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Electron power absorption and plasma uniformity control by structured electrodes in capacitive RF discharges

Li Wang[1], Peter Hartmann[2], Zoltan Donko[2], Yuan-Hong Song[3], Julian Schulze[1,2]
[1] Ruhr-University Bochum, Germany
[2] Wigner Research Centre for Physics, Hungary
[3] Dalian University of Technology, China
e-mail (speaker): wang@aept.rub.de

In the applications of capacitive coupled plasmas (CCP) in microelectronics industry such as plasma etching and plasma enhanced chemical vapor deposition etc., uniform plasma density is required to ensure a good process performance. However, nonuniformity of the plasma density is commonly found at various discharge conditions due to electromagnetic effect and edge effect etc. In this work, we study the effects of structured electrodes on electron power absorption and their ability to improve the plasma uniformity by graphics processing unit-based 2d3v particle-in-cell/Monte Carlo simulations. By tracing the trajectories of selected electrons and the time evolution of their energy and velocity in a single ring-shaped trench embedded in the powered electrode, the electron bounce resonance heating in the trench is found to lead to a locally enhanced electron power absorption and plasma density above the trench. As shown in figure 1, using these trench effects, the plasma uniformity above the wafer placed on a planar powered electrode can be remarkably improved by including multiple trenches in the opposing grounded electrode, which enhance the ionization and plasma density at their respective radial positions [1].

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References

[1] Li Wang *et al.*, "Effects of structured electrodes on electron power absorption and plasma uniformity in capacitive RF discharges", J. Vac. Sci. Technol. A 39, 063004 (2021)

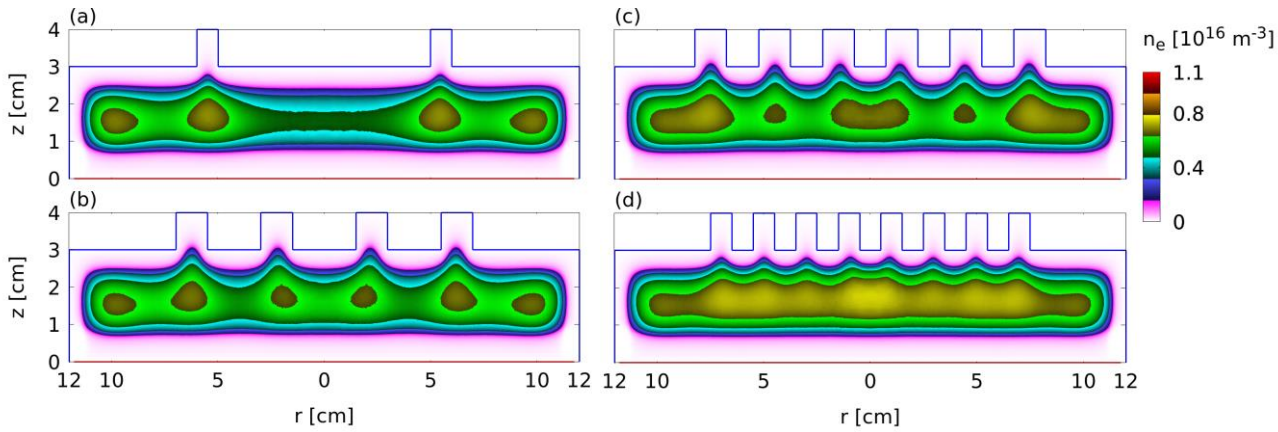

Figure. 1 2D spatial distributions of the time-averaged electron density for a reactor with ring-shaped trench(es) at the grounded electrode: one trench (w = 1 cm, d = 1 cm) at r = 5.5 cm (a); two trenches (w = 1.5 cm, d = 1 cm) at r = 2.25 cm and r = 6.25 cm (b); three trenches (w = 1.5 cm, d = 1 cm) at r = 1.5 cm, r = 4.5 cm, and r = 7.5 cm (c); and four trenches (w = 1 cm, d = 1 cm) at r = 1 cm, r = 3 cm, r = 5 cm, and r = 7 cm (d).