Diffuse discharges in helium and air: role of fast secondary electrons

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We report on results from a computational investigation of nanosecond pulsed discharges in helium and air using a two-dimensional fluid and fluid-Monte Carlo simulations. Essential difference between discharges initiated in helium and air is observed. The diffuse discharge in helium is formed due to fast (but not runaway) secondary electrons as a result of ion bombardment of the cathode and Auger neutralization without any assumptions on the critical role of runaway electrons. Energetic secondary electrons emitted from surfaces are treated by the kinetic Electron Monte Carlo Module with account for elastic, inelastic and super elastic collisions. Conventional fluid equations describe the bulk electrons with relatively low mean energy.

1. Introduction

Diffuse discharges in atmospheric pressure air, helium and other gases in tube-to-plane gaps are initiated by short high-voltage pulses using cathodes of small radius of curvature. The diffuse forms of such discharges are usually attributed to gas pre-ionization by runaway electrons [1].

2. The model

We computationally investigated the formation of nanosecond pulsed discharges in helium and air using a two-dimensional fluid and fluid-Monte Carlo simulations. The model, *nonPDPSIM*, used in this paper is discussed in Refs. [2,3]. The discharge is ignited in a cylindrical chamber between a tubular and a plane electrode. The voltage pulse amplitude is 120 kV and the pulse rise time is 1 ns. For air (O_2^+ ions dominate) the energy of the beam of fast secondary electrons is 4 eV, for helium – 16 eV.

3.Results

The ionization sources S_{MC} produced by fast electrons and electron density in the conventional streamer with account for fast electrons are shown in figure 1. Tracks of electron avalanches in front of the streamer are clearly visible in figure 1b and 1e. These tracks follow the trajectories of sources S_{MC}. In air only a few avalanches produced by fast electrons are observed which do not overlap and thus cannot result in essential pre-ionization in the gap. The resulting discharge is shown in Figure 1c. In helium multiple overlapping avalanches produced by fast electrons are observed thus indicating the generation of the diffuse discharge. The resulting electron density is shown in figure 1f.

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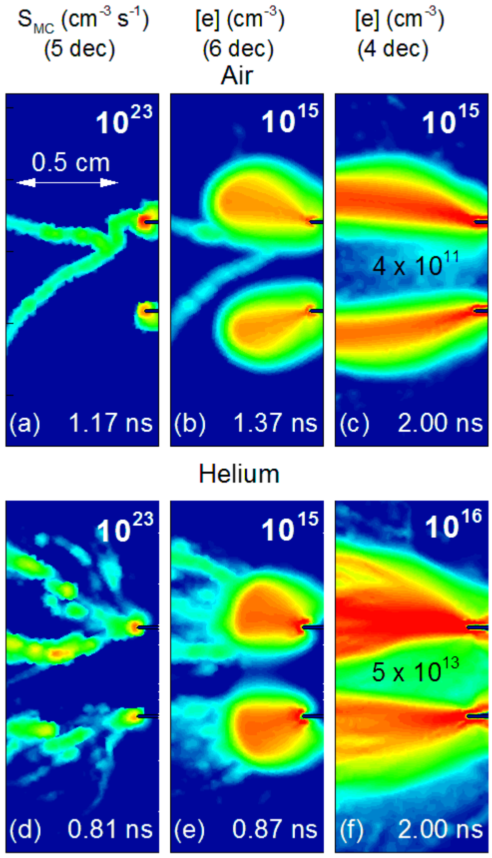

Figure 1. Ionization sources S_{MC} produced by beams of fast secondary electrons and resulting electron density in the evolving streamer shown for two time moments. (a,b,c) – air, (d,e,f) – helium.

5. References

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