# Ionization-front propagation in nano-second pulsed plasmas near atmospheric pressure: analyses by particle-in-cell (PIC) simulation

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Plasmas at or near atmospheric pressure with low gas temperature can be an efficient source of free radicals and other highly reactive chemical species. Such plasmas have been used for various processing such as polymerization, material surface modification, sterilization, and liquid treatment. A low-gas-temperature plasma may be obtained with short-rise-time high-voltage pulses with sufficiently long off periods. The goal of this study is to clarify the discharge formation mechanism of such discharges. In recent experiments [1,2], it has been shown that, during the formation of an atmospheric-pressure plasma between parallel conducting electrodes or electrodes covered with dielectric layers, an ionization front propagates in the direction toward the cathode with a high velocity. In this study, a 1d2v (one dimensional in space and two dimensional in velocity) particle-in-cell (PIC) simulation with a Monte Carlo collision method is used to simulate the dynamics of such plasmas [3]. The discharge characteristics obtained from the numerical simulations are in good agreement of the experimental observations. It has been found that, in the pre-breakdown phase, the externally applied fast-rising electric field is strongly enhanced near the cathode due to large accumulation of space charge, which then strongly enhances ionization near the cathode. This process is essentially different from the well-known Townsend mechanism for the formation of a slower discharge, in which ion transport to the cathode for continuous generation of secondary electrons is considered to be a prerequisite for discharge breakdown.

References

(1) T. Ito, K. Kobayashi, U. Czarnetzki, and S. Hamaguchi, J. Phys. D: Appl. Phys. **43** (6) 062001 (5pp) (2010).
(2) T. Ito, T. Kanazawa, and S. Hamaguchi, Phys. Rev. Lett. (2011) *in press*.
(3) C. W. Lo and S. Hamaguchi, J. Phys. D: Appl. Phys (2011) *in press*.