advantage over transmission measurements that both δ and β can be deduced experimentally and measurements are carried out on bulk samples. The drawbacks of this method include its sensitivity to surface contamination and roughness.

InP is an important III-V semiconductor for both semiconductor and photo electronics. This material is used as a substrate for epitaxial indium gallium arsenide based opto-electronic devices. InP is an important material for making x-ray semiconductor detectors. Detectors made with these materials are being used in soft x-ray applications. However, to the best of our knowledge no experimentally measured optical constants of InP are available in the soft x-ray region. In the present study, InP wafer is used to determine optical constants using angle dependent reflectance experiments in the 50-200 Å wavelengths region. Measured data are compared with tabulated values from Henke et al. Reflectance measurements are performed on Indus-1 synchrotron source using soft x-ray reflectivity beam line.

Figure A.2.1 shows the experimental value of InP optical constants derived from angle dependent reflectivity measurements. The derived δ and β vales are in good agreement with the tabulated values below the Phosphorous L edge with a slight variation of 10%. At higher wavelengths, near Indium N_2 edge of 160.7 Å the derived δ's deviate abruptly from the tabulated values. An edge shift of 0.4 Å towards lower wavelength side from the Phosphorous L edge of 92 Å is observed. Such edge shift is earlier reported in boron carbide compound materials and the reason was attributed to variation in chemical stochiometry.

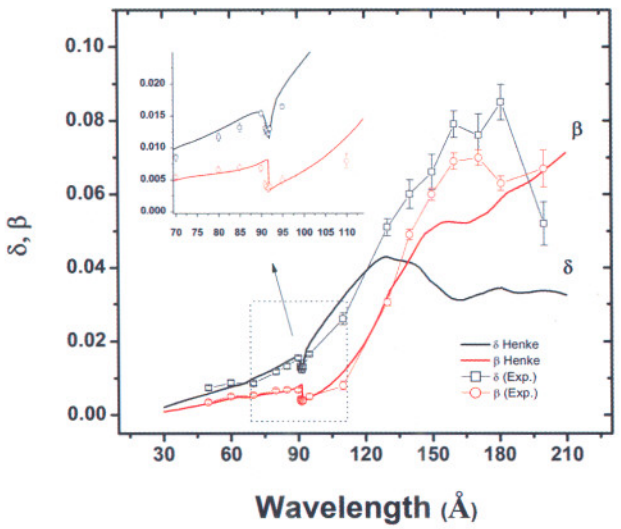

Fig.A.2.1: Measured values of InP optical constants are shown as discrete points along with the error bars. For the comparison, Henke's data are shown by continuous lines. In the inset, optical constant near phosphorous L edge is shown where measured data are in close agreement with Henke's values. Near Indium N_2 edge of 160.7Å, a huge discrepancy between experimental and tabulated values is found.

The measured β's are in good agreement with tabulated values below the phosphorus L edge with a maximum deviation of 13%. In the vicinity of the edge the β's are 50% lower than the tabulated values. Above 120 Å wavelength region the β values are 30% higher than the tabulated values. Large discrepancy between measured and tabulated values of δ and β is found near N_2 edge region of Indium (160.7 Å). In this region, measured ratio of β / δ is found to be less than one in contrary to tabulated ratio whose value is more than one. For more details please see Applied Optics 49 (2010) 5381.

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A.3: Qualitative Estimation of Thin Film Composition by Soft X-ray Reflectivity Analysis

Soft x-ray reflectivity (SXR) has been previously recognized for the characterization of different thin films and multilayer structures. However, optical index profile derived over extended wavelength region of soft x-ray regime has not been utilized to obtain compositional details. In recent years, Si-rich a-SiN_x:H (SRSN) thin films have gained considerable attention due to their potential applications in optoelectronic devices, photonics and third generation solar cells. Considering SRSN film as particular example, in the present work, we demonstrate that soft x-ray reflectivity near the Si $L_{2,3}$ edge can be used to analyze compositional details of the thin film.

The SRSN thin film was deposited using Hg-sensitzied photo chemcial vapour deposition (Photo-CVD) on n-type Si (100) substrate. SiH_4 (4% in Argon) and NH_3 were used as the reactant gas sources. The substrate temperature and deposition pressure were fixed at 200°C and 0.8 Torr respectively. X-ray photoelectron spectroscopy (XPS) measurements using a Mg K_α (1253.6 eV) were carried out to analyze bonding environment. Angle-dependent soft x-ray reflectivity (SXR) measurements near Si $L_{2,3}$ absorption edge were carried out using soft x-ray reflectivity beam-line on Indus-1 synchrotron facility. Reflectivity (θ-2θ) scan with an angular resolution < 0.01° were performed from 0-50° in the s-polarized geometry.

Soft X-ray reflectivity curves, both experimental (open circles) and fitted (solid lines) of SRSN film at selected wavelengths near Si $L_{2,3}$ absorption edge are shown in Fig.

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.

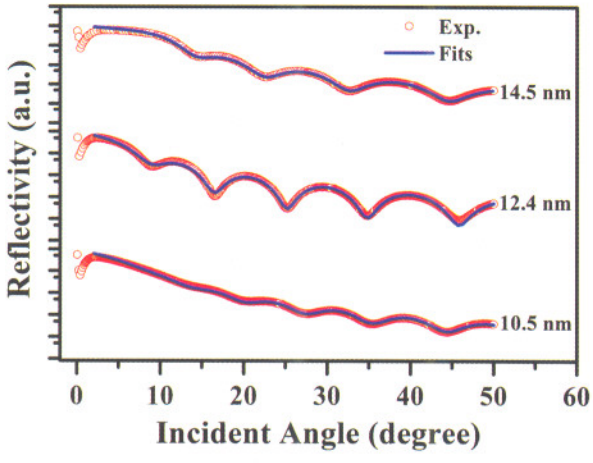

Fig.A.3.1: Reflectivity curves both experimental (open circles) and fitted (solid lines) of SRSN film.

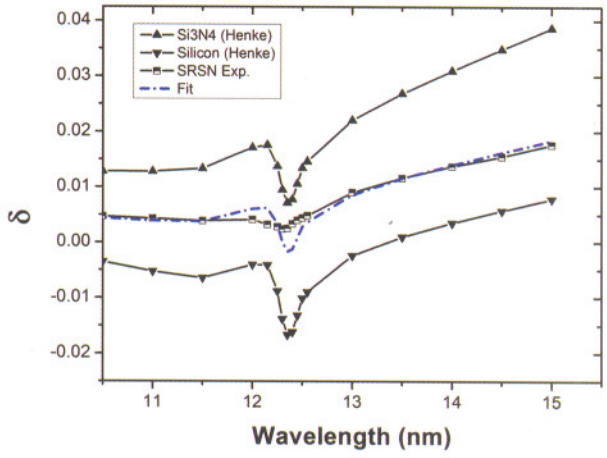

Fig. A.3.2: Optical index profile (δ) for SRSN film at various wavelength near the Si L2,3 absorption edge.

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

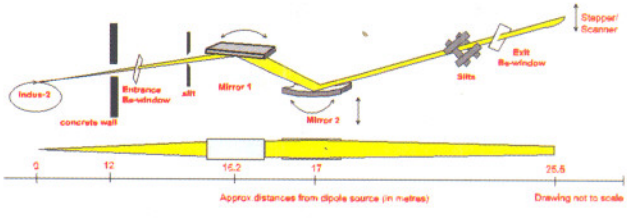

Fig. A.4.1: Optical design of SDXRL beamline.