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Energy for the Future

Energy Conversion and Energy Storage

April 2011

Energy Research at the University of Ulm

Over the past few decades, the demand for energy has been rising continuously. Parallel to this, it has become clear that fossil sources of energy are becoming increasingly scarce and will, in the foreseeable future, completely disappear. With other sources of energy, either the impact on the environment and climate is playing an increasingly important role (coal-burning power plants) or the issue of final disposal and security has not yet been resolved (nuclear power). Moreover, it is nearly impossible to increase the amount of energy generated by means of hydraulic power in Europe.
Despite the politically supported introduction of renewable energies such as wind power, solar thermal energy, photovoltaic energy and biomass energy, the following questions always play a central role, even in the long run:

How can power from primarily CO_2-neutral sources (e. g. solar power) be utilised and, more importantly, how can it be converted into affordable energy?

How can this energy be decentrally stored and transported, so that it can be utilised at any given time and without interruption?

The University of Ulm recognised the enormous need for research in this area early on and thus focused its research activities on »energy conversion and energy storage«. The emphasis of these interdisciplinary projects is on fields with a direct application orientation, such as battery research, biofuels and biogas, fuel cells, organic photovoltaics or hydrogen production. Further important fields in the search for solutions to the complex challenges at hand include efficient analytics, coupled with theory and simulation, and automatic control engineering.

The close cooperation on regenerative energies with the Centre of Solar Energy and Hydrogen Research (ZSW) and the recently established Helmholtz Institute Ulm for Electrochemical Energy Storage (HIU) place lasting emphasis on the significance of the research done in Ulm in the area of sustainable energy generation, energy storage and batteries/electromobility. In our brochure »Energy for the Future«, we would like to present to you our diversified research work. If your interest has been awakened and you have any questions or would like to discuss something with us, we would be delighted to hear from you and perhaps even have a personal chat.

Peter Bäuerle

Vice-President for Research

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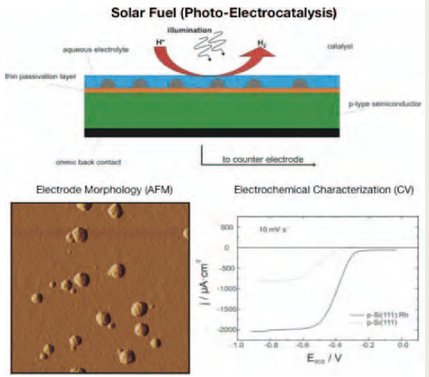
Batteries | Electrochemistry



The experimental works at the Institute of Electrochemistry focuses on the basics of electrochemistry, in particular the microscopic structure of electrode/electrolyte-interfaces (as present in batteries, fuel cells, or photo-electrochemical devices) and the occurring redox-processes.

- Electrochemical interfaces
- Electrocatalysis (and Photo-electrocatalysis)

Institute of Electrochemistry
http://www.uni-ulm.de/index.php?id=12457

Future mobility and renewable energies require new energy storage systems.
We provide the complete value chain from battery materials to the finished cell, test batteries under extreme conditions and verify their safety, durability and performance characteristics.

- Battery characterisation, safety tests and thermal investigations
- Cells manufacturing technology, materials research and analytics

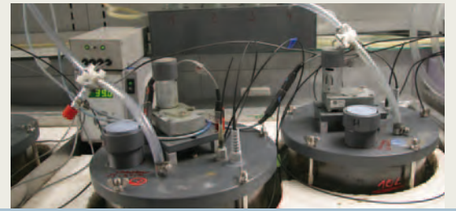
Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (ZSW)
http://www.zsw-bw.de

Biofuels | Biogas

Biobutanol is a biofuel suitable for conventional combustion engines. Its characteristics are similar to those of petrol and significantly superior to those of the bioethanol used to date.

- *Clostridium acetobutylicum*: Improvement of butanol production by metabolic engineering

Institute of Microbiology and Biotechnology
http://www.uni-ulm.de/index.php?id=7869

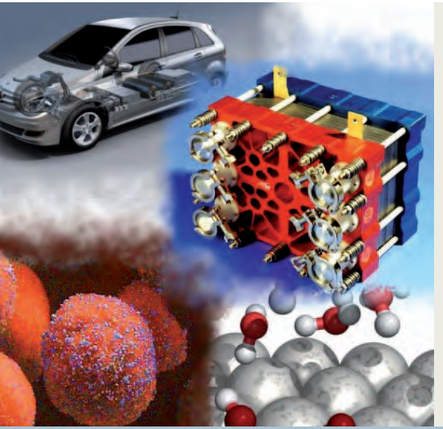


Biogas is often in competition with the food supply when it comes to the use of renewable resources. Our research focuses on the utilisation of waste material for generating energy, where the stability of the fermentation process and the composition of the microbial population are of key interest.

- Importance of plants as biofilm carriers for process stability
- Fermentation of waste plant material and municipal organic waste

Institute of Systematic Botany and Ecology
http://www.uni-ulm.de/index.php?id=31144

Fuel Cells (FC)



We investigate fundamental aspects of electrocatalytic reactions and processes important for low temperature fuel cells (lt FC). In close collaboration with institutional/ industrial users, we develop strategies for the optimisation of materials and processes.

- O_2 reduction in lt FC – fundamental aspects and low-Pt or Pt-free cathode catalysts
- Oxidation of organic fuels in direct oxidation FC – fundamental aspects and reaction optimisation

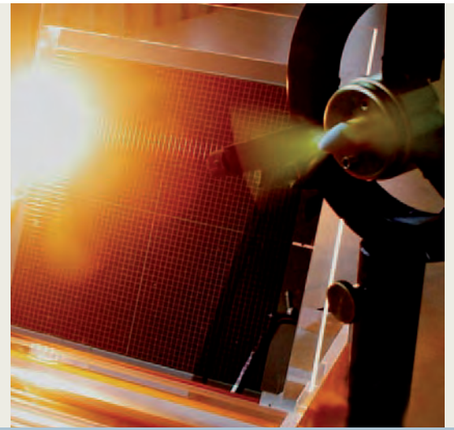
Institute of Surface Chemistry and Catalysis
http://www.uni-ulm.de/index.php?id=2630

We develop, optimise and test fuel cells and application systems. The development at ZSW focuses on vehicle drive trains as well as stationary and portable systems. Our know-how spans the entire value chain: from the fundamentals to the integration of complete fuel cell systems.

- FC: materials, components, modelling and processes
- FC stacks, systems, system applications and test centre

ZSW
http://www.zsw-bw.de

Organic Photovoltaics

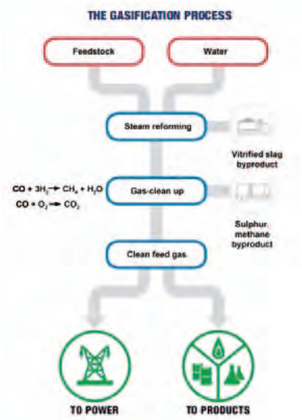


Organic photovoltaics is a technology of the future that is aimed at using printing processes to enable the low-cost production of flexible, large-scale modules, with the aid of synthetically produced organic dyes and semiconducting polymers.

- Synthesis and development of novel dyes and organic semiconductors for applications in organic electronics and photovoltaics
- Characterisation and analytics of organic semiconductors and materials

Institute of Organic Chemistry II and Advanced Materials
http://www.uni-ulm.de/index.php?id=4409

Hydrogen Production and Hydrogen Purification



This Institute's fields of research include the catalytic production of hydrogen. Here ruthenium complexes are used which catalytically produce hydrogen upon light excitation when triethylamine is present in acetonitrile.

- Catalytic Production of Hydrogen

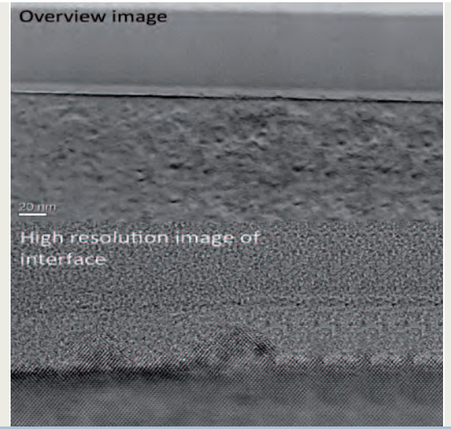
Institute of Inorganic Chemistry I
http://www.uni-ulm.de/index.php?id=13102

To avoid poisoning of the anode catalyst, CO has to be removed from fuel gases for low temperature fuel cells to below 10 ppm. In collaboration with institutional/industrial partners, we investigate fundamental aspects of catalytic processes for the removal of CO from realistic fuel gases.

- Removal of CO from H_2-rich fuel gases for fuel cells via water-gas shift reaction and selective oxidation of CO
- Selective methanisation of CO in CO_2- and H_2-rich fuel gases for fuel cells in stationary applications

Institute of Surface Chemistry and Catalysis
http://www.uni-ulm.de/index.php?id=2630

Electron Microscopy

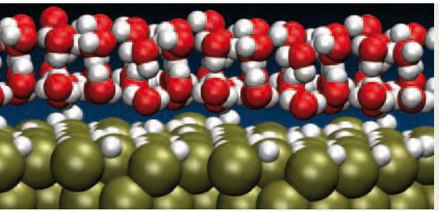


Analytical electron microscopy enables the determination of the chemical composition and crystal structure of samples down to individual atoms. In the »New Materials for Energy« field of research, it is possible to determine the local Li distribution within Li-based batteries during the charging and discharging phases. The electrically active areas of thin-film solar cells can be analysed locally. Analytical electron microscopy is also essential for researching and understanding new classes of materials such as graphenes, carbon nanotubes and fullerenes.

- Research on new materials for energy storage (Li batteries)
- Research on new concepts for solar cells
- Basic research nano carbons (graphenes, nanotubes, fullerenes)
- Development of new microscopy techniques for imaging materials sensitive to electron beams

Central Facility of Electron Microscopy,
Material Science Electron Microscopy Group
http://www.uni-ulm.de/index.php?id=5469

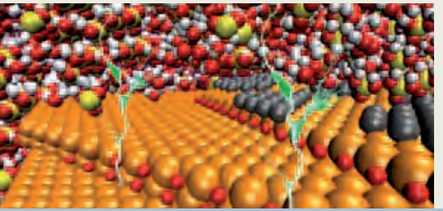
Theory | Simulation



At the Institute of Theoretical Chemistry, elementary processes of electrochemical energy storage and conversion are studied at the atomic level with ab initio methods in order to contribute to the improvement of fuel cells and batteries.

- Structure of the electrochemical electrode-electrolyte interface
- Description of electrocatalytic processes and reactions

Institute of Theoretical Chemistry
http://www.uni-ulm.de/index.php?id=20035

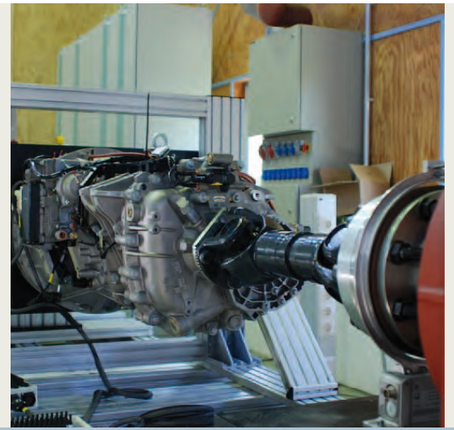


The theoretical simulations at the Institute of Electrochemistry focus on a fundamental understanding of electrochemical systems. The processes occurring in energy-relevant applications (e. g. batteries) are investigated at the molecular level using a multiscale approach.

- Fundamentals of electrochemistry
- Process-simulation in energy-relevant systems

Institute of Electrochemistry
http://www.uni-ulm.de/index.php?id=12457

Automatic Control Engineering



Innovative control and optimisation concepts are key elements for the energy-efficient operation of technical systems. In addition to the conceptual development of these methods, the analysis, modelling and simulation of the typically complex technical systems are of importance. Areas of application are, for instance, alternative automotive powertrain concepts and in-car power management, enhanced by vehicle environment detection and situation assessment for future driver assistance and safety systems.

- Electromobility and driver assistance systems
- Innovative energy-efficient control concepts
- Diagnosis and supervision of batteries and fuel cell systems
- Modelling and control of mechatronic systems

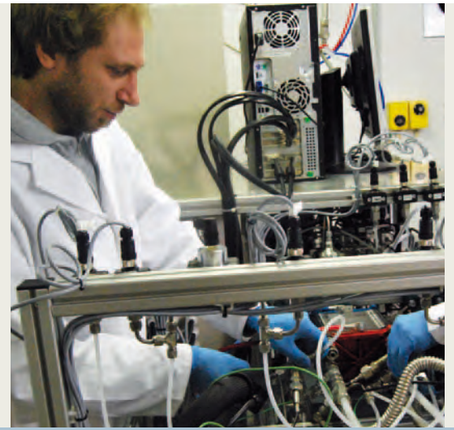
Institute of Measurement, Control and Microtechnology
http://www.uni-ulm.de/index.php?id=3629

Helmholtz-Institute Ulm for Electrochemical Energy Storage (HIU)

Powerful, affordable battery systems are necessary in order for electromobility to be cost-effective in the future. Another prerequisite for future-oriented battery technology is that fundamental research is broadened in order to integrate fluctuating renewable energies, such as wind and solar, into the energy system. The Karlsruhe Institute of Technology (KIT), a member of the Helmholtz Society, is rising to this challenge. The KIT founded the Helmholtz Institute Ulm for Electrochemical Energy Storage (HIU) on 1 January 2011 in cooperation with the University of Ulm. Associated partners are the German Aerospace Centre (DLR), also a member of the Helmholtz Society, and the Centre of Solar Energy and Hydrogen Research Baden-Wuerttemberg (ZSW).

Helmholtz-Institute Ulm for
Electrochemical Energy Storage (HIU)
http://www.hiu.kit.edu

ZSW | WBZU



Technologies for power generation and mobility are undergoing a major change with the decline of the fossil sources of energy. Here renewable energies will play an increasingly important role. New, efficient and intelligent technologies for energy conversion and storage will become indispensable: fuel cells and batteries.

- Applied research through the entire value chain
- High-level education and training of experts from trade, industry and academia at the »Weiterbildungszentrum Brennstoffzelle Ulm e. V.«
- Energy storage in batteries and supercapacitors
- Fuel cell development and manufacturing, modelling and simulation

Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (ZSW)
http://www.zsw-bw.de
http://www.wbzu.de

Int. M.Sc. Energy Science and Technology

The International Master of Science Programme in Energy Science and Technology was designed to provide students, both national and international, with a comprehensive education in the scientific and technological aspects of modern techniques for energy conversion and energy storage.

http://www.uni-ulm.de/index.php?id=6675
http://www.uni-ulm.de/index.php?id=202

Bachelor | Master Study Courses Chemistry

Course offered only in German.
The University of Ulm provides the perfect environment for studying chemistry. An attractive mix of theory and practical experience not only ensures a well-founded basic education in chemistry, but also offers you the opportunity to specialise in current fields, e. g. energy research, according to your individual aptitude and interest.

studienberatung.chemie-wirtschaftschemie@uni-ulm.de
http://www.uni-ulm.de/index.php?id=202

Study Courses

Bachelor | Master Study Courses in Physics

Course offered only in German.
The University of Ulm offers scientific programmes in the field of physics both at bachelor's and master's degree levels. These programmes impart the full breadth of the experimental and theoretical basics of physics while at the same time allowing for an emphasis that corresponds to the department's profile.

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http://www.uni-ulm.de/index.php?id=202

Int. M.Sc. Course Advanced Materials

The International Master of Science Programme Advanced Materials at the University of Ulm is an interdisciplinary course of studies with emphasis on nanomaterials and biomaterials. It will prepare you to play an active role in shaping advanced materials in the future. It combines topics from the fields of nanomaterials and biomaterials with the necessary foundations in materials science, chemistry, physics, biology and medicine.

http://www.uni-ulm.de/index.php?id=6764
http://www.uni-ulm.de/index.php?id=202

Are you interested?
If you have any questions, please contact us!

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