§6. Electrostatic Coupling of Antenna and the Shielding Effect in Inductive RF Plasmas

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Recently, much attention has been paid to an inductively coupled RF plasma as an innovative plasma source for nuetral beam production[1] as well as material processing.Even in such an inductive plasma, the capacitive coupling from a RF antenna has been observed[2] and leads to the sputtering of the insulating wall materials contacting the antenna. In this study, the capacitive coupling from an antenna has been quantitatively estimated, measuring a dc self-bias voltage induced on the surface of the insulator by electrostatic fields.[3]

Figure 1 shows the spatial distribution of dc self-bias voltage V_{DC} along a 1 turn loop antenna of 10 ~ 11 cm in radius for two different thickness of antenna insulating cover, where θ is the azimuthal position along the circular antenna as defined in Fig.1. A large negative bias of ~130 V was observed at the input RF power of 500 W in the case of the antenna covered with thin insulator of 1 mm in thickness. For thick insulator of 8.8 mm in thickness, the bias V_{DC} considerably decreased but ion energy E_i bombarding the insulator surface was still as high as ~ 40 eV since $E_i = e(V_p - V_{DC})$ and the plasma potential V_p = ~ 20 V. Concerning the azimuthal distribution of V_{DC} the bias becomes more negative at the point on the RF feed side (θ ~ 350°) than on the ground side (θ ~ 10°) of the antenna loop.

On the other hand, the power dependence of V_{DC} was examined for the thick insulator antenna and the thin insulator antenna where θ = 330 ~ 350° . As shown in Fig.2, the bias becomes increasingly negative with increasing RF power while the plasma potential remains almost constant at ~ 20 V and κTe= 2.5 ~ 4 eV.

Finally, in order to suppress the electrostatic coupling effectively, an electrostatic shield was formed, and its effect on the self-bias voltage was examined for the thick insulator antenna. The value of V_{DC} becomes positive and close to the floating potential given by a Langmuir probe. Thus, the shield effect was clearly recognized in comparison with the unshielded antenna.

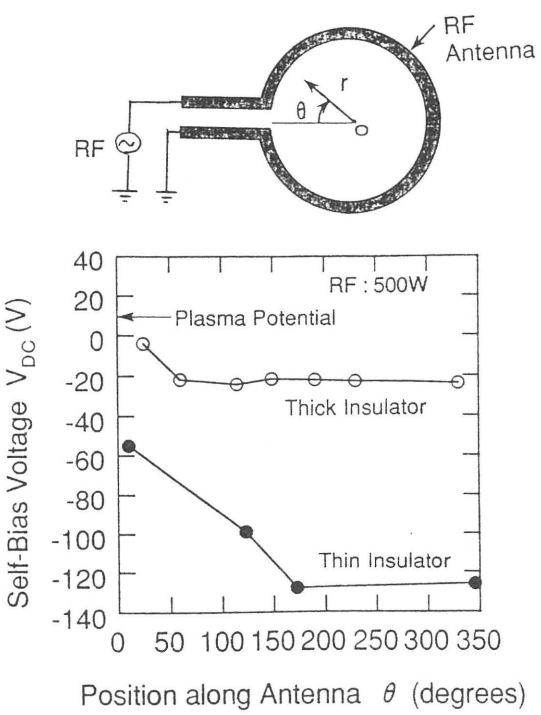

Fig. 1. Self-bias voltage along the antenna covered with thin insulator and thick insulator.

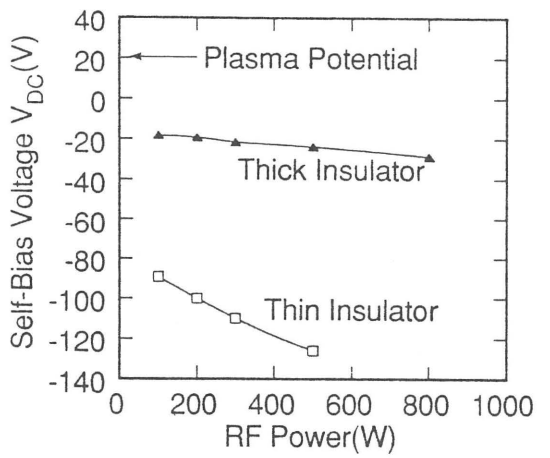

Fig. 2. Self-bias voltage v.s. rf power for the antenna with thin and thick insulators.

References

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3) Y. Hikosaka, M. Nakamura and H.Sugai: Jpn. J. Appl. Phys., 33 (1994) 2157