

PO4102

One-dimensional Simulation of rf CH₄ Plasma using a fluid modelzeng lin¹, shao lv², feng wang³, yong wang², de ba², qing han², chun liu²¹Northeastern University, ShenYang, China ²Northeastern University, Shenyang, China ³Shenyang Aeroengine Research Institute, Shenyang, China

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A one-dimensional fluid model for a rf methane plasma is presented. The equations solved are the particle balances, assuming a drift-diffusion approximation for the fluxes, and the electron energy balance equation. The self-consistent electric field is obtained from the simultaneous solution of Poisson's equation. The electron-neutral reaction rates are expressed as a function of the average electron energy, which are obtained from the solution of the Boltzmann equation. In total, 20 species (neutrals, radicals, ions, and electrons) are included in the model, as well as 49 reactions (27 electron reactions, 7 ion-neutral reactions, and 15 radical-neutral reactions). The fluid model yields, among others, information about the electric-field, the electron reaction-rates, and also the densities of different species in the plasma. It is found that, besides the inlet gas CH₄, neutral gases of H₂, C₂H₆, C₃H₈, C₂H₄, and C₂H₂ are also present at high densities in the plasma. The main radical in the plasma is CH₃, with a density about 10¹⁹m⁻³. At low pressure (e.g., 18Pa) the most important ion is found to be CH₅⁺, at higher pressure (e.g., 67Pa) C₂H₅⁺ becomes the dominant ion. Radical and ion fluxes towards the electrode (except C₂H₅⁺) increase slightly as a function of power.

Keywords

Methane plasma

Radio-frequency discharge

Fluid model

Boltzmann equation