Parameters of the atmospheric pressure CW microwave discharge sustained by focused gyrotron radiation

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Résumé

A nonequilibrium plasma of a microwave discharge, supported by continuous wave (CW) of a gyrotron at a frequency of 24 GHz, was investigated. The discharge is realized by focused microwave radiation on the flow of argon from the gas tube at atmospheric pressure. The value of the electric field strength in focal waist reached 1.8 kV/cm. A spark discharge was used to initiate the microwave discharge. The radiation power of the gyrotron varied from 900 to 5000 W. The emission spectra of pure argon plasma were recorded in the range 300-1000 nm using an ASEQ LR1 emission spectrometer with a resolution of 0.3 nm. The relative intensity of the emission lines of argon atoms was used to determine the electron temperature. The electron temperature was in the range from 0.3 to 1.5 eV, depending on the heating power and the gas flow rate. The gas temperature was estimated by comparing the continua of the spectra obtained with the spectrum of blackbody radiation with given temperature. According to the estimations, the gas temperature did not exceed 3000 K. Based on the obtained results on the measurement of temperatures, it can be asserted that the investigated atmospheric pressure discharge is nonequilibrium.

The electron density in the discharge was measured using microwave interferometry. The essence of the method consists in recording the change in the phase of the probe radiation as it passes through the plasma torch. Knowing the length of the path traversed in the plasma, it is possible to determine the average value of the electron density. The Gunn diode with a frequency of 35 GHz was used as a source of probing wave. To determine the phase change, the Keysight Infiniium Z oscilloscope with a transmission frequency of up to 63 GHz was used. It was possible to observe a phase change of the probing wave at a frequency of 35 GHz on the oscilloscope screen in real time. As a result, it was found that the average value of the electron density was close to the cut-off density for the frequency of 24 GHz and was 5 ± 2x10^12 cm^(-3). Depending on the heating power and the gas flow rate, the values of the average electron density remain constant practically.

The realization of a CW nonequilibrium microwave discharge at atmospheric pressure is especially important for various plasmachemical applications. In such a discharge, it becomes possible to accelerate the plasma-chemical reactions due to the high electron temperature. The increased pressure in the discharge provides high production rate, which makes this type of plasma torch attractive for industrial applications. The use of powerful microwave radiation of the gyrotron to sustain a nonequilibrium plasma at atmospheric pressure will allow the decomposition of highly stable molecules, for example, volatile fluorides and halides.

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