【Grant-in-Aid for Scientific Research on Innovative Areas (Research in a proposed research area)】

Science and Engineering

Title of Project：Science on Interfacial Ion Dynamics for Solid State Ionics Devices

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【Purpose of the Research Project】

Solid-solid interfaces generate entirely new functions different from the intrinsic nature of each solid material. In this project, unique interfacial ion dynamics around the hetero/homo interfaces of solid state ionics materials (SSIM) are systematically investigated so as to establish design principles for fast ion transport and concentrated ion storage around interfaces, that is, "*Interface Ionics*".

【Content of the Research Project】

There are two kinds of SSIM; i) insertion electrode material (electrode), where electrons or holes move faster than ions. ii) solid electrolyte, where ions moves faster than electrons or holes. When these two SSIMs are combined, an equilibrium state is formed through the rearrangement of all the charged carriers (electron, hole, and ion) and then their electrochemical potentials become equal. As a consequence, the electrode/solid electrolyte interface obtains different properties with each intrinsic SSIM due to space charge layer formation, mechanical relaxation (strain distribution), etc., which provide unique interfacial ion dynamics (Fig. 1). The aim of this project is to investigate these physical and chemical modulations around the interface in detail and establish the interface design principle which makes it possible to generate novel functions around the interfaces. This project integrates chemistry, physics, advanced measurement, theory and data science, and material science and consists of the four research groups (Fig. 2).

Gp-A01 fabricates model interfaces using single

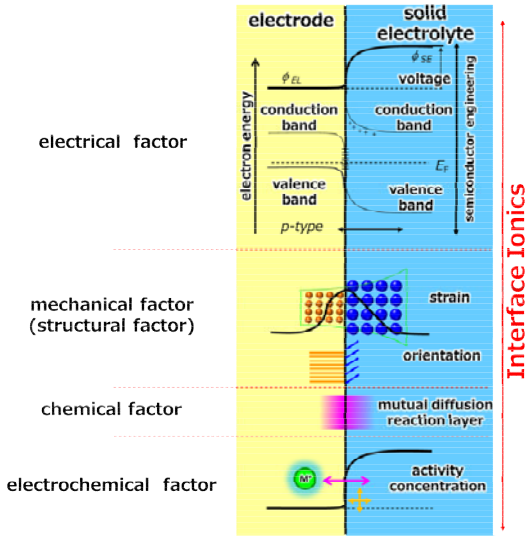

Fig.1 Schematic image of various factors affecting "*Interface Ionics*".

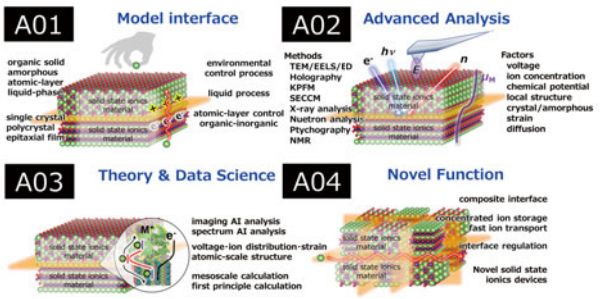

Fig. 2 Overview of research groups.

crystalline substrates, epitaxial thin films, etc. and investigates their interfacial ion dynamics. Gp-A02 analyzes modulation and distribution of voltage, ion concentration, chemical potential, local structure, etc. around the interface using advanced measurements. Gp-A03 clarifies ions and electrons distribution and their dynamics around the interface using multi-scale theoretical calculation and informatics analyses. Gp-A04 develops advanced materials especially focusing on metastable phases with lattice defects and lattice strains by combining crystalline and amorphous SSIMs.

【Expected Research Achievements and Scientific Significance】

"Interface Ionics" clarifies design principle of interface in all-solid-state batteries where fast ion transport and concentrated ion storage is expected in the right space for high-rate charge-discharge reactions and high capacity electrode materials. Furthermore, those interfaces are effective to develop novel solid state ionics devices such as all-solid-state capacitor, superconductor, transistor, actuator, electret, et al.

【Key Words】

Solid State Ionics Devices; Advanced devices using SSIMs such as all-solid-state battery, all-solid-state capacitor, etc.
Interfacial Ion Dynamics; Unique ion dynamics generating around the hetero/homo interfaces of SSIMs.

【Term of Project】

FY2019-2023

【Budget Allocation】

1,127,800 Thousand Yen

【Homepage Address and Other Contact Information】

https://www.interface-ionics.jp/