RESONANCE AND NONRESONANCE Ionization INSTABILITIES IN RF AND microwave dischargeS

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For the first time ionization instability of plasma in a field of plane electromagnetic wave has been described by Gildenburg and Kim [1]. Later it has been shown [2] that in the spatially limited low pressure microwave discharge the given instability leads not only to change space plasma structure, but to appearance of resonances at electron densities, when the size of plasma becomes multiple to some number of half waves of the standing surface wave, exciting on plasma boundary. The resonance causes the reduction of the power of incident wave, necessary for discharge maintenance, due to reduction of reflection coefficient and the appearing of ambiguous relation between electron density and amplitude of the wave.

The development of the instability leads to a partial transformation of the plane wave to the surface wave and the appearance of non-uniform distribution of the electron density in the discharge. With this partial transfer of the energy of the incident wave to the standing surface wave, the total electric field can exceed the incident wave field, ensuring that the conditions of the integral balance of particles in the plasma are fulfilled.

Evolution of electron density perturbation is defined by two processes – negative feedback owing to a total current continuity (as in striations) and positive one due to excitation of a surface wave close to a resonance. In the given work the theory [2] has been improved with taking in consideration of both processes that has allowed to reach better coincidence with experiment. In addition, a theory of ionization instability in a discharge tube with infinite length is developed. In this case, the excited running (not standing) plasma density perturbations and surface waves can be excited. The length of disturbance depends on the density of electrons. Similar to the case of the tube with finite length, the external field, needed to maintain the discharge in the advanced mode of instability, lower than for the homogeneous plasma.

Experiments [3] have shown the qualitative consent with the theory.

A similar theory was developed for the high-frequency capacitive discharge (with frequencies of 100 MHz or higher) with large electrodes. For the excitation of this type of discharge, as a rule, symmetric surface wave propagating along plasma – space charge sheath – electrode interface is used. Calculations have shown that in certain cases, instability leads to antisymmetric wave excitation. The length of this wave is substantially less than the length of the symmetrical one. The interference of the waves causes the appearance of non-uniform plasma density distribution along the electrode.

References

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