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Concurrent multi-scale modelling of vacuum arc plasma initiation

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The complex physical mechanisms involved in the formation of vacuum arcs have been of interest for many decades. Vacuum arcs are relevant in many engineering disciplines, but the physics behind them is not yet fully understood. In recent years, there have been many experimental and computational studies focused on understanding aspects of vacuum arcs.

Our work focuses on further development of a simulation model to describe the physical processes starting from electron emission and leading to the formation of an ionized plasma. The FEMOCS code is extended to include plasma simulation based on previous work on ArcPIC. Emission of electrons and heating of the cathode is simulated using the finite element method, while plasma simulation is performed using the particle-in-cell method with Monte Carlo collisions. We add evaporation of neutral atoms from the cathode, as well as ionization processes for multiple species of ions, notably impact ionization and direct field ionization.

A static nanotip is simulated with different parameters to study local field thresholds leading to thermal runaway. We find that our simulations are largely in agreement with experimental results. The most significant interactions contributing to initial formation of vacuum arcs are identified. The most important collision for plasma formation is found to be impact ionization of neutrals into Cu+ ions, while higher-order ions are found to play a lesser role. Direct field ionization of neutrals is also found to be significant at high fields.

Topic

Modeling and Simulations

Author: Mr KOITERMAA, Roni (University of Helsinki)

Presenter: Mr KOITERMAA, Roni (University of Helsinki)

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