. An interdisciplinary Empa team is analyzing the risks of nanoparticles for unborn children in collaboration with clinical partners of the Cantonal Hospital of St. Gallen and research partners from the University of Geneva. This project focuses on the placenta as the interface between the mother and the child, which fulfils many vital functions influencing the development of the fetus. The team analyzes the immune/inflammatory effect of nanoparticles on the placenta and the immune cells of the umbilical cord blood. It could be shown that nanoparticles can impact the interactions between the placenta and the unborn child and negatively affect the formation of blood vessels. Such projects are important elements for the risk assessment of novel nano-materials.

Early diagnostics in body fluids

Biosensing in body fluids becomes an important research field in real-time monitoring and early diagnostics. The sensing in sweat or wound exudates is non-invasive, and nanoscale materials can be used to improve the sensitivity, especially for biomarkers present in very low concentrations. An important research field is the early detection of infections. Novel sensors detect the enzymes or volatile components released by bacteria, which could be demonstrated to increase the detection sensitivity. A research team from Empa, Balgrist and ETH Zurich developed a sensor for the early and precise detection of life-threatening complications after ab-dominal surgery. A sensor in the wound drainage system analyzes the wound secretions and reacts to the presence of various enzymes with a color change that can be detected with the naked eye. The project received the Empa Innovation Award 2024. //

Solutions for the climate, the environment and society

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In 2015, the global community agreed in the Paris Climate Agreement to limit global warming to below 2°C compared to pre-industrial levels and to make additional efforts to ensure that it does not exceed 1.5°C. Less than ten years later, the 1.5°C target has already been missed, and current global measures will probably not be sufficient to meet the 2°C limit either. So on the one hand, we need to step up our efforts to bring greenhouse gas emissions to net zero as quickly as possible and curb global warming after all. On the other hand, we need to prepare for the expected further rise in temperatures and the associated extreme weather events – such as floods, storms and droughts – and protect society and infrastructure from these dangers.

Avoiding climate change and preparing for it

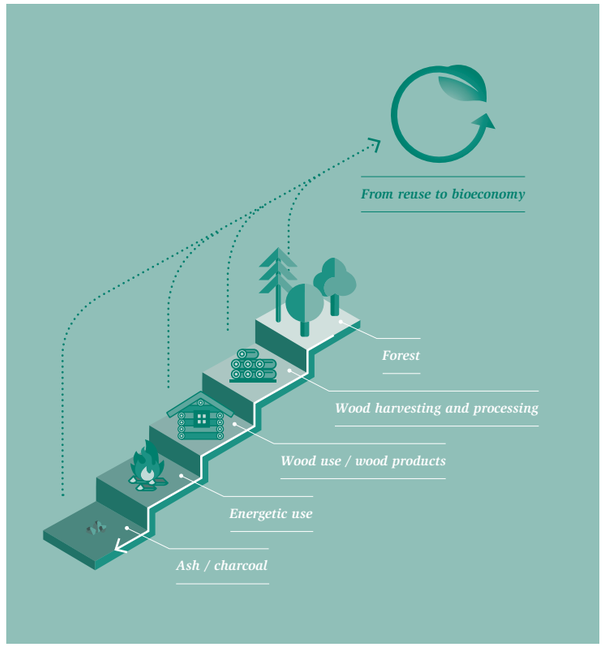
These two topics are closely linked and must be tackled together accordingly. This is precisely the aim of the "Climate Solutions" initiative launched at the beginning of 2024, in which Empa and Eawag, the ETH Domain's aquatic research institute, are contributing their complementary expertise to further develop and test practicable solutions. As a first step, projects were launched on the joint campus in Dübendorf, such as the scientific monitoring of a new geothermal probe field to store excess heat underground from summer for heating requirements in winter. In addition to optimizing energy storage, the effects on groundwater and living organisms in the soil are also being investigated. Another focus topic is the establishment of so-called blue-green infrastructures on the campus, for example to retain water during heavy rainfall or to provide cooling during heat waves through water evaporation and shading. In the future, this collaboration will be expanded to other topics and additional partners will be involved.

Wood – the all-rounder

Wood is considered one of the most important and versatile resources in the conversion of the construction sector, various branches of industry and the energy system to net zero. This raises the question of how much wood will be available for which application and how this precious natural resource can be used as efficiently and sustainably as possible. Empa, together with its "sister institute" for forests, snow and landscape (WSL), has presented a comprehensive analysis of wood flows in Switzerland, which can serve as a solid basis for decision-making. Because one thing is clear: Far too much wood is burned directly today instead of first being used in a utilization cascade in material applications, such as timber construction, and only used to generate energy after several recycling steps. Here, too, the connection between combating climate change and adapting to it becomes clear: We use wood from the forests to avoid CO_2 emissions and at the same time we will have to plant other tree species in the future that are better adapted to higher temperatures and long droughts, which in turn will determine the availability and type of wood resources that can be used in the future.

Green oases for noise-stricken city dwellers

But nature has even more to offer, also in our cities: A field study led by Empa in the city of Zurich revealed how green spaces can contribute to quality of life. Following an online survey, over 200 people were visited at home and hair samples were taken to determine their stress levels. The result: People who live near green spaces are less stressed. This confirms what was previously only suspected from experiments in controlled test environments: The negative effects of urban noise can be partially compensated for by green spaces. The researchers now hope that this finding will be incorporated into future revisions of noise legislation and urban planning.



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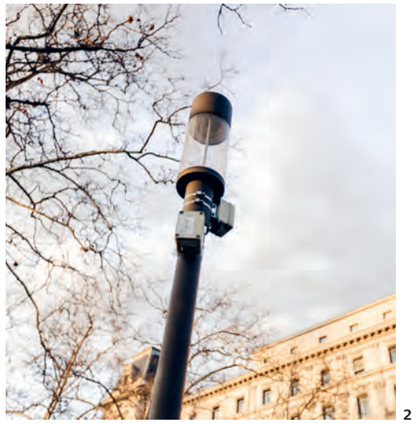

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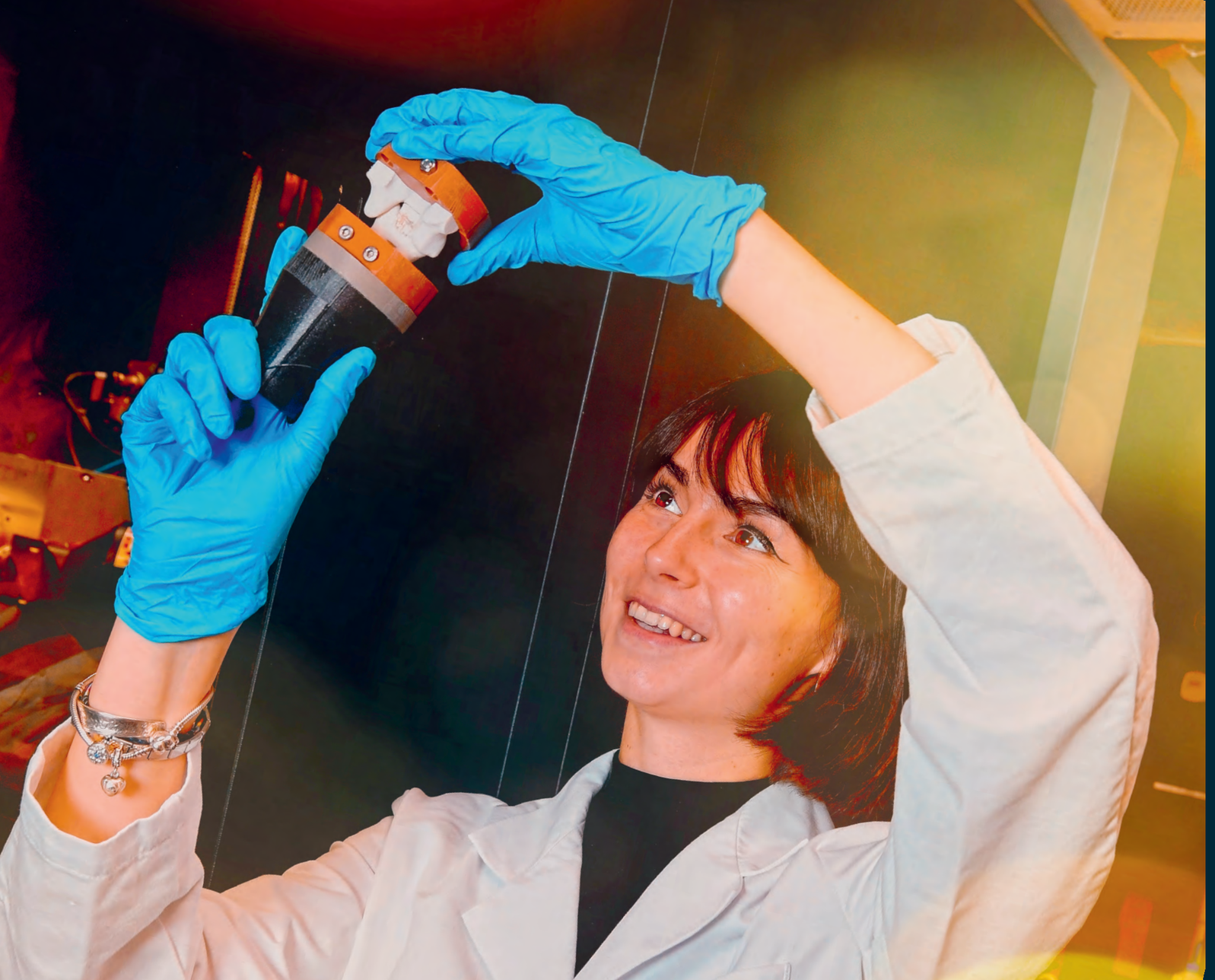
Empa and WSL researchers have precisely analyzed the material flows of wood in Switzerland. Too much wood is still burned directly today instead of being used in a utilization cascade and only used to generate energy after several recycling steps.

2
Inconspicuous: Two CO_2 measuring devices from "ICOS Cities" on a street lamp in Zurich. Image: Pekka Pelkonen / ICOS RI

How much CO_2 does Zurich emit?

Nature and the sustainable materials it provides us with therefore offer us many advantages to help us achieve our net zero target more quickly, make our cities even more liveable and increase our resilience to climate change. It is also becoming increasingly important to measure exactly how far a city is already on its way to net zero emissions in order to determine the effectiveness of the measures taken and make progress more tangible. This is the ambitious goal of the EU project "ICOS Cities", on which Empa is working together with research partners from all over Europe. Zurich was selected as one of three pilot cities and equipped with a dense CO_2 sensor network. The researchers are now in the process of linking the measurement data with high-resolution atmospheric transport models in order to determine the actual emissions. The method will then serve as a blueprint for other cities. //



From Research to Innovation

Top-flight research and a proximity to industry – the two poles between which Empa operates. The institute is able to offer its partners tailored solutions thanks to efficient and individual forms of collaboration and a broad spectrum of services. Whether it be with a view to developing new products and applications, optimizing technologies, solving specific problems or bringing technical specialists up to the state of the art – with more than 600 highly qualified scientists and a top-class infrastructure, Empa is the place to be.

Practical benefits of our research for industry

Marlen Müller, marlen.mueller@empa.ch

Knowledge and new technologies are important "raw materials" for the Swiss economy. That is why the transfer of these immaterial goods and close cooperation with companies are of central importance to Empa. The joint projects should offer our partners practical benefits, and the results should flow quickly into the companies.

The objectives of this applied interdisciplinary research at Empa for its partners are manifold: We work together on solutions for specific problems, we substitute non-sustainable materials, we improve processes or develop new products, materials and production methods thanks to innovative approaches.

More sustainable blind tapes thanks to water-based coating

As part of an Innosuisse project, together with Huber & Co. AG Bandfabrik from Oberkulm in the canton of Aargau, a new and sustainable coating for blind tapes was developed. The blind tapes with this new coating can be produced in a much more environmentally friendly way, as the previous solvent-based coating has been replaced by a water-based one. Blind tapes produced using this new manufacturing method are currently being tested by our business partner and will be used in various residential construction projects in the future.

Stardust against skin diseases

Widespread skin diseases such as psoriasis or neurodermatitis are difficult to treat. Even new active ingredients in conventional ointments or lotions often do not penetrate deep enough into the affected skin layers. If the skin could be made more permeable in the short term, the therapeutic agents could be delivered more effectively to their target.

Empa researchers have found an innovative solution together with industry partner Aldena Therapeutics: Nanoceramic stars made of aluminum oxide embedded in a gel create tiny short-term skin wounds that allow the active ingredient molecules to penetrate the skin and then close again on their own. This material development was also funded by Innosuisse.

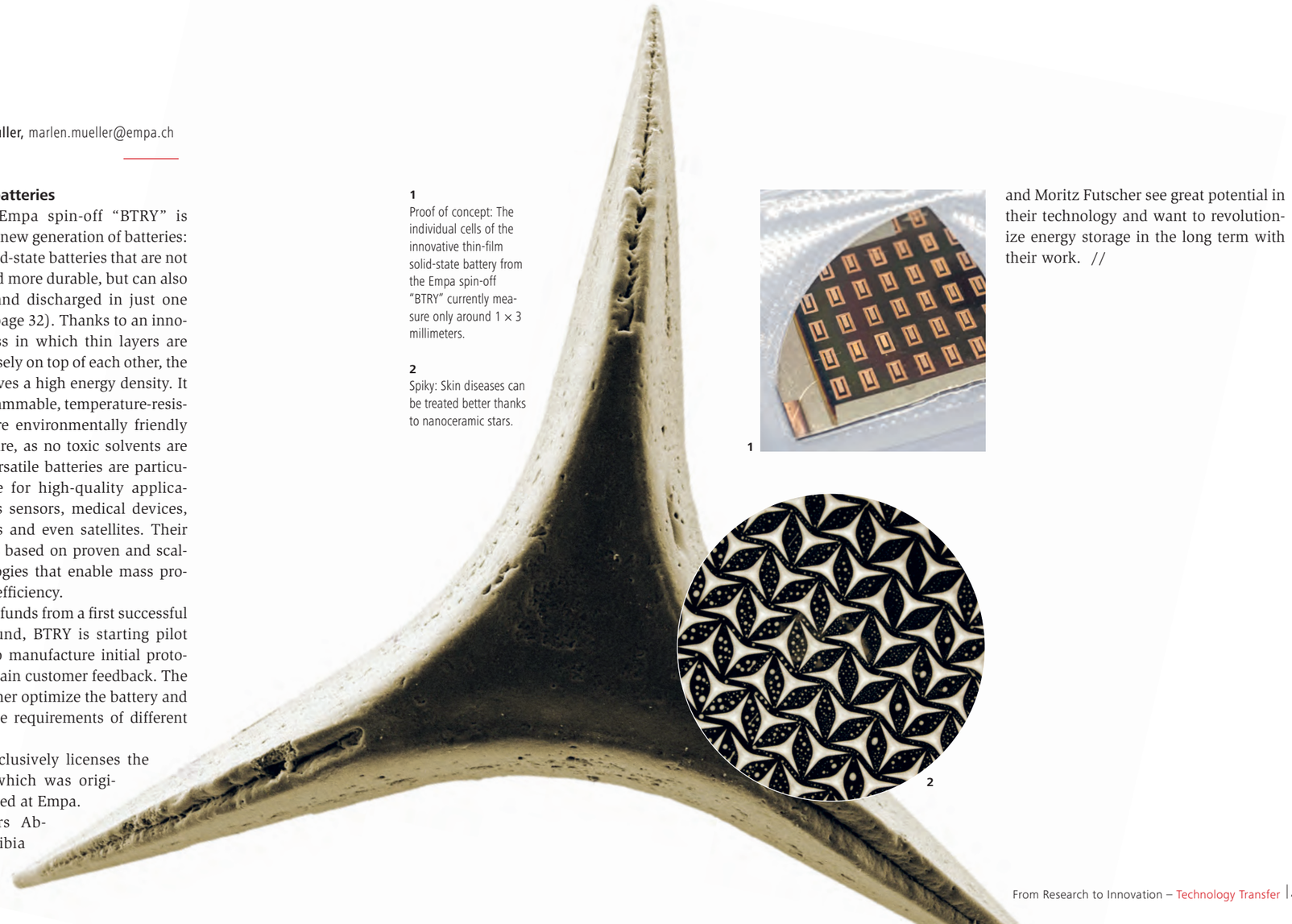
Through the collaboration with Empa, Aldena is now transferring this innovative approach from research to clinical applications. This technology transfer illustrates how scientific findings can be integrated into functional materials, opening up new possibilities in dermatological and cosmetic research.

Rethinking batteries

The young Empa spin-off "BTRY" is working on a new generation of batteries: Thin-film solid-state batteries that are not only safer and more durable, but can also be charged and discharged in just one minute (see page 32). Thanks to an innovative process in which thin layers are stacked precisely on top of each other, the battery achieves a high energy density. It is also non-flammable, temperature-resistant and more environmentally friendly to manufacture, as no toxic solvents are used. The versatile batteries are particularly suitable for high-quality applications such as sensors, medical devices, smartwatches and even satellites. Their production is based on proven and scalable technologies that enable mass production and efficiency.

With the funds from a first successful financing round, BTRY is starting pilot production to manufacture initial prototypes and obtain customer feedback. The aim is to further optimize the battery and tailor it to the requirements of different markets.

BTRY exclusively licenses the technology which was originally developed at Empa. The founders Abdessalem Aribia and Moritz Futscher see great potential in their technology and want to revolutionize energy storage in the long term with their work. //



1
Proof of concept: The individual cells of the innovative thin-film solid-state battery from the Empa spin-off "BTRY" currently measure only around 1 × 3 millimeters.

2
Spiky: Skin diseases can be treated better thanks to nanoceramic stars.

There is no lack of business ideas

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The pipeline of the business incubator glaTec is also well filled in 2024. This is mainly due to the increasing popularity of the Empa Entrepreneurship program. In two calls for applications in 2024, four outstanding applications were selected from seven very good applications and the budding young entrepreneurs were given the opportunity to prove the feasibility of their business ideas within a year.

The spectrum of future Empa spin-offs is broad. It ranges from software for energy management as a service to exploit the opportunities of electromobility and intelligent buildings for the energy transition, to a heat-resistant drone for analyzing the sources of fires and inspecting blast furnaces, to a new technology for the efficient and scalable production of terahertz filters with numerous applications ranging from medical diagnostics such as skin cancer detection and molecular spectroscopy to the further development of telecommunications, including 6G. In other words, many new product ideas that will create jobs in Switzerland in the future.

Close cooperation between the research institutions of the ETH Domain

It is pleasing to note that, in addition to another Eawag spin-off project, the WSL spin-off RAMMS AG was founded last year. The Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) became a new glaTec member and is represented on the board by Christoph Hegg, deputy director of WSL.

1

2

1
Thanks to its insulating aerogel casing, the "FireDrone" can record data from the fire even in extreme heat and forward it to the emergency services.

2
The patented airflow amplifier from the Empa spin-off "Ionic Wind Technologies" accelerates ionic wind much more strongly than was previously possible.

High quality of the young companies, both in the glaTec …

In 2023, glaTec start-ups raised a total of almost four million Swiss francs from investors and foundations; last year, the figure was already over five million Swiss francs, a significant – and extremely pleasing – increase and proof of the high quality of the young companies at glaTec. This is also confirmed by the excellent rankings of the Empa spin-offs Viboo AG and BTRY AG in 50th and 52nd place in the ranking of the 100 best start-ups in Switzerland 2024.

… as well as in Startfeld

In 2024, Donato Rubinetti and his startup "Ionic Wind Technologies" won the "Startfeld Förderpaket" as well as the "Startfeld Rohdiamant". The St. Galler Kantonalbank prize, endowed with CHF 10,000, recognizes early-stage projects from research and educational institutions. The spin-off uses the power of electrostatic fields to convert electric current directly into air currents – without the need for conventional bulky fans and blowers. This innovative, noiseless technology is suitable for cooling systems, drying processes or air purification. Ionic wind systems are significantly more energy efficient than conventional ventilation systems and therefore help to improve the environmental balance and reduce costs. Initially, "Ionic Wind Technologies" focuses on the cooling of electronic devices.

The Empa spin-off will soon be able to qualify for the "HSG START Accelerator". This new funding program is designed to support technologically strong start-ups that already have products and customers in their growth and prepare them for attracting investor funding. To this end, the University of St. Gallen, START Global and Switzerland Innovation Park East (which includes Startfeld) are pooling their expertise and networks in startup promotion. The program is currently being largely financed by the Canton of St.Gallen and is intended to be self-supporting in the long term. //

Talent promotion strengthens strategic research areas

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The Empa Zukunftsfonds received donations totaling CHF 3.2 million in 2024. Thanks to the generous donations from foundations and private individuals – including a substantial contribution from a private donor and a legacy from Heinz A. Oertli – important new research projects were launched and the careers of young talents were decisively promoted. Last year, the donations were used to fund five doctoral students and four postdoctoral researchers.

Research fund on antimicrobial resistance

Thanks to the generous support of a private donor, a fund has been set up for research into antimicrobial resistance. This field is a focal point of Empa's health research (see p. 36). Prolonged use of incorrectly dosed antibiotics can cause germs to develop resistance. As a result, they become "immune" to all antibiotic substances developed to date. According to the World Health Organization (WHO), around 5 million people worldwide already die every year as a result of infections with resistant germs – this figure is likely to double by 2050 if nothing is done. Researchers at Empa are working on various approaches to combat this "silent pandemic". The projects for the prevention, detection and treatment of antibiotic resistance are based on new materials and technologies. The new fund is intended to further strengthen this area of research in the coming years and at the same time support promising young research talent. The aim is to continuously expand the fund's assets.

A legacy for ophthalmology research

In June 2024, Heinz A. Oertli, a friend and supporter of Empa, passed away at the age of 94. During his lifetime, Heinz Oertli built up a company for the development and manufacture of precision instruments for eye surgery. As the topic of ophthalmology remained close to his heart even after the sale of the company, he decided to set up a fund at Empa in 2022. The "Heinz A. Oertli Fund for Ophthalmology" has made various projects possible over the past three years. Three doctoral students and one postdoctoral researcher have thus been given the opportunity to embark on a scientific career – such as Martina Viola. The postdoctoral researcher is working on a functional tissue adhesive for the efficient treatment of infected corneal injuries. On the one hand, this should have an antimicrobial effect and, on the other, prevent collagen degradation. The aim is to enable seamless healing, which would help many people worldwide who suffer from corneal defects. With the legacy that Heinz A. Oertli left to Empa, the fund will now be able to support further ophthalmology projects for at least ten years

Transforming CO_2 into raw materials

Greenhouse gas emissions caused by humans, especially CO_2 and methane, are leading to constant global warming with numerous consequences, such as dwindling biodiversity and increasing environmental disasters. The problem is that emitted CO_2 is only eliminated from the atmosphere naturally over the course of many centuries. For this reason, Empa has launched the "Mining the Atmosphere" research initiative (see p. 28). In this initiative, 13 research departments are working together on technologies to remove excess CO_2 from the atmosphere and make it usable as a raw material.

One of the "Mining the Atmosphere" projects was launched thanks to the generous support of the climatoor Foundation and the Dimitris N. Chorafas Foundation. In this project, Empa researchers Dirk Hegemann and Ramses Snoeckx want to develop a novel process for the conversion of CO_2. They are using plasma technology for this purpose. Plasma, the fourth state of matter, is highly reactive and offers great potential to replace current production processes based on fossil fuels. Plasma energy is used to break down gases into charged particles, which enables a variety of reactions. For example, CO_2 extracted from the atmosphere can be converted into CO and O_2. CO can then be used to produce chemicals or in the steel industry. If successful, the new process could therefore achieve a twofold reduction in CO_2 emissions: firstly by using CO_2 extracted from the atmosphere as a raw material and secondly by replacing existing manufacturing processes that currently emit large amounts of CO_2. //

1
Empa researchers Dirk Hegemann and Ramses Snoeckx are developing a novel process for the conversion of CO_2 with the aid of a plasma reactor.

2
Postdoctoral researcher Martina Viola is working on a functional tissue adhesive for the efficient treatment of infected corneal injuries.

Meeting global challenges with global partnerships

Prof. Dr Tanja Zimmermann, tanja.zimmermann@empa.ch

An essential feature of research at Empa is its claim to contribute to solving "real" problems – in other words, to have an impact in the real world. This is why national and international exchange is so important – on the one hand, to disseminate the knowledge and innovations created in Empa's laboratories to the world, and on the other hand, to receive new ideas, inspiration and questions "from the outside", so to speak. What's more, most of our current challenges cannot be mastered by oneself, so international networks and partnerships are absolutely essential.

Several visits and meetings with partners from Germany were on the agenda last year. In March, for example, a delegation from Baden-Württemberg led by Petra Olschowski, Minister of Science, Research and the Arts, visited Empa, Eawag and NEST to discuss sustainable construction technologies and sustainable water use and to explore opportunities for closer cooperation, such as that which already exists with the Karlsruhe Institute of Technology (KIT) in NEST's UMAR unit.

Several meetings have already taken place with KIT with the intention of cooperating more closely in the field of quantum technologies and health research in the future. And in December, another German delegation of decision-makers from politics, administration and industry met with Empa's Directorate to discuss future technologies.

In March, a BASF delegation led by CEO Martin Brudermüller met with Empa's Directorate and ETH Board President Michael Hengartner and inspected the (then) shell construction of the latest NEST unit STEP2, of which BASF is the main partner and in which the company intends to bring numerous innovations to market maturity.

The traditionally good relations with partners in the UK were also further strengthened last year. The British Ambassador to Switzerland and Liechtenstein, James Squire, visited Empa in St. Gallen in April; together with Empa Director Tanja Zimmermann, he toured several laboratories and exchanged ideas with various start-up founders on the topic of entrepreneurship at the neighboring OST Innovation Park. And in October, a delegation from Innovate UK, the British innovation promotion agency and thus the counterpart to Innosuisse, visited Empa together with various British start-ups to exchange ideas at NEST on the topic of artificial intelligence and its application in the construction and building sector and on effective start-up promotion, while also exploring possible synergies.

Despite the much longer journey, several delegations from Asia also found their way to Empa. In April, for example, Singapore's Building Authority visited NEST and discussed the future of construction with Empa Deputy Director Peter Richner. One of the starting points was the multidisciplinary research project Cooling Singapore, which was conducted jointly with the Singapore-ETH Center (SEC) and in which a digital urban climate twin of the city state was developed in order to get the problem of urban heat in Singapore under control with the help of urban planning and construction. In April, the ambassadors of the ASEAN countries were guests, and in October, a ministerial delegation from South Korea also visited NEST and some research projects in the field of quantum technologies.

Empa Director Tanja Zimmermann and Pietro Lura, Head of the Concrete and Asphalt lab, paid a visit last September to sign an agreement with the Qatar Infrastructure Authority on increased cooperation in the field of sustainable road surfaces.

And in April, Lorenz Herrmann, member of Empa's Directorate, was part of a Swiss delegation led by State Secretary Martina Hirayama from the State Secretariat for Education, Research and Innovation (SERI) to identify opportunities for cooperation with partners in Poland as part of the Swiss cohesion contribution. Shortly before this, a Polish delegation led by the Łukasiewicz Research Network had already visited Switzerland to define research fields of common interest together with the institutions of the ETH Domain. //

1
Peter Richner (2nd from left) presents the NEST unit Urban Mining and Recycling to a delegation from Baden-Württemberg led by Petra Olschowski, Minister of Science, Research and the Arts.

2
Empa researcher Francis Schwarze (center) presents the marble wood project to the British Ambassador to Switzerland and Liechtenstein, James Squire (left).

3
In April, Lorenz Herrmann (right) was part of a Swiss delegation led by State Secretary Martina Hirayama from the State Secretariat for Education, Research and Innovation (SERI) to identify opportunities for cooperation with partners in Poland as part of the Swiss cohesion contribution.

4
In December, a delegation from Germany with decision-makers from politics, administration and business met with representatives of Empa's Directorate to discuss future technologies. The picture shows Bernhard Siegfried Loos, Member of the Bundestag (MP).

5
A BASF delegation led by CEO Martin Brudermüller (center) with Empa's Directorate and ETH Board President Michael Hengartner in the (then) shell construction of the NEST unit STEP2, of which BASF is the main partner.

6
In April, Empa Director Tanja Zimmermann welcomed ambassadors from ASEAN countries to Empa.

Full House

Dr Michael Hagmann, michael.hagmann@empa.ch

Dialog generally works best in direct interactions, i.e. face to face. Empa took this to heart in the past year – and aimed to literally rub shoulders with its stakeholders from the public, politics and business at several major events.

Open lab doors at the Dübendorf campus

The highlight of the year was certainly the Open Lab Day in Dübendorf in September. Despite cool and occasionally rainy weather, around 7,000 visitors flocked to the new Empa-Eawag campus. At around 70 booths, guided tours, workshops and lectures, young and old alike were able to get to know Empa's research live in various topics such as Energy Transition, Climate Change, Dwindling Resources and Healthy Life, Healthy Environment. The audience was also able to explore the brand-new co-operate research campus with numerous innovations from the Empa labs, such as a large geothermal probe field that stores summer heat for the winter. For young people who wanted to get hands-on, Empa presented its range of apprenticeships. Moreover, various Empa spin-offs showed how innovations make their way from Empa's laboratories to the real world.

The day before the big event, Empa invited its partners from politics and industry to an exclusive Peek Preview and exchanged views with them on the central challenges of our times – i.e. the topics mentioned above – and discussed how these can be met with the help of innovative technologies.

Empa exhibit at the Swiss Museum of Transport

But that's not all: Two new NEST units were opened in 2024 – STEP2 with main partner BASF in August and the Drone-Hub with Imperial College London and EPFL in November (see page 20). And since 2023, Empa has been involved in the ETH Domain's Joint Initiative, Energy Science for Tomorrow, together with ETH Zurich, EPFL and PSI. Through a partnership with the Swiss Museum of Transport in Lucerne, the goal is to promote dialog with the public on the topic of the energy transition and net zero in order to jointly develop a climate-neutral energy system. In October, a new exhibit was inaugurated in the Experience Energy! exhibition at the Swiss Museum of Transport: the Emission Explorer. With this Empa exhibit, visitors can playfully determine their individual carbon footprint – and find out in which areas of life they can personally make a concrete contribution to a more sustainable society and a smaller carbon footprint.

To coincide with the opening of the Emission Explorer, the Energy Days were held at the Swiss Museum of Transport from October 18 to 20. Over three days, the public came into contact with numerous aspects of Empa's energy and materials science. More than 1,000 visitors went on an energy management challenge with robots from the Smartfeld educational initiative, with which Empa works closely at its St. Gallen site. Animated lectures and handicraft lessons on the Empa children's book "Zukunfts(K)reise" (Journey to the Future) enabled children to come into contact with concepts from Empa research on planetary boundaries and circular economy. In addition, Empa researchers and their colleagues from PSI presented the joint Synfuels initiative and had engaged discussions about synthetic fuels and flying in the future.

Mining the Atmosphere

Empa's communication and outreach activities in 2024 focused on the highly ambitious research initiative Mining the Atmosphere, which aims to capture atmospheric CO_2 on a large scale and bind it into economically useful and key materials such as concrete and other building materials. Empa researchers presented this vision and initial results such as a carbon-containing concrete at open-i in Zurich, the successor event to the Swiss Innovation Forum, at Swissbau and – virtually – via a special feature of the Bright Minds livestream, during which Peter Richner and Nathalie Casas explained this approach by numerous examples – but also pointed out the many obstacles that still need to be overcome.

Likewise, our "regular" guided tours of NEST and through the Empa laboratories were, again, highly popular in 2024; Empa welcomed a total of almost 12,000 visitors to its sites.

1
One of Empa's goals is to familiarize in particular young people – i.e. future decision-makers – with the technologies that will shape our future.

2
Tom Russi (right), Head of Project and Program Promotion at Innosuisse, and Empa Director Tanja Zimmermann listen to researcher Michael Stuer presenting the Star Cure ceramics project.

3
The Green parliamentary group visited NEST, where Managing Director Reto Largo (right) explains the highlights of the HiLo unit.

4
Nobel Laureate Stanley Witthingham (far right) visited Empa together with participants of the Swiss Battery Days. The pioneer in the development of lithium-ion battery technology was particularly interested in the battery research in the laboratories of Corsin Battaglia (far left).

5
In the new House of Energy at the Swiss Museum of Transport, the interactive exhibition Experience Energy!, created with the participation of Empa, invites the public to engage with the complex topics of energy and sustainability.

6
Young and old alike enjoy the stories of the Empa children's book "Zukunfts(K)reise", which was presented for the first time at the Energy Days.


1


2


3


4


5


6

That's how versatile Empa is!

Melina Spycher, melina.spycher@empa.ch

2024 was once again characterized by the diversity and commitment of a wide variety of people. Empa employees contributed to the research institution's top performance with their unique skills and perspectives. In addition to the continuation of proven initiatives, new projects and networks were established to further strengthen an inclusive and respectful working environment.

Networks promote the exchange of ideas

Last year, the regular "Women meet Women" lunches were brought back to life. The lunches are a platform to promote exchange between Empa and Eawag female employees and to provide space for networking and mutual support. Exciting guests talked about their careers, such as Tanja Zimmermann, Katharina Maniura and Sara Marks (Eawag). Barbara Favre also presented the "Advance" network, of which Empa is a member (since 2021) and benefits from exciting courses and events. The "Women meet Women" lunches have now established themselves as a popular meeting place and actively contribute to strengthening the network of female employees.

Another milestone was the establishment of the LGBTQIA+ network "Queers and Peers", also together with Eawag. With regular informal meetings, this provides space for open dialog, mutual support and the visibility of LGBTQIA+ topics within the two research institutions.

Empowering women in science and leadership

The second round of the feM-LEAD program ("female Mentoring: Leadership for Equity and Diversity") got off to a successful start with six female participants from Empa. The mentees from the four ETH research institutions benefited from individual 1:1 mentoring, interactive workshops, pitching sessions, intervision and diverse networking opportunities. The program underlines Empa's commitment to supporting women in their professional development and increasing the proportion of women in management positions in the long term.

Promoting young talent with enthusiasm

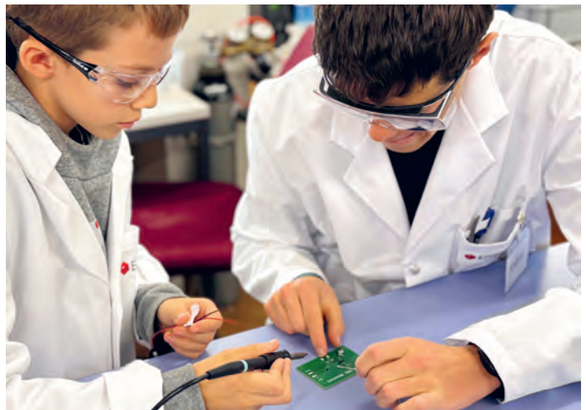
National Future Day was once again a complete success in 2024. 79 children and young people visited Empa and experienced exciting workshops and insights into the world of science and technology.

1
Empa Director Tanja Zimmermann (left) spoke to a pleasingly large group of female employees at one of the "Women meet Women" lunch seminars, which were relaunched in 2024.

2
Melina Spycher presented the Diversity, Equity & Inclusion (DEI) group at the open day in Dübendorf.

3
The National Future Day 2024 allowed young people to experience research and development up close.

1



3

2

This event enabled young people to experience research and development up close and sparked enthusiasm for STEM professions.

Further highlights

On the Open Day, the "Diversity Wheel" offered visitors the opportunity to engage with diversity issues at Empa in a playful way. The "Potluck Apéro" as part of the "Homes of Empa" project brought employees together to share culinary specialties from their home countries and thus bring Empa's cultural diversity to life.

Empa will continue its efforts to create a diverse, inclusive and respectful working environment in the future. The positive developments in 2024 encourage us to take new initiatives and further expand existing programs. //

The research campus is being upgraded to a living space

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Since May 2024, the role of Sustainability Officer has been shared between Empa and Eawag with the aim of pursuing a more synergistic approach to sustainability management for both institutes at all sites. The environmental team has also been expanded with volunteers from both institutes. The team acts as a think tank, motivator, information provider and coordination point, and also implements projects itself.

Campus living space 1

For some years now, the campus in Dübendorf has been gradually developing from an industrial area into a pedestrian-oriented and lively research campus. In the past year, the campus has changed noticeably, particularly with the realization of the "Green Belt". In the long term, this is intended to create a multifunctional space that combines human use, education and research as well as the promotion of biodiversity. The campus is intended to convey an atmosphere of openness, innovation and inspiration. Inter- and transdisciplinary demonstrators or open-air experiments on current topics such as heat reduction, sponge city or blue-green infrastructure are also to be realized. Research should be able to be experienced in a practical and interactive way on the campus.

Green areas and biodiversity

The "campus habitat" should have a high diversity of plants and animals that live together with people and work activities in a dynamic ecosystem. Typical characteristics are species and habitat diversity, connectivity, near-natural design, integration of water ecosystems and environmentally friendly management. The aim is to design and maintain all green spaces according to nature-oriented principles. The "Nature & Economy Foundation" certificate is being sought for all Empa and Eawag sites. Recertification was successfully carried out last fall at the Eawag and Empa sites in St. Gallen. The process at Empa in Dübendorf has not yet been completed. In addition to the recertification, guidelines for ecological green space management have also been drawn up.

Another aspect on the campus is the minimization of light emissions. These have a particular impact on safety, energy efficiency and ecology. A concept for the design and optimization of outdoor lighting on the campus is currently being developed. The aim is to develop functional, aesthetic and sustainable lighting solutions. Last year, a project was also launched to make interior lighting more efficient by increasing the use of LEDs and smart technologies.

Energy and climate

In order to further reduce our own greenhouse gas emissions, building emissions are to be reduced by more than 75 percent by 2030 compared to 2006. To this end, the existing medium-temperature network (VL 38°C) is to be expanded and the flow temperatures in buildings reduced to 50°C (currently 65°C). In addition, a large, seasonal geothermal storage facility with 144 geothermal probes will be built in 2023 to serve as a heat source and sink. Smart, self-learning thermostats in all buildings, which were installed at the end of 2024, are to ensure a further reduction in heating requirements. All these measures should make it possible to dispense with natural gas or biogas from 2030. Including peak load coverage by the existing biogas cogeneration plant, the measures will lead to a reduction in CO_2 emissions of over 90% compared to 2018.

In addition to the adjustments to the heat supply, more renewable energies are to be used on campus. To this end, a solar potential analysis is currently being carried out for all roof areas. The analysis evaluates the suitability potential of the areas and serves as a basis for decision-making for a project roadmap.

In addition to these projects, topics were also tackled at a strategic level last year. For example, a climate and environmental strategy is currently being developed. Further topics in the areas of energy – such as cooling supply and appliance efficiency –, climate (e.g. mobility) and the environment (e.g. plastic recycling in the laboratories) are being examined more closely and projects derived. //

2

3

1
Where cars were previously parked, the "Green Belt" has now been created. For several years now, the Dübendorf campus has been gradually developing from an industrial area into a pedestrian-oriented and lively research campus.

2
The participants in the "Clean-up Day" in St. Gallen are delighted with the new sand lens they created for ground-nesting insects.

3
Larger objects were also recovered from the Glatt at the Dübendorf site on "Clean-up Day".

Facts and Figures

Researchers like measuring, including their own performance: In 2024, Empa researchers and engineers published 809 academic papers and filed patent applications for 17 developments. At the end of the year, 112 projects funded by the Swiss National Science Foundation (SNSF), 69 projects backed by Innosuisse and 92 EU projects were underway at Empa. Together with other start-ups in Empa's two business incubators, the 37 spin-offs employed a total of 1,223 people.

Empa's annual financial statement has been compiled, as at all institutions in the ETH Domain, based on IPSAS (International Public Sector Accounting Standards). It is available at *www.empa.ch/web/s604/annual-reports.*

Risk Management

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The aim of risk management at Empa is to identify potential risks for the company and its employees at an early stage and to take appropriate measures. This system contributes to a practiced safety culture, sensitized employees and a constantly improving safety situation at Empa. In 2024, a new risk management regulation was drawn up that explicitly defines the institution's objectives, strategy and the willingness to take risks in various categories of activity and sets out the framework for the work of risk management.

GruPrinciples in dealing with risks

Empa has aligned its regulations in this area with the specifications for risk management in the ETH Domain and at the federal level. Its safety and risk policy sets out the systematic handling of the various risks in a binding manner and defines the willingness to take risks on a topic-specific basis, the acceptance of these risks and how they are to be dealt with. All measures are primarily aimed at protecting the life and limb of employees, guests and all persons within Empa's sphere of influence. Further objectives are the protection of material assets and the environment from negative impacts, the preservation of the know-how acquired and the protection of Empa's intellectual property and reputation. The main focus of these efforts is on prevention.

Risk management is carried out according to a standardized process that begins with a periodic inventory of risks. Each risk is evaluated according to its potential impact and probability of occurrence and assessed in various dimensions, e.g. financial and reputational risk. Finally, measures to contain the risks are defined and implemented. The risk management process and the status of the measures are regularly reviewed in risk controlling and, if necessary, adjusted accordingly.

Open house and other challenges

In September 2024, a major event with around 7,000 visitors was held at the Dübendorf site in the form of an open day. Risk management preparations for this event began the year before. To approve the event, the local authority required a comprehensive security concept with solutions for a wide range of problems. For example, vehicle barriers had to hold back traffic while allowing the emergency services unhindered access at all times. The concept ranged from emergency communication to pilot services, radio instructions, safety-related assessment of the scientific experiments, personnel management at the posts and on the site to dealing with suspicious luggage or other found objects. This complex set of rules was drawn up and implemented by the Risk Management team and successfully implemented on the day of the event. It incorporated the results of numerous discussions with the municipality, the police, Dübendorf Airport and other stakeholders.

Another focus in 2024 was safety tours of the entire campus and all research departments. These provided a comprehensive overview of the safety situation in the departments; no critical or serious deficiencies were found, minor deficiencies were identified and rectified immediately.

Further development of the security organization

Employee training is a key aspect of prevention – a challenge with more than 680 people joining and leaving the company and academic guests every year. Risk Management therefore offers a wide range of training courses for different user levels in the areas of chemical, nanotechnology and laser safety, etc.

The company rescue service and the fire and chemical team maintained their training regime in the past year. The level of training was further improved with selective further training. Internal, integral exercises provided important input for further improvements to processes. Following joint exercises with blue light organizations, further optimizations were implemented on both sides.

The topic of information and IT security became even more relevant in view of the general threat situation and the increase in cyber-attacks. A specialist team implemented an information security concept, various directives on information security and corresponding measures. In addition, a new emergency concept was implemented for various scenarios, from cyber-attacks to “normal” risks.

An audit by the Swiss Federal Audit Office (SFAO) and penetration tests by external experts focused on the security of the general operating infrastructure (OT) in 2024. Although no major risks were discovered, a number of selective improvement measures were defined. //

Human Resources Development

(previous year's figures in brackets)

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At the end of 2024, 1,097 (1,058) people, including trainees, were working at Empa. This corresponds to a full-time equivalent (FTE) of 1028.7 (994.5) positions, due to numerous part-time employments.

Scientific staff, including PhD and postdoctoral students, comprises 644 (610) individuals. Of these, 101 (99) are Senior Scientists. Technical and administrative staff comprised 410 (403) persons in the year under review. The proportion of women, at 32.4 (31.6) percent, reflects the gender distribution among graduates from Swiss universities and ETH in the scientific disciplines represented at Empa.

The proportion of foreign citizens was 546 (494), or 49.8 (46.7) percent of the total staff. The EU accounts for 321 (279) persons, or 58.5 (56.5) percent of all foreign employees.

Empa offers vocational training for a number of professions and currently employs 43 (45) apprentices. As in previous years, all Empa apprentices successfully passed their final exams in 2024. //

STAFF END OF 2024

	2023	2024
Scientific staff	**610**	**644**
Technical and administrative staff	**403**	**410**
Apprentices	45	43
Total	**1058**	**1097**

Key Figures

SCIENTIFIC OUTPUT

	2023	2024
ISI publications	**746**	**809**
Conference contributions	**1400**	**1478**
Doctoral studies completed	**49**	**41**
Doctoral studies in progress	**231**	**250**
Teaching activities (in hours)	**6732**	**6767**
Prizes and awards	**81**	**98**

MEDIA EXPOSURE

	2023	2024
Radio	105	143
TV	45	57
Print	1250	970
Online	7550	6380
Total	**8950**	**7550**
Languages	41	41

KNOWLEDGE DISSEMINATION & TECHNOLOGY TRANSFER

	2023	2024
New R&D agreements	**238**	**194**
Active exploitation contracts	**45**	**47**
New exploitation contracts	**12**	**5**
New patent applications	**10**	**17**

EMPA ACADEMY

	2023	2024
Empa events	**85**	**60**
Scientific conferences	29	18
Events for industry	17	13
Conferences for science and business	19	16
Events for the public	13	13
Participants	6408	4143
On site visits / online	5385 / 1023	3725 / 418
Open House (Dübendorf)	**—**	**7000**

SPIN-OFFS & START-UPS (Startfeld & glaTec)

	2023	2024
Companies total	**147**	**161**
thereof spin-offs	37	37
Employees total	**1188**	**1223**
thereof employees of spin-offs	221	216

CURRENT PROJECTS

	2023	2024
Swiss National Science Foundation (SNSF)	**100**	**112**
Innosuisse	**84**	**69**
EU projects	**90**	**92**

Bodies of Empa

ETH Board

The ETH Board has overall responsibility for the management of the ETH Domain, which incorporates the two Federal Institutes of Technology (ETHZ, EPFL) and the four federal research institutes (PSI, WSL, Eawag and Empa).

CHAIRMAN

Michael O. Hengartner Prof. Dr

VICE-CHAIRWOMAN

Pascale Bruderer Entrepreneur and independent board member

MEMBERS

Kristin Becker van Slooten Dr, EPF Lausanne
Marc Bürki Dipl. El.-Ing., Swissquote
Beatrice Fasana Dipl. Ing. Lm, Sandro Vanini SA
Anna Fontcuberta i Morra Prof. Dr, EPF Lausanne
Susan Gasser Prof. Dr, Dr. h.c.mult., Universität Basel
Joël Mesot Prof. Dr, ETH Zurich
Cornelia Ritz Bossicard Independent board member
Christian Rüegg Prof. Dr, Paul Scherrer Institut PSI

Industrial Advisory Board

A body of experienced personalities which advises the Empa management on fundamental concerns.

CHAIRMAN

Stefan Ramseier Dr, Consenec AG

MEMBERS

Burkhard Böckem Dr, Hexagon Geosystems Services AG
Christof Dutoit Straumann Group
Beat Flühmann Dr, Vifor Pharma Group
Markus Hofer Dr, Bühler AG
Katharina Lehmann Blumer-Lehmann AG
Samira Jafari Dr., Dätwyler AG
Chris Luebkeman Dr, ETH Zürich
Céline Mahieux Shell (Switzerland) AG

Research Commission

The Commission advises Empa's Board of Directors on questions of research, the choice of R&D spectrum and the evaluation of internal R&D projects.

CHAIRMAN

Andrea Bergamini Dr, Empa

MEMBERS

Georg Spescha Dr, Empa (Manager)
Rowena Crockett Dr, Empa
Urs T. Dürig Dr, SwissLitho AG
Thomas Egli Prof. em. Dr
Alexander Ehret Dr, Empa
Thomas Geiger Dr, Empa
Costanza Giampietro Dr, Empa
Dirk Hegemann Dr, Empa
Inge Katrin Herrmann Prof. Dr, Empa
Joachim Mohn Dr, Empa
Dorina Opris Prof. Dr, Empa
Daniele Passerone Prof. Dr, Empa
Patrik Soltic Dr, Empa
Bart van Damme Dr, Empa
Mateusz Wyrzykowsky Dr, Empa

Organizational Chart 2025

RESEARCH FOCUS AREAS (Research Priorities)

Nanoscale Materials and Manufacturing Technologies
Dr Lorenz Herrmann

Built Environment
Prof. Matthias Sulzer

Health
Prof. Dr René Rossi
Prof. Dr Katharina Maniura

Energy, Resources and Emissions
Dr Nathalie Casas

DIRECTORATE

Director
Prof. Dr Tanja Zimmermann

Deputy
Dr Urs Leemann

Members
Dr Nathalie Casas
Dr Lorenz Herrmann
Prof. Dr Manfred Heuberger
Dr Urs Leemann
Prof. Dr René Rossi

Research & Strategy Support
Dr Björn Niesen

RESEARCH, KNOWLEDGE AND TECHNOLOGY TRANSFER PLATTFORMS

NEST
Reto Largo

move
Dr Nathalie Casas

ehub
Philipp Heer

Coating Competence Center
Dr Lars Sommerhäuser

Empa Academy
Claudia Gonzalez

Business Incubators
glaTec
Mario Jenni
Startfeld / SIP Ost
Peter Frischknecht

International Research Cooperations
Prof. Dr Tanja Zimmermann

DEPARTMENTS

Advanced Materials and Surfaces
Dr Lorenz Herrmann

Engineering Sciences
Prof. Matthias Sulzer

Materials Meet Life
Prof. Dr René Rossi
Prof. Dr Manfred Heuberger

Energy, Mobility and Environment
Dr Nathalie Casas

Corporate Services
Dr Urs Leemann

LABORATORIES

High Performance Ceramics
Dr Johann Jakob Schwiedrzik

Joining Technologies and Corrosion
Dr Lars Jeurgens

Advanced Materials Processing
Prof. Dr Patrik Hoffmann

nanotech@surfaces
Prof. Dr Roman Fasel

Mechanics of Materials and Nanostructures
Prof. Dr Johann Michler

Thin Films and Photovoltaics
Dr Yaroslav Romanyuk

Surface Science and Coating Technologies
Dr Lars Sommerhäuser a.i.

Functional Polymers
Prof. Dr Frank Nüesch

Structural Engineering
Prof. Dr Masoud Motavalli

Mechanical Systems Engineering
Prof. Dr Giovanni Terrasi

Computational Engineering
Dr Ivan Fabrizio Lunati

Experimental Continuum Mechanics
Prof. Dr Edoardo Mazza

Concrete and Asphalt
Prof. Dr Pietro Lura

Urban Energy Systems
Dr Georgios Mavromatidis

Sustainability Robotics
Prof. Dr Mirko Kovac

Magnetic and Functional Thin Films
Prof. Dr Hans Josef Hug

Cellulose & Wood Materials
Dr Gustav Nyström

Biomimetic Membranes and Textiles
Prof. Dr René Rossi

Advanced Fibers
Prof. Dr Manfred Heuberger

Nanomaterials in Health
Prof. Dr Peter Wick

Biointerfaces
Prof. Dr Katharina Maniura

Transport at Nanoscale Interfaces
Prof. Dr Michel Calame

Building Energy Materials and Components
Dr Wim J. Malfait

Materials for Energy Conversion
Prof. Dr Corsin Battaglia

Advanced Analytical Technologies
PD Dr Davide Bleiner

Nano Particles
Prof. Dr Jing Wang

Air Pollution / Environmental Technology
Dr Lukas Emmenegger

Chemical Energy Carriers and Vehicle Systems
Christian Bach

Materials for Renewable Energy
Prof. Dr Andreas Züttel (Antenne Sion)

Technology and Society
Dr Patrick Wäger

Acoustics / Noise Control
Dr Jean Marc Wunderli

ICT-Services
Fabio Consani

Mechanical Engineering / Workshop
Stefan Hösli

Finances / Controlling / Purchasing
Susann Hug

Communikation
Dr Michael Hagmann

Human Resources
André Schmid

Knowledge and Technology Transfer / Legal
Marlen Müller

Real Estate Services
Kevin Olas

CENTERS

Electron Microscopy Center
Prof. Dr Rolf Erni

Center for X-ray Analytics
Prof. Dr Antonia Neels

Analytics Center
Markus Zennegg a.i.

Library (Lib4RI)
Dr Lothar Nunnenmacher

Entrepreneurship / Industry Relations
Gabriele Dobenecker

Fundraising
Dr Martin Gubser

Scientific IT
Prof. Dr Eleni Pratsini

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A complete overview of the vested interests can be found at: *https://www.empa.ch/web/empa/vested-interests*

Empa – The Place where Innovation Starts

Empa
Materials Science and Technology

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