X-ray focusing polychromator using elliptically curved, laterally graded multilayers

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X-ray multilayers working as a focusing polychromator have been developed. The multilayer structure is laterally graded so that the X-ray energy changes approximately linearly to position on the mirror. The energy range was designed to be 5–33 keV. With a slight bent of the multilayer mirror, reflected polychromatic X-rays focus onto the specimen and diverge downstream. Since the relation between direction and energy is fixed, the intensity distribution measured by a CCD camera gives spectroscopic data. A multilayer focusing polychromator enables independent designs of the focal length and the spectral dispersion, which is a great advantage compared to a focusing polychromator using a curved crystal [1].

The designed mirror shape as an X-ray focusing mirror is an ellipse as illustrated in Fig. 1. Synchrotron radiation sources are assumed. The distances from the source to the mirror and from the mirror to the specimen are 30 m and 0.7 m, respectively. The grazing angle is 0.9°. The mirror size is 0.6 m. The distance between the downstream end of the mirror and the specimen is 0.4 m, which is enough large for large equipments such as a trough of a liquid sample. A Cu block was polished into a base plate of the elliptical shape to clamp multilayer-coated Si wafers.

Laterally graded multilayers were deposited by our ion beam sputtering deposition apparatus equipped with a programmable shuttering system [2]. Figure 2 shows the geometry of the moving shutter making a thickness gradient. Because of the substrate size limitation of our deposition system, the designed 0.6 m long substrate was divided into four 150 mm long segments. Figure 2 drawing a whole substrate is just ideal. Material combinations of SiC/C and V/C were chosen to obtain high reflectance and high spectral resolution below and above 12 keV, respectively. Thus, we deposited a SiC/C and three V/C multilayers on each 150 mm long, 0.7 mm thick Si wafers for 5−12, 12−19, 19−26 and 26−33 keV, respectively.

The multilayer focusing polychromator was applied to X-ray specular reflectometry [3]. Recently time-resolved measurements were performed on a specimen at an air/water interface [4].

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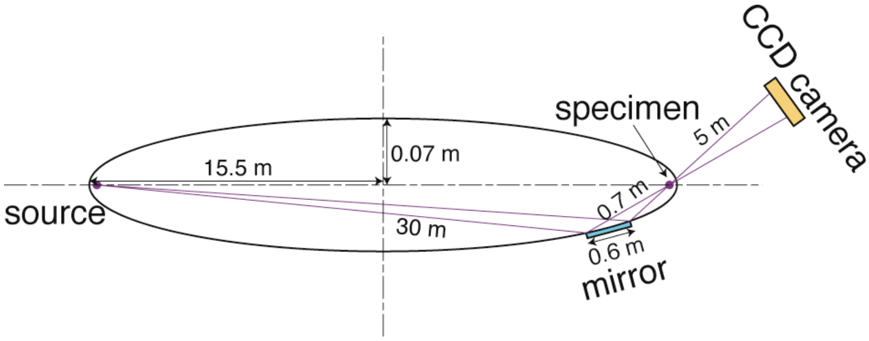

Fig. 1. Design of an elliptic focusing mirror.

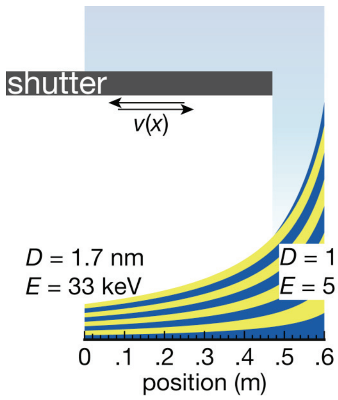

Fig. 2. Multilayer deposition using a moving shutter.