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Performance of a new Monochromator for a 200 kV Analytical Electron Microscope

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We have been developing a 200 kV analytical electron microscope, which is equipped with a monochromator[1]. The target performance of the microscope is to achieve an energy resolution of 0.2 eV with a smaller than 2 nm diameter probe on a specimen plane. The monochromator is located between the extraction anode of a ZrO/W emitter and the accelerating tube. The monochromator consists of two Wien-filters and a slit for energy selection. The slit is inserted between the two filters. This configuration of the two Wien-filters and the slit produces a monochromatic, achromatic and stigmatic electron beam on the specimen plane.

We reported about the old type monochromator[2], which consisted of an asymmetric combination of two different octopole-type Wien-filters, the lengths of the upper and lower filters along the optical axis having been 40 mm and 10 mm, respectively. Though the ultimate energy resolution was 0.14 eV with the monochromator, the shape of the beam on the specimen plane was oval, which implies that the imperfect achromaticity was obtained on the specimen plane.

To achieve an achromatic beam on the specimen plane, we have manufactured a new monochromator[3], which consists of two dodecapole-type Wien-filters (Fig. 1) and a parallel shaped slit for energy selection. The lengths of both the filters are 30 mm and the slit is inserted at the mid-plane plane of the two filters. The upper filter and the electro-static round lens at the entrance of the monochromator make the first energy-dispersed focus on the slit. The lower filter cancels the energy dispersion and makes an achromatic and stigmatic focus at the exit of the monochromator. In this paper, the results of the performance test of the monochromator are reported.

Figure 2 shows the energy dispersions for the various potential values of the monochromator (from 800 eV to 1400 eV), which are related to the effective filter length. The filter length decreases with the strength of the excitation of the Wien-filter. The energy dispersion decreases with the filter length and with the potential of the monochromator. The energy dispersion is 19.5 μm/eV for a potential of 1000 eV and for a filter length of 67.5 mm. The value of the energy dispersion is sufficient to obtain an energy resolution of 0.2 eV using the energy selection slit.

Figure 3 shows the shape of a 200 keV electron beam on the specimen plane with the filter length of 67.5 mm. We have achieved an almost round shaped beam or a better achromatic beam of a 4 nm diameter on the specimen plane with the new monochromator. A smaller beam than a 2 nm diameter on the specimen plane at the achromatic condition of the monochromator will be obtained by using the probe forming lens system.

We have succeeded in obtaining an energy-dispersed beam on the slit and a stigmatic and achromatic beam at the exit of the monochromator.

References

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3. K. Tsuno, D. Ioanoviciu, G. Martinez: Microsc. Microanal., 9 (Suppl. 2), 944-945 (2003).

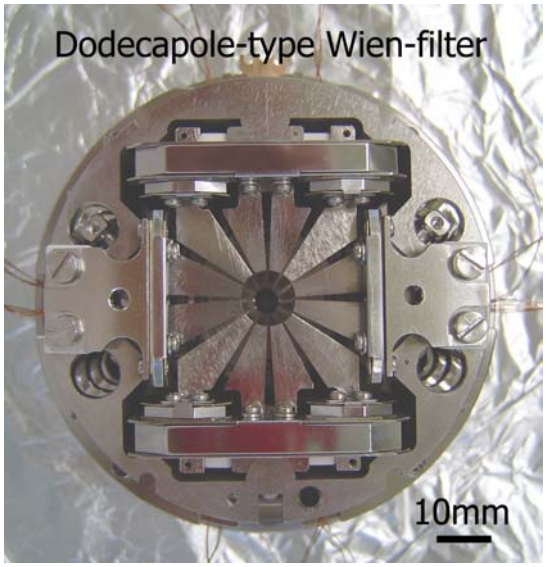


Figure1
Top view of Dodecapole-type Wien-filter

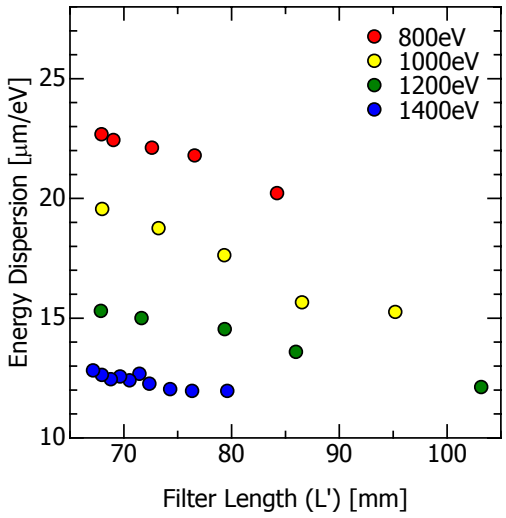
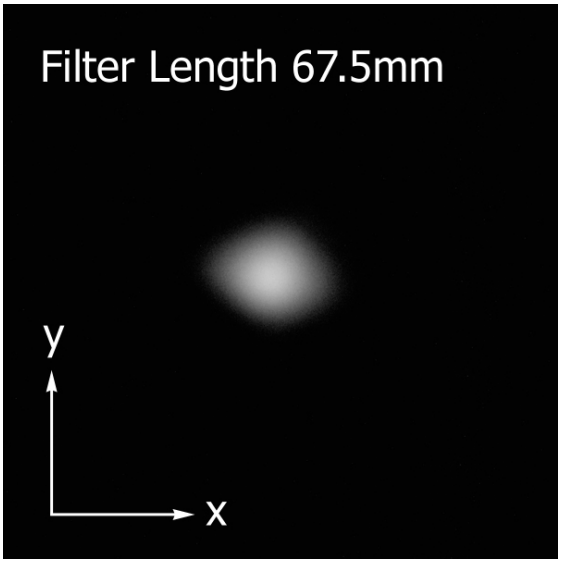
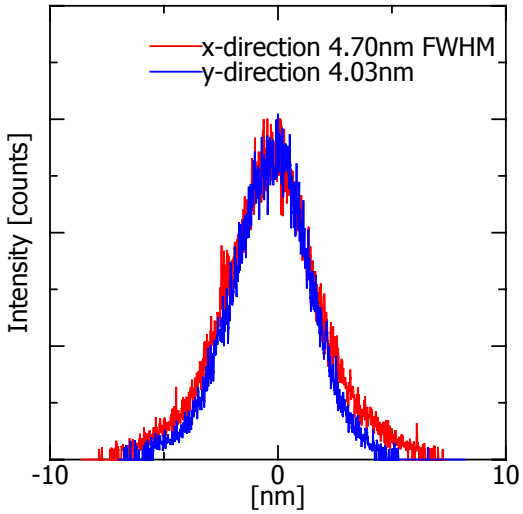


Figure 2
Values of the energy dispersion on the slit depending on the filter length of the Wien-filter



(a)



(b)

Figure 3
(a) Beam shape on the specimen plane with the monochromator turned on and the excitation of the filter length of 67.5mm
(b) Intensity profiles of the beam on the specimen plane

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