Recent improvements in soft x-ray multilayer diffraction gratings

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In recent years the development of multilayer gratings is of increasing interest for soft x-ray optical monochromator and spectrometer applications. The multilayer coating of phase gratings provides diffraction efficiencies which make the operation of gratings at (near) normal incidence angles reasonable. Any deviation, however, of the groove profile from ideal shape will redistribute the efficiency within the diffraction orders, while irregularities like ruling errors and microroughness will increase straylight between the regular diffraction peaks and reduce multilayer reflectivity, respectively. The goal of our work is to improve multilayer diffraction gratings towards higher diffraction efficiencies, lower stray- light and high ruling density. Mo/Si multilayer coatings were deposited by electron beam evapo- ration at UHV conditions onto a ruled blaze grating (1221 L/mm) and a holographically recorded sinusoidal grating (6600 L/mm). The surface topography of the gratings have been studied by Atomic Force Microscopy (AFM) before and after the multilayer coating procedure. Besides for groove geometry characterization these measurements were evaluated with respect to surface mi- croroughness and groove efficiency. The monochromatic diffraction efficiency has been measured by the use of Synchrotron Radiation from the Berlin electron stora- ge ring BESSY. For the multilayer blaze grating coated with 20 Mo/Si bilayers of 10.5 nm period thickness a very high +1st order diffraction efficiency of 32% (with respect to the incoming intensity) at 13.8 nm wavelength has been measured, which can be explained by the perfect matching of the multilayer period thickness (10.5 nm) and the blaze angle (0.80) as well as a low facet surface roughness due to a refined groove forming technique, which has been measured by AFM to be 0.5 nm (r.m.s.). In the case of the multilayer sinusoidal grating coated with 18 Mo/Si bilayers of 8.5 nm thickness we have measured 11% absolute diffraction efficiency at 13.1 nm wavelength in (both) first diffraction orders. Due to the high ruling density, which is near the limit of UV lithography, this grating has the capabili- ty for high resolving power even at (near) normal incidence.

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2. U. Kleineberg, H.-J. Stock, A. Kloidt, K. Osterried, D. Menke, B. Schmiedeskamp, U. Heinzmann, D. Fuchs, P. MŒller, F. Scholze, G. Ulm, K. F. Heidemann, B. Nelles; J. Electr. Spectr. Rel. Phenom. (in press)