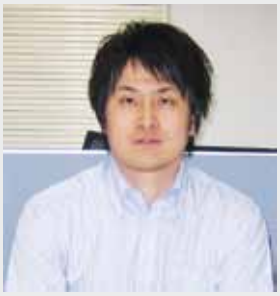
Study of Ion Conductive Materials for Novel Energy Storage/Conversion Devices

Research Center of Integrative Molecular Systems
Division of Trans-Hierarchical Molecular Systems



KOBAYASHI, Genki
Research Associate Professor
[gkobayashi@ims.ac.jp]

Education
2006 B.E. Kanazawa University
2008 M.E. Tokyo Institute of Technology
2010 D.S. Tokyo Institute of Technology

Professional Employment
2010 Postdoctoral Fellow, Tokyo Institute of Technology
2011 Assistant Professor, Kanagawa University
2012 JST-PRESTO Researcher (Adittional post)
2013 Research Accosiate Professor, Institute for Molecular Science

Awards
2010 ACerS Spriggs Phase Equilibria Award, American Ceramics Society
2011 Tejima Doctoral Dissertation Award, Tokyo Institute of Technolog

Member
Technical Fellow
IMAI, Yumiko
KUBOTA, Akiko
Secretary
KAWAI, Shigeko

Keywords Solid State Ionics, Oxyhydride, Battery, Energy Storage/Conversion

Recently, the demands for advanced electrochemical devices providing high energy density have been growing because of the expansion in application and a need for diversification of energy sources. In order to achieve the requirement, it will be essential not only to improve the existing devices such as lithium secondary batteries and fuel cells, but also to develop a novel energy storage/conversion system (Figure 1). In other words, a development of a novel electrochemical device possessing excellent battery performances that would be required in future is not an extension of the research on the existing devices. On the basis of these backgrounds, we are tackling two research topics; (i) improvement of battery performance with controlling the interface between electrode and electrolyte in lithium secondary batteries (ii) the exploration of novel ion conductive phenomena in solid.

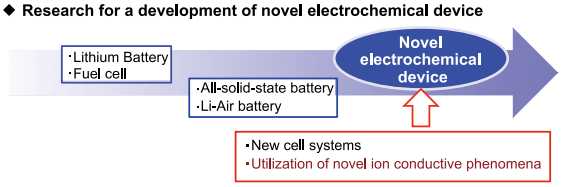


Figure 1. The concept of our research toward the realization of new electrochemical device.

(i) Control of the Cathode/Electrolyte-Interface in Lithium Batteries for Enhancement of the Performance

A surface modification of the cathode materials for lithium batteries with other metal oxides or phosphate is suggested as an effective method to inhibit the capacity degradation for lithium batteries. The main role of the surface modification layer has been considered the protection of a surface crystallinity of cathode materials from side reactions with electrolyte, but it has not been fully understood. To clarify the role of a surface modification, we examine the crystal structure of the modified cathode material, the chemical bonding state of coating layer and deterioration behavior of the cathode material using *ex situ* X-ray diffraction, transmission electron microscope and Hard X-ray photoelectron spectroscopy.

(ii) Synthesis and Property of Hydride Conductive Oxyhydride

We focus on hydride ions (H^-) as a new mobile ion. Hydride ion conductors are the new frontier materials in the research field of solid-state ionics and electrochemistry. Indeed, hydride ion conduction is particularly attractive for electrochemical devices such as fuel cells and batteries, because hydride ions have suitable ionic radii as mobile ions and strong reducing properties. The ionic radii of hydride ions are similar to oxide and fluoride ions, which may provide high ionic conduction in the crystal lattice. The standard potential for H^-/H_2 at about –2.3 V is comparable to the value of –2.4 V for Mg/Mg^{2+}; therefore, energy storage/conversion devices effectively utilizing a H^- conduction phenomenon and the redox reaction of H^-/H_2 are expected to show high energy density. However, the ionic conducting characteristics of hydride H^- ions are not established yet and the interplay between elementary H^- mobility, lattice structure, functional properties and materials synthesis are mostly lacking. Although a possibility of H^- conduction was indicated in several materials, the conclusive evidence for pure hydride ion conduction has not been provided yet, due to difficulties in identifying hydride ions. Recently, our group reported for the first time pure H^- conductivity in new oxyhydrides. We try to synthesis new H^- conductive materials on the basis of our previous works.