O 2: Symposium Interfacial Challenges in Solid-State Li Ion Batteries

Time: Monday 9:30–12:15 Location: HSZ 02

Invited Talk O 2.1 Mon 9:30 HSZ 02

Interfacial challenges in solid- state Li ion: some perspectives from theory — •Alan Luntz[1], Saskia Stegmaier[1], Johannes Voss[1], and Karsten Reuter[2] — [1]Stanford University, Stanford, CA, USA — [2]Technical University of Munich, Munich, Germany

Unfortunately, interfacial challenges severely limit power and cycle life in all solid- state Li ion batteries. We use theory to investigate some of the origins of these limitations with both continuum theory and DFT. The obvious ones are electrochemical stability of the electrolyte at the anode/cathode interfaces and mechanical issues relating to maintaining interfacial contact during cycling while inhibiting Li dendrite growth. We are especially trying to understand if any fundamental limitations exist from the structures of the double layers that form at the solid electrolyte- electrode or other interfaces in the solid-state stack. These can be quite different than in conventional liquid Li ion batteries. We use Li3OCl as a prototypical Li ion superionic conductor and discuss its properties and discuss its interface with model electrode interfaces.

Invited Talk O 2.2 Mon 10:00 HSZ 02

Will solid electrolytes enable lithium metal anodes in solid state batteries? — •Jürgen Janek, Dominik Weber, and Wolfgang Zeier — Institut für Physikalische Chemie, Justus Liebig-Universität, Gießen, Germany

In order to achieve solid state lithium batteries with higher energy densities [1], lithium metal anodes are one of the primary options. However, reversible and morphologically stable plating of thick lithium metal films is difficult, as void formation and dendrite growth may occur - leading to impedance growth and/or short-circuits. Ceramic electrolytes are considered as a potential solution to this problem. In this lecture the interface between solid electrolytes and lithium metal anodes will be discussed in depth, and the occurrence of both thermodynamic and kinetic instabilities will be highlighted. In particular, the existence of SEI ("solid electrolyte interphases"), forming between lithium metal and the solid electrolyte, will be demonstrated for a number of solid electrolytes. It will also be shown that the growth of these SEI layers follows a typical square-root law-type behavior in SEI formation in liquid electrolytes.

[1] J. Janek and W. Zeier, Nat. Energy 1 (2016) 16141

Invited Talk O 2.3 Mon 10:30 HSZ 02

Hybrid Electrolytes for Solid-State Batteries — •Hans-Dieter Wiemhöfer — Inst. Inorganic & Analyt. Chem., WWU Münster — Helmholtz-Institute Münster

Rechargeable lithium batteries with largely increased energy and power densities are a primary goal at present world wide. At the same time, enhanced safety concerns cause the need to replace current liquid electrolytes by new high performance electrolytes combining higher mechanical, thermal and electrochemical stability. Finally, this leads to the development of hybrid electrolytes. The primary idea is to construct electrolytes fulfilling a multitude of requirements based on a combination of components and phases, often coupled with approaches to achieve stable meso or micro porous networks down to chemically designed nanostructures. Starting from ion conducting inorganic solids and glasses, the combination with polymers and salt-in-polymer systems opens a wide range for possibilities for chemical design, tailoring and fine tuning of electrolyte properties of such hybrid systems. The concept will be illustrated with a number of examples, for instance, self organized block-copolymer networks acting as porous containers for fast ion conducting channels. Future all solid state batteries are expected to profit from hybrid concepts as well. For instance, volume changes during charging/discharging of active electrodes need an elastic polymer network acting as a glue and stabilizing a good contact and charge transfer kinetics of solid electrolyte/solid electrode interfaces.

15 min. break

Invited Talk O 2.4 Mon 11:15 HSZ 02

Neutron diffraction on solid-state battery materials — •Helmut Ehrenberg[1], Anatoliy Senyshyn[2], Mykhailo Monchak[1], Sylvio Indris[1], and Joachim Binder[1] — [1]Karlsruhe Institute of Technology (KIT), Institute for Applied Materials (IAM) — [2]Heinz Maier-Leibnitz Zentrum (MLZ), Technische Universitaet Muenchen, Garching, Germany

Solid-state batteries are a promising approach to safer electrochemical energy storage and higher energy densities. Bottle necks are interface reactions and transport limitations in the solids. Advanced and optimized materials must provide dedicated properties, for example a good Li-ion conductivity for sufficiently high current densities and only small volume changes to preserve mechanical integrity. Neutron diffraction offers unique features to elucidate the underlying structure-property relationships, which determine the resulting performance parameters on cell level. Selected examples are shown, which demonstrate the capabilities of neutron diffraction to reveal Li-ion diffusion pathways as in the $Li_{1.3}Al_{0.3}Ti_{1.7}(PO_4)_3$ (LATP) superionic conductor, Li occupation numbers at intermediate states of charge as for $LiCoPO_4$ or a comparison of volume changes between commercial and alternative zero-strain electrode materials. The capabilities of solid-state batteries are discussed.

Invited Talk O 2.5 Mon 11:45 HSZ 02

Sulfate-based Solid-State Batteries — •Yuki Katoh — Toyota Motor Europe NV/SA, Hoge Wei 33, Zaventem, Belgium

Large-scale batteries are in high demand for applications such as plug-in electric hybrid or electric vehicles, and smart electric power grids. The all-solid-state battery is the most promising candidate for future battery systems, due to the high energy density obtaining by direct-series-stacking of the battery cells. However, the poor electrochemical characteristics of the all-solid-state battery, due to higher cell-resistivity than conventional liquid electrolyte batteries, still remain as an unsolved issue. We will demonstrate an all-solid-state battery with extremely high power performance that employs the superionic conductors having the Li10GeP2S12-type crystal structure. The battery can operate over a wide temperature range with extremely high current drains of 3 mAcm-2 (-30 C), 100 mAcm-2 (25 C), and 1000 mAcm-2 (100 C). Careful electrochemical examination of the all-solid-state battery with the same battery configuration as a liquid electrolyte system revealed that the rate characteristics are simply dependent on the difference in state of electrolyte. The vert high power characteristics of solid state battery comes from intrinsic ion transportation mechanism of solid electrolyte.