Dissociation of CO_2 and gas heating in nanosecond capillary discharge

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Optical and electrical diagnostics of nanosecond discharge ignited in pure CO_2 at moderate (10-20 mbar) was performed. The reduced electric fields of 250-300 Td were registered after the front of the fast ionization wave. The absolute downstream densities of CO_2 dissociation products were measured by FTIR. The values of CO_2 dissociation fraction of 20% at single pulse regime and 90% at 300 Hz repetition rate have been obtained. The corresponding values of energy efficiency of both regimes were equal to 20% and 5%.

№ of pulse	**1**	**2**	**3**
Peak current	58 A	68 A	27 A
W, eV/particle	0.42	0.6	0.2

The gas temperature measurements were performed by the means of OES in CO_2:N_2 mixtures. The following values of the gas temperature were derived: 400 K, 800 K and 1100 K in 1st, 2nd and the 3rd pulses separated by 250 ns. The corresponding values of the peak current and specific deposited energy are given in the table above. It can be concluded that the phenomenon of the so called fast gas heating [1] has been observed. The radial profile of electron density has been observed by an ICCD imaging. Both gas temperature and electron density distribution are in agreement with the numerical modeling.

The numerical modelling of the discharge has shown that the vibrational kinetics is not dominant in the case of high electric fields whereas the excitation of electronic levels of CO and O plays the leading role in the discharge kinetics. More precisely, the reactions

$$CO(a) + O(^3P) \rightarrow CO + O(^1S)$$

$$O(^1S) + O(^3P) \rightarrow O(^1D) + O(^3P)$$

$$O(^1D) + CO_2 \rightarrow O(^3P) + CO_2$$

contribute the most in the gas heating. The part of energy of the discharge energy delivered to gas heating before 2 μs after the discharge ignition was equal to 23%.

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Références

[1] N A Popov. Fast gas heating in a nitrogen–oxygen discharge plasma: I. Kinetic mechanism.Journal of Physics D: Applied Physics44.28(2011), p. 285201

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