Determination of the layered structure in Mo/Si multilayers using a laterally graded multilayer

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The composition of multilayer coatings can be derived from grazing incidence x-ray reflectometry (GIXR) via simulations of the multilayer reflectivity and comparison with the experimental data. The general disadvantage of the curve fitting method used, namely the probability of finding local minima in the fitting procedure, can be solved by specially designed computer algorithms that allow to find a global minimum [1]. However, since these fitting procedures are based on simplified theoretical models, the global minimum does not necessarily have to correspond to the real parameters of the multilayer structure. Moreover, close to best fits can be obtained for different sets of parameters due to the basically under-determined nature of the problem.

A solution to this consists of using an increased number of experimental points from different sets of multilayers produced in the same experimental conditions but with a small, controlled variation of one of the parameters in every set. This allows one to obtain data on the influence of those parameters, and, thus, in the simulations to distinguish between different parameters that may have the same effect on the GIXR reflectivity. We have applied this method in determining the multilayer period composition, including thicknesses and optical constants of individual layers [2]. To this end a laterally graded multilayer was used, where only the thickness of the spacer layer was varied. The well known modulation of the Bragg peak intensities of 0.154 nm x-rays was then used to determine the thickness and the composition of the silicides formed at the boundaries.

The method was applied in the investigation of Mo/Si multilayers produced by e-beam evaporation and ion-beam smoothening. The impact of the polishing conditions on the thickness and composition of the intermediate layers was investigated, showing that 0.8-1.6 nm thick interlayers are formed at the boundaries depending on the energy of the polishing ions. According to the optical indices found, the interlayers consist of a Mo_5Si_3+$MoSi_2$ mixture or pure $MoSi_2$ depending on the energy of the polishing ions. The study allowed optimization of the composition of Mo/Si multilayers for use at near-normal incidence in the 12.5 to 15 nm wavelength area for Extreme UV Lithography.

1. S. Kirkpatrick, M.P. Vecchi, Science, vol. 220, p.4598 (1983)
2. A.E. Yakshin, E. Louis, P.C. Görts, E.L.G. Maas, and F. Bijkerk, Phys. B. (subm.)