DYNAMICS OF NEAR-ATMOSPHERIC-PRESSURE HYDROGEN PLASMAS DRIVEN BY PULSED HIGH VOLTAGES

Chieh-Wen Lo[1,2] and Satoshi Hamaguchi[1]
[1]*Center of Atomic and Molecular Technologies, Osaka University, Osaka, Japan*
[2]*Department of Physics, National Cheng Kung University, Tainan, Taiwan*

The goal of this study is to explore the fundamental physics and formation mechanism of hydrogen plasmas, which is driven by a nano-second scale pulsed voltage under high pressure. A 1d2v (one dimensional in space and two dimensional in velocity) particle-in-cell[1] simulation program for electrostatic plasmas has been developed for this purpose. Monte Carlo collisions with a null collision operator[2] are also included in the simulation code. The hydrogen plasma is generated between two parallel electrodes, i.e., a grounded anode and a cathode connected with an external voltage source. The applied voltage is a triangular pulse with a peak value of -2 kV and a duration of 10 nanoseconds. With the use of the code, details of electron and ion dynamics of the hydrogen plasma and their energy distribution functions have been investigated.

As the initial condition, a low-density uniformly distributed plasma is placed in the discharge region. This low-density plasma may be considered to represent a remnant of the previous discharge pulse. The simulations have revealed that, at the initiation of the discharge, electrons move toward the anode generating more charged particles whereas the ions hardly move due to their large inertia. As the plasma density increases, numerous ionization and electronic excitation processes occur and result in the formation of a high-density plasma bulk near the anode as well as emission of visible light. Macroscopic dynamics of the discharge obtained from the simulations have been found qualitatively consistent with the experimental observations[3].

The simulations have also shown that, despite the high collisionality, electrons in the bulk (at the center of the discharge region) can transiently exhibit non-Maxwellian energy distributions (i.e., two-temperature distributions), which indicates that, in such a fast discharge formation process, the system is not necessarily in local thermal equilibrium.

1. C. K. Birdsall and A. B. Langdon, *"Plasma Physics via Computer Simulation"*, McGraw-Hill, New York (1985).
2. V. Vahedi and M. Surendra, Comp. Phys. Comm. **87** (1995), 179.
3. T. Ito, K. Kobayashi, U. Czarnetzki, and S. Hamaguchi, J. Phys. D: Appl. Phys. (2010), *in press*.