PULSED MICROPLASMAS GENERATED IN TRUNCATED PARABOLOIDAL MICROCAVITIES: SIMULATIONS OF PARTICLE DENSITIES AND ENERGY FLOW

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Microplasmas generated within cavities having the form of a truncated paraboloid, introduced by Kim et al. [Appl. Phys. Lett. 94, 011503 (2009)], have been simulated numerically with a two-dimensional, fluid computational model. Microcavities with parabolic sidewalls, fabricated in nanoporous alumina ($\text{Al}_2\text{O}_3$) and having upper (primary emitter) and lower apertures of 150 µm and 70 µm in diameter, respectively, are driven by a bipolar voltage waveform at a frequency of 200 kHz. For a Ne pressure of 500 Torr and 2 µs, 290 V pulses constituting each half-cycle of the driving voltage waveform, calculations predict that ~10 nJ of energy is delivered to each parabolic cavity, of which 26-30 % is consumed by the electrons. Once the cathode fall is formed, approximately 65% and 8% of the input energy is devoted to driving the atomic ion and dimer ion (Ne$_2^+$) currents, respectively, and the peak electron density of ~$6 \times 10^{12}$ cm$^{-3}$ is attained ~90 ns following the onset of the first half-cycle (positive) voltage pulse. Specific power loading of the microplasma reaches 150 kW-cm$^{-3}$ and the loss of power to the wall of the microcavity drops by as much as 22% when the excitation voltage is increased from 280 V to 310 V. The diminished influence of diffusion with increasing pressure is responsible for wall losses at 600 Torr accounting for < 20% of the total electron energy.

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