Atmospheric-pressure microwave-driven cold plasma jet source for applications: portable design and diagnostics

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A prototype of a multipurpose microwave plasmatron, developed and manufactured earlier for biomedical and other applications, allows to generate cold atmospheric-pressure plasma jets by means of external portable plasma torch with a wide outlet of 2.5 cm in diameter. The plasmatron operates at a frequency of 2.45 GHz, has a microwave power in the waveguide of up to 2.5 kW and a power in the torch of up to several hundred watts. The plasma torch consists of cylindrical common chamber with 6 rod-like electrodes which form a regular hexagon in a cross-section. Discharges are initiated in Ar flow between the rod-like electrodes and the inner wall of the discharge chamber near the outlet of the chamber. Ar of high purity (99.998%) was used with the flow rate in the range from 0 to 10 standard liters per minute. We studied temporal features of the formation of the discharges in the torch in continuous and pulse-periodic modes of magnetron power supply. For the plasmatron developed, three-phase AC circuit is used with three step-up transformers and three diode arms. The circuit makes it possible to conduct the operation of the magnetron in a continuous mode. In order to realize a pulse-periodic mode of magnetron operation, one of the diode arms in the circuit was switched off. For diagnostics of the plasma generation modes we measured probe floating potential in the plasma jet using oscilloscope. In the continuous mode the floating potential oscillated weakly around a constant value which depends on the distance to the torch. It was found that the pulse-periodic mode was carried out with a frequency of 50 Hz and a pulse duration of 15 ms. Formation of spark channels was observed. In the continuous mode spark discharges did not occur, and the discharges between the electrodes and the inner wall of the chamber were glow type. The method of emission spectroscopy was used to study both electrode discharge in the plasma torch and afterglow plasma behind the torch outlet (cold plasma jet). Molecular lines of NO, OH, N_2, NH and atomic lines of Ar were found in the spectrum in the discharge channels. Based on the analysis of the spectra, it was found that the translational plasma temperature in the discharge channel can reach 1500 K. In the spectrum of the cold plasma jet, due to its weak luminescence, only the molecular lines OH and N_2 were reliably observed. The work was supported by the Russian Foundation for Basic Research (grant No. 18-08-01312).