ONE-DIMENSIONAL SCALING WITHA MULTILAYER REFLECTING MASK

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The paper considers multilayer X-ray mirrors (MXM) application as multilayer reflective masks (MRM) for one-dimensional compression of a pattern applied to a mask.

The principle of operation is based on the fact that the visible dimension of a flat object depends on the angle of inclination (θ) of the object to the observer. Then the ratio of the visible dimension (tb) of the object to the real size (t_m) can be written as $t_b/t_m = \sin\theta$. Therefore, if we direct X-rays to a MRM at an grazing angle, we will get an image of this plane shrunk in one dimension at a plane perpendicular to the reflected beam.

The reflective mask is a W/Si MXM (with a period d~2.5 nm) on a glass substrate with a pattern of absorbing material deposited on top of the MXM. The pattern was formed by depositing a relatively thick coating of W through a flat grid with rectangular holes ~50 μm separated by walls ~50 μm.

The MRM was irradiated in the synchrotron center, Lund, Sweden, in white radiation. The wavelength range of the incident beam is λ = 0.25-0.45 nm, the grazing angle of incidence on the MRM was 4°. A one-dimensionally compressed image of the pattern on the MRM was printed on a SU-8 photoresist, which was located at a distance of L~40 mm from the mask. The picture obtained upon irradiation with an MRM is walls ~50 μm in size, which are formed when radiation is reflected from regions lying in the plane of incidence of radiation, and a shrunk image with a characteristic element size of 4.3 - 6 μm at the perpendicular plane. The reduction is at least 8 times compared to the original size of the mask elements.

We also took into account the diffraction effects estimating the actual size of the compressed element. So, the real size of the compressed element will be $t_b=t_m\times\sin\theta + 2L\lambda/\sin\theta$; or taking into account Bragg's law ($2d\sin\theta=n\lambda$) – $t_b=\lambda\times t_m/2d + 2Ld/t_m$. Taking into account this formula and the real dimensions of the mask, the size of the elements on the photoresist will be 11.5 microns. Consequently, the experimental decrease is at least twice the calculated one.