Depth dependent structural probing of magnetic multilayers by Grazing Incidence XAFS study at Indus-2 SRS

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Interface plays an important role in the performance of the magnetic multilayer devices hence it is indispensable to ascertain the internal structure of interfacial regions in multilayers including interface roughness and inter-diffusion/compound formation at the interfaces. X-ray absorption spectroscopy (XAS) is an important technique to investigate element specific local structure in a system. Though it is not really a surface sensitive technique, however by carefully preparing the sample and choosing proper grazing angle of incidence, and thereby controlling the nodes and anti-nodes of the X-ray standing waves generated inside the multilayer, we can probe depth selective XAS in a multilayer structure. In order to perform the depth dependent XAFS study of magnetic multilayer system a grazing incidence XAFS (GIXAFS) measurement facility has recently been set up at the Energy Scanning EXAFS beamline at Indus-2 SRS, RRCAT, Indore, India.

In this GIXAFS experimental setup, a 2-Circle goniometer with a 5-axis sample stage was used to orient the sample, where the sample was kept at the center of the goniometer and two detectors have been used for simultaneous fluorescence and reflectance measurements on the samples. The correct grazing angle of incidence on the sample is ascertained by the reflectivity measurement while XAS measurements have been done by collecting the total fluorescence measurement by a Si drift detector. An ionization chamber detector is used for measuring the incident flux. Fig.1 shows the photograph of the set up. In this paper, we present the development of this facility as well as the results obtained on 5bi-layer Ni (60Å)/Ti(60Å) and Co (66Å)/Ti(67Å) multilayer structures deposited by sputtering technique on c-Si substrate in an indigenously developed d.c. magnetron sputtering unit.

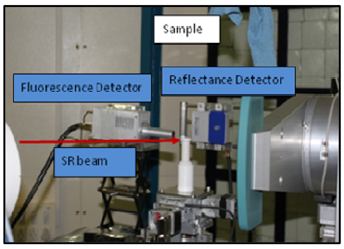

Fig.1

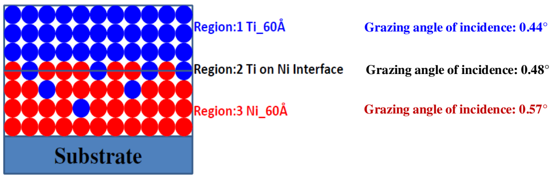

Fig.2

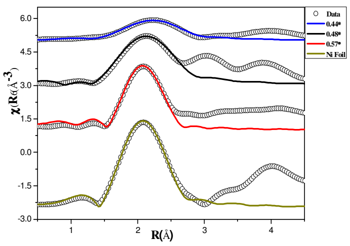

Fig.3

Fig. 2 shows the three regions of a Ni/Ti multilayer, where local structure around Ni atoms can be probed by Ni K-edge EXAFS at the three grazing angles of incidence. The angles have been estimated by simulation of X-ray standing wave electric field inside the multilayer structure. Fig.3 shows the $\chi(R)$ versus R plots for the Ni/Ti sample at the above three angles of incidence obtained from Ni-K-edge EXAFS measurements carried out using the above set up, along with the respective best fit theoretical curves. The above figure shows how the radial distribution function changes and becomes closer to that of a Ni foil as the grazing angle of incidence and hence the depth of probing is increased.