collimating horizontal beam and focusing the beam in the vertical direction. Using two mirror system and Be-window assemblies, SR spectrum is tuned between 1.5keV to 20keV.

Commissioning of SDXRL beamline is initiated after testing the front end controls and beamline radiation safety interlocks scheme. After commissioning the remotely operated Phosphor screen based x-ray beam monitor and Be-window protection system, SR was observed through Be-window of BL-07 frontend on November 26, 2010. Fig. A.4.2 shows SR beam observed on phosphor screen at 17.8 m (after the two mirror system). Splitting is seen due to physical obstruction in the SR beam path. SR beam acceptance for beamline are 5 mrad (Horizontal) and 0.2 mrad (Vertical). The observed beam size at a distance of 17.8 m is 9.5 mm (vertical) 70.4 mm (horizontal). The vertical beam size is limited by aperture height of Be-window assembly. To obtain the estimated horizontal width (~90 mm) of SR beam, fixed mask

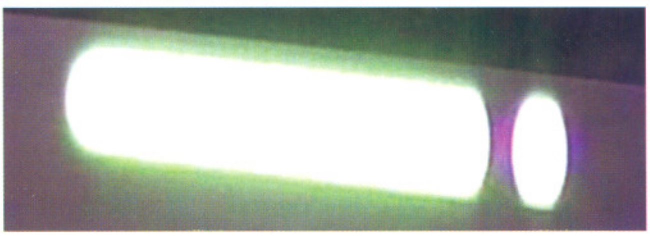

Fig. A.4.2: SR observed on the phosphor screen

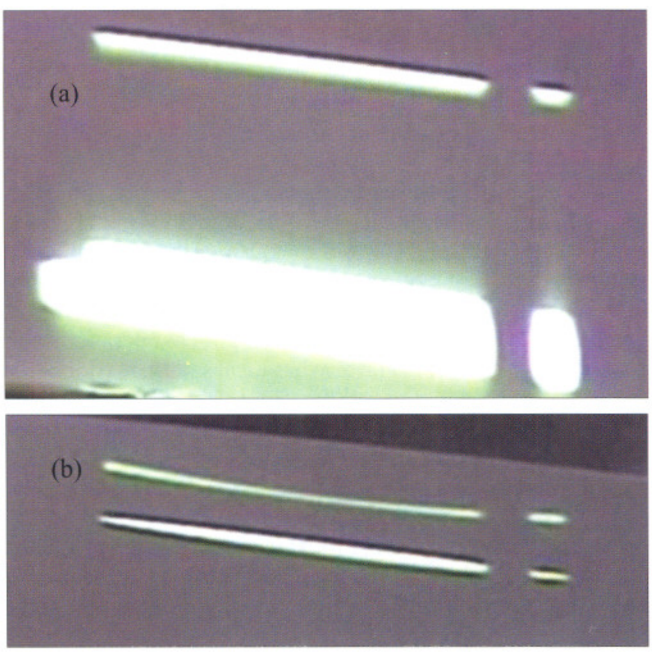

Fig. A.4.3: SR Beam on phosphor screen after two mirror system when mirror(s) set at (a) grazing incidence angle for mirror M1 ($\theta_1 = 0.4^0$), (b) grazing incidence angle for M1 ($\theta_1 = 0.40$) and M2 ($\theta 2 = 0.254^0$).

aperture in the front end needs to be increased.

The beam position of SR is a critical parameter for aligning beamline optics. SR from Indus-2 is available at a height of 1250 mm from the floor. X-ray photodiode and wire scanner are used to detect the centre of gravity of SR beam in vertical direction. The vertical height of beam is observed at 1249 mm downstream to Be-window assembly (~15m) and 1249.5 mm downstream to two mirror system (~17.8m). The error in measurement of beam position is ~ 0.5-1mm. The further qualification of the beam is under progress.

Movement (angular and translation) of the two mirrors provides the beam at fixed height at experimental station and tunes the energy band from white spectrum of SR. Both mirrors are set in angular range of 0-2^0 with 1 arcsec resolution. Mechanical movement accuracies of the mirror manipulator and vacuum tests of the chamber were performed before installing the M1 and M2. During trials we are trying to set the mirrors at various angles for tuning the energy spectrum. Fig. A.4.3(a) shows the beam bouncing from M1 when it is kept at grazing incidence angle of 0.4^0, the direct beam in top and reflected beam at bottom. Fig. A.4.3(b) shows beam reflection from M1 followed by M2 (0.254^0), reflected beam from the second mirror is on top and direct beam is on bottom. This mirrors setting can tune energy pink band between 4 -10 keV. Further qualification of two mirror system is under progress. SR beam at various lengths of beamline is being characterized for effective use of SDXRL beamline optics and vacuum hardware. After the full qualification of the beamline in terms of SR beam size and spectrum, exposure of photo-resist will be started for high aspect ratio fabrication of microstructures.

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A.5: Growth of Short period (<2nm) x-ray multilayer mirror

Multilayers with smaller periods in the range of 1 to 2 nm are of great interest. This is related to their widespread use as radiation-stable dispersive optical elements, polarizers for synchrotron radiation, dispersive elements for X-ray diagnostics of high-temperature plasmas, normal incidence reflectors for (soft) x-ray microscopy in the water window (2 to 4 nm) and for applications in x-ray astronomy. Most of these applications require high spectral selectivity and high reflectance.

In X-ray Optics Section of ISUD, we are fabricating high reflectance normal incidence mirrors for developing Scwarzchild microscope for soft x-ray reflectivity/ fluorescence beamline on Indus -2, polarimeter for soft x-ray

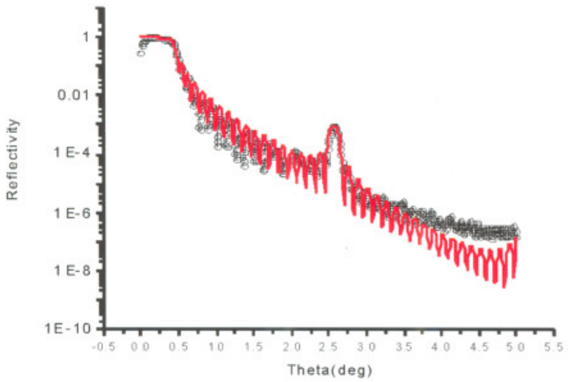

Fig.A.5.1 : X-ray reflectivity pattern (dots) of short period W/Si Multilayer mirror along with fitting (redline)

polarization experiments and hard x-ray super mirrors for Indus 2. Development of short period multilayers is a pre-requisite for the above mentioned goal.

Depositing these structures with good periodicity and low roughness is a technological challenge. At low period thicknesses (< 2nm), intermixing of layers reduces reflectivity significantly. If intermixing is not controlled, the desired performance from the multilayer structure would not be achieved.

We report deposition and characterization of short period W/Si and W/C multilayers using an in-house developed ion beam sputtering thin film deposition system. Base pressure in the chamber before deposition was $2x10^{-6}$ mbar and during the deposition was maintained at ~ $4x10^{-4}$ mbar. Before deposition, r.m.s roughness of each substrate was measured by grazing incidence x-ray reflectivity (GIXRR) technique on a reflectometer developed in house on a sealed tube with Cu target (8.05 keV) .

Figure A.5.1 shows the reflectivity pattern of 20 layer

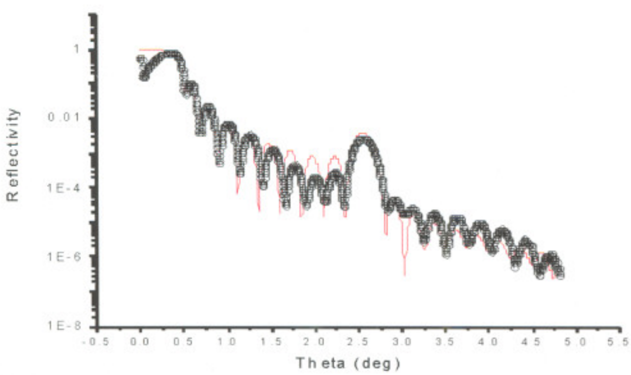

Fig. A5.2: X-ray refletiity pattern (dots) of short period W/C Multilayer mirror along with fitting (red line)

pair W/Si multilayer mirror along with the best fit line. The estimated period thickness is 1.7 nm and the reflectivity of the Bragg peak was 0.09 % at 2.57° theta. The thickness of W layer was 1 nm with a roughness of 0.45 nm and of Si layer was 0.7 nm with a roughness of 0.6 nm. Reflectivity analysis also revealed that there is significant intermixing taking place at the interface of W and Si. Densities of W and Si layer have got considerably changed.

Figure A.5.2 shows reflectivity pattern of 10 layer pair W/C multilayer mirror along with the best fit line. In this case, the estimated period from the fitting was of 1.74 nm and the reflectivity of the Bragg peak was 0.28 % at 2.54° theta. The thickness of W layer was 1.04 nm with a roughness of 0.4 nm and of Si layer was 0.7 nm with a roughness of 0.5 nm. In this case no intermixing was observed and densities of W and C layer were as expected.

It can be seen from the above data that reflectivity of W/C multilayer mirror is much higher (0.28%) than of W/Si multilayer mirror (0.09%) of same period. The major reason for this is that the roughness of C layer is smaller than the roughness of Si layer and lower intermixing at W/C interface compared to W/Si. This development is very useful for our aim of developing hard x-ray super mirrors and normal incidence mirrors in water window region. Efforts are going on to further reduce the multilayer period.

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A.6: Control Integration of Indus-2 BL-21 Front End

A beamline front end is typically the part of the beam line, which is inside the inaccessible, shielded ring area and connects the actual beam line housing the experimental station to the ring with needed regulating and controlling mechanisms for synchrotron beam and vacuum. Every front end has its local controls for facilitating local operations and procedures. Every front end also has local safety interlocks for ensuring safe operation of the front end. However, it is required to have co-ordinated operations with the machine controls to allow proper, safe and authorized use of the beam lines. Safety aspects related to radiation levels around the experimental area and vacuum in the ring as well as the front end are of primary concern. Proper use concerns the control of 'safety shutter', which allows the photon beam to the beam line and closely monitoring vacuum before opening the gate valves.

The control co-ordination concerns the permission to open gate valve 1 (GV1) in the front end, permission to open and close safety shutter (SS), withdrawing the permissions for SS and GV1 in case of unsafe conditions.