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Numerical Study of Dusty Particle Motion in Plasmas with Considering Charging Processes

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In the plasma reactor, the existence of dust particles might cause the damage of etched patterns on wafers [1]. Therefore, charging and moving of dust particles in low temperature plasma is investigated via the numerical framework integrated using COMSOL-multiphysics software and the self-developed Dust-in-Plasma (DiP) code. The evolution of plasma and gas in an electron cyclotron resonance (ECR) plasma source can be first simulated using the COMSOL-multiphysics software, and the DiP code is used to calculate the trajectory of dust particles with the consideration of the charging process. The trajectory is determined by considering five kinds of force [2], while the Orbital Motion Limited (OML) theory [3] is adapted to model the charging process of dust particles.

The numerical results show that dust particles are negatively charged and are trapped near the plasma sheath, which is consistent with experimental observation [4]. Figure 1 illustrates the trapping regions for various dust particle sizes. It is found that the trapping regions and behaviors of dust particles highly depend on their sizes. The smaller the dust size is, the longer the charging time is. The mobility of dust particles also depends on their size, therefore, the charging time of micron-sized dust particles is much shorter than its moving time scale. The charging processing can be ignored while calculating the dust particle trajectories. However, the charging process needs to be self-consistently treated along with the calculation of their trajectories for dust particles of nanometer size.

References

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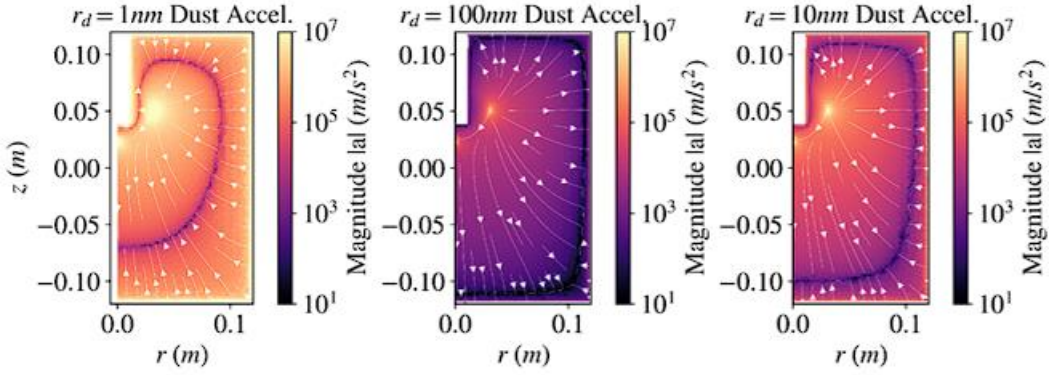

Figure 1: The acceleration map of dust particles in a typical electron cyclotron resonance (ECR) reactor is determined by calculating the forces acting on the particles, assuming dust particles are fully charged.