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Optimizing Power Delivery using Impendence Matching Networks with Set-Point and Frequency Tuning for Pulsed Inductively Coupled Plasmas

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Radio frequency (RF) power delivery to plasma processing reactors for microelectronics fabrication use impedance matching networks to minimize reflected power. During pulsing, the plasma impedance can significantly change, thereby requiring real-time-adjustment of the components of the network to maintain efficient power transfer. The pulses are typically too short for these components to be adjusted during the pulse. Other strategies are needed to maximum impedance matching during pulsing. One strategy is to select network components to match the power at a single time to optimize power delivery either early or late in the pulse. This also enables tailoring of the power during the pulse. Matching pulsed inductively coupled plasmas (ICPs) by this method is challenged by the capacitive-to-inductive transition at the beginning of the pulse. Another strategy varies the RF frequency, an adjustment that can be done rapidly. The network components and plasma impedance are frequency dependent, enabling real-time matching by adjusting RF frequency. Implementation requires a feed forward frequency trajectory instead of a reflected power driven feedback loop employed in frequency tune generators.

Impedance matching of pulsed ICPs was computationally investigated using the Hybrid Plasma Equipment Model and compared to experiments . Pulsed ICPs were operated in 20 mTorr Ar/Cl2. Set point matching at different times can suppress or enhance the capacitive portion of the E-H transition, thereby controlling oscillations in plasma potential. Impedance matching by frequency tuning over a few MHz for a base frequency of 10 MHz achieves matching over a limited range of change in plasma conditions, depending on the network components and termination capacitance of the antenna. Frequency tuning is then a more robust form of set-point-matching, broadening the time during the pulse that matching can be achieved.

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