Depth analysis of Al/ZrC interfaces using SIMS and x-ray reflectivity techniques

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X-ray waveguide is analogous to optical fibre where the beam is guided through a core sandwiched between a cladding materials. This concept is used to generate nanosize beams in x-ray regime. In x-ray waveguides, the electric field of incident beam is 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. In the literature very few attempts have been made to understand the role of materials combination, film roughness, interface width, etc. on the performances of waveguides. The main challenge in x-ray waveguide optics is to overcome fabrication difficulties to make smooth interfaces and prevent intermixing between the guiding and cladding layers.

In the present study time of flight secondary ion mass spectroscopy (ToF-SIMS) and soft x-ray reflectivity (XRR) measurements, carried out to analyse interfaces in a C/Al/ZrC/Al/W waveguide structure. The scheme of the sample is shown in Figure 1 where indicated thicknesses are the aimed oens during the design. The Carbon layer was coated to protect the top Al layer from the ambient. The sample was prepared in an ion beam sputtering setup using Ar ion beam in a 3CM dc ion source. ToF-SIMS analysis was done using 30 keV Bi^{1+} ion beam. XRR measurements were carried out using the Indus reflectivity beamline. ToF-SIMS depth profiles of C, Al, Zr and W are shown in Figure 1. They suggest that interdiffusion is taking place at all the interfaces. Details of XRR analysis and SIMS data will be presented and a correlation between optical performances and elemental profiles will be given.

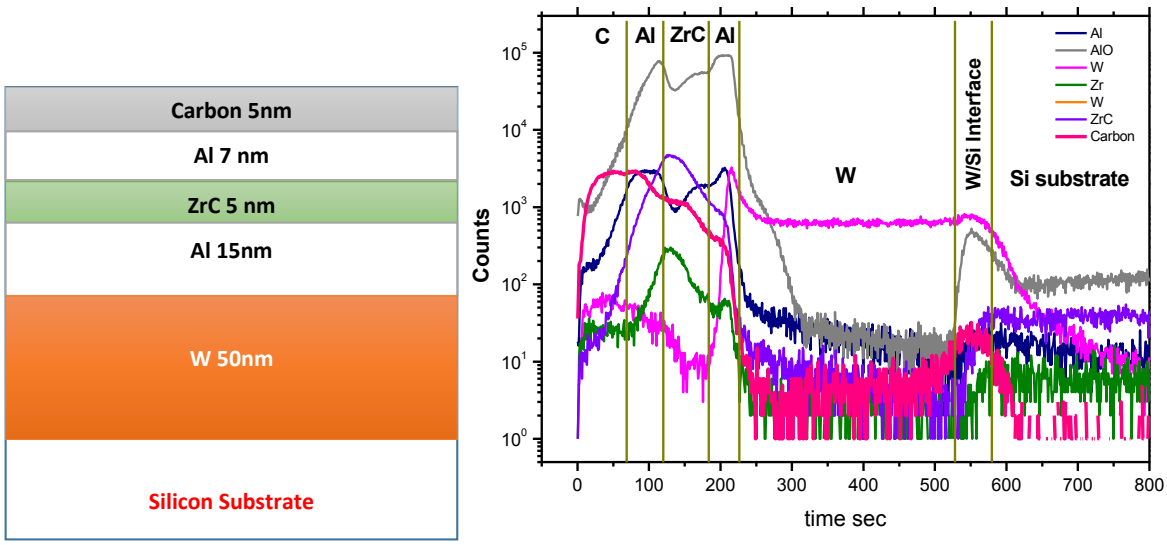

Fig. 1: (left) design of the sample; (right) ToF-SIMS depth profiles of the as-deposited C/Al/ZrC/Al/W on silicon substrate.

Study of the Au-Cr bilayer system using x-ray reflectivity, GDOES and SIMS

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Gold thin films are used in grazing incidence x-ray reflectivity mirrors in the 100-1500 eV soft x-ray region on synchrotron beamlines because gold presents a flat reflectivity performance. In order to provide a good adhesion with silicon or fused silica substrates, a binding layer of chromium is often used. These mirrors should exhibit no interdiffusion in order to get high and stable optical performances.

We study, as a model, a Au/Cr bilayer system deposited by electron beam evaporation technique on a float glass substrate. An as-deposited sample is characterized by using three complementary techniques: soft x-ray reflectivity (XRR), glow discharge optical emission spectrometry (GDOES) and time of flight secondary ion mass spectroscopy (ToF-SIMS). XRR informs about the thickness and roughness of the different layers while GDOES is used to obtain the elemental depth profile of the stack, with a nanometer depth resolution and SIMS to obtain the elemental and chemical depth profile with a nanometer depth resolution also.

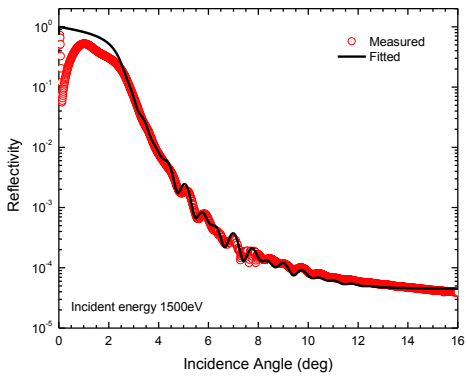
The XRR measurements shown in Figure 1 confirm that the sample is a bilayer stack with Au and Cr layer thicknesses of 24.2 and 10.3 nm respectively and interface roughnesses of 0.55 and 0.83 nm. The depth profiling is obtained from the SIMS measurements and is shown in Figure 2. From the SIMS data one infers that:

- a contaminated exits at the top of the stack;

- at the interfaces between the Au and Cr layers, a possible AuCr solid solution is evidenced;

- between the Cr layer and the glass substrate, Cr is oxidized.

Such a study shows the interest of combing complementary techniques in order to determine the in-depth composition of multilayer stacks of nanometer thickness.



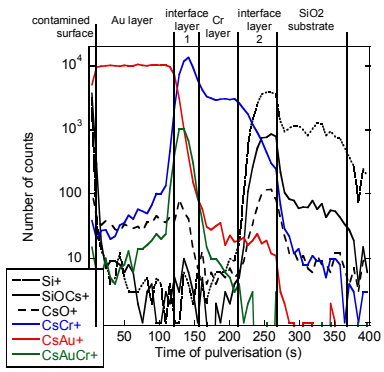


Fig. 1 (left): Measured and fitted SXR curves.
Fig. 2 (right): ToF-SIMS depth profiles.

Study of Pd/Y based multilayers with B_4C barrier layers using high energy photoemission spectroscopy combined with x-ray standing waves

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We use hard x-ray photoemission spectroscopy (HAXPES) combined with x-ray standing waves to characterize a series of Pd/Y based periodic multilayers designed to work in the 7.5-11 nm range. The samples are prepared by magnetron sputtering. For different samples thin B_4C barrier layers are inserted at different locations within the stack: at the Pd-on- B_4C interfaces, at the B_4C-on-Pd interfaces or at both interfaces. These barrier layers are expected to improve the reflecting performance of the multilayers [1,2]. The aimed period of the samples is 4 nm. The experiments consist in obtaining the core level photoemission spectra of the various elements for a series of grazing angles. The angular scan is made in the range given by the Bragg law, considering the multilayer period and the incident photon energy, in order to generate to strong standing wave in the stack. Owing to the period of the multilayer and the presence of a 2.5 nm-thick capping layer, the photon energy is chosen to be 10 keV in order to probe the first 5-6 periods of the stack. Thus the Bragg angle is a little less than 1°. Rotating the sample enables putting the nodes of the electric field at some particular location of the stack, thus to make the excitation depth-selective, coming from one interface or another or from the center of one given layer. The changes of the chemical shift of the Pd 2p and 3d, Y 2p and 3d, N 1s, C 1s and B 1s core level peaks as a function of the angle, that is to say as a function of the location in the stack will give information about the possible interfacial processes taking place in the multilayers.

[1] P. Jonnard et al. Surf. Sci. 604 (2010) 1015.
[2] M. Prasciolu et al. Appl. Opt. 53 (2014) 2126.