EmpaNews

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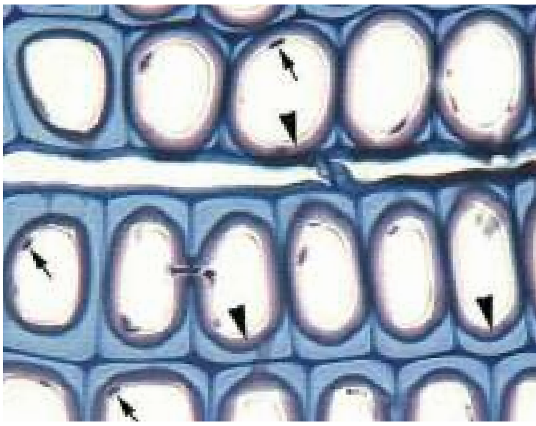
Smart buildings

EMPA
Materials Science & Technology



Research for the common good

This has been our trademark for more than 120 years. A tie made of 24 carat gold, in contrast, hardly fits that bill. Even so, this luxury accessory for the well-to-do man (also available on loan to the author) is a perfect example of technology transfer "à la Empa". What's at issue here is not simply frivolous neckwear, but rather the plasma technology process developed at Empa, which for the first time makes it possible to put an ultra-thin coating on thread. It's useful for the manufacture of antibacterial medical textiles for the operating room, for electrically conductive fibres, and so on and so forth... Hence, the gold tie is just a "by-product". With a retail price of CHF 7,500 quite an expensive one, though.

At first glance, too, the world's smallest electric car, measuring only 4 x 2 nanometres, is simply a technical gimmick, perhaps best described as playing molecular Lego bricks. Truly useful innovations are a different ballpark altogether, you might think. But hold your horses! It's experiments like these that offer scientists a fundamental understanding of the behaviour of materials and surfaces. This knowledge, in turn, is exactly what we need to develop new materials with improved properties, for instance optimised membranes for batteries or more efficient coatings for solar cells. In other words, basic research such as mentioned here is the engine driving innovation, the fertile soil of sorts, in which innovative technologies can take root and thrive.

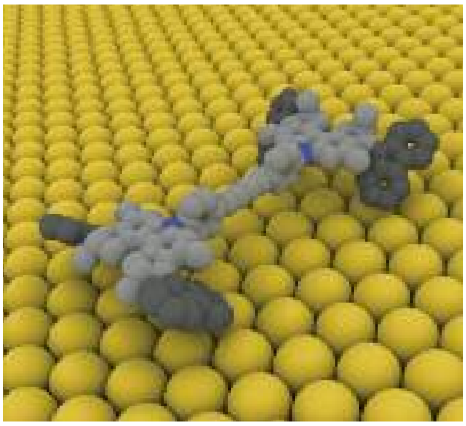
There are more tangible examples in this issue's Focus section, in which we venture a glimpse into the future of buildings. And we're really thinking big here: with "NEST", our visionary "building lab", we hope to do nothing less than invent the future – at least the one we want to live in.

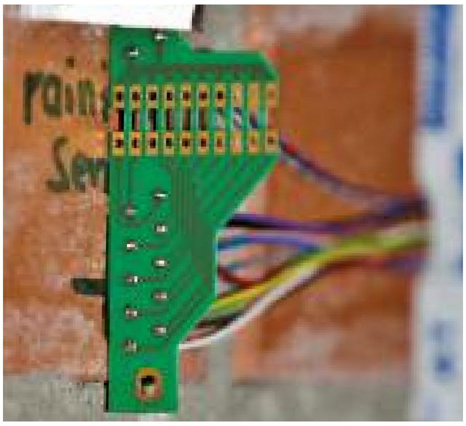
Enjoy your reading!

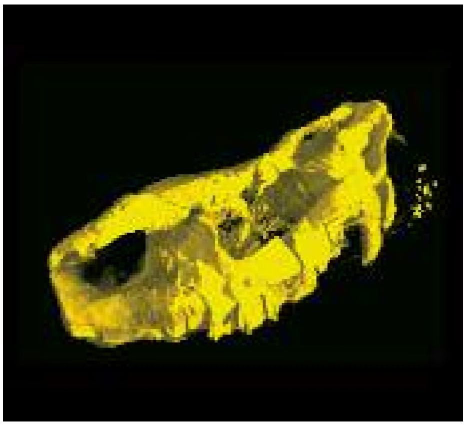
Michael Hagmann
Head Communications

Cover

Buildings are here to stay for quite some time – and thus are not well suited for short-term experiments. With its "NEST" building lab, Empa intends to solve this problem; it consists of a reinforced concrete backbone – a docking station of sorts –, upon which innovative residential and office modules will be installed. In NEST, visionary building concepts can prove their value in everyday use.







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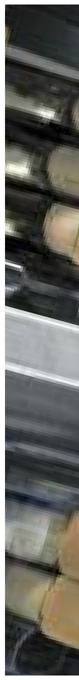

Instruments from the fungus laboratory

A blindfold listening test in front of a panel of experts shows that violins made of wood treated with fungus need not take a second seat to a Stradivarius. However, these modern day "miracles of sound" have, up to now, only been crafted as a handful of individual specimens. To produce more of these biotech violins, researchers are working on optimising and standardising the techniques for fungal treatment of tonewood. In this they've found a new financial backer in the Walter Fischli Foundation.

TEXT: Martina Peter / PICTURES: Christian Grund (13 Photo), Empa, zVg

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1
Francis Schwarze checks the sound of a violin in his fungus laboratory.

2
Project leader Iris Brémaud examines wooden blanks in the climate chamber and checks on the work being done by the violin maker's biological assistant.

Which budding talent doesn't dream of just once being able to play on a Stradivarius, the ultimate in the arts and crafts of violin making? As we all know, these instruments are few and far between and unaffordable for just about everyone. Modern violins with comparable sound qualities would be very welcome. Empa researcher Francis Schwarze has created one together with a Swiss violin maker – and with the help of the wood-rot fungi Physisporinus vitreus, which selectively breaks down certain structures in wood, thereby considerably improving its resonance properties.

Applying it in a controlled manner, the fungus "attacks" conifer wood and gives it structural properties similar to the wood used to make musical instruments in the late 17th and early 18th centuries. This wood grew during the "Maunder Minimum". The climate at that time – long, hard winters and cool summers – lad to slower growth, narrow and more uniform annual rings and lower density. Schwarze has had several "fungus violins" produced from the biotech-treated wood, and their sound was clearly preferred to paired "normal" contemporary instruments. They even exceeded expectations when compared to a historical violin. At a symposium in 2009, two "fungus violins" went up against a Stradivarius in a blindfold listening test. The expert jury and the audience found their sound more pleasing than the instrument made by the Italian master from Cremona.

Generous financial support from the Walter Fischli Foundation

To enable sufficient numbers of such violins to be crafted with fungus-treated tonewood, Schwarze has developed a standardised biotech process. To continue the fungus vio-

Podcast:
Bio-tuning for excellent sound

www.worldradio.ch/wrs/news/switzerland/stradivarius-squares-off-against-fungi.shtml
For smartphone users: scan the QR code (e.g. with the "scanlife" app)

lin project, he has found a new financial support in Walter Fischli, the founder of the biotech company Actelion, or to be more precise, his foundation. Fischli, an enthusiastic amateur violinist, plans to support Schwarze financially because the project combines his two "passions" – science and music (see interview p. 6). An interdisciplinary project, which started in September and is intended to run for three years, is attempting to develop a defined and controlled wood-treatment process.

The project is being led by Iris Brémaud. Not only is she an expert in the properties of instrument wood, she is also passionate for the techniques and history of musical instruments, played music herself, and learned how to make classical guitars and lutes in an English musical instrument workshop. Her passion for the diversity of wood properties and instruments even took her to Japan. "The range of sounds of music there is completely different than in European music", she explains. "That is related to the fact that in Asia hardwoods are often used to make soundboards of traditional instruments, whereas in Europe conifer wood is preferred." In the next few years, she will study wood from spruce and maple trees in greater depth. For her, it's clear that working with the wood-rot fungus is very enlightening in order to better understand which wood structures and components determining tonal properties.

Interdisciplinary collaboration

As project partner, Brémaud and Schwarze teamed up with violin maker Michael Baumgartner, who in his studio in Basel is in the third generation of artisans making string instruments. However, countless tests on untreated and treated wood samples must be carried out before he can get his first fungus-treated-wood. One of Brémaud's tasks is to find out in a first phase which wood samples appear to be suited for further use in violin making.

For her studies, Brémaud can count on the interdisciplinary support of a large number of colleagues at Empa. Ultrasound expert Jürg Neuenschwander, for example, is using a method based on air-coupled ultra-sound, a technique which was only just recently developed as part of a PhD thesis, to study the distribution of acoustic velocity and attenuation. The method, which is currently used to detect poorly glued spots in laminates, could also be employed to determine in which areas the rot fungus was active and where it was not. Erwin Hack, an expert for optical measurement techniques, is also on board. He measures the deformation patterns of wood plates as they vibrate, which is in the range of a few micrometres, and to do so he uses laser speckle interferometry. With this method he can describe how various types of lutherie wood and even complete instruments radiate acoustically. //

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Science and violin making – combined in an ideal way

A patron explains his project

Empa is resuming its "fungus violin" project. Its goal is to develop a standardised process for the fungal treatment of wood to manufacture violins and other musical instruments. The continuation was made possible by the Walter Fischli Foundation who is financing the project's second phase.

A biochemist and biotech entrepreneur such as yourself and a research project dealing with wood for manufacturing violins – this doesn't seem like a natural fit. How did it come about that your Foundation is supporting this Empa project?

Walter Fischli: I first heard about this exciting fungus violin project in the media. Because I'm a biochemist, play the violin and have a special interest in large Italian instruments, I called Francis Schwarze out of pure curiosity. During the very first conversation I learned that, even though the results were very promising, the project could not be continued for financial reasons. I believe it would have been unforgiveable to let this interesting project, which combines science and violin making in an ideal way, simply fade away. Thus I decided to support it.

What is it that fascinates you about this project?

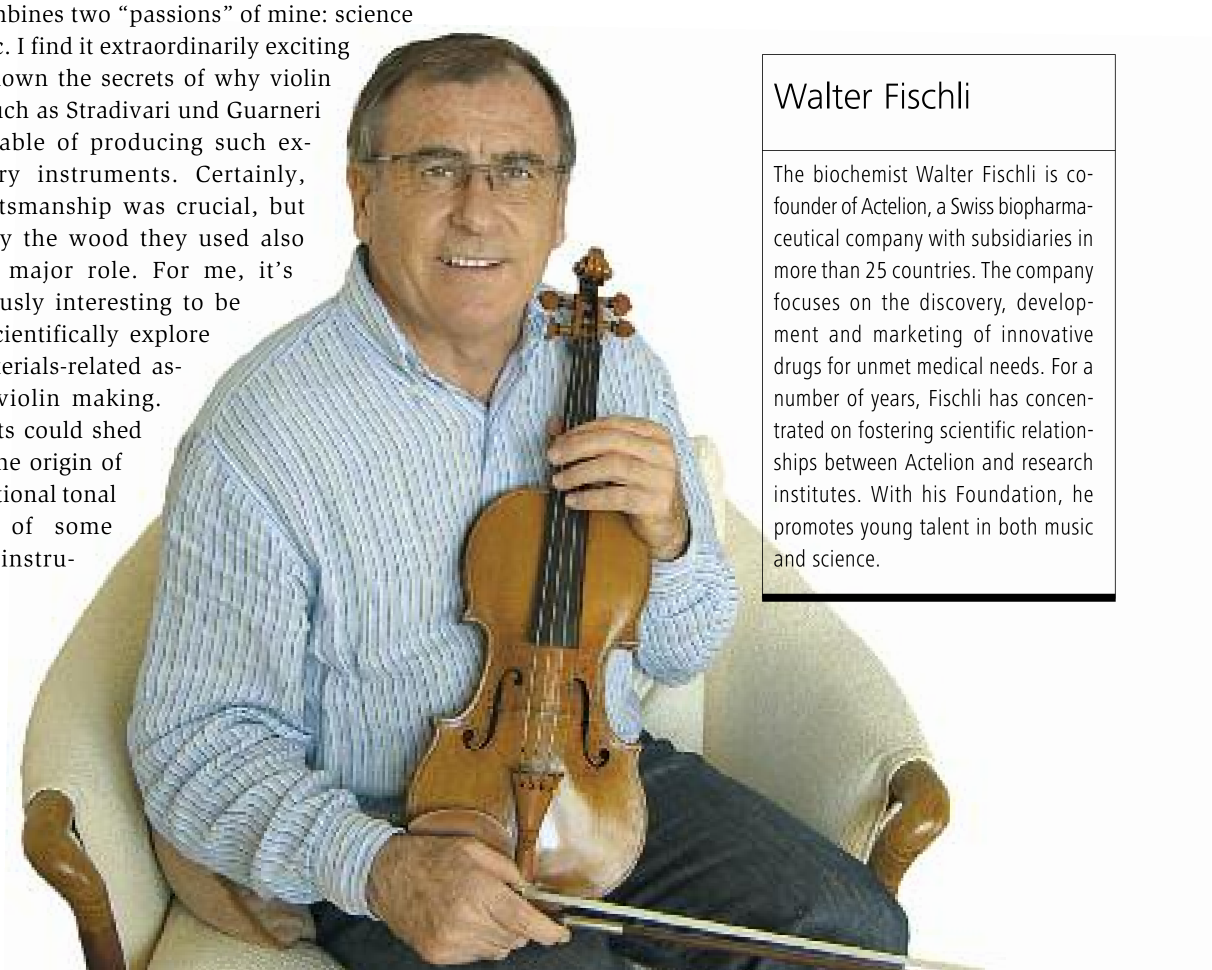
It combines two "passions" of mine: science and music. I find it extraordinarily exciting to track down the secrets of why violin makers such as Stradivari und Guarneri were capable of producing such extraordinary instruments. Certainly, their craftsmanship was crucial, but apparently the wood they used also played a major role. For me, it's tremendously interesting to be able to scientifically explore these materials-related aspects of violin making. The results could shed light on the origin of the exceptional tonal qualities of some antique instruments.

What are the goals you pursue with your Foundation?

We support budding talent – not just musicians but also scientists who don't have the necessary financial means. Here, for example, we're dealing with highly talented young students who are allowed to participate in the master classes of famous artists such as Cecilia Bartoli as part of the Menuhin Festival in Gstaad. Our Foundation also supports young talent from the scientific community who are pursuing especially innovative ideas. In evaluating them, we work closely with other institutions, which can prescreen possible candidates for us.

On a personal level, what are your hopes for the violin project?

My goal is to help talented young violinists find an instrument, which they not only can afford but, in terms of tonal qualities, is at the same level as a violin made by one of the great masters. I'm even ready to participate in privately financing the project further in case a company would eventually want to commercialise this biotech process; the Foundation itself does not pursue any commercial interests and operates as a non-profit organisation. //



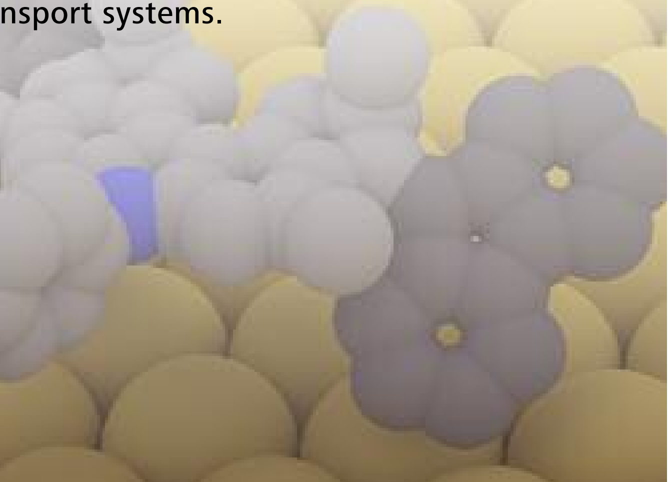
Walter Fischli

The biochemist Walter Fischli is co-founder of Actelion, a Swiss biopharmaceutical company with subsidiaries in more than 25 countries. The company focuses on the discovery, development and marketing of innovative drugs for unmet medical needs. For a number of years, Fischli has concentrated on fostering scientific relationships between Actelion and research institutes. With his Foundation, he promotes young talent in both music and science.

The world's smallest electric car

Empa researchers have developed an emission-free, noiseless 4-wheel car with electric propulsion. However, you'd have quite a difficult time taking a seat in it – the car is just 4 x 2 nanometres in size and thus represents a decisive step in the future of molecular transport systems.

TEXT: Michael Hagmann / PICTURE: Empa

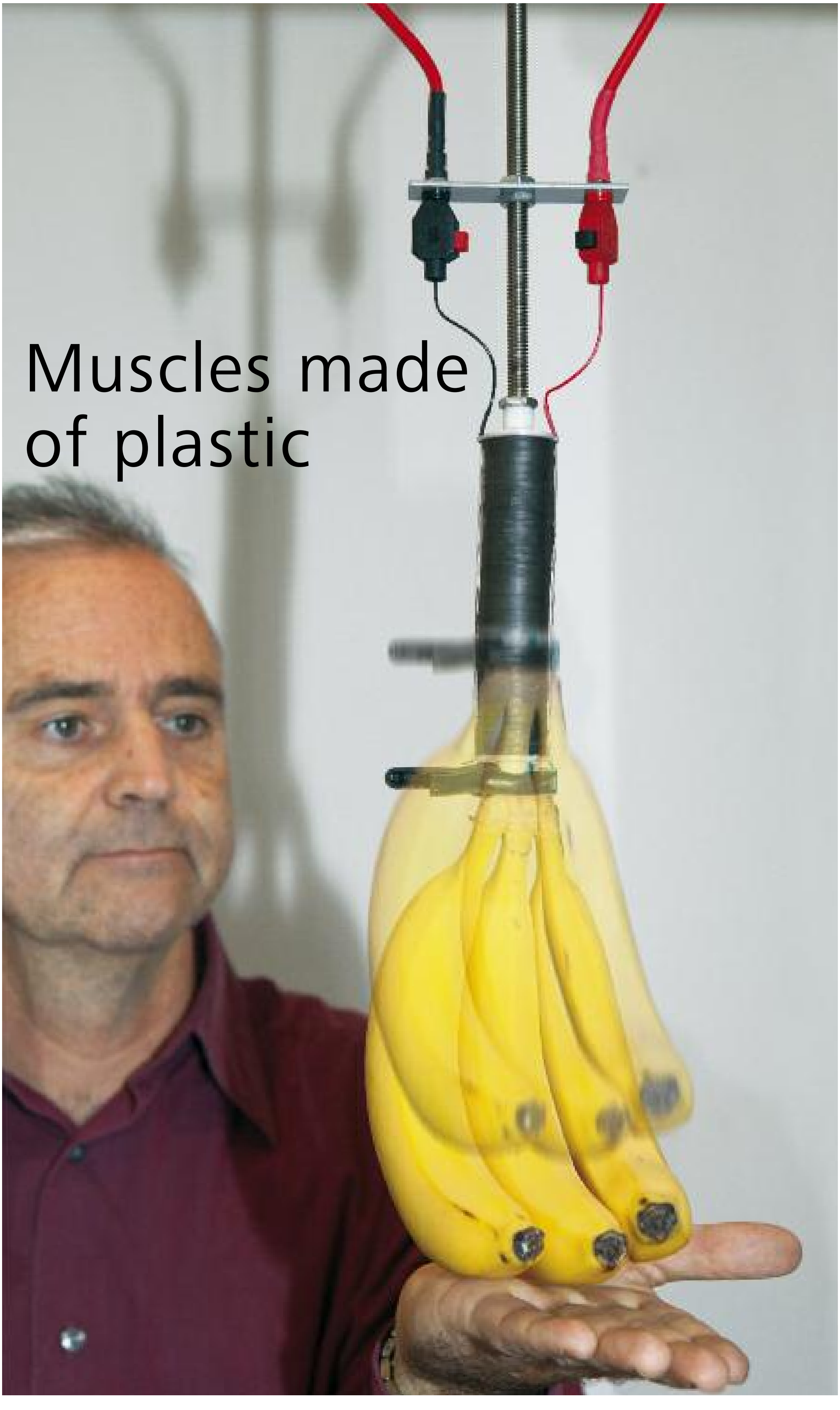


A car consisting of a single molecule. That's something Empa researchers have developed together with their colleagues at the University of Groningen in the Netherlands. With the help of a principle copied from nature, it travels in a virtually straight line over a copper surface. In cells, what are known as motor proteins glide alongside other proteins, similar to a train on rails, and in the process "burn" ATP (adenosine triphosphate). The nano car – about one billion times smaller than a VW Golf – is a synthetic molecule made of four motor units, which needs neither petrol nor rails to move forward; its "wheels" run on electricity.

Refuelling is done via the tip of a scanning tunnelling microscope (STM), requiring a voltage of at least 500 millivolts. The electrons tunnel through the molecule and trigger structural changes in the motor units, turning each wheel one-half revolution. If the wheels turn simultaneously, the auto (theoretically) moves forward along a straight line. The difficulty here is to stimulate all four motor units simultaneously. After ten STM stimulations, the car travels a good six nanometres, but the car must be refuelled every time the wheels rotate half a revolution.

A further experiment shows that the molecule actually functions as predicted. The central axis consists of a C-C single bond, around which the front and rear half of the car can rotate freely. It is thus possible that the molecule could "land" on the copper surface the wrong way round with the rear wheels turning forwards and the front ones turning backwards – so the car remains in gridlock. If it lands in the correct orientation, all wheels rotate in the same direction and the car starts to move. Because all four motor units can be stimulated simultaneously, the car has its own version of a "4-wheel drive". There's no reverse gear, though, because the wheels rotate in just one direction.

With this nano car, the researchers have demonstrated in a proof-of-concept that individual molecules can absorb external electrical energy and directly convert it into targeted motion. In doing so, they have made a decisive step towards the development of molecular transport devices, which in future should allow them to perform specific tasks on the nano-scale. //



Muscles made of plastic

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1
Gabor Kovacs puts one of his artificial muscles to work: this stack, which can lift a bunch of bananas, contains 2500 individual polymer layers.

2
This prototype of a pneumatic valve is controlled by artificial muscles and has proven its value during several years of industrial usage.

Artificial muscles are superior to electrical motors in many areas – such as in robotics or motorised prostheses. It could, however, be quite some time until we see replacements arrive in large volumes; so far, these devices are mostly hand-produced prototypes. Empa researcher Gabor Kovacs, though, is looking into mass production.

TEXT: Rainer Klose / PICTURES: Empa

With this system, we would have certainly won that arm wrestling competition", exclaims Gabor Kovacs from Empa's Mechanical Systems Engineering Laboratory with a wry smile. It is not with fond memories that he looks back upon that "man-vs.-machine" contest. In 2005, three international teams faced off to show in a spectacular way what artificial muscles can accomplish. Each team had developed a robotic arm, but back then research on artificial muscles was still in its infancy. The result was sobering; all three robotic arms lost to their human opponent, a 17 year-old female student.

Since then a lot has happened. Artificial muscles, more properly known as electroactive polymers (EAPs), have become stronger and more reliable. Lecturing at ETH Zurich, Kovacs is introducing the next generation of engineers to this topic. The principle of operation is easy to understand: a thin sheet of polymer, 10 to 100 micrometres thick, is placed between two capacitive plates made of flexible conductive material. The polymer must be elastic, non-compressible and a good insulator. When an electrical voltage is applied to the capacitors, they attract each other and squeeze the elastic polymer flat. An artificial muscle is generally built up as a stack with dozens or even several thousands of these individual muscle layers. It behaves just like its natural archetype: when a voltage is applied to it, the muscle contracts and at the same time becomes thicker.

Artificial muscles remain intact even after hundreds of operating cycles, their design is simpler than that of an electric motor, and they don't require any transformational mechanism to convert the rotations of an electric motor into a pulling or pushing motion. No wonder, then, that prototypes are already being investigated in everyday situations. Several years ago Kovacs and his team built a pneumatic valve from artificial muscles, one that even today continues to do its job in an industrial prototype. Applications in the consumer electronics industry are also being looked into. For instance, artificial muscles could allow the creation of a force-feedback touch screen which verifies the user's key entry; for this, a pressed button yields and afterward springs back to the surface.

Video:
Long Stacked EAP Actuator

http://www.youtube.com/watch?v=Ga_IafGRWyE
For smartphone users: scan the QR code
(e.g. with the "scanlife" app)

There's no shortage of ideas

Before any such success, though, there's still lots of work ahead. While there are hundreds of ideas for the uses of artificial muscles, only a few ambitious companies have dared to start mass production. This is where Empa is playing a role. Even now, Kovacs can suggest three possible manufacturing methods which are to be further developed at Empa.

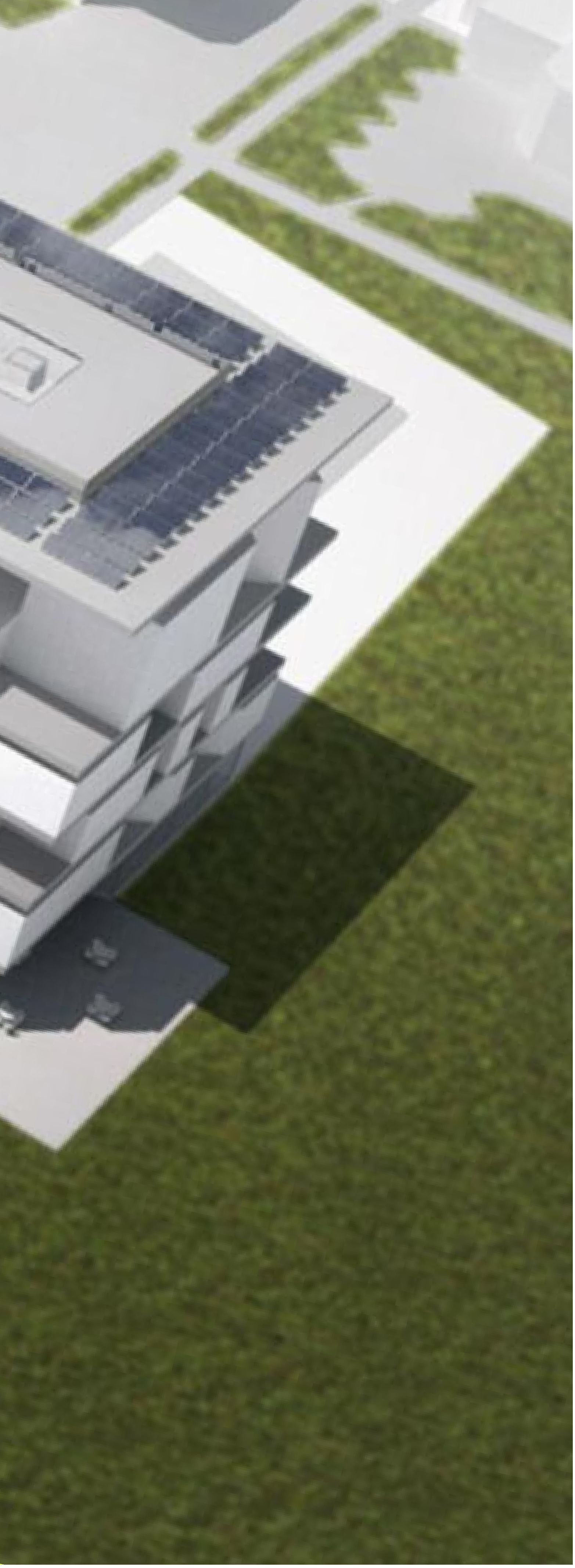
- For large-volume production and low-cost applications, the team plans to develop a stacking machine to layer individual muscle layers on top of each other. This machine fabricates artificial muscles cost-effectively using prefabricated foil.
- Then, for muscles in an especially complex, delicate structure, high-precision manufacturing is needed. Such components would be plotted from fluid raw materials. A precise 3D positioning robot is already operating in the Empa labs, and it can produce components with micrometre accuracy.
- Actuators with high efficiency even at low voltage, are to be manufactured using magnetron sputtering. For that, the entire production process takes place in a vacuum. A rotatable drum absorbs liquid silicon, which is then cross-linked under UV light. The next step in the process sputters a nanometre thin layer of silver, which acts as an electrode. The following step adds the next silicon layer, then again another silver layer, and so on.

The most advanced of these techniques is the plotter method using fluid raw materials. Empa's Functional Polymers Laboratory was heavily involved in the development of the electrode materials. And there's even been a spin-off company, which resulted from this interdisciplinary collaboration. The start-up Compliant Transducer Systems (CT Systems), headed by Kovacs, was founded in August 2011 and intends before long to mass-produce plotted artificial muscles. Another spin-off – Optotune – is already one step ahead; it is building lenses that can be focused continuously with the help of artificial muscles (see article on p. 24). These lenses are superior to conventional systems in terms of size, manufacturing costs, energy consumption and robustness and thus are of great interest to companies producing smartphones. In other words, before long Empa researcher Kovacs will no longer have to deal with mere arm-wrestling competitions. //

Experiments with buildings? NEST makes it possible!

Buildings are here to stay for a long time, a fact that hinders experimentation on them. With its "NEST" building lab, Empa is looking for a way out of this dilemma. In NEST, only the supporting structure is permanent – all the rooms, including their facades, are interchangeable.

TEXT: Rainer Klose / GRAPHICS: Gramazio & Kohler; Empa



NEST will be erected in the heart of the Empa campus in Dübendorf, which means researchers, guests and curious visitors won't have to go far.

What do we actually need windows for?" asks Peter Richner. This is not a purely rhetorical question because in Richner's view the price we pay for a lovely vista is a huge thermal weak point in the facade: energy escapes through windows. Richner, who as member of Empa's Board of Directors is responsible for the Civil and Mechanical Engineering Department, digs deeper into this issue. "Why not simply forget about windows? We could build houses with webcams outside and flat-screen displays inside." Such a building could be perfectly insulated. Richner looks out of his office window (which is still there for now), scrutinising the dense fog and adding another interesting option. "Imagine you don't like today's weather. You simply push a button on the display and in an instant the sky turns blue. Wouldn't that be much more pleasant?"

In some ways Richner is right, but then again, maybe not. Who would like to live in such a building? Which investors would dare to construct such a building and then tear it down after the inhabitants moved out, shaking their heads? In today's construction business, this daring idea would never stand the slightest chance.

Darwinism in building construction

Even so, we could soon learn what life in such a "flat screen panorama loft" would actually be like. The "NEST" building lab is intended to make this possible. A reinforced concrete core with a central stairway forms the backbone of the experimental house. Rooms, flats or even entire floors are attached to the outside. Then all sorts of visionary and pragmatic ideas will encounter contemporary and traditional living concepts in real life. A windowless "flat-screen loft" could be located immediately adjacent to a completely ecological passive house module, walls perhaps made of hemp fibre and brick clay, illuminated by wax candles. Next to it there might be a high-tech module with the latest heating and ventilation electronics, all controlled with an iPhone.

The modular research house should, however, not only encourage wild ideas but also lead to useable future concepts, much faster than would be possible in any other setting. What works well catches on, and what is flawed will be replaced by another module after two years. It's indeed the survival of the fittest in building construction.

What will life be like in tomorrow's flats?

Certainly, a selection of purely showcase modules would have little scientific significance. That's why people are intended to actually move into NEST and report on their experiences. Plans call for a mixed usage with large open offices, conference rooms and flats. "We can imagine almost everything", says Richner, "from single-room flats for graduate students to 3-room split-level flats for

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guest professors who come to do research for a semester and bring their families." NEST inhabitants will thus have the chance to experience how houses of the future affect people.

NEST is to be built on the Empa campus, that is, within eyeshot of its research staff, and a few of their projects are presented on the following pages. Research in construction has been a main area of activity ever since Empa was established. However, until now there were few possibilities to implement visionary concepts in a type of open-air laboratory. "In real life, a building must work from the very beginning", explains Richner. "There's virtually no place for trial and error." Back in 2005, during the construction of the Forum Chriesbach on the Empa-Eawag campus, Empa's experts on building technologies and construction would have been delighted to be able to experiment with various types of facades. That, though, would not have been compatible with its use as Eawag's administrative building. "Today that building is a state-of-the-art structure. It's excellent, but static", says Richner. Each construction experiment ends as soon as construction is completed.

To be able to continue with experiments, Empa created the autonomous "Self" container, in which energy self-sufficiency and insulation have reached levels unknown thus far. But even "Self" was finished eventually. The institute even decided to drop out of the Monte Rosa Alpine hut project. "It's not hard to tell that a mountain hut is a poor place for running experiments," explains Richner. "If something goes wrong, you need a helicopter in order to make any repairs."

Mistakes are OK

NEST, located in the middle of Empa's premises, is intended to solve this problem. Here it's OK to make mistakes. Here it's OK to take a chance because the inserted modules are exchanged after two or three years, paving the way for experiments in construction techniques with calculable risks. The supply backbone of reinforced concrete, on the other hand, is a long-term investment in construction research; it will remain in use for decades.

Department head Richner wants to solicit proposals for various project phases. Topics such as "building automation vs. passive climate control" would be possible; a number of options for renovating older buildings could be investigated. Because each module is connected to the core structure with a type of umbilical cord, it's possible to record and compare the flow of thermal energy, the need for chilled air in summer, electricity and water consumption. Richner is convinced that international research projects will also show interest. "There's nothing like NEST anywhere else, it will be unique in the world."

The truly most ambitious construction research project in Switzerland

In the end, NEST also serves as a research laboratory for Eawag, the Swiss Federal Institute of Aquatic Science and Technology. Water supplies and waste water methods will be investigated, while new options for recycling so-called grey and black water can be tested in an actual setting and under defined conditions.

Still, this truly most ambitions construction research project in Switzerland exists only on paper. At the moment, detailed planning is being done to prepare for the construction bidding for the backbone, which will start at the end of 2012 if everything goes as planned. At the same time, the search is on for industrial partners in Switzerland and abroad who would like to take part in the first round of experiments. Even after this first test phase, NEST will be constantly changing shape and will investigate the "hot"questions pertaining to our living and working environment. This knowledge will then be passed on to the building and construction industry in seminars and conference series. //

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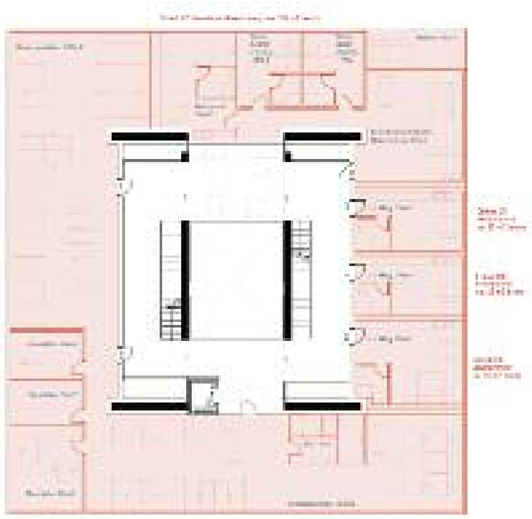

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1
NEST's floor plan: each platform offers more than 600 m^2 of space for experiments. The staircase, lift and utility shafts are located in the core of the building.

2
NEST in various stages of completion: the research modules can be independently attached or removed.

3
Enjoying the pleasures of summer in the NEST cafeteria.

We need more sustainable construction

TEXT: Peter Richner, member of the Empa Board

Whether our society can achieve the agreed sustainability goals depends above all on how we build – and which materials we use for that purpose. That's because construction, operation and maintenance of Swiss buildings consume by far the most resources. Specifically, around half of our energy needs come from buildings, and each year in Switzerland some ten tonnes of construction materials are used per person. At the same time, buildings are greatly responsible for our quality of life. Besides, architecturally successful and functionally pleasing buildings endow a sense of identity and create long-term value. The bottom line is this: there's no sustainable society without a sustainable built environment.

Even if the quality of Swiss buildings at first glance seems quite impressive, we cannot close our eyes to a series of challenges. In view of recent policy decisions related to energy and the necessity to massively cut CO_2 emissions, present-day energy consumption in Swiss buildings – which are fuelled primarily by fossil-based energy carriers – will sooner or later prove to be no longer acceptable. In addition, a large number of buildings must not only be made energy-efficient, many of them must be completely renovated so they meet future requirements in terms of comfortable and attractive living and working space. Around 1.5 million buildings will have to be replaced (or extensively renovated), which will likely keep us busy for decades.

"Present-day energy consumption in Swiss buildings is no longer acceptable."

There is also the need to upgrade our transport and supply infrastructure. For instance, roughly 40 per cent of the bridges in the Swiss motorway network are older than 40 years. But it doesn't stop there: based on a growing population, this infrastructure must be continually expanded or at least adapted to meet our increasing need for mobility. The associated costs will place an enormous financial burden on the public sector in the coming years and decades.

Empa's Research Focus Area "Sustainable Built Environment" is targeted at making a contribution towards overcoming these challenges. In the development of new construction materials, the primary focus is on reducing the consumption of resources – either through new materials with a lower fraction of grey energy, new high-performance materials with improved properties or the recycling of construction materials. Examples here include innovative cements with a significantly lower CO_2 balance and a recently developed aerogel insulating plaster. In both cases, basic research was conducted at Empa, while at the same time we are in close contact with industrial partners who can bring these innovative approaches to market as fast as possible. For example, in the next few months the first buildings will be insulated with the new plastering system.

We must rise to the challenge of doing comprehensive renovations of existing building complexes from the standpoint of technology, finances and urban design. To achieve this, we cannot limit ourselves to dealing with individual buildings; it is perhaps more important to address neighbourhoods, districts or even entire cities. This includes questions relating to well-being and health: how must buildings be arranged so there is no excessive heat build-up especially in urban environments (the "heat island" effect), which subsequently brings a large cooling load? How can we ensure that air pollutants do not accumulate in our cities?

Sustainable construction which conserves our resources means we must erect buildings for the long term and make sure their portion of grey energy and grey CO_2 is kept to a minimum. In this regard, lightweight construction has great potential, but there are still a few things we must optimise in terms of fire safety, acoustics and thermal masses – and these are all areas where Empa is actively conducting research.

However, (construction) research will eventually only be successful if it leads to practical applications, and so pilot projects are very important. A new material or system might promise to fulfill our expectations, but often this is proven only when it is first used in an actual building where interactions with other components and users come into play. The Forum Chriesbach at the Empa-Eawag campus, the "Self" container for living and working, which is self-sufficient in terms of energy, and the brand new "NEST" project are all examples of how Empa is promoting technology transfer and at the same time gathering new stimulus for its research. //

What's going on in this NEST?

The planned building lab on the Empa campus should serve, quite literally, as a platform for new ideas in construction and sustainable, energy-efficient solutions. Research modules for future residential and office rooms are installed on each open floor. Building services are supplied centrally from the inner core.

VISION
02

Plus-energy common room: intelligent glass architecture, adaptive photovoltaic protection from the sun, innovative lighting systems.

VISION
04

Creative workplace: efficient, networked working space, energy-conserving communication technologies, intelligent lighting.

VISION
05

Residential module for visiting scientists: passive room module made of state-of-the-art natural materials, the comfort of nature, minimal technology

Retaining the summer sun inside concrete

Concrete is the most popular construction material in the world, with 20 to 30 billion tonnes being used each year. A project at Empa now demonstrates that concrete is not only solid and durable, but can do far more: serve as a seasonal heat store.

TEXT: Nicole Döbeli / PICTURE: iStockphoto

A hot stone cools off slowly, especially if it is wrapped up in insulation material. Even so, it continually loses heat. Because it's not so simple to wrap up entire buildings that get heated up during summer, Empa researchers Josef Kaufmann and Frank Winnefeld sought another solution for a seasonal heat storage method.

Conventional concrete consists of up to 15 per cent of the mineral ettringite. When it warms up to above 50 °C, ettringite begins to evaporate water. If water is later added to the dehydrated material, the hydration reaction releases heat. In order to store as much thermal energy as possible, the concrete must thus contain the maximum amount of ettringite. That, however, is possible only with special cements, one being calcium sulphoaluminate cement (CSA), which has long been used for concrete production in China and can contain as much as 80 per cent ettringite. There is another advantage compared to conventional cement: during its production, CSA cement releases 40 per cent less CO_2.

Kaufmann and Winnefeld manufactured concrete slabs made of CSA cement and piled them up to blocks in which heating coils had been embedded. In the summer, if the blocks are warmed to 80 °C for instance with the help of solar collectors, the ettringite begins to release water. The vapour is collected and condensed. What remains is dehydrated concrete, which can be stored without any loss of thermal energy.

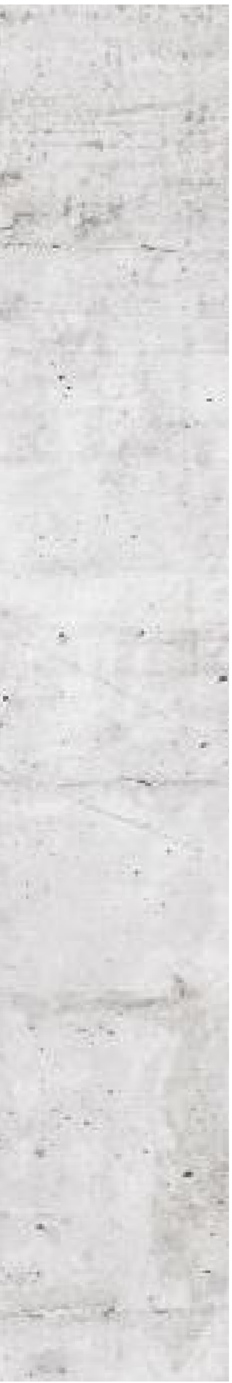
In winter, the process runs in reverse: water or water vapor is added to the concrete, taken up by the ettringite – which then releases thermal energy that can be "harvested" through the heating coils. The advantage compared to other thermal storage methods is that the release of heat can be regulated by the amount of water added to the concrete. In this way, for example, under-floor heating can be maintained all winter long at 25 °C, or domestic hot water can be kept at 40 °C.

The concrete storage scheme also offers another advantage; the difference in volume between dehydrated and hydrated concrete is insignificantly small as opposed to a paraffin wax storage system, which expands when the paraffin melts. To heat a single-family home (Swiss Minergie-Standard) over the winter months, a cube of concrete with a volume of 15 cubic-meters (fed by a collector area of 15 square-meters) would suffice, because the heat-storage-capacity is larger compared to a water or paraffin thermal storage unit. From a cost point of view, concrete is also competitive; a tonne of CSA-based concrete costs less than 400 Swiss francs, whereas a ton of paraffin is about 1000 Swiss francs. And with one to one and a half charging cycles per year, the "concrete heating" should last for at least 30 years.

Kaufmann and Winnefeld have already patented the process. They now intend to further develop and test the concrete heat store in collaboration with industrial partners. //

The Empa alternative: chemical thermal storage

Storing surplus summer heat for the winter months is also possible with what is known as sorption storage, for example with NaOH, in other words caustic soda. In a sorption storage system developed by Empa researcher Robert Weber, water is driven out of the NaOH sorbent during summer months using heat from solar collectors. The water vapour is condensed and stored separately from the dehydrated sorbent. In winter, the stored water is added back to the sorbent releasing thermal energy, which can be used to heat a home or produce domestic hot water. The advantage compared to conventional thermal storage systems is that there are no thermal losses during the storage period. In addition, the volume is roughly five times smaller than with a comparable water storage system; for a passively heated single-family house, a 7 m^3 storage tank is adequate to generate heat and domestic hot water from solar energy throughout the entire year.



And now the forecast …

With the help of a database and thermodynamics software, the properties of concrete can be calculated in advance and optimised accordingly. The benefits are substantial: CO_2 emissions can be reduced and building components kept up much longer.

TEXT: Nicole Döbeli / ILLUSTRATION: Empa

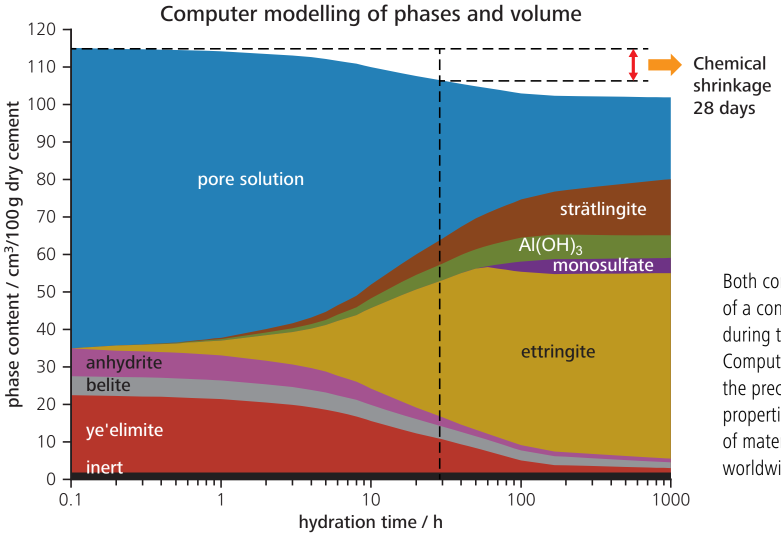
From six to eight per cent of the global CO_2 emissions are caused by the manufacture of cement, even though far less CO_2 is released per tonne of cement compared to steel or aluminium – specifically, just less than a tonne. The problem lies in the quantity. Globally, some three billion tonnes of cement are produced each year and rising.

One way to alleviate this situation is to use raw materials with a lower carbon content so that CO_2 emissions during cement production sink. If structures built this way kept up for much longer, that would be an additional step towards CO_2 reduction.

Barbara Lothenbach devotes her time to improving cement mixtures. Because there are (at least theoretically) any number of recipes for cement, she has helped develop a computer program to predict the chemical reactions during the setting of cement. GEMS (the Gibbs Energy Minimisation Selector), as the program is called, originated at the Paul Scherrer Institute (PSI) where it will be developed further. GEMS performs thermodynamic modelling of materials, and it calculates how materials behave and change under certain circumstances and over time. Lothenbach has "fed" GEMS with the values from Empa's cement database. This allows her to model a virtual manufacturing process using all cement minerals and additives registered in the database to create every possible mixture and then calculate their properties and behaviours – even over a span of years.

One research project, for instance, is addressing the long-term stability of concrete in the construction of tunnels. If mountain water containing sodium sulphate penetrates into a tunnel, it reacts with the concrete to make ettringite and thaumasite, two minerals that reduce concrete's structural strength and thus make it more prone to flake or chip off. With the help of GEMS, Lothenbach can simulate this reaction. That make it possible, when planning a construction project, to select a suitable cement mixture to prevent the build-up of ettringite and thaumasite. For example, fly ash can be mixed into the cement to make it more resistant to water containing sulphates. With this computer simulation, Empa is a worldwide leader in the thermodynamic modelling of cement. //

Computer modelling of phases and volume



Both composition and volume of a concrete sample changes during the setting process. Computer modelling helps with the precise prediction of the properties for a given mixture of materials. Empa is a worldwide leader in this area.

A good insulation pays off

Using state-of-the art electronics, Empa researchers are investigating replicas of walls from older buildings in the lab to test and improve innovative interior insulating materials and renovation techniques. Not only homeowners will benefit from optimally insulated buildings – but Switzerland's carbon footprint, too.

1

TEXT: Rainer Klose / ILLUSTRATION: André Niederer / PICTURES: Empa

Energy policy starts in the living room, because comfortably warm Swiss homes make the country dependent on imported oil and gas. The Swiss Federal Office of Energy (SFOE) measures this dependency each year and it's increasing. In 2010, energy consumption reached a new record: 911,550 terajoules (253 billion kilowatt-hours), which is 4.4 per cent more than in 2009 and a solid 30 per cent increase compared to 1980.

Are we at least ecological when it comes to our energy consumption? Not really. Last year, we imported among other things 4.5 million tonnes of light heating oil and 3.1 million cubic metres of natural gas. Taken together, these non-renewable energy carriers covered approximately a third of Switzerland's energy needs. In contrast, renewable energy didn't come anywhere close – 0.2 per cent each from biogas and solar power, and 1.2 per cent from environmental sources of thermal energy (geothermal, water, air).

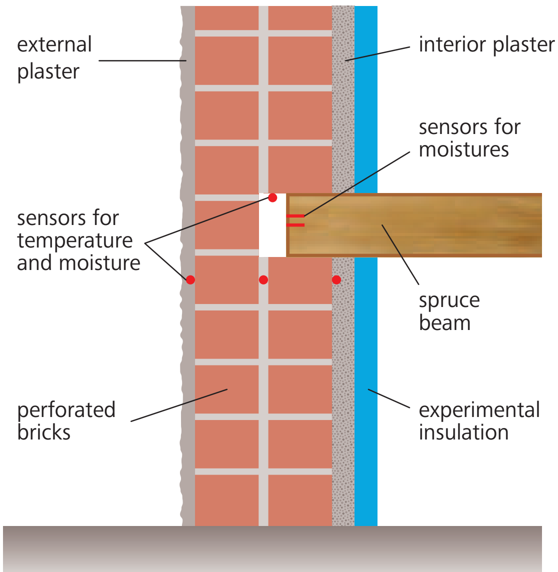
The conclusion is simple: we continue to heat our homes, offices and public buildings primarily with imported fossil fuels. According to SFOE statistics, room heating "eats up" more energy than all domestic transportation in Switzerland, it consumes twice as much as all industrial processes, ten times more than all lighting and 30 times more than communications, Internet and consumer electronics. Reducing CO_2 emissions, therefore, is mainly about one thing: insulating buildings. Not only new construction must fulfil increasingly higher standards, but especially older buildings – in Switzerland roughly 1.4 million of them – must be renovated to conserve energy.

The challenge here is that the Federal Commission for the Protection of Nature and Cultural Heritage wants to preserve the visual appearance of historical buildings and seldom allows insulation on the exterior. And so the only choice is insulating from inside, a solution with a number of strings attached to it. Insulation done too well can threaten an older building, even ruining it to the point where it is uninhabitable, says building physicist and engineer Thomas Stahl. "If old brick walls are insulated from inside, the wall can freeze through on the outside. That brings the danger of frost spalling, which impairs load capacity." Things can get even worse if load-bearing wooden beams are insulated improperly. "Condensate develops on a beam's raw edge, and it can rot through within just a few years. Then you might as well tear the house down," the Empa researcher says.

1
High tech and older buildings: this electronic humidity sensor is situated behind the exterior surface of the reconstructed wall similar to what you might find in an older building. Dozens of sensors are installed in the test walls, and their readings indicate how well the insulation is working.

2
Insulation tests being conducted on three test walls: each exterior wall is exposed to severe climactic conditions (sun, rain, sub-zero temperatures) in a climate chamber, while the «interior wall» is accessible from the laboratory.

3
Project leader Thomas Stahl explains the construction of the wall section. The new insulation should not result in the beam getting mouldy, otherwise the building's structural stability is at risk.



To avoid this, Stahl is systematically investigating the interaction of old buildings with modern methods of insulation. But how do you simulate an older building? Quite simply – with bricks, roughcast and wood, in other words, the building materials of those times. Also needed is a powerful environmental chamber in which these materials can be "tortured".

The set-up

Located in the construction hall at Empa there are three identical wall sections which represent typical home construction from the 1950s. They have support structures made of red perforated brick, an outer skin of limestone cement plaster, and an inner layer of white lime plaster with no insulation. In addition, a spruce beam is sticking into each wall; inside, it rests on a piece of the wall and is protected from outdoor weather conditions only by a thin brick wall. "With this section of the wall we can test how our insulation interacts with a typical ceiling beam of an older house", explains Stahl. The spruce beam is more than 100 years old and was purchased from a dealer specialising in historical construction materials.

2

3

The experiment

The wall sections are then placed within Empa's climate chamber and subjected to tests designed by EOTA (European Organisation for Technical Approvals). The exterior wall is exposed to rain and sun for 25 days, cooled to temperatures below freezing and warmed up once again. The inside of the wall section remains at laboratory conditions: 40 per cent humidity, 22 °C. "This test is quite dramatic", says Stahl, "and it simulates the actual stresses that arise over more than a year."

After data for the unaltered wall is collected, the walls are insulated and once again subjected to the EOTA test. Here, special attention is paid to see if something goes wrong. Does water collect in the wall? Does the beam get damp? In case of doubt, the test is repeated with the beam left unprotected without any insulation. According to Stahl, "We want to document how to avoid mistakes."

In order to determine if a wall being tested is getting cold or wet, Empa researchers embed specially developed moisture sensors within the plaster. The spruce beam is also studded with sensors. The old construction wall in the Empa laboratory is in fact a completely wired high-tech climate spy, and a perfect foundation for performing insulation experiments. "We want to know exactly what is happening inside the wall, why it happens and how bad things get when it happens," explains Stahl.

The experiments at Empa are not being conducted in isolation but rather as part of a larger research project called Sahib (Sustainable Renovation of Historical Buildings). Three industrial partners are involved in the first round of experiments. They supply a variety of insulating systems (see box) and want to run a comparison test under identical conditions.

The findings

The goal of this head-to-head comparison, though, is not to name a winner or a loser. Of course, not every material has equally effective insulating properties. The test will show what new types of insulation have to offer – as well as their limits. Afterwards, the materials will be entered into an international database for construction materials, which will be accessible to architects and designers around the world. Properties to be listed will include, among other things, the sorption isotherm (a value for moisture retention), thermal conductivity, thermal cappacity, porosity and density as well as the water vapour diffusion resistance factor μ (see box). In addition to raw numeric values, the tests also supply knowledge about the interaction of the insulation with the entire wall system. In this way, manufacturers can access detailed knowledge about the material properties of their products. Their customers then purchase construction materials, which have been extensively tested-instead of buying a pig in a poke.

Theory and practice

The experiments will also pay off for Thomas Stahl. The future of building technologies lies in computer simulation, fed with data about various materials. Data from the 25-day EOTA test can be extrapolated to many years on a computer. Because the test walls can be reused and equipped with new layers of insulation, Empa's investigations over the next several months will supply large amounts of new data, which can be used to refine current computer models. Both homeowners and tenants will profit from this knowledge, and in the long run, also the Swiss carbon footprint. //

Empa testing of interior insulation

EPS (extruded polystyrene) with capillary active additive, thermal conductivity approx. 0.035 W/(m K), water vapour diffusion resistance factor* approx. 30, weight by volume 20 – 40 kg/m^3
Aero gel insulation sheet, thermal conductivity 0.0131 W/(m K), water vapour diffusion resistance factor* 11, weight by volume 150 kg/m^3
Vacuum-insulated panel, thermal conductivity 0.007 W/(m K), water vapour diffusion resistance factor*: impervious to water vapour, weight by volume 180 – 220 kg/m^3

* The water vapour diffusion resistance factor μ indicates the permeability of a material to water vapour compared to a stationary layer of air. A higher value of factor μ means the material is more impervious to water vapour. Because of issues dealing with interior climate, many building owners prefer water vapour- permeable construction materials. Experts, though, disagree as to what conclusions to draw from this parameter.

A window for any occasion

Smart glass, which becomes dark, translucent or UV-reflective at the push of a button, offers considerable advantages in building technologies. Manufacturing such glass, though, is complicated and expensive. Empa researcher Matthias Koebel is on a quest to find cost-effective processes.

TEXT: Rainer Klose / PICTURES: Empa, iStockphoto

Someday soon, rolling down window blinds will be considered hopelessly old-fashioned. When people get home in the evening, they will turn on the lights and, instead of drawing their curtains closed, will simply "dial up" their living room windows using a smartphone app. In an instant, those windows will become translucent, and the evening will begin undisturbed by neighbours' curious gazes.

To make such visions reality, we need what is referred to as smart glass. These are window panes with coatings, which change their optical properties when an electric voltage is applied: from clear to translucent, from bright to dark, from transparent to reflective. They will make window blinds superfluous, curtains will be nothing more than decorative elements.

Matthias Koebel, an expert in the chemistry of colloids and surfaces at Empa, is working to bring this type of futuristic window into our lives. Smart glass already exists today, but manufacturing it with complex vacuum sputtering processes is expensive. Thus, these days we encounter smart glass only in small surfaces: automotive rear-view mirrors that dim themselves automatically, museum showcases, which become translucent and serve as a projection screen, or cabin windows in the new Boeing 787 Dreamliner turning dark at the push of a button. It would be very desirable to make all of these properties available to large glass surfaces, but to do so we need an inexpensive coating method which can easily be adaptaed to large industrial processes.

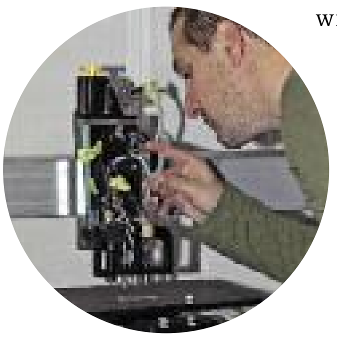
Colloids from an ink jet printer

This is where Koebel enters the scene. He is an expert in colloidal solutions and thus very experienced in getting insoluble materials to "hover" in liquids or to turn them into extremely small particles invisible to the eye. Koebel is convinced that with the help of colloids it should be possible to create inexpensive coatings on large surfaces.

The first experiments are already under way, and Koebel's laboratory is equipped with a type of professional ink jet printer. "With it, we can apply thin layers of only 100 to 200 nanometres on glass. They dry within seconds and afterwards can support additional functional layers", explains the researcher. "This lets us systematically build up layered structures of high complexity." An important aspect for this functionality is a uniform layer thickness. After they dry, finished samples are examined with a scanning electron microscope (SEM), atomic force microscope (AFM), optical spectroscopy and other conventional surface-specific methods.

Within Empa, Koebel is coordinating the "Empa Window" project, leading a team which deals exclusively with smart materials for windows. These activities, which began just several months ago, are already bearing their first fruit in the form of two EU project proposals. In both cases, the research partner is the Fraunhofer Institute for Solar Energy Systems (ISE) in Freiburg/Germany. The researchers at ISE have decades of experience with glass coatings, and in this project they are developing a "dry" sputtering process, in which the coatings are vapour-deposited in a vacuum. Empa, in contrast, is investigating the possibilities and properties of layers applied with "wet chemicals", specifically using colloidal solutions.

It could be quite some time, though, before the first electrically switchable panes of glass are available on the market. Thus, whether they like it or not, today's home owners will still have to install "old-fashioned" window blinds, but their replacement is already being worked out in Dübendorf. //



Matthias Koebel fills his "lab printer" with a colloidal solution. The functional layer is printed on a glass microscope slide, dried and then analysed in a scanning electron microscope.

"Steam blasting" with real gold

Empa researchers are writing fashion history with a vacuum coating system. Using high tech methods, they can produce a yarn with a layer of pure 24-carat gold. This spring, the material will have its premiere on the catwalk of an haute couture collection; a line of neckties is already available.

TEXT: Rainer Klose / PICTURES: Empa; Vincent von Ballmoos

Project manager Martin Amberg is looking through a peephole inside his coating system, obviously pleased, even though there's really not much to see. Violet light fills the interior of the apparatus roughly the size of a home refrigerator. Threads are strung up side by side in the machine and move past the peephole.

The violet light emanates from a piece of gold which is degraded into its atoms by high-energy radiation. The result emanates from the other end of the apparatus. A thin tube, almost like a straw, points upwards; from its top, a thread is pulled out and wound on a bobbin. The coiled thread shines with a golden hue in the sunshine coming through the window into this industrial building.

In an adjoining room at the Tersuisse spinning mill in Emmenbrücke, with Empa's assistance, a world's first is taking shape: a fibre with a 24-carat gold coating. Fabrics woven from it sparkle with the characteristic colour of this precious metal, but they don't require customers to make any compromise. The fibres have a soft feel, are abrasion-proof and can even be safely put in a

>>

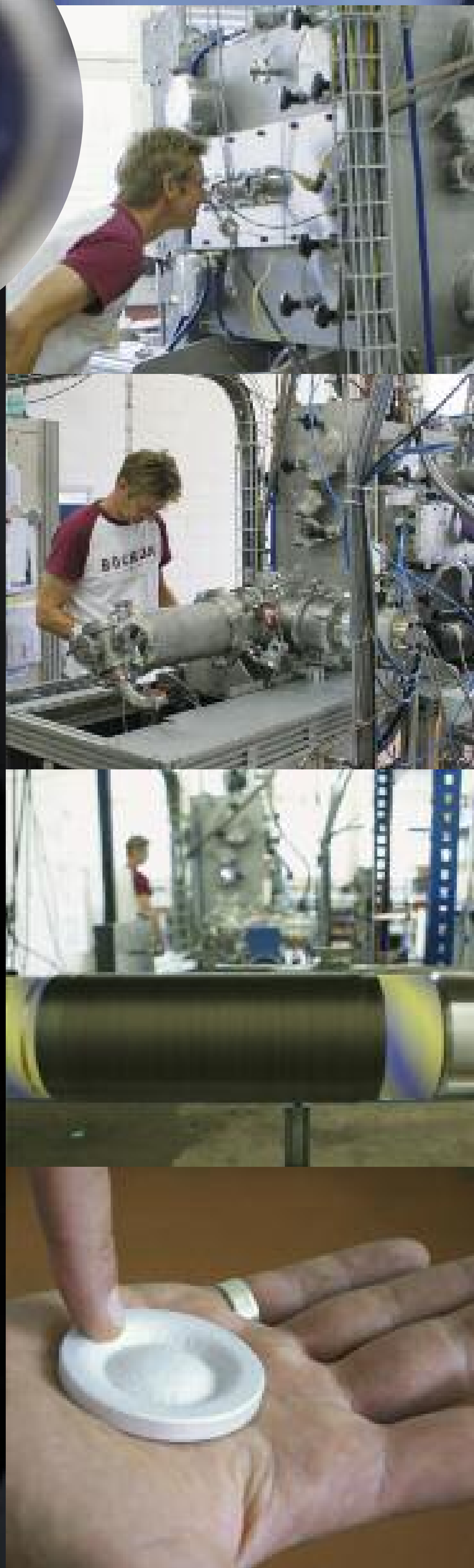
washing machine. This fibre has been in production since summer of 2011. The first batch went to the spinning mill at Weisbrod-Zürrer AG in the town of Hausen am Albis, where it is processed together with black silk into material intended for ties. Starting with a panel of fabric which contains 25 grams of gold, it is possible to make three ties, a bow tie and a pocket handkerchief. It goes without saying that such products are not an inexpensive indulgence.

But how does the gold get on the fibres? Empa researchers decided to use a process called magnetron sputtering. For this, they require only a bit of electricity, a medallion made of gold, a few litres of argon gas and a vacuum container large enough to unwind 4,000 metres of thread in narrow loops. Anyone who has assembled all this can vaporise gold at room temperature and fabricate gold thread. Inside the coating system, the gold piece, called a target, is bombarded with fast-moving argon ions. Atoms of gold are “knocked out” and deposit themselves on a polyester thread, which is pulled slowly through the machine just a few centimetres from the target.

Of course, things aren’t quite that simple, the devil is in the details: for instance, how the polyester thread has to be prepared so that gold actually sticks to it, which operating voltage and layer thickness yield the best effect – all trade secrets. When the first proud owners will put on their gold ties at Christmas of 2011, this moment will mark the culmination of a 10-year research project. That’s how long textile experts at Empa in St. Gallen have been testing and refining the magnetron sputtering method. To gain systematic experience, they sputtered all sorts of metals – titanium, aluminium, steel, copper and silver – and let them rain onto various fibres.

The project’s goal was initially a thread of silver, which immediately found a number of markets. Silver-coated fibres have an antibacterial effect, something of interest to, for example, clothing manufacturers who use it to make odour-free socks. In addition, fashion designers were looking for durable silver-coated textiles. Furthermore, silver conducts electricity extremely well, making the Empa-developed fibre extremely well suited for use in various sensors and as an antistatic filter material for industrial applications. “What is possible with silver might also work with gold”, the project partners thought to themselves. So in January 2010 they started working on “Project Gold Fibre”.

There were, however, many problems to be solved. How much gold is necessary to make the threads shine? Does a base of silver improve the sheen? Can silver and gold be applied in the same stage, thereby allowing an “alloy” to be manufactured directly on the thread? The result of a series of tests showed that an amount of 3 grams of pure gold per kilometre of thread produces a lovely sheen in



1

a discrete antique shade of gold. Further, if the base is made of silver, the gold shines considerably brighter; the colour is as striking as on a large piece of gold jewellery. The silver layer can be applied in the same process stage if gold and silver targets are inserted next to each other in the machine and are bombarded simultaneously. Thus, a gold coating can be manufactured for a wide range of fashion accessories and various tastes. While a businessman might want a tie in a discrete antique gold, it might be desirable to have the delicate embroidery on a woman's evening gown shine somewhat brighter.

After 24 months, Project Gold Fibre is reaching a successful conclusion. The further processing of the yarn is being taken over by two partner companies who were involved in the project from the very beginning: Weisbrod-Zürrer and the embroidery and decorative material factory Jakob Schlaepfer in St. Gallen. A limited series of gold ties is already on sale for the Christmas season. Because of the limited amount of available gold fibre, there will only be a dozen gold ties for affluent customers around the world. Exclusivity, a precious material and high-tech production methods have their price – a buyer must come up with 7,5000 Swiss francs for a tie. For this price, though, he can be assured that he is wearing roughly eight grams of pure gold.

In future, too, the gold ties won't be going into mass production. At full capacity, 600 pieces could be manufactured annually. Certainly, though, it will be far fewer because a part of the fabric production is being reserved for the second project partner, Jakob Schlaepfer, who plans on using the golden fabric for its winter 2012/13 haute couture collection, which will be presented this spring. //

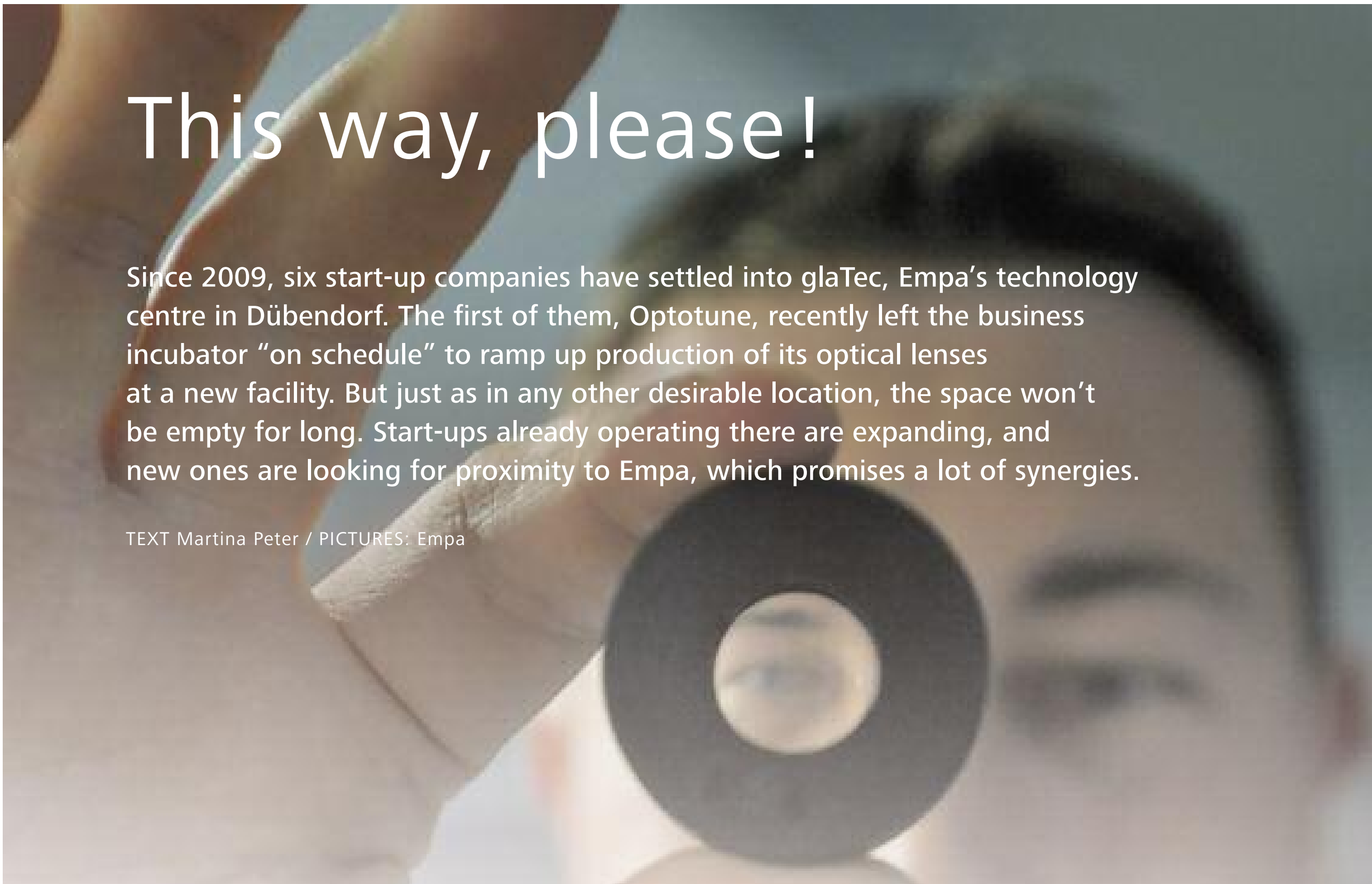
2

1
Project leader Martin Amberg monitors the vacuum-coating system, in which a simple polyester thread is "transformed" into a true gold thread. Bottom photo: a silver target that has already been used. Bombardment with argon ions etches a circular groove in the metal.

2
On location at the Hofmann tie plant in Zurich: the gold fabric consisting of gold threads and black silk is cut by hand and sewn into an elegant tie. Bottom photo: Martin Amberg and textile engineer Chokri Benkhaled Kasdallah are very pleased with the result of their efforts.

Video:
Gold-plated clothes

http://tv.empa.ch/empa_tv_goldkrawatte_20111201.m4v
For smartphone users: scan the QR code
(e.g. with the "scanlife" app)



This way, please!

Since 2009, six start-up companies have settled into glaTec, Empa's technology centre in Dübendorf. The first of them, Optotune, recently left the business incubator "on schedule" to ramp up production of its optical lenses at a new facility. But just as in any other desirable location, the space won't be empty for long. Start-ups already operating there are expanding, and new ones are looking for proximity to Empa, which promises a lot of synergies.

TEXT Martina Peter / PICTURES: Empa

Optical instruments for the aerospace market; a wireless monitoring system for mechanical structures; an intelligent bed for the bedridden; a process to analyse and sort grain by the tonne; resilient components for machine construction; optical lenses, the focus of which can be changed continuously – all these products and processes come from a single building, Empa's glaTec technology centre in Dübendorf. Or in other words, from the companies that operate there, including Empa spin-offs and other start-ups whose names have a high-tech ring to them such as Decentlab, compliant concept, QualySense, Monolitix, Optotune and Micos Engineering.

When the first start-up – Optotune – moved into glaTec, its founders already had something in their arsenal that many young companies lack: a fully-fledged business plan with a pretty mature idea about their product. The company's flexible optical lenses, which can be focused continuously with "artificial muscles", are clearly superior to conventional systems in terms of size, manufacturing costs, energy consumption and robustness. Even so, "It's possible to put together a demo version in virtually no time, but the real test is whether you can also sell it to potential customers", relates Mark Blum, co-founder and COO of Optotune. The products from this start-up can be used in a variety of applications, for example in lighting fixtures for museums, shopping centres or homes, but also for fast-operating barcode scanners or as an optical zoom in a smartphone.

What the Optotune team was looking for and found in 2009 at Empa's business incubator was urgently needed space with the necessary infrastructure as well as a research group in immediate vicinity working on a similar topic – electro-active polymers (EAP) or artificial muscles. With Empa researchers led by Gabor Kovacs and Silvain Michel, they were not only able to exchange technical ideas but also set up a suitable laboratory – an aspect of importance to Empa. "For us, it's a central concern that start-ups are a good fit with Empa so we can develop joint research projects", notes glaTec's Managing Director Mario Jenni.

Different challenges

Each start-up faces completely different challenges. For Optotune, finding suitable premises as well as having contact with other researchers was most important, whereas other start-ups might need help with market studies or coaching for (often tedious) negotiations with potential investors. "Especially in the early phase of establishing a company, a path is chosen, which somehow predetermines the chances for ultimate success", points out Jenni. Therefore, it's crucial for neo-entrepreneurs to seek out support at a rather early stage. This means, for instance, bringing experts into the team to address business issues or to guide the new-comers during negotiations. Adds Jenni, "This is eventually the path to independence."

What is glaTec?

The non-profit promotion agency glaTec operates a technology centre at Empa in Dübendorf to support the establishment and development of companies and innovative processes in the areas of materials and environmental science and technology. glaTec is funded by Empa, Eawag (the Swiss Federal Institute of Aquatic Science and Technology), glow (the Glatt Valley Economic Promotion Agency), the Economic Promotion Agency of the canton of Zurich as well as the cities of Dübendorf and Zurich. *www.glaTec.ch*

Success at glaTec

One hundred experts recently selected Optotune as the best start-up of the year under the auspices of ifj Institut für Jungunternehmen (Institute for Entrepreneurship) in St. Gallen. The ranking lists a total of 100 companies from all over Switzerland. In addition, the two glaTec companies QualySense (#26) und compliant concept (#73) also made it into the Top 100.

Laboratory-testing of a compliant concept mattress.

Video:
Plastic muscles for mobile phone cams

http://tv.empa.ch/empa_tv_neuartige_linsen_20090402.m4v
For smartphone users: scan the QR code
(e.g. with the "scanlife" app)

Potential tenants at glaTec are spin-offs from institutions within the ETH Domain, external start-up companies, R&D units working separately from their companies as well as public-private partnerships. Optotune is a spin-off of ETH Zurich; at this time, glaTec is home to three Empa spin-offs, one external start-up and an ABB spin-off (see table). "Our focus", explains Jenni, "is clearly on early-phase projects working in the areas of materials science, environmental science and technology." It goes without saying that not every company that would like to become part of this Empa technology centre can be accepted. The admission process is quite selective; projects are first painstakingly evaluated by glaTec's Advisory Committee. Businessmen, CTI start-up experts as well as those with experience in marketing, legal issues and financing examine the applications in great detail, sounding out the proposals with regards to innovation, market potential and feasibility. Only then does Empa's Board of Directors take a decision as to whether a company will be accepted into their incubator.

Advice, support, contacts

It sometimes happens that members of the Advisory Committee also take on the role of coach who can address the start-up's key issues, just in case Jenni, an experienced businessman himself, can't provide further assistance. For such situations, he has ready access to a large number of contacts from his professional network or can provide tips as to how and where to find the right expert for a specific problem. Jenni also works closely with other entrepreneurial promotion agencies such as the Swiss Innovation Promotion Agency CTI, tebo (Empa's technology centre in St. Gallen) and ifj Institut für Jungunternehmen (Institute for Entrepreneurship).

Start-ups which set up operation in the business incubator can stay as long as three years. During this time, they profit from advantageous rental rates and Empa's first-class infrastructure. Afterwards, the companies should have sufficient equity or debt capital to set up operations elsewhere – and free space for other budding companies.

Optotune was successful in doing just that. As planned, this past summer the company moved to Dietikon in the Limmat Valley, where it is ramping up production of its lenses so as to be prepared for the new-product introductions of its various customers. Concerning the initial assistance they received at glaTec, the successful entrepreneurs are extremely grateful. "We'll never forget the friendly, cooperative people we had the pleasure of getting to know at Empa", they wrote to Jenni.

Now that Optotune has moved out of the Empa complex, there are currently five companies residing in the technology centre, three of them Empa spin-offs.

- compliant concept GmbH is developing an intelligent bed system with the goal of preventing the bedridden from developing bedsores.
- Decentlab GmbH supplies a wireless monitoring system for the flexible supervision of structures and construction sites.
- Monolitix AG develops and markets components and systems for machine construction, in particular solid joints as well as compliant mechanisms and systems.
- The external start-up QualySense AG offers a process, which sorts grain deliveries by the tonne, doing so with high precision according to biochemical parameters.
- The ABB spin-off Micos Engineering GmbH specialises in optical instrumentation for the European space market. //

New member of the Empa Board

At its December meeting the ETH Council, the strategic management and supervisory body of the ETH Domain, appointed a new member to Empa's Board of Directors: Brigitte Buchmann, a chemist and expert in air pollution emissions. She will assume leadership of the Mobility, Energy and Environment Department on 1 September 2012.

In her role as department head, Brigitte Buchmann will succeed Peter Hofer, who is retiring in mid-2012. She studied chemistry at the University of Zurich and in 1988 received her PhD in organometallic chemistry. In 1989, Buchmann joined Empa and managed the Emissions Group in the Laboratory for Air Pollution/Environmental Technology. She also took over as project manager of the National Air Pollution Monitoring Network (NABEL), which helps establish the scientific basis underlying Swiss air-pollution policy. Based on her experience and success with the Swiss measurement network, she has since 1995 headed up the World Calibration Centre for ozone within the Global Atmosphere Watch Programme (GAW) of the WMO (World Meteorological Organisation).

As Laboratory Head since April 2002, Buchmann has consistently focused on developing new techniques for measuring atmospheric trace substances as well as on computer modelling of pollutant sources. She used satellite data to investigate Switzerland's air quality and in this way "propelled" pollution measurements into the third dimension. As a member of the Swiss Commission for Space Affairs as well as serving as a Swiss delegate to the ESA, she was involved at a strategic level in the use of satellites for earth observations.

Taking a peek inside

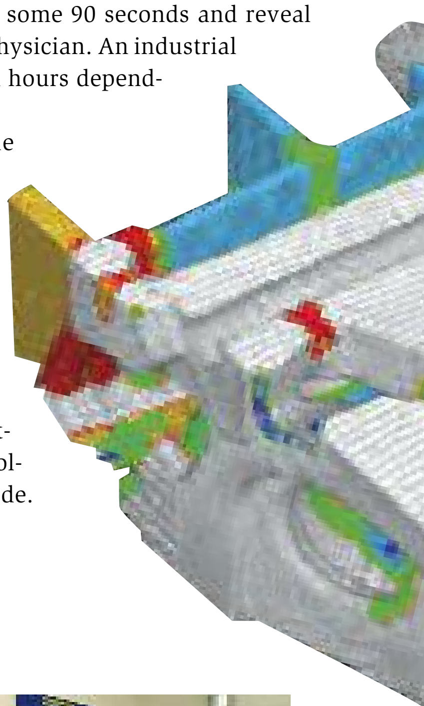
It was during a company Christmas party exactly 20 years ago that Empa took delivery of its first computer tomograph. Today, Empa is one of the leading institutes in the area of industrial computer tomography and operates four systems. But it's by no means just industrial components ending up under the X-rays...

Consider, for example, cheese. What is the distribution of holes in Swiss cheese? This was one of the tasks assigned to Empa during an applications contest. The most challenging ones were selected, and for each one a computer tomograph (CT) scan was made at no charge. By looking at the cross section of a wheel of cheese it is possible to see exactly how many holes it has, how large they are and where they are located.

Empa's CT experts have also peeked inside a Toblerone chocolate, trumpets, rhinoceros skulls and gold Celtic artefacts. These "exotic" cases, though, are the exception rather than the rule. Nine of ten contracts come from industry, which depends heavily on the nondestructive testing of components or 3D analyses. For example, what if the blueprints for old components are no longer available but new parts must be manufactured according to the old pattern? A computer tomograph of the original component reveals how it was designed and built.

In contrast to a medical computer tomograph, those for industrial purposes must be much more precise. Correspondingly, industrial tomographs take much longer to illuminate everything inside. A medical CT scan can take some 90 seconds and reveal everything that is important to a physician. An industrial CT scan, though, can take several hours depending on the system and material.

Empa works with one of the largest computer tomographs in Europe. With it, researchers can make images of components weighing as much as two tonnes such as parts of lorry engines. At the other end of the scale, things are wide open, too. The Empa tomograph has no problem at all spotting a 25 micrometer error on a solder joint just a few millimetres wide.



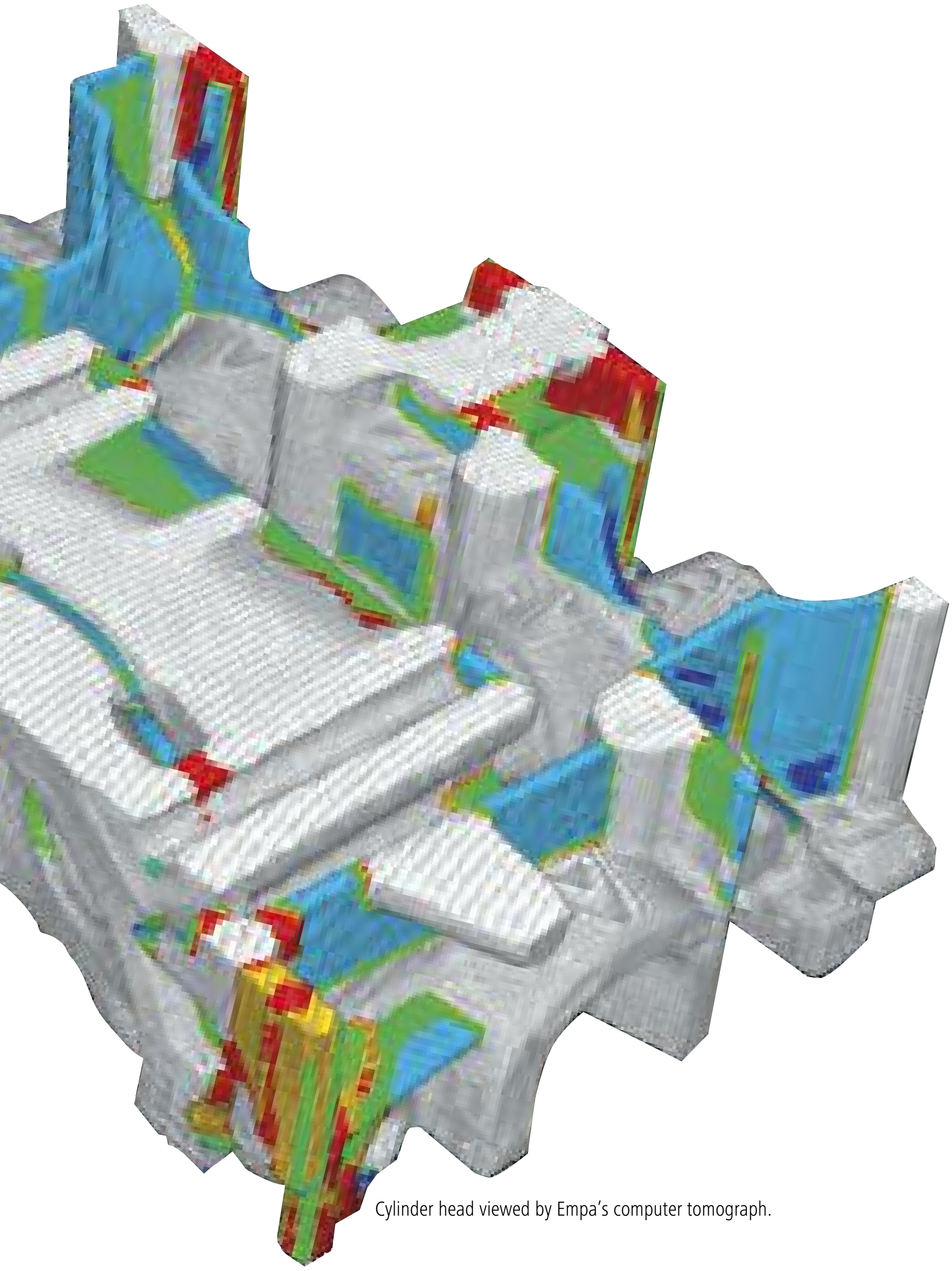
Alexander Flisch prepares a fossil for the CT analysis.

2011 Swiss Design Prize

Textile designer Annette Douglas has received the highly coveted 2011 Swiss Design Prize in the category "Textile Design Award A" for the CTI project "Sound-absorbing, translucent and lightweight textiles". She was awarded the prize together with the company Weisbrod-Zürrer and Empa scientists Reto Pieren and Kurt Eggenschwiler, who worked out the acoustic fundamentals for the world's first sound-absorbing and translucent curtain.

The two experts from Empa's Acoustics/Noise Control Laboratory first developed a computer model, which not only describes the fabric's microscopic structure but also its macroscopic composition. Then, with the help of acoustic measurements on woven samples, they optimised the fabric. Next, Douglas succeeded in translating the new findings into weaving techniques. Finally, Weisbrod-Zürrer customised the manufacturing process so that the curtains can now be produced on an industrial scale.

The jury praised these efforts, saying that the materials are a true, valuable innovation, which should soon be established on the market. "They are characterised by a simple, unobtrusive appearance, which nonetheless retains elegance and class, and they will open entirely new opportunities for interior design."



Cylinder head viewed by Empa's computer tomograph.

Energy from sewage sludge

Producing energy from waste – that was the topic of Silvan Weder's high school graduation project. Inspired by an article in "Spektrum der Wissenschaft" – the German edition of "Scientific American" –, he got in touch with Empa. "The goal was to produce energy exclusively from biogenic waste products so that power generation does not compete with foodstuff production", he explains. Working with Empa researcher Andreas Borgschulte, he created an experimental set-up. In it, biowaste such as plant debris is deposited in an airtight container, which is placed in a water bath with a constant temperature of 60 °C. Beforehand, though, the biowaste is injected with sewage sludge containing special thermophilic bacteria, which produce hydrogen while fermenting the material. The resulting gas can then be used, for instance, in a fuel cell to generate electricity.

"The tragic incidents in Fukushima have further sparked discussions about alternative sources of energy", notes Weder, "and tying this topic into current global events fascinated me and was an additional motivation." Research has been conducted around the world for quite some time to produce hydrogen from energy crops such as corn. Biogenic waste represents an alternative that would be more sustainable.

Opinion

Johann N. Schneider-Ammann

Federal Councillor
Johann N. Schneider-Ammann
Swiss Minister for Economic Affairs

“As entrepreneur, I have often sought collaboration with Empa. I’ve thus come to appreciate what an exceptional performance they effect. Empa, to me, is at the heart of Switzerland’s knowledge and technology transfer network and a key to our success in creating innovations.”

Events

9 January 2012
Seltene Metalle für Zukunftstechnologien
Empa, Dübendorf

13 January 2012
Faserverbundwerkstoffe im Automobilbau und Transportwesen
Empa, Dübendorf

19 January 2012
Feinstaub – Inhaltsstoffe und Quellenzuordnung
Empa, Dübendorf

25 January 2012
Nanotechnologie für den Cleantech-Bereich
Stade de Suisse, Bern

5 March 2012
Holzforschung an der Empa
Empa, Dübendorf

7 March 2012
Nanotechnologie – Neue Materialien mit Chancen und Risiken
Empa, Dübendorf

16 – 20 April 2012
Intensive course: Nanopowders and Nanocomposites
Empa, Dübendorf

26/27 April 2012
3-Länder-Korrosionstag
Empa, Dübendorf

12/19/26 June 2012
Fahrzeugflottenmanagement – ganzheitlich betrachtet
Empa, Dübendorf

Details and additional events at
www.empa-akademie.ch

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