Interface engineering method for ultra-thin Cr/Ti soft x-ray multilayer

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Abstract: Cr/Ti multilayers are one of the suitable candidates in the "water window" wavelength range (2.4–4.4 nm) because the theoretical near-normal incidence reflectivity is as high as 64% at wavelengths just above the Ti 2*p* edge (2.73 nm). However the reported reflectivity of real Cr/Ti multilayers at near-incidence angles is lower than 3%.[1] The large disparity between the theoretical and the measured reflectivity is caused by several physical limitations, among which the most important is the extreme sensitivity to interfacial imperfections for the ultra-short periods (Λ~1.4 nm) used. Recently, there has been a huge effort to develop techniques that can reduce the interface width of multilayers. One recent attempt involved the intentional incorporation of light-element impurities such as N into multilayers. It has been shown that the incorporation of N in Cr/Sc[2] or B_4C/La[3] multilayers can form nonstoichiometric nitride multilayers with reduced inter-diffusion or reaction between the constituent layers and leads to major improvements in the soft x-ray reflectivity. Concerning Cr/Ti multilayers, B or C is a better choice than N because of the stronger absorption of N in the applicable wavelength range of Cr/Ti multilayers, which is slightly lower than the N *K* edge (3.02 nm). In this work, we intentionally incorporated B and C into ultra-thin Cr/Ti soft x-ray multilayers by co-deposition of B_4C at the interfaces during DC magnetron sputtering deposition. The effect on the multilayer structure and composition has been investigated using x-ray reflectometry, x-ray photoelectron spectroscopy, and cross-section electron microscopy. The B and C is mainly bonded to Ti sites, forming a nonstoichiometric TiB_xC_y composition, which hinders the diffusion of Cr into the Ti layers and dramatically improves the interface quality of Cr/TiB_xC_y multilayers. As a result, the near-normal incidence soft x-ray reflectivity increases from 4.48% to 15.75% at wavelength of 2.73 nm.

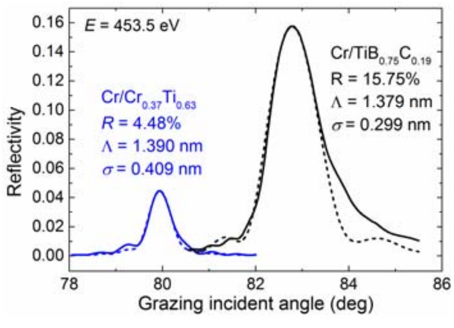

Fig. 1. Soft x-ray reflectivity from the Cr/Ti multilayers with and without B_4C.

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