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Tender X-ray multilayers for high throughput grating monochromators

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1 Introduction

The structure of proteins and organelles have been investigated by hard and soft X-rays, respectively, and there is a growing interest in their functions in bio cells. It means that the visualization technology of the distribution of the trace elements such as Si, P, and S is demanded and that development of high throughput monochromators working in the tender X-ray region where the *K* shell energies of those elements exist is an important issue. A possibility that a diffraction grating coated with a periodic multilayer can have high diffraction efficiency through 1–8 keV was demonstrated [1], while there was not a suitable monochromator of the varied deviation angle type matching with a narrow band multilayered diffraction grating. Authors have found that the Suzuki type varied deviation angle monochromator [2] matches a multilayered diffraction grating well and have a plan to build a Suzuki type tender X-ray monochromator employing a multilayered diffraction grating.

In the present study, multilayer reflectance were measured in 1–8 keV region, on the assumption that high reflectance multilayers deposited on mirror substrates can enhance diffraction efficiency when deposited on grating substrates. W/C, W/Si, Re/C and Re/Si were chosen as candidate materials.

2 Experiments

W/C, W/Si, Re/C and Re/Si multilayers were deposited on Si wafers by ion beam sputtering method. Period number, period thickness and thickness ratio (heavy material layer thickness/period thickness) were 20, ~6.3 nm and 0.5, respectively, for all samples.

Reflectance measurements were performed at BL-11D and BL-20B beamlines at the Photon Factory, and at a laboratory X-ray diffractometer at Tohoku University, in 1-1.5 keV, 5-6 keV and 8.04 kV regions, respectively.

1.5 keV monochromatized beam with low energy contamination supplied by the grating monochromator at BL-11D was filtered through a 12 μm thick Al foil.

The third and fourth order diffraction contamination of the double crystal monochromator at BL-20B were analyzed by the multilayer reflectometry. A W/B_4C multilayer with a period thickness of 2.11 nm and a period number of 60 was used. Figure 1 shows the measured reflectance at 5 keV with a vacuum path to minimize the optical path length in air (~200 mm). Reflection signals due to the third and fourth order diffraction were observed. Through a quantitative analysis of the reflectance [3], spectral purity was obtained and measured reflectances shown below were corrected to those for pure 5 keV light. Similar analysis procedure was performed at 6 keV, where the vacuum path was not used.

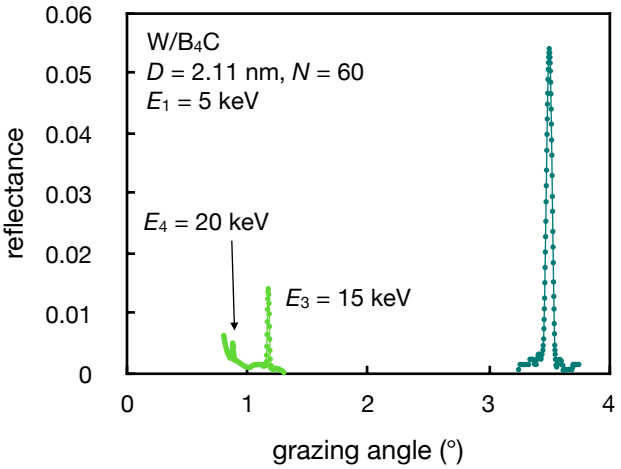

Fig. 1: Measured reflectance of a short period W/B_4C multilayer at 5 keV at BL-20B.

3 Results and Discussion

Measured reflectances are plotted in Figs. 2–5. All the samples showed a high performance. Re/C was the best among the present samples.

Reflectance measurements of W/B_4C and Re/B_4C, which are also candidate materials for a high reflectance mirror are being performed. Then, deposition of multilayers of highest reflectances on 3200 *lines*/mm diffraction grating substrates and evaluation of them are planed.

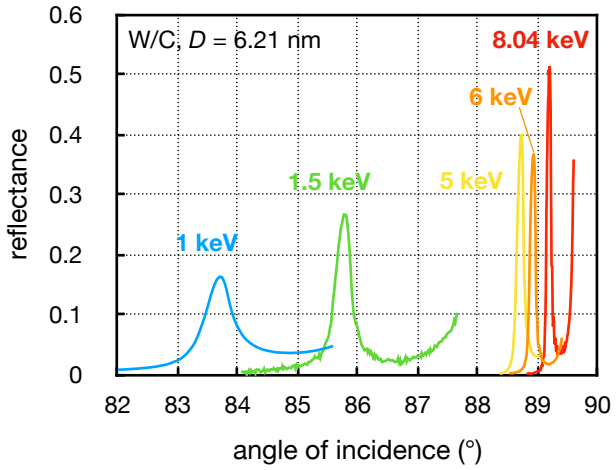

Fig. 2: Measured reflectance of a W/C multilayer.

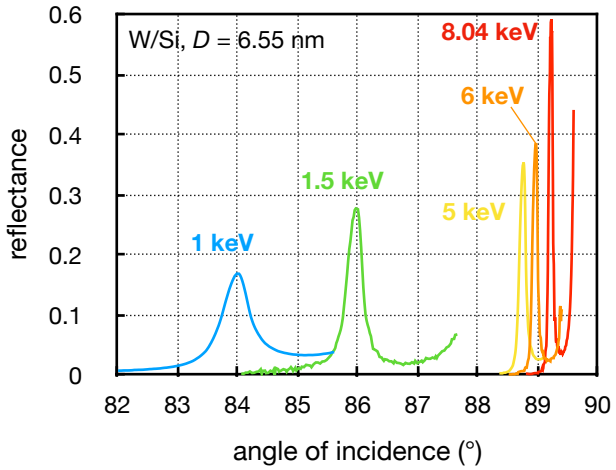

Fig. 3: Measured reflectance of a W/Si multilayer.

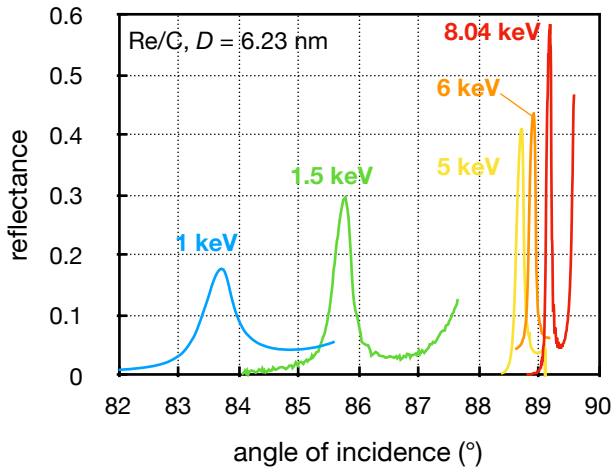

Fig. 4: Measured reflectance of a Re/C multilayer.

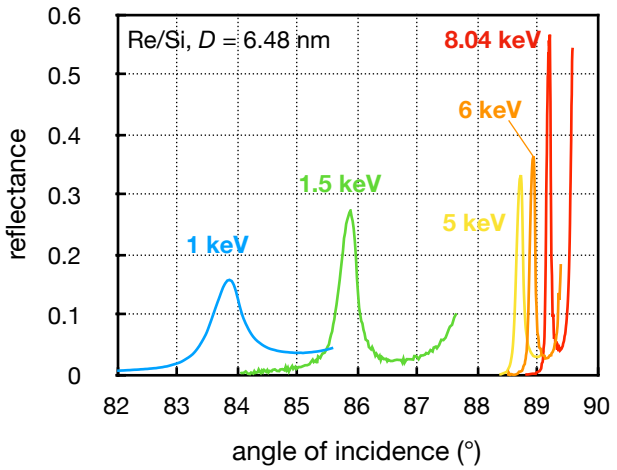

Fig. 5: Measured reflectance of a Re/Si multilayer.

Acknowledgement

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References

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