A.3.1. A well known Parratt recursive formalism was used to get the best fit. A three layer model comprising of (1) the top layer, (2) the middle SRSN layer, and (3) interfacial layer (IL) between SRSN film and Si substrate was considered across its depth. Each constituent layer was parameterized with the optical constants δ (dispersion) and β (absorption) while keeping all the other fitting parameters (thickness and roughness) constant. Optical index profile (δ part) as a function of wavelength near Si $L_{2,3}$ absorption edge as obtained from SXR fits are shown in Fig. A.3.2. The δ profile corresponding to the top contaminated layer and IL is not plotted as this layer is of no interest to us. It is clearly evident from Fig. A.3.2 that the optical index profile of SRSN layer lies in between the reference profile of Si and $Si_3N_4$ obtained from CXRO website. This in very simple way indicates that the film is a mixture of Si and $Si_3N_4$. The presence of Si will induce structural changes and so the values of optical index for SRSN film are shifted from $Si_3N_4$ towards Si. This simple comparison confirms that as deposited film is Si-rich.

Further, for quantitative analysis, a volume fraction of these two entities can be varied to get the best fit for measured optical index profile. However, taking into account hydrogen incorporation in SRSN film, a third entity of hydrogen plus void is also included to determine the composition of the film by rigorous calculation. Interestingly, a composition of SRSN film as 30% (H + voids) + 42% ($Si_3N_4$) + 28% (Si) by volume fraction results into a fit, which is in good agreement with the observed experimental data [see Fig. A.3.2]. Though our method is not intended for an accurate determination of film composition but it gives us reasonable values that are expectable both theoretically and experimentally. However, the actual composition of film should also be deduced with some physico-chemical analysis such as Nuclear Reaction Analysis (NRA) or Secondary Ion Mass Spectroscopy (SIMS). In summary present study suggests that soft x-rays reflectivity can be a powerful non-destructive characterization tool for the compositional analysis of the thin films.

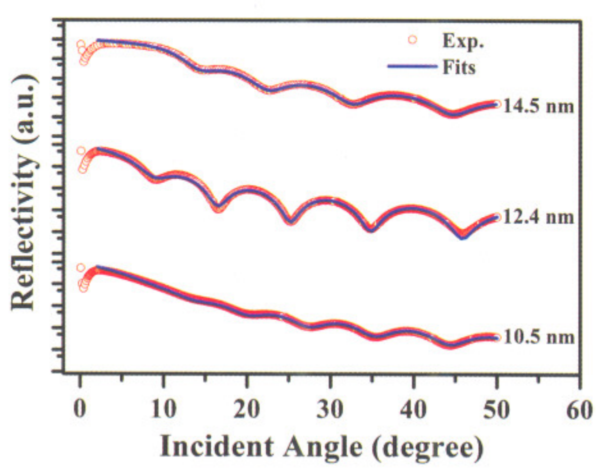


*Fig.A.3.1: Reflectivity curves both experimental (open circles) and fitted (solid lines) of SRSN film.*

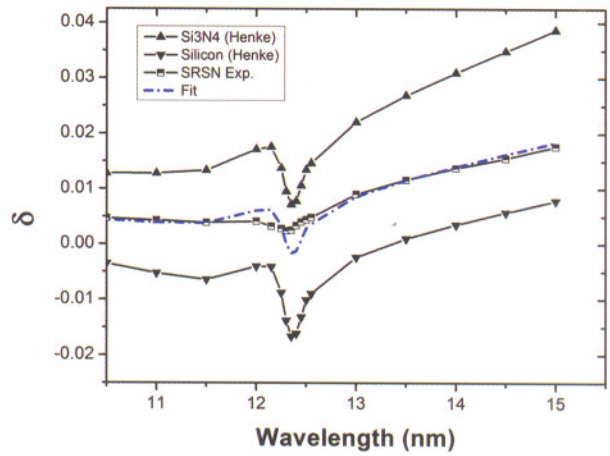


*Fig. A.3.2: Optical index profile (δ) for SRSN film at various wavelength near the Si L2,3 absorption edge.*

For more details please see Applied Physics Letter 97 (2010) 151906.

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**A.4: Soft and Deep X-Ray Lithography beamline on Indus-2: Commissioning Trials**

Soft and Deep X-ray lithography (SDXRL) beamline is undergoing commissioning. This beamline is installed on the Indus-2 bending magnet port (BL-07). The beamline is dedicated for X-ray lithography which is a widely used technique for the fabrication of three-dimensional high aspect ratio microstructures. Fig. A.4.1 shows the optical design of SDXRL beamline. The optical design of this beamline consists of a plane mirror (M1) and a torroidal mirror (M2) placed at 16.2 m and 17 m respectively from the tangent point. The first mirror is used for defining the synchrotron radiation (SR) high energy cut-off. The second mirror is used for

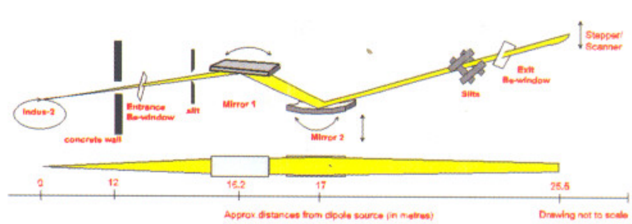


*Fig. A.4.1: Optical design of SDXRL beamline.*

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

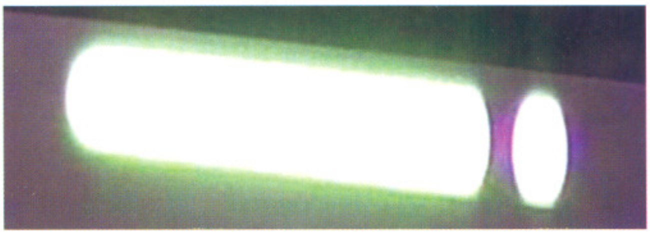

*Fig. A.4.2: SR observed on the phosphor screen*

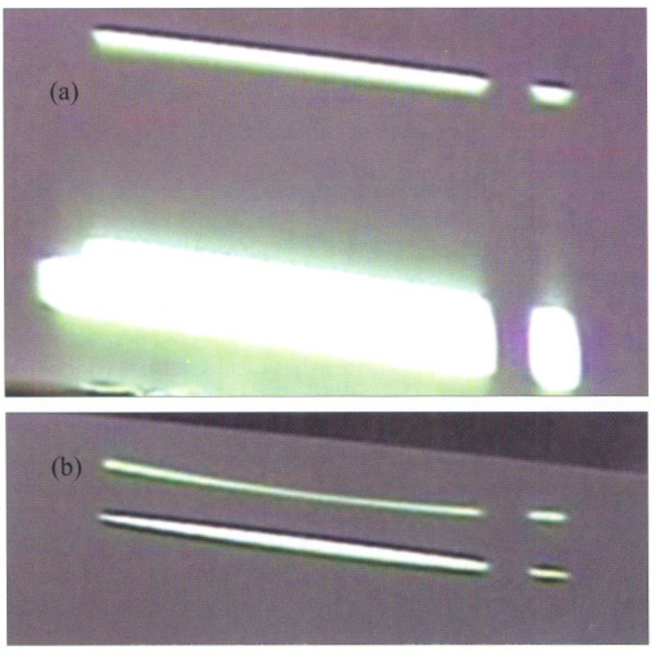


*Fig. A.4.3: SR Beam on phosphor screen after two mirror system when mirror(s) set at (a) grazing incidence angle for mirror M1 ($\theta_1 = 0.4^0$), (b) grazing incidence angle for M1 ($\theta_1 = 0.40$) and M2 ($\theta 2 = 0.254^0$).*

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