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Micron-scale Field Emission Model for PIC-DSMC Simulations Based on Nanoscale Surface Characterization

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We present a model for stochastic, micron-scale field emission for use in Particle-In-Cell Direct Simulation Monte Carlo (PIC-DSMC) simulations of vacuum discharge. PIC-DSMC simulations of mm-sized electrodes cannot resolve atomic-scale (nm) surface features and therefore we generate micron-scale probability density distributions for an effective "local"work function, field enhancement factor, and emission area. Each micron-scale surface element in the PIC-DSMC simulation draws independent values from the atomic scale measured distributions for local work function and topological field enhancement factor (beta). In the present work, we use data from atomic-scale (nm) surface characterization using Scanning Tunneling Microscopy (STM), Atomic Force Microscopy (AFM), and Photoemission Electron Microscopy (PEEM) to generate a representative probability density distribution of the work function and field enhancement factor (beta) for a sputter-deposited Pt surface. We compare simulated Fowler-Nordheim field emission currents from the (˜nm) mesh-resolved, as-measured surface with the currents generated using the micron-scale model on a coarse mesh with a perfectly flat representative surface. Some effort has been made to compare emission currents for the coarsened model to equivalent current densities from atomic-scale STM current measurements.

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