DOI: 10.1017/S1431927603444772
Microsc Microanal 9(Suppl 2), 2003

"MIRAI-21" ANALYTICAL ELECTRON MICROSCOPE - PERFORMANCE OF THE MONOCHROMATOR -

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We have been developing a high-energy-resolution analytical electron microscope under the project "MIRAI-21", which enables us to investigate both crystal- and electronic-structures of advanced materials in nanometer scale areas [1,2,3]. MIRAI means "Future" in Japanese and the abbreviation of Microscope for Innovative Research and Advanced Investigation. This microscope is constructed based on the JEM-2010FEF, and equipped with a newly developed Wien-filter monochromator and an improved Ω–filter analyzer. The microscope was aimed for a point resolution of 0.19nm and an energy resolution of 0.2eV at less than a 2nm diameter probe. In this paper, the basic design and the test results of the monochromator are reported.

A new monochromator is located between the extraction anode of the ZrO/W emitter and the acceleration tube. Figure 1 shows the arrangement of electric plates (+ and -) and magnetic poles (S and N) of the octopole-type Wien filter. The monochromator consists of two octopole-type Wien-filters[4] and a slit for energy selection, which is placed between the two filters. The upper Wien-filter disperses the incident electron beam and forms a line focused image on the energy selection slit. The lower Wien-filter cancels out the energy dispersion of the upper filter and forms a round shaped electron beam at the exit of the monochromator. It should be noted that each filter can generate a quadrupole field to control the beam shape.

Figure 2 shows the zero-loss peak profiles for different energy-selection settings. A peak width of 0.71 eV was obtained without energy selection. The other two were obtained different widths of the energy selection slit. The best energy resolution is 0.19eV at present. The beam current of the profile for a 0.19 eV energy width is about 1/10 of that of the profile of 0.71 eV.

Figure 3 shows beam shapes (lower) and their intensity profiles (upper) at the specimen position. The beam shapes were obtained by applying a quadrupole E-field in the second Wien-filter. The beam shape of Fig.3(a) was obtained without energy selection. The beam does not show a circular shape, which is due to imperfect setting of the quadrupole correction field. Figure 3(b) shows a circular beam shape of less than 1 nm in diameter obtained at an energy selection setting of 0.26 eV. Detailed results will be reported at the meeting.

The present study is supported by the project "Technology Transfer D98-04" of Japan Science and Technology Corporation.

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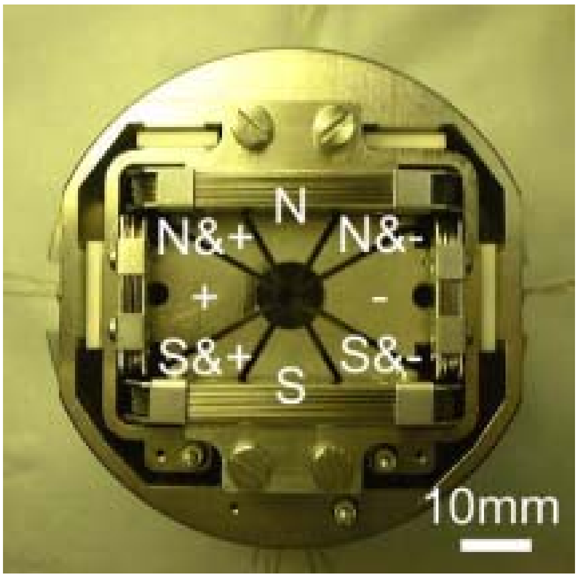

Figure 1. Octopole-type Wien filter.

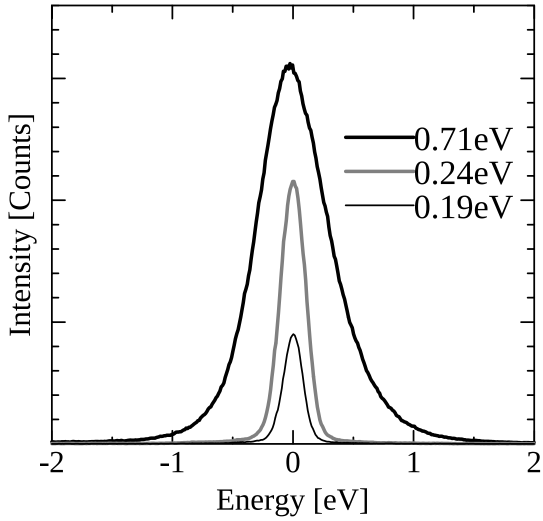

Figure 2. Zero-loss peak profiles for different energy-selection settings.

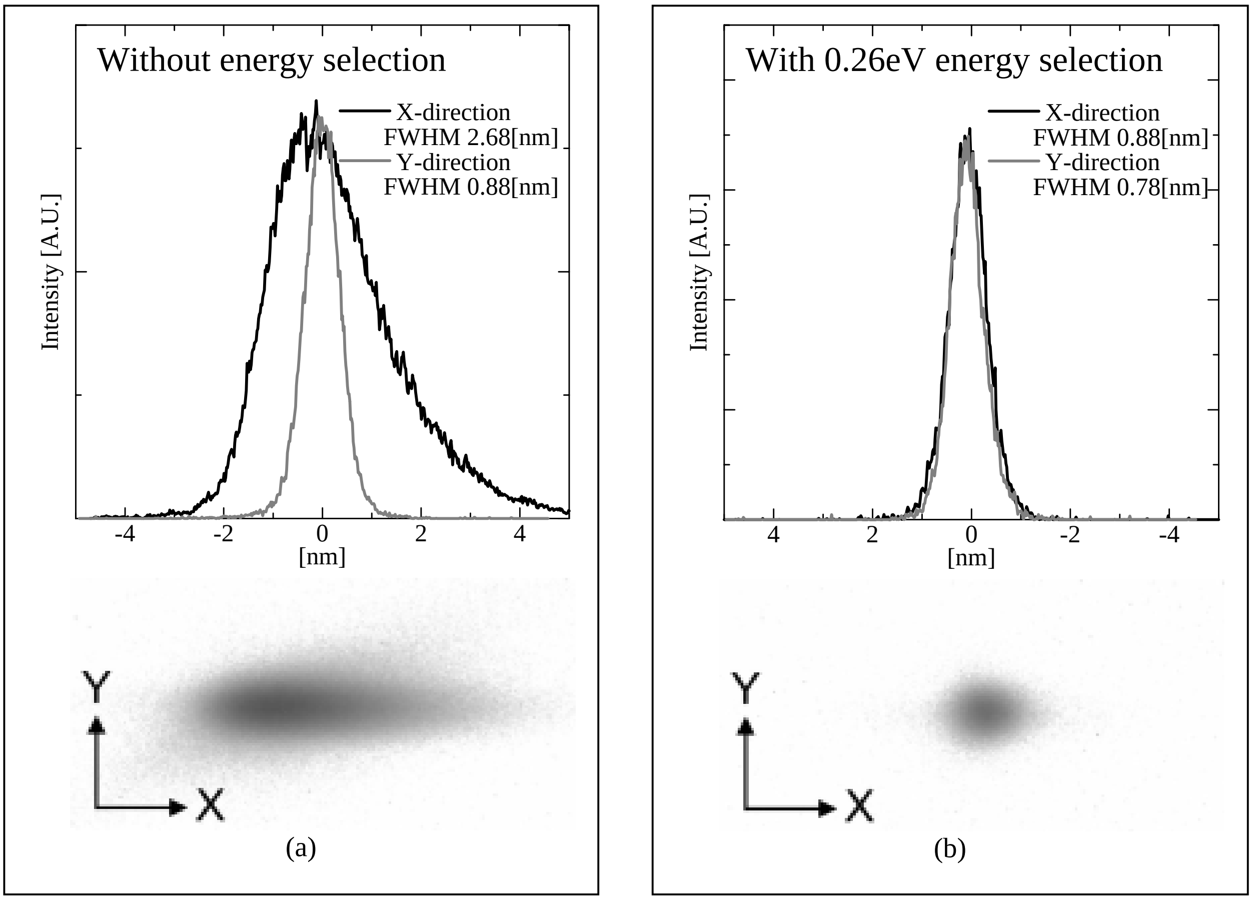

Figure 3. Beam shapes at the specimen position (lower) and its intensity profiles (upper). (a) was obtained without energy selection. (b) a circular beam has a width of less than 1 nm. The beam was obtained with an energy selection setting of 0.26 eV.

https://doi.org/10.1017/S1431927603444772 Published online by Cambridge University Press