Type of presentation: Poster

IT-1-P-1961 Development of Phase Contrast Scanning Transmission Electron Microscopy

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Phase contrast transmission electron microscopy (P-TEM) is a powerful tool to enhance the image contrast of transparent materials such as ice-embedded biological specimens and polymer materials. In P-TEM, a phase plate is placed at the back-focal plane (BFP) of the objective lens (OL). It gives a phase shift for scattered electron waves, resulting in a change of phase contrast transfer function (PCTF) from sine to cosine type. Eventually, phase variation of specimens is converted into intensity variation. Among various types of phase plates, a carbon film phase plate with a small central hole is the most practical[1]. However, there is a serious issue that high-density electron beam (cross-over) on the phase plate causes the charging and/or the alteration of the phase plate, resulting in decreasing the life time of the phase plate.

To overcome this issue, we are developing phase contrast scanning transmission electron microscopy (P-STEM). Figure 1 shows the schematics of P-TEM and P-STEM. According to the reciprocity theorem, the same contrast appears in the P-TEM and the P-STEM if a phase plate is placed at a front-focal plane (FFP) of an OL in P-STEM. In P-STEM, a cross-over is not formed on the phase plate, so that improvement of the phase plate life time is expected. In our experiments, we used a field emission electron microscope (JEM-2100F) equipped with a Schottky electron source, to obtain a coherent small probe on a specimen. Phase plate is placed on a condenser lens aperture plane conjugate to the FFP of the OL.

On the other hand, it is well known that the small detection angle is needed to obtain good phase contrast in STEM imaging. Figure 2 compares a conventional bright-field STEM and a P-STEM images of amorphous carbon film with different detection angle shown in Fig. 1. And Fourier transforms of the conventional bright-field STEM image and the P-STEM image with β = 4 mrad show the sine shape. By contrast, that of the P-STEM image at β = 0.3 mrad shows the cosine shape, which proves that the P-STEM can be achieved with small detection angle.

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

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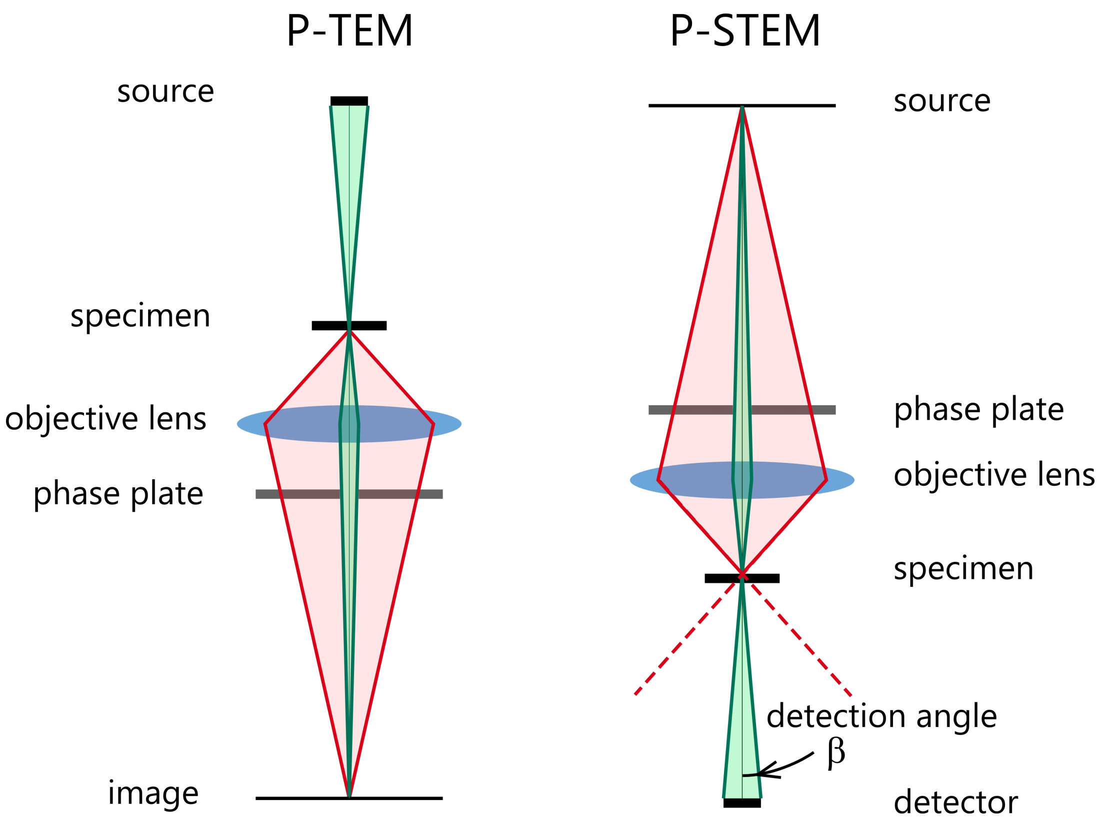

Fig. 1: Schematic of P-TEM (left) and P-STEM (right). The phase plate is placed at the BFP of the objective lens in P-TEM and the FFP of the objective lens in P-STEM.

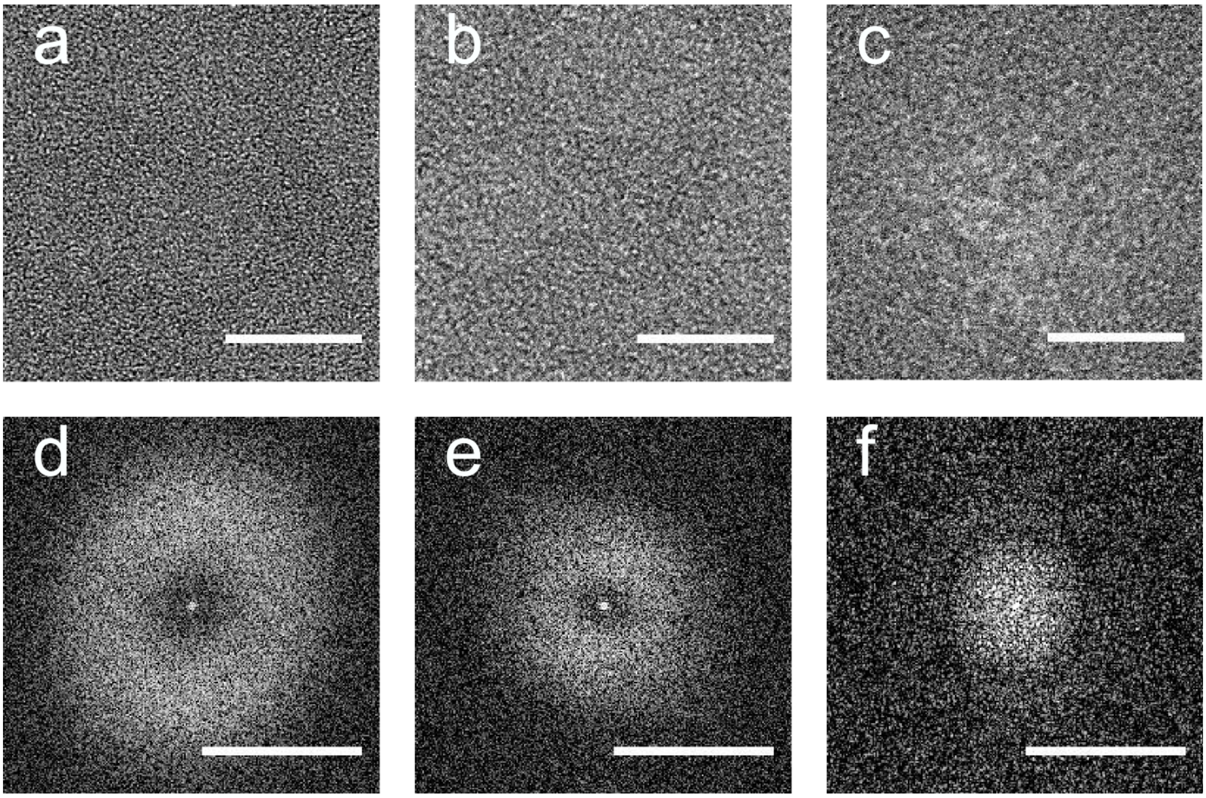

Fig. 2: Conventional bright-field STEM and P-STEM images of amorphous carbon film. All images are taken close to focus. (a) Conventional bright-field STEM image. (b) P-STEM image with β = 4 mrad. (c) P-STEM image with β = 0.3 mrad. (d)-(f) Fourier transforms for images shown above. Scale bars; 10 nm in (a)-(c), 4 nm^{-1} in (d)-(f).