Beryllium-based multilayer mirrors for EUV spectral range

N.I. Chkhalo, V.N. Polkovnikov, N.N. Salashchenko, M.V. Svechnikov, Yu.A. Vainer, S.Yu. Zuev

Institute for Physics of Microstructures of RAS, Nizhny Novgorod 603950, Russia

The development of reflective optics is subject to continuous improvement of the optical properties of the multilayer mirrors MLM. To date, almost all of the MLMs for EUV range (10-40 nm) reached or almost reached the limit values of the reflection coefficients. Of course, this statement refers to the well-known and used in practice combinations of materials.

Improve the performance of structures through the use of some additional methods (barrier layers, ion polishing, ion assisting) is possible, but it can hardly give a substantial effect. It is, in particular, the increment of reflection coefficient for a few percent. Of course, even such a gain is very important for many applications.

Typically, the transition to a qualitatively new level occurs when using new materials. In this work as a basis for design effective MLMs are encouraged to apply beryllium.

There are about 10 published papers in the literature, which are devoted to Mo/Be, Rh/Be and Ti/Be MLM and where Be is considered only as spacer. Our theoretical calculations show that while the wavelength lies in range 11-17 nm Be is only a spacer, but in the 17-40 nm region, it may be considered as a scattering material with the little, “spacer-like” absorption. The combination of these physical properties results in unique X-ray optical properties; particularly theoretical Be/Al, Be/Mg and Be/Si MIS have a maximum reflectance of more than 70%, and a high spectral selectivity at the same time. Equally high reflection coefficients are achievable near the wavelength of 11.2 nm (MLMs Mo/Be, Ru/Be).

In this work we focus primarily on the performance of EUV multilayers based on beryllium (Be/Al and Be/Si/Al) for use in solar physics, specifically in high-spectral-resolution instruments employing normal-incidence mirrors.

Film deposition was carried out by DC magnetron sputtering. Deposition was carried out in an argon environment. The mirror reflectivity in the EUV range was measured using a reflectometer with grazing incidence spectrometer with a spherical grating RSM-500. Structure parameters (viz. period, individual layer thickness, density, transitional layer width) were determined from measurements on a diffractometer Philips X’Pert Pro at a wavelength $\lambda = 0.154$ nm.

As results, we note the following. Firstly, it is shown that, judging by the behavior of the optical constants in the wavelength range 17-40 nm, Be can be used as the scattering material rather than as a spacer. This conclusion was confirmed experimentally. We received a record reflectance (up to 60%) with spectral selectivity $\Delta\lambda_{mirr} = 0.4$ nm. Secondly, the efficiency of application Si interlayers on the boundary of Be-Si-Al (in the structure of Be/Si/Al), which have increased reflectance in the 17 nm to 43 to 60%, is shown. Taking into account the long-term stability of Be/Al multilayer structures, there weren’t changes in reflectance at a wavelength of 17.14 nm within 1 year after deposition, we can confidently expect that the structure of Be/Al can be competitive in the longer wavelength region.

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