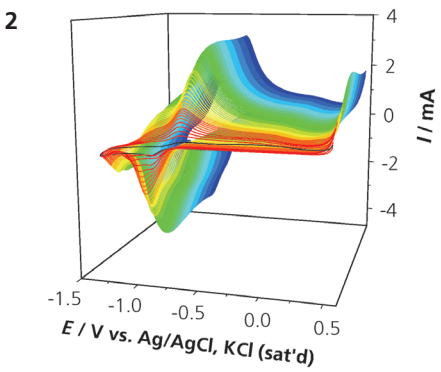
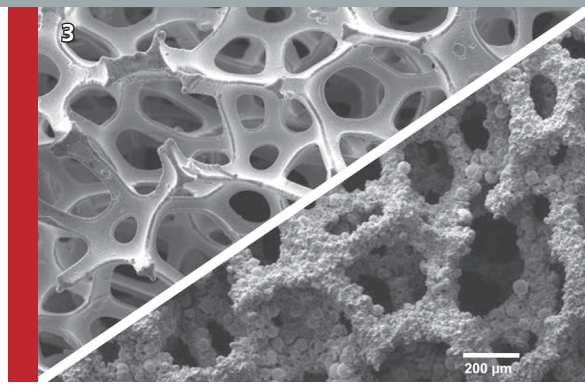
Fraunhofer
IFAM

FRAUNHOFER INSTITUTE FOR MANUFACTURING TECHNOLOGY
AND ADVANCED MATERIALS IFAM, BRANCH LAB DRESDEN





1 *Double-potentiostat set-up for electrode testing*
2 *Multi-cycling voltammogram of an amorphous iron-cobalt alloy*
3 *Nickel foam electrodes with multi-hierarchy porosity*

ELECTROLYSIS TECHNOLOGY

Green Hydrogen by Water Electrolysis

In view of the shortage of fossil energy resources, hydrogen is becoming an important energy carrier because it can be produced directly from renewable energy sources by water electrolysis. It is mandatory to provide 'green' hydrogen at low cost in order to build up a hydrogen energy cycle for a sustainable and environmentally friendly economy.

At Fraunhofer IFAM Dresden, various electrode materials are fabricated and tested regarding their electrochemical, structural and mechanical properties. The electrodes are designed in order to increase the long-term efficiency of both the hydrogen (HER) and the oxygen evolution reaction (OER). Different aspects have to be considered to increase the efficiency: long-term stability, high electrocatalytic activity, high surface area and the management of the gas flow.

Electrode Design

Electrocatalysts are fabricated as surface coatings on planar or porous template structures. The desired electrochemical and mechanical properties can be adjusted by elemental composition, electrode pretreatments and processing conditions.

3D Electrodes with Multi-Hierarchy Porosity

Porous materials, e.g. meshes, foams or fleeces, offer the possibility to enlarge the surface area of the electrode. In addition, the two-phase flow (gas bubbles, electrolyte) can be directed through the porous structure reducing Ohmic losses. At Fraunhofer IFAM, various porous electrode structures can be produced and tested at the customer's request. Moreover, powder-metallurgical and electrochemical methods can be employed to achieve roughened surface structures on the microscale. Thus, 3D electrodes with a multihierarchy porosity are obtained which exhibit a huge active surface area for HER and OER.

Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM Branch Lab Dresden

Winterbergstrasse 28
01277 Dresden | Germany

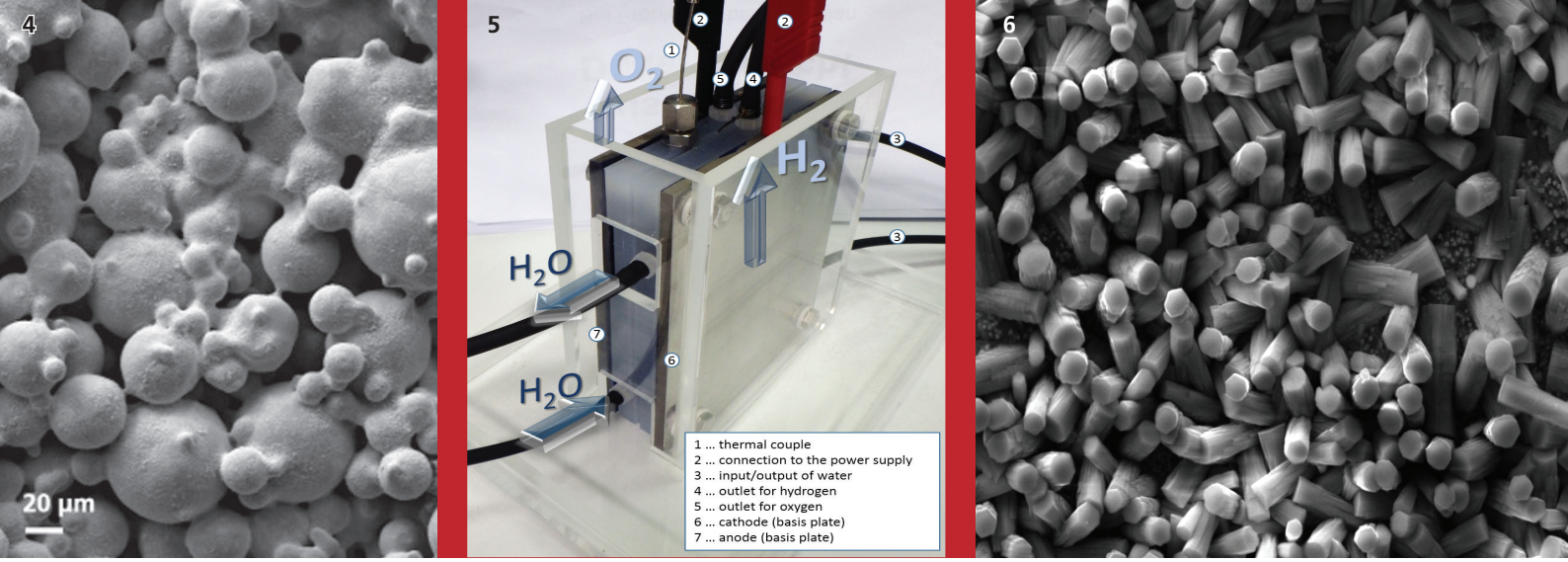
Contact

Dr. rer. nat. Lars Röntzsch
Phone: +49 351 2537 411
E-mail: Lars.Roentzsch
@ifam-dd.fraunhofer.de

Dr. rer. nat. Christian Immanuel Müller
Phone: +49 351 2537 416
E-mail: Christian.Mueller
@ifam-dd.fraunhofer.de

Fax: +49 351 2537 399

www.ifam.fraunhofer.de/h2



Electrochemical and Structural Evaluation

For the development and improvement of high-performance electrode materials it is mandatory to elucidate the structure-property relationships of the materials. At Fraunhofer IFAM Dresden, state-of-the-art electrochemical analysis equipment, e.g. electrochemical scanning tunneling microscopy (EC-STM), are available in order to investigate the electrochemical properties and the surface morphology of the electrode materials.

Analysis techniques:

- Electrochemical analysis
  - Cyclic voltammetry (CV)
  - Impedance spectroscopy (EIS)
  - Polarization methods
- Scanning tunneling microscopy (STM)
- Electrochemical STM (EC-STM) and scanning electrochemical potential mapping (SECPM) for *in situ* experiments

Electrode Testing under Real Operation Conditions

All electrode materials are tested under realistic operation conditions to demonstrate their applicability (80 °C, 30 wt.%-KOH). For this purpose, lab-scale electrolyzer cells are available in which the electrical energy consumption per generated hydrogen volume is determined. Due to the simplicity of the system different electrode configurations can be easily realized.

Lab-scale electrolyzer cells:

- Single cell or short-stack design
- Operating conditions
  - Up tp 80 °C
  - Up to 30 wt.%-KOH
  - Atmospheric pressure
- *In situ* gas quality monitoring

4 *Sintered electrode surface structure*
5 *Single-cell lab electrolyzer for electrode testing*
6 *Advanced electrodes with nanowhisker catalysts*

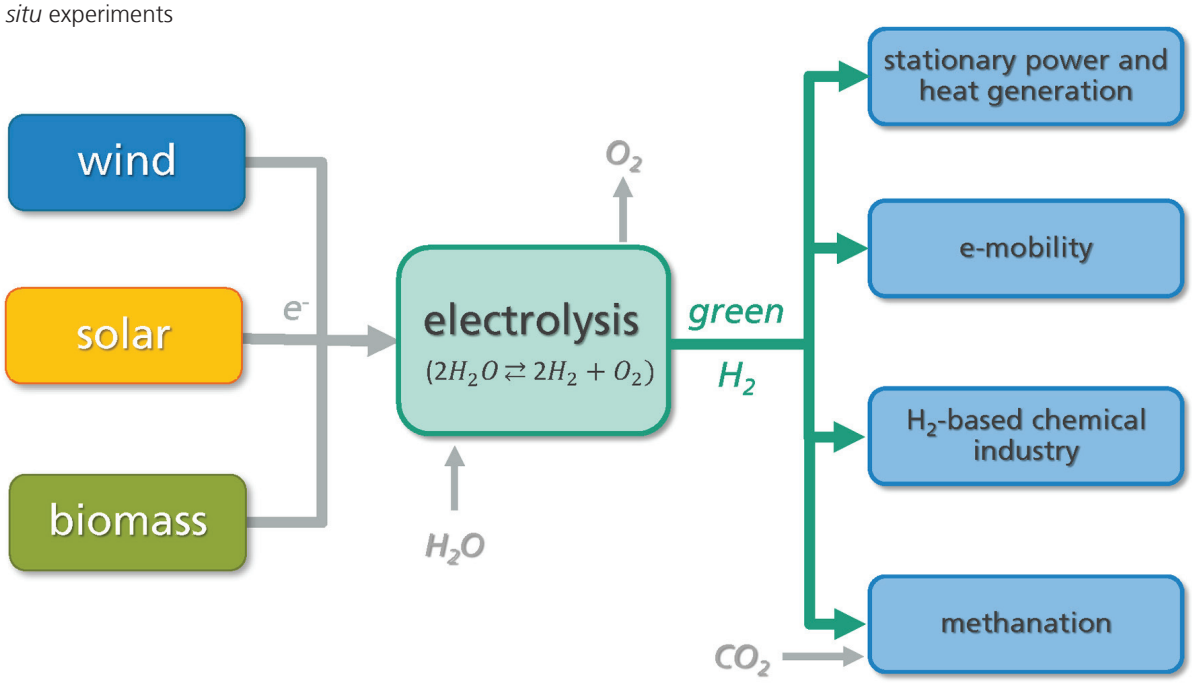


Fig. 1: Schematic of 'green' hydrogen production by water electrolysis and hydrogen utilization pathways