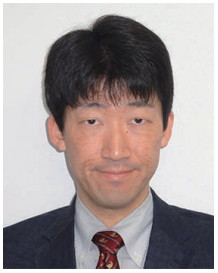
【Grant-in-Aid for Scientific Research (S)】

Broad Section D



Title of Project : Creation of platform for the next generation synchrotron radiation microspectroscopy by multi-dimensional X-ray ptychography

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Research Project Number : 18H05253 Researcher Number : 00415217
Keyword : Synchrotron radiation, X-ray ptychography, Phase retrieval, X-ray absorption spectroscopy

【Purpose and Background of the Research】

Many practical materials are heterogeneous complex systems with domain structures from nanometer to sub-micrometer scale. Therefore, it is important to understand correlation between the fine structures and the function at nano-meso scale when we design and develop new functional materials.

So far, we have developed high-resolution and high-sensitivity X-ray ptychography that is nano structural imaging method based on the synchrotron coherent X-ray diffraction and phase retrieval calculation. Recently, we have demonstrated ptychographic-XAFS method which can visualize both the structure and chemical state of bulk materials at the nanoscale.

In this study, we will improve ptychographic-XAFS method, and then apply to correlation analysis of the fine structures and the function of various functional materials. Finally, we will create the platform for the next generation synchrotron radiation microspectroscopy.

【Research Methods】

We dramatically reduce the measurement time of ptychographic-XAFS method using X-ray optics approach and information technology approach. We establish multi-dimensional X-ray ptychography, in which ptychographic-XAFS method is extended to three-dimensional space by combining with computed tomography. We perform the correlation analysis of the fine structures and the function of functional materials, such as catalyst materials, polymeric materials, and magnetic materials.

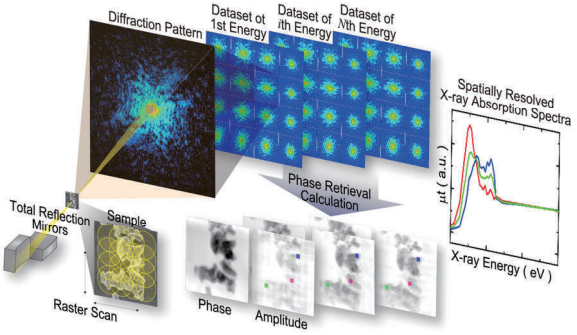

Figure 1 Representation of ptychographic-XAFS method.

【Expected Research Achievements and Scientific Significance】

Currently, TEM-EELS is widely used as a main tool for microspectroscopy. However, it is difficult to observe thick samples more than a few tens nanometer in thickness by TEM-EELS. On the other hand, multi-dimensional X-ray ptychography can observe the thick samples at ten nanometer resolution, and hence can pioneer the frontier of science of correlation between the structure and the function of heterogeneous complex systems.

The next generation synchrotron facilities provide us high-intense coherent X-rays. By utilizing the platform in the next generation synchrotron facilities, the design and development of new functional materials will be facilitated.

【Publications Relevant to the Project】

・A. Suzuki, K. Shimomura, M. Hirose, N. Burdet, and Y. Takahashi, "Dark-field X-ray ptychography: Towards high-resolution imaging of thick and unstained biological specimens", Scientific Reports 6, 35060 (2016).
・M. Hirose, K. Shimomura, N. Burdet, and Y. Takahashi, "Use of Kramers-Kronig relation in phase retrieval calculation in X-ray spectro-ptychography", Optics Express 25, 8593-8603 (2017).
・M. Hirose, N. Ishiguro, K. Shimomura, N. Burdet, H. Matsui, M. Tada, and Y. Takahashi, "Visualization of heterogeneous oxygen storage behavior in platinum-supported cerium-zirconium oxide three-way catalyst particles by hard X-ray spectro-ptychography", Angewandte Chemie International Edition 130, 1490-1495 (2018).

【Term of Project】

FY2018-2022

【Budget Allocation】

136,400 Thousand Yen

【Homepage Address and Other Contact Information】

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