A.1: Design, development and commissioning of "Soft X-ray Reflectivity Beamline" at Indus-2

A vacuum ultra-violet/ soft x-ray beamline covering energy range of 10-300 eV was commissioned in Indus-1 synchrotron source in 2000. This beamline is useful to probe the K and L absorption edges of low Z elements up to Z=18. Now a soft x-ray reflectivity beamline (BL-3) with an extended energy region of 100-1500 eV has been designed, developed and commissioned at Indus-2 synchrotron source to cover other elements like transition metals and rare earth elements. With this, the total number of operational beamlines at Indus-2 has become thirteen.

X-ray reflectivity is a non-destructive tool to study surfaces and interfaces of thin films and multilayers. Soft x-ray resonant reflectivity is a powerful tool to study buried interfaces due to its increased sensitivity around the absorption edges of the constituent materials. In the soft x-ray region, the k-space resolution is significantly higher compared to grazing incidence x-ray scattering, thus allowing structural information in the range of 100 to 250 nm. Determination of optical constants is important to model and predict the actual performance of x-ray optical elements. Measurement of reflectivity of mirrors, efficiency of gratings and detectors, transmission of thin film filters and multilayer structure is another area of interest.

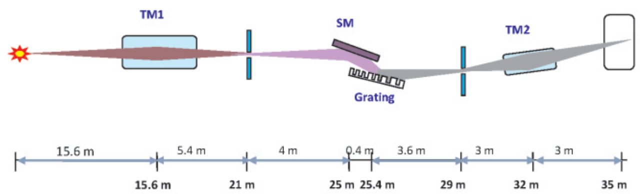

Fig A.1.1: Optical layout of soft x-ray reflectivity beamline installed at Indus-2 bending magnet source (BL-3)

The design of soft x-ray reflectivity beamline (BL-3) is based on a constant deviation angle variable line spacing plane grating monochromator (PGM) with Hettrick type optics. This has been chosen because of its simplicity of mechanism and less number of optical elements. The optical layout of the beamline is shown in Fig.A.1.1. This beamline is installed on a 5^o port of bending magnet source. The r.m.s electron source size at this port is 0.203 mm (H) x 0.272 mm (V). The first optical element of the beamline is a horizontally deflecting and vertically mounted toroidal mirror, TM1, which accepts 2 mrad (H) and 3 mrad (V) of the emitted bending magnet radiation. TM1 focuses the light vertically on to the entrance slit S1, and horizontally on to the exit slit S2. The second mirror is a spherical mirror SM, which is vertically deflecting and forms a convergent beam on the plane grating. After SM, the white light is diffracted by the plane grating and desired wavelength is focused on the slit S2. Three interchangeable gratings G1, G2 and G3 of line densities 1200, 400 and 150 lines/mm are used to efficiently cover the whole energy region. The monochromatized light is focused on to the sample by horizontally deflecting and vertically mounted toroidal mirror TM2. The soft x-ray radiation gets strongly absorbed in any material and hence no window is used to separate the Indus-2 storage ring from the beamline. The whole beamline thus operates in UHV environment with pressure < 3×10^{-9} mbar.

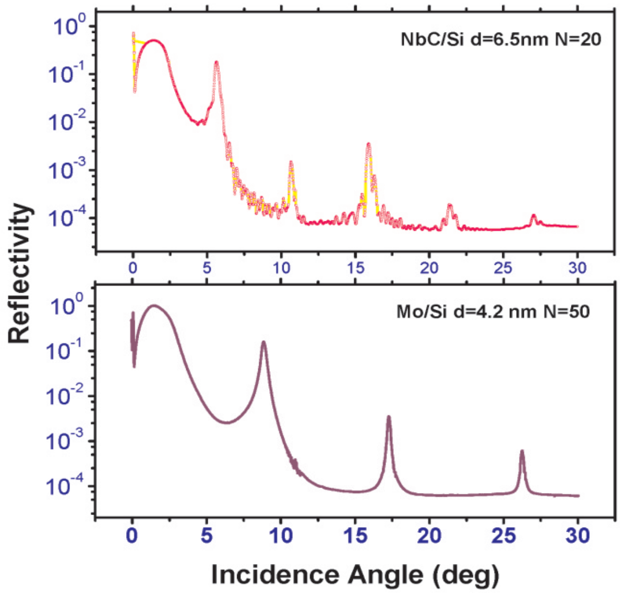

Fig A.1.2: Reflectivity curves of NbC/Si and Mo/Si multilayers measured using ~1000eV photon energy at new soft x-ray reflectivity beamline of Indus-2.

The PGM used in the beamline is custom designed and fabricated by M/s Horiba Jobin Yvon, France. It has three holographically made gold coated gratings having 150, 400 and 1200 lines /mm. Energy scan in the PGM is done using a sine-drive mechanism. The beamline installation and commissioning was started in a phased manner. Initially all the crucial optical components were placed at their theoretical position and aligned with the help of RRCAT alignment group. Later on, the actual alignment was carried out by taking x-ray beam through a temporary mounted beryllium window at the end of the frontend. Later, the whole beamline was evacuated to ultra-high vacuum level and SR beam at very low current was used for further alignment and vacuum conditioning. Initial calibration of the monochromator was checked using the L-absorption edge of Ni filter. The beamline has since been used for several reflectivity measurements of multilayers at different photon energies. The typical reflectivity graph of NbC/Si multilayer and Mo/Si multilayer recorded at BL-3 is shown in Fig.A.1.2.

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