

# e-conversion

The Magazine

Fall 2022



Focus on photovoltaic research

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# Full of energy into the future

## News from our Cluster of Excellence

Dear readers,

After the long lean period due to the pandemic, we finally have the opportunity to discuss our science face to face again. We are particularly looking forward to the highlight of the year, the e-conversion conference in Venice at the beginning of October. We want to use the meeting especially to prepare the way for *e-conversion 2.0*, the second funding period starting from 2026, for which we will soon be submitting our application.

So an extremely intensive time awaits us. Our scientists will be investing a lot of work in fleshing out the visions that will help us to achieve a successful future. In that connection, we are already issuing internal calls for tender on thematically oriented projects, each of which is equipped with several PhD positions and material resources. The young scientists working on these projects will each contribute their specific expertise to the further development of research in the cluster in accordance with the horizontal approach of e-conversion across methods, technologies and disciplines. To ensure it succeeds, we have established an extensive experimental infrastructure over the past few years, enabling us to work on both the e-conversion 1.0 projects and the visions for e-conversion 2.0.

We are supported by renowned researchers from all over the world. We can call on both the advice of our Scientific Advisory Board and the commitment of our Hans Fischer Senior Fellows, who work on pioneering research topics together with our PhD students in Munich and Garching. Conversely, our young scientists have the opportunity to spend time abroad at one of our international partner institutes. Furthermore, communicating our science to society and economy is extremely important to us. As soon as the restrictions brought in as a result of the pandemic ceased to apply, we embarked on an extensive education program for schools and in the coming months we want to tackle cooperation with industry in the form of transparent laboratories at partner companies.

In this issue, you will find out plenty about our current work on the fundamentals of the use of renewable energies, which is becoming even more relevant and urgent in light of the current energy and economic policies. This time we are spotlighting photovoltaic and our battery research with a major overview of the topic.

We wish you a good read!

Prof. Ulrich Heiz, Prof. Thomas Bein and Prof. Karsten Reuter  
Cluster Coordinators of e-conversion

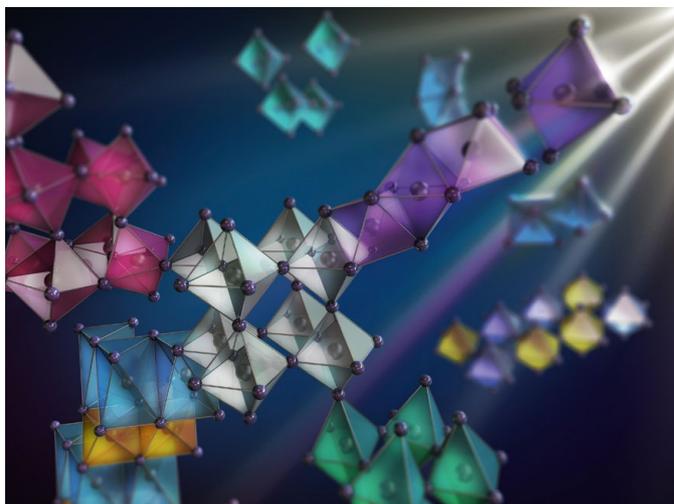


Figure 1 Artist's impression of perovskite building blocks, a promising class of materials in photovoltaics. See article on page 5

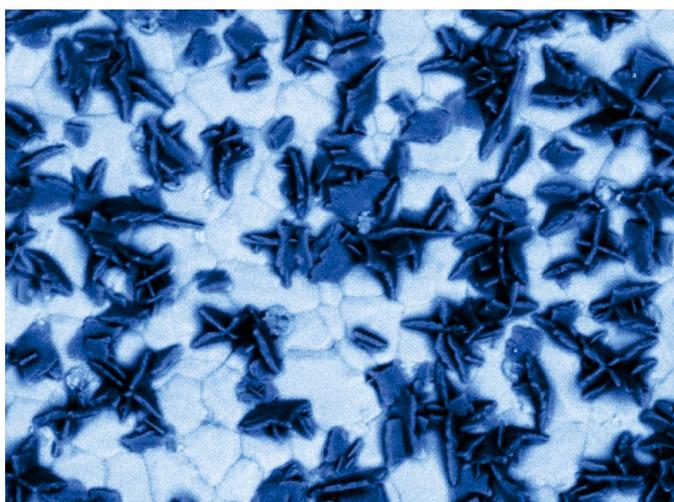


Figure 2 Surface of a perovskite structure treated with phenanthroline to repair defects (SEM image). Dark areas: phenanthroline-rich regions. See article on page 5

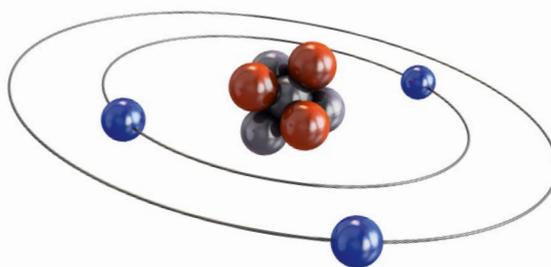


Figure 3 The lithium atom is small and separates easily from its outer electron – perfect for high-performance lithium-ion batteries. In the future, however, it could take on completely different functions. See interview on page 16

# The perfect cell

About the status quo and photovoltaic research at e-conversion



**Since May 2022, home builders in the German state of Baden-Württemberg have been obliged to install a photovoltaic system on their roof. Numerous other federal states will start in 2023 with an obligation for commercial buildings. What proportion of our electricity needs does photovoltaics really cover? How can we increase it? What stands in the way? This article gives an overview of the status quo and shows how the scientists at e-conversion are helping to shape the solar cells of the future.**

## A few figures first

Electricity consumption in Germany will continue to rise significantly. In 2018, still unaffected by the coronavirus pandemic, it was 595 TWh (terawatt-hours, one TWh corresponds to one billion kilowatt-hours). In a scenario for 2030, consumption is around 655 TWh – an increase of ten percent. The corresponding study from fall 2021 was prepared by [Prognos AG](#) on behalf of the former Federal Ministry for Economic Affairs and Energy (BMWi). According to the study, the growth in electromobility, electric heat pumps, the generation of electrolysis hydrogen and the production of batteries are primarily responsible. According to the [statista.de](#) portal, photovoltaics accounted for 8.8% of total electricity generation in Germany in 2021. Its share of electricity generation from renewable energies was 21%. Definitely expandable ...

## What slows expansion?

The technical challenges can be summarized in simple terms in four points: relatively low efficiency, harmful and scarce components, suboptimal production processes, lack of long-term stability.

**Point 1** The degree of efficiency is ultimately what determines costs. It indicates what percentage of incident solar energy is converted into electrical energy. According to a study by the photovoltaic industry, the [International Technology Roadmap for](#)

[Photovoltaic \(ITRPV\)](#), the top models among solar cells achieve 22 percent (back-contact solar cells). However, their production is very complex. In the laboratory, the figures for a classic silicon solar cell are 26 percent and for the promising perovskite tandem cells 24 percent ([Nature 2022, 604](#)).

**Point 2** A number of solar cells contain the toxic heavy metals lead and cadmium. Other types of solar cell require indium or ruthenium. While both of these elements are non-toxic, global supplies will soon be exhausted. These cells are correspondingly expensive – and at some point can no longer be produced.

**Point 3** According to scientists, the future of photovoltaics lies in organic solar cells and so-called perovskite tandem cells. In order to manufacture large-area elements, their production processes must be optimized. That includes being able to produce the cells at low temperatures and in simple conditions, not in a clean room as is the case with silicon cells. Alternative methods such as printing solar cells are also extremely promising.

**Point 4** Even if points 1–3 are solved, the problem of stability remains. The organic components in particular, such as the polymers, are very susceptible to heat and UV radiation.

## The perfect cell

The requirements for the perfect solar cell are therefore high: cost-effective, easy to manufacture, non-toxic, high-performance, stable, absorption of a broad spectrum of light, recyclable, slim and flexible, uncomplicated to handle. If researchers could combine the good properties of all existing solar cells in one, they would have achieved their goal. Ask experts how many types of solar cell there are, and the answer is enough to make you dizzy. For the sake of order, we will arrange them into three groups here: 1. established solar cells that are already on the market, 2. those that are in the development phase, and 3. those in the research phase. Silicon solar cells are firmly established.

The commercial use of organic solar cells is slowly increasing. Perovskite tandem cells are gradually moving towards market maturity. And the following types are being intensively researched and optimized: various thin-film solar cells based on amorphous silicon, dyes, cadmium or indium compounds and quantum dots. Details of all solar cell types can be found on pages 6 and 7.

**The right material - research at e-conversion**

Ultimately it is the material of a solar cell that dictates whether it is successful or not. It determines how effectively the charge carriers are separated, and thus the efficiency. In addition, the material is responsible for the width of the absorption spectrum, the flexibility of the solar cell and its environmental compatibility. Consequently including for the scientists at e-conversion, everything revolves around materials: the analysis and optimization of known structures and the design of completely new materials. Our three examples (see right) represent an enormous variety of research projects on which cluster members from different disciplines work closely together.

**Looking to the future**

It's pretty clear that the days of red tile roofs are numbered, and soon solar cells will be sparkling in the sun on every roof. Beyond that, what might the future of solar technology look like? One of our scientists, Prof. Müller-Buschbaum (Chair of Functional Materials, TU Munich), dares to make a prediction: "My guess is that organic solar cells and perovskite-based tandem solar cells will prevail in particular. In general, these solar cells can find a place in many areas of everyday life: in windows, on facades, in car finishes, or in clothing. They mean every citizen can become self-sufficient and no longer needs an external power supply. In parallel, electricity for public services will probably be generated from large solar farms that could be built on fields, roads or even lakes."

Prof. Müller-Buschbaum's research literally goes far beyond that. In initial experiments, he and his team have sent modules with organic solar cells on a journey into space to test their performance and stability ([www.tum.de](http://www.tum.de)): "The very low weight of these novel solar cells, together with their flexibility and design versatility, has the potential to fundamentally revolutionize satellite solar panels. Moreover, these solar cells may also hold the key to future visions such as going to Mars."



Prof. Dr. Peter Müller-Buschbaum (left) and Lennart Reb (right) in the laboratories of the Professorship of Functional Materials at the Technical University of Munich with the payload module for the research of solar cells in space. Publication: Perovskite and Organic Solar Cells on a Rocket Flight. L. Reb et al., *Joule* 2020, p. 1880-1892



As early as 2011, a Swiss team of architects created a graphic model for roofing highways with solar cells (labor3.ch). Scientists from the Fraunhofer Institute for Solar Energy Systems (ISE) in Freiburg, together with Austrian colleagues from the Austrian Institute of Technology (AIT), are currently testing the feasibility and efficiency of the idea



The material structure in perovskite solar cells changes more in vacuum than in nitrogen

# A look into the lab

## Photovoltaic projects at e-conversion

### Why do solar cells age?

Prof. Peter Müller-Buschbaum  
Chair of Functional Materials,  
TU Munich

Prof. Müller-Buschbaum's team is large, and the projects are correspondingly diverse. Some of them investigate how solar cells age and how this can be prevented. For perovskite cells, for example, the experts were able to show that the material structure changes more in a vacuum than in pure nitrogen. What is particularly fascinating about their work is that the observations can be made while the solar cell is in operation (*operando*) [1]. On the one hand, they use state-of-the-art X-ray diffraction techniques that can examine the perovskite crystal structures non-destructively. On the other hand, measurements with synchrotron radiation and neutrons, which are carried out at the FRM II research neutron source in Garching, among other places, provide deep insights into the material. The results do not flow directly into the design of current cells. But they do help decisively with understanding the fundamental behavior of the molecules, explains Prof. Müller-Buschbaum: "New materials are constantly leading to improvements in the efficiency of solar cells, and their function must then be fundamentally understood in elaborate experiments. It is important to know the background and draw conclusions for new developments."

The aging of a material is closely related to its structure. That is why Prof. Müller-Buschbaum and his team are also investigating what influence the manufacturing process has on the photoactive layers for different types of solar cell, what defects arise in the process and whether the addition of certain substances leads to improved structures.

See illustration on page 4

### Filling up on sun unleaded

Prof. Thomas Bein  
Chair of Physical Chemistry and Nano-  
sciences, LMU Munich

One goal of Prof. Bein and his group is environmentally friendly solar cells based on metal halide perovskites and related materials. They are investigating which metal or combination of metals can replace lead, which has so far been unbeatably powerful but is highly toxic. Generally, bivalent lead ( $\text{Pb}^{2+}$ ) sits in the center of perovskite crystals. Its electron configuration and its environment in the crystal are responsible for allowing photons of sunlight to excite one of its electrons particularly easily and separate it from the positive charge. Finding substitutes for lead is a challenge. Experiments with tin ( $\text{Sn}^{2+}$ ), which is also bivalent, often lead to less stable structures because tin oxidizes easily.

The chemists are therefore developing so-called double perovskites in which, instead of  $\text{Pb}^{2+}$ , a monovalent metal ion (e.g. silver:  $\text{Ag}^{1+}$ ) and a trivalent metal ion (e.g. bismuth:  $\text{Bi}^{3+}$ ) alternate inside the octahedron [2]. The two metal ions allow for significantly more combinations of suitable perovskite elements ( $\text{A}_2\text{B}^+\text{B}^3\text{X}_6$ ), ideally including a particularly photoactive variant. "The investigations are concerned, for example, with questions about the best possible capture of sunlight, as well as the lifetime and mobility of the generated charge carriers, so that they can ultimately be used as electric current," explains Thomas Bein. "It is encouraging that many of the double perovskites studied so far have shown themselves to be remarkably stable under the conditions of an operating solar cell."

See Fig. 1 on page 2

### The big electron show

Prof. Achim Hartschuh  
Nano-Optics, Department of Chemistry,  
LMU Munich

Looking through Prof. Hartschuh's microscope you will see a vivid hustle and bustle. With the help of femtosecond lasers, he and his team observe live how light-excited electrons whiz through the material of solar cells. The lasers emit ultra-short light pulses lasting only a few femtoseconds (fs:  $10^{-15}$  seconds), to which the electrons react by releasing fluorescence beams. The scientists can detect these using methods of so-called time-resolved fluorescence spectroscopy.

One object of investigation is perovskite thin films. Prof. Hartschuh's group analyzes the mobility and diffusion of the charge carriers and under what conditions and how fast they recombine. The material is the decisive influencing factor for the behavior of the charges. "It is therefore essential that we can examine its structures down to the nanometer level," says Prof. Hartschuh. "We use various techniques of scanning probe microscopy and receive valuable information as to why the charge carriers get bogged down at certain points. With this knowledge, we can then search for specific solutions."

Often, defects on the material surface promote the unwanted recombination of charges. One solution is the following: By adding a certain substance, phenanthroline, the chemists have managed to cover these spots and improve the lifetime of the charge carriers [3].

See Fig. 2 on page 2

[1] Degradation mechanisms of perovskite solar cells under vacuum and one atmosphere of nitrogen. *Nature Energy* 6, 977–986 (2021)

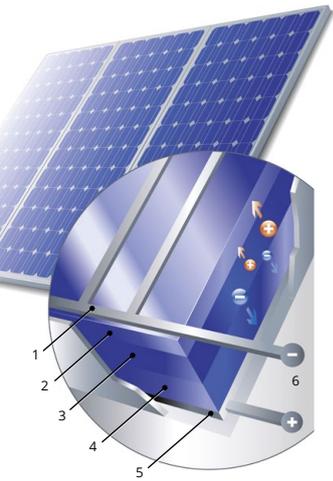
[2] 2D/3D Hybrid  $\text{Cs}_2\text{AgBiBr}_6$  Double Perovskite Solar Cells: Improved Energy Level Alignment (...). M. T. Sirtl et al., *Adv. Energy Mater.* 2103215 (2022)

[3] 1,10-Phenanthroline as an Efficient Bifunctional Passivating Agent for  $\text{MAPbI}_3$  Perovskite Solar Cells. *ACS Appl. Mater. Interfaces* (2021)

# One principle – many ways

## A short guide through the solar cell jungle

Sunlight excites electrons in the semiconductor material of the solar cell. These move as negatively charged particles in the direction of one electrode, leaving a *hole* – a positive charge. These holes migrate to the second electrode and current flows through a connected load. This does not happen if the two charge carriers combine beforehand (recombination). The permanent separation of electrons and holes is therefore crucial for the development of efficient solar cells.



- 1 Negative electrode
- 2 n-doped silicon
- 3 Boundary layer
- 4 p-doped silicon
- 5 Positive electrode
- 6 Electric circuit

### 1. Silicon-based solar cells

This type of cell usually consists of two layers of crystalline silicon, into each of which individual foreign atoms are integrated (doping). One example is phosphorus and boron, which each contribute an additional electron (P) and hole (B), creating a negative (n-) and a positive (p-) layer. A barrier layer forms between them, blocking the recombination of electrons and positive charges. A distinction is made between monocrystalline and polycrystalline cells: Layers grown from a crystal or cut from a silicon ingot.

**Advantages** Good efficiency (mono: about 20%, poly: about 15%), established technology, stable

**Disadvantages** Mostly rigid and heavy, non-transparent, energy-intensive production and therefore long energy payback time (time until cells have produced the energy used in their production)

**State of the art** Common market share approx. 90%, technology significantly improved in recent years, current flow in some cases so strong that significantly thinner cells with less material consumption would be possible, these could also be easily bent and enabling higher efficiency with partial shading

**Bestseller** PERC cells (Passivated Emitter Rear Cell), the rear reflects light and is therefore used twice, also generates less heat, but is somewhat less stable

**Promising** Heterojunction cells, crystalline silicon with a thin layer of amorphous silicon, which among other things reduces the loss of electrons, efficiency approaching 30%



### 2. Thin-film solar cells

A 1–2 μm thin layer of non-crystalline silicon, cadmium telluride (CdTe) or copper indium gallium diselenide (CIGS) serves as the active material. It is deposited on glass or a plastic or metal foil.

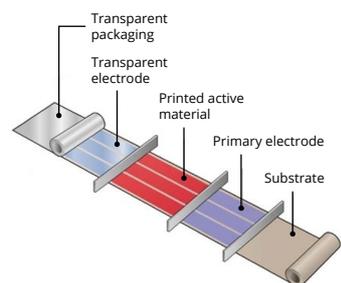
**Advantages** Simple and inexpensive production (CIGS more expensive), semi-transparent possible, absorb well even in weak light, use in combination with conventional silicon cells as much more effective tandem or stacked cells is being investigated

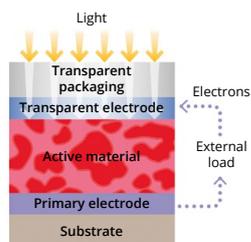
**Disadvantages** Efficiency has been increasing only slightly for years (approx. 5–7%, but CIGS 12–15%), less stable than crystalline silicon cells, sometimes scarce or toxic components (Ga, In, Cd)

**State of the art** Market share approx. 10%, world record efficiency for a four-junction solar cell in the lab: 47,6% (ISE Freiburg)

### 3. Organic solar cells

Certain organic polymers (plastics) are electrically conductive and can act as semiconductors as well. The active layer of the solar cell usually consists of a mixture of two organic materials. One compound conducts the free electrons to the anode, the other transports the positive charge to the cathode. Thanks to their material properties, all elements of an organic solar cell can be printed on top of each other as thin and flexible layers.

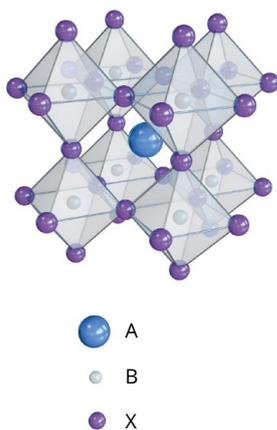




**Advantages** Flexible, light and thin, simple and inexpensive to produce by printing or spray coating without high-temperature processes, the absorption spectrum can be easily adjusted by adapting the material, which means that it can also be almost transparent, no pollutants, low material consumption due to film thicknesses of less than 1  $\mu\text{m}$ , easy disposal, easy retrofitting of buildings

**Disadvantages** Efficiency still with room for improvement (18% in the lab), stability lower than silicon cells

**State of the art** First suppliers of solar films on the market, production of large-area films starts



#### 4. Perovskite-based solar cells

Perovskites are minerals with a characteristic crystal structure, whose building blocks are composed according to the empirical formula  $\text{ABX}_3$ . *A* stands for an ammonium compound, *B* for a metal ion (often lead or tin) and *X* for a halide ion (e.g. iodine, chlorine, bromine). Perovskite cells are constructed like a sandwich: The light-absorbing perovskite material is in the middle. Below and above mostly titanium dioxide or a layer of organic material conducts the separated charges to the electrodes. Combined with classic silicon cells, so-called *tandem cells* are being developed, with a significantly higher light yield due to an extended absorption spectrum.

**Advantages** Simple production – similar to organic solar cells, high efficiency (25% in the lab, with tandem cells almost 30%), adjustable absorption spectrum

**Disadvantages** Organic compounds sensitive to oxygen, heat, moisture and even minor structural changes, many contain lead or cadmium

**State of the art** Production facilities for research projects in operation



#### 5. Dye solar cells

In plant photosynthesis, the green chlorophyll absorbs the sun's energy. Dye solar cells work in a very similar way, in which the light excites electrons in artificial dyes. A conductive glass substrate serves as the electrode and is coated with titanium dioxide and the dye. On top of this is a liquid or solid electrolyte and a second glass support as a counter electrode.

**Advantages** Low cost, absorb even diffuse light, can be produced in any color (with a correspondingly modified absorption range)

**Disadvantages** Low efficiency with little increase over the years (13% in the lab), short lifetime

**State of the art** Interesting in terms of design thanks to colored cells, example: Lausanne Congress Center (see image), production on an industrial scale is still difficult, environmental concerns regarding the liquid electrolyte



#### 6. Quantum dot solar cells

Quantum dots are nanoscale composites of atoms (e.g. PbS and CdS) which have special new physical properties due to quantum mechanical effects caused by their diameter of a few nanometers. Inorganic quantum dots containing lead or cadmium absorb light very well and, as semiconductors, efficiently transport the resulting charge carriers to the electrodes.

**Advantages** Lightweight and flexible – depending on the carrier material, simple production from liquids – similar to organic solar cells, absorption spectrum well adjustable via the size of the quantum dots and the material, particularly interesting for the infrared range (IR), which makes up a large proportion of sunlight, near-transparent therefore possible (cells absorb IR radiation and let visible radiation through)

**Disadvantages** Still low efficiency (18% in the lab), low stability, contains toxic elements such as Pb or Cd

**State of the art** As solar cells still completely at the research stage

# Real eye-catchers

## Cover arts for scientific publications

**Many specialist publishers offer scientists the opportunity to submit a suitable graphic with their paper for the cover pages of the journal. Those whose cover art is selected can be happy, as there is no better advertising placement.**

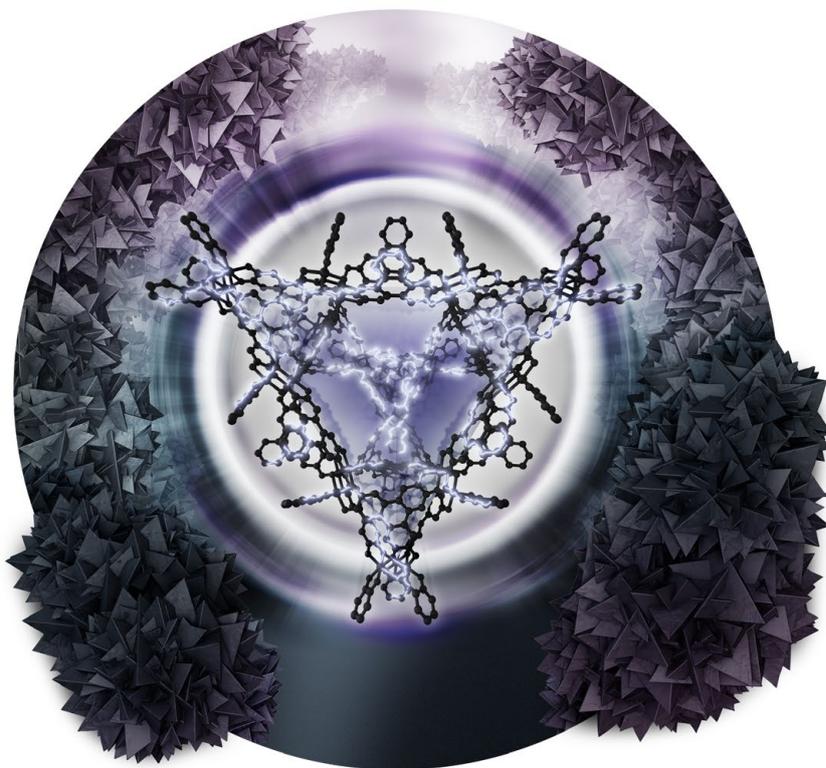
Vera Hiendl is media designer at e-conversion and so far more than 20 of her graphics have been selected by scientific journals. There is a long process behind every picture: First, there is the one-on-one conversation with the scientist, because it is important to understand the principles of the work and to filter out the core messages. The next process for Vera is the brainstorming regarding the visualization of these key messages. "I do it best when I fully concentrate on the topic. Then I start to scribble sketches. In the next step, I visualize the ideas in 3D and graphic programs." Several optimization loops follow. Depending on the topic, her ideas and the input of the scientists, the graphic either stays close to scientific structures, builds bridges to everyday items or is shown in an abstract manner. "To create the cover art for the metal-organic framework (MOF) publication, I first identified the prominent characteristics of the newly discovered material together with leading authors. This effort

resulted in the development of a graphic that combines all the special properties of the MOF in a balanced composition with an artistic point of view." The graphic shows the molecular material's tetrahedral shape, matching the crystal morphology. The MOF is a pitch-black material that absorbs a broad fraction of visible light. This property was illustrated by dark colors for the crystal and its surroundings, giving the image a dramatic and mysterious tone. The media designer illustrated the property of electrical conductivity by using lightning bolts that spread across the molecule. The final cover art was well received by the publisher and chosen to serve as the front cover of the issue.

Each cover art should tell the unique story of the publication. Working out the right combination of properties is a major challenge. "With every cover graphic I learn something new and it never gets boring." Vera also deeply appreciates the cooperation with the scientists. "Without the inspiring input, ideas and feedback from the authors, such a great work would never be produced."

Find more cover arts here:

<https://www.e-conversion.de/cover-gallery>

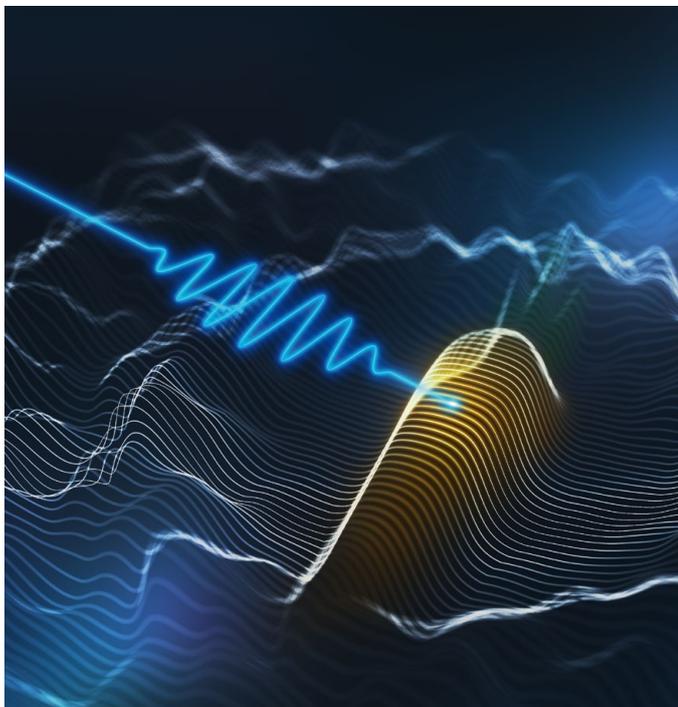


The unique cubic metal-organic framework (MOF) Fe-HHTP-MOF is a highly crystalline, porous and pitch-black material with high electrical conductivity.

› An Electrically Conducting Three-Dimensional Iron-Catecholate Porous Framework, *Angew. Chem. Int. Ed.* 2021, 133, 33

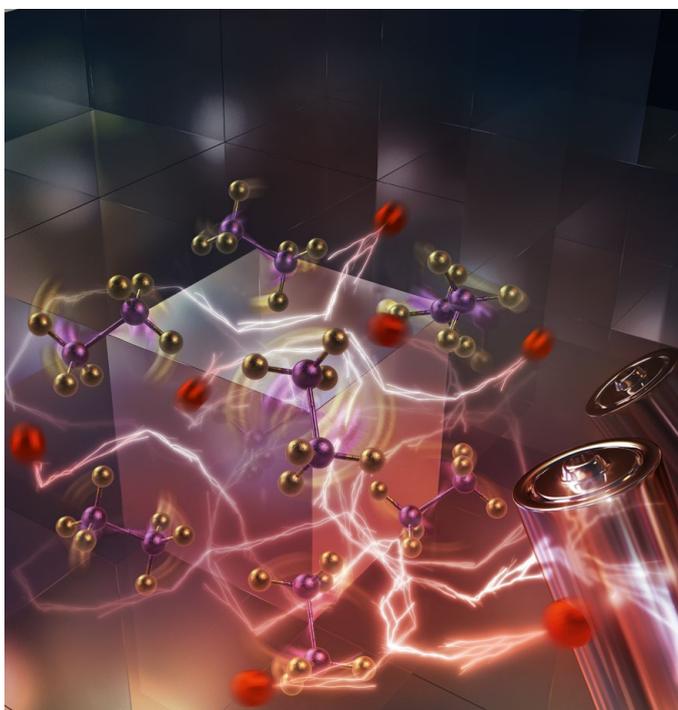
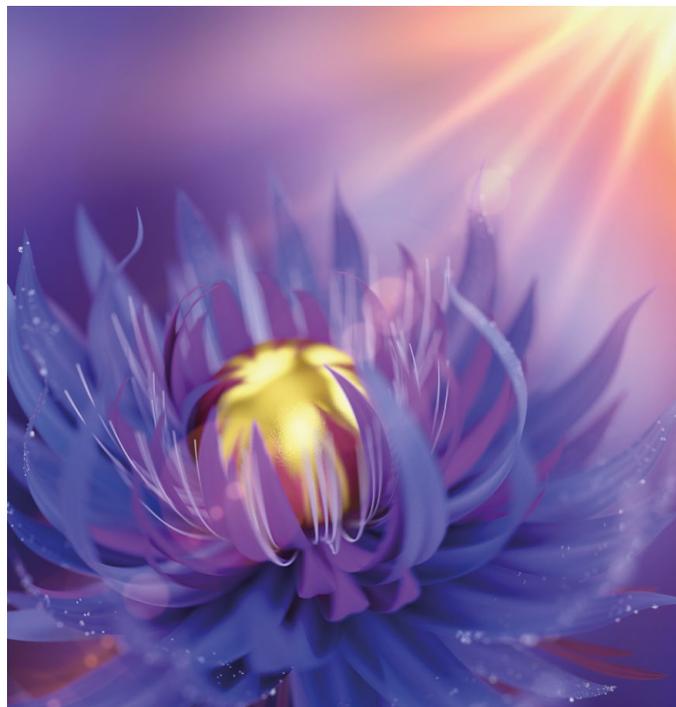
Carotenoid is made to *vibrate* by light absorption. After excitation, the carotenoid relaxes back to its ground state in a few picoseconds.

› Understanding Carotenoid Dynamics via the Vibronic Energy Relaxation Approach, *J. Phys. Chem. B* 2022, 126, 22, 3985–3994



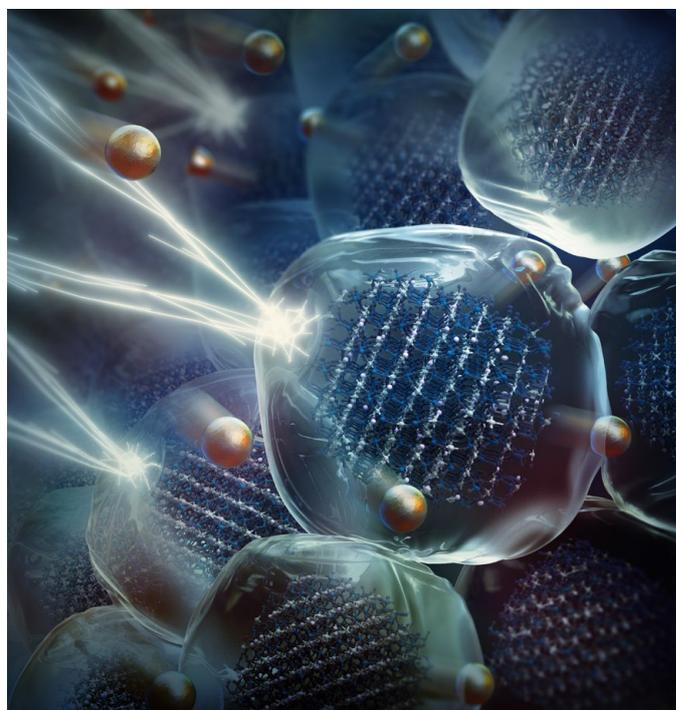
A plasmonic nanoparticle can be encased with different materials. In this way, the photocatalytic property can be modified and used for solar fuel production.

› Hybrid Plasmonic Nanomaterials for Hydrogen Generation and Carbon Dioxide Reduction, *ACS Energy Lett.* 2022, 7, 2, 778–815



The novel  $\gamma$ -polymorph of the ion conductor  $\text{Na}_4\text{P}_2\text{S}_6$  is formed above 580 °C. This polymorph shows fast sodium ion conductivity paired with low activation energy.

› Superionic Conduction in the Plastic Crystal Polymorph of  $\text{Na}_4\text{P}_2\text{S}_6$ , *ACS Energy Lett.* 2022, 7, 4, 1403–1411



Nanoscale analysis of the LATP solid-state electrolyte reveals a thin complexation layer which encapsulates the crystalline grains and separates charge carriers.

› Nano-Scale Complexions Facilitate Li Dendrite-Free Operation in LATP Solid-State Electrolyte, *Adv. Energy Mater.* 2021, 26, 2100707

# Energy of the Future

A review: lecture series with the LMU Center for Advanced Studies (CAS)

The question of efficient and sustainable energy production and storage has never been more pressing. An environmentally conscious economic and climate policy must be based on in-depth knowledge. The lecture series *Energy of the Future* aims to present the potential of current energy research to a wider public audience and to discuss its political relevance. The online events were organized by the *LMU Center for Advanced Studies* and took place between May 2021 and June 2022.



All talks are available as video and audio at:  
[https://www.cas.uni-muenchen.de/publikationen/casvideo/channel\\_energy/index.html](https://www.cas.uni-muenchen.de/publikationen/casvideo/channel_energy/index.html)

## Climate Change and Our Current Energy System

Johan Rockström painted a realistic and depressing picture of the state of the earth: heatwaves, floods, forest fires, hurricanes, plagues of locusts. In addition, he asked: Are we risking irreversibly destabilizing the whole system? According to Rockström, one way out of the climate crisis could be the *Carbon Law* – the simple rule of thumb that we should halve fossil CO<sub>2</sub> emissions every ten years.

**Speaker** Prof. Johan Rockström (Potsdam Institute for Climate Impact Research/University of Potsdam)

**Presentation** Dr. Jeanne Rubner (Journalist, Bayerischer Rundfunk)



**Cutting emissions by half every decade is the pace we need to follow.**

Johan Rockström

## The Potential of Sustainable Energy Production

Synthetic fuels will be essential for energy distribution, for trucks, ships and aircraft and as raw material for the chemical industry. Prof. Leitner discussed the required process called *power-to-liquid*. The idea is to use renewable energy to produce hydrogen, add CO<sub>2</sub> or CO and synthesize synthetic fuels. The CO<sub>2</sub> will come from biomass, recycled waste or will be directly captured from the air (Carbon capture and utilization, CCU). A Norwegian company is currently building a huge *power-to-liquid* factory while the KIT in Karlsruhe has just developed a mobile device for decentralized operations. It includes all the necessary steps in one container: from the filter that captures CO<sub>2</sub> from the air to the tap where the fuel comes out.

**Speaker** Prof. Walter Leitner (Division of Molecular Catalysis MPI for Chemical Energy Conversion/ RWTH Aachen)

**Presentation** Prof. Ulrich Heiz (Catalysis Research Center, TU Munich)



**Synthetic fuels are indispensable for reaching the climate goals.**

Walter Leitner

Every day, around 94 million barrels (15 billion liters) of oil are consumed on earth. Filled into large beer barrels you could build a chain that stretches 1.5 times around the world



## Future Visions for a Sustainable Energy System

For Friederike Rohde it is crucial to critically interrogate the different claims of society, science, politics and economy to shape the future of our energy systems. For her PhD thesis, she scientifically accompanied three pilot projects on *Urban Smart Grids*, analyzed the future visions of various stakeholders and here she presented her results. The projects are part of the initiative *Zukunftsort Berlin* and will test the feasibility of different ideas on how the future of our energy system might look. Johannes Lercher is convinced that the energy systems of the future will revolutionize the entire industry. This will happen worldwide, because many countries are dependent on electricity imports. For Prof. Lercher it is also important to promote the recycling of carbon from waste and biodegradation products. The pharmaceutical and chemical industries, for example, could thus become independent of fossil resources.

**Speakers** *Friederike Rohde* (Institute for Ecological Economy Research IÖW/TU Berlin),  
*Prof. Johannes Lercher* (Professor for Technical Chemistry, Catalysis Research Institute, TU Munich/e-conversion)

**Presentation** *Prof. Karen Pittel* (LMU/ifo Institute Munich)

“

**What we are going to be undertaking is the biggest industrial revolution since the development of the steam engine in the mid-19th century.**

*Johannes Lercher*

## Sustainable Energy Use in Mobility

Central topics of this event were the importance of hydrogen as an energy carrier, the idea of the 15-minute city and the possibilities for sustainable aviation. Prof. Gasteiger made it clear that the use of hydrogen only makes sense if its production runs completely on renewable energy. Prof. Moreno sees the greatest opportunity for sustainability in avoiding mobility. His idea of the 15-minute city implies that all areas of life such as work, local services or leisure can be reached within 15 minutes without a car. Prof. Rao, in turn, presented research projects on climate-neutral flying. He emphasized that the main problem is not CO<sub>2</sub> emissions from aircraft, but compounds such as nitrogen oxides (NO<sub>x</sub>) and water vapor.

**Speakers** *Prof. Hubert A. Gasteiger* (Technical Electrochemistry, TU Munich/e-conversion),  
*Prof. Carlos Moreno* (Entrepreneurship, Territory and Innovation, Université Paris 1),  
*Prof. Arvind Gangoli Rao* (Faculty of Aerospace Engineering, TU Delft)

**Presentation** *Dr. Irene Feige* (Institute for Mobility Research (ifmo), BMW)

“

**We need sufficient renewable electricity for fuel cell electric vehicles. Otherwise hydrogen based transportation makes absolutely no sense.**

*Hubert A. Gasteiger*

## Energy Knowledge Transfer

If the coronavirus pandemic achieved any good, that was pointing up the urgent need for a permanent dialogue between science, business and politics. Particularly in the area of climate policy and energy transition, it is beyond dispute that a concerted interaction between research and practical implementation in business and politics is needed to tackle the huge tasks ahead. To start, the guests gave an insight into their professional background and their main tasks and ways of working. Then a very lively and open discussion started about the individual and common aims, thematic interfaces and how it might be possible to better advance each other's projects. All speakers agreed on the importance of knowing the views and needs of all parties in order not to bypass each other but to work closely together to efficiently advance the energy transition.

**Speakers** *Dr. Peter Lamp* (Head of the battery cell technology research department, BMW),  
*Prof. Jennifer Rupp* (Professor of Electrochemical Materials, MIT and TU Munich/e-conversion),  
*Martin Stümpfig* (Bündnis 90/Die Grünen parliamentary group, Bavarian State Parliament)

**Presentation** *Dirk Vilsmeier* (Journalist, Bayerischer Rundfunk)

“

**As a scientist, you should have the courage to call somebody in industry and say, "Hey, I think this idea is really useful for you. Let's talk about it."**

*Jennifer Rupp*

# The scientists of tomorrow

## We support students and teachers

**The influence of natural sciences and technology on all areas of social life is increasing, as is demand for specialists in these fields. For several years, however, there has been a drop in performance in the natural sciences subjects at German schools. Various surveys have made it clear that there are major gaps and uncertainties in the German education system, both in basic science education and in the promotion of talent.**

e-conversion is committed to getting young people, especially girls, excited about natural sciences and providing them with practical experience. The focus is on having fun doing research. Encouraging young people is now a very large and active part of e-conversion's support programs.

### The student lab of e-conversion



Moritz Feil leads many workshops

The scientific backbone of the student activities is Moritz Feil, PhD student at the chair of Prof. Katharina Krischer. The former physics teacher has grown fond of his

academic hobby, didactics and student support: "Young people show incredible creativity and enthusiasm – if they are properly motivated. I see it as my challenge and my privilege to reveal this motivation. With this in mind, at e-conversion's student lab, I focus on detailed engagement with simple experiments and free discussion with and between students."

Moritz Feil regularly welcomes school classes and W-seminar groups in order to deepen topics related to energy conversion and climate physics. It is in this context that the new project of supporting

particularly gifted students has come into being. The first plans for the coming school year with the future partner schools have already begun.



e-conversion is also present at Girls' Day

### Association of Munich Student Labs – MUC-Labs



The so-called extracurricular learning locations in and around Munich were eager to develop common profiles and use synergies. That was what motivated them to organize themselves regionally. In April 2020, various extracurricular learning locations, including

e-conversion, merged to form a joint association, the MUC-Labs e.V. The aim of the association is to encourage pupils' interest in mathematics, natural sciences and technology (STEM). To achieve this goal, the members meet regularly and organize public events such as the *Day of the Munich Student Labs*. In dialogue with teachers and experienced didacticians, MUC-Labs develops innovative and interdisciplinary learning concepts as well as offers to supplement natural science lessons in school.

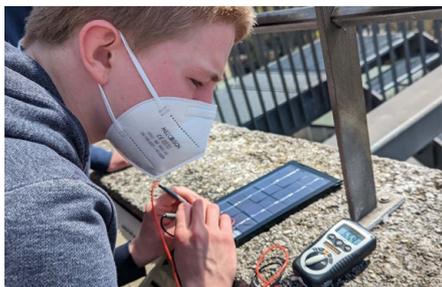


e-conversion presents MUC-Labs at the science festival FORSCHA

Further information at: <http://muc-labs.de>

`print('Hello world!')`

## Holidays for the future



How much electricity does the sun provide today?

After the pandemic, children and young people have to do a lot of catching up. This applies not only to the curriculum but also to the social life they have missed. For this reason, the German government has approved the *Catching up after Corona for children and young people* action program worth two billion euros for 2021 and 2022. Part of this program consists of promoting offerings from extracurricular places of learning in order to create additional stimuli and strengthen the personal development of young people. Through *LernortLabor* – Bundesverband

der Schülerlabore e. V., it was possible to apply for funding for such extracurricular supplementary offerings under the BMBF program. Almost 100 student laboratories in Germany are now receiving a total of 4.8 million euros. This will enable them to create more than 100 additional educational opportunities nationwide, in which more than 36,000 children and young people from all types of school will be able to participate this year.

MUC-Labs offers so-called Lab Tours, during which the participants can visit a different school lab every day for four days during the holidays. During the summer holidays, e-conversion too opened its doors for the Lab Tours. Together with Deutsches Museum and the local energy provider Stadtwerke München (SWM), e-conversion has launched another holiday program on the topic *Energy 2022 – Holidays for the Future*, which is funded by the BMBF. In four-day interactive and participatory holiday activities, students in

eighth to tenth grades deal with the topics of energy and climate change. Various workshops, visits to SWM power plants and to museums give the participants insights and inspiration for further discussions and the development of future concepts, which they can then present to the audience at the joint closing event at Deutsches Museum.



Solar energy workshop by e-conversion

Further information at: <https://www.deutsches-museum.de/energie-22> or <https://www.explore.tum.de/explore/minterlebnis>

## TUMjunior kids research photosynthesis

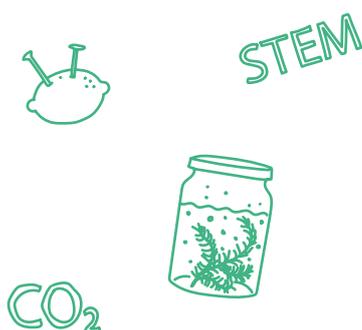


TUMjunior is a STEM cooperation project with the Department of Educational Sciences at TUM. The goal of this project is to systematically and sustainably

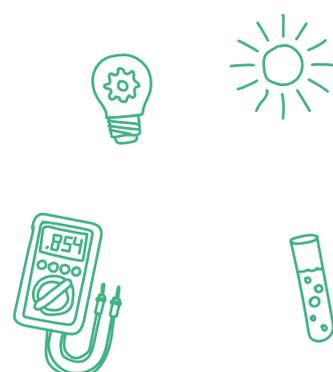
integrate field trips into the classroom, arouse interest in STEM topics and introduce students to scientific ways of thinking and working for research-based learning. e-conversion has developed the topic *The sun as the origin of life and the future of energy supply using the example of photosynthesis* for the sixth grades. 17 school classes have already visited us and explored the processes of photosynthesis with hands-on experiments.



What part of light does chlorophyll transmit? You can find out with spectral glasses



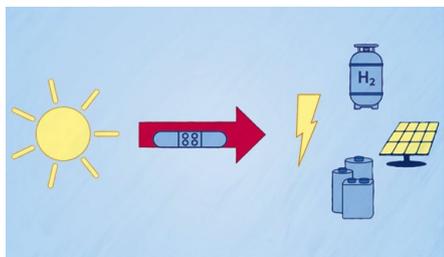
**Contact for the e-conversion school programs**  
Silke Mayerl-Kink, [silke.mayerl@tum.de](mailto:silke.mayerl@tum.de), 089-289 52778



# Always in motion

Videos about our research and the people behind it

Visit our YouTube channel and see how colorful and dynamic our cluster is. The shooting of the videos *Science in 100 seconds* during the graduate retreat was particularly creative. True handicraft and acting skills came to the fore!



## All about e-conversion – the short movie

### Five facts about our cluster

Energy conversion? What is that? Clusters of Excellence? What are they good for? This short movie gets to the heart of what our research is all about and why Clusters of Excellence are the perfect institution for developing and successfully implementing truly innovative ideas. Get to know us!



## Women in Science

### Clear the stage for our female scientists

According to a UNESCO study, the proportion of women in research worldwide is only 30 percent, and it is even lower in higher positions. There are many reasons and just as many ways to do something about this imbalance. Female role models play a very important role – highly qualified scientists who are very successful and enthusiastic about advancing the world through their research. In the *Women in Science* video series, female researchers from our cluster report on their career paths, the special challenges and the prejudices they were confronted with as women in science. They also give hints and explain why being a scientist is their dream job.

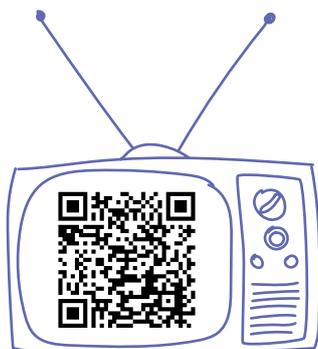


## Science in 100 seconds

### Technical terms – explained in a nutshell

Energy research is full of terms that appear in the media again and again, but which many people do not really understand. Our doctoral students shed light on the subject and explain key technical terms briefly, crisply and entertainingly. The videos were created as part of the PhD student retreat 2021 in Ettal, Bavaria.

*Making-of  
science in 100 seconds*



YouTube e-conversion  
[tiny.cc/ec-yt](https://tiny.cc/ec-yt)



There are many steps from idea to finished video: finding a term, formulating a definition, drafting a storyboard, making props, rehearsing the recording and then – action!

# Exzellent erklärt

## Podcast of the German Clusters of Excellence



The podcast *Exzellent erklärt* (Excellently explained) is a project of the 57 Clusters of Excellence initiated by e-conversion. In each episode, top researchers from the clusters talk to podcaster Larissa Vassilian to explain even highly complex topics in an entertaining and easy-to-understand way. The content ranges from African studies to the future of medicine to quantum physics and shows listeners how diverse and top-class research in Germany is. For the researchers, the podcast in turn offers the opportunity to present their work with little effort and a high degree of authenticity.

### Great success

What is also unusual about *Exzellent erklärt* is its genesis and its success. In just nine months, a team of eleven representatives from the 57 Clusters of Excellence developed the concept and got the podcast up and running. A year after the start in September 2021, 17 episodes have been released and the podcast has 17,000 subscribers (as of August 2022).

### e-conversion on air

In the e-conversion podcast episode, Prof. Dr. Bettina Lotsch (LMU Munich/MPI for Solid State Research) and Sina Stegmaier (TU Munich) provide insights into battery research. What are

the problems of the current batteries? How might you solve them? The two chemists also explain how batteries actually work and what materials are needed for a powerful battery. In addition, they reveal what solid-state batteries are all about, in which the car industry in particular has such high hopes.



### How to listen

The podcast can be subscribed to via all major podcast platforms, e.g. [ApplePodcast](#), [Spotify](#), [Podcast Addict](#), [GooglePodcast](#). Or you can listen to the episodes online at [www.exzellent-erklart.de](http://www.exzellent-erklart.de).



[www.exzellent-erklart.de](http://www.exzellent-erklart.de)

# A team full of ideas

## The new Student Board of e-conversion



Full of ideas and plans, the Student Board 2022/23 has got to work. The focus of the e-conversion Graduate Program is on professional and personal exchanges and further training opportunities. First, the team plans meetings where PhD students present their projects and give lab tours. BBQ evenings and other informal events are also on the list. One event will provide information on the research stays abroad that are possible through the Graduate Program.

More info on the program and entry requirements:

[www.e-conversion.de/graduate-program](http://www.e-conversion.de/graduate-program)



# Lithium - the jack of all trades

Jennifer Rupp

**Talking to Jennifer Rupp, you immediately sense her power and her passion for research. She seems to draw on an inexhaustible source of ideas – and consequently she and her team pursue a large variety of projects. Their focus is on a type of battery that might revolutionize e-mobility: solid-state batteries. However, it is not only science itself that Jennifer Rupp is passionate about. It is her heartfelt wish to contribute to the shift in statistics towards more diversity in academia and industry.**

**For a material scientist your field of research is very broad: energy storage, data storage, even sensors for chemicals. Is there a kind of umbrella?**

Yes. One example is our research on lithium solid-state materials and functions. We are fascinated with the question of what else a simple ion like lithium can do beyond energy storage. Lithium ions can move in selected solids on the one hand very fast, and on the other hand they can alter an electronic state by structural changes upon lithiation and delithiation. As an outcome one can either use these classically for energy storage but also to switch a resistive state for neuromorphic computing chips operating faster than transistors.

**Is there an application where you could combine both functions?**

Today, the battery, processor and sensors of one device are often made using a large number of different materials. The question is if future electronics can operate on a smaller common share of lithium (Li) materials in their storage, sensing and processing functions. Also in terms of recycling and reducing materials, that makes a lot of sense. And we were happy to see that the company Ericsson decided to support this new research direction on *Lithionics* with me as the lead and colleagues at MIT.

**But do we have enough lithium?**

We have much more sodium and its derived chemistries have come along in a remarkable way. But I think that lithium currently outperforms, and so far it looks like we have enough in reserve. What is more concerning in terms of resources is

elements such as cobalt that is present in the battery's cathode. Congo has 80 percent of the world's reserves and often child labor is involved in its mining. If everybody wants to drive an electric vehicle in the future – and the projection is that by 2030, the level should reach 30 percent in Germany – we will have to mitigate socio-economic risks and consider alternative resources. Early on in my career at MIT, I decided to no longer accept industry projects that work on these types of chemistries related to cobalt. To bring about change I believe that the brightest people should tackle the toughest problems, which means finding and inventing alternative chemistries.

**What is your latest project?**

Last spring my team and I gathered data for a rather eye-opening plot concerning Li battery solid-state materials: It takes on average 8–15 years from the prediction of a new solid electrolyte battery material to its synthesis. That is pretty shocking, and is devastating news considering climate change and the need for storage of renewables. So, our team decided we can no longer continue as we are doing right now, the chemistry we are conducting is simply too slow to be of help. In bio-pharmaceutical development this problem was recognized much earlier. We are kind of motivated to transfer these tools to battery ceramic manufacture and to shorten these time spans and the human-labor years. To do that, we are researching in our new cyber physical production lab which ceramic routes are best suited for high throughput design of battery materials. And we are investigating whether machine learning

algorithms used in pharmaceuticals for structure recognition can be transferred or differ in their use for Li materials. All in all, we anticipate that you can significantly shorten the time from 15 years from prediction to ideal manufacture of a battery component in the future.

**How closely are you working together with industry?**

I love to hear about the real problems of companies and to consult and work with them to tackle the real challenges in society. We should perhaps write one academic paper fewer a year and instead consider what achieves the biggest impact for our community and society. In the field of energy, clearly that means shortening the translation times from discovery to battery integration of materials and cell prototypes.

**At MIT you established a special mentoring program for females, LGBTIQ and scientists of color. Why did you decide to do so?**

If I look around me then it is obvious that we have to bridge the ever-present gender gaps and bring more scientists and engineers of color into our material science and chemistry communities. Looking back, my mentors were essential in shaping my own biography. I think I had the same potential as today when I was 30, but I did not always receive the mentoring that I could have had before I came to MIT. I am really thankful to have had very few but strong and high-achieving female and minority role models in my international field who took the time to listen to and support me. Looking back it was not always easy and I sometimes

had to fight for even equal rights or opportunities as a scientist. So I decided to not be sad about it, but rather transfer the energy felt in those moments into mentoring and supporting current underrepresented groups to change the landscape. Forming the LILA mentoring program is only a small contribution, but I truly believe if every accomplished scientist considered how to invest in activism towards statistical balance in color and gender in academia and industry, the world in terms of leadership would look VERY different. So, folks, no time to lose, let's do it and change the look of our leadership!

#### How do you charge your own battery?

Firstly, by having the best assistant and the most fantastic and trusting team in the world. The other thing is to plan very well, work hard, but also allow yourself to hang loose. I love my children and I

do spend a lot of time with them, and in summer most of the time you will find me on the water doing stand-up paddling. To innovate one needs to be able to truly relax your mind. Over the years I have become very selective in what I do, which scientific problems I work on, and I write only very few but hopefully recognized quality papers.

**Thank you very much for this interview and we wish you all the best for your time at e-conversion and TU Munich!**



#### Vita

- PhD in material science at ETH Zurich
- Postdoc at the Massachusetts Institute of Technology (MIT)
- Assistant professor at ETH Zurich
- Assistant professor at MIT
- Associate professor at MIT
- Since October 2021 professor for *Solid-State Electrolyte Chemistry* at TU Munich

#### More on the topic

**Video** Online discussion with Jennifer Rupp as part of the e-conversion series *Energy of the Future* (see p. 11)

**Podcast** More on solid-state batteries in the e-conversion episode of the podcast *Exzellent erklärt* (see p. 15)

## Prizes & honors 2021–2022

#### Engineering heroes

**Dr. habil. Taybeh Ameri** is one of the *Top 50 Women in Engineering 2021*. The award is given by the Women's Engineering Society "to inventors and innovators [...] who identify an unmet need, create the solution, or improve on existing products and processes to make our lives easier." ([wes.org.uk](https://wes.org.uk))

#### ERC Grant and Izatt–Christensen Award

In 2022 **Prof. Ivan Huc** receives an ERC Advanced Grant for his projects on foldamer molecules simulating DNA structures. The Izatt–Christensen Award 2021 honors his research in macrocyclic and supramolecular chemistry.

#### Outstanding theoretical chemist

**Prof. Frank Neese** was awarded the Schrödinger Medal 2022 by the *World Association of Theoretical and Computational Chemists* for "his pioneering development of new quantum chemical methods for theoretical spectroscopy and local electron correlation, and their applications to real-life chemical problems."

#### Italian Chemical Society award

The *Italian Chemical Society* awards **Prof. Frank Neese** with the Luigi Sacconi Medal 2021. He receives the award for his particularly relevant and outstanding achievements in molecular theory and spectroscopy.

#### Fellow of the International Society of Electrochemistry

Our member **Prof. Hubert Gasteiger** received a Fellowship of the *International Society of Electrochemistry*.

#### Highly Cited Researchers 2021

In 2021 five members of e-conversion are on the list of *Highly Cited Researchers*. We congratulate: **Prof. Thomas Bein, Prof. Hubert Gasteiger, Prof. Stefan Maier, Prof. Frank Neese and Prof. Robert Schlögl**.

#### Heidelberg Academy of Sciences and Humanities

Since 2021 **Prof. Bettina Lotsch** has been a full member of the *Heidelberg Academy of Sciences and Humanities*.

#### Prestigious Award Lectures

In 2021, **Prof. Bettina Lotsch** was invited twice to give a special Award Lecture: The *Chemical Research Society India* invited her to give the Prof. C.N.R. Rao Award Lecture, dedicated to a world-leading Indian solid state and material chemist. At the University of Birmingham she gave the prestigious Haworth Lecture.

#### Outstanding catalysis research

**Prof. Johannes A. Lercher** was awarded the Alwin Mittasch Prize 2021. The *German Catalysis Society* recognizes his contributions to the development and understanding of solid catalysts for new raw material sources.

# Welcome

## Our new members

**e-conversion attracts more and more top scientists: Since 2021 we have been able to welcome eight new members. We are happy that they have joined our cluster and wish them lively exchanges and fruitful cooperations.**



**Dr. Dominik Bucher** (*Physical Chemistry, TUM*) uses defects in diamonds as quantum sensors for NMR (Nuclear Magnetic Resonance) spectroscopy. His group works at the unique interface between quantum sensing and (bio)chemistry with the goal to perform NMR spectroscopy on smallest length scales – from nanoscience

and surfaces to microfluidics and single-cell biology. The chemist studied at TU Munich and did his PhD in biophysics at LMU Munich. At Harvard University he developed a new NMR technology for microscopic volumes and femtomole detection limit. In 2019 Dominik Bucher started as a junior group leader at TUM.



**Dr. Johanna Eichhorn** (*Walter Schottky Institute, TUM*) researches solar energy conversion reactions and interfacial charge transport of semiconductor-based multi-layer photoelectrodes at the nanoscale. The results could benefit the realization of efficient and stable photoelectrodes for solar energy conversion. After finishing

her PhD in physics at TU Munich, Johanna Eichhorn spent nearly five years at the Lawrence Berkeley National Laboratory (USA). In 2019 she returned to TU Munich to the group of Prof. Ian Sharp. Since last year, the physicist has been junior research group leader and member of the Young Academy of the Bavarian Academy of Sciences and Humanities.



**Prof. Benjamin Fingerhut** (*Theoretical Chemistry, LMU*) studied chemistry at LMU Munich, received his PhD degree in 2011 and then joined the Mukamel group at the University of California, Irvine. In 2014 he moved as group leader to the Max Born Institute, Berlin and later on received a renowned ERC starting grant.

Prof. Fingerhut's research focuses on ultrafast phenomena at biological interfaces and the development of efficient numerical methods for the description of condensed phase dissipative quantum dynamics. In June 2022, he accepted a call from LMU.



**Prof. Ivana Ivanović-Burmazović** (*Inorganic Chemistry, LMU*) works on the control and modulation of redox processes in living systems, biomimetic catalysis and chemical energy conversion. The scientist did her PhD in chemistry at the University of Belgrade, followed by a time as assistant professor. In 2008, Ivana Ivanović-Burmazović completed her habilitation at Friedrich-Alexander University, Erlangen-Nuremberg, and was appointed as the Chair of Bioinorganic Chemistry. Since 2020, she has held the Chair of Bioinorganic Chemistry and Coordination Chemistry at LMU Munich.

Since 2020, she has held the Chair of Bioinorganic Chemistry and Coordination Chemistry at LMU Munich.



**Dr. Thomas Lunkenbein** (*Fritz Haber Institute Berlin*) studied chemistry at Bayreuth, where he also did his PhD. In 2012 Thomas Lunkenbein moved as postdoc to the Electron Microscopy Group at the Fritz Haber Institute in Berlin. Since 2018 he has led the group himself. One focus of his research is to gain knowledge on

selected materials and catalysts relevant for energy conversion. In particular, the group uses a variety of state-of-the-art analytical electron microscopes to control the synthesis of new catalysts as well as to monitor structural developments induced under catalytic conditions down to the atomic level.



**Prof. Knut Müller-Caspary** (*Physical Chemistry, LMU*) is an expert in multidimensional transmission electron microscopy (TEM). Within his scientific career path at EMAT in Antwerp, RWTH Aachen and FZ Jülich he developed methodologies such as momentum-resolved scanning TEM and ultrafast electron detection.

With these tools, the scientists can dive into materials to the sub-atomic scale. For instance, they are able to map and measure electrical charges and thereby analyze the structural, chemical and electrical properties of materials to understand optoelectronic processes, e.g. in solar cells, or site-specific catalyst performance. Since 2021 he has been professor at the Chemistry Department of LMU.





**Prof. Jennifer Rupp** (Department of Chemistry, TUM) is specialist in designing solid-state materials for new ways of energy storage as well as for information devices. The first topic includes stable hybrid and solid-state batteries with a high capacity and materials to convert solar energy into synthetic fuel. In the field of information storage and transfer, she develops neuro-morphic computing materials and elements that work beyond classic binary digit transistors. Jennifer Rupp studied at TU Vienna, obtained her PhD in material science at ETH Zurich, and worked at NIMS Tsukuba Japan and MIT. From 2012 to 2016 she was assistant professor at ETH, and afterwards worked at MIT. Since 2021 Jennifer Rupp has held a professorship in Solid-State Electrolyte Chemistry at TU Munich (see also interview on p. 16).



**Prof. Marc Willinger** (Department of Chemistry, TUM) is another outstanding expert on electron microscopy. The Austrian scientist studied physics at TU Vienna and obtained his PhD from TU Berlin. After a postdoc at the Fritz Haber Institute (FHI) in Berlin and four years at the University of Aveiro in Portugal, he came back to the FHI as group leader. He started to develop and implement tools for multi-scale *in-situ* and *operando* electron microscopy. In 2018 Prof. Willinger moved to ETH Zurich, to work as Technical Director at the Scientific Center for Optical and Electron Microscopy (ScopeM). In April 2022 he arrived at TU Munich, where he is now building up and equipping the new Chair of Electron Microscopy with research emphasis on energy materials.

## Goodbye

All the best for a new start

**It is a pity every time one of our scientists leaves Munich. On the other hand, this creates a lively e-conversion alumni network around the globe. We wish our former members all the best and hope that they stay closely connected with our cluster!**



**Prof. Stefan Maier** will have to travel half way round the world to reach his new workplace. He is going to start at Monash University in the south-east of Melbourne, Australia, as Head of the Monash School of Physics and Astronomy.

## Hans Fischer Senior Fellows

**We are happy that two other renowned scientists are guests at e-conversion as Hans Fischer Senior Fellows. As part of the fellowship program of the TUM Institute for Advanced Study, they will research exciting new topics for three years together with members of e-conversion.**



**Prof. Naomi Halas**, from Rice University (Houston, Texas), starts a project with Prof. Jonathan Finley from the Chair of Semiconductor Nanostructures and Quantum Systems (Walter Schottky Institute, TUM). She holds professorships in Electrical and Computer Engineering, Biomedical Engineering, Chemistry and Physics and Astronomy. She is founding director of the Laboratory for Nanophotonics at Rice University and the director of the Smalley-Curl Institute.



**Prof. Peter Nordlander**, also from Rice University, collaborates with the group of Prof. Stefan Maier, Chair in Hybrid Nanosystems at LMU Munich. Peter Nordlander is Wiess Chair of Natural Science and holds three professorships: Physics and Astronomy, Electrical and Computer Engineering, Materials Science and Nanoengineering.



**Prof. Harald Oberhofer** moved to the University of Bayreuth and is now leading one of the Chairs for Theoretical Physics. His focus is on Computational Materials Design.



We are delighted for our former member **Dr. Jacek Stolarczyk** about his new position at the University of Krakow, Poland. Since December 2021 the physicist has held a professorship at the Marian Smoluchowski Institute of Physics.

# Outlook

Save the dates



## FORSCHA 2023

May 5 – 7, 2023

Theresienhöhe/Alte Messe, Munich

The participation of e-conversion in the Munich science fair FORSCHA 2022 was a great success. Our cluster will therefore certainly be represented again in 2023 with a booth, lectures and workshops.

## 11th International Conference on Quantum Dots

July 11 – 15, 2023

GALILEO Science Congress Center, Garching near Munich

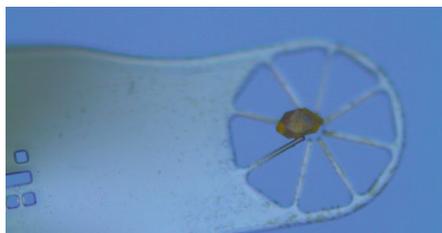
The conference series started in Munich in 2000 and since then has regularly brought together the world's leading scientists in the field of quantum dot research.



Due to the current situation, we cannot be sure that all events can take place. Please check in advance on our website at [www.e-conversion.de/events](http://www.e-conversion.de/events).

# Mysterious science

Guess and win



You can find our current science quiz on our website at [www.e-conversion.de/mysterious-science](http://www.e-conversion.de/mysterious-science). Win great prizes from the world of science and energy.



[www.e-conversion.de/mysterious-science](http://www.e-conversion.de/mysterious-science)

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