Empa News

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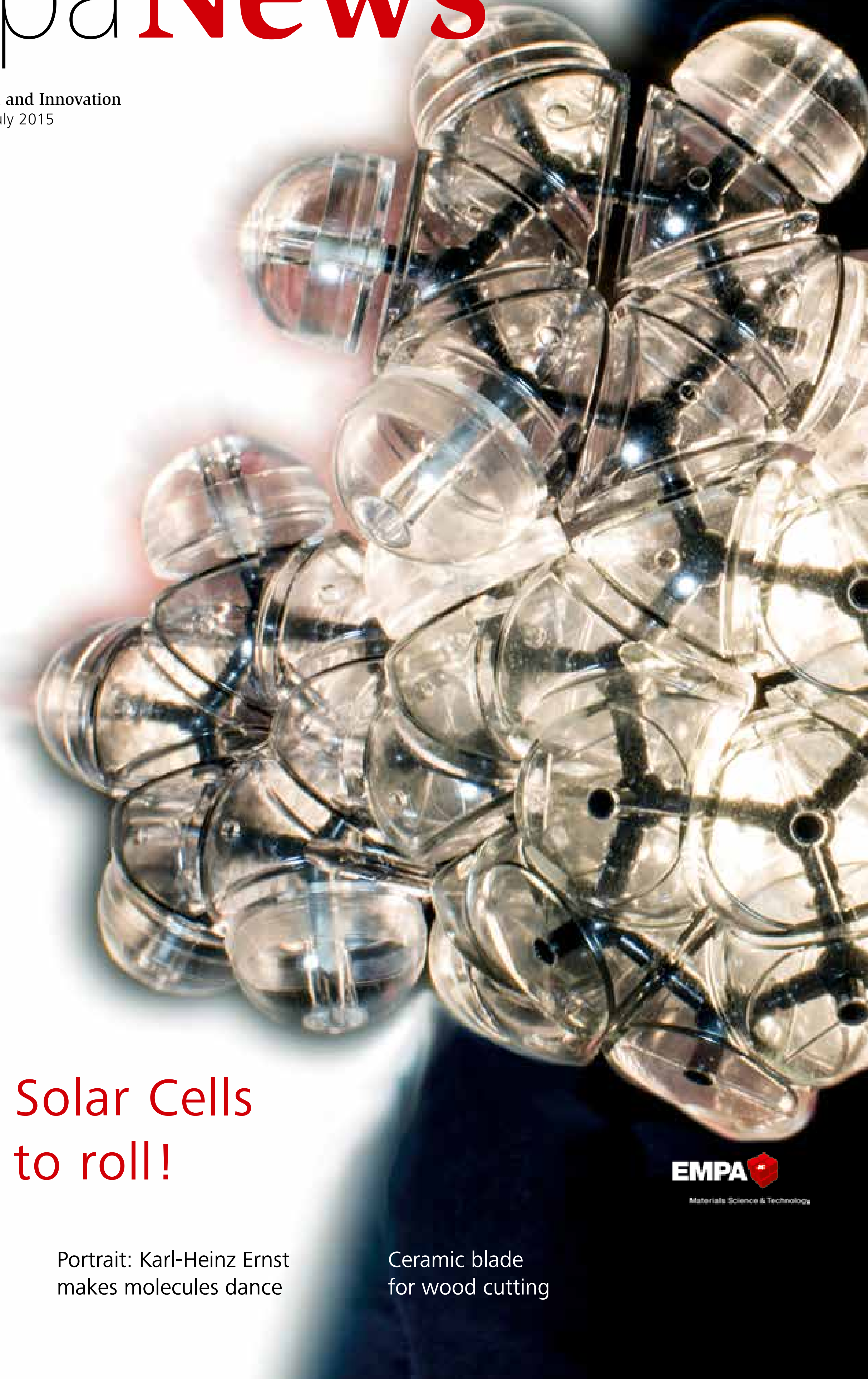


Flexible Solar Cells – ready to roll!

EMPA
Materials Science & Technology

Anesthetics in Antarctica

Portrait: Karl-Heinz Ernst makes molecules dance

Ceramic blade for wood cutting

MICHAEL HAGMANN Head of Communications

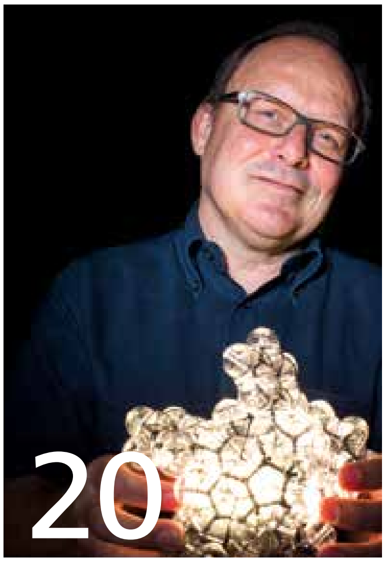
Out and about

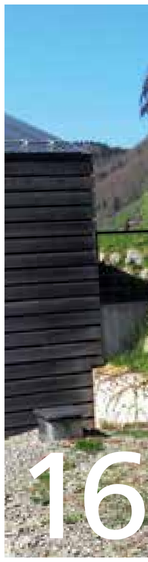
Almost all research labs the world over have one thing in common: they give rise to new, unprecedented innovations. The novel ideas, concepts, technologies and materials that Empa researchers and engineers conceive and develop need to hold their own in the real world, too, i.e. pass the practical test. After all, Empa researchers want to make a difference and help find solutions to pressing questions, whether it be in the energy or healthcare sectors or in the quest for a clean environment.

Therefore, the true litmus test for innovations does not take place in the lab, but rather "on the street". Empa scientists are, therefore, frequently out in the field – at the Korean King Sejong research station in Antarctica or on the Jungfraujoch to analyze air samples and trace climate gases and other man-made air pollutants, for instance (p. 8 ff.). Or at the inauguration of a pilot production plant for flexible thin-film solar cells, with which Empa/ETH Zurich spin-off Flisom is hoping to shake up the solar industry (p. 4). Or near Rütli mountain meadow, where a home-owner has had the first prototype of a novel Empa "concrete heating system" installed in his garage (p. 16).

The latter example also goes to show how the transfer of technology from the lab to practice sometimes takes place in peculiar ways – and that a healthy dose of courage is always necessary: a few years ago, home-owner (and construction physicist) Mark Zumoberhaus read an article in a commuter newspaper about the concrete heat storage system that was being developed at Empa and immediately got in touch with the researchers. This coming winter, the visionary will be heating his vacation home in Seelisberg with solar power from Empa's ettringite concrete for the first time – without any guarantees or double flooring whatsoever. Hats off!

Enjoy reading!





Cover
*Molecular model of Karl-Heinz Ernst's "waddling duck": the researcher specializes in chiral structures and specifically constructed molecules, which can move when «tickled» by the scanning tunneling microscope (STM). In February 2015, Empa awarded him the title of «Distinguished Senior Researcher». **Portrait on page 20.***

Focus

Atmosphere

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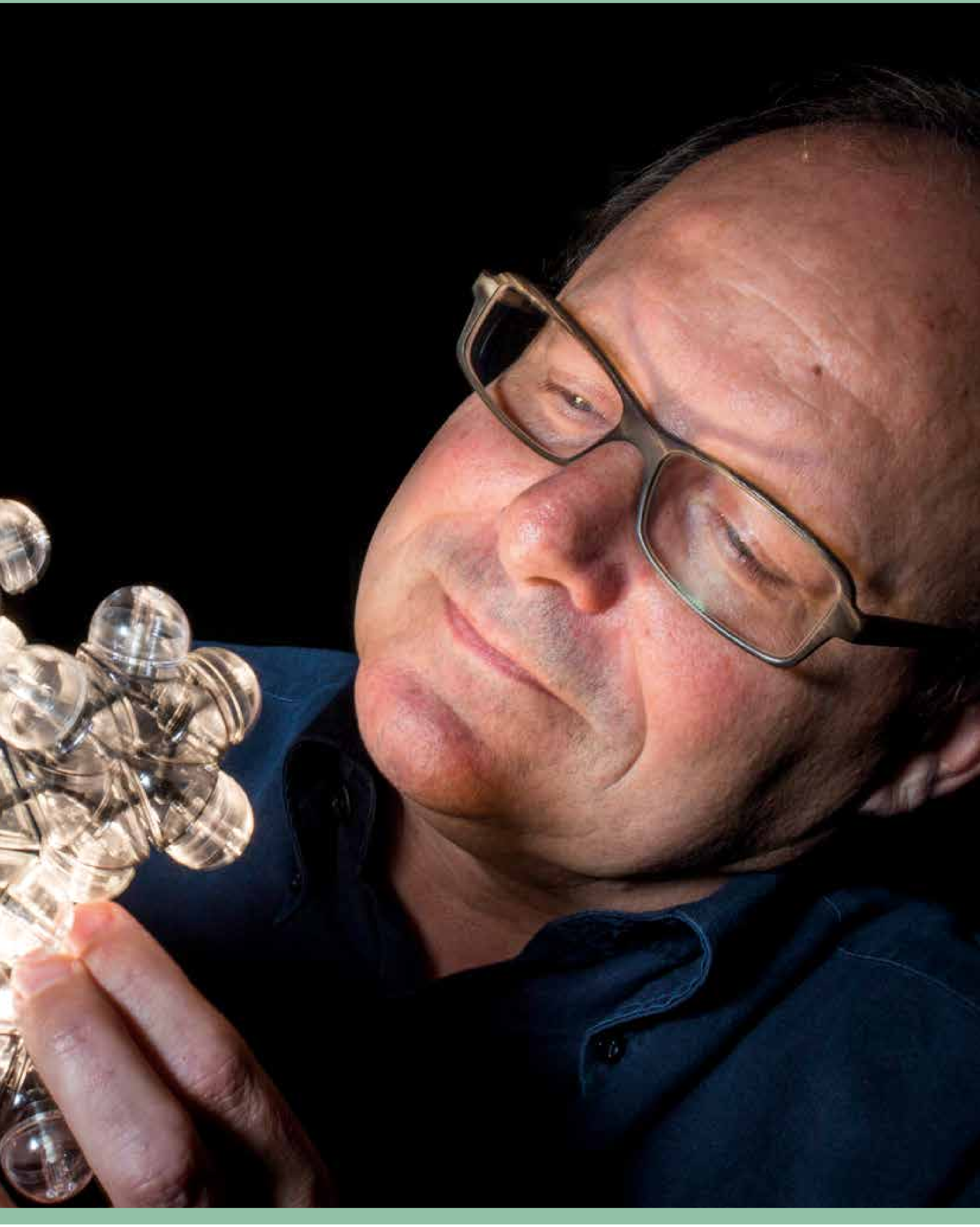
An unexpected journey

Karl-Heinz Ernst was recently awarded the title of "Distinguished Senior Researcher" by Empa's Board of Directors. His career took many twists and turns before he eventually ended up at Empa. And his research field also has a lot to do with changes of direction. For more than twenty years, he has been investigating the chirality of molecules.

TEXT: Cornelia Zogg / PICTURES: Gian Vaitl, private

Karl-Heinz Ernst could be described as a behavioral scientist for molecules. Since the beginning of his career, the chemist has been fascinated by the question of how molecules react to external influences and why they only behave in certain ways. He researches left- and right-handed, so-called chiral molecules and their behavior on different surfaces. Indeed, numerous chemically identical compounds, such as proteins or sugar molecules, can occur in two different configurations. In other words, the molecules only differ in the spatial arrangement of their atoms and behave like an object and its mirror image. These are referred to as enantiomers (mirror-image isomers), the properties of which can differ greatly from one another.

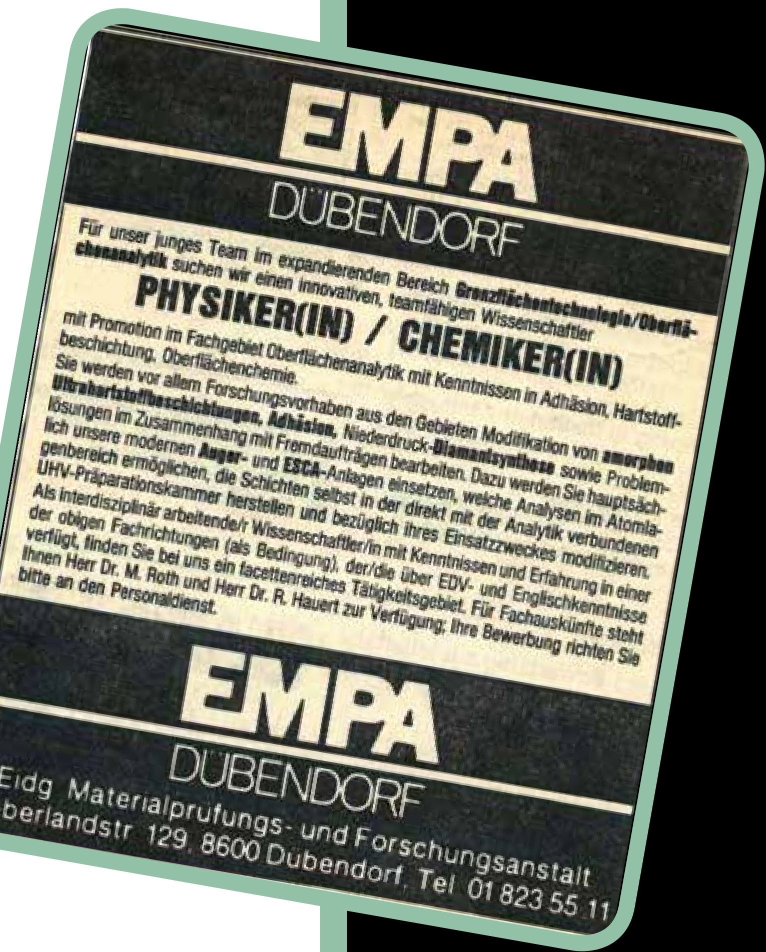
One particularly drastic example is the sedative Contergan, which was commonly prescribed in the 1960s. While the right-handed form of the substance thalidomide ensured a good night's sleep, the left-handed molecule caused severe fetal deformities in pregnant women. As both enantiomers usually form together in the chemical synthesis of these kinds of substances, the problem can only be solved by painstakingly separating one form from the other. This is often achieved through crystallization, where only one of the two enantiomers is precipitated – a process which, although in use for more than a century, is still not understood at a molecular level and usually only succeeds through plain trial and error. Ernst and his team have been researching how chiral molecules recognize and interact with each other for almost 20 years.



One step at a time

Initially, an academic career was not exactly on the cards for Ernst. By the age of 15, he had already had enough of school, dropped out and opted for a apprenticeship as a chemical-technical assistant. "I never liked school. Except chemistry, that is," says Ernst. But he did finish high school later on and eventually studied chemical engineering at the Technische Fachhochschule Berlin (University of Applied Sciences Berlin). His plan was to get a decent job in industry. Before long, however, he had a change of heart. During a summer job at the tire manufacturer Continental, suddenly a light-bulb went on in his head. "I realized that chemists with a PhD always told the chemical engineers what to do. So it dawned on me that I had to keep going." This meant a chemistry degree at the Freie Universität (FU) Berlin and ultimately a dissertation, in 1990, on the topic of hydrogen adsorption on monocrystalline metal surfaces at the FU Berlin and the Berliner Elektronenspeicherring-Gesellschaft für Synchrotronstrahlung m.b.H. (BESSY).

With these qualifications under his belt, Ernst (finally) looked to return to his original plan and join the chemical industry. Once again, it didn't work out, more due to the general economic situation than to ambitious plans. The crisis in the 1990s prevented him from entering industry – and then he stumbled across an Empa job ad in the FAZ. "Analytical methods such as ESCA and Auger, which were mentioned explicitly in the ad, are surface techniques that only insiders understand. That's what caught my eye," Ernst recalls.



Spurred on by boredom

Once he had been selected from around 130 applicants and offered the position, he focused on these methods. "I was involved in setting up the former Surfaces and Joining Technology lab," explains Ernst. "We were on the lookout for material flaws." When a metal broke somewhere – whether it be in plane crashes or cable car accidents – it was their job to find the cause and analyze the material surfaces at the breakpoints as closely as possible. "Most of the assignments came from industry and we were primarily a service-provider operating in the background." There were some truly spectacular cases to study, including a jumbo jet that had crashed into a house in Amsterdam, which Ernst helped to explain using his highly sensitive analysis methods.

Nowhere near challenging enough for the new member of Empa in the long run, however; Ernst simply got bored. His ambitions went way beyond merely looking for flaws. He was still fascinated by basic research, such as the behavior of certain molecules under different external influences and on different surfaces, which had already intrigued him during his diploma thesis – in particular, why on one surface, enantiomers like to gather with their own kind or left- and right-handed isomers prefer to mix on another surface. "We're looking for answers to detailed questions like this – small pieces of the puzzle, but which might give rise to fresh knowledge somewhere down the line."

His interest in these basics made him react immediately to a suggestion from his former supervisor, Roland Hauert: "We can now also submit our own research proposals," as he once mentioned to Ernst in passing – and thus triggered the next phase of his career. Ernst submitted a project to the Swiss National Science Foundation (SNSF) with the aim of applying chiral molecules with a spiral structure to a surface and subsequently vapor-depositing metal, which was supposed to take on the

specific properties of the molecules. His project idea went down extremely well with the management committee of the former National Research Program 36 "Nanosciences" and even though he was a no-name in Switzerland, his application was approved and actively supported. Ernst endeavored to vapor-deposit copper and palladium on the molecular structure, but it didn't go as planned. Vapor-depositing the metal at around 100K (-173°C) destroyed the spiral structure. However, the project still took him forward. "Back then, the thinking was too simple," he admits. "But we observed interesting effects on the way to this new material and carried on our research in this direction." Perhaps Ernst was simply ahead of his time. "Today, there are gentler methods. Maybe I'll give it another try soon," says Ernst with a telling grin.

Worth all the blood, sweat and tears

He didn't always feel like smiling in the early days at Empa, however. "At the beginning of the early 1990s, Empa already carried 'research' in its name, but it hadn't reached the labs or people's minds yet." He had to fight hard for every instrument and every project, and it wasn't until the leadership changed and Empa focused entirely on research under Louis Schlapbach that things started to go uphill for Ernst. "Give this man a lab," came the cry and overnight the ball started rolling. The Nanoscale Materials Science lab was launched and Ernst joined it right away. Publications in prestigious journals soon followed.

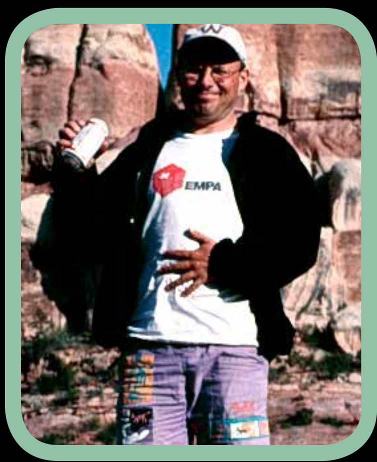
Among other things, his team succeeded in using an electron beam to make molecules oscillate with high precision in the scanning tunneling microscope (STM), which enables individual atoms and molecules to be manipulated. The molecules begin to hop, twist or even change into their mirror-image configuration. With the aid of the STM, Ernst and his team were able to demonstrate this behavior visually, which caused a sensation and made a name for them in the research world. One example of this was a molecular car, where Ernst's team made the wheels of the vehicle rotate. As they only turned in one direction when stimulated by an electron beam, it was possible to "drive" the molecule across a surface. In 2011, media all over the world reported on the project and the Chinese Academy of Sciences even hailed it as one of the ten most important discoveries of the year.

Now the researchers want to follow up this project. They are currently studying engine molecules – which Ernst affectionately calls "waddling ducks" – and trying to find our why these molecules only ever wander in one direction and not the other. "This is very fundamental research. How molecules behave and work is not all that easy to understand and we want to do our bit to help. Sometimes you have to do crazy things. And we do. We make molecules hop."

It is not only Ernst who benefited from the institute's change of direction. Empa also stood to gain. "Nobody abroad had heard of Empa before. Nowadays, I often get approving glances," says Ernst, whom the Board of Directors made a Distinguished Senior Researcher in early February in recognition of his achievements – an honor that so far Ernst shares with just one other fellow researcher, Oliver Gröning.

Freedom and desistence

However, it is not possible to keep on doing "crazy" things all the time. Sticking to guidelines and rules is especially important in the supervision and education of budding young researchers. Oftentimes, though, university regulations are too strict and don't give the young researchers enough leeway, Ernst complains. Project plans, milestones and predictability are called for. Ultimately, the PhD thesis needs to be completed within three years. Major (or even just surprising) discoveries are hardly possibly anymore under these conditions, says Ernst. It takes freedom and desistence – within the scope of sabbaticals, for instance. He regularly took time off to do things that deviated from his everyday routine. "Disconnecting" is key for him; removing yourself from existing processes to gain a fresh perspective or generate new ideas. But he also had to fight for this freedom. "Nobody comes up to you and says: Why don't you go away for a couple of months and have a think."



Ernst has also been a professor of chemistry at the University of Zurich since 2010. "That doesn't exactly make taking time out any easier," says Ernst. The chair fell into his lap. He didn't apply; the position was offered to him by the current President of the University of Zurich, Michael Hengartner. "At 47, I was already a bit long in the tooth for the post and just thought: now, really?" Nowadays, becoming a professor in your early thirties is commonplace. Nonetheless (or perhaps because of this), he accepted his "late" appointment and meanwhile even regards his career path as a kind of experiment: "You simply have to give many things a go," he says, shrugging.

He approaches research with the same openness: success in small steps. But here – unlike with his molecules – it makes no difference whether they go left, right or straight on. After all, in research you often have to take a detour to pass the finishing line in the end. //