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Development of a 200kV atomic resolution analytical electron microscope

Isamu Ishikawa, Eiji Okunishi, Hidetaka Sawada, Yoshihiro Okura, Kazuya Yamazaki, Takaki Ishikawa, Motoharu Kawazu, Madoka Hori, Mitsuhisa Terao, Masahiko Kanno, Shinichi Tanba and Yukihito Kondo

JEOL, Ltd., 1-2 Musashino 3-chome, Akishima, Tokyo 196-8558, Japan.

The spatial resolution of the transmission electron microscope has been dramatically improved by the development of the spherical aberration corrector. Especially the STEM (scanning transmission electron microscope) Cs corrector improved the probe current by one or more figures. As a result, the transmission electron microscope equipped with a STEM Cs corrector has allowed us electron energy-loss spectroscopy (EELS) and energy-dispersion X-ray spectroscopy (EDS) with an atomic resolution at high speed [1,2,3].

We have aimed to improve the analysis performance of EELS and EDS of the transmission electron microscope equipped with a Schottky type electron gun and a STEM Cs corrector. We have developed a new atomic resolution analytical electron microscope JEM-ARM200F [Fig.1] by improving the mechanical stability and the electrical stability. The present paper reports the basic performance of the microscope and application results of high-resolution observations and atomic resolution elemental mappings.

For atomic resolution analysis, it is necessary to improve the mechanical stability and electrical stability if the spherical aberration correction is applied. Mechanical vibrations of the microscope were reduced by optimizing the design of the column and the base frame using the finite element method. Furthermore, in order to suppress the influences of the external magnetic field, temperature change, air flow, sound noise, etc., the column is equipped with a heat insulation shield and a magnetic shield and is covered with a mechanical cover, as shown in Fig.1. Electrically, the accelerating voltage stability and the objective lens current stability were improved about two times the values of our former conventional instruments. Furthermore, the deflector stability was also improved about two times so as to hold atomic resolution of the atomic resolution analysis.

A high-angle annular dark-field (HAADF) image of Fig.2 shows an 0.078nm dumbbell image of Si[112], which was taken by a JEM-ARM200F with the STEM Cs corrector. These image were obtained with a 10pA probe current. Figure 3 shows EELS maps of $SrTiO_3$. These images were obtained with a probe current of 150pA and an acquisition time of 0.03 second per pixel, total acquisition time being 3.5 minutes. The thickness of the specimen was estimated to be 24nm from a thickness measurement by EELS. (A) shows a HAADF image acquired simultaneously with the EELS spectra. The atomic position can be clearly seen. (B) shows the element map by an RGB display. (C), (D) and (E) show strontium, titanium and oxygen maps. Each atom position can be seen definitely.

We have succeeded in fully bringing out the ability of the STEM Cs corrector using the newly developed platform. We believe that this microscope provides a powerful tool in the researches of materials science.

References

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Fig.1 JEM-ARM200F with STEM Cs corrector

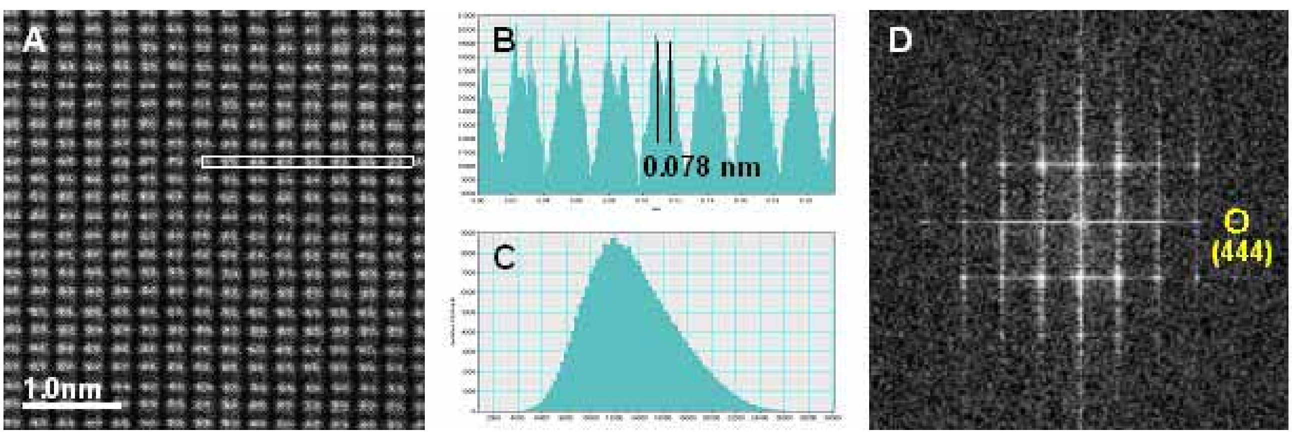

Fig.2 A) High-angle annular dark-field image of Si [112] taken by JEM-200F with STEM Cs Corrector. B) Line profile of the white square area of A (Raw data). C) Histgram of intensity in A, the horizontal and vertical axes being intensity and number of pixels. D) Fourier transform of image A, the lattice spacing of (444) being 0.078nm.

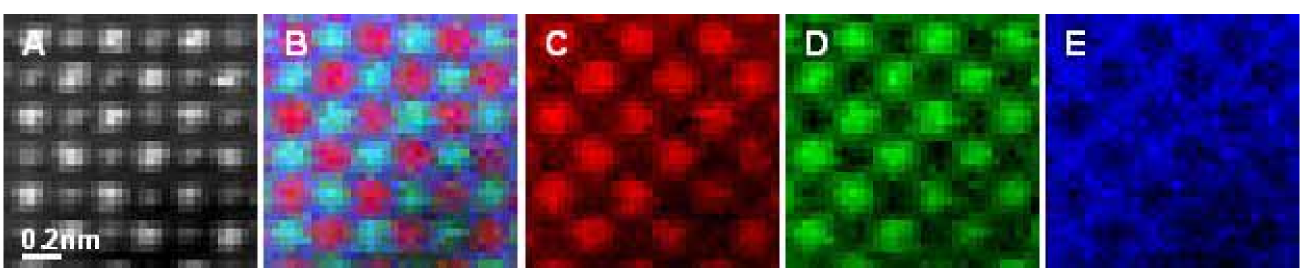

Fig.3 EELS maps of $SrTiO_3$ obtained by JEM-ARM200F with STEM Cs Corrector. A) HAADF image acquired simultaneously with EELS signal. B) EELS map with an RGB display. C) Sr-M map, D) Ti-L map and E) O-K map.
These images were taken at a probe current of 150pA with an acquisition time of 0.03 second per pixel, total acquisition time being 3.5min with the use of drift compensation. The images are shoen with 32 x 32 pixels.

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