MM 9: Functional Materials - Battery Materials II

Time: Monday 11:45–13:00 Location: H26

MM 9.1 Mon 11:45 H26

New Approach to Deposit Functional Thin-Films for Battery Application: CO2-Laser Assisted Chemical Vapor Deposition — •Christoph Loho[1,2], Azad Darbandi[1,2], Ruzica Djenadic[1,2,3], and Horst Hahn[1,2,3] — [1]Joint Research Laboratory Nanomaterials, Technical University of Darmstadt and Karlsruhe Institute of Technology, Germany — [2]Institute for Nanotechnology, Karlsruhe Institute of Technology, Germany — [3]Helmholtz Institute Ulm, Germany

The research on thin-film batteries is driven by an increasing demand for micro-sized power sources, because of the progressive miniaturization of electronic components over the last decades. Especially an all-solid-state thin-film battery is desirable, since its excellent safety properties and easy integration in microelectronics, e.g. in RFID tags, are outstanding advantages.

In this presentation we report on a new established technique to deposit functional thin-films for battery application. This CO2-laser assisted chemical vapor deposition (LACVD) makes use of solid precursors, which evaporate instantaneously by absorption of microwave laser radiation. The deposition of the thin-films, acting as cathode, anode or solid-state electrolyte, then takes place on a diode laser heated substrate. By tuning the process parameters several structural features, such as the degree of crystallinity, density and thickness of the films can be adjusted. As one prominent example, a thin film of LiCoO2 was deposited onto a platinum substrate and electrochemically characterized. Further investigations comprise X-ray diffraction (XRD), Raman spectroscopy as well as scanning electron microscopy (SEM).

MM 9.2 Mon 12:00 H26

Comparative computational study of Si, Ge, and Sn as anode materials for Mg batteries — •Sergei Manzhos[1], Oleksandr Malyi[2], and Teck L. Tan[2] — [1]Department of Mechanical Engineering, National University of Singapore, Blk EA #07-08, Singapore 117576 — [2]Institute of High Performance Computing, A*STAR, 1 Fusionopolis Way, #16-16 Connexis, Singapore 138632

Magnesium batteries are emerging as a viable high energy density alternative to Li batteries that also circumvent potential Li supply risks. Most research has focused on the design of cathode materials for Mg batteries. Mg metal, while being safer than metallic Li, results in poor reversibility. The rechargeability and voltage could be improved by using an insertion anode, but theoretical studies of high-capacity Mg insertion anodes are lacking. We present ab initio calculations of the behavior of Mg atoms in bulk Ge, Si, Sn and their Mg alloys and evaluate their potential as insertion type anode materials. We show that despite the fact that Si and Ge could provide the highest specific capacities (3817 mAh g-1 and 1476 mAh/g, respectively) for Mg storage, they result in significant lattice expansions and slow Mg diffusion. Sn appears as a more attractive anode material with the barrier to diffusion as low as 0.32 eV and the smallest expansion among the three materials.

MM 9.3 Mon 12:15 H26

A room-temperature sodium/oxygen battery — •Pascal Hartmann[1], Conrad L. Bender[1], Anna Katharina Dürr[2], Jürgen Janek[1], and Philipp Adelhelm[1] — [1]Institute of Physical Chemistry, Justus-Liebig-University Gießen, Gießen, Germany — [2]BASF SE, BCI/E-M311, Ludwigshafen, Germany

In this work we discuss the charge/discharge characteristics of analog sodium/oxygen and lithium/oxygen cells that are built up by a metallic anode, liquid electrolyte, and a porous carbon cathode. Compared to the Li/O_2 cell, the Na/O_2 cell shows a superior performance, with a higher discharge capacity at higher current densities and in addition with significantly lower overpotential for the charging process. In addition to pure oxygen, the cells were also cycled under different gas mixtures. In addition to the electrochemical measurements, we characterized the discharge products cells using x-ray powder diffraction, Raman spectroscopy, x-ray photoelectron spectroscopy, and electron microscopy. We clarified the cell reactions and the origin for the high discrepancy in the electrochemical performance for lithium and sodium based oxygen batteries. In summary, we show that the charge/discharge characteristics in analog Li/O_2 and Na/O_2 batteries significantly differ from each other: In particular the sodium based cells show higher discharge capacities at higher current densities as well as lower overpotentials for the discharge and charge reaction.

MM 9.4 Mon 12:30 H26

Electrochemical investigation and analytical TEM on sputter deposited V_2O_5 thin film electrodes — •Tobias Gallasch, Frank Berkemeier, and Guido Schmitz — Institut für Materialphysik, Westfälische Wilhelms-Universität, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany

Thin film electrodes (10 nm - 200 nm) of Vanadium Pentoxide (V_2O_5) are prepared by ion beam sputtering. Cyclic voltammetry as well as chrono-potentiometric measurements demonstrate that the films reach the theoretical capacity for lithium storage of 400 mAh/g and that they can be operated in a wide current range (charge/discharge rates between C/44 and 77 C). Furthermore, the Li^+ diffusion coefficient is determined by cyclic voltammetry and compared to results of the concentration dependent GITT technique.

In contrast to electrochemical studies on bulk material, the sputter-deposited thin films of this work provide a well-defined geometry. Therefore, fundamental processes, such as Li transport and cyclic aging can be studied in detail via analytical TEM an HR-TEM. Additionally, in this work, we are in particular studying the charge/discharge process via the EELS technique, which is sensitive on smallest changes in composition and can help to locally determine the lithium concentration within the V_2O_5 thin films.

Thus, we present a combination of fundamental electrochemical methods with high resolution and analytical TEM, to obtain detailed information about structural changes within the electrode material during the intercalation and deintercalation reaction.

MM 9.5 Mon 12:45 H26

Large Area Ultrathin Alumina Membranes to Fabricate Highly Ordered heterojunction Core-Shell Nanostructure — •Ahmed Al-Haddad[1,2], Huaping Zhao[1], Ranjith Vellacheri[1], Yan Mi[1], Samar Tarisch[1,2], and Yong Lei[1] — [1]Fachgebiet 3D-Nanostrukturierung, Institut für Physik & IMN MacroNano (ZIK), Technische Universität Ilmenau, Prof. Schmidt Str. 26, 98693 Ilmenau, Germany. — [2]Department of Physics, College of Science, University of Al-Mustansiryah, Baghdad, Iraq.

Using an innovative technique, we created a large area of ultrathin alumina membranes (UTAMs) on silicon substrates to fabricate highly ordered silicon nanoporous arrays and silicon nanowires arrays by wet-chemical etching. Then CdTe is electrochemically deposited on silicon nanowires and silicon nanoporous structures, producing Si-CdTe core-shell nanowires and CdTe-Si core-shell nanostructures, respectively. This approach is aiming at the realization of high efficient solar cells based on Si-CdTe core-shell nanowires. Morphology and crystallization of the resulting core-shell nanowires were investigated by scanning electron microscope, X-ray diffraction and transmission electron microscope. The optical absorption investigation was also carried out for these arrays. The proposed fabrication method is an ef*cient and controllable technique that can be utilized to develop photovoltaic devices of core*shell structures with different compound semiconductor materials.