SAND2018-11682C

Slides for Mikhail Benilov

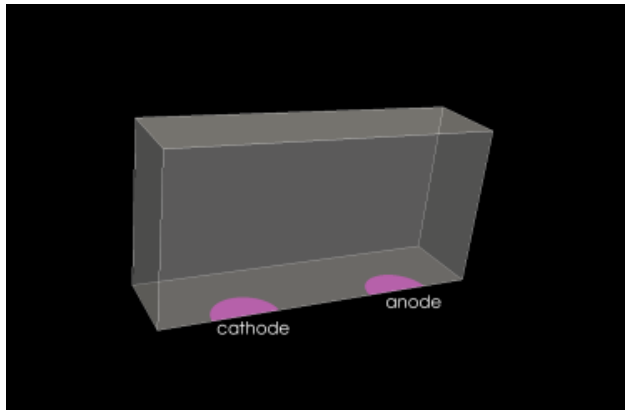
Matt Hopkins

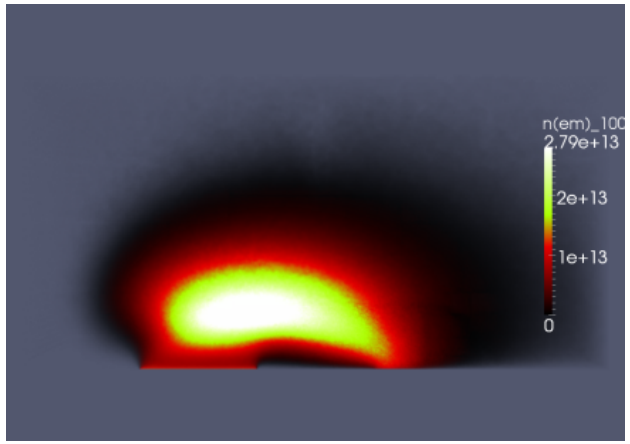
Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy?s National Nuclear Security Administration under contract DE-NA0003525.

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

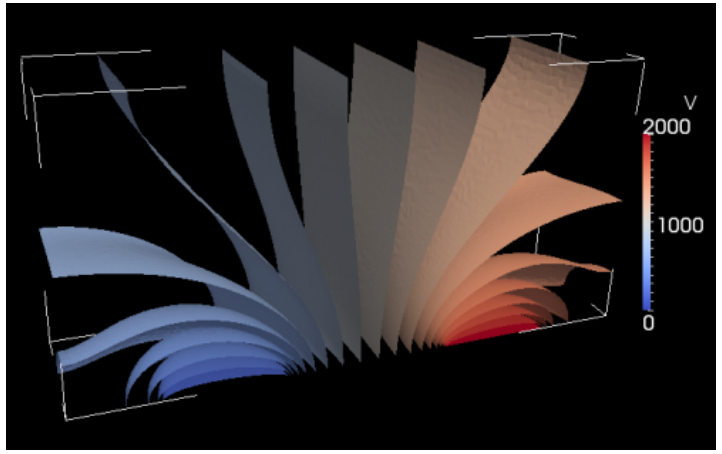
PIC-DSMC Aleph Simulation of Vacuum Arc Initiation

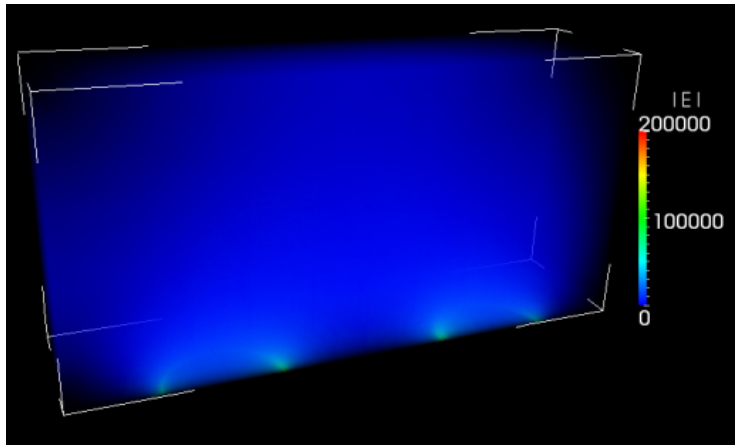
- Vacuum arc initiation dynamics are initially kinetic / non-fluid.
- How to manage the transition from kinetic to fluid if aspects of both are important?



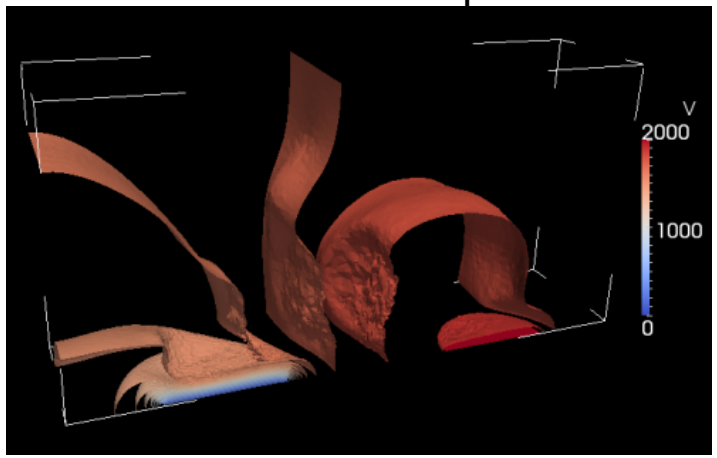


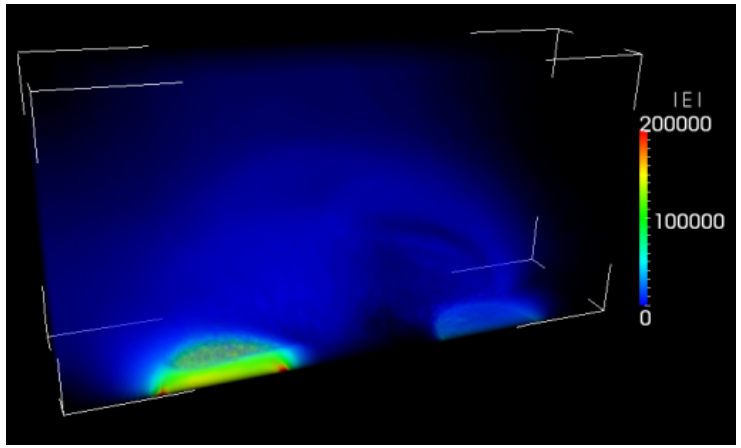
t = 0





t = 390 ps





Prior simulation was in the direction of vacuum discharge initiation.

Density units in the plots are in cm^{-3}, not m. $10^{13}/cm^3$ is $10^{19}/m^3$.

- There was a Cu background of 300 mtorr, 300K. Not real vacuum!
- 2 kV across interelectrode spacing = 0.75 mm.
- Electrode model was “simple”. Secondary emission of Cu and e- from impacting e- and Cu+. Yields were 1.0 (Cu+ -> Cu at anode, Cu+ -> Cu and e- at cathode) and 0.01 (e- -> Cu at anode, e- -> Cu at cathode)
- Initiating electrons were a small flux from the cathode. Cu also influxed from cathode.
- Simulation eventually “fails” (correctly!) because of very high plasma density causing non-resolution of space/time scales. I.e., when a fluid model would be the better method. Simulation dt = 10 fs.

Question: how to transition if initiation details, when the system is non-fluid, are critical?

Electrode behavior

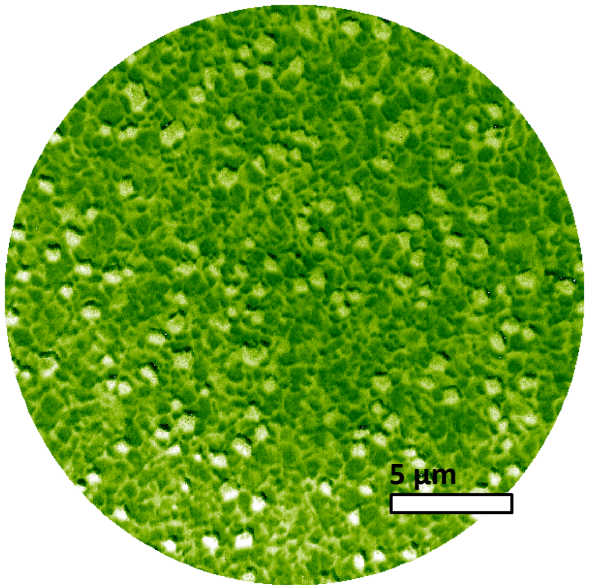
To me, an unmet need for predictive simulation is to properly account for electrode behavior. Gaseous discharge is easier than vacuum discharge in this respect (initiation issues are not as difficult).

Current mode: (1) suggest a model, (2) simulate with this model and dial parameters around until results are qualitatively correct and in line with expectations, (3) claim model is “right”.

This is a wrong approach. Hypothesized models must be challenged by well-designed experiments. E.g., the secondary yields used in simulations are (almost?) never the actual yields measured for a surface in an associated experiment. Yields are chosen from other publications and/or just “picked” as in the mode above.

(more relevant to vacuum discharge, not gaseous)

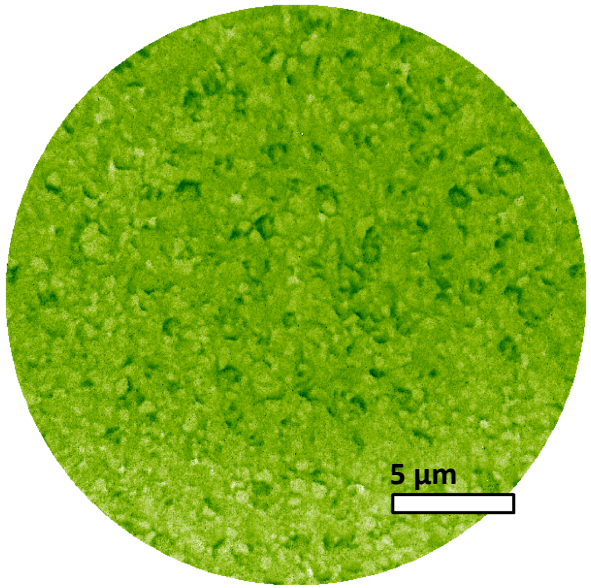
Air-exposed



4.9 5.0 5.1

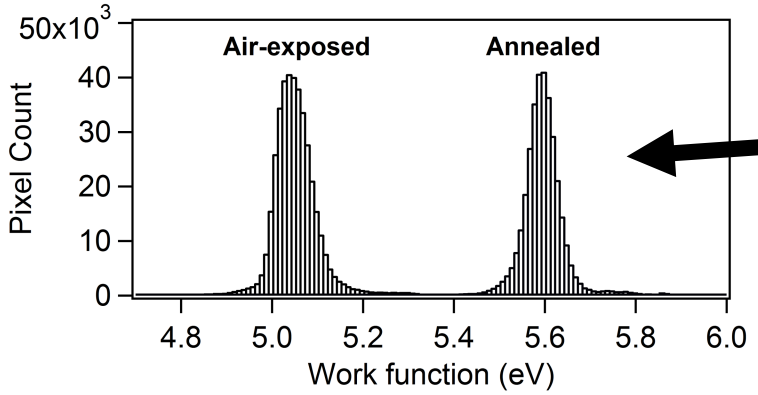
Work function (eV)

Annealed



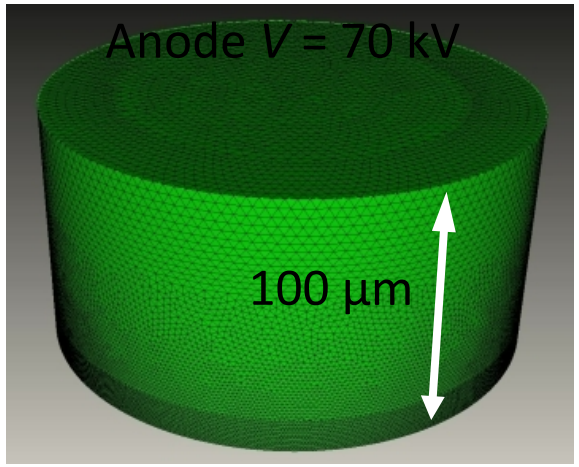
5.4 5.5 5.6 5.7

Work function (eV)



Work function distributions measured on same surfaces used in discharge experiments.

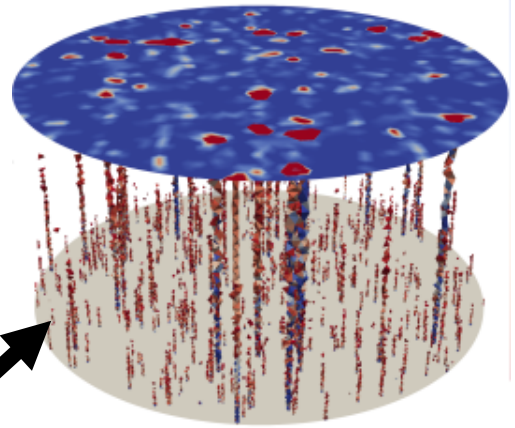
Use distribution in simulations!



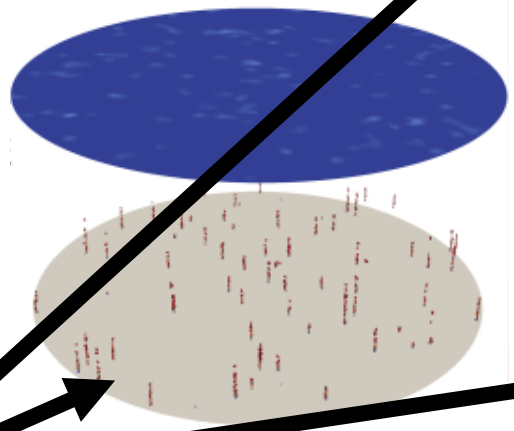
Grounded cathode, Δx = 1 µm

Air-exposed Pt

1st random # seed



Annealed Pt



2nd random # seed