§10. Effects of Dust Related Materials on Optical Performance of Si Substrates

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First mirror, which is used for the observation of the plasma radiation in a wide wavelength range, have to survive in an extremely hostile environment and maintain the best possible performance throughout the entire lifetime of fusion reactor [1,2]. Because the performance of optical and laser diagnostic systems significantly depends on characteristics of the first mirrors, the first mirrors are important elements for diagnostics of fusion devices [2]. Therefore, we have to find methods to mitigation impurity deposition and erosion of mirrors and understand their mechanisms and any other factors that affect the mirror performance. Until now, we have found that the amount of dust particles, which are produced by plasma-wall interaction, can be reduced by using negative bias to substrates during the main discharges in the Large Helical Device (LHD) [3]. In this study, we have measured optical characteristics of Si substrates located on the first wall in LHD during 17th campaign.

Deposition experiments were carried out during an entire period of LHD 17th campaign. Low- resistance Si substrates (0.01-0.02 Ω • cm) were located at the first wall in 7O port. DC bias voltages were -70 V and 0 V with respect to the vessel wall. Surface area of the substrates faced to the plasma is 6 x 10 mm^2. After the deposition, their reflectance was measured in 200-2500 nm with a spectroscope. Their surface morphology was analyzed with an atomic force microscope (AFM).

Figure 1 shows reflectance of Si substrates. For both bias voltages, reflectance below about 500 nm in wavelength is lower than that for the initial Si substrate. The substrates biased -70V tend to have higher reflectance than the grounded ones. Negative bias potential attracts positive ions and repels electrons, negative ions and dust particles charged negatively [3]. Possible factors of this result are modification of carbon film properties caused by 1) the heat of recombination of H+ ions, 2) an increase of incident energy of H+ ions [4] and 3) reduction of dust particle deposition.

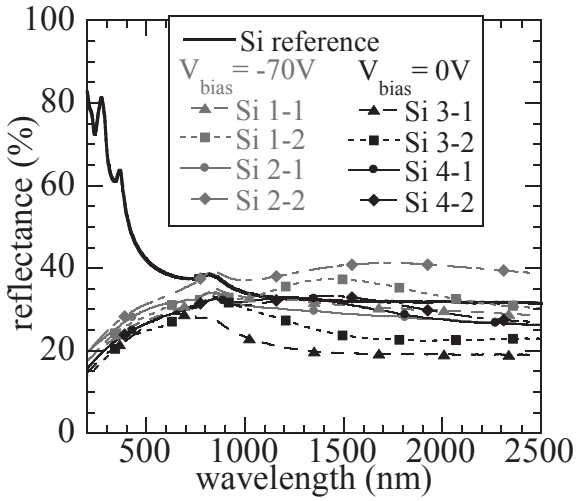

Fig. 1. Reflectance of Si substrates for V_{bias}= -70 V and 0 V.

We have analyzed these AFM graphics to find out the relationship between reflectance and surface of deposition on the substrates. We have obtained root-mean-square (RMS) roughness Rq of each surface of the deposition from these images. Reflectance is inversely correlated with Rq of the deposition on the Si substrates regardless of the bias voltage as shown in Fig. 2.

These results suggest that degradation of reflectance is suppressed by applying negative bias voltage to the substrates.

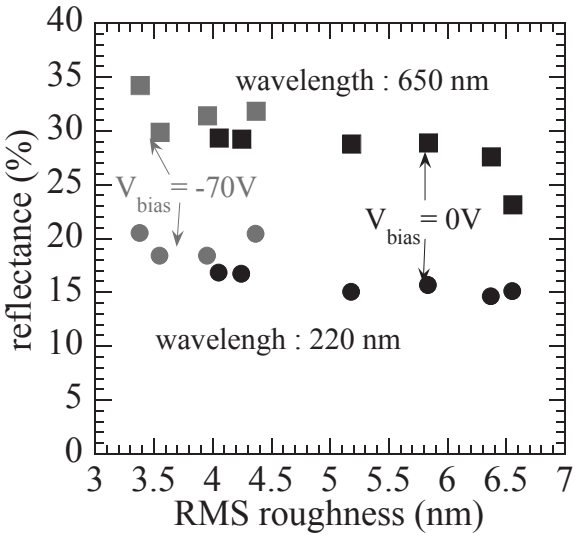

Fig. 2. Roughness dependence of reflectance.

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