Multilayers for soft X-rays and extreme-UV applications from Institut d'Optique- Orsay

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The aim of the Physic of Thin Films research group of the Laboratoire Charles Fabry de l'Institut d'Optique is to elaborate multilayers for X-ray optics and to study their properties from a Materials Science point of view.

We focus our research on multilayer applications in the very low energy range (E<100 eV, λ >10 nm) for optics needed by new X-ray sources (3rd generation synchrotron, laser X, high order harmonics generation) and for X-ray spectroscopy of the solar corona in astrophysics, and also at higher energies (E<1 keV, λ > 1 nm) for quantitative X-ray analysis of light elements.

Mo/Si and B/Si multilayers with spacings ranging from 4 nm to 30 nm are currently deposited in a new designed UHV reactor which allows both ion sputtering and electron beam deposition technics. The layer thickness and spacing reproducibility is controlled by an *in-situ* soft X-ray reflectometer coupled with a quartz crystal microbalance. The deposition chamber is typically cryo-pumped until the residual pressure is in the 10^{-9}– 10^{-10} mbar range. Ultra-high purity targets and crucible loads are used to sputter and evaporate the materials. The equipment is implemented in our new cleanroom (class 1000).

The optical index profiles and the multilayer spacings are deduced from the reflectance measurements at several wavelengths with a classical X-ray tube (CuKα ; λ= 0.154 nm) and on the SA23 beam line of superACO storage ring at LURE–Orsay in the energy range E= 50-100eV.

Moreover, atomic thicknesses and contamination of the different layers are determined with nuclear technics (Rutherford Backscattering Spectrosopy and Nuclear Reaction Analysis) and correlated to the geometric thicknesses given by X-ray reflectometry). The quality of the interfaces is observed by cross-sectional TEM. The stresses in the multilayers are deduced from interferometric measurements of the substrate curvature.

By using all these technics, we produce B/Si multilayer mirrors which present a reflectivity of R= 25 % for a 30° glancing angle at a photon energy of 98 eV (λ = 12.6 nm). In the same way, we deposit Mo/Si multilayers and obtain Bragg-Fresnel lenses to focuse laser X beam at 34 nm and 13.9 nm respectivally. We also explored the feasability of beam splitters for X-ray interferometry by depositing Mo/Si multilayers on 0.1 µm thick Si_3N_4 membranes. Finally, narrow band pass monochromators could be processed by etching a linear 0.3µm/1µm grating in Mo/Si multilayers with spacing of 9 nm.

The present report puts forward all of the above and also other results obtained in our multilayer mirrors study.