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RF Langmuir probes, revisited

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Though probes have been used for n_i and T_e measurements in rf plasmas for many years and commercial systems are available for automatic scans of $I-V$ curves, accurate results are by no means guaranteed. Strange $I-V$ curves obtained in the past two years have led us to re-examine the problem of Langmuir probes in low-density plasmas in severe rf environments. There are five main problems. First, the Bernstein-Laframboise theory used for small λ_D/R_p (Debye length/probe radius) have been shown to be inaccurate[1]. We therefore use thin probes and the OML (orbital-motion-limited) theory for large λ_D/R_p, but at low n the electron curve is not exponential. Second, we find that the plasma potential drifts with probe voltage V_p on a msec or longer timescale. This can be explained, but the effect is larger than expected. Third, the drift can be overcome by rapid sweeping of the $I-V$ curve, but too fast a V_p scan would be distorted by the inductance of the choke chain. Fourth, rf compensation is done with a chokes and a large compensation electrode[2] (CE). We find that CE cannot do most of the job; the chokes have to have large impedance at their self-resonant frequencies. But tuning the choke chain is not easy. Finally, cleaning the probe tip is difficult at $n \approx 10^9$ cm^{-3} because not enough current can be drawn to the probe. This is seen in very slow drifts of the ion current, in the order of seconds. A good rf probe requires careful construction of the compensation elements and judicious choice of the scan speed.

[1]F.F. Chen, Phys. Plasmas **8**, 3029 (2001).
[2]I.D. Sudit and F.F. Chen, Plasma Sources Sci. Technol. **3**, 162 (1994).