FORMATION OF WIDE STREAMERS IN AIR AND HELIUM: THE ROLE OF FAST ELECTRONS*

N.YU. BABAEVA[1], G.V. NAIDIS[1], V.F. TARASENKO[2]
[1]Joint Institute for High Temperatures RAS, Moscow 125412, Russia
[2]Institute of High Current Electronics SB RAS, Tomsk 634055, Russia

Experimental and computational studies of subnanosecond breakdown of atmospheric-pressure air in nonuniform electric fields revealed that the ionization waves have nearly spherical or conical shapes [1]. In this work, we discuss the results from the computational studies of nanosecond pulsed discharges in air and helium. The model, *nonPDPSIM*, used in this paper, is a two-dimensional code which is executed on unstructured numerical meshes. In the model, the kinetic Electron Monte Carlo Module integrates the trajectories of fast electrons. The energies of fast electrons are recorded to compute electron energy distributions (EEDs). From the EEDs, electron impact source functions and sources of secondary electrons are computed.

We demonstrate that wide and diffuse discharges can be formed due to fast electrons. The discharge is initiated near the cathode having a small radius of curvature and propagates towards the flat anode as shown in Fig. 1. Fast electrons are periodically emitted from the surface of the cathode during ion bombardment. The pulse has 2 ns duration, 0.2 ns rise and 0.2 ns fall time with a peak voltage -110 kV, the gap is 8.5 mm.

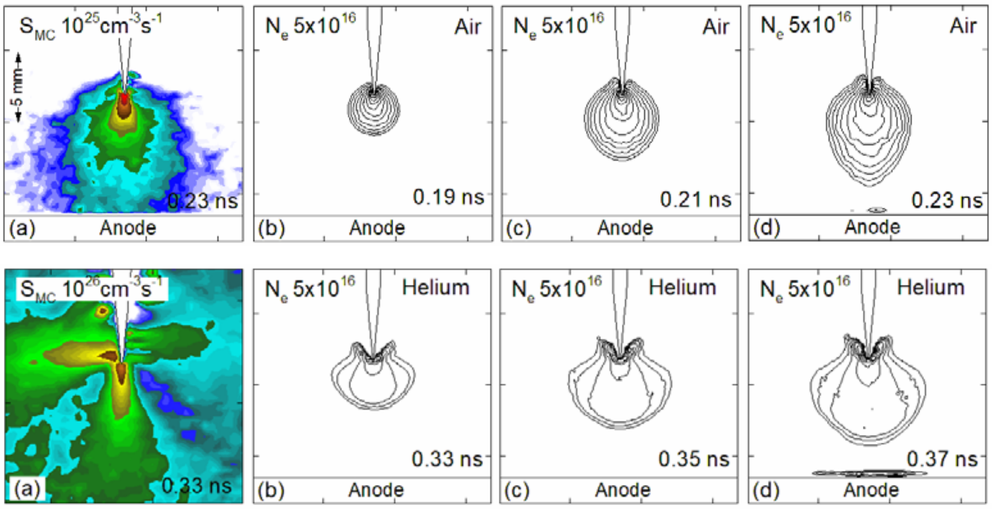

Fig.1. (a) Sources of fast electrons obtained from Monte Carlo simulations (plotted on 3 decades log scale); (b) to (d) Electron density at three successive time moments (plotted on 3 decades log scale). Maximum values are shown in each frame. The upper row of frames shows the development of a streamer in air, the bottom row – in helium.

The secondary electrons are emitted from the cathode surface as a beam of electrons with the typical energy of 4 eV for air and 16.6 eV for helium. These values correspond to the energy difference $I - 2W$. Here I = 12.1 eV is the ionization potential of oxygen molecules (O^+_2 is the most abundant ion) and I = 24.6 eV is the ionization potential for helium. W = 4 eV is the work function for a metal (copper) electrode. The process of secondary electron emission by ions (Auger neutralization) is discussed in detail in [2]. With more energetic beam electrons emitted from the cathode in helium, horizontal (as well as vertical) tracks of these electrons are observed (Fig. 1a, bottom row). This results in a wider streamer formation as compared to that in air. Note that air streamers calculated with account for fast beam electrons are also wider than conventional streamers (driven only by photoionization).

REFERENCES

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