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PIC-DSMC Simulations of Plasma Dynamics and Expansion During Vacuum Arc Initiation

Recent work on vacuum discharge with electrodes held at cryogenic temperatures [1] found interesting anode breakdown spot morphology that exhibited a "shielded"region at the center of the spot where melt did not occur. If the surface melt is due to electron energy flux, then the observed anode spot feature suggests a central region where the electron flux is excluded. This bears a striking resemblance to the electron focusing dynamics observed in simulations of high energy beam transport through a background gas [2]. In this work we use Sandia's Particle-In-Cell (PIC) Direct Simulation Monte Carlo (DSMC) code, Empire, to perform 3D simulations of vacuum arc initiation accounting for the observed arc properties in the FREIA cyrogenic discharge experiments and examine the evolution of the arc plasma and energy flux to the anode in order to understand the observed anode features.

[1] M. Jacewicz, M. Coman, I. Profatilova, W. Wuensch, S. Calatroni, I. Popov, and Y. Ashkenazy, "Exploring high gradient limit with cryogenic experiments at FREIA laboratory", MeVarc 2024, Lake Tahoe, https://indico.cern.ch/event/1298949/cont

[2] B.M. Medina, P. Grua, K.L. Cartwright, D. Hebert, N. Szalek, C. Caizergues, I. Owens, E.L. Rhoades, J. Gardelle, and C.H. Moore, "Verification and benchmarking relativistic electron beam transport through a background gas", Comp. Phys. Comm. 288, 108721 (2023)

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Modeling and simulations

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