ACCELERATOR PROGRAM

A.1 Soft and deep X-ray lithography (SDXRL) beamline on Indus-2

Synchrotron radiation sources, with their high brightness and high photon flux, are useful for high spatial resolution (~100nm) X-ray lithography (E~1.5keV) and for the fabrication of high aspect ratio (~100-1000) three-dimensional structures (E ~ 4-20keV). It is proposed to install soft and deep X-ray lithography (SDXRL) beamline on Indus-2. Application includes, the fabrication of hard X-ray optics, micro machining devices, photonic band-gap crystals, quantum wires and quantum dots devices, 3D microstructures, and MEMS related sub-components. Optical design of the beamline is completed [CAT-2004 –12].

***Fig A.1.1** Optical design of SDXRL beamline on Indus-2*

Optical layout of the SDXRL beamline is shown in fig. A.1.1. The beamline can also operate in no optics mode, with mirrors moved out of the beam path. The beamline optical elements consist of a plane mirror and a torroidal mirror. The angle of incidence on these mirrors, in combination with the filters defines the energy window. Energy spectra at various incidence angles and in no optics mode are shown in fig. A.1.2. The horizontal and vertical acceptances of the beamline are 5mrad and 1mrad respectively. Beamline performance is optimized on the following parameters: run out error (< ± 2.1mrad), penumbral blur (< ± 0.8mrad), power delivered at wafer location (5-75 mW), beam size at sample/mask (55 (H) x 2 (V)mm^2) and horizontal intensity uniformity (< ±3%). Detailed ray tracing calculations of the beamline optics are done using software packages RAY and SHADOW and power calculations are done using XOP modules.

Using the beam line configuration with mirror(s) angle $q_1 = 1.7^0$ and $q_2 = 1.75^0$) aerial image formed at mask-wafer stage is shown in fig. A.1.3. Beam size is enlarged at mask-wafer stage by scanning X-ray stepper/scanner in vertical direction. Considering beamline acceptance and performance, mirror sizes are limited to 100mm (width) and 750mm (length). Surface roughness values of 3Å, 5Å and 10Å for mirrors are used to study its effect on image at the mask-wafer stage. Effect of slope errors (0 to 271mrad) in meridional plane, on beam image are simulated. Torroidal mirror misalignments (0-1000 mm in translation and 0 to 207 seconds in rotation) and their effects on beam shape and size are simulated.

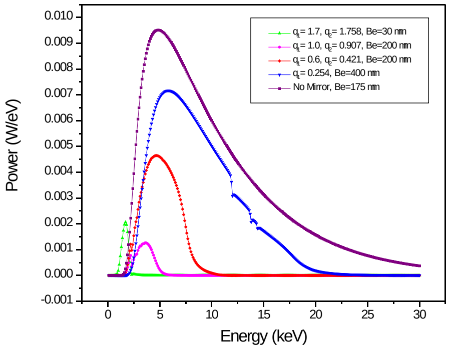

***Fig. A.1.2** Energy-power spectrums offered by SDXRL beamline for various mirror angle settings*

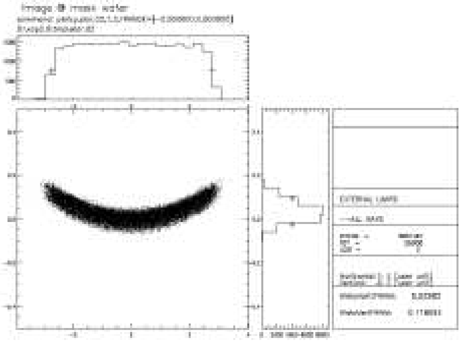

***Fig. A.1.3** Spot diagram of beam image at mask wafer stage grazing incidence angles of plane mirror (q_1 = 1.7^0) and torroidal mirror (q_2 = 1.75^0).*

The calculations are done by considering 300mA beam stored in Indus-2 storage ring at 2.5GeV with 5mrad horizontal acceptance and vertically integrated power.

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A.2 Growth of CuO and FeO nanorods

Quasi one-dimensional nanostructures, such as nanowires and nanorods have attracted great attention during past few years due to their unique physical, chemical and electronic properties and for their potential applications in the field of nanodevices, field-emitters, and catalysts. For commercial exploitation of these nanoscale structures, it is necessary that the technique used for their growth is reproducible and simple, which still remains a challenge. CuO is an indirect band semiconductor and its nanorods exhibit large field emission and catalytic properties. Over the past couple of years nanorods of CuO have been produced by