§8. Electrostatic Coupling in an Inductive RF Discharge

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Recently, much attention has been attracted to an inductively coupled RF plasma as an innovative plasma source for neutral beam production [1] as well as material processing. Even in an inductive discharge, a capacitive coupling from a RF antenna has been observed to be distributed along the antenna conductor[2] and leads to the sputtering of insulating wall materials covering the antenna [3]. In this study, electrostatic shielding of a RF coupler is attempted, and the shielding effects are investigated.

The electrostatic shield of an antenna is formed as follows. The 20-cm-diam. one-turn insulated antenna is wrapped by grounded metal sheet which has many slits of 2 mm in width at intervals of ~ 2 cm in the azimuthal direction to prevent a secondary RF current from flowing over the shielding metal sheet.

Figure 1 shows the RF voltage ϕ_{RF} induced capacitively on a static probe as a function of the distance Δr from the surface of the antenna in the absence of plasmas. The electrostatic coupling from the shielded antenna is drastically reduced compared with the unshielded antenna. Futhermore, a magnitude of the electrostatic coupling is evaluated by monitoring thebias voltage V_{DC} on a metal segment which is attached on the surface of the antenna immersed in a plasma. As shown in Fig. 2, the value of V_{DC} for the shielded antenna becomes positive and close to the floating potential given by a Langmuir probe. Therefore, antenna shielding leads to the decrease in the potential difference between plasma and antenna surface, suggesting the possibility of extending the operation lifetime of RF antenna by electrostatic shielding since the thermal load by ion bombardment is reduced.

On the other hand, the antenna shielding makes the electron temperature not changed but the plasma density halved, probably caused by the eddy current loss in the shielding metal sheet and partly by the lack of power input due to the capacitive (electrostatic) coupling.

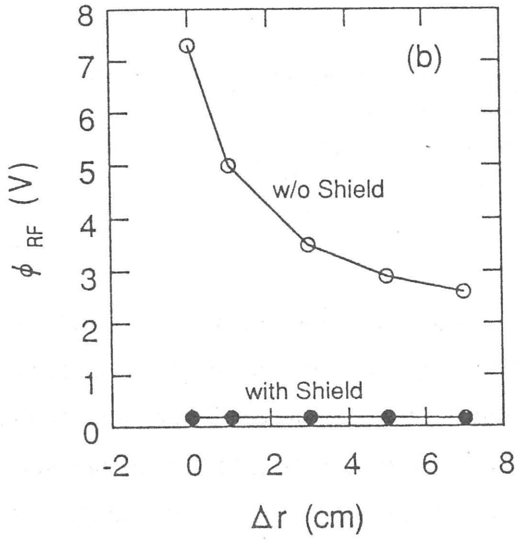

Fig. 1. Δr v. s. RF voltage ϕ_{RF} for the unshielded and shielded antenna.

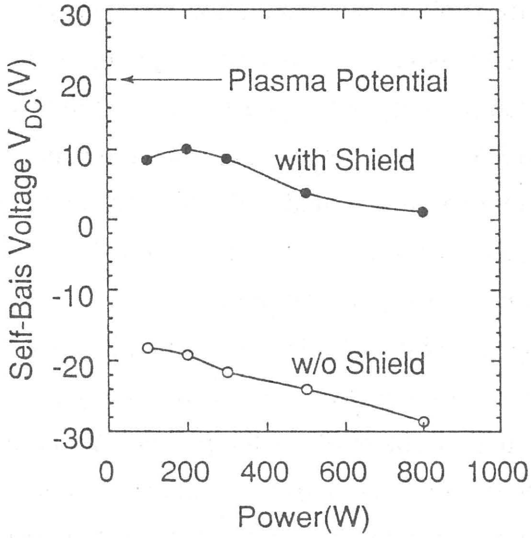

Fig. 2. Self-bias voltage V_{DC} v. s. RF power for the unshielded and shielded antenna.

References
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