A.4 Indigenous development & batch production of UHV components for Indus-2

A.4.1 Photon absorbers

Photon absorbers are installed in the down stream of bending magnet chambers in Indus-2 to absorb non-experimental synchrotron radiation. Grazing incidence water-cooled photon absorber (without any water to vacuum joint) were designed & developed to dissipate the high power density of $10.5 kW/cm^2$ (normal incidence). Fabrication of helium leak tight UHV compatible assembly of photon absorber is an important task in the fabrication of UHV system of Indus-2. The success of assembly requires special considerations at various stages like geometry design, FEM thermal analysis, material testing, profile machining on CNC, vacuum furnace brazing & quality assurance. There are 64 such photon absorbers (4 in each BM chamber) mounted in Indus-2 storage ring. 80 nos (keeping 16 spares) were planned for production in 5 batches. So far production of 4 batches has been completed & 5^{th} one is in progress. Photograph of a typical photon absorber is shown in fig. A.4.1.

Fig. A.4.1 Photon Absorber for Indus-2

A.4.2 RF-shielded bellow assembly

The radio frequency (RF) shielded bellow assembly has been designed & developed for the Indus-2 electron storage ring. The RF-shield is a usual finger type but has a special cantilever type spring-finger to press the contact finger to the beam tube. It is a flexible mechanical structure that maintains good electrical contact between adjoining Al-alloy vacuum chambers while absorbing the thermal expansion during beam operation or baking.

It reduces the excitation of higher order modes, ensures smooth flow of image (wall) current. Critical stages in the development of RF-shield are: design and FEM analysis, wire-cutting and forming, precipitation hardening, heat-treatment in vacuum furnace and plating. 44 bellow assemblies are required to be installed in Indus-2. The photograph of a typical RF-shielded bellow assembly is shown in fig.A.4.2.

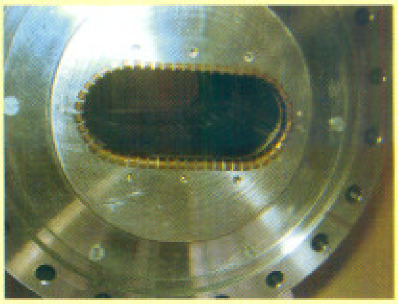

Fig. A.4.2 RF-shielded bellow assembly for Indus-2

A.4.3 Diamond seals

A highly reliable & low cost UHV compatible Al-alloy gasket called "diamond seal" has been designed and developed for connecting Al-alloy vacuum chambers (homogeneous joints) as well as vacuum chambers to auxiliary UHV hardwares like stainless steel (SS) ion pump, gauges and bellows etc (heterogeneous joints). Material of construction for these seals is Al6063-T5. So far, 300 Nos in various sizes have been successfully produced and are ready for use. Sketch of a typical UHV demountable joint, consisting of diamond seal is shown in fig.A.4.3.

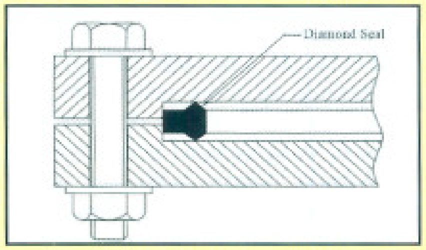

Fig. A.4.3 Diamond Seal for Indus-2

(Reported by: D P Yadav; dpyadav@cat.ernet.in)

A.5 Grazing incidence hard x-ray reflectometer

Grazing incidence x-ray reflectivity technique is a non-destructive method for the characterization of surfaces and interfaces on atomic scales. X-ray reflectivity (XRR) profiles are extremely sensitive to film thicknesses, layer compositions and interface roughness. To measure XRR, one needs a collimated radiation of a low angular divergence along with the precise control over incident and exit angles ($\approx 0.001°$). The large dynamic range ($\geq 10^5$ counts) is required to scan the large angular range and that needs the high intensity x-ray source. In brief, to realize a complete XRR setup one requires precise goniometer, high intensity source, beam collimator, detector and monochromator and finally the skill to put them all together in a specific manner.

In CAT, the grazing incidence reflectometry work was started with the aim to install the experimental system on reflectometry beamline in Indus-1. In view of that, before Indus-1 commissioning, the reflectometry station was set on a CAT developed rotating anode x-ray generator (RAX). It was aimed to rebuild the same after commissioning the beamline on Indus-1 via purchasing the new hardware. The system was successfully commissioned on RAX and later moved to Indus-1 beamline. Presently the new XRR system is under commissioning and soon will be available in new shape. Here we describe our experience with grazing incidence reflectivity setup installed on RAX. Significant effort had been made to use the hardware developed indigenously or available in the local market.

In CAT XRR system, for carrying out the θ-2θ rotary motion of sample and detector, a goniometer had been fabricated using the two rotary stages. Stepping motors had been used to drive the stages in micro stepping mode. For accurate positioning of rotation axes relative to each other the stages were mechanically pre-aligned on a co-ordinate measuring machine. For moving the sample in and out of the beam a linear translation stage is mounted on sample rotation stage.

For an initial experiment, due to geometrical constraints, the reflectometer system was set on a point source window of RAX. The whole goniometer system was geometrically aligned in 8° configurations by adjusting the height corresponding to x-ray take off angle. Fig. A.5.1 shows the schematic of x-ray reflectivity setup with a grazing incidence monochromator. A beam of 0.05 degree angular divergence was generated using a 150μm slit before the sample. Sample holder with the spring loading mechanism was used to maintain the sample surface at the axis of the goniometer. An exit arm monochromator using a graphite crystal was set to record the reflected Cu K_α(λ=1.54Å) radiation. A large rocking- curve- width graphite crystal (0.24°), allowed using a low precision manual rotary mount. The graphite crystal was set to diffract 1.54Å (Cu K_α) and a GM counter was employed to detect the radiation. The small count rate-handling capacity (3000c/s) of GM detector forced us to measure large dynamic range of reflectivity pattern in different power settings of RAX.

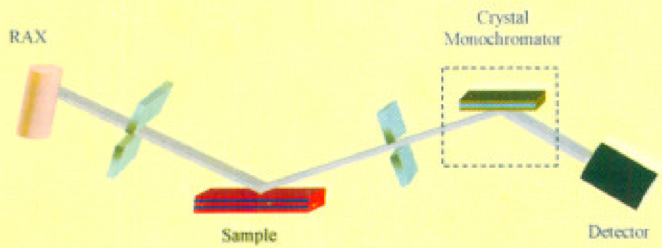

Fig. A.5.1 Schematic of x-ray reflectivity setup using exit arm monochromater

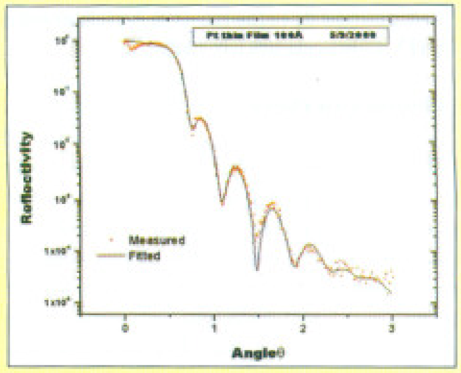

Fig. A.5.2 XRR spectra of Pt thin film (100Å) deposited on float glass. Continuous curve represents the fitted spectra. Reflectivity is measured at λ=1.54Å

The test experiments of x-ray reflectivity were carried out on thin film and multilayer samples. Representative reflectivity measurement of 100Å Pt thin films is shown in fig. A.5.2. In this samples the interference fringes corresponding to 100Å film thickness were recorded. This measurement was performed with tube parameters of 30kV, 30mA. Due to footprint effect at extreme grazing angle on finite size sample, a dip in reflectivity pattern near the zero degree was observed. The reflected intensity was normalized to incident intensity, for obtaining the absolute reflectivity.

Presently efforts are underway to commission a new XRR system in CAT. The hardware required has already been procured. The required mechanical attachments are fabricated. This new system is being commissioned on a new sealed tube x-ray source.

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A.6 Total reflection x-ray fluorescence spectrometer

Total reflection x-ray fluorescence (TXRF) spectrometry is a modern technique for the determination of ultra-trace amounts of elements in various kinds of samples. This technique is a variant of the well-established energy dispersive x-ray fluorescence (EDXRF) technique. The versatility of TXRF stems from: (i) the amount of sample needed is very small, (ii) detection sensitivities at sub-ppm level in relative terms and in picograms in absolute mass levels, and (iii) ability to do surface characterization of thin films and surfaces. In TXRF, the primary x-ray beam excites the specimen at a glancing angle less than the critical angle thereby exploiting the effect of total reflection of x-rays. This mode of x-ray fluorescence excitation eliminates the large Compton scattering of the primary x-ray beam from the sample bulk, which is the major limiting factor for