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Development of a segmented detector for aberration corrected scanning transmission electron microscopes

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A traditional single channel bright or dark field STEM detector acquires a signal from only a circular or annular region of the diffraction pattern, resulting in that information about the azimuth distribution of electron scattering cannot be detected. To obtain such information simultaneously, several types of segmented detectors have been developed [1-4]. They have plural segmented areas for detection and can acquire signals from each area individually and simultaneously. There is, however, no report of a segmented detector, which can be utilized for atomic-resolution imaging. Such multi-acquisition at atomic resolution requires a sufficient S/N ratio to obtaine images at fast scan speed by a small detection area. We have developed a new segmented detector system which can acquire sixteen STEM images from different detector areas simultaneously. We demonstrate atomic-resolution STEM imaging using this newly developed detection system in an aberration-corrected 200 kV STEM [5].

Figure 1 shows a scheme of our experiment. The detector is composed of scintillator (YAG) and fiber bundle for transmitting scintillated photons to PMTs. The fiber bundle is composed of two portions. The first fiber bundle is composed of a number of fine fibers. The bundle transfers the luminescence pattern of the scintillator to the other end of the bundle. The diameters of the fine fibers are about 60 □m, which is fine enough to transfer the pattern with sufficient resolution to the second fiber bundle. The second fiber bundle consists of sixteen distinct sector-shaped fiber bundles with four radii and azimuth angles. The luminescence pattern transferred by the first bundle is divided into sixteen parts at the connection of the first and second bundles. The divided light signal is then transferred to the sixteen PMTs. The signals from the PMTs are simultaneously sampled by an electronic system controlled by a computer. Then, sixteen STEM images are displayed on a monitor by a newly developed software system. The PMT detection system allows us to detect the signals at fast scan with controllable wide dynamic range of amplification.

Figure 2(a) shows the shape of the detection areas, which is acquired by scanning a probe on the detection surface. Figure 2(b) shows STEM images of Si[110] with sixteen detectors. Images at the same radius over four segmented detection areas are shown at the bottom of the window (Fig. 2(b) A-D). An annular dark field image using a conventional detector is also acquired simultaneously (Fig. 2(b) E). The system successfully obtained atomic-resolution images formed with electrons of different scattering angles simultaneously.

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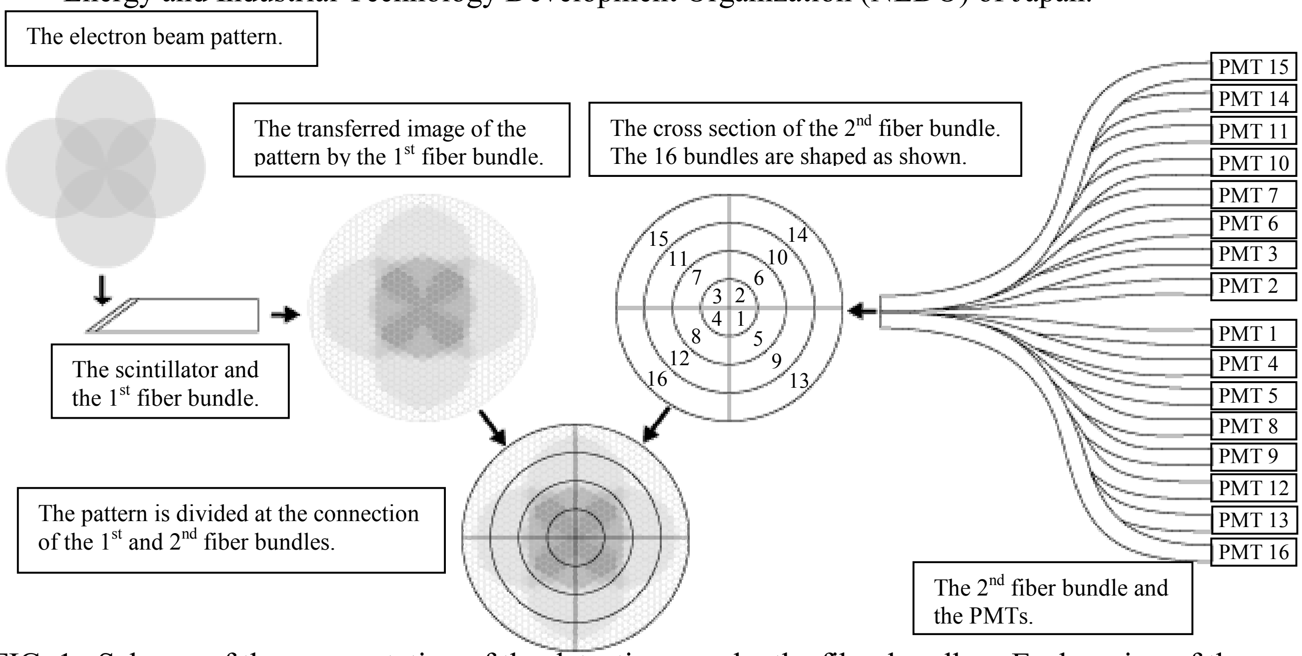

FIG. 1. Scheme of the segmentation of the detection area by the fiber bundles. Each region of the cross section of the 2nd bundle is connected to the PMT with the same number.

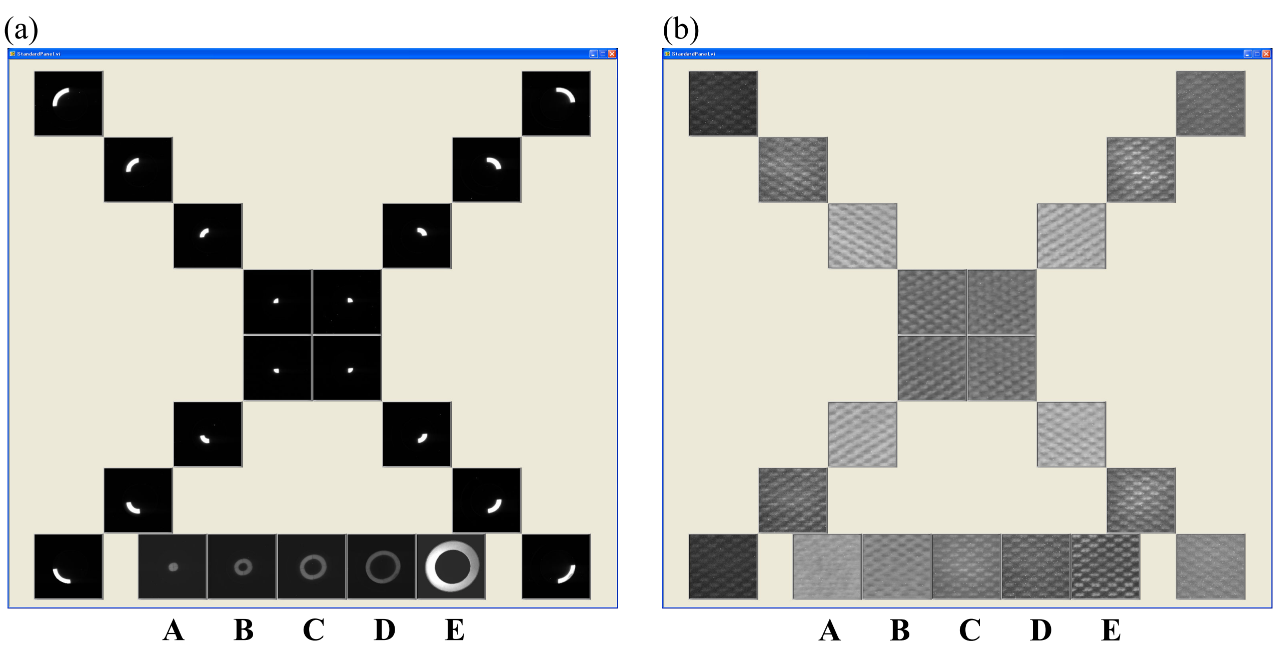

FIG. 2. Screen shots of the image display window. (a) The geometrical configuration of the segmented detection area, acquired by scanning a probe on the detection surface. (b) The STEM images of Si[110] on different radii and azimuth angles.

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