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Open Issues in a Self Consistent RF Vacuum Arc Model

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We find that a general vacuum arc model seems to require four stages: a trigger, ionization, plasma evolution, and surface damage. Within this framework, a large number of mechanisms operate, involving field emission, surface failure, ionization, plasma interactions with the surface and surface interactions with plasma. Field emission is complicated by the duty cycle, space charge, nearby plasma and the geometry of field enhancements. RF field emission is uniquely slow and inefficient, but enhanced by nearby plasma. Surface failure can involve electromigration, diffusion, exploding wire physics, explosive electron emission and an ordinary Coulomb explosion. During the ionization stage, image charge can collect ions near the metallic surface, and sputtering can increase the plasma density from a few atoms to a system that produces Amps of current. We find that sputtering yields increase when the surface melts. Surface instabilities may limit the plasma density and can produce macro particles and dust. Both Maxwell stress and plasma pressure act on the surface. After the plasma is gone, surface tension and capillary waves dominate the micro-surface, while differential cooling and cracking dominate the macro-surface. In the RF case, a unipolar arc, confined by image charges and fueled by sputtering and instabilities, seems to determine the evolution of the surface. A wide range of variables is involved in arcs with many surface micro-geometries, ns to ms timescales, possible pre-existing plasma and magnetic fields. This work seems relevant to arcing in tokamaks, accelerators, micrometeorite impacts, HVAC transmission lines and dielectric breakdown.

Topic

Modeling and Simulations

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