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Two-dimensional fluid simulation of VHF-ICP source with parallel resonance antenna

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The governing equations which are considered in two-dimensional cylindrical fluid simulations argon discharge with parallel resonance antenna are the continuity equation, the momentum equation with drift-diffusion approximation, the energy balance equation for electrons, the wave equation for azimuthal induced electric field, and Poisson equation for electrostatic electric field [1]. The power (P_i) transferred from ith segment of antenna in the external circuit with the variable capacitor to the plasma is expressed as $P_i = \frac{1}{2}R_{pi}|I_{ci}|^2$ ($i = 1, 2, 3$) [2].

The dimensions of the reactor are 27 cm × 27 cm. The antenna consists of three parallel segments, which the total lengths of inner, center, and outer segments are 1.38, 2.04, and 2 m, respectively. At the condition of 27.12 MHz, 10 mTorr, and 850 W, the resistances (Ohm) and the reactances (Henry) of inner, center, and outer segments are 0.017 and 44.1 (inner), 0.025 and 65.5 (center), and 0.024 and 63.9 (outer), respectively. The variable capacitor is connected in series with outer segment to independently control the current along outer segment, as shown in Fig. 1(a). For a variable capacitor of 0 pF, the currents along three parallel segments are 31, 20, and 21 A, respectively. As the variable capacitor changes from 0 to 63 pF, the direction of the current along outer segment is in the opposite of others and the currents along three parallel segments are 62, 40, and −100 A, respectively. Fig. 1(b) shows the radial distribution of plasma density calculated at 5 cm above the substrate with respect to variable capacitor. For a variable capacitor of 63 pF, the non-uniformity of plasma density calculated from $r = 0$ cm to $r = 15$ cm is 3% at 2 cm above the substrate.

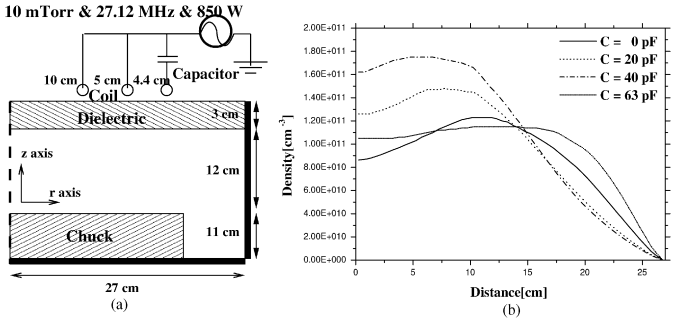

Fig. 1. (a) Schematic diagram; (b) radial distribution of plasma density with respect to the capacitor.

In conclusion, the uniformity in radial direction of the plasma density is improved by controlling the currents along segments of antenna through the variable capacitor.

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