66th GREEN Open Seminar

2018/4/11(Wed) 10:00～11:00

Venue : Auditorium, 1F, WPI-MANA Bldg., Namiki Site, NIMS

Molecular Processes in Li- and Na-Ion and Redox Flow Batteries

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Abstract

Batteries play an ever growing role in todays and future technologies. Applications can range from portable electronics over electrification of road traffic to using renewable energies 24h/365d. Demands on the performance are thus very different and a thorough understanding is a pre-requisite for further improvement. In particular, a detailed understanding of the molecular processes is important for energy and power density, cycle life (degradation mechanisms) and safety of batteries. Two types of batteries will be discussed, intercalation batteries and redox flow batteries.

Intercalation batteries have become an important technology for electricity storage as can be seen from the success of Li-ion batteries. Since there are issues regarding the broad availability of lithium, attempts are made to have other ions intercalated such as magnesium and sodium. In addition, the molecular understanding of the processes, especially at the interface, are still underdeveloped. Studies were performed using Scanning Tunnelling Microscopy (STM) and other techniques to investigate

- the electrochemical behaviour of the ion intercalation for Li and Na,
- the molecular processes upon formation of the SEI in a Li-Ion battery,
- the intercalation process of Na in HOPG in glyme electrolyte.

For the Li-ion system the interfacial layer between electrode and electrolyte (SEI layer) is crucial for its functioning but little is known about the mechanism of its formation[1]. The STM results elucidate the initial stages of the process and under which conditions the reversible formation changes to an irreversible formation of the SEI. The results for Na show a large lattice expansion upon intercalation which is reversible and can be sustained over many intercalation–de-intercalation cycles. The data also suggest that the intercalation of Na in glyme electrolyte occurs in the solvated state of the ion. This is a remarkable effect since one would assume that the activation barrier is quite high because of the large structural changes.

The current technology of redox flow batteries, RFB, uses the $V^{2+/3+}$-$V^{4+/5+}$ redox couple for storing electricity. This all-vanadium system has many advantages, however, some performance issues exist. Novel redox electrochemistries try to overcome the limitations regarding energy and power density. Some examples of our recent work regarding organic6 and inorganic[7] systems will be given.

References

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