Development of an Electrostatic Spherical Aberration Corrector dedicated for SEMs

Kawasaki, T.[1], Yoshida, R.[1], Kato, T.[1], Nomaguchi, T.[2], Motomura, S.[2], Nishinaka, K.[2], Agemura, T.[2], Tomita, M.[3] and Ikuta, T.[4]

[1] Japan Fine Ceramics Center, Japan, [2] Hitachi High-Technologies Corporation, Japan, [3] Vacuum Device Ltd., Japan, [4] Osaka Electro-communication University, Japan

The spherical aberration (Cs) correction has been an essential issue to improve the spatial resolution in the electron microscopes. The Cs-correctors consisted of multi-pole lenses have successfully realized sub-angstrom resolution in (S)TEMs [1]. In contrast, ones for SEMs have not been put in practical use, because these correctors require complex control of many optical components with high accuracy and stability, resulting in bulkiness and exorbitant costs. In order to solve these problems, the authors had proposed a very simple and compact Cs-corrector with electrostatic filed formed between annular and circular electrodes [2-3], so called ACE (**A**nnular and **C**ircular **E**lectrodes) corrector, as schematically shown in Figure. 1(a). In this paper, we report about development of our novel Cs correction device installing in a conventional SEM column and preliminarily results by using it.

The ACE corrector can compensate phase shift arising from positive Cs in an original lens system with that from electrostatic potential around the annular electrode. The former phase shift can express as wave aberration function including Cs and defocus values. A part of this function, restricted by the annular slit, show parabolic shape approximately. The projected potential distribution inside the annular slit is also a parabolic function, but upside down. Therefore, they can be canceled out with each other. This is a principle of Cs correction in the present system from the viewpoint of wave optics.

Figures 1(b) and (c) show a schematic illustration and a photograph of the developed system [4]. This consists of four components; (1)Annular and circular electrodes, (2)Mounting unit for the electrodes, (3)Position aligner connecting with the mounting unit and (4)Alignment system. These components are attached into the conventional SEM; SU 5000 (Hitachi High-Technologies Corp.) as shown in Fig. 1(c). SEM images obtained at 30 kV by the developed system are shown in Figure 2. The specimen here is gold particles supported on a carbon substrate. By inserting the electrodes in the SEM optics, the image is a little blurred owing to the annular slit mainly, as shown in Fig. 2(a). In contrast, spatial resolution is improved with increasing a voltage applied to the circular electrode (the annular electrode is grounded in the present experiment) (Fig. 2(b)). These results clearly demonstrated that higher-resolution image can be obtained by setting the annular and circular electrodes in optimal conditions even in the conventional SEM.

[1] M. Haider, et al., *Optik* **99** (1995) 167. [3] T. Kawasaki, et al., PCT/JP2016/053691
[2] T. Kawasaki, et al., *Suf. Int. Anal*, **48** (2015) 1160[4] This development was supported by SENTAN, JST

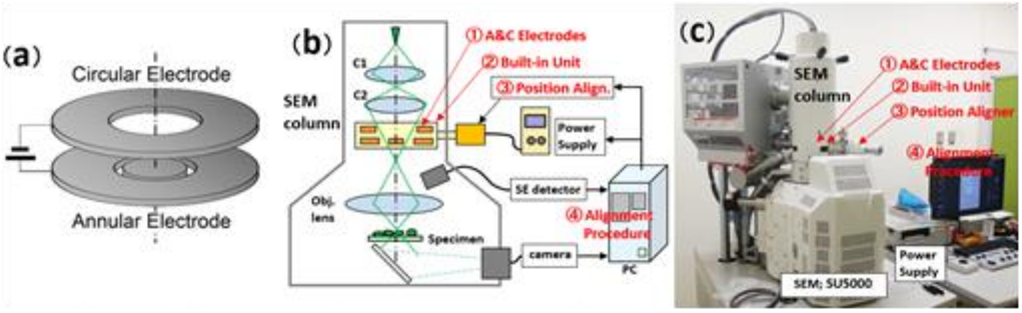

Fig 1. Schematic illustrations of (a) ACE corrector electrodes and (b) the developed SEM system. (c) photograph of the system.

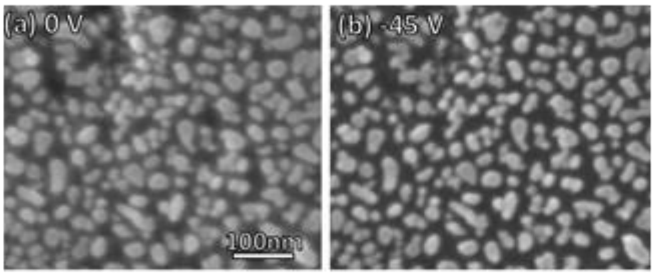

Fig 2. SEM images of Au particles; (a)ACE corrector OFF and (b)ON (@30kV)