Multilayer X-ray gratings with High Efficiency in the 1-5 keV Energy Domain

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Covering a grating with a multilayer (ML) coating, in order to increase the grazing angle and access higher X-ray energies, is not a new idea. However a ML coated grating is a thick object with respect to X-ray propagation, and its diffraction properties cannot be deduced by a simple combination of the ML reflectivity and the diffraction pattern of the surface relief. On the contrary, peculiar diffraction properties occur from the fact a ML grating structure behaves as a 2D periodic structure with a strong coupling between the two directions of diffraction.

Though practical optimization is not possible without an electromagnetic propagation code, the condition for the reinforcement of a selected diffracted order can be deduced from simple crystallographic considerations. A maximum efficiency in first order can be predicted when the material distribution in the unit cell is antisymmetric. Experimental efficiencies of 15% have been measured on Mo/Si gratings at 1.4 keV. Calculations of the first order efficiency of a perfect Mo/ B_4C ML grating yield values over 30 % around 2 keV. The maximum theoretical efficiencies closely follow the transmission of the high index material and generally increase with the energy. However the dimension of the required structure follows the wavelength and adds difficulties to control the manufacturing process for highest performances.

SOLEIL synchrotron has included the ability of using ML gratings in several monochromators. We will review the progresses made toward their implementation.