On improving impedance probe plasma potential measurements in low density plasma

DAVID WALKER, Sotera, Inc, DAVID BLACKWELL, RICHARD FERNSLER, WILLIAM AMATUCCI, Plasma Physics Division, Naval Research Laboratory — We have used impedance probes of various sizes and shapes in demonstrating a method of determining plasma potential, $\varphi_p$, when the probe radius is much larger than the Debye length. The method\(^2,3\) relies on applying a small amplitude ac signal to a probe in a plasma and measuring the complex reflection coefficient, $\Gamma$, as a function of varying probe bias, $V_b$. $\text{Re}(Z_{ac})$ (the real part of the ac plasma impedance determined from $\Gamma$) is plotted versus $V_b$, and a minimum predicted by theory occurs at $\varphi_p$ for a large range of electron density, $n_e$.\(^4\) However, the frequency range of the applied signal is restricted and as $n_e$ decreases it becomes even more restrictive. In addition, the minimum in $\text{Re}(Z_{ac}) \ (\sim 1/n_e)$ becomes more difficult to discern. Here, we suggest additional means to isolate $\varphi_p$.

These measures (1) incorporate $\Gamma$ to search for a minimum, (2) use not only the first derivative of $\text{Re}(Z_{ac})$, but also that of $\text{Im}(Z_{ac})$ with respect to $V_b$ and, (3) use the second derivatives of both. With the additional indicators, $\varphi_p$ is more easily detected in low density plasma. We present data for cylinders, spheres and a disk.


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\(^4\)\textit{Phys. Plasmas 17}