Study of ZrC/Al interfaces by making a Al/ZrC/Al/W waveguide structure

A. Singh[1], M. H. Modi[1], R. Dhawan[1], P. Jonnard[2], J.-M. André[2], K. Le Guen[2], M.-Y. Wu[2]

[1]*Indus Synchrotrons Utilization Division Raja Ramanna Centre for Advanced Technology, Indore 452013, India*

[2]*Sorbonne Universités, UPMC Univ Paris 06, CNRS UMR 7614, Laboratoire de Chimie Physique - Matière et Rayonnement, 11 rue Pierre et Marie Curie, F-75231 Paris cedex 05, France*

philippe.jonnard@upmc.fr

Summary

ZrC/Al multilayer is found suitable for soft x-ray region near the Al L absorption edge. Intermixing of Al at the interfaces is a serious problem in order to achieve the calculated reflectivity performances from an experimentally grown multilayer. In this study our aim is to investigate the Al/ZrC interfaces by making a waveguide structure as Al/ZrC/Al/W. We combine x-ray reflectivity (XRR) and grazing incidence x-ray fluorescence (GIXRF) techniques to study the x-ray waveguide made of 4 or 5 layers. Structural parameters of the stacks, density, thickness and roughness of the layers, are determined through a fitting process.

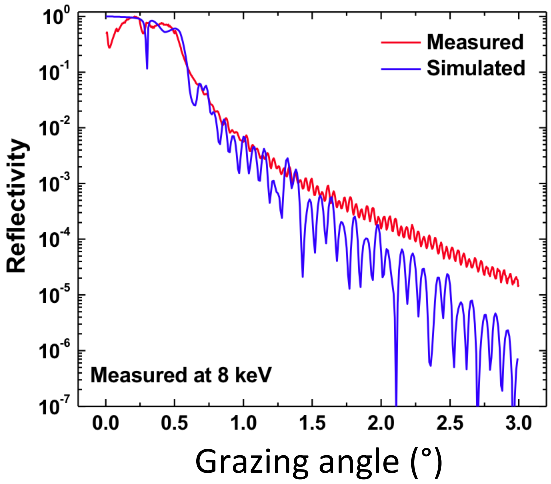
Experiments and simulations

In x-ray waveguide, the electric field of a radiation can be confined inside a layer through the generation of x-ray standing waves. The guiding layer is generally made of a light material surrounded by two layers made of heavy materials. Waveguides can be used to generate a beam of nanometer size or to study a material placed at the maximum of the electric field in order to benefit from a selective and efficient excitation.

Here we study ZrC/Al interfaces by making an x-ray waveguide of 4 layers: Al(7nm) / ZrC(5nm) / Al (15nm) / W (50nm) / Si substrate. Sample has been produced by ion beam sputtering technique. Grazing incidence XRR measurements are carried out using Cu Kα source. GIXRF measurements are performed at 10.25 keV photon energy along with simultaneous reflectivity measurements.

Figure 1 shows the measured and simulated x-ray reflectivity at 8.05 keV incident photon energy. Both measured and calculated reflectivity pattern suggest that the Kiessig fringes are narrowly spaced. The interference fringes can be well resolved if measurements are performed at longer wavelengths, as it is evident from the calculated soft x-ray reflectivity curves shown in Figure 2. The soft x-ray reflectivity measurements are being performed at Indus-1 reflectivity beamline.

In Figure 3 the depth distribution of the electric field within the Al/ZrC/Al/W sample is shown. The map shows this distribution for different values of the grazing angle of the incident radiation on the sample. We see that the first guided mode exists mainly in the second Al located between the ZrC and W layers when the grazing angle is 0.23°. The Figures 4 shows the GIXRF curve recorded using W Lα characteristic emission. The differences between the experiments and the simulations with perfect stacks (without interlayer or roughness) and with the aimed thickness (indicated above) clearly indicate that the actual stacks do not corresponding exactly to the designed ones. Fitting of the curves will enable us to reach the correct description of the waveguides. This work is in progress.



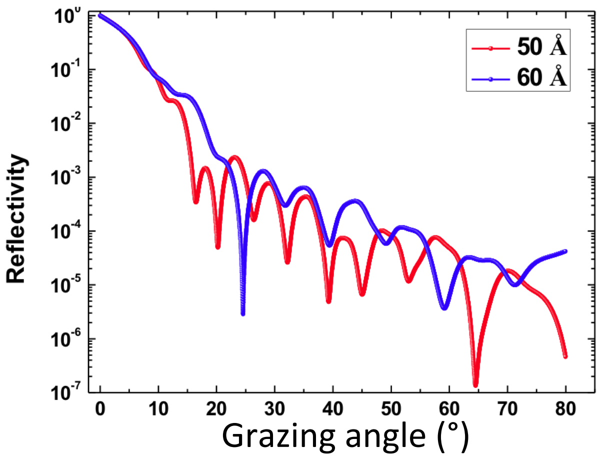


Figure 1 (left): XRR at 8.05 keV of the Al/ZrC/Al/W and the simulation obtained with a perfect stack with 0.5 nm roughness with the aimed thicknesses.

Figure 2 (right): Simulated soft x-ray reflectivity (SXR) obtained with a perfect stack (Al/ZrC/Al/W) with the aimed thicknesses. Simulations are carried out for 50 Å (248 eV) and 60 Å (207 eV) incident wavelengths.

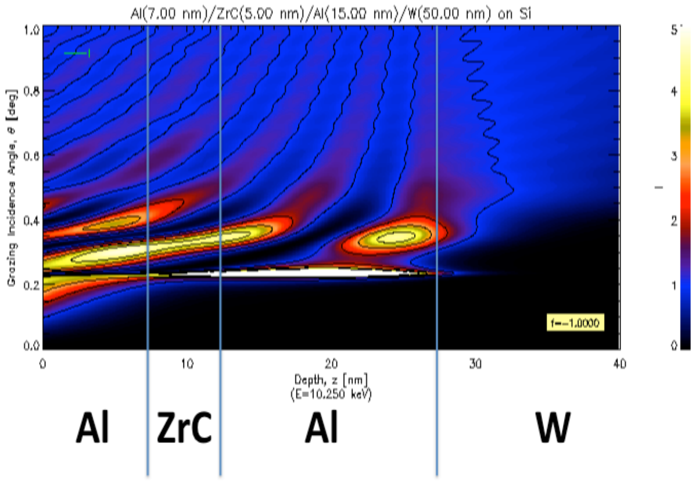


Figure 3: Depth and angular distribution of the electric field inside a Al/ZrC/Al/W waveguide excited by a 10.25keV radiation.

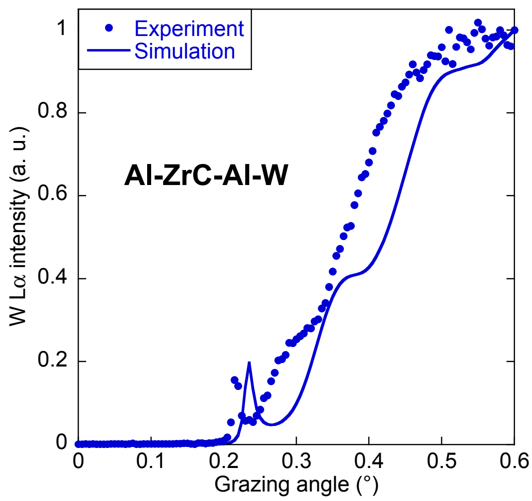


Figure 4: GIXRF of the W Lα radiation excited at 10.25keV of the Al/ZrC/Al/W and the simulation obtained with a perfect stack with the aimed thicknesses.