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Development of a wideband multilayer grating with a new layer structure for a flat-field spectrometer attached to transmission electron microscopes in the 2-4 keV range

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Introduction

We have been developing a compact wavelength-dispersive soft x-ray emission spectrometer to be able to attach to electron microscopes. Soft X-ray emission spectroscopy combined with transmission electron microscopy (TEM-SXES) should be a hopeful method to reveal both physical properties and chemical-bonding states of identified small specimen areas of various compounds. Original TEM-SXES instruments, which had been developed in our previous study, can detect soft x-ray emission (SXE) spectra of the 60-2000 eV range.[1)] However it is necessary to develop a new SXES instrument that covers a much wider energy range in materials science, space science, industry, etc. It is of importance to detect and analyze SXE spectra between 2 keV and 4 keV, e.g., Pt-*M* (2.05 keV), In-*L* (2.84 keV) and Te-*L* (3.77 keV) emission bands. Observation of the SXE spectra in this energy range needs a multilayer grating because in which a typical grating with the gold coating is no longer practical. A conventional multilayer grating has high diffraction efficiency but narrow band in energy at a fixed angle of incidence. This indicates that the SXES instrument should employ a mechanism for wavelength scanning to cover the required energy range. It is unsuitable for the spectrograph to attach to electron microscopes. To overcome this problem, we have invented a new multilayer structure that enables to uniformly enhance the reflectivity in a few keV energy range at a fixed angle of incidence.[2)]

Experimental and results

A new layer structure to uniformly enhance the reflectivity consists of W and B_4C. It was fabricated on the surface of a newly designed holographic laminar-type varied-line-spacing master grating by an ion-beam sputtering method. The master grating was fabricated by Shimadzu Corp., whose designated parameters were as follows: curvature radius 11,200 mm; effective grating constant 1/2400 mm; groove depth 2.8 nm; duty ratio of the grooves (land/grating constant) 0.5.[2)]

The experiments were carried out at BL-11B of PF using a newly developed evaluation apparatus for measurement of reflectivity and/or diffraction efficiency of optical elements.[2)]

Figure 1 shows the measured and calculated diffraction efficiencies of the first diffraction order of the multilayer grating (MLG) with the new layer structure at a fixed angle of incidence of 88.65° in the energy region of 2.1-4.0 keV. The diffraction efficiency of the new MLG is over 1 % in the 2.1-3.8 keV range, whose average and standard deviation are estimated to be 1.8% and 0.6%, respectively. It has been revealed that the new MLG shows good performance compared with the Au-coated grating, is obviously effective to uniformly enhance the diffraction efficiency, and works practically in the 2-4 keV region.

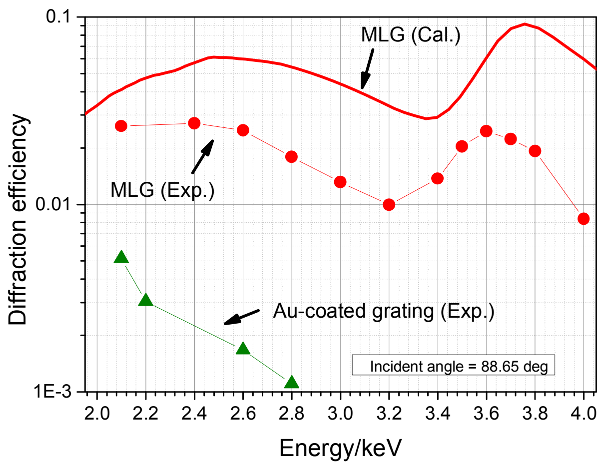

Figure 1 Measured and calculated diffraction efficiencies of first order light of the new MLG at a fixed angle of incidence of 88.65°, as a function of the incident photon energy. For the comparison, the measured efficiency of the Au-coated grating at the same incident angle is also shown.

References

[1] M. Terauchi, M. Koike, K. Fukushima, and A. Kimura, J. Electr. Microsc., 59, 251-261 (2010).
[2] T. Imazono et al., to be published elsewhere.

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