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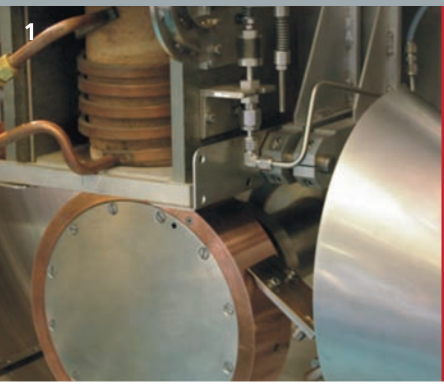
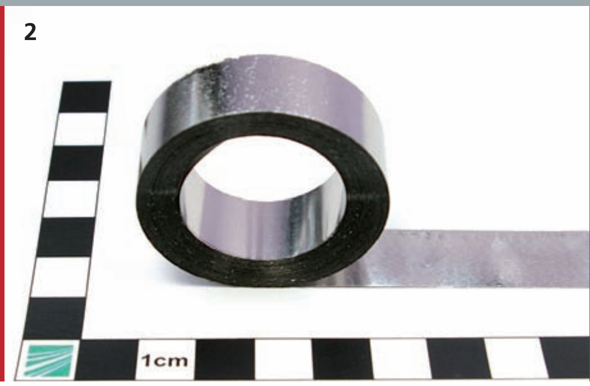
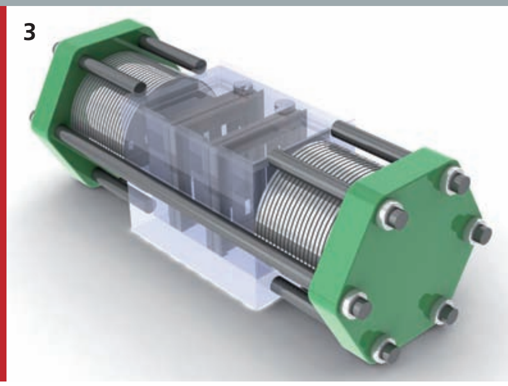






1 *Melt spinning device at Fraunhofer IFAM Dresden*
2 *Ductile amorphous Fe-Ni ribbons*
3 *Schematic setup of an electrolyzer equipped with amorphous electrodes*

ELECTRODE MATERIALS FOR ALKALINE WATER ELECTROLYSIS

Sustainable H_2 Production 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, new electrode materials for electrolysis are fabricated and tested regarding their electrochemical, structural and mechanical properties. In view of alkaline water electrolysis, the materials are designed in order to increase the efficiency of both the hydrogen (HER) and the oxygen evolution reaction (OER) combined with very good mechanical properties. This leads to a reduction of the production costs of green hydrogen.

Electrode Materials

Glassy metal alloys are considered as electrode materials because they have shown high electrocatalytic activities for HER and OER. These materials can be produced as ribbons by melt spinning which is a rapid solidification technique. The advantage of these materials is their cost-efficient production. The desired electrochemical and mechanical properties can be controlled by the composition of the alloys and the processing conditions.
Characteristics of melt-spun ribbons are:

- 20 - 80 µm in thickness
- homogeneous element distribution
- amorphous
- ductile

Amorphous Metals

Various melt-spun Fe- and Ni-base alloys are being developed and tested:

- Fe-base alloys: Fe-Co, Fe-Ni, Fe-Co-V, Fe-Co-Mo, Fe-Mo, Fe-V
- Ni-base alloys: Ni-Mo, Ni-V

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

Winterbergstrasse 28
01277 Dresden | Germany

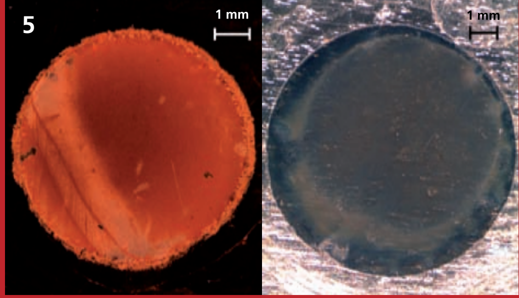
Contact

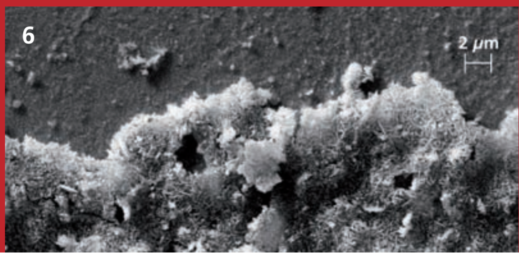
Dr. rer. nat. Lars Röntzsch
Phone: +49 351 2537 411
E-mail: Lars.Roentzsch@ifam-dd.fraunhofer.de

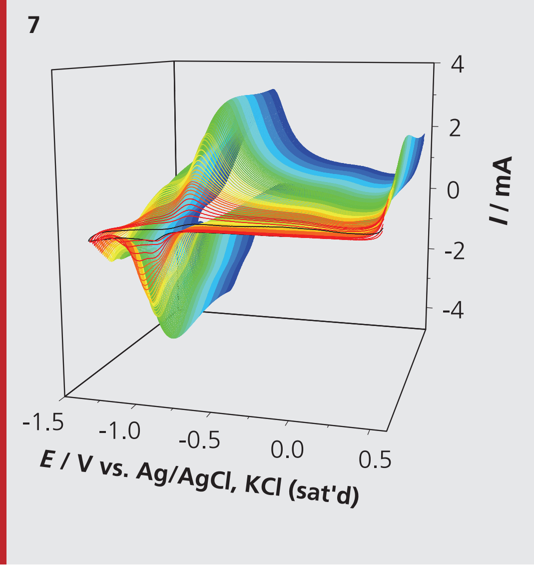
Dr. rer. nat. Christian Immanuel Müller
Phone: +49 351 2537 416
E-mail: Christian.Mueller@ifam-dd.fraunhofer.de

Fax: +49 351 2537 399

www.h2materials.de
www.ifam-dd.fraunhofer.de







Fabrication of Amorphous Materials

Amorphous metallic alloys are produced via rapid solidification in a melt spinning device. The respective master alloy is melted in an induction furnace. The melt is squeezed through a slit nozzle onto a fast rotating cooling wheel, thereby generating amorphous ribbons at a cooling rate in the range of 10^6 K/s.

Parameters:

- Induction heating
  - up to 1700°C
- Cooling wheel
  - Cu-base alloys
  - 3000 min^{-1}
- Ribbon width
  - 10 - 20 mm
- Ribbon thickness
  - 20 - 80 µm

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 and electrochemical scanning probe 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
- Atomic force microscopy (AFM)
- Scanning tunneling microscopy (STM)
- Electrochemical STM equipped with a bipotentiostate for *in situ* potential mapping of the electroactive surface

4 *Electrochemical cell and potentiostate*

5 *Comparison of the electrode surface after multi-sweep cyclic voltammetry: crystalline Fe (left) and amorphous Fe-Co (right)*

6 *Anodically activated electrode surface*

7 *Multi-cycling voltammetry of an amorphous Fe-Co ribbon*

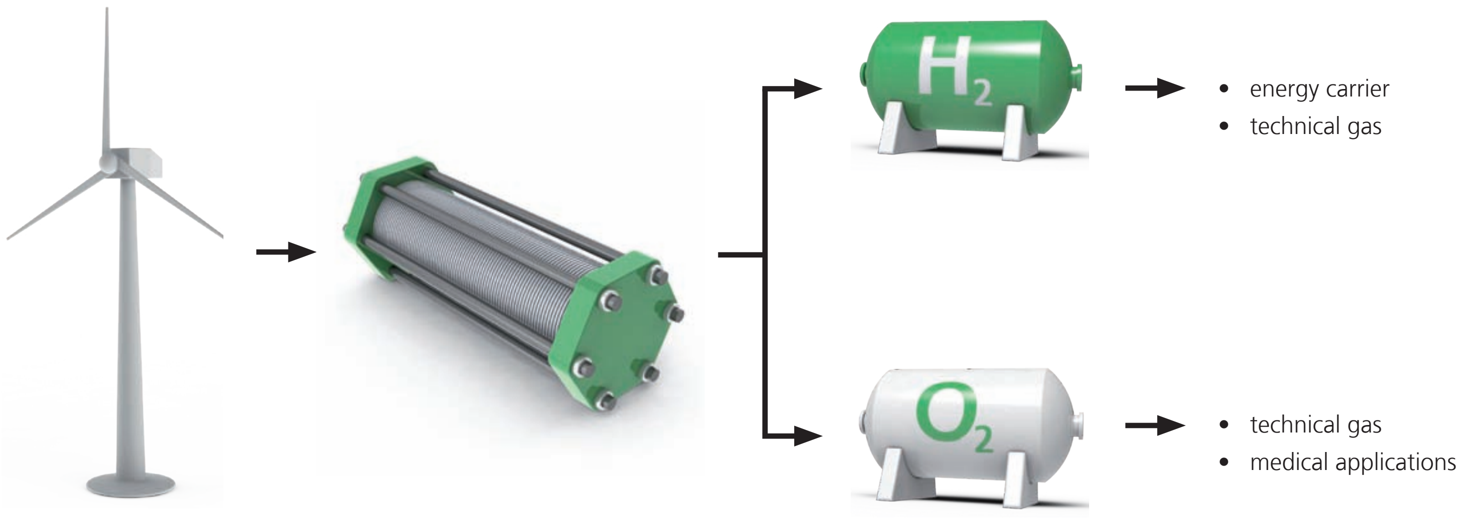


Fig. 1 Schematic of 'green' hydrogen production by alkaline water electrolysis using renewable wind energy