Characterization of Cr/Sc multilayers by XRR and XRF enhanced by x-ray standing waves

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Summary

We characterize Cr/Sc multilayer mirror and several derivative systems designed to work in water window range using x-ray reflectivity (XRR) and x-ray fluorescence (XRF) enhanced by x-ray standing waves. Experiments were performed at soft x-ray at the BEAR beamline of the Elettra synchrotron facility in Italy. Samples differ by elements present within the stack, thickness and order of deposition. Structural information of the multilayers is revealed by comparing the experimental data with simulations [1-2]. Performances of the different systems are compared.

Experiments and results

The Cr/Sc multilayers [3] were fabricated by sputtering deposition. We made derivative samples by adding B_4C barrier layers [4] or by replacing Cr by CrN hoping nitrogen would lower the inter-diffusion extent [5,6]. A better optical performance is expected for the derivative systems. The following table gives the aimed structure of the multilayers.

Sample	Structure	Period	Cr	Sc	B4C
MP14082	$[Cr/Sc]_{100}$ + B_4C cap	1.6	0.6	1.0	/
MP15005	$[B_4C/Cr/Sc]_{100}$ + B_4C cap	1.9	0.6	1.0	0.3
MP15007	$[Cr/B_4C/Sc]_{100}$ + B_4C cap	2.2	0.6	1.0	0.6
MP15008	$[B_4C/Cr/Sc]_{100}$ + B_4C cap	2.2	0.6	1.0	0.6
MP15009	$[B_4C/Cr/Sc]_{100}$ + B_4C cap	2.5	0.6	1.0	0.9
MP15013	$[CrN/Sc]_{100}$ + B_4C cap	1.6	0.6(CrN)	1.0	/

Both XRR and XRF are measured for each sample. Figure 1 shows the reflectivity (θ-2θ measurement) of all samples with incident beam energy at 395eV, which is the working energy the mirror is designed for. The energy of the incident beam for XRF is determined by x-ray absorption spectroscopy through total electron yield measurement around Cr $L_{2,3}$ edge. To perform the XRF induced by standing waves, we scan the intensity of the Cr Lα emission while rotating the multilayer around the first diffraction order. Figure 2 gives an example of our experimental results along with the corresponding simulation for a multilayer with perfect interfaces. For the simulations, densities of different layers are taken from IMD database and refractive indexes are from CRXO online database. In the simulations we will have to vary the variables such as thickness of each layer in the stack, roughness, inter-diffusion extent and the optical constants of the involved materials to create theoretical curves to fit the experimental curves. This fitting work is in progress.

Preliminary results indicate a better performance of derivative systems over the original Cr/Sc system. Comparisons also suggest a preference of Cr/B_4C/Sc system over B_4C/Cr/Sc system. Nitrogen is believed to have a positive contribution of preventing the inter-diffusion and maintaining the interfaces relatively sharp.

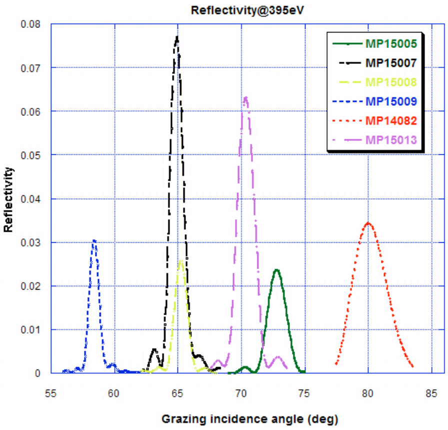

Figure 1: XRR of all samples at incident beam energy 395eV.

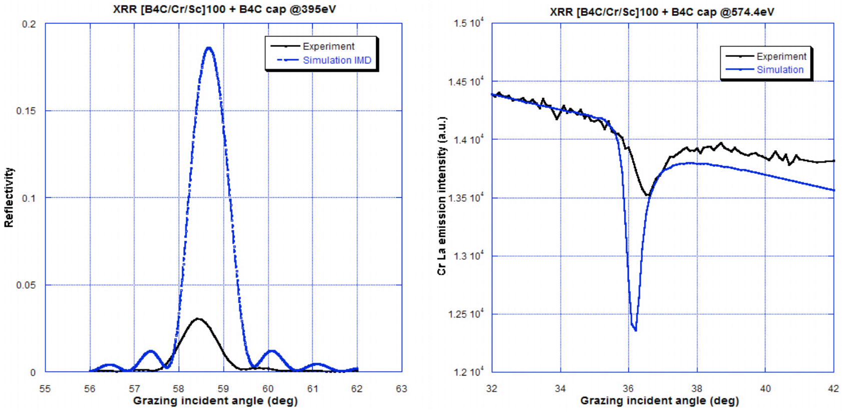

Figure 2: XRR (left) and XRF (right) of Cr Lα of $[B_4C/Cr/Sc]_{100}$ + B_4C cap and the simulation fit, incident beam energy is 395eV for XRR and 574.4eV for XRF. Simulations in the figures are done considering neither roughness nor inter-diffusion.

Acknowledgments

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