Ray tracing simulations are done with 10A° surface roughness on the mirror surface. The meridional slope error was 4.8 μrad and sagittal slope error was 8.9 μrad. The height of heat bump on the first crystal of the monochromator was taken into consideration at photon energy of 3 keV. The calculations were done by considering 300mA current in Indus-2 storage ring with 2.5GeV electron energy. The detail ray tracing and calculations were done by RAY and SHADOW simulation programs and XOP.

(Contributed by : Arijeet Das; arijeet@cat.ernet.in, A.K. Sinha and R.V. Nandedkar)

A.7 Data acquisition system (DAS) for reflectivity beam line on Indus-1

A DAS has been developed for reflectivity beamline on Indus-1. Its function pertain to control/monitor the following components of beam line:

1. Rotation of the toridal grating in the grazing incidence monochromator tracked by an encoder on serial bus.
2. Goniometer motions involving three-axes movements of three stepper motors, one for rotating the sample, second for rotating the detector and third for providing translation motion to the sample. Software controls the motion of these stepper motors using a driver card residing on PCI bus.
3. Synchrotron radiation photon beam current monitors on GPIB bus
4. Synchrotron radiation electron beam current monitor on a serial bus.
5. Continuous scan mode, which has increased the data acquisition rate significantly, which in turn saves significant beam time.

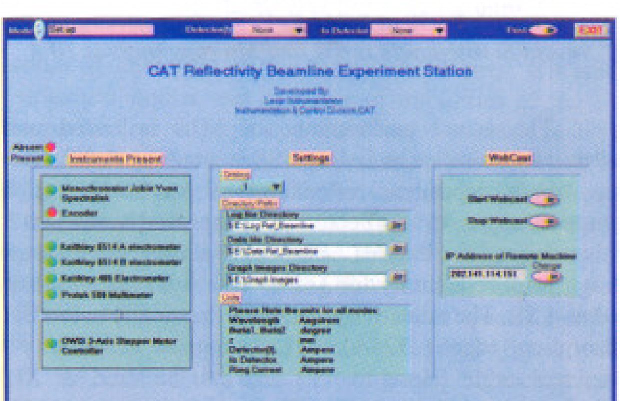

Fig. A.7.1 Main control panel for reflectivity beam line software

This LabView based software checks which of the instruments are connected and available. It further allows the user to select any of the following experiment modes:

i) Wavelength Scan	ii) Angle Scan
iii) Time Scan	iv) Continuous scan

The software acquires and on line plots of direct and reflected beam currents and ring current as a function of wavelength, angle or time depending on the mode. Various beamline, experiment and user defined parameters are stored in a log file. There is an option to store graph images for ready reference. File name is generated automatically based on experiment mode, date, time and user defined filename field. The experiment panel can be viewed on a remote PC anywhere on the network (fig. A.7.1). Earlier data can be overlaid on the graph for comparison purpose. Important parameters are saved in a configuration file for use in the successive runs.

(Contributed by : Shradha Palod; shradha@cat.ernet.in, P.P. Deshpande, V.P. Bhanage, M.H. Modi, A.G. Bhujle)

A.8 X-ray standing wave characterization of layered materials

Angle dependent grazing incidence X-ray fluorescence (GI-XRF), is another variant of total reflection X-ray fluorescence (TXRF) technique. By changing the incidence angle, the depth sensitivity of a layered material can be enlarged to nanometer regime. X-ray standing wave (XSW) effects occur in multilayer Bragg peak region as in perfect crystal.

Divergence of incident primary beam is one of the major sources of systematic error in X-ray standing wave characterization of single and multilayer thin films. Primary beam divergence significantly alters XSW profile of a layered material and can lead to large errors when used with higher excitation energies. These errors can be corrected by introducing beam divergence effects in the model calculations. In the present study we have evaluated optimum beam divergence below which the primary beam divergence effects need not be incorporated. For example, a primary beam of divergence 0.005° can be used with confidence in case of Mo-Kα excitation for XSW characterization of multilayers. On the other hand, this requirement of beam divergence can be relaxed up to 0.01° for Cu-Kα excitation.

Fig. A.8.1 shows the measured GI-XRF profile and reflectivity profile of a Fe/Si multilayer of parameters N = 10, d=16.8nm, Γ = 0.262 using Cu-Kα excitation energy. These ML samples were prepared using an ion beam sputtering system developed in-house. The measured GI-XRF profile

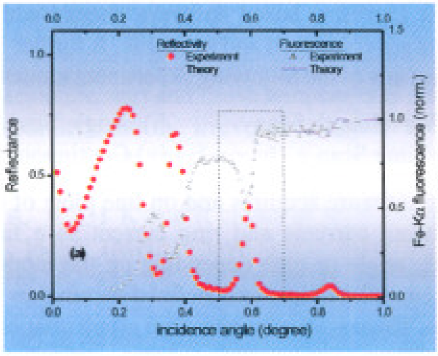

***Fig. A.8.1** Variation of Fe-Kα fluorescence intensity (triangle) fitted GI XRF profile (blue line) and measured reflectivity (circle) and fitted reflectivity profile (gray line) for a Fe/Si multilayer*

distinctly shows XSW oscillations up to three Bragg reflections. The experimental reflectivity and fluorescence profiles match closely with calculated profile at 0.03^{0} beam divergence. This observed value of primary beam width agrees with expected value of beam divergence of 0.026^{0} as we have used our first slit of 40µm at a distance of 110 mm from X-ray tube window.

(Contributed by: M K Tiwari; mktiwari@cat.ernet.in, S.R. Naik, G.S. Lodha, R.V. Nandedkar)

A.9 Development of soft x-ray/ extreme ultra violet Mo/ Si multilayer mirrors and their characterization using Indus-1

Multilayer (ML) mirrors are playing an important role in the exploitation of soft x-ray/extreme ultra violet (XUV) region of the electromagnetic spectrum, and have received attention due to both the science and technology interests. Such mirrors have found wide applications in synchrotron radiation beam lines, materials science, astronomy, x-ray microscopy, x-ray laser, x-ray lithography, polarizer and plasma diagnostics. High reflectivity with moderate spectral bandwidth at normal/near normal incidence can be achieved by using alternate layers of high and low density materials with periodicity in nanometer range. Their fabrication requires the capability to deposit uniform, ultra thin (few angstrom) films of different materials with thickness control in atomic scale. Thus one requires a proper understanding of substrate surfaces, individual layers, chemical reactivity at interfaces and finally ML structure for particular applications. The performance of the XUV ML is limited by contrast in optical constants of the two materials, interfacial roughness and chemical reactivity of two materials and the thickness errors of individual layers.

Our present focus is on the physics of MLs and development of XUV ML optical devices for synchrotron radiation applications, and present some of Mo/Si XUV MLs fabricated using the indigenously developed ultra high vacuum electron beam evaporation system. The MLs have been characterized using hard x-ray reflectivity (XRR) and the performance of MLs is tested on Indus -1 synchrotron radiation (SR) source.

We show in fig. A.9.1, a typical hard XRR spectrum measured using Cu Kα (λ=1.542 Å) of Mo(30Å)/Si(60 Å) ML with number of layer pairs, N=30. Bragg peaks up to fifth order clearly shows a well-defined layer structure of the ML. The measured reflectivity spectrum is fitted using Parratt formalism with four-layer model. The best-fit results show Mo-on-Si interlayer thickness is 10 Å whereas Si-on-Mo interlayer thickness is 8 Å.

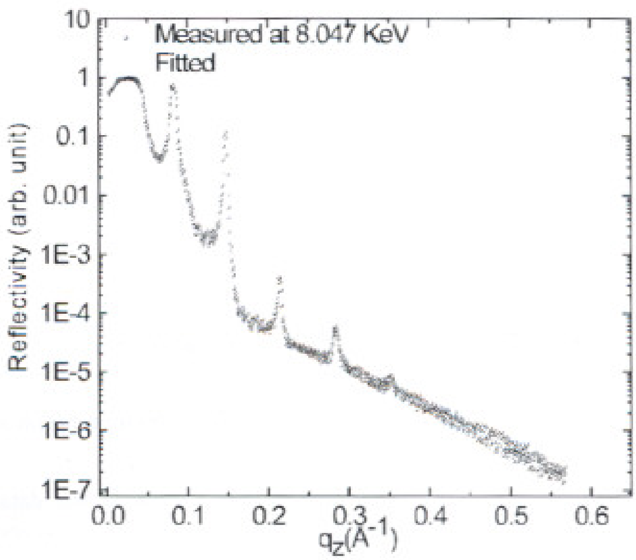

***Fig. A.9.1** X-ray reflectivity of Mo (30Å)/Si (60Å) ML with N=30 at 8.047 KeV. The best-fit results reveal Si roughness is 8 Å and Mo roughness is 10 Å*

The actual performance of MLs is tested using reflectivity beamline on Indus -1 SR source. Fig.A.9.2 shows, wavelength dependent reflectivity of Mo/Si ML at 46^{0} incidence angle. 45 % reflectivity with spectral bandwidth 2.9 Å is achieved for this ML. Fig. A.9.3 shows, the measured Bragg peak reflectivity for 115 to 160 Å wavelength using Indus -1 SR. The reflectivity decreases drastically below Si L-absorption edge (~124Å). ML has good reflectivity at Brewster angle (close to 45^{0}) and can be used as XUV polarizor for Indus -1 SR. These polarizers have wide application in XUV ellipsometry.