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THE PROCESS OF IONIZATION IN THE LOW-PRESSURE MICROWAVE DISCHARGE SUSTAINED BY A SURFACE WAVE *)

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The ionization process in a microwave discharge sustained by a surface electromagnetic wave [1] (SEW) was investigated. The discharge was excited with a surfaguide (f = 2.45 GHz, λ0 = 12.25 cm) in a quartz tube filled with argon gas at a pressure of 10–2–10–1 Torr. A long plasma column was realized with an average electron concentration ne, significantly exceeding the critical concentration for the SEW [2] $n_{\min} = (1 + \varepsilon_{\mathrm{d}})n_{\mathrm{c}}$, where εd is the dielectric constant of quartz, and nc is the critical plasma concentration. The ionization front velocities, ionization frequencies, and radial and longitudinal plasma density distributions were measured in experiments. The absolute values of the cross-sectional average electron concentration were determined by the dispersion ratio of the SEW [3], which relates the electron concentration to the measured surface wavelength. To measure the rate of increase (ionization frequency) of the average cross–section electron concentration, diagnostics using the method of passing microwave waves (5.5–7.5 GHz) with a waveguide system was used [4]. At νen << ω (νen is the frequency of collision of electrons with neutral atoms, ω is the frequency of the microwave field), the relaxation length of the electron energy is le >> a (where a is the radius of the tube), and the electron temperature is Te = const along the discharge cross section. Thus, plasma density distributions were measured by the integral intensity of plasma glow using collimated photodetectors. The radial profiles were obtained by the method of transverse images with subsequent processing using the Abel method.

A numerical model has been created that simulates the distribution of the SEW electromagnetic field over a plasma column specified using the Drude model for low-temperature plasma [4] and does not take into account the ionization process. This model makes it possible to study the distribution of the SEW field inside and outside the plasma depending on the given values of ne(r) and νen, corresponding to the experiment.

The initial process of discharge development was modeled using the electromagnetic KARAT code, which is based on the he particle-in-cell (PiC) method [5]. The length of the system did not exceed λ0, which is typical for antenna systems [6]. The frequency range varied from 0.5 to 2.5 GHz in 0.5 GHz increments. The code made it possible to study in detail the characteristic areas where the electron concentration passes the critical nc and 2nc corresponding to the condition of SEW propagation.

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