Abstract Submitted
for the DFD19 Meeting of
The American Physical Society

Vorticity Generation in a Single Nanosecond Spark Discharge Due to Shock Curvature BHAVINI SINGH, LALIT RAJENDRAN, PAVLOS VLACHOS, SALLY BANE, Purdue University — Spark plasma discharges are generated by raising the voltage difference between two electrodes, until breakdown voltage is reached, resulting in ionization of gas in the electrode gap. This rapid release of energy results in the formation of a shock wave as well as a region of hot gas that expands and cools with time. At later times, vortex rings are formed near each electrode that entrain ambient gas into the electrode gap to cool the hot gas kernel. However, the mechanism(s) responsible for the generation of vorticity in the flow field, and the effect of electrical energy deposited in the gap on this vorticity is unclear. We hypothesize that the shock wave formed at the time of the discharge generates the vorticity by means of baroclinic effects due to shock curvature, and this vorticity field then develops into the pair of vortex rings observed at later times. In this work we develop a detailed analytical framework to relate the vorticity generation to the shock curvature and energy deposited in the electrode gap, and test this framework using 700 kHz shadowgraph and 100 kHz pulse-burst Particle Image Velocimetry (PIV) measurements. We extract the shock curvature from the shadowgraph images and compare the predicted vorticity field from the framework with the measured vorticity field from PIV. These measurements along with the framework will help ascertain the role of shock curvature and energy deposited on the vorticity generation.

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Date submitted: 29 Jul 2019 Electronic form version 1.4