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Campaign Title: Parylene-N Coatings of Thin Foils for the Mitigation of Neutral Contaminant Desorption and Plasma Formation

User Facility and Dates of Research:

Sandia National Laboratories – Mykonos Facility

September 23, 2024 – October 25, 2024

Research Team:
Principle Investigator: Ryan McBride (UMich)
Principle Experimenter: Trevor Johannes Smith (UMich/SNL)
Target Fabrication & Design: Steven Larson (SNL); Alex Sarracino (SNL)

Description of Work: Previous experiments utilizing the planar MITL foil platform (T.J. Smith et al. RSI 2021) on the 1-MA, 100-ns Mykonos facility have shown neutral atomic and molecular hydrogen in the gap after rapid heating of the foil surfaces before breakdown. Additionally, previous attempts at using parylene-N as a coating for power flow surfaces on the 1-MA, 100-ns Zebra facility have shown tamping of the electrothermal instability at thicknesses of 50-60 µm (T.M. Hutchinson et al. Phys. Rev. E 2018).

This campaign aimed to characterize the effects of different thicknesses of Parylene-N as a coating for electrode surfaces to dampen neutral contaminant desorption into anode-cathode gaps and prolonging the formation of power flow plasmas. Using the planar MITL foil platform, parylene-N thicknesses of 1, 5, 10, 20, and 50 um were coated onto 200-um thick foils.

VUV spectroscopic measurements were made to determine the density of hydrogen in the gap before breakdown, while gated and streaked visible spectroscopy measurements determined the constituents in the plasma in the gap after breakdown. ICCD imaging captured the evolution of plasma formation in the gap while avalanche photodiodes were able to capture when first light occurred on the anode. Lastly, a residual gas analyzer was able to determine the vacuum background and determine if there was any losses to the thickness of the parylene-N while under vacuum.

Outcome: These targets were fired on the Mykonos facility with charge voltages of +/-70 kV with a typical peak current of 800 kA. While VUV spectroscopy showed low density, low temperature molecular hydrogen in the gap before plasma breakdown, once plasma formed, the parylene-N coating began to ablate and move into the gap; this occurred faster for thinner coatings of parylene-N. 1-D Gated visible spectroscopy across the gap showed no mitigation to low density plasmas in the gap which was verified by visible ICCD gap-side-on imaging and localized streaked visible spectroscopy near the cathode surface. It is also noted that high density, high temperature plasmas emitted Planckian blackbody light at the location of the foil and foil surfaces. The plasma that formed on the vacuum facing cathode surface of the parylene-N coatings around peak current often formed small finger like perturbations running the length of the electrode. Additionally, large plasma columns were often seen breaking through the parylene into the gap. These findings were also confirmed for slower heating rates on the MP3 platform with 50-um parylene-N coatings.

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Benefits of ZNetUS Funding:

ZNetUS funding enabled target fabrication with the Thin Films and Coatings group at SNL for work on a dissertation. Purchases such as a new 200 AMU residual gas analyzer will enable future experiments like plasma cleaning on power flow surfaces. Additionally, the high cost of VUV optics was able to be covered for these experiments and enabled high precision measurements.

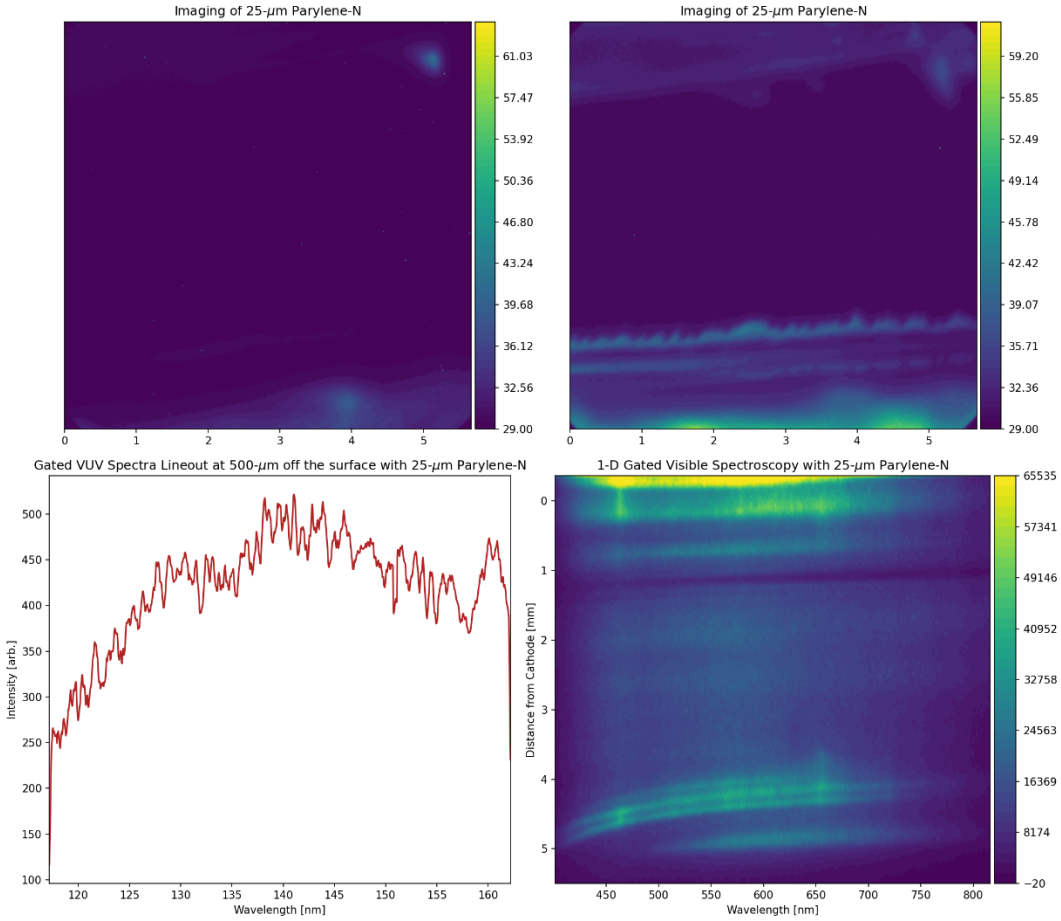

Fig. 1. The top left photo is a ICCD image at the start of plasma formation at 60% current rise with the top right image at peak current. The image goes from anode (top) to cathode(bottom). The bottom left hand image is a VUV spectroscopy lineout 500-um off the surface of the cathode showing molecular hydrogen at ~2000-3000K before plasma breakdown. And the bottom right image shows a 1-D lineout of gated visible spectroscopy across the gap from the cathode (top) to anode (bottom) at the same time the top right image is taken.

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