LOW PRESSURE SEMICONDUCTOR PROCESSING TRANSPORT PROPERTY MODELING USING DIRECT SIMULATION MONTE CARLO

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In order to extend the capability of the Hybrid Plasma Equipment Model (HPEM)[1] simulation code to increasingly lower operating pressure conditions, the direct simulation Monte Carlo (DSMC)[2] method is used to improve the modeling of the heavy particle species in a hollow cathode magnetron (HCM) plasma reactor, a device used to implement the Ionized Metal Physical Vapor Deposition (IMPVD) technology.

The DSMC, at the current stage, is inserted between the fluid kinetics-Poisson module (FKPM) and plasma chemistry Monte Carlo module (PCMCM) module of HPEM as an correction to the FKPM at the low-pressure condition. The DSMC module initializes a large number of simulated particles (each represents 10^9 real atoms) at different computation cells in the plasma reactor with positions and instantaneous velocities according to the number density, temperature, flux from the FPKM. The continuous process of particle movement and interaction is uncoupled, i. e., at each time step every particle is moved according to its velocity subjecting to the electric and magnetic fields, then, the interaction between the particles is modeled by appropriate by collision and reaction models where the heavy-heavy particle reactions are implemented by total collision energy model while the electron impact reactions are introduced by the electron impact rate coefficients and source functions. In each HPEM iteration, the time-accurate DSMC calculation will be performed for a physical time of 1 μ, same as the FKPM module, with 10,000 DSMC steps. Sampling will be performed after 9,000 steps and the number density, temperature, and flux will be obtained by averaging the sampled particles at difference cells for different species. These properties along with the electric field will be output to the PCMCM module.

Detailed models and simulation results will be presented in the conference paper.

1. V. Vyas, and M. J. Kushner, M. J., “Scaling of Hollow Cathode Magnetrons for Ionized Metal Physical Vapor Deposition,” Journal of Vacuum Science and Technology A, Vol. 24, No. 5, 2006, pp. 1955–1969.
2. G. A. Bird, *Molecular Gas Dynamics and the Direct Simulation of Gas Flows*, Clarendon Press, Oxford, UK, 1994.