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Effects of dust deposition on optical characteristics of substrates
基板の光学特性に対するダスト堆積の影響

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We have studied effects of dust deposition on optical characteristics of the substrate to realize long life time of optical equippements in fusion devices. We have measured reflectance of Si substrates set in LHD during an entire period of LHD 17th campaign. The degradation of optical characteristics of substrates has been suppressed by applying negative bias voltage to the substrate because the negative potential modifies fluxes of electrons, ions, and dust particles towered the substrate. We also have found that reflectance is inversely correlated with the surface roughness of the substrate irrespective of the bias voltage.

1. Introduction

In-vessel plasma-facing components have to survive in an extremely hostile environment and maintain the best possible performance throughout the entire lifetime of fusion reactor [1,2]. The first mirror is in-vessel metallic mirror which is used for the observation of the plasma radiation in a wide wavelength range. Because the performance of optical and laser diagnostic systems significantly depdend on characteristics of 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.

So far, we have found that the amount of carbon and metal dust particles increases with bias voltage of substrates for the dust collection during the main discharges in the LHD [3]. In this study, we have measured optical characteristics of Si substrates located on the first wall in Large Helical Device (LHD) during 17th campaign.

2. Experimental

Experiments were conducted during an entire period of LHD 17th campaign. LHD has divertor and first wall consisted of graphite and SS316, respectively. DC biased low-resistance Si substrates were located at 7O port as shown in Fig. 1. The DC bias voltages V_{bias} were -70 and 0 V with respect to the vessel wall. Surface area of the each substrate exposed to the plasma is 6x10 mm^2. Reflectance of each Si substrate was measured with a spectroscope. The substrate surfaces after exposure were analyzed with an atomic force microscope (AFM).

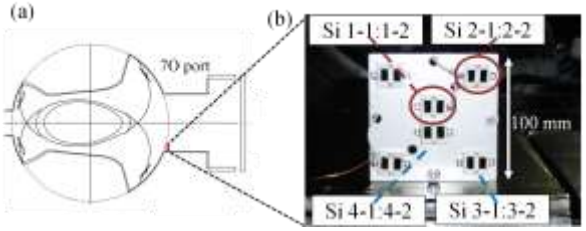

Fig. 1. (a) Cross-sectional view of LHD and (b) image of substrate folder (SS304). Substrates within red round in (b) were biased -70 V and the others were grounded.

3. Results and Discussion

Figure 2 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 [4,5] and 3) reduction of dust particle deposition.

Fig. 2. Reflectance of Si substrates

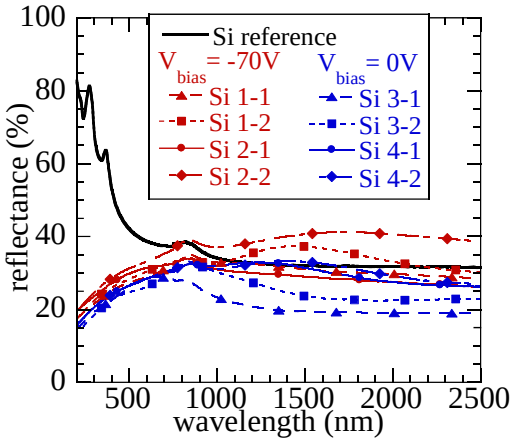

Figure 3 shows typical AFM images of surface of deposition on Si substrates for V_{bias}= -70 and 0 V, respectively. We have analyzed these AFM graphics to find out the relationship between reflectance and surface of deposition on the substrates.

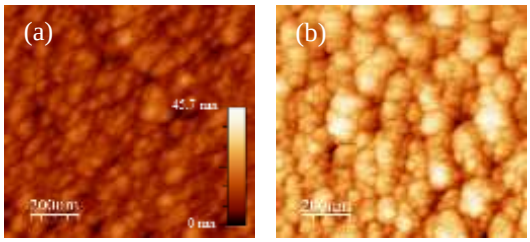

Fig. 3. Typical AFM images of surface of deposition on Si substrates for (a) V_{bias} = -70V and (b) 0 V.

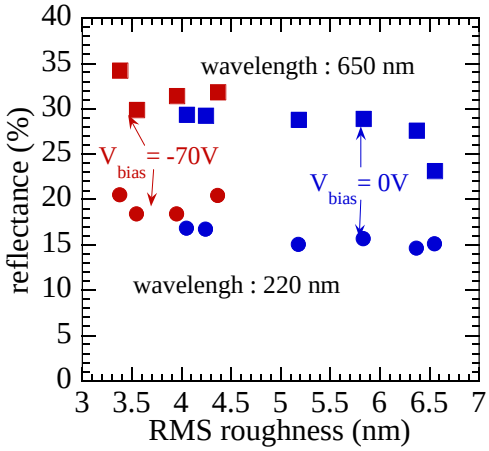

Fig. 4. Roughness dependence of reflectance

We have obtained root-mean-square (RMS) roughness R_q of each surface of the deposition from these images. Reflectance is inversely correlated with R_q of the deposition on the Si substrates regardless of the bias voltage as shown in Fig. 4.

4. Conclusions

We have examined the relationship between deposition on DC biased Si substrates and their reflectance. Degradation of reflectance might be suppressed by applying negative bias voltage to the substrates. We also have found that reflectance is inversely correlated with the surface roughness regardless of the bias voltage.

Acknowledgments

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