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Development of Coherent Imaging Methods Using Synchrotron Radiation and FEL

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Coherent imaging is a growing field in optical science. It requires no lens for image formation, but instead numerically reconstructs object images from the coherent diffraction data by extending the methodology of x-ray crystallography to non-crystalline samples. An important application is the three-dimensional imaging of cellular organelles with x-rays, as we demonstrated for unstained human chromosome using undulator radiation from SPring-8 [1]. We successfully observed high electron density structure near the axis of the mitotic chromosome, a first for unlabeled condition, demonstrating high image-contrast of the method.

In order to make measurement more efficient and also to achieve higher spatial resolution, we later introduced focusing optics, and located the sample at the focal position. As focusing optics, we used Kirkpatrik-Baez mirrors with sub-nanometer figure error fabricated by elastic emission machining (EEM) [2]. We achieved half-period resolution down to 3.0 nm in 2D imaging for a silver nanocube sample, and better than 10 nm in 3D imaging for a Au/Ag nanobox [3].

By using extreme ultra-violet (EUV) FEL from the SCSS (SPring-8 compact SASE source) test accelerator, we succeeded in a femtosecond snapshot holography [4]. Fig. 1 shows the experimental setup. This is a first-step toward microscopy with atomic resolution in both space and time, and taking movie of atoms in motion using x-ray FEL (XFEL). We also discuss biological application using XFEL.

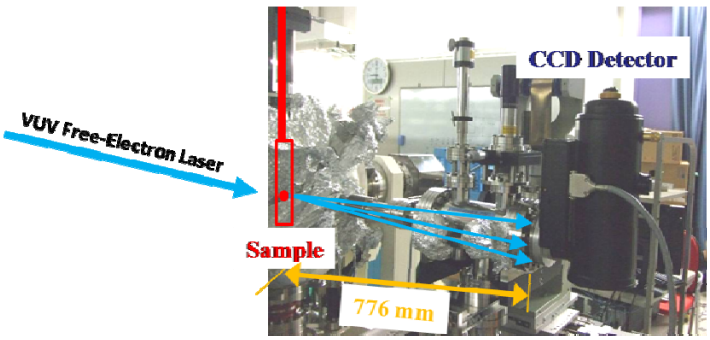

Fig. 1 Experimental setup for femtosecond snapshot holography experiment using EUV-FEL from the SCSS test accelerator.

Reference

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