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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 (II)

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1 Introduction

Soft X-ray emission spectroscopy combined with transmission electron microscopy (TEM-SXES) is a helpful technique to understand both the physical property and chemical-bonding state of identified specimens in nanoscale. Original TEM-SXES instruments can detect soft x-ray emission (SXE) spectra in the 60-2000 eV range.[1] It is important to develop a SXES instrument to be able to cover a much wider energy range from 50 eV to 4000 eV. [2] It is because it is required to detect and analyze SXE spectra such as Li-*K* (55 eV), Pt-*M* (2.05 keV), In-*L* (2.84 keV) and Te-*L* (3.77 keV) emission bands in the fields of science, industry, etc. Unfortunately, it is difficult to observe 2-4 keV x-rays using a spectrograph equipped with a conventional grating with gold coating because such gratings are no longer practical due to Au-*M* resonant absorption. It is known that multilayer gratings are useful in higher energy region than ~2 keV. A conventional multilayer grating has high diffraction efficiency but narrow band in energy if it is used at a fixed angle of incidence. This indicates that the SXES instrument should employ some mechanisms for wavelength scanning to cover the required energy range. It is unsuitable as the spectrograph for TEM instruments. To overcome this problem, we have invented a new multilayer structure consisting of W and B_4C layers that enables to uniformly enhance the reflectivity in a few keV energy range at a fixed angle of incidence. [3]

We previously reported the diffraction efficiency of a multilayer grating in 2-4 keV, which the new layer structure was deposited on the gold-coated surface of a laminar-type varied-line-spacing (VLS) holographic master grating (M-MLG$_N$). [4] Here, we describe the diffraction efficiency of the identical multilayer-coated replica grating (R-MLG$_N$), and show that it works as the wideband multilayer grating along with M-MLG$_N$.

2 Experiment and Results

We prepared two replica gratings fabricated from the identical laminar-type VLS master grating having the radius of curvature of 11,200 mm, an average groove density of 2400 lines/mm, a 2.8 nm groove depth, and a 0.5 duty ratio, where all were produced holographically by Shimadzu Corp. The wideband multilayer was deposited on the gold-coated surface of one replica grating (R-MLG$_N$) by an ion-beam sputtering method. The other was left as just an Au-coated grating (R-AG) to compare the diffraction efficiencies. The layer structure on R-MLG$_N$ was evaluated by an x-ray diffraction profile and confirmed to be as designed.

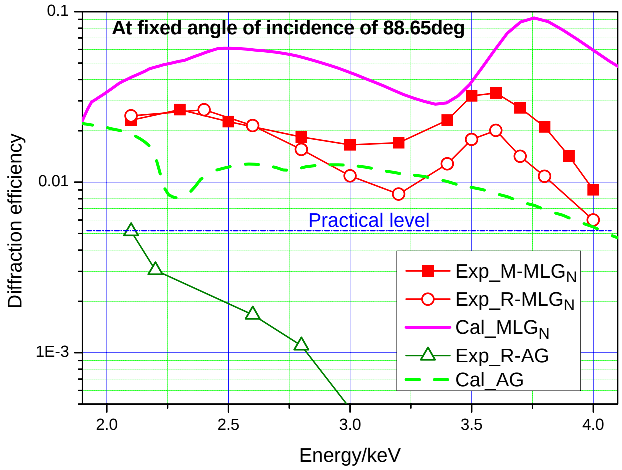

Figure 1 Experimental diffraction efficiencies of M-MLG$_N$, R-MLG$_N$, and R-AG at 88.65° in 2.1-4.0 keV. The calculated results are also shown.

The experiments were carried out at BL-11B using an original evaluation apparatus for diffractometry and reflectometry. [4] Figure 1 shows the experimental diffraction efficiencies of M-MLG$_N$, R-MLG$_N$, and R-AG at a fixed angle of incidence of 88.65° in the energy region of 2.1-4.0 keV. Both M-MLG$_N$ and R-MLG$_N$ show wideband diffraction efficiencies and much higher than that of R-AG. They are also the higher efficiencies over the whole energy region than the practical level indicating as the efficiency at around the threshold of typical gold-coated gratings. The new multilayer scheme we have invented is obviously effective to uniformly enhance the diffraction efficiencies at fixed incident angle in 2-4 keV.

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References

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