Highly efficient multilayer-coated blazed gratings for tender X-ray energy range

Andrey Sokolov[(1)], Qiushi Huang[(2)], Friedmar Senf[(3)], Jiangtao Feng[(2)], Stephanie Lemke[(1)], Svyatoslav Alimov[(1)], Jeniffa Knedel[(1)], Oliver Kutz[(1)], Tino Seliger[(1)], Grzegorz Gwalt[(1)], Franz Schäfers[(1)], Frank Siewert[(1)], Igor V. Kozhevnikov[(4)], Runze Qi[(2)], Zhong Zhang[(2)], Wenbin Li[(2)], Zhanshan Wang[(2)]

andrey.sokolov@helmholtz-berlin.de

(1) Helmholtz-Zentrum Berlin für Materialien und Energie, BESSY-II, Albert-Einstein-Str. 15, 12489 Berlin, Germany
(2) Key Laboratory of Advanced Micro-Structured Materials MOE, Institute of Precision Optical Engineering, School of Physics Science and Engineering, Tongji University, Shanghai 200092, China
(3) Institute for Physics and Astronomy, Potsdam University, Karl-Liebknecht-Str. 24 – 25, 14476 Potsdam, Germany,
(4) Shubnikov Institute of Crystallography of Federal Scientific Research Centre "Crystallography and Photonics" of the Russian Academy of Sciences, Leninskiy pr. 59, Moscow 119333, Russia

Multilayer-coated blazed gratings (MLBG) are very promising optics for high flux grating monochromators that can as well to cover the tender X-ray range (E=1.5-3.5 keV) which is difficult for commonly used single coated diffraction gratings or crystal monochromators. 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, several MLBGs prototypes with a line density of 2400 l/mm and different blaze angles were fabricated by mechanical ruling and subsequent ion etching process. These gratings were coated with Cr/C and Ni/B_4C multilayers with a several d-spacing values. The ML d-spacings was matched by optimization in each case for the blaze angle and selected diffraction conditions. The deposited multilayers on the blazed grating structure replicated the grating profile with negligible smoothing, as it was observed by transmission electron microscopy and by AFM. The tender X-ray measurements of the MLBGs shows a record efficiency reaching up to 60% [1]. The experimental results prove the validity of the numerical simulations which indicates a more rigorous way to design the optimal MLBG structure. Basis on collected data a real MLBG were produced for X-ray microscopy beamline at BESSY II.

[1] Andrey Sokolov, Qiushi Huang, Friedmar Senf, Jiangtao Feng, Stephanie Lemke, Svyatoslav Alimov, Jeniffa Knedel, Thomas Zeschke, Oliver Kutz, Tino Seliger, Grzegorz Gwalt, Franz Schäfers, Frank Siewert, Igor V. Kozhevnikov, Runze Qi, Zhong Zhang, Wenbin Li, Zhanshan Wang "Optimized highly efficient multilayer-coated blazed gratings for the tender X-ray region" Opt. Express 27(12), 16833-16846 (2019)