

**HL 10: Functional materials I - Energy storage (organized by MM)**

Time: Monday 10:15–11:30

Location: IFW A

HL 10.1 Mon 10:15 IFW A

**Graphene-based supercapacitors for energy storage under extreme temperature conditions** — ●RANJITH VELLACHERI, AHMED AL-HADDAD, WENXIN WANG, HUAPING ZHAO, CHENGLIANG WANG, ZHILIE WANG, and YONG LEI — Ilmenau University of Technology, Institute of Physics & IMN MacroNano (ZIK) 98693 Ilmenau (Germany)

Graphene-based supercapacitors have been fabricated for energy storage in a very wide range of temperatures. The optimized supercapacitors showed good charge storage capabilities from  $-24\text{ }^{\circ}\text{C}$  to  $50\text{ }^{\circ}\text{C}$ . Specific capacitance of the electrode obtained from charge/discharge measurements was  $91\text{ F/g}$  at room temperature (RT) and no considerable change when tested at different temperatures (e.g.  $73\text{ F/g}$  and  $100\text{ F/g}$  at  $-24\text{ }^{\circ}\text{C}$  and  $50\text{ }^{\circ}\text{C}$ , respectively). Our samples also exhibited outstanding capacitance retention and cyclic stability at different operating temperatures. Extremely low equivalence series resistance (ESR) and charge transfer resistance were confirmed by electrochemical Impedance measurements. Especially, the low ESR could also result in high power density even at low operating temperatures. We believe that our results highlight the great prospective of the graphene-based supercapacitors for the efficient energy storage at extreme environments with a wide range of temperature difference

HL 10.2 Mon 10:30 IFW A

**Nano-Engineered Three-Dimensional Core/Shell Nanotube Arrays for Realizing High Performance Asymmetric Supercapacitors** — ●FABIAN GROTE, LIAOYONG WEN, HUAPING ZHAO, and YONG LEI — Ilmenau University of Technology, Institute of Physics & IMN MacroNano (ZIK) Prof. Schmidt-Str. 26, 98693 Ilmenau

The ongoing technological advances in areas such as electric mobility, consumer electronics, and energy harvesting set new demands for energy storage systems. The next generation of high performance devices requires a strongly enhanced electrochemical performance as well as operating safety, limited environmental impact, and economic viability. In order to fulfill these aims a crucial role is addressed to supercapacitors. Today, the main challenge is to increase the specific energy of supercapacitors without sacrificing specific power. Thereby the development of novel functional nanostructures for energy storage is a key challenge. Hence we nano-engineered a complex 3D electrode material based on free-standing open-ended core/shell nanotube arrays with tailored functions, using anodic aluminum oxide nano-templates and atomic layer deposition. The core provides a well electron transport through the entire electrode matrix and the thin shell guarantees a well utilization of the active electrode material. Importantly, we designed and nanostructured both the negative and positive electrode materials individually, using an innovative material combination of polypyrrole and manganese oxide. It is shown that the asymmetric electrode nature of the prepared supercapacitor device enabled us to increase the cell voltage to  $1.7\text{ V}$ , which is a major leap to increase the specific energy.

HL 10.3 Mon 10:45 IFW A

**Temperature induced modifications of hydrides in Gd(0001) thin films** — ●SARA WANJELIK, SAMUEL KÖNIGSHOFEN, and MATHIAS GETZLAFF — Institute of Applied Physics, University of Düsseldorf

Hydrogen in metals has been of great interest in research for the past few decades. But only few investigations are carried out by imaging techniques with a lateral resolution on the nm-scale. Even less research deals with the initial stage of hydride formation. Here we present STM measurements on thin Gadolinium films grown on a W(110) surface concentrating on the initial steps of hydrogen absorption. Absorption of hydrogen at room temperature results in hydride formation. We

observe plastic deformations due to the larger volume of the hydrides. On the one hand, disk-like islands with a diameter of approximately  $3\text{ nm}$  and a height of  $0.3\text{ nm}$  occur, while on the other hand there are connected areas formed by ramps. The islands arrange in chains. It has also been observed that a new feature, a triangular shaped structure appears together with the islands. Maps of the differential conductivity prove that it has a different electronic structure. The origin of the island and the other structure is not fully understood and yet a field of open research. Additionally, we will present modifications of these structures induced by increasing temperature up to that point which they vanish at.

HL 10.4 Mon 11:00 IFW A

**Hydrophobicity patterning of gas diffusion media for polymer electrolyte fuel cells** — ●INDRO BISWAS<sup>1</sup>, PAWEŁ GAZDZICKI<sup>1</sup>, MARTIN TOMAŠ<sup>2</sup>, and MATHIAS SCHULZE<sup>1</sup> — <sup>1</sup>German Aerospace Center (DLR), Institute of Technical Thermodynamics, Pfaffenwaldring 38-40, 70569 Stuttgart, Germany — <sup>2</sup>University of West Bohemia, New Technologies Research Centre, Univerzitní 8, 306 14 Plzeň, Czech Republic

Polymer electrolyte fuel cells with their high gravimetric energy density face a water balance problem especially under variable loads, e.g. in automotive conditions: The excess product water needs to be removed from the fuel cell while maintaining a humidified membrane.

The gas diffusion layer, which also provides contact to the electrochemically active components, has to achieve the passive management of the water balance. Heterogeneously hydrophobic gas diffusion media have already shown to be more capable of balancing these opposing requirements than conventional materials. Various methods of patterning gradients of hydrophobicity are applied, like microperforation and laser, focused X-Ray and ion beam irradiation. The modifications are analysed with photoemission and infrared spectroscopy and compared for their performance, applicability and scalability.

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HL 10.5 Mon 11:15 IFW A

**NMR Investigations of the Aluminium Substituted Barium Clathrate  $\text{Ba}_8\text{Si}_{46}$**  — ●MATEJ BOBNAR, IRYNA ANTONYSHYN, MICHAEL WEDEL, DUONG NGUYEN, ULRICH BURKHARDT, YURI PROTS, BODO BÖHME, LIUDMILA MUZICA, RAUL CARDOSO, WALTER SCHNELLE, IGOR VEREMCHUK, MICHAEL BAITINGER, and JURI GRIN — Max-Planck-Institut für Chemische Physik fester Stoffe, Nöthnitzer Str. 40, 01187 Dresden

Clathrates are interesting for their thermoelectric properties, due to their high electric and low thermal conductivity.  $\text{Ba}_{8-x}\text{Si}_{46}$  is a type I clathrate obtained at  $800\text{ }^{\circ}\text{C}$  and at high pressure of  $2\text{--}5\text{ GPa}$ . The covalently bonded Si atoms form a framework of small, 20 atom, and large, 24 atom, cages that are fully or partially filled by Ba atoms. Some of the Si atoms may be substituted by a number of other atoms, including Al.  $\text{Ba}_8\text{Al}_x\text{Si}_{46-x}$  is reported with a homogeneity range of  $8 \leq x \leq 15$ . Our investigations, however, begin with a clathrate of even lower Al content,  $\text{Ba}_8\text{Al}_{6.8}\text{Si}_{39}$  and continue towards the Al-rich phases. We try to determine, which Si atoms are substituted by Al and how a disorder increases or decreases with a growing Al content. Since Al and Si stand next to each other in the periodic table of elements, they are very difficult to discern by X-ray. For this reason, the NMR was employed, which observes local environments of each nucleus separately and gives some hints about the intrinsic properties of the samples. In this work, we present a model for Al and Si distribution in the clathrate I framework based on  $^{29}\text{Si}$  and  $^{27}\text{Al}$  NMR results.