Abstract Submitted
for the GEC17 Meeting of
The American Physical Society

Plasma Density Perturbation by Microwave and Magnetic Probes

VALERY GODYAK, Retired, NATALIA STERNBERG, Clark Un. — Magnetic probes (B-dot, or BDP) have been used over decades for measurement of rf electric field and plasma current. Recently, a variety of microwave probes (MWPs) has been proposed for plasma density measurement. In both cases, insertion of B-dot or microwave probes causes unaccounted plasma disturbance around the probe. Recent analyses of MWP probes has shown that they are based on too simplified and unrealistic assumptions about plasma uniformity, sheath capacitance evaluation, cold plasma permittivity, and a Maxwellian EEDF. The assumption of plasma uniformity around the probe is the most serious and common drawback of all MWP and the majority of BDP techniques. Plasma perturbation by a probe has the same localization area as that of MWP and BDP sampling area. This may result in essential difference between measured plasma parameters and those in absence the probe. In this presentation, we give an analysis of plasma perturbations by a spherical probe for arbitrary collisionality. The results were obtained by solving numerically a set of fluid equations for neutral plasma with cold ions, taking into account ion inertia and nonlinear ion friction force. In addition, an analytical solution was found for the collisionless case. The calculation showed a significant plasma density depletion around the probe growing with gas pressure. The depletion of plasma density should underestimate plasma density values inferred from MWP measurement, and dramatically distort rf field and current within BDP. The last is demonstrated for rf field and current distributions in inductive discharge at low gas pressure..

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Date submitted: 07 Jun 2017 Electronic form version 1.4