ADVANCED ENGINEERING MATERIALS
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Special Section: "Institute of Energy and Climate Research at Forschungszentrum Jülich"

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A radical and rapid transformation of the energy and transportation sectors is required on a global scale in order to stop the massive greenhouse gas emissions which have been modifying our planet at an alarming pace. In order to limit temperature increase and climate change with dramatic ecological and societal consequences, a deep decarbonization of the whole economy is required. Coupling of the different sectors has to be realized by using complementary energy vectors, such as electricity, chemical energy carriers like hydrogen, synthetic fuels, biomass. To address this challenge, clean and sustainable technologies for fossil-free power generation, energy conversion and storage need to diffuse broadly within the next decades. Advanced engineering materials are the key for developing such new technologies.

Forschungszentrum Jülich is a member of the Helmholtz Association of German Research Centres and is one of the largest interdisciplinary research centres in Europe. It was founded in 1956 as a public nuclear research centre. Its basic funding comes from the Federal Republic of Germany (90%) and the Federal State of North Rhine-Westphalia (10%). Today, with more than 6,000 employees, its portfolio has significantly been expanded, going from future information technologies, supercomputing, brain research to sustainable bioeconomy. Nevertheless, the topic of energy remains one of the main pillars of Jülich application-driven basic research, with the goal of enabling an energy system based on renewable energy. The contributions to research and development made by the Institute of Energy and Climate Research (IEK) thus include energy conversion and storage technologies as well as the mechanisms of climate change. The interdisciplinary approach is facilitated by the application of complementary scientific methods and the utilization of a joint infrastructure.

As reflected by the contributions of this Special Section, materials science and engineering plays a central role in all areas of energy research carried out at Forschungszentrum Jülich.

First, photovoltaics and photocatalysis activities cover materials development, solar cell design, manufacturing and testing. Y. Liu et al. present here the development of new silicon alloy for the use in heterojunction solar cells, whereas C. Maurer et al. evaluate the impact of laser treatment on the properties of hydrogenated amorphous silicon.

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Credit: Forschungszentrum Jülich / Sascha Kreklau

Many technologies rely on rare earth and critical chemical elements. For example, neodymium is a key ingredient of permanent magnets used in wind turbines. In the context of systems analysis and technology evaluation, A. Schreiber et al. focus on the life cycle analysis of the production of neodymium by electrolysis in molten salt.

Jülich scientists develop and optimize electrochemical storage systems such as batteries, fuel cells, electrolyzers and further Power-to-X technologies. As an example of those applications, a dual phase oxide material suitable for oxygen transport membranes is mechanically characterized by F. Zeng et al.

For power generation and aircraft propulsion, the efficiency and liftetime of gas turbines must be increased. Jülich scientists are contributing solutions from materials research. For example, the role of temperature in the hot corrosion of a NiAl coating on a commercial Ni-based superalloy is highlighted by Y. Wang et al. Protective coatings with columnar microstructures are excellent candidates for thermal barrier applications as reported by G. Mauer and R. Vaßen. The introduction of ceramic matrix composites as structural materials makes the development of environmental barrier coatings necessary, as shown by C. Gatzen et al. Finally, J. Fiebig et al. describe how thermal spray processes can be used for the repair of gas turbine components, which is a very attractive approach from an economical point of view.

Materials processing and integration into components is an important step for the development of technologies.

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The possibilities offered by electric field assisted sintering for energy applications is reviewed by M. Bram et al.

Specific radiation resistant materials and high heat flux materials for future fusion reactors are covered by J.W. Coenen. More specifically, Y. Mao et al. detail how the fiber-volume fraction affects the mechanical properties of W_f/W composites.

Last but not least, the safe, long-term management of nuclear waste remains an important issue. D. Bosbach et al. give an overview of Jülich research on materials chemistry and solid solutions.

We hope that you will enjoy reading this Special Section and get a better impression of the depth and variety of activities related to advanced materials at Forschungszentrum Jülich!