High-resolution Coherent X-ray Diffraction Imaging at SPring-8 and SACLA

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Abstracts: *Coherent X-ray diffraction imaging allows us to two-dimensionally or three-dimensionally visualize the electron density distribution of thick samples. We developed a method of high-resolution coherent diffraction imaging using a high-intensity X-ray beam focused by Kirkpatrick-Baez mirrors at SPring-8 and SACLA. We applied it to observe shape-controlled Au/Ag nanoparticles. The three-dimensional electron density distribution and Au-rich regions of individual particles were visualized at SPring-8. The relationship between the size distribution of particles and their internal structures were evaluated at SACLA.*

Coherent diffraction imaging with hard-X-ray beams allows us to two-dimensionally or three-dimensionally observe thick objects, and also provides us with structural information, such as the electron density distribution, that cannot be obtained by probe microscopy or electron microscopy. We have a method of developed high-resolution coherent diffraction imaging using a high-intensity X-ray beam focused by Kirkpatrick-Baez mirrors[1,2] at SPring-8 which is a third-generation synchrotron radiation facility in Japan. For example, we visualized the three-dimensional electron density distribution of a shape-controlled Au/Ag nanoparticle[3] and the Au-rich regions of ~450 individual Au/Ag nanoparticles[4] at sub-10-nm resolution.

Recently, X-ray free electron lasers (XFELs) have become available at the SPring-8 Angstrom Compact Free Electron Laser (SACLA) in Japan. XFELs provide almost completely transverse coherent X-rays with an extremely large number of photons in a single pulse and a duration of less than 100 fs. We first performed the coherent diffraction imaging analysis of nanoparticles using focused hard-X-ray free-electron laser pulses, allowing us to analyze the size distribution of particles as well as the electron density projection of individual particles[5]. We measured 1000 single-shot coherent X-ray diffraction patterns of shape-controlled Ag nanocubes and Au/Ag nanoboxes and estimated the edge length from the speckle size of the coherent diffraction patterns. We then reconstructed the two-dimensional electron density projection with sub-10-nm resolution from selected coherent diffraction patterns. This method enables the simultaneous analysis of the size distribution of synthesized nanoparticles and the structures of particles at nanoscale resolution to address the correlations between the structures of individual components and the statistical properties in heterogeneous systems such as nanoparticles and cells.

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