Broadband stack mirrors for the EUV range: calculation, manufacturing and characterization.

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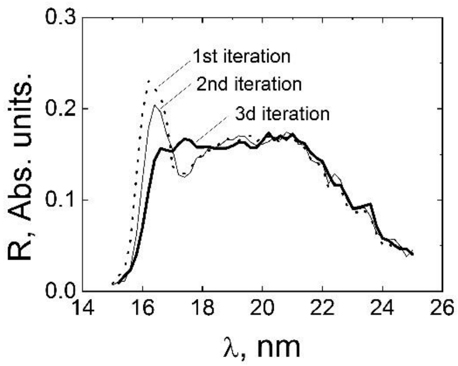
We studied aperiodic broadband Mo/Si structures for the KORTES Sun Study Facility currently being developed for the ISS. The complex of KORTES equipment contains a spectroheliograph, which allows recording the emission spectra of solar flares, micro flares and coronal mass ejections. The spectral range of the instrument is determined by its broadband focusing X-ray mirror. In this regard, it is necessary to develop and manufacture a mirror with the maximum uniform reflection in the spectral range of 17–21 nm. For the purpose we have designed and experimentally studied "stack" broadband Mo/Si mirrors, composed of some different periodic mirrors deposited on to each other.



Mathematically searching for optimal mirror parameters is minimizing the functional $F = \int [R(\lambda) - R^{target}]^{2m} d\lambda$, as a function of layers' thicknesses and the numbers of periods in different stacks. $R(\boldsymbol{\lambda})$ here is a reflection curve and R_{targ} is the target function (plateu) which is chosen as a compromise between the height and smoothness of the reflection curve. The optimisation was carried out using the differential evolution algorithm implemented in the Multifitting program [1]. Optimized structure composed of 3 periodic mirrors of 32, 3 and 3 pairs of Mo and Si and a protective layer of 1.4 nm Si on the top. The periods was equal to 9, 8.8 and 11.2 nm.

Samples were prepared by the method of magnetron sputtering in an argon atmosphere at a pressure of 10^{-3} Torr. The mirrors reflection characteristics were studied on a reflectometer developed by the authors. It is equipped with a high-resolution Czerny–Turner spectrometer with a flat diffraction grating and two spherical collimating mirrors for monochromatization [2]. The source of X-ray radiation was a highly ionized plasma generated by a high-power laser radiation impact on a solid-state target. Scanning over spectrum was performed by rotating the diffraction grating. If the measured reflective characteristics of the mirror differ from the calculated values, it is necessary to define the mirror's real parameters in order to correct the technological process [1]. In practice, the production of multi-layered mirrors is an iterative process, so a quick and proper characterization of mirrors comes to the fore. For Mo/Si stack structures composed of three periodic mirrors deposited on each other, it is possible to achieve uniform reflection at the level of 16% in the spectral range of 17–21 nm with a good reproducibility. We also used this methodology to develop a Mo/Be structure. This broadband mirror consists of 6 periodic mirrors and operates in the range of 11.1 - 13.8 nm with reflection at the level of 12%. The studies have proven that stack mirrors are preferable to conventional "stochastic" aperiodic mirrors in terms of the certification and the speed of the production.

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[1] Svechnikov M., Pariev D., Nechay A., et al. J. Appl. Cryst., 50, 1428 (2017)

[2] Garakhin S. A., Zabrodin I. G., Zuev S. E. at al. // QUANTUM ELECTRONICS // V. 47, № 4 (2017), p. 385-392