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Development of An 0.2eV Energy Resolution Analytical Electron Microscope

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We developed a high energy-resolution electron energy-loss spectroscopy (EELS) microscope (JEM-HREA80) to investigate detailed electronic structures of materials [1,2]. The microscope is equipped with an octapole-type Wien-filter monochromator and analyzer. The energy and spatial resolutions were 50meV-0.2eV and 30-100nm in diameter, respectively. On the other hand, we developed an Ω-filter electron microscope (JEM-2010FEF), which enables us to perform precise crystal structure refinement in a sub-nanometer scale using the CBED method [3,4]. Since it does not have a monochromator, its energy resolution of EELS spectra remains at about 1eV, which is not sufficient for the detailed study of electronic structures of materials.

We have started to manufacture a new 200kV electron microscope under a project "MIRAI-21", which enables us to investigate both crystal- and electronic-structures of advanced materials in nanometer scale areas [5]. MIRAI means "Future" in Japanese and the abbreviation of Microscope for Innovative Research and Advanced Investigation. The microscope has a point resolution of 0.19nm and an energy resolution of 0.2eV at a less than 2nm diameter probe. In this paper, the basic design of the microscope and the test result of the monochromator are reported.

Figure 1 shows the appearance of the MIRAI-21 microscope. 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 monochromator is located between the extraction anode for the ZrO/W emitter and the acceleration tube. The monochromator consists of two octapole-type Wien-filters (Fig.2) and an energy-selection slit, which exists between the two filters. . Astigmatic focus is used to reduce the Boersch effect, as shown in Fig. 3. The filter 1 (WF1) disperses the incident electron beam and forms a line-focused image on the energy selection slit. The filter 2 (WF2) cancels out the energy dispersion of WF1 and forms a stigmatic electron beam at the exit of the monochromator.

The basic performance of the monochromator was tested using a remodeled 120kV-type electron microscope with a LaB_6 filament. Figure 4(a) shows the astigmatic beam shape, which elongated in the direction, perpendicular to the energy-dispersion direction at the energy-dispersion plane (the slit position). The electron beam energy ingoing to the monochromator was 800eV. The electron beam was shifted about 70μm by a 4eV change of the electron-beam energy. Thus, the energy dispersion was about 17μm/eV. Figure 4(b) shows the electron-beam shape at the exit of the monochromator under the same incident beam condition as Fig.4 (a). It should be noted that the beam has an almost round shape.

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References
[1] M. Terauchi, M. Tanaka, K. Tsuno and M. Ishida: J. Microscopy, 194 (1999) 203.
[2] M. Terauchi and M. Tanaka: J. Surface Analysis, 3 (1997) 240.
[3] M. Tanaka et al.: J. Microscopy, 194 (1999) 219.
[4] K. Tsuda and M. Tanaka: Acta Cryst., A55 (1999) 939.
[5] M. Tanaka et al.: Inst. Phys. Conf. Ser., 165 (2000) 217.

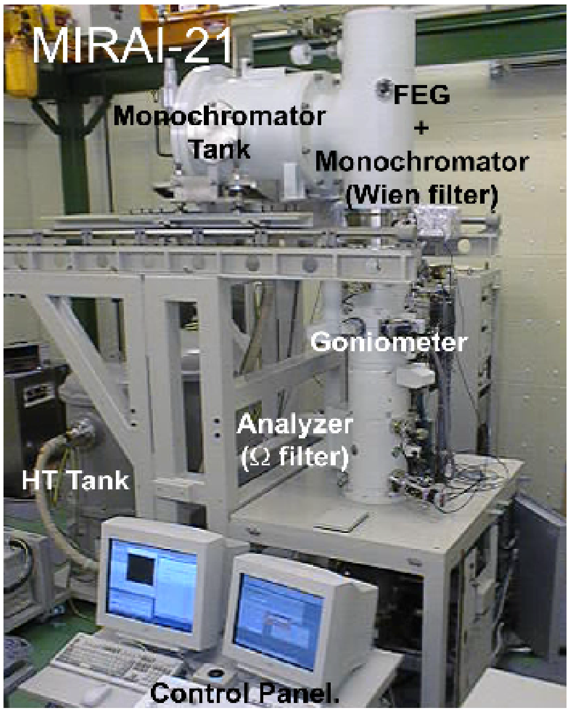

FIG. 1. Appearance of MIRAI-21

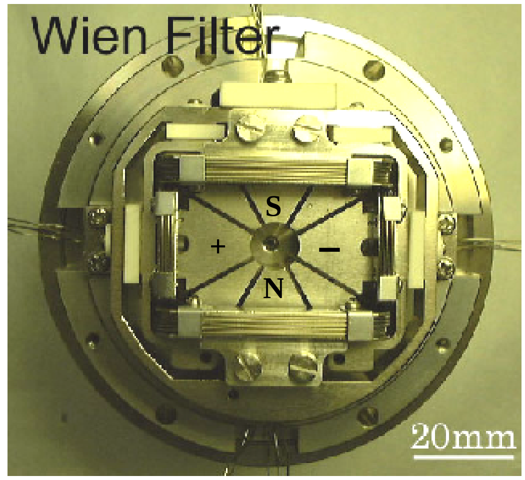

FIG. 2. Octapole-type Wien filter

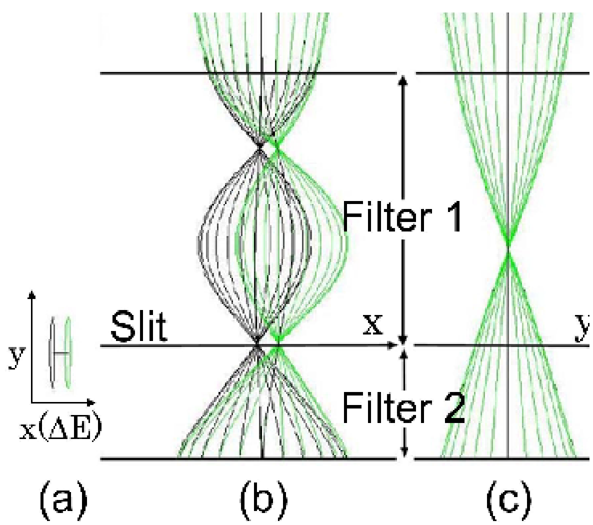

FIG. 3. (a) Beam shape on the slit. (b) Ray-path in dispersion direction (X-Z). (c) Ray-path in non-dispersion direction (Y-Z).

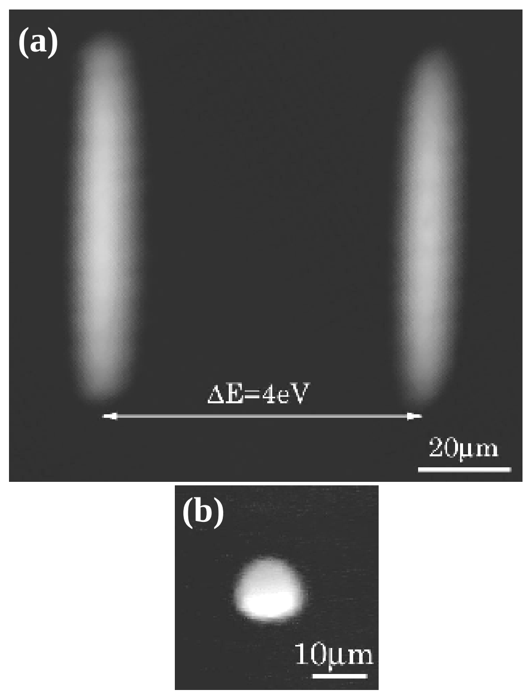

FIG. 4. (a) Astigmatic beam shape on the slit with an energy dispersion of about 17 μm/eV. (b) Stigmatic beam shape at the exit of the monochromator.

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