

Design, fabrication and characterization of highly efficient multilayer blazed gratings for the tender X-ray region

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Multilayer-coated blazed gratings (MLBG) are very promising optics for high flux grating monochromators that can cover the tender X-ray range ($E=1.5-3.5$ keV). To achieve the maximum efficiency, the exact relation between the multilayer d-spacing and the grating blaze angle was studied by numerical simulations. The results significantly deviate from the one predicted by conventional equations with the assumption of an “on-blaze” operation mode of the grating. The effect of multilayer interface imperfections, and the relations between grating resolution, acceptance and the d-spacing were also investigated. In order to verify the simulations, three MLBGs with a line density of 2400 l/mm and blaze angles of 1.0° , 0.8° and 0.6° , respectively, were fabricated by mechanical ruling and an subsequent ion etching process. These gratings were coated with the same Cr/C multilayer with a d-spacing of 6.3 nm. The d-spacing matches the blaze angle of 1.0° as it was found by the new simulation. The multilayer on the blazed grating structure replicated the grating profile with negligible smoothing, as observed by transmission electron microscopy and by AFM. This can be attributed to the gradual variation of the grating profile generated by the particular manufacture process. The tender X-ray measurements of the MLBG with 1.0° blaze angle showed a record efficiency reaching 60% at 3.1 keV and 4.1 keV. All three gratings exhibited an efficiency tendency as predicted by our calculations. The experimental results prove the validity of the numerical simulations which indicates a more rigorous way to design the optimal MLBG structure.