Two channel EUV mirror for solar missions: design, performances and stability

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Among future solar missions, the Solar Orbiter mission of the European Space Agency (ESA) in the framework Cosmic Vision program plans to study the surface of the Sun with an orbit that comes up to 0.2 astronomic units. The Sun gives a discrete emission spectrum where each emission lines is linked to the temperature of ionised materials, for example FeXX-XXIII at $\lambda = 13.3$ nm (eruptions $1.6\ 10^7$K), FeX at $\lambda = 17.5$ nm (quiet corona ~$8\ 10^5$K), FeXII at $\lambda = 19.5$ nm (quiet corona ~$1.5\ 10^6$K), HeII at $\lambda = 30.4$ nm (cold corona $5\ 10^4$K) and FeXVI at $\lambda = 33.5$ nm (active regions $2.5\ 10^6$K). For these wavelengths, it is necessary to get for the EUV optics the highest reflectivity and a good spectral selectivity. In order to reduce the mass of payload instrumentation and to limit the diameter for the entrance aperture in the heat shield, we have developed some multilayer coatings which can select two emission lines with high rejection of unwanted lines.

We present here the design method, the performances and the stability of these two channel mirrors. A three component multilayer mirror [1] is used as nominal structure. This structure increases reflectivity in the spectral range 20-40 nm compared to Mo/Si basic structure, and can provide a high reflectivity in two consecutive Bragg order peak. This kind of coatings has already been qualified in thermal cycling and wet atmosphere [2] and realised for the rocket mission Herschel [3].

When the two emission lines match two consecutive Bragg's order, one can design a two channel mirror by choosing an appropriate periodic multilayer. For example, we have designed, performed and measured a mirror with 2nd order Bragg peak at 19.5 nm and 3rd order at 13.3 nm.

When the two emission lines do not match exactly consecutive order, we propose a design method based on a superposition of two periodic multilayers. We have shown that this solution allows to adjust the wavelength position of the two reflectivity peaks and also to efficiently reject unwanted emission lines. Several dual channel mirror were designed and deposited: 17.1 nm & 30.4 nm (cut off 33.5 nm) and 17.5 nm & 33.5 nm (cut off 30.4 nm). Their performances have been measured on Trieste Synchrotron and are very close to theoretical simulations. The stability of such two channel mirror has been evaluated under thermal cycling and wet atmosphere.

[1] J. Gautier et al « Study of normal incidence of three-component multilayer mirrors in the range 20-40nm » Applied Optics vol44, N°3, 384 (2005)
[2] Ch. Hecquet et al, « Design, conception, and metrology of EUV mirrors for aggressive environments », SPIE Proceedings Vol: 6586 (2007)
[3] F. Auchère et al. « HECOR: a HElium CORonagraphy aboard the Herschel sounding rocket », SPIE Proceedings Vol. 6689 (2007)

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