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IT-4-P-1423 Development of high-efficiency DF-STEM detector

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Most recently, observations at low accelerating voltages have been increasingly popular for carbon-based materials such as carbon nanotubes or graphenes, to reduce knock-on damage due to irradiation of an electron beam. High-resolution dark-field (DF) imaging in a scanning transmission electron microscope (STEM) has been widely used for structural analysis in materials science. In conventional system, a STEM signal is detected as light intensity emitted from a scintillator which is hit by electrons. The conventional detector showed low signal conversion efficiency from an electron to a STEM image signal at low accelerating voltages, since the STEM detector is optimized for high energy electrons. Thus, a detector with good efficiency from low to high accelerating voltages is sought after. The STEM detector is consisted of a scintillator, a glass light guide and a photomultiplier tube. Many materials for scintillator were tested to improve the efficiency. The scintillator of the STEM detector is selectable either a powder scintillator or a single crystal scintillator. However, the good efficiencies from low to high voltages were not found yet so far. We measured the efficiency for powder and single crystal scintillators whose chemical compositions were the same, depending on the accelerating voltages. The measured results showed that the scintillation efficiency for the single crystal becomes higher than that of powder at accelerating voltage greater than 100 kV. Combining these features, we have developed a hybrid type scintillator, which consisted of powder deposited layer and a single crystal substrate. The luminescent quantum efficiency of the hybrid scintillator was measured to be twice as large as that of the single crystal at 60 kV and was about 8 times higher than that of the powder at 300 kV, and covers the observation at the accelerating voltages from low to high voltages. Especially, it is useful for low voltage observations of carbon-based materials consisted of few atomic layers that produces weak scattering of electron.

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