Numerical Impedance Matching Design for Capacitively Coupled Plasmas

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Low-temperature plasma sources are driven by various power supplies, and circuit parameters directly determine the properties of the plasma. Simulating the nonlinear coupling between the plasma and the external circuit is crucial. In simulating the entire discharge system, the effects of the RF cable sometimes must also be considered. The plasma can be described using fluid or PIC/MC (Particle-In-Cell/Monte Carlo) models. The bidirectional nonlinear coupling of lumped circuit, distributed circuit, and electromagnetic models has always been an unresolved issue. We have proposed a second-order numerical transmission line model based on the Lax-Wendroff method, establishing multiple nonlinear boundary conditions to achieve self-consistent bidirectional nonlinear coupling between the PIC/MC or fluid model, the circuit model, and the transmission line model [1]. Based on this method, we conducted systematic simulations of capacitive coupled plasmas (CCPs) containing an impedance matching network (IMN) and successfully implemented impedance matching designs: (1) Implemented single-frequency and triple-frequency CCP impedance matching using an iterative method for an L-type matching network [2, 3]; (2) Achieved impedance matching of a single-frequency CCP containing a transmission line and an L-type matching network using a gradient descent method [4]; (3) Adjusted the frequency of the RF source using a bisection method to achieve impedance matching; (4) Employed different objective functions and trained existing simulation data using machine learning techniques to provide an impedance matching parameter space[5]. These models are of certain reference value for related basic research and engineering applications. [1]

This work was supported by the China National Natural Science Foundation (12275095, 11975174 and 12011530142).

References

[1] Computer Physics Communications 282, 108468 (2023).
[2] Journal of Applied Physics 132, 083302 (2022).
[3] Plasma Processes and Polymers, e2400017 (2024).
[4] Physica Scripta 99, 025610 (2024).
[5] Journal of Vacuum Science & Technology A 42, 013001 (2023)