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Development of Objective Aperture Holder for Mounting Compact Cs Corrector on Conventional SEM

Tsunenori Nomaguchi[1], Shunichi Motomura[1], Kenichi Nishinaka[1], Toshihide Agemura[1], Tadahiro Kawasaki[2], Ryuji Yoshida[2] and Takeharu Kato[2]

[1.] Electron Microscope System Design 1st Dept., Hitachi High-Technologies, Hitachinaka, Japan.
[2.] Nanostrucutres Research Laboratory, Japan Fine Ceramics Center, Nagoya, Japan.

Aberration corrected (scanning) transmission electron microscopes ((S)TEM) are well known all over the world. However, there is little example of scanning electron microscope (SEM) equipped with an aberration corrector although an improvement of spatial resolution of SEM is also being required. Therefore, we are developing a new compact spherical aberration (Cs) corrector and an objective aperture holder for mounting it on conventional SEMs.

A schematic diagram of the compact corrector is shown in Figure 1. This corrector was proposed by Kawasaki et al. and named ACE corrector [1]. It is composed of annular and circular electrodes. The annular electrode is grounded as well as a SEM column and a negative voltage is applied on the circular electrode. As a result, an electrical field which has a concave lens effect is generated on the annular slit. The Cs of the objective lens is canceled by this field. The most important merit of this corrector is the extremely simple structure. That is why it can be mounted on conventional SEMs just by modifying an objective aperture holder. Because of its simple structure, a correction accuracy of it may be inferior to that of a complex Cs corrector which is composed of several multipole lenses and transfer lenses. But ACE corrector can provide stable performance even after acceleration voltage or working distance is changed. Furthermore, it will be expected to expand depth-of-focus because electrons goes through the annular slit. These features suit well to conventional SEMs.

A schematic diagram of an evaluation apparatus is shown in Figure 2. The developed objective aperture holder with ACE corrector was mounted on Schottky Field Emission SEM SU5000 (Hitachi High-Technologies Corp.), which has a field free objective lens. And Figure 3 shows SEM images using it. A sample is gold nanoparticles on a carbon rod. Figure 3(a) and (b) were taken by applying 0 volt and a several volts to the corrector respectively. This result demonstrates that the spatial resolution is improved by applying a few volts to the ACE corrector.

Finally, only a unit for supporting ACE correctors shown in Figure 2(b) is totally different from a normal objective aperture holder. The structure of this unit can be used to other SEMs. Therefore, this technique will be easily spread into other conventional SEMs [2].

References:

[1] T. Kawasaki *et al,* Suf. Int. Anal **48** (2016), p. 1160.
[2] This development was supported by SENTAN, JST.

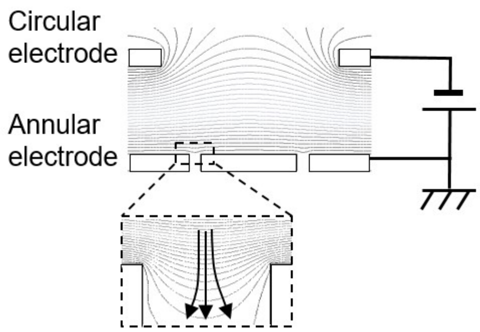

Figure 1. Schematic diagram of the compact Cs corrector. Thin gray lines show equipotential lines. The arrows show that the electrons expand after going through the annular slit of ACE corrector.

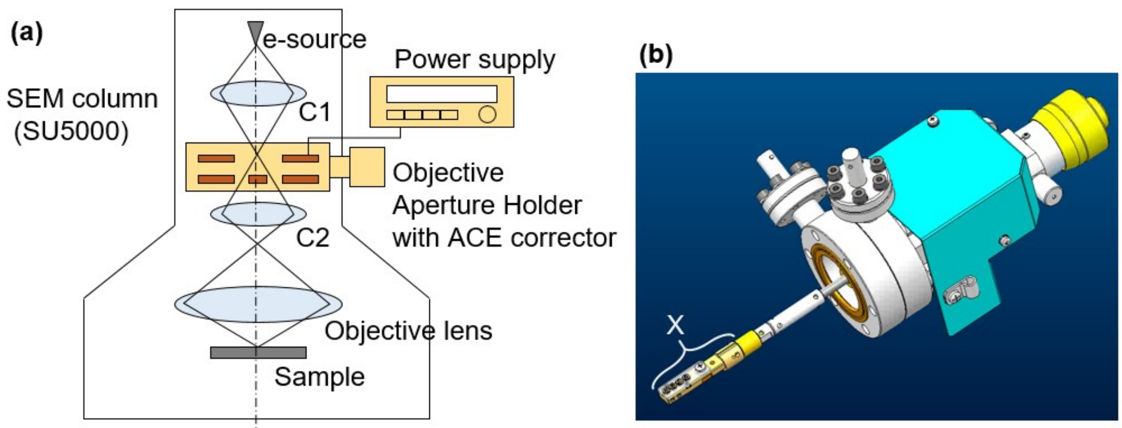

Figure 2. Schematic diagram of the evaluation apparatus based on SU5000 produced by Hitachi High-Technologies Corporation. (a) The position of the ACE corrector in SEM column (b) 3D-CAD model of the developed objective aperture holder. ACE correctors are supported by a unit "X".

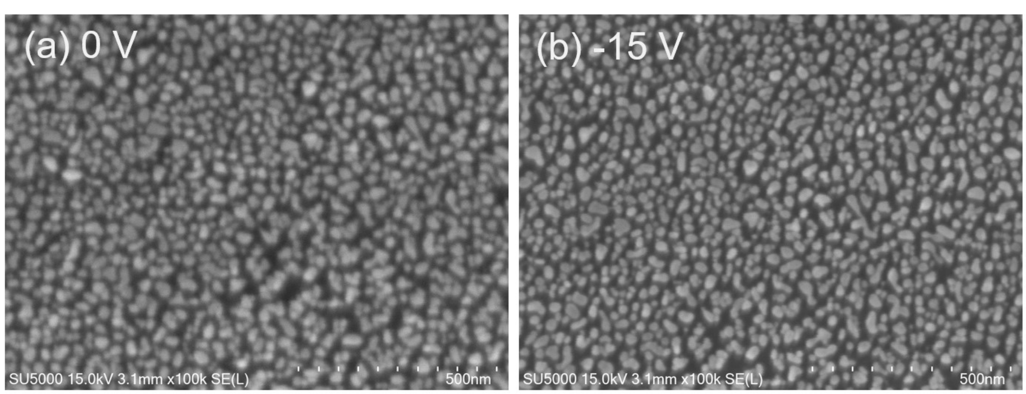

Figure 3. SEM images of gold nanoparticles on a carbon rod. These images were taken under the following conditions; Acceleration Voltage: 15 kV, Working distance: 3 mm, Voltage of ACE corrector: (a) 0 V and (b) -15 V.