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Relativistic 1D PIC-MCC modeling and simulation of impedance collapse in high-voltage diodes

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A relativistic one-dimensional particle-in-cell (PIC) Monte Carlo Collision (MCC) model is developed to study velvet cathode plasma formation and expansion in high-voltage diodes. Velvet cathodes are used in high-power vacuum diodes for pulsed power systems such as magnetically insulated line oscillators (MILOs) for generating high-power microwaves (HPMs) and magnetically insulated transmission lines (MITLs) used in Z-pinch. A self-consistent plasma simulation model is required to understand the power scaling of these devices as they operate at higher applied voltages up to megavolts (MVs)[1]. The 1D PIC-MCC simulation model considers physical processes such as Fowler-Nordheim field emission (FNFE) with field enhancement, electron-neutral/ion-neutral collisions, and electron-electron/ion-electron Coulomb collisions. Simulation results predict gap closure rates consistent with experiments. Studies conducted on the effect of critical parameters, such as outgassed neutral layer (type of gas, density), pulse waveform, and field-enhancement factor, will be presented.

[1] Dale R. Welch, David V. Rose, Nichelle Bruner, Robert E. Clark, Bryan V. Oliver, Kelly D. Hahn, and Mark D. Johnston. Hybrid simulation of electrode plasmas in highpower diodes. Physics of plasmas, 16(12):123102–123102, Dec 2009.

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