Numerical simulation of electromagnetic effects in very high frequency capacitively coupled plasma

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Large-area capacitively coupled plasmas (CCP) driven at very high frequency are widely used for material etching and thin film deposition. For higher driven frequencies and larger chamber size, electromagnetic effects such as standing wave and skin effects can negatively affect the plasma uniformity. In an asymmetric CCP reactor, there exists both z-symmetric radially propagating surface wave modes (responsible for the well-known standing wave effect and the skin effect), and antisymmetric modes (responsible for the telegraph effect). In this work, a two-dimensional axisymmetric fluid model coupled with the Maxwell equations, solved in the linearized frequency domain, along with an equivalent circuit model determining the voltage between electrodes, is developed to examine the electromagnetic and electrostatic effects. In our simulation, these electromagnetic and electrostatic effects are clearly captured. The simulation results show that a peak of electron density appears at the radial edge at low driven frequencies and low gas pressures due to the excitation of axially anti-symmetric mode and electrostatic edge effect. The standing wave effect will be enhanced with increasing frequency or decreasing pressure, and the skin effect will be enhanced with increasing the input power. In addition, a stop band effect previously observed by Lee *et al* is also studied in detail.

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