

HL 53: Energy materials (other than photovoltaics)

Time: Friday 9:30–11:00

Location: EW 202

HL 53.1 Fri 9:30 EW 202

Oxygen vacancies: effective strategy to boost sodium storage performance — •YANG XU, MIN ZHOU, CHENGLIN ZHANG, LIYING LIANG, and YONG LEI — Institut für Physik & IMN MacroNano (ZIK), Technische Universität Ilmenau, 98693, Ilmenau, Germany

Utilization of oxygen vacancies (OVs) is an effective strategy to boost electrochemical performance in sodium-ion batteries. We demonstrated that OVs could benefit oxide anodes regardless of their crystallinity, by taking amorphous SnO₂ nanoarrays and crystalline MoO_{3-x} nanosheets as examples. The OV-containing SnO₂ nanoarrays delivered reversible capacities of 376 mAh g⁻¹ after 100 cycles (0.05 A g⁻¹) and 220 mAh g⁻¹ after 800 cycles (1 A g⁻¹) as well as great rate capability by retaining 200 mAh g⁻¹ at 20 A g⁻¹. Moreover, by coating the MoO_{3-x} electrode with an ultrathin Al₂O₃ layer, the long-term cycling capacity and rate capability of MoO_{3-x} were increased by four and ten times, respectively, comparing with the MoO₃ electrode. Electrochemical kinetic study revealed that OVs could greatly enhance charge transfer/transport properties at the electrode/electrolyte interface and within the electrodes. Our work opens up new possibilities of designing strategies in energy storage systems.

[1] Y. Xu, M. Zhou, C. Zhang, C. Wang, L. Liang, Y. Fang, M. Wu, L. Cheng, Y. Lei, *Nano Energy* 2017, 38, 304. [2] Y. Xu, M. Zhou, X. Wang, C. Wang, L. Liang, F. Grote, M. Wu, Y. Mi, Y. Lei, *Angew. Chem. Int. Ed.* 2015, 54, 8768.

HL 53.2 Fri 9:45 EW 202

Evaluate the Role of Nanostructure Current Collector in Supercapacitor Electrode when the Electroactive Material is in the Form of Thick Layer — •LONG LIU, HUAPING ZHAO, YANG XU, SHIPU XU, CHENGLIN ZHANG, and YONG LEI — Institut für Physik & IMN MacroNano (ZIK), Technische Universität Ilmenau, 98693, Ilmenau, German

Electroactive materials (especially pseudocapacitive materials) are generally in the form of ultrathin conformal coating in supercapacitor electrodes based on nanostructured current collectors, thus the resultant low mass loading of electroactive materials largely limits the applications of nanostructured current collectors. Here, supercapacitor electrodes with nickel nanorod arrays as nanostructured current collectors and MnO₂ as electroactive materials are fabricated to study the role of nanostructured current collectors in determining the energy storage capability when electroactive materials are in thick layer rather than ultrathin conformal coating. Electrochemical analysis revealed that Ni nanorods could create numerous electrical conductive tunnels in the thick-layer electrodes to dramatically alleviate the contact resistance at the electroactive-materials/current-collectors interface. These results open up new opportunities for nanostructured current collectors to construct supercapacitors with superior energy storage capability.

[1]. Liu L., Zhao H.P.*, Wang Y., Fang Y.G., Xie J.L., Lei Y.*, *Adv. Funct. Mater.*, 2017, DOI: 10.1002/adfm.201705107.

HL 53.3 Fri 10:00 EW 202

Structure function correlation of Co₂Mn_{1-x}Fe_xO₄ regarding the OER — •MAIKE UPTMOOR and KATHRIN M. LANGE — Bielefeld University, Germany

A promising approach for a clean energy future is to store solar energy in a chemical fuel like hydrogen by photoelectrochemical (PEC) water splitting. Because the production of oxygen at the anode is sluggish compared to the one of hydrogen it is of high relevance to develop new catalytic materials to accelerate the oxygen evolution reaction (OER) thus enhance the overall efficiency of this process. First row transition metal oxide catalysts are very promising candidates because they are abundant have low costs and are stable in several oxidation states.

Thin films of the transition metals oxides Co₂Mn_{1-x}Fe_xO₄ are investigated in detail. They are synthesized by co-sputtering and subsequently post annealed to obtain a crystalline structure. Several measurements are performed to correlate the structure to the catalytic activity. The crystal structure and morphology are analyzed in detail by X-ray-diffraction (XRD) and secondary electron microscopy (SEM). Electrochemical methods are performed in a three electrode configuration with an alkaline electrolyte while the metal oxides sputtered on gold layers act as working electrode in the electrochemical-setup. Different methods are performed to measure the activity and the stability

of the sample, among others cyclic voltammetry and chronopotentiometry. First results of the structure characterization and electrochemical measurements of the material will be presented.

Schwanke, C., et al. (2017). *Sci Rep* 7: 44192.

HL 53.4 Fri 10:15 EW 202

Template-based nanoengineering strategies for photoelectrodes design toward enhancing photoelectrochemical water splitting — •HUAPING ZHAO, RUI XU, YAN MI, LONG LIU, YAOGUO FANG, and YONG LEI — Institut für Physik & IMN MacroNano (ZIK), Technische Universität Ilmenau, 98693, Ilmenau, Germany

Solar-driven hydrogen production through photoelectrochemical (PEC) water splitting is considered as one of the most highly-efficient approaches to utilize the unlimited solar energy economically and environmentally. The architecture of photoelectrode plays an important role in determining the overall PEC performance. As known that nanostructures have the significant capability of decoupling light absorption and charge carrier collection, and shortening minority carrier diffusion distance compared to bulk structures, various nanoengineering strategies therefore have been developed for the rational photoelectrode design aiming at improving the PEC energy conversion efficiency. Remarkably, template-based nanoengineering strategies provide the opportunities to rationally design nanoarchitected photoelectrodes. Studies have shown the fact that template-realized highly-ordered nanostructure arrays can spatially redistribute the light intensity and efficiently scatter light in the device resulting in enhanced light absorption, and thus will enable high quantum efficiencies for solar energy conversion. Moreover, such nanostructure arrays could facilitate carrier collection via orthogonalizing the direction of light propagation and carrier collection, resulting in significantly improved PEC performance.

HL 53.5 Fri 10:30 EW 202

Photolytic water splitting by surface-conditioned n-GaP(100) photoanodes — •WAQAS SADDIQUE, GERHARD LILIENKAMP, and WINFRIED DAUM — Institute of Energy Research and Physical Technologies, Technical University Clausthal, Clausthal-Zellerfeld, Germany

III-V semiconductors are candidates for photoelectrochemical (PEC) water splitting but they are prone to corrosion and suffer from corrosion-related decrease of efficiency. Gallium phosphide (GaP) has an indirect band gap of 2.26 eV which covers both the hydrogen evolution potential (HEP) and the oxygen evolution potential (OEP). Thus, in principle, GaP can be used as photocathode and photoanode. We have studied the structural and chemical surface modifications of n-GaP(100) photoanodes before and after extended PEC treatment by scanning electron microscopy (SEM), atomic force microscopy (AFM), Auger electron spectroscopy (AES) and X-ray photoelectron spectroscopy (XPS). An approximately 2 nm thin stable oxide film is produced at the surface of n-GaP(100) photoanode via oxidizing the surface at 0.8 V vs RHE (reversible hydrogen electrode) and subsequent hydrogenation to passivate the electrically active defects in the oxide film. After appropriate surface-conditioning, PEC water splitting was observed at potentials between 0 and 0.3 V. After extended PEC treatment, AFM revealed a very flat surface, and no sign of corrosion were observed. XPS results indicate that the surface oxide consists mainly of Ga₂O₃, while small amounts of GaPO₄, P₂O₅ and metal-like Ga are also present in the topmost layers.

HL 53.6 Fri 10:45 EW 202

Activating CO₂ for photocatalytic reduction at the semiconductor surface — •VERONIKA KÖNIG, PETER BUDWEISER, JACEK STOLARCZYK, and JOCHEN FELDMANN — Chair for Photonics and Optoelectronics, Department of Physics, Ludwig-Maximilians-Universität, Munich, Germany

In modern photocatalysis sunlight is used to convert water or carbon dioxide into solar fuels like molecular hydrogen or methane. Semiconductor materials thereby serve as the catalyst and reaction site. They absorb the sunlight, separate electron-hole pairs and transfer the charges to the respective molecules triggering electrochemical reactions that ultimately lead to the formation of the desired solar fuels.

Compared to water splitting CO₂ reduction is even more challenging due to the high stability of the CO₂ molecule. The reduction potential

for the initial placement of an electron on the CO₂ is much more negative than the potential of the conduction band edges of most known semiconductor materials, making appropriate catalysts rare.

Copper (I) compounds such as Cu₂S have been found to be promising candidates for CO₂ reduction^[1] and were shown by our group to produce CH₄ and CO^[2]. Here, we use Cu₂O nanocrystals ranging from

10 to 100 nm in size in combination with ZnO for better charge separation. We investigate ways to increase the efficiency of photocatalytic CO₂ reduction by activation of the CO₂ molecule at the nanocrystal surface to lower the barrier for the initial one-electron reduction.

^[1] Habisreutinger, S., et al. *Angew. Chem. Int. Ed.* 2013, 52, 7372

^[2] Manzi, A., et al. *J. Am. Chem. Soc.* 2015, 137, 14007