PLASMA SHEATH EQUATION FOR Non-MAXWELLIAN ELECTRON ENERGY DISTRIBUTION FUNCTION

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Low-pressure plasma gas discharge plasma is very often used in processing equipment for microelectronics. This plasma can be described in terms of Langmuir and Tonks plasma and sheath (LT) equation [1] or its generalization [2] which additionally take into account charge exchange. It was assumed in [1, 2] that electron energy distribution function *fe* (EEDF) is Maxwellian, and electrons are in equilibrium with the ambipolar field. Numerical calculations [3] show that EEDF can significantly affect the plasma potential and electron density spatial distribution. In this paper we consider the self-consistent solution of the kinetic equation for the electron and the Poisson equation for the ambipolar field in assumption of free ions drop on the wall.

The movement of ions is described in accordance with classical LT equation [1]. The model assumes that the electrons are born by ionization with zero velocity. Electrons’ heating is connected HF or DC current passing along discharge axis. Elastic electron-atom collisions lead to the diffusion and drift of the electrons along the energy axis and to local (at the point of collision) EEDF isotropizaton. A plane and a cylindrical plasma column are considered. We assume just as in [1, 2] that the distribution of the ambipolar potential ϕ toward the boundary is monotonous. Below, we write the equation for the plane geometry.

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We use the following notation: *x*, *y*, *z*, *Vx*, *Vx*, *Vz* for coordinates and velocity of the electrons, *e*>0 for elementary charge, *m*, *M* for masses of the electrons and ions, *Zi*(*x*) for the number of ionization in the volume *dxdydz* in the neighborhood of *x, I*(***V****,x*) for electron collisions integral, which includes ionizing and elastic collisions. Conditions of equality of the fluxes of electrons and ions is fulfilled at the boundaries of the discharge *x* = ±*L* .

Further simplification of the equation based on the difference of the characteristic times of the oscillations of the electrons in the potential well τ1, isotropization time EEDF τ2 and electrons drift along the energy axis as a result of elastic collisions time τ3. To obtain an analytical solution, the potential distribution in the plasma region is represented as a power series. On the energy axis we highlight areas ambipolar potential well, the potential well created by the space-charge sheath and the ionization region.

Calculations show that influence of EEDF on the value of the ionization rate in the plasma is small, but its effect on the potential difference between the plasma and the wall is significant.

References

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