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Cr/Sc/Mo multilayer reflectors for water window condenser application

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1 Introduction

Laboratory scale soft X-ray microscopes have been realized by developments of laser produced plasma sources and multilayer optics. Especially microscopy in the water window region between *K*-absorption edges of C and O enables living cell observation at 10 nm order resolution. Recently unresolved transition arrays of highly charged ions of high-*Z* elements such as Au, Pb and Bi are proposed as water window soft X-ray sources [1]. To make enough use of spectrally integrated high power of high-*Z* plasmas, condenser mirrors of high reflectance and wide reflection band, as well as high numerical aperture are required [2]. In this study, grazing incidence multilayer reflector for Bi plasma emission around 310 eV has been developed. A fewer layer number and consequently wider reflection band have been realized with a stacked Cr/Sc/Mo tri-layer structure compared to conventional Cr/Sc bi-layers.

2 Multilayer Design

In optical design of multilayers reflecting 310 eV soft X-rays, Sc is an excellent material because of its low absorption. Figure 1 shows optical constants of several materials frequently used in soft X-ray multilayer fabrication. Cr has also low *k* and large *n* difference from Sc. High reflectance normal incidence Cr/Sc multilayers have been reported [3]. In addition to the stacked bi-layer model, stacked tri- or more layer structure including thin high-*k* layers were proposed to achieve high reflectance with fewer periodic number [4]. For 310 eV soft X-rays, Mo was chosen as the third material because a large triangle formed from Mo, Cr and Sc in *nk*-plane implies fast reflectance growth. Mo layer thickness was limited to 1.4 nm in the optical design because island structure in the early part of Mo thin film growth process up to a 1.4 nm has been reported [5].

Designed multilayer is Cr (3.6 nm)/ Sc (4.8 nm)/Mo (1.4 nm) 10 tri-layer terminated by 11th Cr layer. The cross sectional view is illustrated in Fig. 2. Calculated reflectance is shown in Fig. 3. A peak reflectance similar to Cr (3.7 nm)/Sc (6.2 nm) 20 bi-layer and a wider reflection band than Cr/Sc 10 bi-layer are expected.

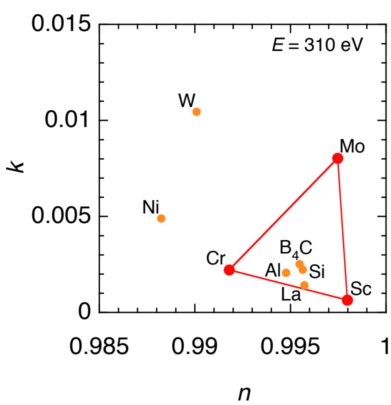

Fig. 1: Optical constants of several materials at 310 eV.

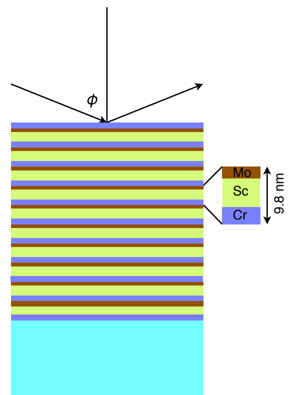

Fig. 2: Cross sectional view of the designed multilayer.

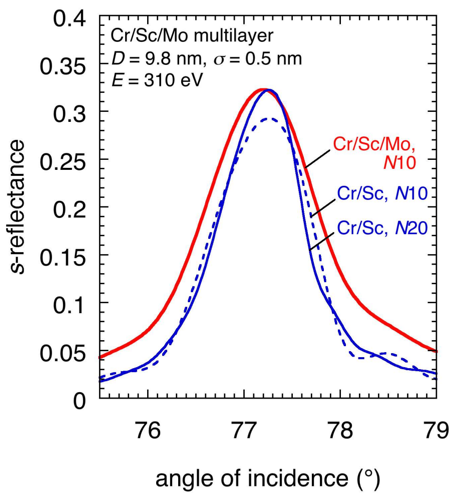

Fig. 3: Designed reflectances of Cr/Sc/Mo and Cr/Sc multilayers.

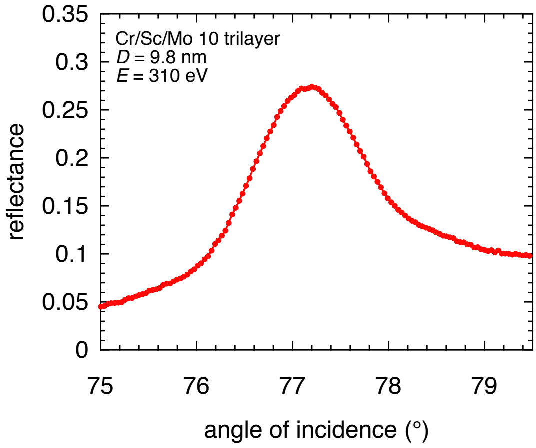

Fig. 4: Measured reflectance of a Cr/Sc/Mo multilayer.

2 Experiments and Results

Cr/Sc/Mo 10 tri-layers were deposited on Si wafers by ion beam sputtering. Reflectances were measured at BL-11D, the Photon Factory. Results are shown in Fig. 4. The peak angle and the band width agreed with expectation. The peak reflectance was 27.4%, which is high enough for the practical use. Deposition of multilayers of the present design to condenser mirror substrates for soft-X-ray microscope is being planned.

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