Study of strongly non-uniform non-equilibrium microwave plasma in nitrogen by means of double probe and optical methods

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One of the important problems in the physics and applications of non-equilibrium gas discharge low temperature plasma is the study of the structure of discharges. This is especially important in the study of strongly inhomogeneous discharges in which the plasma composition and physico-chemical processes depend on the spatial coordinates. Here we studied distributions of plasma properties in the electrode microwave discharge described in details in [1, 2]. The discharge chamber of the installation is a stainless steel cylinder 15 cm in diameter with windows for the observation of the discharge disposed in the cylindrical wall. Electrode/antenna (5-mm-diameter cylindrical copper tube) is introduced into the chamber through a vacuum seal in the upper end along the axis of cylinder (the axis of the discharge). The discharge chamber was differed from that described in [1, 2] by introducing the substrate holder.

The main task of the study was investigation of plasma parameters in nitrogen at a pressure of 1–5 Torr and incident power of 60–100 W (frequency 2.45 GHz) in the space between the tip of the electrode and the substrate holder by probe and emission spectroscopy methods.

The parameters of the electron component of plasma were studied by double electric tungsten probes (probe diameter is 100 mm, length of the non insolated part is 2.1 mm, the distance between the probes is 2.8. mm) [3]. The developed system of Z**-**R displacement of probes was placed inside the side pumped metal cylinder, mounted on the flange of one of the windows in the chamber. System was developed for displacement of probes along the axis of the discharge and the radius with steps of 0.1 mm.

The emission spectra from the EMD were recorded through the optical window by an AvaSpec 2048 spectrometer with the spectral range of 200–700 nm and a resolution of 1 nm. A quartz condenser projected the image of the plasma in the plane of the input aperture of optical fiber movable in the Z-R directions with a spatial resolution of the system of no worse than 0.10 mm. The radiation of the plasma integrated along the observation axis was detected. Optical windows were also used to make photos of EMD with digital camera K-008.

Detailed study of spatial distributions of parameters of electron component of EMD and discharge emissivity give general dependencies of plasma properties on gas pressure and incident microwave power. The main goal was study of possibilities of control the plasma parameters near the substrate holder. It was shown that plasma properties in this region are practically independent of the incident power keeping the same the pressure. Decreasing the pressure leads to increase the plasma density and concentration of excited particles at the same incident power.

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