【Grant-in-Aid for Specially Promoted Research】

Science and Engineering (Engineering)

Title of Project : Atom-by-atom imaging of ion dynamics in nano-structures for materials innovation

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Research Project Number : 17H06094 Researcher Number : 70192474
Research Area : Engineering
Keyword : Atomic/electronic structure characterization

【Purpose and Background of the Research】

It is well known that nano-structures such as interfaces, surfaces, dislocations and point defects crucially determine the macroscopic properties of materials and devices. Thus, it is important to fundamentally understand the relationships between nano-structures and their properties, in order to create better and/or novel property materials and devices. Through advances in aberration correction technology over the last decade, scanning transmission electron microscopy (STEM) has achieved sub-0.5Å spatial resolution and it has become possible to directly characterize nano-structures inside materials at atomic dimensions. However, the above atomic-resolution imaging methods are currently limited to image nano-structures in a stationary manner. To fundamentally and thoroughly understand the relationship between nano-structures and their properties, it is needed to observe nano-structures dynamically, i.e. when they actually exhibit their functional properties. In particular, atom and ion dynamics around nano-structures will be the key to understand the properties of many materials and devices. However, it is still a major challenge to realize

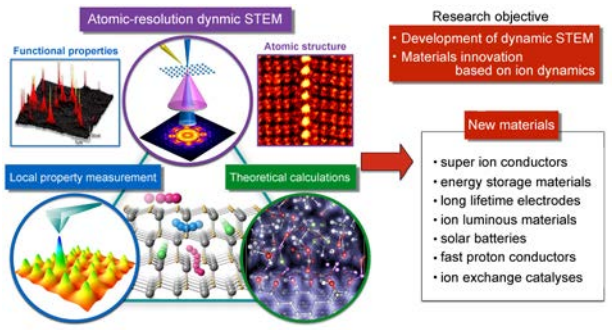

Figure 1 Project overview

atomic-scale dynamic observations of nano-structures inside materials under working conditions.

【Research Methods】

In this project, we divide our research plan into three main parts. The first part is the development of direct and dynamic imaging techniques of atoms and ions inside materials based on aberration-corrected STEM. The second part is the application of the newly developed atomic-resolution dynamic imaging techniques to actual materials science and engineering problems. In the third part, we develop better and novel property materials based on the design and control of local atom and ion dynamics around nano-structures.

【Expected Research Achievements and Scientific Significance】

We plan to develop our atom-resolved imaging techniques based on STEM to be capable of directly imaging atom and ion dynamics of nano-structures under working conditions. This development should have tremendous impact in both academia and industry – directly visualizing atom and ion dynamics while materials and devices exhibit their functional properties will offer a new stage to fundamentally understand the relationships between nano-structure and functional properties.

【Publications Relevant to the Project】

1. N. Shibata, S. D. Findlay, Y. Kohno, H. Sawada, Y. Kondo, Y. Ikuhara, "Differential Phase-contrast Microscopy at Atomic Resolution", Nature Phys. 8, 611–615 (2012).
2. S. Kondo, T. Mitsuma, N. Shibata, Y. Ikuhara, "Direct observation of individual dislocation interaction processes with grain boundaries", Sci. Adv. 2, e1501926-1-7 (2016).

【Term of Project】 FY2017-2021

【Budget Allocation】 454,000 Thousand Yen

【Homepage Address and Other Contact Information】

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