Darmstadt Symposium

THE GREAT TRANSITION

The importance of critical metals for green energy technologies

July 13th 2017, 09:00 – 18:00
in the Orangerie in Darmstadt

Organized by:

Symposium chair:
Prof. Dr. Oliver Gutfleisch, TU Darmstadt und Fraunhofer IWKS

Symposium co-chairs:
Prof. Dr. Wolfram Jaegermann, TU Darmstadt
Prof. Dr. Peter Schaaf, TU Ilmenau

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TECHNISCHE UNIVERSITÄT DARMSTADT
RESPONSE

The great transition – the importance of critical metals for green energy technologies

Symposium on Thursday, July 13th 2017, 09.00 – 18.00, in the Orangerie in Darmstadt

SCOPE:
The unsustainability of our fossil fuel based society and economy is at the beginning of the end. Today, the critical supply of primary and secondary resources directly impacts on the development and cost of advanced materials which form the basis for a number of latest green energy technologies. The efficient utilisation or substitution of strategic metals with more sustainable and earth abundant elements is the big challenge for the Great Transition.
Well-known experts from academia and industry will give key-note lectures addressing the substitutionability of critical metals in the different classes of functional materials. The aim is to develop new materials and efficient energy technologies with a reduced supply risk and enhanced environmental sustainability.

The workshop is jointly organised by the **DGM Fachausschüsse *Funktionswerkstoffe*** and ***Werkstoffe der Energietechnik*** and the **Jung-DGM** Darmstadt. Co-organisers are the ***Fraunhofer Project Group Materials Recycling and Resource Strategies IWKS***, the Hessen **LOEWE Excellence Cluster *RESPONSE***, the **TU Darmstadt Profile Area Future Energy Systems** and the **KIC EIT Raw Materials.**

Symposium chair:
Prof. Dr. Oliver Gutfleisch, TU Darmstadt und Fraunhofer IWKS

Symposium co-chairs:
Prof. Dr. Wolfram Jaegermann, TU Darmstadt and Prof. Dr. Peter Schaaf, TU Ilmenau

Location:
Orangerie in Darmstadt
Bessunger Str. 44
64285 Darmstadt

Registration fees:
- 80,- Euro
- 50,- Euro for DGM Members
- 10,- Euro for Jung DGM and for Students

The registration fee includes coffee breaks, lunch and beer & brezels at the end of the day.

Registration and detailed information:
http://www.mawi.tu-darmstadt.de/fm/funktionale_materialien/index.en.jsp

Program

08:30 – 09:30	Registration and Coffee
09:30 – 09:40	*Opening* - Prof. Oliver Gutfleisch, TU Darmstadt and Fraunhofer IWKS
Power-to-fuel, Energy Storage	
09:40 – 10:10	Prof. Robert Schlögl, Fritz-Haber-Institute, Max-Planck-Society: *Chemical Energy Conversion*
10:10 – 10:40	Prof. Andreas Züttel, EPFL Lausanne, Laboratory of Materials for Renewable Energy (LMER): *Hydrogen, hydrides and synfuels from renewable energy*
10:40 – 11:00	Coffee
11:00 – 11:30	Prof. Peter Schaaf, TU Ilmenau: *Hybride nanocomposites for photocatalysis*
11:30 – 12:00	Prof. Maximilian Fichtner, Helmholtz-Institute Ulm, KIT: *New materials for electrochemical storage - from post Li ion to post Li systems*
12:00 – 12:30	Jun.-Prof. Ulrike I. Kramm: *Substitutional catalysts for fuel cell applications*
12:30 – 13:30	Lunch
Photovoltaics and Thermoelectrics	
13:30 – 14:00	Prof. Kornelius Nielsch, Leibniz Institute IFW Dresden: *The Importance of 3D Topological Insulator for Thermoelectric Applications and why we need a Green Topological Insulator*
14:00 – 14:30	Dr. Gilles Dennler, IMRA Europe, Sophia Antipolis, France: *Accelerated discovery of new thermoelectric materials by high throughput ab-initio computations and experimental validation*
14:30 – 15:00	Prof. Wolfram Jaegermann, Material Science, TU Darmstadt: *New thin film multi-absorbers for photovoltaics und photoelectrosynthesis*
15:00 – 15:15	Coffee
Magnetic Materials and Superconductors	
15:15 – 15:45	Prof. Bernhard Holzapfel, KIT, Institute for Technical Physics: *Superconducting materials in energy applications*
15:45 – 16:15	Dr. Michael Krispin, Siemens AG, Corporate Technology: *RE magnets for Green Energy and eMobility*
16:15 – 16:45	Prof. Oliver Gutfleisch, Material Science, TU Darmstadt and Fraunhofer IWKS: *Material criticalities in magnetism for energy technologies*
16:45 – 16:55	Dr. Roland Gauss, EIT Raw Materials GmbH, Thematic Officer Substitution *EIT RawMaterials – Developing raw materials into a major strength for Europe*
16:55 – 17:00	*Closing* - Prof. Wolfram Jaegermann, Material Science, TU Darmstadt
17:00 – 18:00	Beer & Brezels (weather allowing on the terrace to the park)

Session: Power to fuel, Energy Storage

9:40 – 12:30

Chemical Energy conversion

Prof. Robert Schlögl
Max Planck Institute for Chemical Energy Conversion, Muelheim a.d.Ruhr, Germany
Fritz Haber Institute, Berlin, Germany

The world sees multiple efforts to reduce the role of fossil fuels in the energy system. The motivation for this trend is manifold ranging from fears about insufficient resources to local cost structures and energy security arguments. Protecting the global climate from the adverse effects of greenhouse gas emissions is outside Europe rarely the real driver for change. This has not substantially changed after the accord of Paris in global warming. The term "energy system" describes the intricate interactions between technical, economic, and societal factors determining the local structure of energy supply to a society. Such diversity requires a broad consideration of measures and of options of how to de-fossilize the energy supply.

The seemingly easy answer to use solar primary electricity as substitute to fossil resources and to maximally electrify the energy system being postulated by "energy activists" is only at first glance an option. The sheer dimension of the transformation, cost arguments and the inherent volatility require a dual energy system of material and free electrons as energy carriers. Dual systems require free convertibility of energy carriers in both directions. This is easy from material energy carriers to free electrons but extremely difficult in the reverse direction. The presentation will highlight origins of this critical bottleneck for energy systems. No energy system will become sustainable without chemical energy conversion, a technology of instrumental character. Unfortunately we still miss multiple fundamental insights into elementary processes of this technology finding its foundation in the physical chemistry of interfacial processes.

Biography

Robert Schlögl studied chemistry and completed his PhD at Ludwig Maximilian University in Munich. After post-doctoral stays at Cambridge and Basle and a professorship at University Frankfurt, in 1994 he became director at Fritz Haber Institute of the Max Planck Society in Berlin. Furthermore, in 2011 he was appointed founding director of the Max Planck Institute for Chemical Energy Conversion in Mülheim a.d. Ruhr. He is an Honorary Professor at Technical University Berlin, at Humboldt University Berlin and at University Duisburg-Essen, Ruhr University Bochum and a Distinguished Affiliate Professor at TU Munich. His research mainly focuses on inorganic chemistry, heterogeneous catalysis, nanostructures, material science for chemical energy conversion and concepts for sustainable energy supply and storage.

Hydrogen, hydrides and synfuels from renewable energy

Prof. Andreas Züttel
LMER, ISIC, SB, École polytechnique fédérale de Lausanne (EPFL) Valais/Wallis, Energypolis, Rue de l'Industrie 17, CP 440, CH-1951 Sion, Switzerland

Storage of renewable energy becomes more important with increasing contribution of renewable energy to the energy demand. Energy storage for mobility and seasonal storage are the two major challenges, because of the high energy density required and the large amount of stored energy. The technical solution is to produce hydrogen from renewable electricity. Hydrogen production by electrolysis is an established technology also currently we are facing a lack of large scale electrolysers available. The storage of hydrogen under high pressure, in liquid form or in hydrides is a material challenge and limited to 50% of the energy density of liquid hydrocarbons. The hydrogen can be used to reduce CO_2 from the atmosphere in order to synthesize liquid hydrocarbons. This requires large scale electrolyzers, hydrogen storage, adsorption of CO_2 and finally a well controlled reaction of H_2 and CO_2 to a specific product, e.g. octane. The storage of liquid hydrocarbons is a well established technology. The challenges and the solutions for the realization of the technical process will be discussed and an example of the realization of the whole energy conversion chain will be presented.

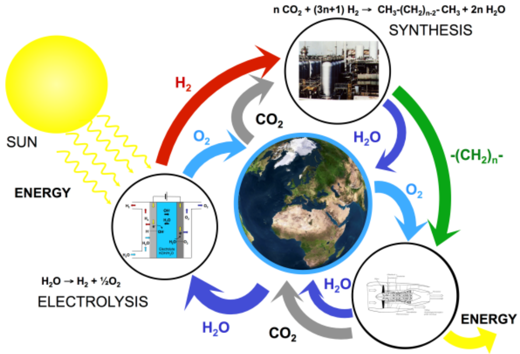


Fig. Schematic representation of the closed materials cycle, where hydrogen is produced from renewable energy and used together with CO_2 from the atmosphere to synthesize hydrocarbons as CO_2 neutral energy carriers.

Biography

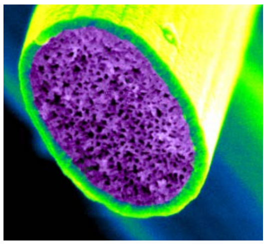
Born 22. 8. 1963 in Bern, Switzerland. 1985 Engineering Degree in Chemistry, Burgdorf, Switzerland. 1990 Diploma in Physics from the Unversity of Fribourg (UniFR), Switzerland. 1993 Dr. rer. nat. from the science faculty UniFR. 1994 Post Doc with AT&T Bell Labs in Murray Hill, New Jersey, USA. 1997 Lecturer at the Physics Department UniFR. 2003 External professor at the Vrije Universiteit Amsterdam, Netherlands. 2004 Habilitation in experimental physics at the science faculty UniFR. President of the Swiss Hydrogen Association „HYDROPOLE". 2006 Head of the section "Hydrogen & Energy" at EMPA and Prof. tit. in the Physics department UniFR. 2009 Guest Professor at IMR, Tohoku University in Sendai, Japan. 2012 Visiting Professor at Delft Technical University, The Netherlands, 2014 Full Professor for Physical Chemsitry, Institut des Sciences et Ingénierie Chimiques, Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland.

Hybride nanocomposites for photocatalysis

Univ.-Prof. Dr. Dr. Peter Schaaf

TU Ilmenau, Institute of Material Science and Engineering, Institute of Micro and Nanotechnologies MacroNano®, Ilmenau, Germany

Nanoparticles, nanowires, and many other nanostructures are produced and investigated for applications for quite some time. The desired functionality is not easy to achieve in a reproducible way. Various methods will be presented how such structures can be produced in a well-defined arrangement and well defined functionality. Nanoporous nanostructures can be easily tuned for applications by advancing them to nanocomposites with desired functionality, which can be used in medicine, energy storage and conversion, photocatalysis and further applications.



References:

[1] Yong Yan, Andreea Ioana Radu, Wenye Rao, Hongmei Wang, Ge Chen, Karina Weber, Dong Wang, Dana Cialla-May, Juergen Popp, and Peter Schaaf. “Mesoscopically bicontinuous Ag-Au hybrid nanosponges with tunable plasmon resonances as bottom-up substrates for surface-enhanced Raman spectroscopy (SERS)”. Chemistry of Materials 28(21) (2016) 7673–7682. http://dx.doi.org/10.1021/acs.chemmater.6b02637

[2] Wenzhi Ren, Yong Yan, Leyong Zeng, Zhenzhi Shi, An Gong, Peter Schaaf, Dong Wang, Jinshun Zhao, Baobo Zou, Hongsheng Yu, Ge Chen, Eric Michael Bratsolias Brown, Aiguo Wu. “A Near Infrared Light Triggered Hydrogenated Black TiO2 for Cancer Photothermal Therapy”. Advanced Healthcare Materials 4(10) (2015) 1526–1536. http://dx.doi.org/10.1002/adhm.201500273

[3] Dong Wang, Yong Yan, Peter Schaaf, Thomas Sharp, Sven Schönherr, Carsten Ronning, Ran Ji. “ZnO/porous-Si and TiO2/porous-Si nanocomposite nanopillars”. Journal of Vacuum Science and Technology A 33(1) (2015) 01A102-1-7. http://dx.doi.org/10.1116/1.4891104

[4] Yong Yan, Moyan Han, Alexander Konkin, Tristan Koppe, Dong Wang, Teresa Andreu, Ge Chen, Ulrich Vetter, Joan Ramón Morantee, Peter Schaaf. “Slightly hydrogenated TiO2 with enhanced photocatalytic performance”. Journal of Materials Chemistry A 2(32) (2014) 12603–13170. http://dx.doi.org/10.1039/c4ta02192d

Biography

Professor Peter Schaaf is full professor and holds the chair of Materials for Electronics and Electrical Engineering at the TU Ilmenau. He is embedded in the Institute for Materials Science and Engineering and in the Institute for Micro and Nanotechnologies MacroNano® of TU Ilmenau. Professor Schaaf studied Physics from 1982 to 1988 at Saarland University in Saarbrücken, Germany. There, he also received in 1991 a PhD in Materials Science and Engineering. In 1992, he moved to Göttingen University and got his habilitation there in 1999. Since 2008, he is full professor at Ilmenau University and holds the chair for Materials in Electrical Engineering and Electronics. His research is focused on functional materials, nanomaterials, thin films and nanoalloys and nanocomposites.

New materials for electrochemical storage - from post Li ion to post Li systems

Prof. Maximilian Fichtner
Helmholtz-Institute Ulm (HIU), KIT

The paper presents recent work from our group on post Li ion and post Li systems for electrochemical storage. In the field of Li-S batteries, it was possible to re-direct the reaction pathway of the sulfur reduction by melt infiltration of the sulfur in ultramicroporous carbon with pore diameters at around 0.5 nm. Thus, the reaction space is restricted and the spacious S_8 ring cannot enter the pores. In effect, smaller allotropes of the sulfur are infiltrated that are in equilibrium with the S_8 until the sulfur has almost completely filled the pores. Moreover, the electrolyte cannot enter the small pores and the Li is stripped at the surface of the carbon, migrates, and makes a quasi-solid-state reaction. No higher order polysulfides are formed in the electrolyte over hundreds of cycles and only one voltage plateau is generated during cycling. Higher sulfur loaded (> 3 mg S/cm^2) electrodes can be made and less electrolyte may be used due to the lack of reacting polysulfides in the liquid.
A logical step towards Li-free systems is the development of the Mg-S battery. This would be particularly attractive as Mg doesn´t form dendrites upon plating and can be used in metallic form without compromising the safety. Moreover, Mg is comparably cheap and abundant and the theoretical energy density of a Mg-S cell is higher than that of the Li-S couple. In this respect, a non-nucleophilic electrolyte was developed that is compatible to sulfur and is easy to prepare from two ingredients (Mg-bisamide and $AlCl_3$) while a variety of solvents can be used. Its electrochemical stability window is 3.9 V and first Mg-S cells were built and cycled for dozens of times. It is shown that an addition of Se to the sulfur considerably increases the electrical conductivity of the cathode thus leading to improved performance. Still, the system suffers from degradation upon cycling, which is again due to the generation of polysulfides, electrode bleeding, and passivation of the Mg surface.
A logical consequence of the upcoming resource situation is the development of high performance materials that are based on renewable resources. In this regard, we have developed a new electrode material, which is based on an organic natural material and which delivers good specific capacities in the order of 170 mAh/g at an average voltage of approx. 3 V. The material can be charged and discharged at rates around 50 C. By a simple modification of the material, the typical issue of organic batteries, the degradation upon cycling, was greatly improved and 80% of the capacity was retained after 6,000 cycles. The material can be used as cathode or anode, or both. Charge and discharge can be done based on Li or other ionic shuttles such as Na ion [3].

[1] *Single step transformation of sulphur to Li2S2/Li2S in Li-S batteries*, M. Helen, M. Anji Reddy, T. Diemant, U. Golla-Schindler, R. J. Behm, and M. Fichtner, Scientific Reports 5 (2015) 12146
[2] *New class of non-corrosive, highly efficient electrolytes for rechargeable magnesium batteries*, Zh. Zhao-Karger, E.G. Bardaji, Olaf Fuhr, and M. Fichtner, J. Materials Chem. A 5 (2017) 10815-10820
[3] *Porphyrin complex as self-conditioned electrode material for high performance energy storage*, P. Gao, Z. Chen, Zh. Zhao-Karger, J.E. Mueller, Ch. Jung, S. Klyatskaya, O. Fuhr, M. Ruben, M. Fichtner, Angew. Chemie Int. Ed. (2017) accepted.

Biography

Maximilian Fichtner is a full professor (W3) for Solid State Chemistry at the Ulm University and head of Materials-I at the *Helmholtz-Institute Ulm for Electrochemical Storage (HIU)*, a German Center of Excellence for Battery Research, with approx. 110 employees. Since 2015 he is also Executive Director of the institute. His current research interest is on novel principles for energy storage and the related materials in insertion and conversion-type battery systems. Recent work has focused on the new class of Li rich materials with rocksalt structure, anionic shuttles, magnesium batteries, and organic electrode materials. He has published more than 250 research and conference papers and is (co-)author of 20 patent applications. His h index is 39.

Substitutional catalysts for fuel cell applications

Jun.-Prof. Dr. Ulrike I. Kramm
TU Darmstadt, Material Science and Chemistry, Catalysts and Electrocatalysts, Germany

In Europe about 1/3 of energy is converted in the transportation sector – most of it in street traffic. The related quantity of CO_2 could be significantly less if standard combustion engines are replaced by electric motors. In fuel cells, the chemical energy of fuels is converted into electricity that could be used for such electric vehicles. The most common fuel cell reaction is the conversion of hydrogen and oxygen to water. However, one mayor problem that hinders commercialization is the required amount on rare and expensive platinum, that catalysis the chemical half-cell reactions.

In this talk, I will shortly introduce the main concept to use hydrogen for a CO_2 free (or neutral) economy as well as some cost estimates related to fuel cells. As it will be seen, non-precious metal catalysts of the group Me-N-C could be possible candidates for a substitution of platinum in fuel cells and could also be of interest for other relevant catalytic reactions.

Biography

Ulrike I. Kramm is a junior professor for Catalysts and Electrocatalysts at TU Darmstadt. The professorship is a bridging position between the departments of chemistry and materials science and embedded in the Graduate School of Excellence Energy Science and Engineering. Ulrike Kramm studied Applied Physics in Zwickau and worked two years as engineer on the development of fuel cell catalysts before she started her PhD thesis at the Helmholtz-Center Berlin for Materials and Energy. Her postdoc period included a scholarship in the group of Jean-Pol Dodelet (INRS-EMT), Canada.
Before she joined the TU Darmstadt she had a guest professorship at TU Berlin, Chemical engineering for one semester.
Her research interest focusses mainly on new and mainly non-precious catalysts for different catalytic applications that are of relevance for the energy transition.
In February 2017 she was awarded a BMBF Young researcher group (Fe-N-C – StRedO2) within the frame NanoMatFutur.

Session: Photovoltaics and Thermoelectrics

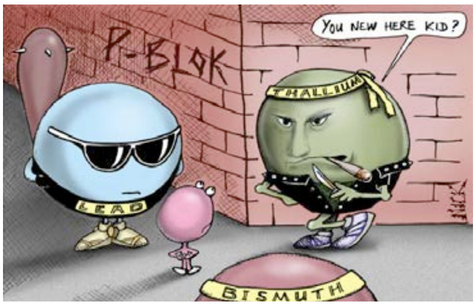
13:30 – 15:00

Leibniz-Institut für Festkörper- und Werkstoffforschung Dresden

The Importance of 3D Topological Insulator for Thermoelectric Applications and why we need a Green Topological Insulator

Prof. Dr. Kornelius Nielsch
Leibniz Institute of Solid State and Materials Research, Dresden, Germany

Thermoelectric materials could play an increasing role for the efficient use of energy resources and waste heat recovery in the future [1]. The thermoelectric efficiency of materials is described by the figure of merit $ZT = (S^2\sigma T)/\kappa$ (S Seebeck coefficient, σ electrical conductivity, κ thermal conductivity, and T absolute temperature). In recent years, several groups worldwide have been able to experimentally prove the enhancement of the thermoelectric efficiency by reduction of the thermal conductivity due to phonon blocking at nanostructured interfaces.



Cartoon: New kid on the block surrounded by the heavy elements.

In this presentation we challenge the interconnection between thermoelectric performance and topological insulator nature of chalcogenide-type materials. While topological surface states seem to play minor role in the thermoelectric transport in (nanograined) bulk materials, it will be shown that they severely contribute to the transport in nanostructures due to their high surface-to-volume ratio [2]. For thermoelectric conversion processes near room temperature and up to 200°C Bi_2Te_3 and related materials are the dominating materials for devices and many attempts replacing this material class has failed. For decades it is was known that heavy elements efficiently damp phonons. In the past 5 years we have learned that Bi_2Te_3 and Bi_2Se_3, due to strongly spin-orbit couple, exhibit topical surface states and are 3D topological insulators. This has stimulated the research on novel materials which exhibit topological surface states, like SnSe.

[1] K. Nielsch, J. Bachmann, J. Kimling, H. Böttner, "Thermoelectric Nanostructures: From Physical Model Systems towards Nanograined Composites", Adv. Eng. Mater. 1, 713-731 (2011)
[2] J. Gooth, J.G. Gluschke, R. Zierold, M. Leijnse, H. Linke, K. Nielsch, "Thermoelectric performance of classical topological insulator nanowires", Semicond. Sci. Technol. 30, 015015 (2015).

Biography

Kornelius Nielsch has studied physics at the University Duisburg, Germany and performed the master thesis on semiconductor nanoparticles from aerosols at Lund University, Sweden in 1997. Thereafter, he joined the group of Ulrich Goesele at the Max-Planck-Institute of Microstructure Physics in Halle, where his Ph.D. thesis focused on nanowire based patterned magnetic media. After Ph.D., he joined as a postdoctoral associate the group of Caroline Ross at MIT in 2002. From October 2003 he was the leader of a nanotechnology research group funded by the German Federal Ministry of Education and Research (BMBF) on Multifunctional Nanowires and Nanotubes at the Max-Planck-Institute in Halle. In 2006, the Hamburg University has appointed him as a W2 professor for experimental physics, where he leads a research team of 25 students, post-doctoral researchers and visiting scientists. From 2009 until 2016 he has coordinated the German Priority Program DFG-SPP 1386 on Nanostructured Thermoelectrics. In 2015 he became the director of the Institute of Metallic Materials at IFW Dresden and full professor W3 at TU Dresden.

Accelerated discovery of new thermoelectric materials by high throughput ab-initio computations and experimental validation

Dr. Gilles Dennler
Department of Advanced Materials, IMRA Europe S.A.S., Sophia Antipolis, France.

Large deployment and market penetration of waste heat recovery devices for motor vehicles require the identification and development of new non-toxic, low cost and earth abundant thermoelectric (TE) materials. To ensure their competitiveness, these materials have to show TE performances at least comparable to the ones of the current reference systems, namely Sb or Se doped Bi_2Te_3. Accelerating the discovery of such new materials appears crucial for fulfilling the demand of the current energy market pull.
In the present study, we employ an integrated computational and experimental approach to search for new thermoelectric materials conforming to the boundary conditions of abundance and non-dangerousness. We have used first principles calculations of thermoelectric transport coefficients and substitutional defect thermochemistry to screen more than 1,500 binary and ternary metal sulfides with a high throughput. The case of a few different promising materials will be discussed in details, with a special focus upon a new ternary metal sulfide, entirely based upon low cost and non-toxic elements. We will show that by carrying out a systematic optimization of the experimental parameters upon the guidance of DFT calculations, we could achieve a power factor as high as 2.7 mW.m-1.K-2 at 540K. This is, to the best of our knowledge, the largest value ever reported on polycrystalline metal sulfides, competing directly with state-of-the-art Bi_2Te_3.

Biography

Gilles Dennler obtained a Ph.D. in Plasma Physics at the University of Toulouse (France) and a Ph.D. in Experimental Physics at Ecole Polytechnique of Montréal (Canada). In 2003, he moved to the Linz Institute for Organic Solar Cells (Austria) directed by Prof. N. S. Sariciftci, where he was appointed Assistant Professor. In 2006, he joined Konarka Technolgies Inc. (Linz, Austria and then Lowell MA, USA) where he served as Director of Research. In 2011, he took the lead of the Department of Advanced Materials at IMRA Europe (France), a research company of the AISIN group, itself member of the Toyota group of companies. His main research interests are photovoltaics, thermoelectrics, and 2D materials.

New thin film multi-absorbers for photovoltaics und photoelectrosynthesis

Prof. Dr. Wolfram Jaegermann
TU Darmstadt, Material Science, Surface Science, Germany

High performance photovoltaic or photoelectrosynthesis converters are expected from multi-junction devices in which two or three different absorber materials are integrated in one device structure. The applicability of such devices has already been proven with mulitjunction cells based on 3-5 semiconductors epitaxial layers or combinations of μc/a-SiH thin films. With triple cells based on 3-5 compounds conversion efficiencies beyond 40% have been achieved but Ga, In, and As as their main ingredient are considered to belong to the class of critical materials which may not exist in the needed amounts. It was also demonstrated that buried junction multiabsorber cells are able to split H_2O to H_2 as possible solar fuel without any additional electrical bias. Therefore materials combinations to be used in tandem or multijunction cells are urgently needed for advanced solar cell converters but have hardly been investigated so far despite their promising perspectives.
Despite the large number of possible semiconductor materials known only very few have been proven to be of use for photovoltaic converters. This fact is in part related to a number of limiting intrinsic macroscopic properties, which must be fulfilled and which so far can hardly be deduced from the composition, structure, and (opto)electronic properties of the related materials. As a consequence, there is an urgent need for a materials genom project for photovoltaic converters, which allows to deduce the needed design and development strategies from fundamental elementary considerations. For the materials selection physico-chemical boundary conditions and materials science aspects of manufacturing must be taken into account, but the availability and environmental risks us the selected elements should be considered in addition. In this talk criticality aspects in materials design will mostly be discussed with respect to demands and possible concepts to reduce the use of scarce and environmentally dangerous material, also considering their recycling, but mostly their substitution by novel materials, and improving their performance by a better understanding of the interrelation of elemental composition, synthesis and processing, and related-efficiency.

Biography

Prof. Wolfram Jaegermann is a full Professor (W3) for Surface Science at TU Darmstadt. He is in addition cofounder of the TU Darmstadt energy center and speaker of the Excellency Graduate School of Energy Science and Engineering and of the TU Darmstadt profile area New Energy Systems. He studied Chemistry at the University of Darmstadt and got his PhD in Bielefeld. Afterwards, he was first group leader and later department head of Surface Science at the Helmholtz Center Berlin. He spent his Post-Doc time at DuPont, Wilmington and got his Habilitation in Physical Chemistry at the FU Berlin.
In 1997 he joined TU Darmstadt. His scientific research interest is related to the surface science of energy materials ranging from thin film solar cells, (photo)electrolysis for fuel production and photocatalysis, batteries, organic semionductors, as well as fundamental aspects of solid/electrolyte interfaces, and of solid semiconductor interfaces. A specific aspect of our research is the development and use of integrated cluster tools, which allow to integrate thin film deposition technologies and different surface science techniques for detailed interface studies and for the manufactoring of demonstrator devices.

Session: Magnetic Materials and Superconductors

15:15 – 17:00

Superconducting materials for energy applications

Prof. Dr. Bernhard Holzapfel
Institute for Technical Physics, Karlsruhe Institute of Technology, Karlsruhe, Germany

Cuprate based High Temperature Superconductors (HTSC) offer significant advantages in modern high power and magnet applications and are currently on the way into commercial products. The extremely high current carrying capability of HTSC superconducting wires and tapes compared to conventional conductors enable huge improvements of power density and connected to that strongly reduced system size, weight and raw material need. In this talk I will review firstly the basics and current status of superconducting material development as well as the realization of HTSC based energy applications like high current industrial or urban power transmission lines. Secondly, using selected examples, I will illustrate and discuss the potential for raw material savings in power and magnet applications using HTSC materials.

Biography

Prof. Bernhard Holzapfel is a full Professor (W3) for Superconducting Materials at the Karlsruhe Institute of Technology and institute director of the Institute for Technical Physics at KIT. He studied Physics at the Friedrich-Alexander-University Erlangen-Nürnberg, where he also received his PhD in 1995. Before he joined KIT in 2013 he was head of the Superconducting Materials group at the Leibniz Institute IFW Dresden. His scientific interests are mainly connected to superconductivity and functional thin films in general. He is active in the investigation of new superconducting materials and their applicability in high current applications. A focus of his scientific work is concentrating on High Temperature Superconducting wires and tapes, covering the development of economic synthesis techniques, understanding their critical current limitation mechanisms and the realization of new power and magnet applications like high power density cables and motors as well as high field superconducting magnets.

SIEMENS
Ingenuity for life

RE magnets for Green Energy and eMobility

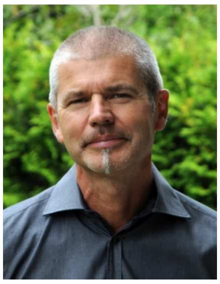
Dr. Michael Krispin
Siemens AG, Corporate Technology, Materials for Power Generation, Germany

Electrical machines based on Permanent Magnets (PM) with high energy density are well suited as highly efficient drives and generators in a wide range of applications. Permanent magnetic synchronous motors (PMSM) up to the MW class have been introduced by Siemens in the 1990ies, only a few years after the discovery of Nd-Fe-B magnets and their availability from mass-production. With increasing need for renewable energy sources and eMobility on land, in water, and even in air, the fields of applications are broadening and therefore demand for high performance permanent magnets is expected to grow. For all of those applications, permanent magnets with maximum energy density and long-term stability are required, which is why today's used magnets rely on rare earth elements. Then again the price rally of rare earth elements in 2011 showed their criticality for applications. Therefore different actions have been taken since then to respond to this challenge including innovations in material design and production processes.

Fig. High performance Permanent magnets used for highly efficient electrical machines (Source: Siemens AG)

Biography

Dr. Michael Krispin is a Project Manager and Research Scientist at Siemens AG Corporate Technology in the field of functional materials research and development. He studied Physics at University of Augsburg where he also did his PhD in solid state physics on the structure of iron oxide nanoparticles. In 2012 he joined Corporate Technology at Siemens AG. His interests are materials for power generation, i.e. fiber reinforced ceramics and hard and soft magnetic materials with particular focus on the reduction of rare earth elements.



Material criticalities in magnetism for energy technologies

Prof. Dr. Oliver Gutfleisch
TU Darmstadt, Material Science, Functional Materials, Germany
Fraunhofer Project Group Materials Recycling and Resource Strategy IWKS, Hanau, Germany

Magnetic materials are key components in energy related technologies, sensors and information technology. Magnets are inseparable from our everyday life. “Green” energy technologies such as wind turbines, electro-mobility and solid state cooling, heavily rely on high performance magnetic materials which have to be available in bulk quantities, at low-cost and with tailored magnetic hysteresis properties [1].
The realisation of these technologies is closely linked to the sustainable availability of the strategic metals for magnetism such as the group of rare earth elements (REE) namely Nd, Gd, Tb, Dy, transition metals such as Co, Ga, Ge, In, and the platinum group metals. Resource criticality is understood here as a concept to assess potentials and risks in using raw materials for certain technologies, and their functionality in emerging technologies. The concept of criticality of strategic metals is explained by looking at demand, sustainability and the reality of alternatives of rare earth elements.

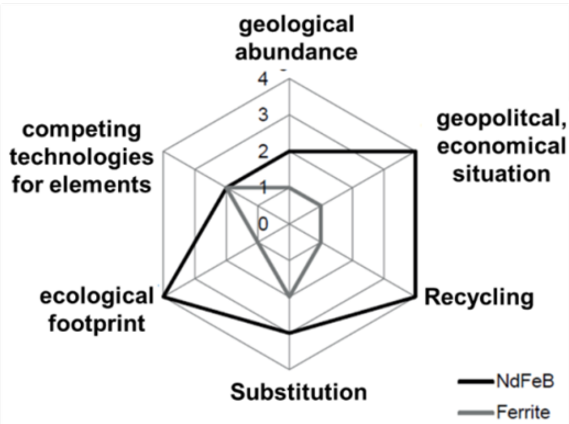


Fig. Spider chart (0 – no risk, 4 – high risk) analysing the criticality factors of metals – here a comparison of high performance NdFeB permanent magnet with low cost-low performance hard ferrite.

[1] O. Gutfleisch, J.P. Liu, M. Willard, E. Brück, C. Chen, S.G. Shankar, Magnetic Materials and Devices for the 21st Century: Stronger, Lighter, and More Energy Efficient (review), Advanced Materials 23 (2011) 821–842.

Biography
Prof. Oliver Gutfleisch is a full Professor (W3) for Functional Materials at TU Darmstadt and a scientific manager at Fraunhofer IWKS Materials Recycling and Resource Strategies. He studied Material Science at TU Berlin, did the Phd in Birmingham, UK, and was a group leader at Leibniz Institute IFW Dresden. 2012 he joined TU Darmstadt. His scientific interests span from new permanent magnets for power applications to solid state energy efficient magnetic cooling, ferromagnetic shape memory alloys, magnetic nanoparticles for biomedical applications, and to solid state hydrogen storage materials with a particular emphasis on tailoring structural and chemical properties on the nanoscale. Resource efficiency on element, process and product levels as well as recycling of rare earth containing materials are also in the focus of his work. In April 2017 he was awarded an ERC Advanced Grant (Cool Innov).

EIT RawMaterials – Developing raw materials into a major strength for Europe

Dr. Roland Gauß
EIT RawMaterials GmbH, Germany

The transition towards renewable energy is a vital component in establishing a Green Economy. This transition in energy use comes with a shift in raw materials use. Today, the accessibility and supply of critical raw materials directly impact the development and cost of advanced materials which form the basis for a number of latest green energy technologies. EIT RawMaterials represents a Knowledge and Innovation Community (KIC) that aims at turning raw materials into a major strength for Europe. This is done by boosting competiveness, growth, and attractiveness of the raw materials sector via radical innovation and entrepreneurship. The community exists of more than 110 partners from across Europe, representing the so-called Knowledge Triangle of industry, universities, and research institutes. Current raw material supply bottlenecks and the use of critical and toxic materials are considered as innovation and business potentials with respect to mineral exploration, mining, processing, substitution, recycling, and the transition towards a circular economy (e.g. industrial symbiosis, design). Successful technologies and business models consider the entire value chain.

Biography

Dr Roland Gauß is a Thematic Officer at EIT RawMaterials responsible for the fields of recycling as well as of substitution of critical, toxic, and low performance materials. He joined from Fraunhofer Project Group Materials Recycling and Resource Strategies IWKS in Hanau, Germany where he worked as Head of Department Functional Materials with the Business Units Magnetic Materials, Energy Materials, and Lighting. His personal research interest is related to metallurgy, the life cycles of materials, and how innovation processes are triggered and pursued by society. Roland Gauß was a research fellow at TU Bergakademie Freiberg (2004) and a Marie-Curie-Research-Fellow at University College London (2006). He received his PhD from the University of Tübingen in 2008 in the fields of economic geology of copper and extractive metallurgy in prehistoric societies.