Recent results in solar imaging using ion beam sputtered multilayers

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Periodic molybdenum/silicon multilayers were previously deposited by using the ion beam sputtering technique on the four quadrants of the SECCHI/STEREO/EUVI telescopes [1] for the selection of Fe IX (λ= 17.1 nm), Fe XII (λ= 19.5 nm), Fe XV (λ= 28.4 nm) and He II (λ= 30.4 nm) emission lines of the solar corona. STEREO was launched on October 25, 2006 and the first images delivered by both EUVI-A and EUVI-B telescopes were obtained in December 2006. In France during his meeting held at Orsay (march 6-8, 2007) the SECCHI/STEREO consortium leaded by Naval Research Laboratory could conclude that the performances of the optics coated with multilayers were nominal. The SECCHI data are now all freely available from NRL[2], from the Stereo Science Center[3], and from IAS[4]. IAS is also involved in the scientific analysis of SECCHI data.

Since STEREO/EUVI a new kind of three-components multilayer periodic structure B_4C/Mo/Si has been developed[5]. This structure was qualified for the first time on HECOR for solar imaging application. HECOR (HElium CORonagraph)[6] is a coronagraph designed to observe the solar corona at λ=30.4 nm between 1.2 and 4 solar radii. The instrument is part of the Herschel sounding rocket payload to be flown from White Sands Missile Range in December 2007. The HECOR observations will provide novel diagnostics of the solar wind outflow. A dedicated multilayer coating was designed for the HECOR toroidal and off-axis EUV mirror. The thickness of each B_4C, Mo, and Si, layer was calculated in order to adjust the period, the bandwidth and the reflectivity. The off axis geometry implies that the quasi-normal incidence angle of the solar radiation onto the total surface is not unique and ranges between 85.94° and 88.84° (grazing incidence on the surface is 0°). The choice was made to get a constant reflectance on the total surface of the mirror at the nominal wavelength λ=30.4 nm with a uniform coating. The theoretical reflectivity of this structure is higher than 40% for N=10 periods and a variation of the reflectivity at λ=30.4 nm is lower than 0.2 % for the whole angular range. The so designed B_4C/Mo/Si multilayer was deposited by using the ion beam sputtering technique in a high vacuum chamber by using a mask for uniformity. The alternate deposition is provided by rotating the three boron carbide, molybdenum and silicon bulk targets (diam. 5") facing the rotating sample holder. The thickness uniformity is lower than ± 1% on the 60 mm mirror diameter. The EUV performances were measured for a reference sample under a 80° incidence angle on the BEAR beamline of the synchrotron facility Elettra at Trieste. The HECOR mirror witness samples were measured on the CEMOX reflectometer (Centrale de Métrologie des Optiques X at Orsay-France) which uses a plasma laser source. CEMOX data were normalized vs synchrotron data. The peak maximum position was within the ±0.2 nm margin and the reflectance was 32%±2%. The temporal and thermal performances of B_4C/Mo/Si HECOR multilayer were evaluated. No significant ageing effect was observed which allows to conclude that this coating is highly stable.

[1] M.F. Ravet et al.,"*Ion beam deposited Mo/Si multilayers for EUV imaging applications in Astrophysics"* in Advances in Optical Thin Films, C.Amra, N. Kaiser, H. Macleod, eds, Proc.SPIE Vol 5250, 99 (2004)

[2] http://secchi.nrl.navy.mil/

[3] http://stereo-ssc.nascom.nasa.gov/

[4] http://idc-medoc.ias.u-psud.fr/

[5] 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)

[6] F. Auchère et al « *HECOR, a HElium CORonagraph aboard the Herschel sounding rocket»* Solar Physics and Space Weather Instrumentation II, San Diego, 26-30 Août 2007, Proc SPIE 6689, (2007).

This work was performed under the auspices of CNES, the french space agency.