Fabrication of multilayer mirrors for the XUV Doppler telescope for solar corona observation

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We fabricated multilayer mirrors for the Solar XUV Doppler telescope which is presently being developed at the Japanese National Astronomical Observatory. The telescope will be launched with the 22nd S520CN-22 rocket in January, 1998. The telescope will be employed to observe the coronal velocity field of the sun by measuring Doppler shifts of the Fe XIV 21.1nm line. For this purpose, multilayer mirrors whose peak wavelengths are tuned to the two wavelengths shifted shorter and longer by 0.15nm from 21.1nm are used. In order to separate the two wavelengths, it is required that the multilayer mirrors have a high wavelength resolution of more than 20. The required reflectivity is more than 10%. We examined the optimum combination of materials for the multilayers and fabricated the multilayer mirrors.

We studied new combinations of silicon carbide/aliminun (SiC/Al) multilayers and popular combinations of molybdenum siliside/silicon (MoSi2/Si) multilayers. SiC/Al multilayers with a thickness period of 10.8nm, layer thickness ratio (SiC layer thickness over the thickness period) of 0.25 and 80 layerpairs were fabricated. MoSi2/Si multilayers with a thickness period of 11nm, layer thickness ratio (MoSi2 layer thickness over the thickness period) of 0.2 and 60 layer pairs were fabricated. The two kinds of multilayers were deposited by ion-beam sputtering on Si wafers. The measured reflectivity and the measured wavelength resolution of the SiC/Al multilayers were 12% and 36 at the wavelength of 21.1nm, respectively. And those for the MoSi2/Si multilayers were 15% and 26 at the wavelength of 21.1nm, respectively. For the purpose of the investigation of the long term stability of these multilayers, the multilayers were heated for 1hour at 573K in vacuum. The MoSi2/Si multilayers retained their periodic structure, but the SiC/Ai multilayers were destroyed. Therefore, we selected MoSi2/Si multilayers for the telescope.

The XUV Doppler telescope consists of a spherical mirror (primary mirror) and a plane mirror (secondary mirror). The primary mirror is doughnut shapedwith the diameter of 158mm and a radius of curvature of 1891mm. The diameter of the secondary mirror is 96mm. We graded the thickness period distribution in the direction of the radius using deposition masks. The thickness perioddistribution in the direction of the radius was adjusted within 0.2% from the target. To measure the Doppler shifts, it is required that the two peak wavelengths of the multilayers should be on either side of 21.1nm. The peak wavelengths of the multilayers were 20.98nm for the shorter wavelength and 21.28nm for the longer wavelength. The measured reflectivities and the measuredwavelength resolutions of the two mirrors were 15% and 26, respectively. To prevent the contamination of a bright He II line at the wavelength of 30.4nm which deteriorates the imaging performance of the telescope, we employed a single-layer antireflection coating (ARC) consisting of a Si layer with an optimized thickness on top of the multilayers. The reflectivity around the 30.4nm was suppressed to 1/500 of the peak reflectivity.

References

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