Empa Quarterly

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FOCUS

With fresh ideas out of the crisis

ALLOYS MADE TO MEASURE
SMART TEXTILES
LONG-LASTING FRUIT THANKS TO PLATINUM

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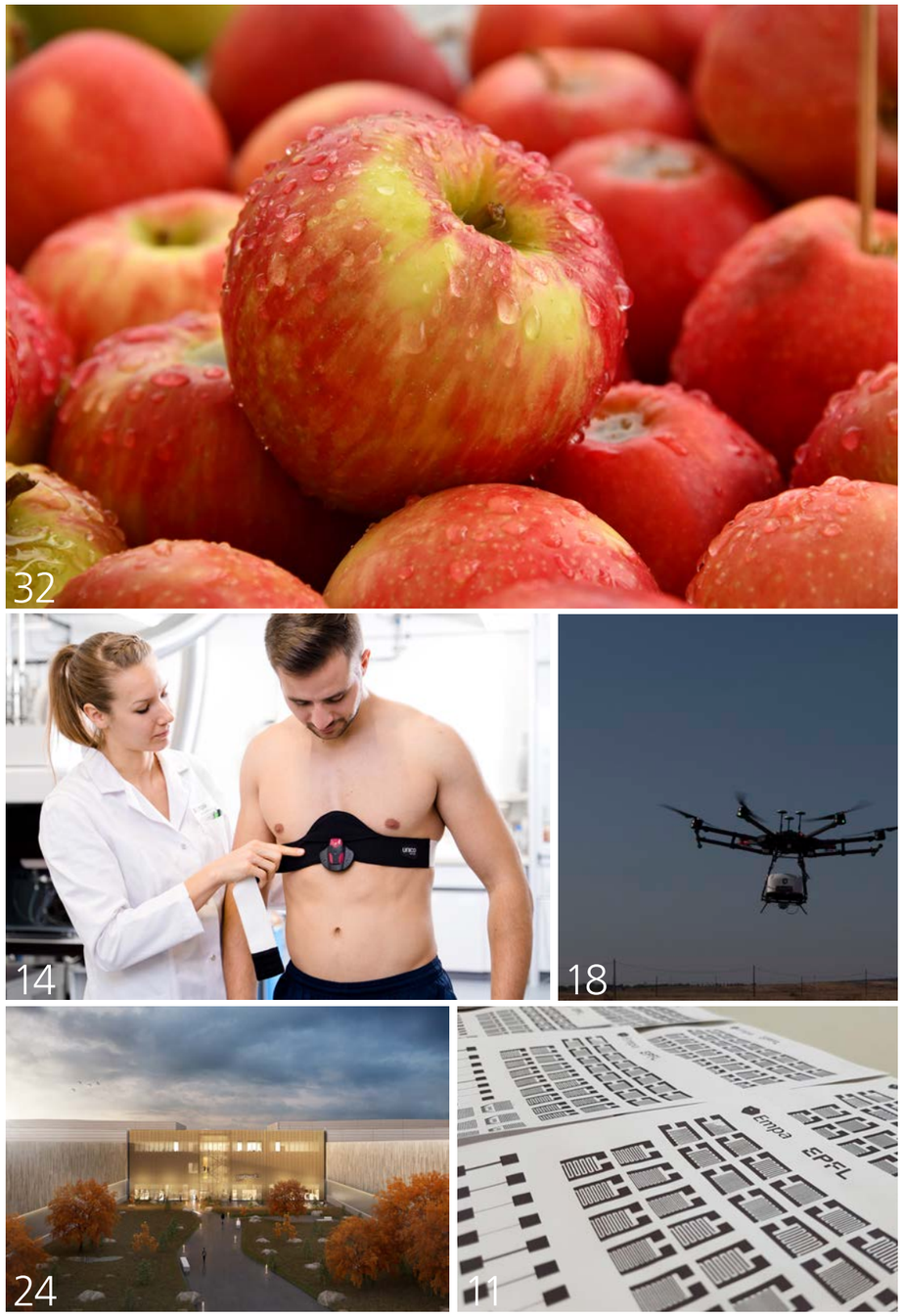
[FOCUS: WITH FRESH IDEAS OUT OF THE CRISIS]



Photos: Unsplash, iStock, Empa

[COVER]

Fresh ideas with innovative power are an important trump card for giving the Swiss economy a new boost.
Image: istock

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NORMAL WAS YESTERDAY

Dear readers

You can't hear the words "Home Office", "Corona Crisis" and "Social Distancing" anymore? Same as us. And yet I can't help but mention this topic at least briefly. For example, this issue was created in "remote control" mode, so to speak. And since we had planned an open house at the beginning of May – which of course fell through – we immediately redesigned the current issue of EmpaQuaterly.

In it we look ahead. And we do so with optimism. For even after these turbulent times, one of Switzerland's trump cards is still likely to hold its own – our innovative strength. We need to keep this up so that we as an economy suffer as little damage as possible. On the following pages you will find some ideas from our laboratories that illustrate how we can achieve this.

What we could also do with in the future would be to continue to listen to scientists when assessing a wide range of issues – from the energy revolution we are striving for to better management of urgently needed goods such as protective clothing. For despite all the inconsistencies in the forecasts about the course of the epidemic, I personally prefer a policy that is as fact-based as possible to the erratic behaviour of political steamrollers – who (especially abroad) are only concerned with securing or gaining power. So may researchers accompany us at press conferences and in the spotlight for as long as possible!

Your MICHAEL HAGMANN

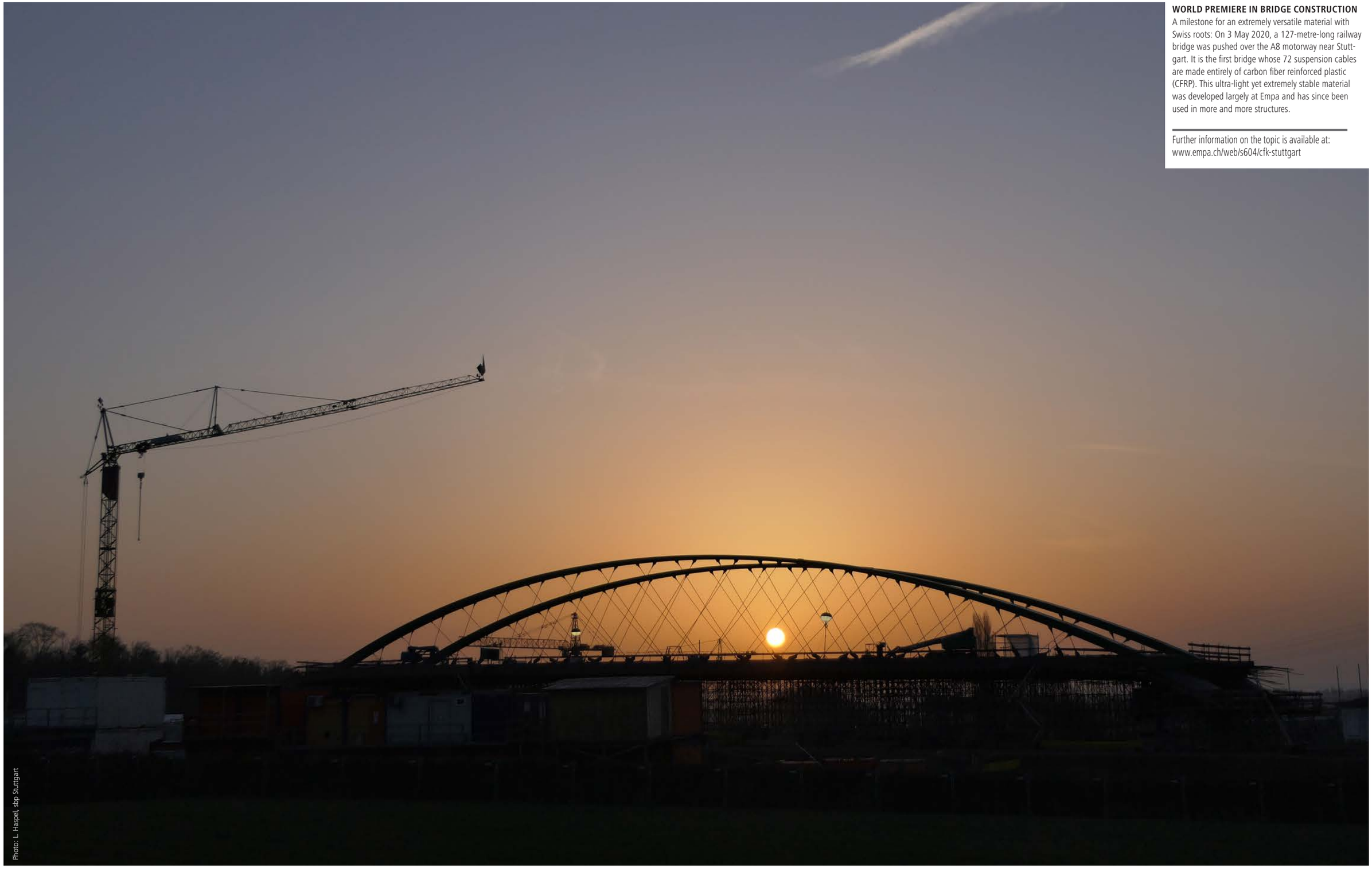


Photo: L. Haspel, sbp Stuttgart

WORLD PREMIERE IN BRIDGE CONSTRUCTION
A milestone for an extremely versatile material with Swiss roots: On 3 May 2020, a 127-metre-long railway bridge was pushed over the A8 motorway near Stuttgart. It is the first bridge whose 72 suspension cables are made entirely of carbon fiber reinforced plastic (CFRP). This ultra-light yet extremely stable material was developed largely at Empa and has since been used in more and more structures.

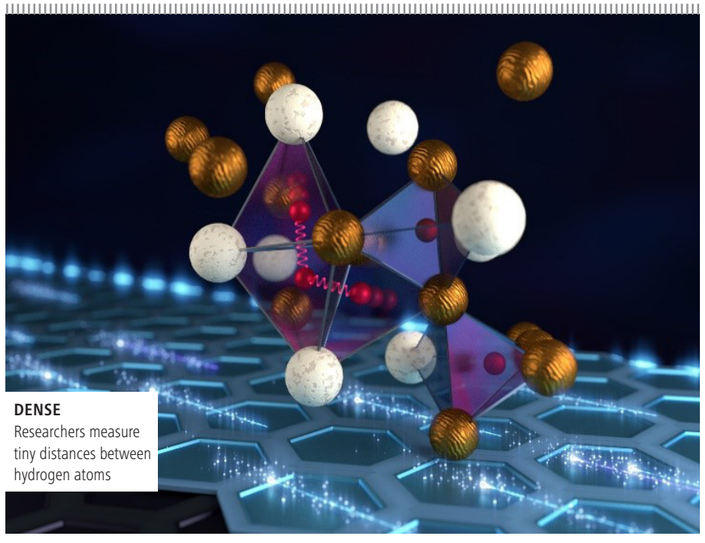
Further information on the topic is available at:
www.empa.ch/web/s604/cfk-stuttgart

"REMASK": JOINING FORCES AGAINST THE MASK EMERGENCY

REUSE
With suitable disinfection methods, the lifespan of face masks can be increased

During the Corona crisis, protective masks have become a rare commodity. In order to equip Switzerland with efficient protective material in future pandemic times, Empa researchers are working on the "ReMask" project together with a national consortium of research, health care and industry: new mask types and technologies for the reuse of existing protective material are being developed – for now, but also for future pandemics. In addition, information on the manufacture of masks and textile protective systems and information on standardised test methods have already been made publicly available.

https://masken.empa.ch



DENSE
Researchers measure tiny distances between hydrogen atoms

SUPERCONDUCTIVITY AT ROOM TEMPERATURE?

A research team from Switzerland, the USA and Poland has demonstrated a uniquely high density of hydrogen atoms in a metal hydride. The smaller distances between the atoms could allow significantly more hydrogen to be packed into the material – up to a point where it could become a superconductor at room temperature and normal pressure.

www.empa.ch/web/s604/hydrogen_density

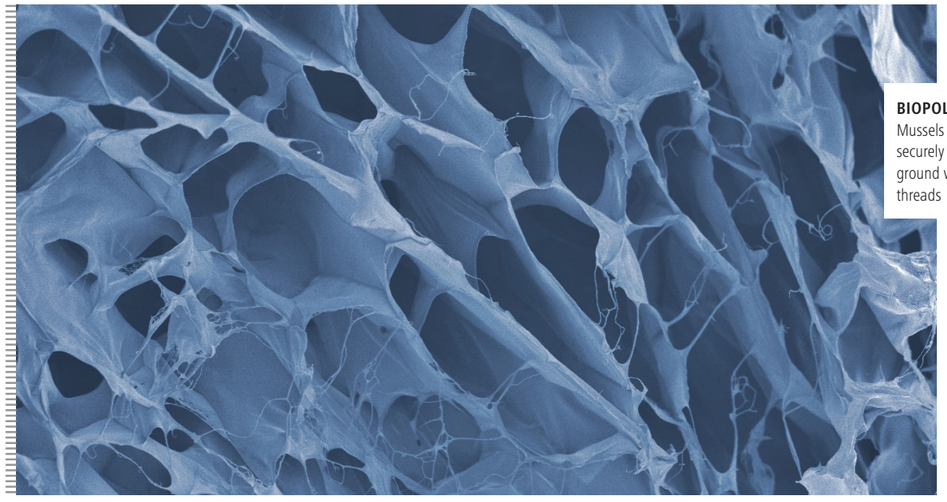
Photos: Jill Hemman / Oak Ridge National Laboratory, US Dept of Energy; iStock

A BIOSENSOR FOR THE COVID-19 VIRUS

A team of researchers from Empa, ETH Zurich and Zurich University Hospital has succeeded in developing a novel sensor for detecting the new coronavirus. In future it could be used to determine the concentration of the virus in the environment – for example in places where there are many people or in hospital ventilation systems.

www.empa.ch/web/s604/coronatest

DETECTING VIRUSES
A new sensor could in future detect the concentration of viruses in the air



BIOPOLYMER
Mussels cling securely to the ground with protein threads

SEA MUSSEL GLUE FOR HEART MUSCLES

If the heart muscle is damaged, repairing the constantly active organ is a challenge. Empa researchers are therefore developing a tissue adhesive inspired by nature which can perfectly reattach defects in muscle tissue. They have taken advantage of the phenomenal adhesive power of sea mussels.

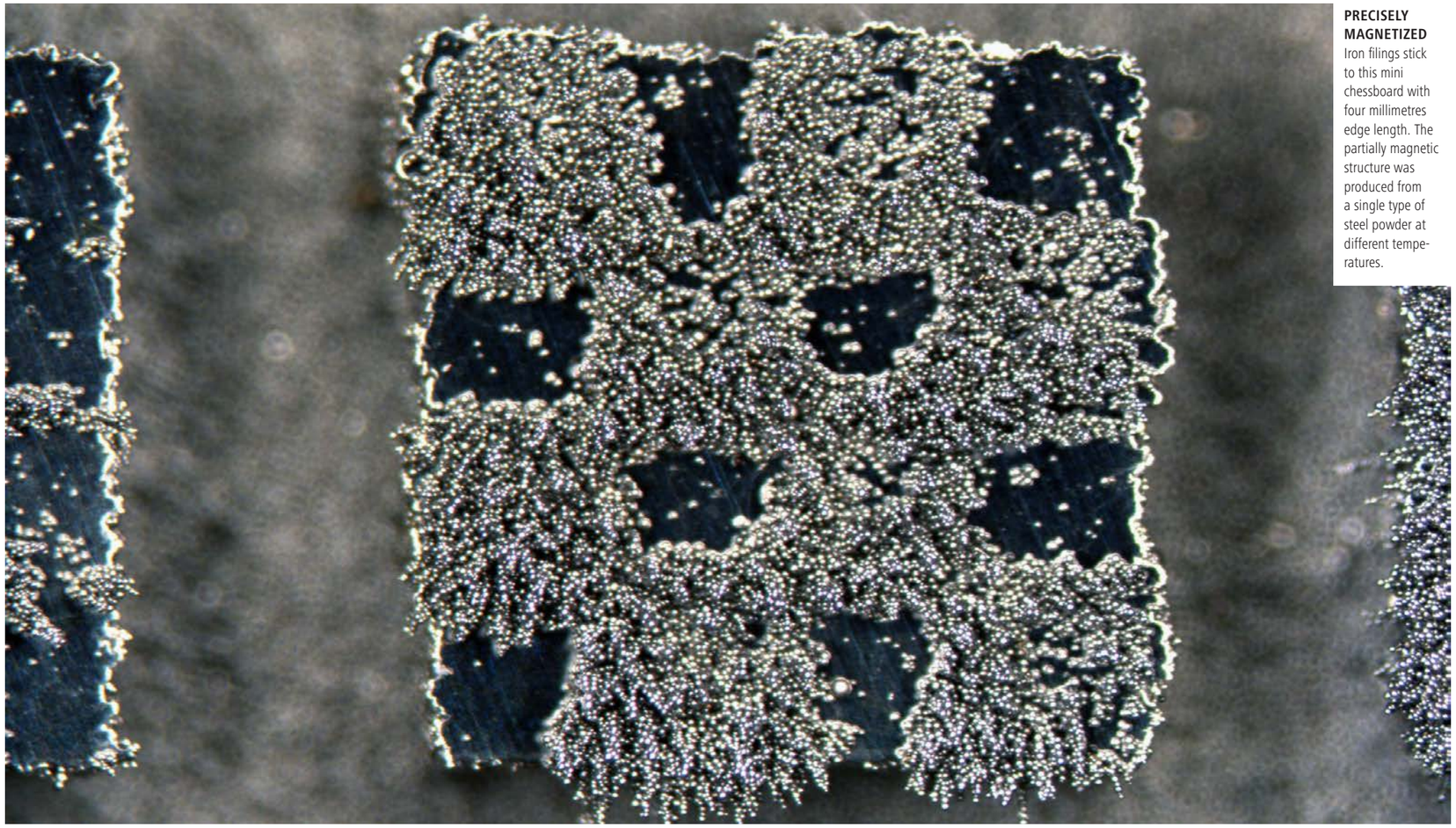
www.empa.ch/web/s604/gewebekleber

Photos: Tomek Baginski, Unsplash; Empa

HOT OFF THE OVEN

During metal processing in the 3D laser printer, temperatures of more than 2'500 degrees Celsius are reached within milliseconds, causing some components of the alloys to evaporate. While widely considered a problem inherent to the process, Empa researchers spotted an opportunity – and are now using the effect to create new alloys with novel properties and embed them in 3D-printed metallic work pieces with micrometer precision.

Text: Rainer Klose



PRECISELY MAGNETIZED Iron filings stick to this mini chessboard with four millimetres edge length. The partially magnetic structure was produced from a single type of steel powder at different temperatures.

Photo: Empa

It looks quite inconspicuous to the casual beholder, hardly like groundbreaking innovation: a small metallic chessboard, four millimeters long on either side. At first glance, it shines like polished steel; at second glance, minute differences in color are visible: The tiny chessboard has 16 squares, eight appear slightly darker, the other eight a bit lighter.

The unassuming material sample goes to show that 3D printing with the help of laser beams and metal powder is not only suitable for creating new geometric shapes, but also for producing new materials with completely new functionalities. The small chessboard is a particularly obvious example: Eight squares are magnetic, eight non-magnetic – the entire piece has been 3D-printed from a single grade of metal powder. Only the power and duration of the laser beam varied.

As a starting point, an Empa team led by Aryan Arabi-Hashemi and Christian Leinenbach used a special type of stainless steel, which was developed some 20 years ago by the company Hempel Special Metals in Dübendorf, among others. The so-called P2000 steel does not contain nickel, but around one percent of nitrogen. P2000-steel does not cause allergies and is well suited for medical applications. It is particularly hard, which makes conventional milling more difficult. Unfortunately, at first glance it also seems unsuitable as a base material for 3D laser printing: In the melting zone of the laser beam, the temperature quickly peaks. This is why a large part of the nitrogen within the metal normally evaporates, and the P2000 steel changes its properties.

TURNING A PROBLEM INTO AN ADVANTAGE

Arabi-Hashemi and Leinenbach managed to turn this drawback into an advantage. They modified the scanning speed of the laser and the intensity of the laser beam, which melts the particles in the metal powder bed, and thus varied the size and lifetime of the liquid melt pool in a specified manner. In the smallest case, the pool was 200 microns in diameter and 50 microns deep, in the largest case 350 microns wide and 200 microns deep. The larger melt pool allows much more nitrogen to evaporate from the alloy; the solidifying steel crystallizes with a high proportion of magnetizable ferrite. In the case of the smallest melt pool, the melted steel solidifies much faster. The nitrogen remains in the alloy; the steel crystallizes mainly in the form of non-magnetic austenite.

During the experiment, the researchers had to determine the nitrogen content in tiny, millimeter-sized metal samples very precisely and measure the local magnetization to within a few micrometers, as well as the volume ratio of austenitic and ferritic steel. A number of highly developed analytical methods available at Empa were used for this purpose.

SHAPE MEMORY ALLOYS BECOME SMART

The experiment, which seems like a mere gimmick, could soon add a crucial tool to the methodology of metal production and processing. "In 3D laser printing, we can easily reach temperatures of more than 2500 degrees Celsius locally," says Leinenbach. "This allows us to vaporize various components of an alloy in a targeted manner – e.g. manganese, aluminum, zinc, carbon and many more – and thus locally change the chemical composition of the alloy." The method is not limited to stainless steels, but can also be useful for many other alloys.

Leinenbach thinks about, for instance, certain nickel-titanium alloys known as shape memory alloys. At what temperature the alloy "remembers" its programmed shape depends on just 0.1 percent more or less nickel in the mixture. Using a 3D laser printer, structural components could be manufactured that react locally and in a staggered manner to different temperatures.

FINE STRUCTURES FOR THE ELECTRIC MOTOR OF THE FUTURE

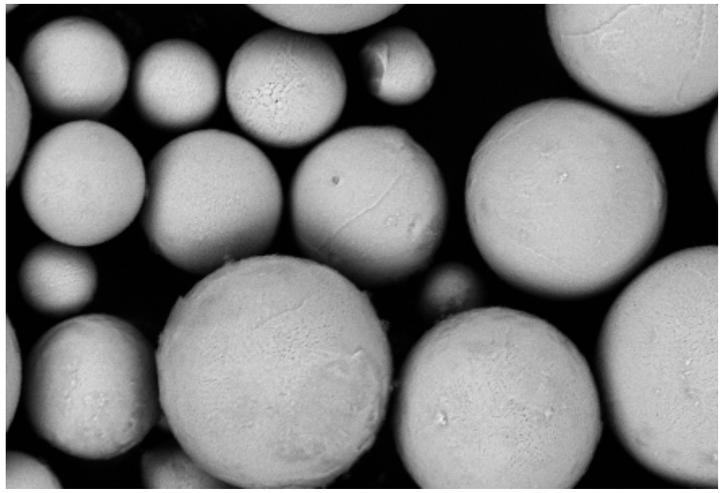
The ability to produce different alloy compositions with micrometer precision in a single component could also be ▶

"In 3D printing, we can easily reach temperatures in excess of 2.500 degrees Celsius."

helpful in the design of more efficient electric motors. For the first time, it is now possible to build the stator and the rotor of the electric motor from magnetically finely structured materials and thus make better use of the geometry of the magnetic fields.

The crucial factor in the discovery of the relationship between laser power, the size of the melt pool and the material's properties was the expertise in the field of Additive Manufacturing, which has been built up at Empa over the last nine years. Ever since then, Christian Leinenbach and his team, as one of the world's leading research groups in the field, have devoted themselves to materials science issues related to 3D laser printing processes. At the same time, Empa researchers have gained experience in process monitoring, especially in measuring the melt pools, whose size and lifetime are crucial for the targeted modification of alloys. ■

Further information on the topic is available at: www.empa.ch/web/s204



SPHERICAL POWDER
Photograph of the P2000 steel powder under the electron microscope. Due to the special spherical shape, the powder flows particularly well. (top)

3D LASER PRINTER
Ariyan Arabi-Hashemi and Christian Leinenbach use a 3D laser printer to fine-tune stainless steel alloys.

Photos: Empa

THE TRANSISTOR OUT OF THE PRINTER

A new revolution in the production of electronic circuits is on the way: Empa researchers are working on electronics that come out of printers. This makes it possible to produce the circuits on all sorts of substrates, such as paper or plastic film – but there are still some hurdles to overcome.

Text: Karin Weinmann

Imagine being able to easily print electronics on any surface. Today, this is no longer a utopia: "Printed Electronics" is an emerging technology that makes it possible to apply circuits to various substrates – using ink and special printers. This is by no means a small market: A new report by the industry association for organic and printed electronics shows that the sector has already developed into a global market worth more than 35 billion US dollars – a market that is expected to continue growing strongly in the coming years.

Traditionally, the manufacturing of electronics has been a complex process that requires expensive equipment. However, the Internet of Things requires a new type of electronics: The circuits no longer have to be as tiny and fast as possible at all costs, but cheap and easy to manufacture – and at the same time they should be realizable on thin and flexible substrates. This includes RFIDs on product packaging, for example. In the future, applications are also conceivable for simple sensors on milk cartons, which indicate when the contents are no longer consumable, or on frozen products, which signal whether the cold chain has been interrupted.

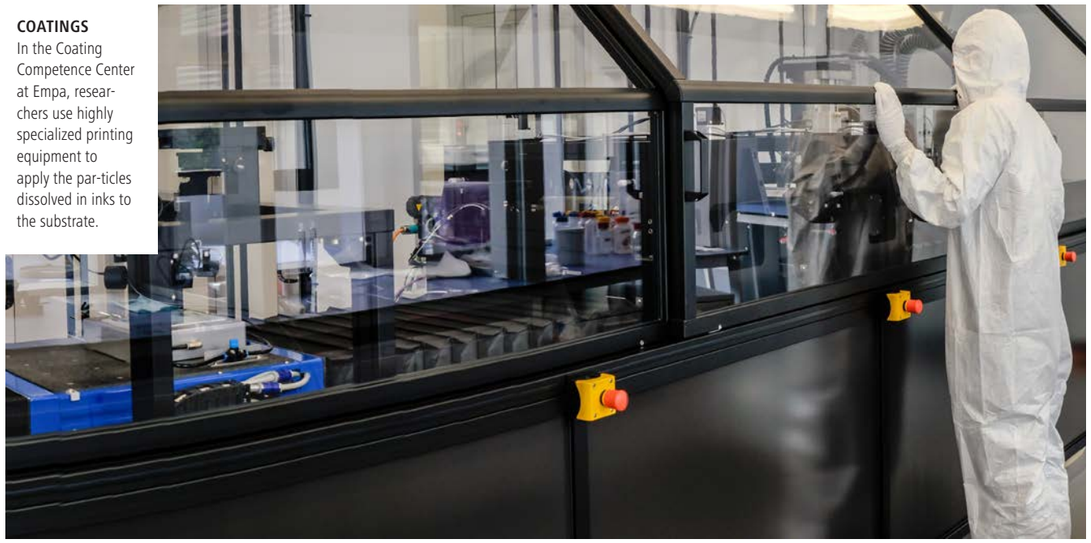
TRANSISTORS ON PAPER AND FILM

Empa researchers Jakob Heier from the Laboratory for Functional Polymers and Yaroslav Romanyuk from the Laboratory for Thin Films and Photovoltaics are working with their teams to advance the technology. Together with researchers from the Paul Scherrer Institute and EPFL Lausanne, they are working on the "FOXIP" research project, short for "Functional OXIdes Printed on Polymers and Paper". The aim of the project is to print thin-film transistors on paper and PET films – using a printing technique that could be suitable for use in industry. Inks in which tiny particles of metal oxides are dissolved are used for this. These are applied to the substrate using various printing techniques – contact ▶

A COMPETENCE CENTER FOR COATINGS

Closing the gap between laboratory research and industrial production for coatings – that is the goal of the Coating Competence Center (CCC) at Empa. Research at the CCC not only focuses on printed electronics, but also on materials, processes and technologies for coatings: These include methods for depositing thin layers on substrates, or additive fabrication, in which components are built up layer by layer. The CCC is structured as a privatepublic partnership: the idea is that all partners along the value chain from science to industry work together to develop new technologies and find creative solutions. The centre is open for collaborations for partners from industry and research.

www.empa.ch/web/coating-competence-center



COATINGS
In the Coating Competence Center at Empa, researchers use highly specialized printing equipment to apply the par-ticles dissolved in inks to the substrate.

printing or an inkjet printer. "Of course, we don't use ordinary office printers for this, but highly specialized equipment," explains Romanyuk. At Empa's Coating Competence Center these printing devices can be found. (see box)

But to be able to reliably print circuits on flexible substrates, a number of challenges must first be solved: From the optimization of the substrate itself, to the composition of the ink and the accuracy of the printing technology, to the thermal curing of the layers without damaging the paper or film.

Starting with the printing substrate: Often this is flexible – for example, paper or a polymer film – and does not have a completely smooth surface, as is the case with silicon wafers, which are used for the manufacture of conventional electronic components. This makes it much more difficult to achieve the necessary precision in the manufacture of the circuits. As a result, the components of printed electronics are currently about a factor of 1000 larger than microelectronics produced by the conventional manufacturing process. "But that doesn't mean that the circuits are huge: We're talking about printing with accuracies in the range of ten micrometers, which is less than the diameter of a hair," Heier explains.

MATERIALS IN INK FORM

Another major challenge is how conductive, semi-conductive and insulating materials, which are necessary for the construction of circuits, can be brought into ink form – and how they can be turned into a continuous material with the desired properties after the printing process.

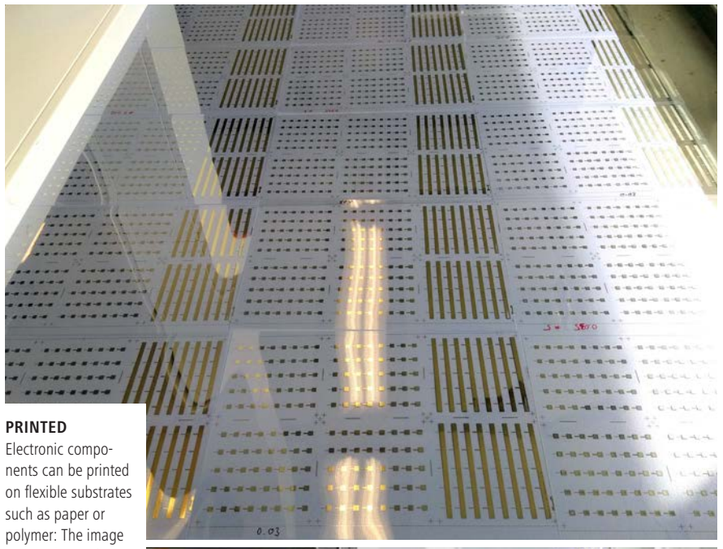
Jakob Heier is researching how these special inks are constructed. An ink includes two parts: small particles of the functional material and solvents that evaporate on their own after application. However, these two components are often not sufficient: Additional binders and additives must be added to make the ink stable and printable. But these are a problem: if they remain in the layer after application, they disturb the desired function of the circuits. They must therefore be burnt out. However, this requires relatively high temperatures – and this in turn can damage the paper or film on which the electronics are printed.

Heier and his team are working on developing a printable ink for graphene layers that only requires the graphene particles and the solvent – in other words, no additives that have to be burnt out. The printed layers should be stable enough to retain the same conductive properties – regardless of whether the substrate material including the printed layer is bent or even twisted. "If this is successful, we will be a big step closer to printing on polymer or paper: at least the printing of conductive tracks will then no longer require post-treatment at elevated temperatures," Heier explains

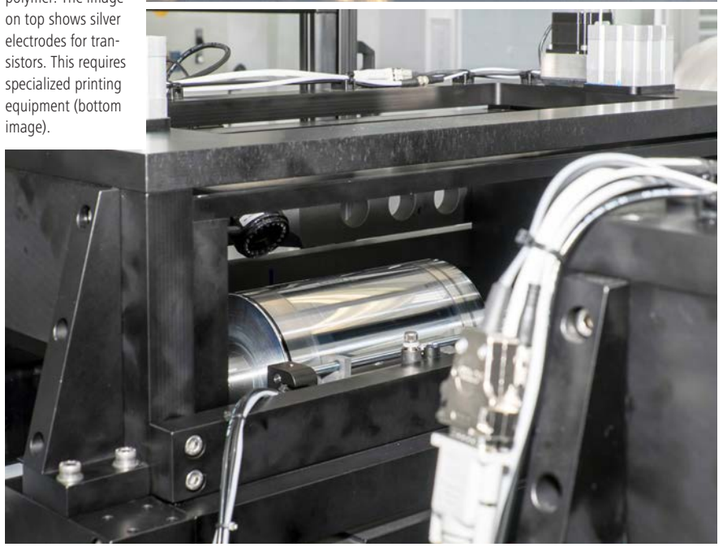
WITH FLASHES FROM THE INK TO THE TRANSISTOR

The situation is different with inks based on metal oxide nanoparticles. Here, the so-called sintering, i.e. the thermal treatment of the printed layers, is necessary in order to recombine the individual particles dissolved in the ink and thus obtain a functional layer.

Photos: Empa



PRINTED
Electronic components can be printed on flexible substrates such as paper or polymer: The image on top shows silver electrodes for transistors. This requires specialized printing equipment (bottom image).



However, both paper and the films used are very sensitive to temperature. Ideally, therefore, only the metal oxide layers should be heated – but the substrate should remain cool. "We use a method called ´flash sintering'," explains Romanyuk. The printed layer is heated with ultra-short flashes, so fast that the substrate material is not heated.

Materials based on metal oxides are a promising material class for printed electronics: they can be conductive, semiconductive or insulating. Compared to inks based on organic materials, oxide materials have a higher electron mobility, which means they have the potential to increase the performance of printed electronic circuit elements. At the same time, the oxide materials are more stable when exposed to air. "Especially exciting is indium tin oxide: It is both highly conductive and transparent at the same time," Romanyuk explains.

His team recently succeeded in printing oxide-based field-effect transistors using an inkjet printer, which could make it possible to create transparent circuits on a transparent substrate in the future.

Thanks to the possibilities offered by the Coating Competence Center (CCC) at Empa, the results of the two research groups are not limited to the laboratory. "The printing technologies developed are based on equipment with which industry is already working," explains Romanyuk. This enables a rapid transition from scientific breakthroughs to the industrial production of new printed electronics. ■

Further information on the topic is available at:
www.empa.ch/web/s209 and www.empa.ch/web/s207

WEARABLE HEALTH

There is more than cool looks about hip clothing for top performance: Thanks to a variety of smart technologies, high-tech clothing today is capable of analyzing body functions or actively optimizing the microclimate. The basis of these novel textiles are "smart" fibers and biocompatible composites that also contribute to innovations in biomedical research such as sensors, drug delivery systems or tissue engineering.

Text: Andrea Six

Sport in winter has its pitfalls. Outside it is freezing cold, and insulating clothing is a must. However, if you move around a lot, your body's own "AC" kicks in: The skin releases liters of cooling sweat. To ensure that we don't freeze in our wet clothes during our well-earned breaks, Empa researchers, in collaboration with industrial partners, have developed an electro-osmotic membrane, which keeps clothing (and the athlete) dry and thus warm. The Swiss high-end sportswear company KJUS has integrated the technology into a ski jacket that can be operated by a smartphone. In experiments in Empa's climate chamber, the researchers also confirmed the functionality and wearing comfort of the jacket with a "pump effect".

AVATAR WITH SUIT AND TIE

Whether jackets and pants are comfortable to wear and release body heat effectively is now predictable thanks to virtual modeling. Empa scientist Agnes Psikuta and her team from the "Biomimetic Membranes and Textiles" lab in St. Gallen have developed software that takes into account fabric characteristics, the body physique and insulating air cushions between skin and clothing. "Using an anatomically customizable avatar, it is possible to simulate how an item of clothing fits perfectly on the body and what thermal effects it has, even when the person is moving," explains Psikuta. Thus, a design for a suit can be optimized on the avatar before it is sewn from actual fabric.

> "To ensure the dosage of these active ingredients is precise, the researchers have devised a tricky control mechanism."

But there are also suits whose wearers have to protect themselves from extreme external conditions: The protective clothing of firefighters must be thermally insulating, fire- and waterproof as well as breathable, but at the same time neither too heavy nor inflexible. Insulating air cushions are, therefore, crucial. Such protective clothing can be optimized in the lab by means of anatomical manikins. "In near-reality experiments, we can find out how the insulation in a protective suit changes depending on whether the wearer is aiming the fire hose at the fire while kneeling or crawling on his knees through a burning building," says Psikuta

FOOT SENSORS FOR ATHLETES

Movement is also the focus of a "garment" designed based on wood: Within the D-Sense project, a flexible joint sensor made of nanocellulose is being developed. The 3D-printed sensor based on renewable resources is biocompatible and lies directly on the skin. It is electrically conductive because the nanocellulose "ink" is combined with silver nanowires during the 3D printing process. When worn as an insole, for example, in the sneaker of a professional athlete, the sensor measures, among other things, load, pressure and the effect of force, so that the movement of the joints ▶

WEATHERPROOF
In spite of minus temperatures, skiing and snowboarding can easily make you sweat. High-tech clothing can help here.

Photo: Mauro Paillex / Unsplash

can be precisely analyzed. "Because of its mechanical properties, nanocellulose is particularly well suited for creating new composite materials," says Gustav Nyström, head of Empa's "Cellulose & Wood Materials" lab in Dübendorf. The multilayer sensor is, therefore, one of the projects within the ETH Domain's Strategic Focus Area "Advanced Manufacturing". The application of such a joint sensor could also be used in future in patients with joint implants in order to accompany the optimal healing process.

DATA ANALYSIS WHILE SLEEPING

AuOther high-tech garments are also ideal for use in state-of-the-art medicine. For instance, even when we are seemingly immobile, say, when we sleep, numerous muscles are active: The heart beats ceaselessly, and the chest rises and falls. But how does the heart beat during sleep? And does our breathing pause, or does it flow calmly and steadily through the night? Empa researchers have developed a cardio belt, which, thanks to embroidered electrodes, can register heart activity throughout the night. Using the Empa plasma coating facility, nanometer-thin metallic layers were applied to the threads, making them conductive, skin-friendly and washable. The flexible measuring device is used, for example, for people who suffer from respiratory arrest during sleep, so-called sleep apnea.

Further clinical applications of the sensor belt are currently being developed with partners from industry and the medical sector. For example, the ECG belt – complemented by sensor technology for measuring body temperature – is intended to support the diagnosis of dementia such as Alzheimer's, since the long-term measurement of vital parameters can provide information on cognitive performance.

Together with researchers from the Université de Haute-Alsace in Mulhouse, Empa researchers are also working on equipping textiles with additional sensors. In this way, the range of applications in medicine and sports and the wear comfort can be extended even further. "We will equip a piece of clothing, such as a T-shirt, with sensors for the analysis of various health parameters," says Simon Annaheim. The core element for the measurement of other parameters such as respiratory rate or oxygen saturation are optical polymer fibers produced by melt spinning.

CAMOUFLAGE FOR ARTIFICIAL HEART PUMPS

Since the micro-design of textile fibers can be precisely controlled by various spinning processes, Empa researchers are also developing membranes that resemble biological tissues. For example, polymer membranes made of highly elastic core-sheath fibers are colonized with human cells so that a multi-layered, functional tissue can grow. This research is part of the "Zurich Heart" project, on which Empa is working together with the University of Zurich, ETH Zurich and Zurich University Hospital. The "living" membranes are intended to line the inner surface of artificial heart pumps as "camouflage", so that the body can better tolerate the device and malfunctions can be avoided.

BACTERIA DETECTIVES

Polymer fibers can also be processed into sensors to detect volatile substances in our breath. Luciano Boesel's team uses electrospinning technology to produce multilayered polymer membranes that are designed to "sniff out" certain gases in human breath. "Volatile amines are formed during bacterial infections such as pneumonia or chronic kidney disease," says Boesel. His team is now developing a highly sensitive amine sensor that will detect traces of different amines in the breath in order to diagnose diseases as early and non-invasively as possible.

MEDICATION TO WEAR

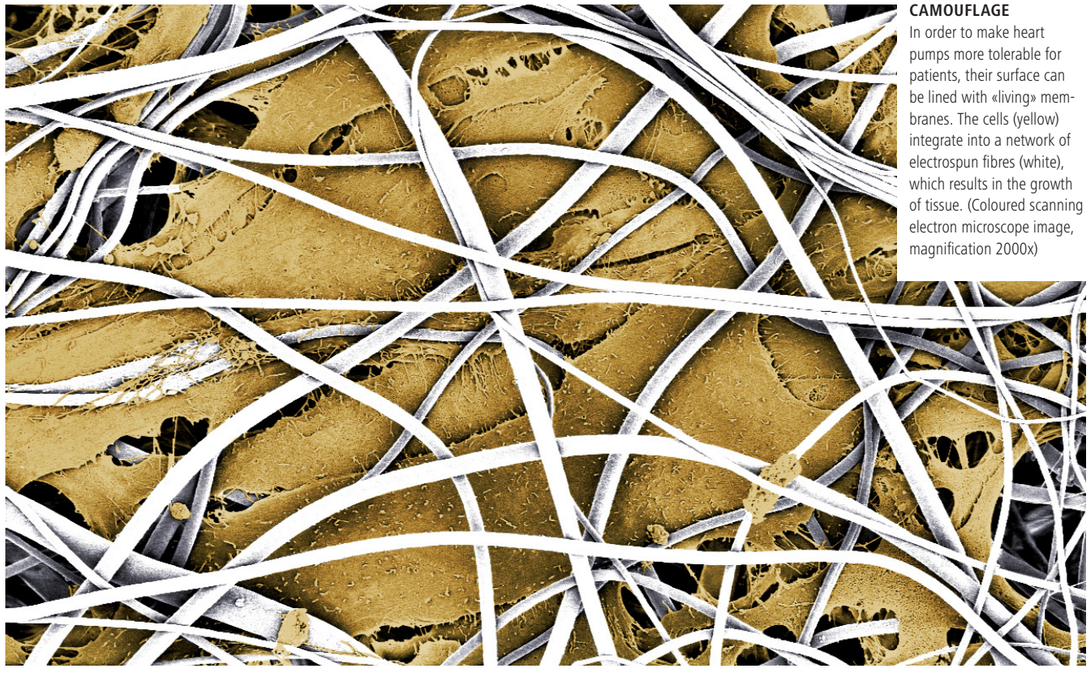
Textile fibers can also be used in the form of "intelligent" wound dressings to indicate a disturbed healing process in complex wounds at an early stage. Moreover, they can release substances such as antibiotics, painkillers or natural remedies. To ensure the dosage of these active ingredients is precise, the researchers have devised a tricky control mechanism: A slight pressure on the wound dressing or a light signal controls the release of the medication. Chemical stimuli from the patient, such as the altered pH value of a wound, can also trigger drug delivery.

NANOBAGS FOR ACTIVE INGREDIENTS

Amin Sadeghpour is exploring the micro- and nanostructure of our clothing even more deeply. He is constructing tiny nanocubes that resemble a cell membrane. With a side length of around 10 nanometers, the cubes hold only the tiniest amounts of active ingredients. However, thanks to their construction from small tubes, it is possible to package different substances together that would normally not be mixable. This is ideal for combining several drugs or vitamins. The biocompatible cubes are grouped together in "nanobags", so-called cubosomes. In the electrospinning process, they can be attached to fibers with which wound dressings or "caring textiles" can be produced.

These nanoelements, biocompatible materials and smart fibers will in future be used to produce garments that not only perfectly fit our avatars, but also lead to top performance in sports and medical practice. ■

Further information on the topic is available at:
www.empa.ch/web/s401 and www.empa.ch/web/s302



CAMOUFLAGE
In order to make heart pumps more tolerable for patients, their surface can be lined with «living» membranes. The cells (yellow) integrate into a network of electrospun fibres (white), which results in the growth of tissue. (Coloured scanning electron microscope image, magnification 2000x)

Photo: Empa

LONG-TERM MEASUREMENT
With the cardio belt made of cuddly tissue and embroidered electrodes, physiologically important parameters can be measured comfortably over a longer period of time.

Photo: Robert Stürmer

CAUGHT IN FLIGHT

Humans are exposed to numerous harmful environmental influences, and it is an international concern to quantify these emissions as accurately as possible in order to be able to take measures to contain them. Empa is also part of these efforts and has, among other things, developed a drone equipped with state-of-the-art measuring instruments which can detect methane leaks. It is also assisting the European Space Agency ESA in the development of new satellites capable of detecting CO_2 sources from space.

Text: Cornelia Zogg

OVERVIEW
The light drone with the mounted quantum cascade laser can measure methane emissions from oil and gas fields on the move.

Photo: Empa

Methane (CH_4) is one of the main causes of global warming, but the contribution of the individual methane sources is still not exactly known. Such quantification would be urgently needed, however, if measures are to be taken to achieve the United Nations (UN) climate targets. Within the Horizon2020 project MEMO2 ("Methane goes Mobile, Measurements and Modelling"), 20 research groups from seven countries are focusing on identifying methane sources and quantifying their emissions using mobile analytical equipment – including Empa.

The MEMO2 researchers have placed a special focus on Romania. With its numerous oil and gas fields, the country is one of the main sources of European methane emissions. Methane escapes to the surface via the drilling shafts of these fields and partly escapes into the atmosphere. Until now, very accurate methane measurements could only be carried out with stationary measuring instruments. Although these are sometimes installed in vehicles, they can then only be used precisely along the road – a costly and unsatisfactory undertaking.

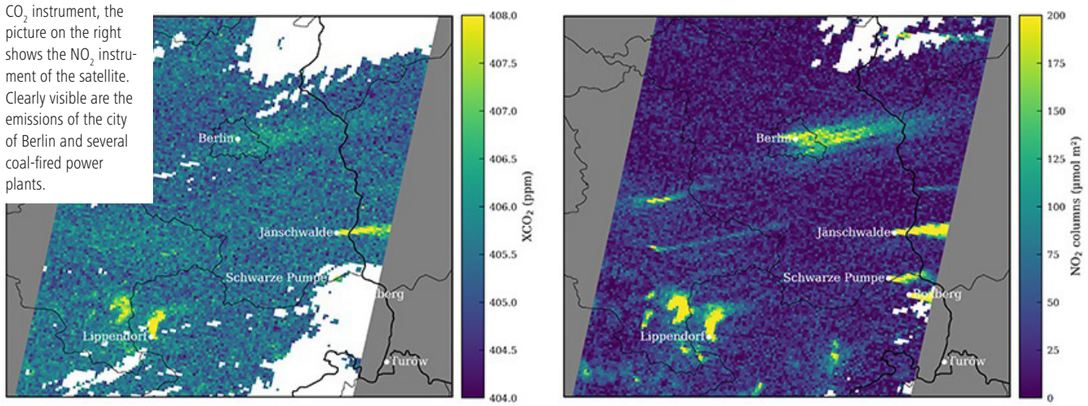
However, Empa researchers have now succeeded in developing a precise and lightweight measuring instrument which can be mounted on a drone to measure CH_4 concentrations and thus determine emissions. "The new spectrometer is a breakthrough in the analysis of trace gases in terms of measurement accuracy, size and weight", explains Lukas Emmenegger, head of Empa's Air Pollution/Environmental Technology lab.

To quantify the methane, Emmenegger and his team use a quantum cascade laser (QCL). The spectrometer mounted on the drone can be used to determine the three-dimensional distribution of methane in the vicinity of a source. Combining this data with wind measurements enables the researchers to calculate the emission of a source. The drone also has the advantage that it allows measurements to be made in places that are difficult to access from the ground. For example, the drone can be used to fly over larger wells or parts of oil fields in order to determine where methane reaches the surface and in what quantities. Such detailed measurements will make it possible to take and verify concrete measures to further reduce methane emissions. Industry is also interested in this, confirms Emmenegger. "Our new measurement technology has already led to numerous enquiries from industry and research. This has resulted in many exciting projects in the field of natural and man-made methane source".

TEN IN ONE GO

But methane is not the only pollutant on the list. It also includes carbon dioxide (CO_2), ozone (O_3) and ammonia (NH_3). However, instruments that can measure these gases are complex, expensive and require a lot of energy, because each gas must be measured with a separate method – at least until now. The two former Empa researchers Morten ▶

SIMULATION
Satellite images from Empa researchers' simulations: The picture on the left shows the measurements of the CO_2 instrument, the picture on the right shows the NO_2 instrument of the satellite. Clearly visible are the emissions of the city of Berlin and several coal-fired power plants.



Hundt and Oleg Aseev have developed a QCL spectrometer that can detect ten environmental gases simultaneously. They recently founded the Empa spin-off "MIRO Analytical Technologies" and have already celebrated numerous successes. Among other things, they received 1.25 million Euros in funding at the beginning of 2020 as part of the Accelerator Program of the "European Innovation Council". Since January 2019 they have also been part of the Business Incubator of the European Space Agency ESA, as their hightech sensor can serve as an important reference – on the ground or airborne – for the observation of environmental gases by satellites.

OBSERVATIONS FROM SPACE

ESA is also relying on Empa's expertise in the preparations for the CO_2M satellite mission ("Copernicus Anthropogenic Carbon Dioxide Monitoring"). The first CO_2M satellites are due to be sent into orbit from 2025 onwards. They will use spectroscopic measurements to produce global maps of CO_2 concentrations in the atmosphere. This will make it possible to determine where and how much CO_2 is emitted by industrial plants, cities and countries. "We were able to give ESA various recommendations for the analytical equipment of the satellites", says Empa researcher Gerrit Kuhlmann. For example, the satellite must be capable of separating the man-made CO_2 emissions from the signals of the biosphere – i.e. the naturally occurring.

An additional NO_2 instrument should therefore be able to separate anthropogenic and biospheric CO_2 signals. In order to test this idea, Kuhlmann and his team simulated the distribution of CO_2 and NO_2 concentrations for the year 2015. The elaborate simulations were carried out on the fastest high-performance computer in Europe, the "Piz Daint" at the Swiss computing centre CSCS in Lugano. The Empa researchers were able to show that a combi-nation of CO_2 and NO_2 measurements provides better and more reliable results than if only one CO_2 measuring instrument were installed on the satellite. The recommendation for the installation of an additional NO_2 measuring instrument has already been taken up by ESA in the planning of the new satellites. ■

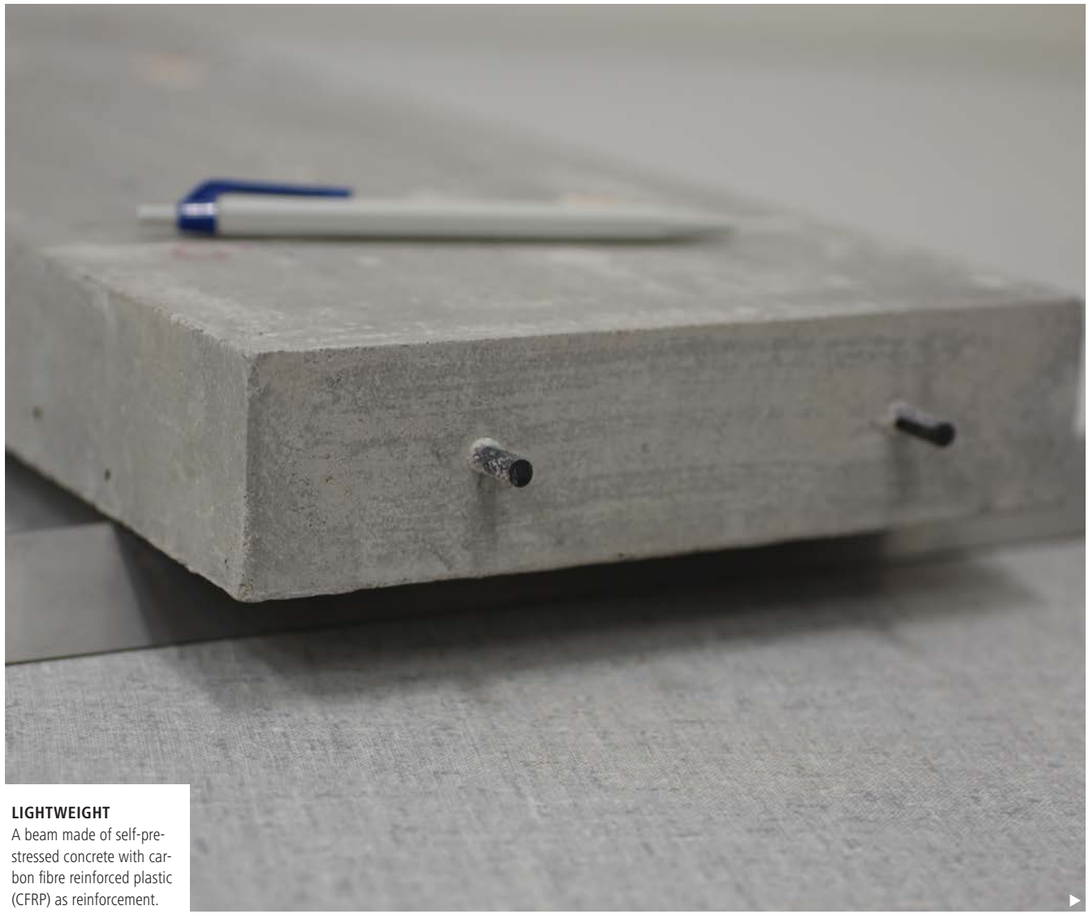
Further information on the topic is available at: www.empa.ch/web/503

Photo: Empa

WHEN CONCRETE LEARNS TO PRE-STRESS ITSELF

Concrete is by far the most widely used building material in the world – and the trend is rising. Using a new type of concrete formula, an Empa team has succeeded in producing self-prestressed concrete elements. This innovation makes it possible to build lean structures much more cost-effectively – and save material at the same time.

Text: Stephan Kälin



LIGHTWEIGHT
A beam made of self-prestressed concrete with carbon fibre reinforced plastic (CFRP) as reinforcement.

Photo: Empa

More than ten billion tonnes of concrete are produced and used worldwide every year. This is more than all other building materials combined. By way of comparison, steel and asphalt – both of which are also used very abundantly – are each produced at around 1.5 billion tonnes annually. Even though the energy required to produce one tonne of concrete and the emissions that go with it are lower than for other building materials, the huge quantities are responsible for a significant environmental impact.

Cement, the binding agent in concrete, is the main culprit. Just under three percent of the world's primary energy is used for the production of four billion tonnes of cement required annually. Cement production is also responsible for up to eight percent of the global CO_2 emissions. According to estimates, the annual production of concrete and cement could even increase by another 50 percent by 2050 due to a growing demand in developing countries. Replacing concrete is not an easy task, though; the building material simply offers too many advantages. These figures show that a more sustainable use of concrete – from production and efficient use of materials to demolition and recycling – will have an enormous impact on our environment and society.

PATENTS IN EUROPE AND THE US

Empa scientists are looking into developing methods to make concrete elements leaner, yet durable and stable, so that materials consumption is reduced. A team led by Giovanni Terrasi, Pietro Lura and Mateusz Wyrzykowski was recently granted a European and a US patent for a self-pre-stressing concrete technology that achieve just this.

Pre-stressing is generally used when a concrete element has to withstand very high loads – for instance, beams, bridges or cantilevered structures. In a conventional pre-tensioning technology, the reinforcements or tendons – usually made of steel – are anchored on both sides of the element before the concrete is cast, put under tension and released again after the concrete has set. The forces generated in the tendons place the concrete under compressive stress: The element is pulled together by the pre-tensioned reinforcement on its inside, so to speak – and is thus much more stable. The problem: Steel is susceptible to corrosion. Therefore, the concrete layer around the pre-stressing steel must have a certain thickness.

> "Our technology opens up completely new possibilities in lightweight construction."

CARBON FIBERS INSTEAD OF STEEL

As early as in the 1990s, carbon fiber-reinforced polymers (CFRP) were used to replace steel reinforcement. Because CFRP does not corrode, it is possible to produce significantly leaner concrete components – with very similar structural properties. "But if you want to pre-stress these CFRP reinforcements in order to be able to build even thinner structures with a higher load-bearing capacity, you reach your limits," says Wyrzykowski. Very expensive pre-stressing beds are required and the anchoring of CFRP bars is much more complicated than that of steel. Thus, pre-stressed CFRP high-performance concrete is still not very widely used.

EXPANDING CONCRETE

The Empa team has now succeeded in completely dispensing with anchoring on both sides of the concrete element, as the concrete does the work by itself: Thanks to a special formula, the concrete expands as it hardens. As a result of this expansion, the concrete puts the CFRP bars in its interior under tension and thus automatically pre-stresses itself. In their laboratory tests, the researchers were able to show that the self-pre-stressed CFRP concrete elements could bear loads comparable to those that were conventionally pre-stressed– around three times more than a non-pre-stressed CFRP concrete element. "Our technology opens up completely new possibilities in lightweight construction," says Wyrzykowski. "Not only can we build more stable structures, we also use considerably less material." The Empa researcher also envisions completely new fields of application: "We can easily pre-stress in several directions at the same time, for example for thin concrete slabs or filigree curved concrete shells," he says, looking to the future. These new applications are now being developed further in cooperation with industry partner BASF. ■

Further information on the topic is available at:
www.empa.ch/web/s308

NEW CONCRETE MIX
Empa researchers Mateusz Wyrzykowski and Volha Semianiuk, with the help of laboratory technician Sebastiano Valvo, are investigating new possibilities for self-tensioned CFRP concrete elements.

Photos: Empa

EUROPE'S RESPONSE TO ELON MUSK

Over the next four years, five research institutes and six industrial companies from seven European countries will work together to find solutions for the next generation of lithium-ion batteries. Also on board as a partner is the Swedish company Northvolt, which intends to set up two large-scale production facilities (gigafactories) for vehicle batteries in Europe.

Text: Rainer Klose

SENSE PROJECT
Vehicle batteries of the future must be manufactured in gigafactories - just as Tesla demonstrates. This is what the gigafactory of the Swedish company Northvolt could look like. Northvolt is jointly working with Empa on the SeNSE research project

Photos: Northvolt AB

The demand for batteries for electric cars will increase dramatically in the next few years. At present, more than 90 percent of these batteries come from Asia. The EU Commission has therefore set up the "European Battery Alliance" in 2017 to build up competences and production capacities for this key technology in Europe. Experts estimate that the European demand for lithium-ion batteries alone will require 10 to 20 so-called "gigafactories" – large-scale producton facilities for batteries.

GENERATION 3B LITHIUM-ION BATTERIES

The research in the SeNSE project is part of this "European Battery Alliance" initiative and is supported by the EU research funding programme Horizon 2020. The eleven research partners of SeNSE – five research institutes and six industrial companies – are conducting research on next-generation lithium-ion batteries – the so-called "generation 3b". In contrast to current traction batteries, this next generation will have higher energy density and improved cell chemistry and battery management system: Instead of pure graphite anodes, the aim is to use silicon-graphite composites. The content of critical cobalt in the cathode will be further reduced. New additives in the electrolyte and interphase design approaches will slow down battery aging and extend cycle life. New sensors will also contribute to a longer service life and improve fast charging capability by supplying data from inside the battery cells to the battery management system. This data should allow a much more refined temperature management compared to today's lithium-ion cells.

COMPETITION WITHIN EUROPE

COBRA This project is lead by the Catalonia Institute for Energy Research (IREC) and aims to develop a novel Li-ion battery technology with superior energy density, low cost, increased cycles and reduced critical materials. The scientists will focus on a Co-free cathode and advanced Silizium composites as anode and as separator material. Three universities and nine enterprises covering the entire value chain are working on COBRA.

3BELIEVE is lead by the Austrian Intitute of Technology (AIT) and aims at the 3b generation of cells for electrified vehicles beyond 2025. The team will use Lithium-nickel-manganese oxide as cathodes, LiFSI as electrolyte, a portfolio of internal and external sensors (22 sensors per module) and an adaptive liquid cooling system managed by a smart battery management system with advanced diagnostic and operational functions.

SERIES PRODUCTION AND RECYCLING

The sustainability of generation 3b cells is also expected to exceed that of the current generation: The cathode will be manufactured without the use of flammable and toxic solvents, which will greatly simplify the series production of the cells and reduce their cost. All aspects of SeNSE research are geared towards producing the next generation of cells in European gigafactories. To be competitive in the future, cost-effective and raw material-saving production methods are there-fore crucial. The SeNSE project also considers the second life use of decommissioned vehicle batteries as stationary storage units and, finally, the recycling of the batteries. The research partners of Empa (CH), which is leading the project, are the Westfälische Wilhelms-Universität Münster (D), the Forschungszentrum Jülich (D), Coventry University (UK), the Austrian Institute of Technology (A), and the companies Solvionic (F), FPT Motorenforschung (CH), Lithops (I), Northvolt (S), Enwires (F) and Huntsman Advanced Materials (CH).

> "Together with four other research institutes and six industrial companies, we are researching into next-generation lithium-ion batteries."

ON THE WAY TO THE GIGAFACTORY

The Swedish company Northvolt plays a decisive role in the research project. The company was co-founded in 2016 by two former Tesla employees, who were involved in the construction of the Tesla gigafactory in Nevada (USA). Northvolt is currently planning the first European gigafactory with a production capacity of 32 GWh per year to be built in Sweden. A further gigafactory with an annual production of 16 GWh is to be built as a joint venture with Volkswagen in Salzgitter (Germany). For comparison, the Tesla Gigafactory in Nevada currently produces around 30 GWh of batteries per year, according to management.

Experts from Northvolt will advise the SeNSE researchers through regular briefings. By the end of the project, a series of battery cell prototypes will have been developed. A demonstrator with 1 kWh storage capacity will demonstrate the capabilities of the battery cell generation 3b. At the end of the project, the production technology developed will find its way into industry in the form of pa-tents. The SeNSE research project ends after 48 months in spring 2024.

SOLID-STATE BATTERIES – GENERATION 4B

Corsin Battaglia's team at Empa is involved in another European research project: The project, called SOLiDIFY, looks even further into the future and is developing future-generation batteries – so-called solid-state lithium-metal batteries. In contrast to today's lithium-ion batteries and those of generation 3b, these solid-state batteries will no longer contain any liquid, flammable components. They are therefore safer and more tolerant to elevated temperatures, can deliver higher power, and can be charged and discharged faster.

According to experts, these batteries – called generation 4b – could be ready for the market in about ten years. At half the weight and half the size, they should deliver the same storage capacity as today's lithium-ion batteries. ■

COORDINATION
The EU project is lead by Ruben-Simon Kühnel, Stephan Fahlbusch and Corsin Battaglia (right)

Photo: Empa

Further information on the topic is available at:
www.empa.ch/web/s501

FRESH BREEZE FOR ENVIRONMENT AND ECONOMY

Empa spinoff TwingTec is now part of Bertrand Picard's #1000solutions of the Solar Impulse Foundation.

Text: Rainer Klose

PROTOTYP
A TwingTec TT100 landing automatically on sunset.

Photo: Twingtec

Following the success of the first solar flight around the world, Bertrand Piccard and the Solar Impulse Foundation has launched the second phase of their action: selecting #1000solutions that can protect the environment in a profitable way, and bringing them to decision makers to help them adopt more ambitious environmental targets and energy policies.

So far, five solutions from Switzerland have received the Label including two that were nominated following the recent selection in March. We are proud to announce that the Empa spinoff Twingtec is now part of the #1000solutions lineup of the Solar Impulse Foundation.

WIND ENERGY 2.0

Promoting Wind Energy 2.0, Twingtech developed an innovative and sustainable energy solution that unlocks the full power of the wind. Horizontal axis wind turbines have limitations which restrain both economically and technically their penetration potential.

TwingTec fills this gap by offering a new wind energy technology which provides key benefits over wind turbines. TwingPower builds on minimal material usage (no tower and no foundation are needed), the compact and mobile units can be fast and easily deployed. Higher altitudes and stronger winds can be accessed as well as the strong off-shore winds in deep water, where the potential for Europe only is estimated to be 4 TW. TwingPower enables new sites for wind energy, higher capacity factors up to 60% and more reducing the need for storage and opportunity to reduce the levelised costs of energy of wind by at least a factor two.

TwingTec's goal is to speed up the transition to sustainable energy by unlocking the full power of wind, a key element of a 100 % renewable world. ■

Further information on the topic is available at:
www.twingtec.ch

WANTED: THE BEST STO-RAGE BATTERY

The demand for batteries to store renewable energy will grow drastically in the coming years. Could we develop more sustainable technologies to save precious natural resources, besides the familiar lithium-ion batteries?

Text: Rainer Klose

ECOPOWER
Storage batteries must be cheap and environmentally friendly to produce. Size and weight are less important.

Photo: iStock

The global economy's demand for lithium-ion batteries will be rising sharply in future. Electric cars depend on them, as do laptops, smartphones and power tools for the construction industry and the DIY sector. Soon another area will follow suit that requires rechargeable batteries at an even larger scale: the storage of renewable energy. The growing quantities of temporarily available green electricity can no longer be stored in pump storage power plants – the congested power grid alone hardly allows this. In several parts of the world pump storage plants are not feasible, due to the geography.

Affordable stationary storage batteries will thus be a hot commodity. They should be made of environmentally friendly materials wherever possible in order not to strain further the world's resources of lithium, cobalt or other pricey metals, which are present in lithium-ion batteries.

Empa and ETH Zurich researchers Kostiantyn Kravchyk and Maksym Kovalenko have taken a closer look at possible alternatives to lithium-ion batteries. They have analyzed dozens of scientific publications by research groups around the world and systematically conducted their own experiments. Their assessments have been published at the beginning of the year in the New Journal of Chemistry, among others.

MOVING AWAY FROM LITHIUM – TOWARDS SODIUM?

One of the simplest ideas would be to replace lithium with sodium. This element is anything but rare: sodium chloride is found in seawater and is accessible all over the world. But this is about it when it comes to advantages. Since a sodium ion is about 50 percent larger than a lithium ion, the sodium cathode materials show poorer electrochemical cycling performance. For instance, sodium cobalt oxide, which is the sodium ion analog of lithium cobalt oxide (i.e., the conventional cathode material of the lithium-ion battery) can sustain much fewer charging cycles. This basically eliminates the cost advantage.

There are also problems on the opposite side of the battery, with the anode material. Graphite (as in lithium-ion batteries) is not suitable for sodium batteries, because it does not store enough sodium ions. Tests with cheap tin, antimony or phosphorus showed good charge storage properties, but when charging, the anode expands percent to about three times its original volume. This impairs the mechanical stability: When subjected to shocks, the bloated material can easily disintegrate, and the battery would be damaged.

With phosphorus anodes it gets even worse: When charging, sodium phosphide (Na_3P_7) is formed in the anode, which, together with water, produces phosphine: an extremely toxic gas that leads to respiratory arrest; this is how metal phosphides act as a rat poison. Hard to believe anyone would like to have such a battery, fully charged with solar power, in their cellars.

HOW ABOUT MAGNESIUM?

In the chemical periodic table magnesium resides next to sodium. It is a small, light atom and can transfer two electrons at once. Magnesium is inexpensive and non-toxic. Could it be used to make batteries? On the anode side of the battery, magnesium has advantages: You don't need graphite (as in lithium-ion batteries), instead you can use a magnesium foil as anode.

However, the small, double-charged magnesium ion brings drawbacks on the cathode side. The high electrical charge on a small diameter leads to high electrical attraction forces. For example, the ion slips into a lattice of cobalt oxide only with great force, and if it is stuck there, it is difficult to extract it again. Anyone who tries to do so by force – i.e. with higher voltages – runs the risk of triggering oxidation and reduction processes in the chemical components of the battery, thereby destroying them. ▶

Besides of that the high voltages, which are necessary to reverse the chemical process makes these batteries very inefficient. As a consequence, such batteries cannot be charged at high speed and can only be used in a small voltage range if they are to last a long time.

ALUMINIUM GRAPHITE BATTERIES

If we walk further along in the periodic table, aluminium is next. This metal is also available in large quantities, non-toxic and inexpensive. It can transfer three electrons at once. Similar to the magnesium battery, the anode is easy to build: An aluminum foil is all you need.

But the rest of the aluminium battery operates fundamentally different from lithium-ion batteries: Lithium-ion batteries employ the "rocking chair" principle. When discharging, the lithium ions migrate from the anode to the cathode; when charging, they migrate back. By contrast, in an aluminium graphite battery, there is no one-directional motion of Al3+ ions from the positive to the negative electrodes. Instead, Al species are "consumed" from the chloroaluminate ionic liquid – the electrolyte – during the charging of the battery by both electrodes. The electrolyte hence plays a double function: It provides aluminium, which is deposited in the form of metal on the anode, and acts as the source of AlCl4- ions needed for the intercalation into the positive graphite electrode during charging.

The amount of electrolyte is, therefore, decisive for the capacity of the battery. Thus, aluminium graphite batteries will be about five times heavier than comparable Li-ion batteries due to their chemical operating principle.

Apart from that, the graphite cathode expands to more than twice its original volume during each charging process and shrinks again during discharging. This means: In any case, such batteries need flexible envelopes and protective casings with sufficient space to "breathe". The expansion and shrinkage also affects the shock resistance and long-term stability. This may need remedies in the construction of the cathode.

NEW BATTERY MANAGEMENT

An additional challenge will be the charging algorithm for non-lithium-ion batteries. The team led by Kravchyk and Kovalenko discovered that the performance of an aluminum-graphite electrode could be increased by up to 25 percent through skillful, step-by-step charging. A research group working in Taiwan, China, USA and Germany found that such electrodes are significantly more powerful when cooled to –10 degrees Celsius. These results illustrate that a completely new battery management system, i.e. new sensors, chargers and algorithms, has to be developed in parallel with these chemically entirely different battery types.

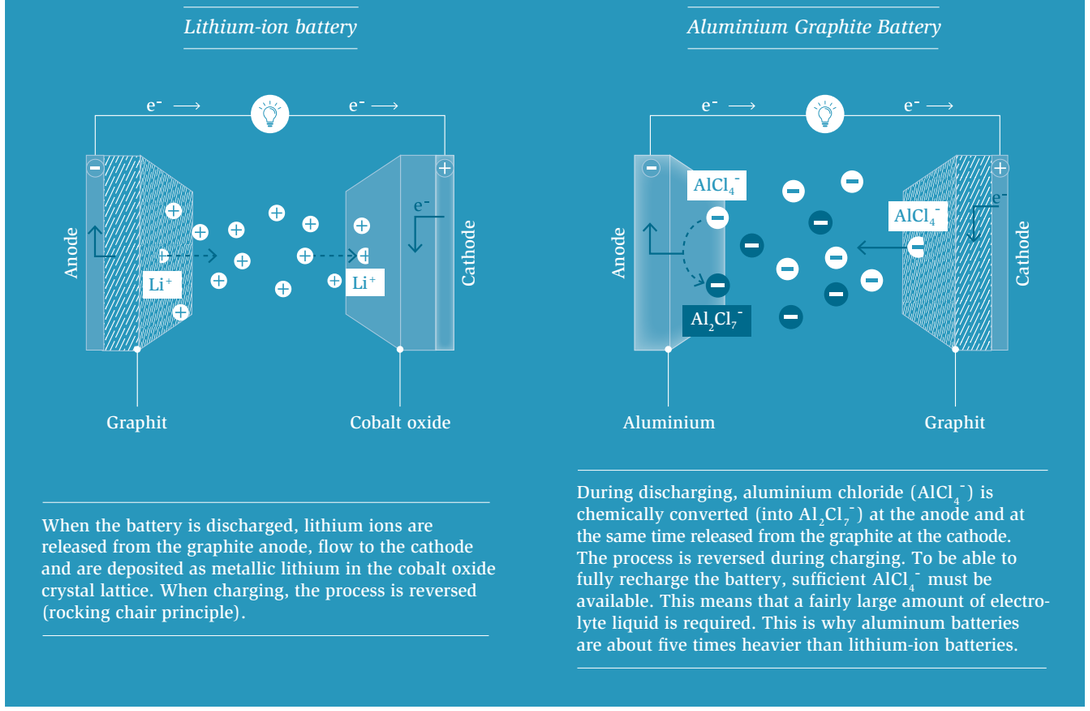
It is still unclear which of the battery technologies described above will prevail and one day can replace lithium-ion batteries in some areas. In their assessment the researchers emphasize that none of these technologies can compete with lithium-ion batteries in terms of energy density. This is not likely to change in future. These types of alternative batteries are therefore only suitable for applications, in which electricity is to be stored as cheaply as possible and the focus is on sustainable production of the batteries.

MORE APPLIED RESEARCH NEEDED

Therefore, a lot of work remains to be done by research groups the world over if alternative battery technologies are to outperform the good, old lithium-ion battery. Kostiantyn Kravchyk and Maksym Kovalenko call for a more holistic approach. "With their lab experiments, researchers often only prove the feasibility of an idea – the cost of all necessary components and the estimated total weight of the entire battery system are mostly neglected," says Kravchyk. However, it is exactly these parameters that are crucial for a possible commercialization. "They should thus be given a much greater consideration in research than to date."

Despite their somewhat sobering study, Kostiantyn Kravchyk will continue to research alternative storage batteries in the future. "Systems using graphite as cathode material are interesting. We were already able to show that the swelling and shrinking of the cathode material is a problem that can be overcome." Together with his colleagues, he is now exploring "semi-solid" graphite electrodes that can last a long time and at the same time transmit electricity very well. ■

Further information on the topic is available at:
www.empa.ch/web/s207/materials-for-batteries



When the battery is discharged, lithium ions are released from the graphite anode, flow to the cathode and are deposited as metallic lithium in the cobalt oxide crystal lattice. When charging, the process is reversed (rocking chair principle).

During discharging, aluminium chloride ($AlCl_4^-$) is chemically converted (into $Al_2Cl_7^-$) at the anode and at the same time released from the graphite at the cathode. The process is reversed during charging. To be able to fully recharge the battery, sufficient $AlCl_4^-$ must be available. This means that a fairly large amount of electrolyte liquid is required. This is why aluminum batteries are about five times heavier than lithium-ion batteries.

Grafic: Hug & Dorfmüller Design AG, Photo: Empa

DIE FORM VON GRAPHIT
Kostiantyn Kravchyk explains the chemistry in an aluminium graphite battery: With well suited graphite, the edges look like a bundle of paper. The large ions from the electrolyte can easily slip into the spaces between the sheets and settle there. If the graphite layers are bruised this does not work so well.

PLATINUM KEEPS FRUIT FRESH

If different types of vegetables and fruits are stored together, they influence each other in the ripening process. This is due to ethylene, which is emitted by some plant-based foodstuff and accelerates ripening. To prevent excessive food waste due to accelerated ripening Empa and ETH Zurich researchers are developing a new catalyst that de-grades ethylene into water and carbon dioxide.

Text: Mara Hausammann

YELLOW
For bananas on the counter to look tempting to buy, they are often picked and shipped unripe.

Photo: pixabay

If freshly bought bananas are stored in a full fruit basket they won't stay yellow very long. Just a few days later, the crooked fruits take on a brownish color and are more likely to be thrown away than be eaten. The reason for this rapid ripening is the chemical ethylene. The gaseous plant hormone not only functions as a messenger substance within an individual fruit, but also influences other specimens nearby. Ethylene triggers a real chain reaction by stimulating the production of (more) ethylene in other plants and fruits. And more ethylene means faster ripening. Therefore, fruits like apples that emit particularly high levels of ethylene cause premature ripening in, say, banana, which shows a particularly strong reaction in response to the hormone. When storing this foodstuff together, rapid ripening can become an undesirable side effect. Fruit cannot be stored as long – which not only leads to losses of food at home in the fridge, but also in the entire supply chain from the importer to the wholesale and retail trade.

PLATINUM FOR SLOWER RIPENING

To counteract the accelerated ripening process, ethylene must be kept away from fruits and vegetables. For this purpose, Empa / ETH Zurich researchers Huizhang Guo and Mirko Lukovic have developed an idea to degrade ethylene released by fruits and vegetables. The concept is based on a delignified wood structure enriched with a catalyst that is dispersed at an atomic level. Wood consists of three basic substances: cellulose, hemicellulose and lignin. The researchers used a protocol developed in the Wood Materials Science professorship at ETH Zurich and Em-pa (https://www.empa.ch/web/s604/holz-paradox-eq66) and dissolved with the help of an acid solution both lignin, wood's binding substance, and a part of the hemicelluloses. This makes the remaining cellulose structure extremely porous with a very large specific surface area. These properties make the delignified wood a perfect natural scaffold for a catalyst.

KATALYST
Mirko Lukovic (in the picture), Huizhang Guo and their team developed a catalyst carrier based on the renewable resource wood.

Photo: Empa

In a next step, the delignified wood is put into two different solutions. The first creates the foundation so that the platinum particles are able to stick to the cell walls of the wood later on; the second contains the platinum particles, which then enter the wood structure.

This concept is similar to the one used in car engines. When ethylene flows through this porous structure, it repeat-edly "bumps into" surface-bound platinum that catalyzes the degradation of ethylene into water and carbon dioxide (CO_2). The Empa team could show that, at room temperature, the catalyst decomposes virtually all of the emitted plant hormone. If the temperature drops to 0 degrees, however, water – one of the reaction products – can no longer evaporate, sticking to the catalyst and preventing any further chemical reaction. To rid the catalyst from the condensed water layer and make it work again, it is sufficient to warm up the entire structure for a few minutes every two hours, Lukovic says.

These results demonstrate the functionality of the catalyst-enriched modified wood. The next step would be an upscaling of the concept to industrial levels, the researchers say. Larger and mass-produced versions of their pro-to-type could be installed in refrigerators and cold stores, thereby slowing down the ripening process and keeping fruits and vegetables fresh for a considerably longer time. What's more, the lifetime of such a catalyst could be as long as the lifetime of the refrigerator itself.

PIONEER ALREADY ON THE MARKET

The concept of catalytically degrading ethylene to extend the shelf life of fruit is not new; since 2015, the Japanese company Hitachi has been producing refrigerators equipped with platinum catalysts. Hitachi uses silica as the framework for the platinum nanoparticles. The Empa researchers have improved this concept by using a wood-based scaffolding and a more efficient utilization of the (rather expensive) platinum catalyst. Delignified wood is an eco-friendly and renewable resource with a remarkably porous and hierarchical structure. This allows platinum nanoparticles of 20 nanometers in size to be evenly and efficiently distributed in a very small volume in order to achieve the desired catalytic effect. Moreover, the technology developed at Empa avoids a potential contamination of the foodstuff with platinum nano/micro particles by fixing the catalyst on the surface of the porous wood structure. ■

Further information on the topic is available at: www.empa.ch/web/s302

CONCRETE AND ASPHALT RESEARCH EXPANDED

SUSTAINABLE
Concrete and asphalt are the two most widely used building materials in the world

Since March 2020 the new Concrete and Asphalt Laboratory has strengthened Empa's research in the field of building materials. Innovative technologies and materials for sustainable production and use are particularly in demand in these specialist areas, as these two building materials, with an annual volume of more than 4.5 billion tonnes, account for by far the largest proportion of all materials used worldwide.

www.empa.ch/web/s604/abteilung-beton-asphalt

SWISS SOLAR FAÇADE BREAKS EUROPEAN RECORD

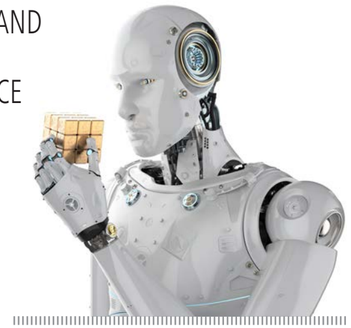
K3 Immobilien AG and werke versorgung wallisellen ag (die werke) have put into operation the most profitable facade solar system in Europe in the new commercial building "K3 Handwerkcity". The groundbreaking energy concept of the industrial park is being scientifically monitored by Empa. The aim is to make the industrial park as ecological and self-sufficient as possible.

www.empa.ch/web/s604/k3-building

ECOLOGICAL
The solar façade produces 400'000 kilowatt hours of renewable electricity per year

Photos: iStock, Empa

OPPORTUNITIES AND RISKS OF ARTIFICIAL INTELLIGENCE



WISE?
The spread of artificial intelligence raises ethical questions

Artificial intelligence (AI) is becoming increasingly powerful and is being used for increasingly complex tasks. This raises ethical questions, for example when AI is used to make decisions for or judge people. An Empa team was heavily involved in a new TA-SWISS study which

www.ta-swiss.ch/themen-projekte-publikationen/informationsgesellschaft/kuenstliche-intelligenz

SYNTHETIC GAS INSTEAD OF FOSSIL ENERGY

CLEAN
Surplus electricity can be converted into synthetic gas

There is a major challenge in converting our energy system to purely renewable energy sources: the winter or rather the supply gap at this time. The conversion of surplus summer electricity into synthetic gas offers a way of ensuring that renewable energy is available in sufficient quantities even in the winter half of the year. It could also be used to power long-distance trucks. The Canton of Zurich is supporting the project with a total of CHF 500,000 from the framework credit to support pilot projects in the energy sector.

www.empa.ch/web/s604/move-mega

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(IN GERMAN)

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