

Characterization of Aberration-Corrected Lorentz TEM Applying a Magnetic Field with Objective Lens

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Lorentz microscopy is one of the powerful observation methods without the influence of magnetic field from the objective lens (OL) of a transmission electron microscope (TEM). Normally, the magnetic field around the TEM specimen is about 2T. This field could affect the observation of magnetic material. To avoid the influence, OL is turned off and the lens under the OL is used as focus lens, where it is called an objective mini-lens (OM) in JEOL instrument. We can use the OL to apply some amount of magnetic field to samples in Lorentz microscopy [1]. Recently, the spherical aberration correction was applied to Lorentz microscopy, the resolution was improved [2]. In addition, the applied magnetic field with OL is possible with spherical aberration correction. In this research, we characterized the detailed capabilities of spherical aberration-corrected Lorentz TEM while applying magnetic field by the OL.

In this time, JEM-ARM300F2 with TEM spherical aberration corrector was used. The pole-piece was wide gap pole-piece. The TEM resolutions with / without spherical aberration correction were investigated in 300kV. The varied resolution with applying the magnetic field and the field of view were also measured at that time. The aberration measurement was done by diffractogram tableau method. The correction area was about 4mrad and the third order spherical aberration coefficient of OM was under 10mm.

The Young's fringe test was performed to check the TEM resolution. The resolution without spherical aberration correction was 1.83nm without applying the magnetic field, 1.75nm with 0.5T and 1.61nm with 1T. On the other hand, they were improved with spherical aberration correction. 0.76nm, 0.67nm and 0.58nm with 0T, 0.5T and 1T were achieved. The effective field of view (FOV) was changed as applying magnetic field with objective lens. FOV was decreased as a function of the applied magnetic field. They were measured to be 200 μ m with 0.3T, and 20 μ m with 1T. This limitation was occurred by replicating of electron beam. The replicating was caused by the aberration of imaging system. On the other hand, the ratios of magnification were increased 6% with 0.5T and 45% with 1T.

The principal plane of complex lens was getting closer to the sample plane as applying magnetic field. The complex lens was formed by OM and OL. This

lens improved the spatial resolution, and this result showed the resolution was limited by the chromatic aberration.

We have addressed making a setting of aberration-corrected Lorentz TEM imaging mode. The TEM resolution was improved by spherical aberration correction of OM. Additionally, applying the magnetic field by the OL, the resolution was also slightly improved. The magnification and FOV were changed as a function of applied magnetic field. In the presentation, which condition could be the better for imaging a magnetic sample will be discussed.

Graphic:

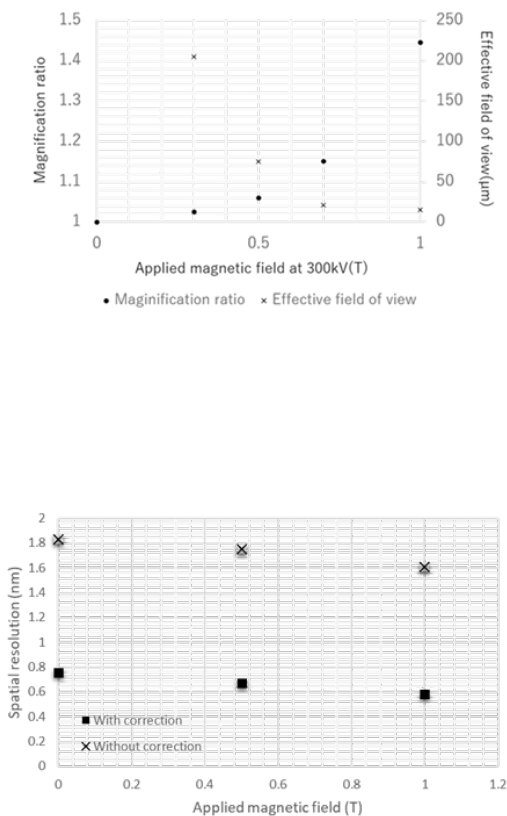


Figure 2. Variation of spatial resolution applying the magnetic field. Acceleration voltage was 300kV. The resolution was improved as applying OL in the both cases of with correction and without correction.

Keywords:

Lorentz, Aberration correction, Magnetic field

Reference:

- [1] Xiuzhen Yu et al, JEOL NEWS 50, 2-10(2015).
- [2] Takuro Nagai et al, PHYSICAL REVIEW B 96,100405(2017)