

SOLAR ENERGY RESEARCH AT HELMHOLTZ-ZENTRUM BERLIN

The main goal is the development of future generations of cost-effective thin-film solar cells and of systems to produce fuels such as hydrogen by direct photoelectrochemical conversion of solar radiation into chemical energy. To reach this objective, research is focused on achieving high efficiencies and substantial reductions in the costs of solar power generation. Translating the fundamental research results at HZB into industrial applications is the purview of PVcomB. PVcomB's main goal is to support worldwide growth of thin-film photovoltaic technologies and products by providing top level technology transfer.

Three Key-Missions

- Keeping the balance between improving existing thin-film technologies to a stage where industrial applications can follow as the next step while also exploring new materials and new concepts for future devices for solar cells.
- Basing scientific and technological progress upon both empirical work and basic research, taking into account fundamental aspects which are becoming increasingly important for the design of innovative nano-technological materials and devices.
- Applying outstanding analytical tools for investigating materials, cells and modules. The combination of two large-scale facilities – the Berlin Synchrotron Radiation Source (BESSY II) and the Berlin Neutron Research Reactor (BER II) – make the Helmholtz-Zentrum Berlin für Materialien und Energie (HZB) a unique research partner within the scientific community.

www.helmholtz-berlin.de/forschung/enma

HELMHOLTZ-ZENTRUM BERLIN (HZB)

Besides the particular competence in Solar Energy Research, HZB is one of the few centres world-wide to offer the whole range of instruments for neutron and synchrotron radiation within one laboratory structure. The HZB operates two scientific large scale facilities for investigating the structure and function of matter: the research reactor BER II for experiments with neutrons and the synchrotron radiation source BESSY II, producing an ultrabright photon beam ranging from Terahertz to hard X-rays.

HZB Quick Facts

- Approximately 1,100 staff (800 at Wannsee and 300 at Adlershof)
- Total budget of about 110 million Euros
- About 100 doctoral candidates from neighbouring universities
- HZB cooperates with more than 400 partners at German and international universities, research institutions and in companies.

Contact Solar Fuels

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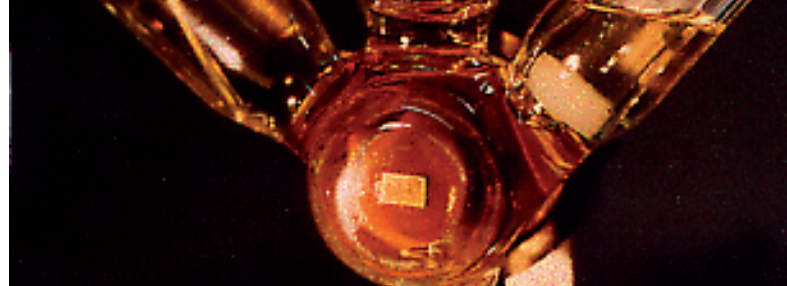
SOLAR FUELS

Solar Energy Research

SOLAR FUELS

As part of the Solar Energy Research division, the Institute of Solar Fuels is working on the development of cost-effective PV hybrid systems that directly convert sunlight into stored chemical energy by producing hydrogen via water splitting. The direct generation of fuels from solar light ranks amongst the most prominent challenges for a sustainable energy technology based on regenerative primary energy sources. This approach could circumvent the inherent challenge of storing solar energy in form of hydrogen or hydrocarbons. Material storage is in demand to guarantee mobility, especially in air transportation applications. For this purpose, the energy conversion of light into electrical energy via photonic excitation of a thin-film PV structure is directly combined with corrosion stable layers at the front and back contacts that catalyze the process of water photolysis at the electrode-electrolyte-interfaces. The generated hydrogen can be stored as compressed gas, liquid-H₂, metal hydride, or methanol.

The inherent problem of the discontinuous availability of sun light can therefore be overcome by reconvertng the stored hydrogen into electricity using a fuel cell.



Simple experimental setup to study the photoelectrochemical activity of semiconductor electrodes

Research Topics

- Development of noble metal-free electrocatalysts for water splitting
- PV hybrid structures as water splitting membranes

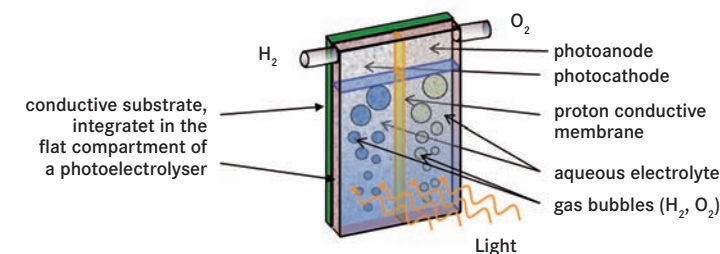
Technological Processes

Various thin film deposition techniques (reactive sputtering, sol gel, atomic layer deposition, spray pyrolysis, electrochemical layer deposition)

Analytical Methods

Electrochemical methods (EIS, R(R)DE, DEMS) in combination with:

- Transient microwave spectroscopy
- Synchrotron radiation X-ray photoelectron and in-situ X-ray absorption spectroscopy



Drawing of a flat PV hybrid electrolyzer. The arrangement shows two active photoelectrodes on a common substrate in one single cell. The cathodic and the anodic side are separated by a conductive membrane, so that it is possible to sample the produced hydrogen and oxygen at different gas outlets.

Projects & Co-Operations (selection)

- Energy Storage and Hydrogen Initiative (EWI) of the Helmholtz Association (HGF)
- H2-Nanosolar - Nanostructures for Light-induced Hydrogen Evolution (BMBF Network)
- Lateral and Vertical Nanostructure Formation on Silicon Electrodes by Controlled Self-organised Processes (DFG)
- Light2Hydrogen - Photocatalytic Cleavage of Water to Hydrogen (BMBF Advanced Research Cluster)
- Technical University Darmstadt (project partner)
- Max-Planck-Institute Colloids and Interfaces, Potsdam-Golm (project partner)

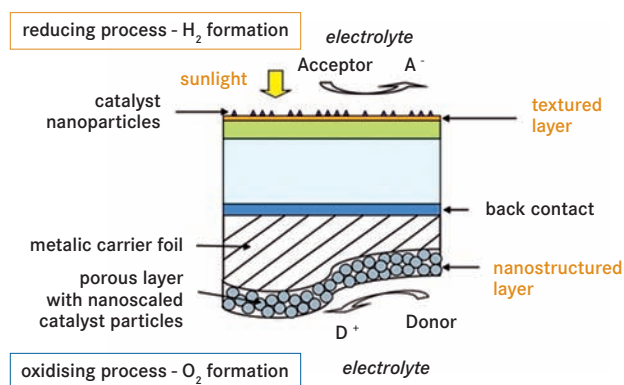


Figure 1: Hybrid electrolyzer consisting of a PV structure with catalytic layers deposited on top of front and back contact.

PHOTOELECTROCHEMICAL DEVICES AND NOVEL CATALYSTS FOR HYDROGEN AND OXYGEN GENERATION

In contrast to the process of photosynthesis in which non-noble metal catalysts (Mn- and Fe-Ni- clusters) convert CO₂ and water into O₂ and hydrocarbons, current artificial systems - combining a solar cell with an electrolyser - employ platinum and ruthenium oxide in the process of water splitting. One of the intriguing research goals is therefore the mimicking of the thylakoid membrane in plants. Thus the development of an artificial "water splitting membrane", allowing the direct conversion of sun light into hydrogen and

oxygen, is of particularly high importance. For stability reasons we have introduced a design that uses hitherto inorganic components: a thin film photovoltaic monolithic, so called back-to-back tandem structure with integrated catalysts at the photocathode (hydrogen generation) and the photoanode side (oxygen generation) to facilitate water splitting by sun light (Figure 1). Alternative to noble metal catalysts, transition metal chalcogenides such as manganates and ferrates as well as molybdenum sulfide are under development.