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IT-1-P-2090 Contrast enhancement of phase objects by using Phase Contrast Scanning Transmission Electron Microscopy

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It is well known that an interaction between electron waves and molecules composed of light elements such as biological molecules is very weak. Therefore, it is very difficult to obtain their high contrast image in transmission electron microscopy (TEM). Contrast enhancement of the phase objects by using a phase plate was proposed at the middle of the 20th century [1], but it was realized at the beginning of 21st century [2]. In the pioneering work by Nagayama, a carbon thin film with a hole in its center is used as a phase plate (PP) and it was placed at a back focal plane (BFP) of the objective lens (OL). A role of the PP is giving a phase shift to scattered wave by means of the mean inner potential of the PP material. Electron waves having a phase shift interfere with electron waves without phase shift. Accordingly, phase image would be able to be visualized.

Applying the principle of reciprocity to scanning transmission electron microscopy (STEM), imaging optics of the STEM is equivalent to that of a conventional TEM. Therefore, a phase contrast scanning transmission electron microscopy (P-STEM) can be used to enhance phase contrast of the phase objects. In the present study, a PP can be set on the condenser lens aperture (CLA) plane that is optically equivalent to a front focal plane (FFP) of an OL. The P-STEM image which enhances image contrast could be obtained by getting an appropriate optical condition. Figure 1 show an example of the comparison of (a) the conventional STEM bright field image and (b) the P-STEM image. Ferritin molecules were used as a specimen. This comparison clearly shows contrast enhancement in P-STEM. In this paper, the results obtained by sung phase contrast microscopy to the STEM mode are introduced.

[1] F. Zernike, Physica 9 (1942) 686.

[2] R. Danev and K. Nagayama, J. Phys. Sci. Jpn. 70 (2001), 696.

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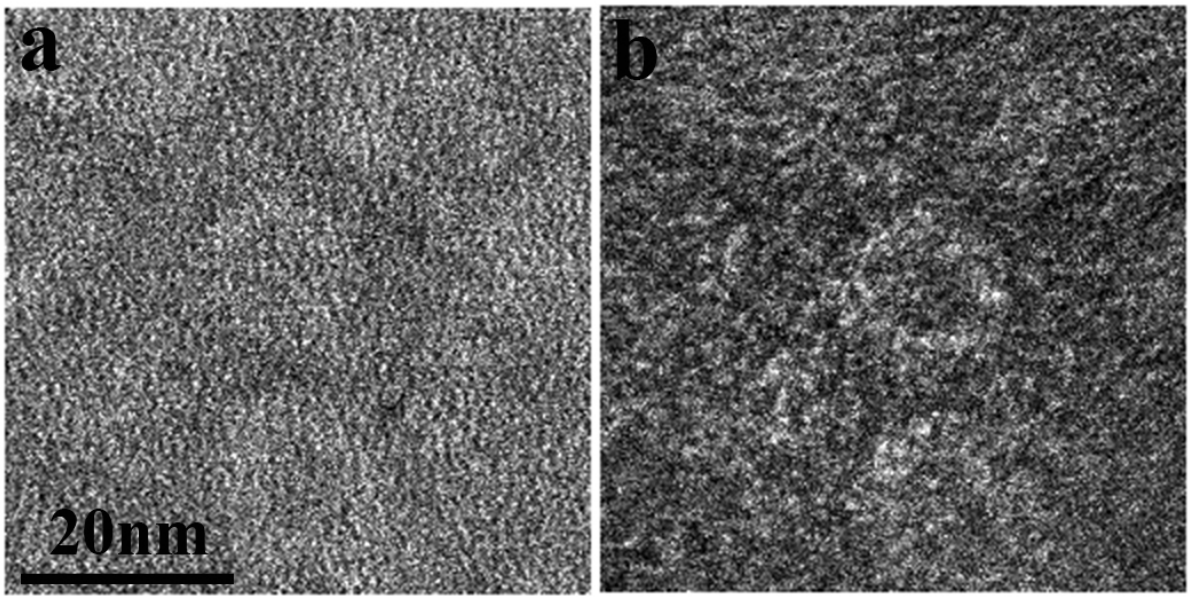

Fig. 1: A comparison of (a) C-STEM and (b) P-STEM images of ferritin molecules. The contrast enhancement in P-STEM is evident.