Interfacial studies in lithium battery reaction

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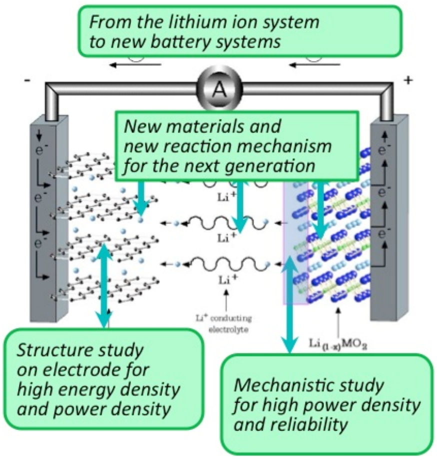
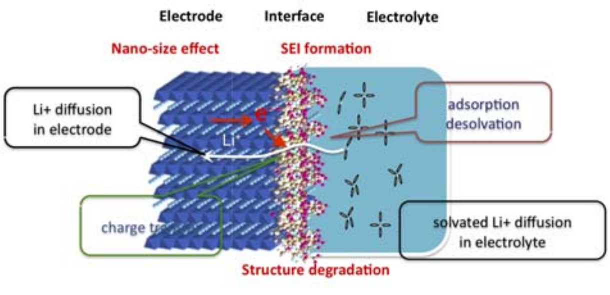
Batteries are a key technology in today's society. They are used to power electric and hybrid electric vehicles and to store wind and solar energy in smart grids. Since the "lithium-ion" configuration using intercalation reaction has been widely accepted, significant efforts have been devoted to attain high energy and power densities to produce an excellent energy storage system.

Intercalation reactions are chemical reactions in which guest ions are inserted in and extracted from gaps in a host lattice without significantly modifying the lattice itself. They form the basis of lithium battery operation, which is driven by electrochemical reactions. Although there are minimal changes to the lattice during intercalation, restructuring of the lattice is often accompanied by a phase transition, which is one of the factors that determine the kinetics and reversibility of lithium batteries. Structural studies of intercalation materials provide valuable information for developing lithium batteries.



Research issues for advanced batteries.

However, little is known about the electrochemical reaction at the electrode surface. Although electrochemical and spectroscopic studies have emphasized the importance of surface reactions on the power and calendar-life characteristics, the surface reaction mechanism still remains unclear. In particular, no experimental techniques have been developed for detecting the surface structure during battery operation. Gaining a thorough understanding of the reactions on the electrode surfaces of lithium batteries is critical for designing new electrode materials suitable for high-power, safe, long-life operation.



Electrode reaction in batteries.

A technique for directly observing surface structural changes has been developed that employs an epitaxial thin-film model electrode and surface X-ray and neutron scattering techniques. In situ scattering studies have revealed dynamic structural changes at the electrode surface during the electrochemical reaction. The surface structural changes commence with the formation of an electrical double layer, which is followed by surface reconstruction in the charge-discharge process. Surface reaction, nano-effect of the electrode reaction, and degradation mechanism of battery reaction will be discussed.