Simulation of Nonthermal Plasma Discharges in Air and CO2 in Sub-millimetre Needle-Plane Gaps Under Fast-Rising Voltages

Timothy Wong

(University of Strathclyde)

Igor Timoshkin

(University of Strathclyde)

Scott MacGregor

(University of Strathclyde)

Mark Wilson

(University of Strathclyde)

Martin Given

(University of Strathclyde)

Interest in the use of high voltage (HV) pulsed power technologies has grown due to the numerous fields in which these technologies have proven effective. Applications range from the development of railgun technology and plasma closing switches (PCS); to plasma medicine, pulsed electric field (PEF) treatment of foodstuffs, and air purification via pulsed plasma discharges. In such applications, the understanding of the pre-breakdown dynamics under fast-rising voltages in various gases is often critical to system design and performance. In the interests of continued component miniaturisation and for the development of novel pulsed micro-electromechanical systems, this work presents the simulation of nonthermal plasma discharges initiated in a gas-filled, 250-micrometre needle-plane electrode gap, under ramp voltages of varying rates of rise. Using the hydrodynamic approach, discharges in atmospheric air and CO2 have been modelled. The results have allowed the effects of voltage polarity and rise rate on the plasma front morphology, propagation characteristics, and plasma composition to be analysed. Differences in the evolution of the plasma front between air and CO2 have also been studied, which may help to inform the choice of gas for use in gas-insulated pulsed power systems.

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