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Simulations of Multi-Phase Processes of Arc Interaction with Electrodes

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Although Explosive Electron Emission (EEE) is well known for vacuum arcs [1], effects of gas pressure on EEE processes have been rarely studied so far [2]. Often, anode erosion associated with crater formation and liquid metal pool on the anode surface has been observed. In our presentation, we will report results of an ongoing work to develop computational models of arc interaction with electrodes for a wide range of gas pressures and arc currents. Simulations of craters on electrode surface, formation of plasma jets, acceleration of ions to high energies, and other phenomena associated with arc interaction with electrodes require coupling plasma physics with multi-phase flow science.
We have developed a Unified Flow Solver (UFS) with dynamically adaptive Cartesian mesh and multi-scale simulation capabilities [3]. The Adaptive Mesh and Algorithm Refinement (AMAR) methodology of UFS is being extended to add multi-phase capabilities for arc interactions with electrodes and electrode erosion processes. We use the Volume of Fluid model to dynamically trace solid-liquid interface and liquid molten pool dynamics, as well as expansion of plasma jet in vacuum and ambient gas.
We have simulated development of a liquid pool of molten Cu surface and formation of splashes and droplets. The dynamically adapted grids capabilities were found to be crucially important to properly resolve the freely moving gas-liquid interface and the electric fields around the sharp edges of the interface. Current work includes simulations of single ectons on tip of Taylor cones formed on liquid cathodes. EEE results in the formation of plasma jets expanding from the cathode. During jet expansions, a non-ideal plasma turns into an ideal plasma. We use hybrid fluid-kinetic models of UFS to analyze effects of ambient gas pressure on the dynamics of EEE-induced plasma processes.

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References

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Authors: Dr KOLOBOV, Vladimir (CFD Research Corporation); Dr ARSLANBEKOV, Robert (CFD Research Corporation); Dr LEVKO, Dmytro (CFD Research Corporation); Dr NEMCHINSKY, Valerian (Keiser University)

Presenter: Dr KOLOBOV, Vladimir (CFD Research Corporation)

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