OAK RIDGE National Laboratory

Characterization and Analysis of Nanocrystalline Diamond as Stripper Foils

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U.S. DEPARTMENT OF ENERGY

1- University of Tennessee at Knoxville
2- Center for Nanophase Material Science
3- Spallation Neutron Source

Identify ways to refine and improve foil stability

- **Develop methods for characterizing Nanocrystalline diamond (NCD) films**
- **Set failure criteria for the films to be judged**
- Identify physical properties of the films
- **Provide post mortem assessment of foils**
- **Understand foil conditioning and provide feedback to minimize SNS conditioning time.**

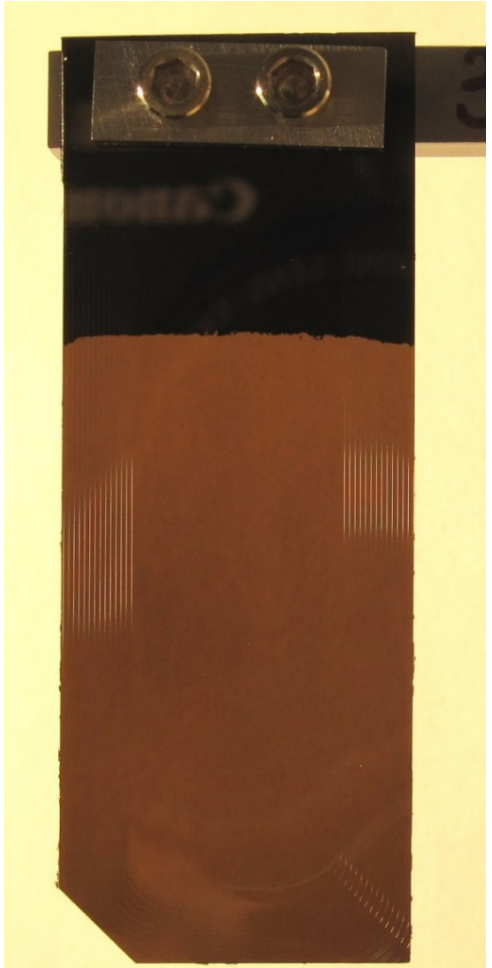
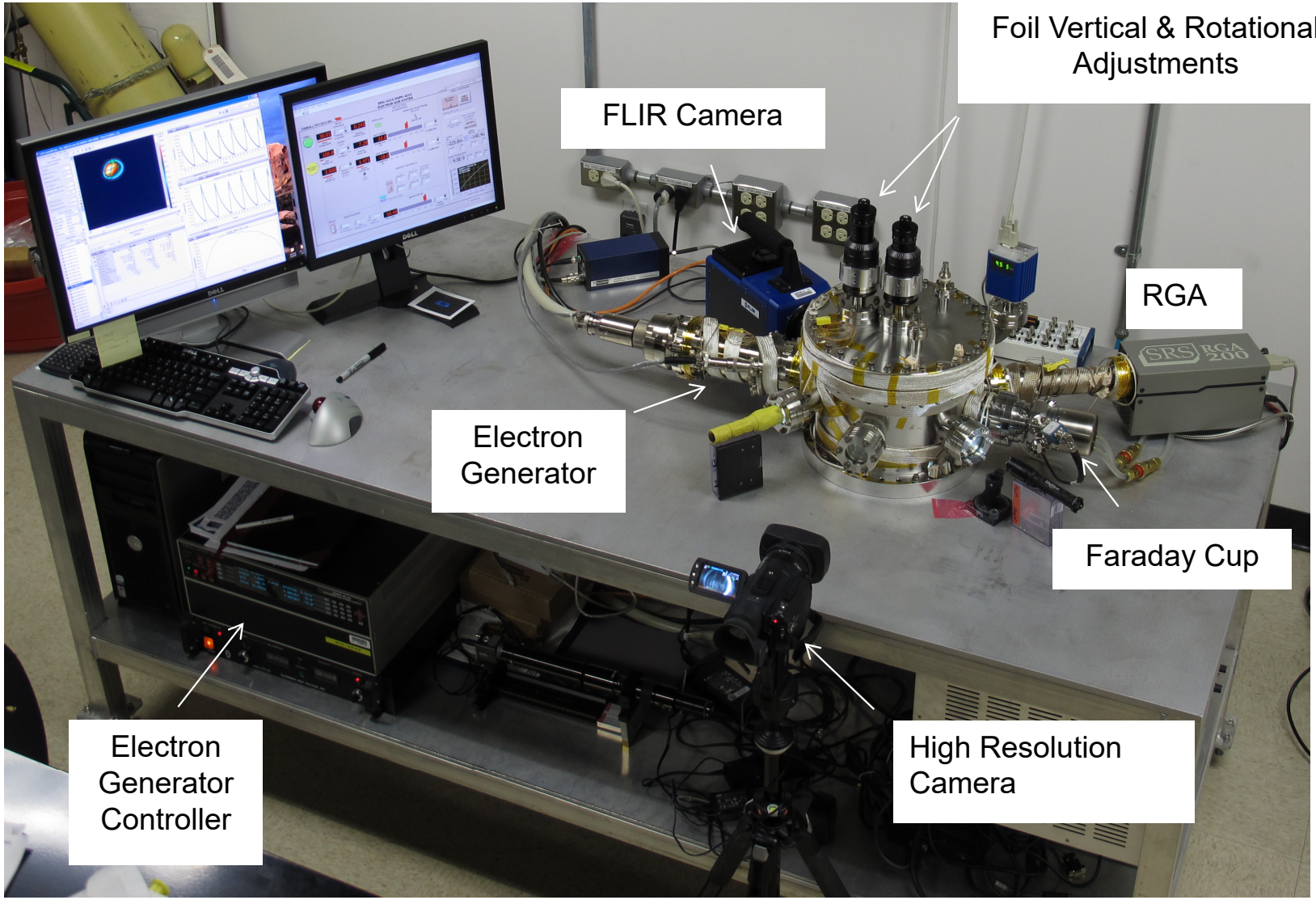


Photo by Chris Luck

Refer to Paper Id 1320 for more information on Foil.

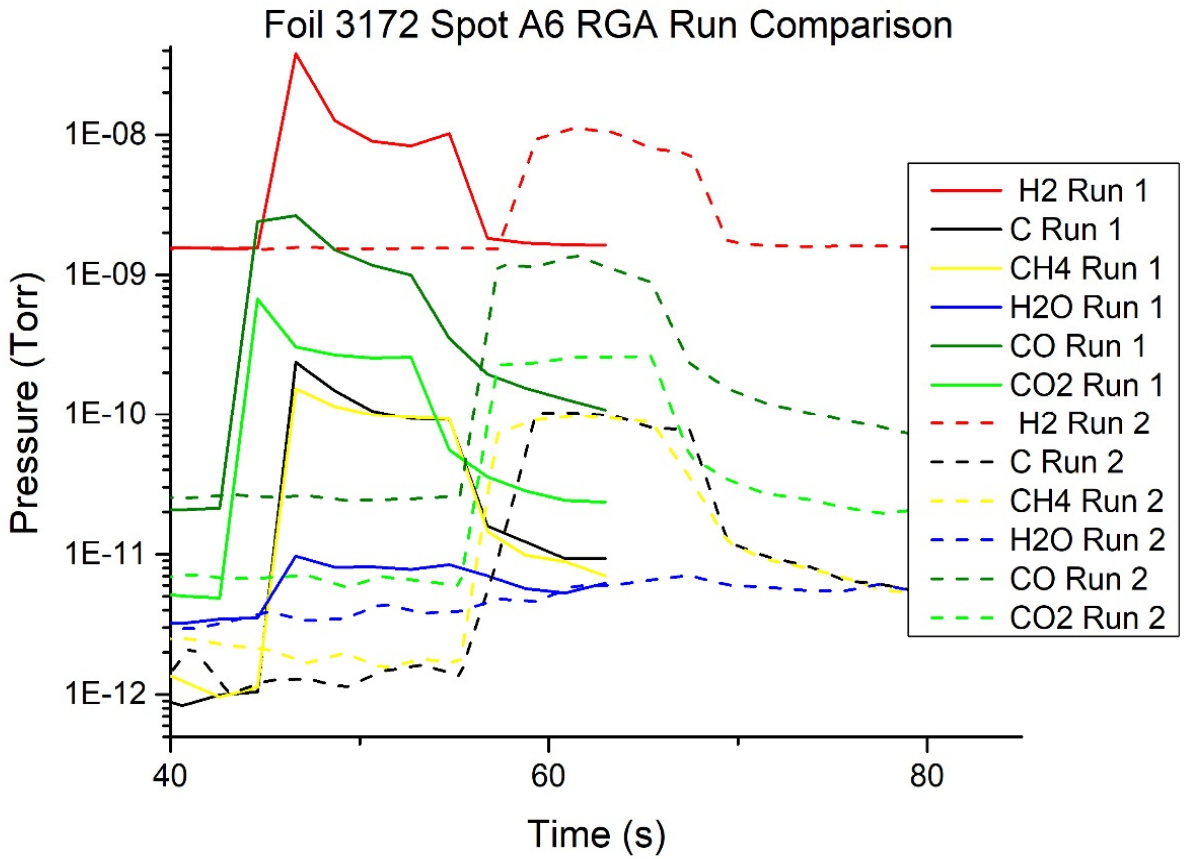
Foil Test Stand

- 5 mA max current
- 30 keV accelerating voltage
- Continuous or pulsed beam
- Pulsed at 60 hz and 1 ms dwell time to emulate the SNS beam.
- Can emulate SNS heat load on small spot.



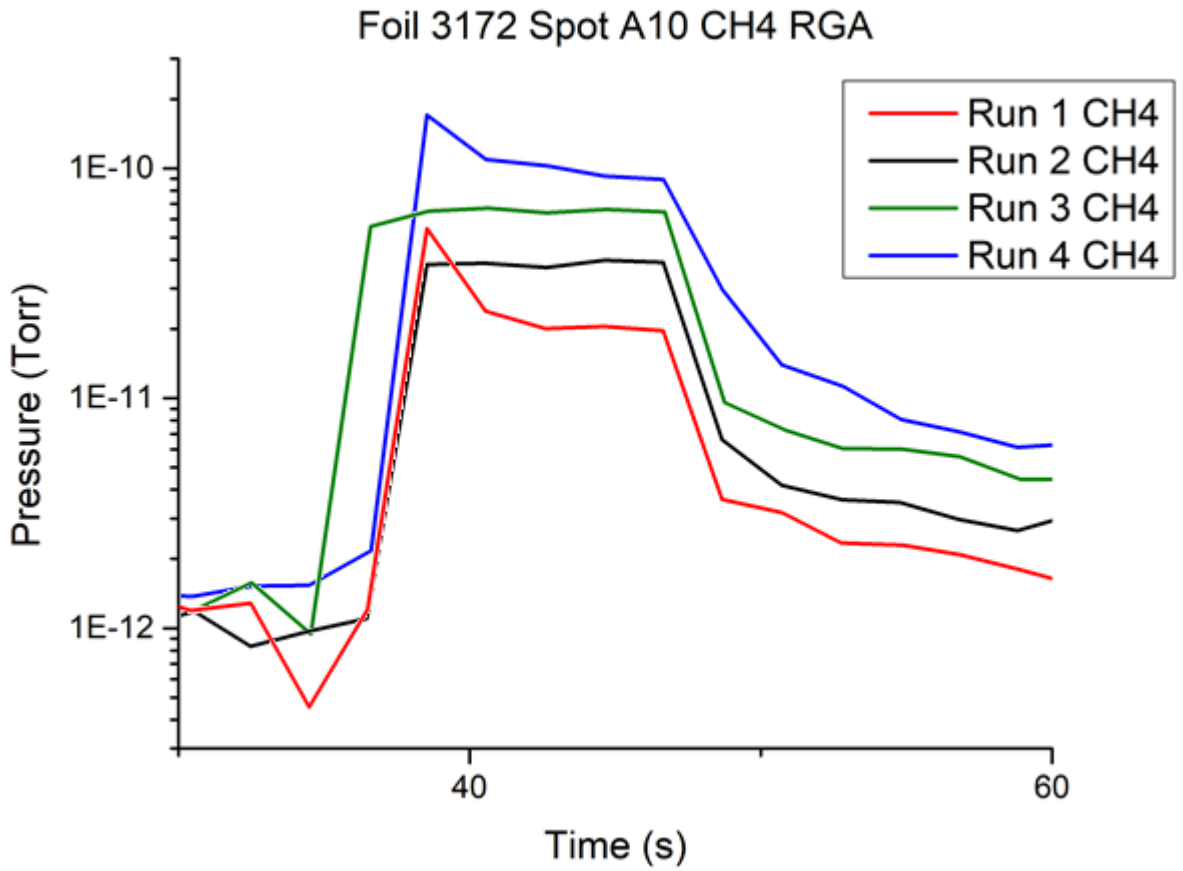
Partial Pressure Spikes – Adsorbed Gasses

- Initial partial pressure spikes were detected in the RGA and thought to possibly be sublimation.
- Consecutive runs on the same at the same beam power do not see repeated partial pressure spikes.
- These initial spikes are attributed to removal of an adsorbed layer.

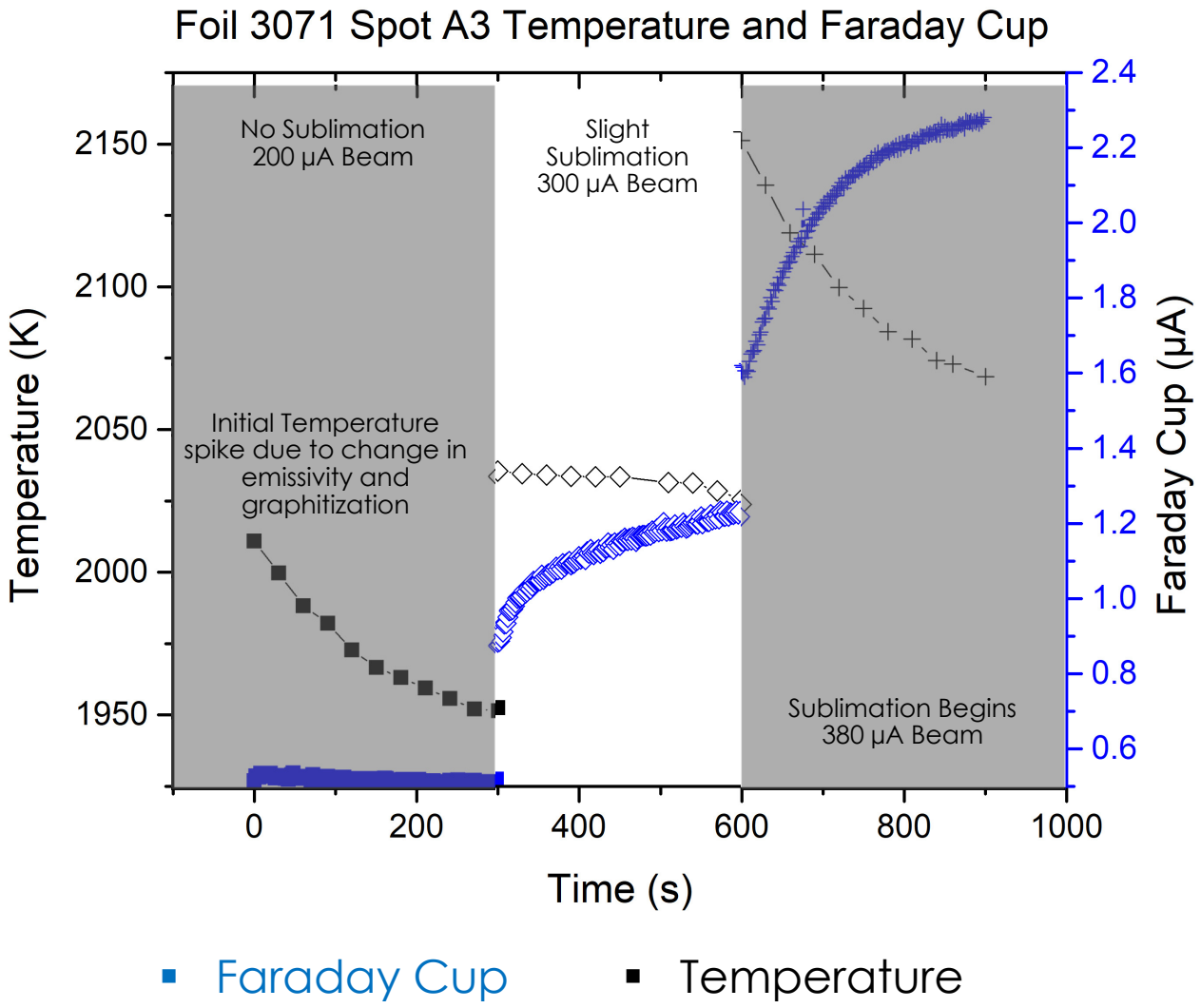


Partial Pressure Spikes – Foil Sublimation

- Repeated runs on the same spot at increasing currents were used to see if a partial pressure spike would occur again.
- It isn't until the current is increased three times that we saw another partial pressure spike.
- This secondary peak is believed to be the onset of sublimation.

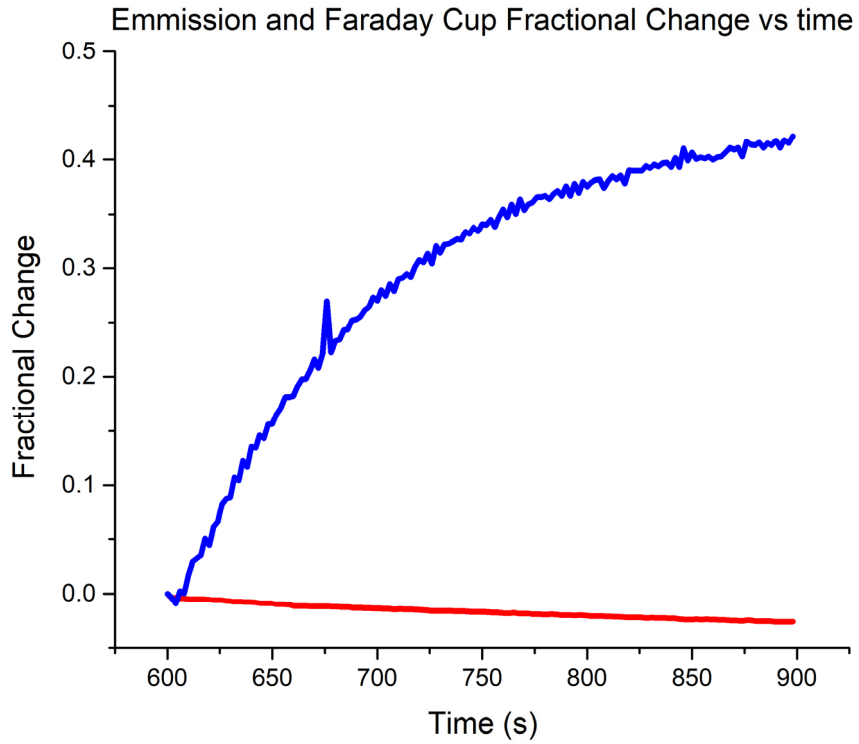


Signs of Sublimation

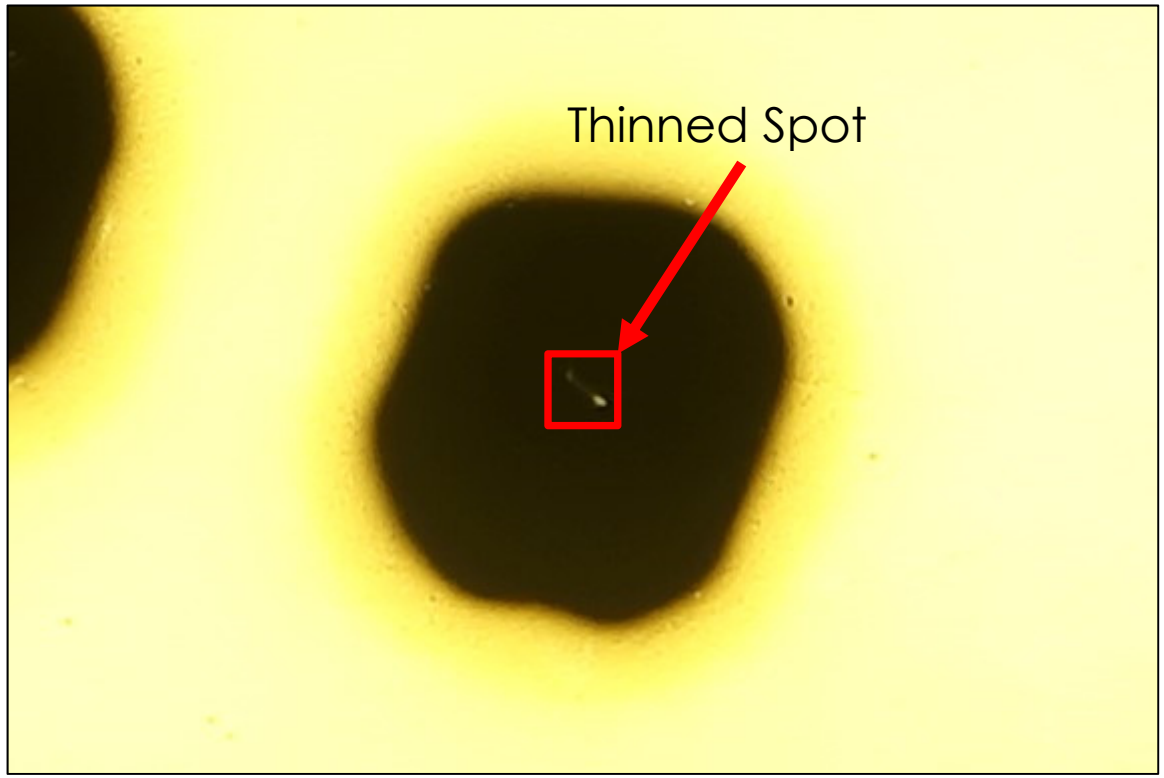


- Three regimes are shown in the plot to the left.
- No sublimation occurs in the far left regime with a temperature peak due to graphitization.
- The middle section demonstrates a fairly stable temperature with slight faraday cup creep.
- The last section shows a failure mechanism starting with the temperature rapidly decreasing and faraday cup current increasing.

Signs of Sublimation



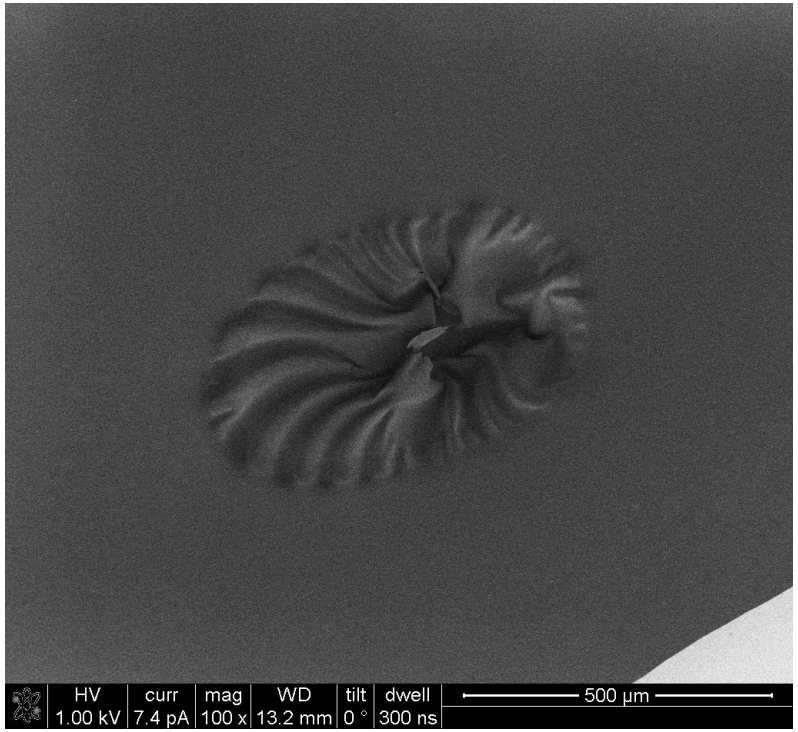
- Faraday Cup
- Emission

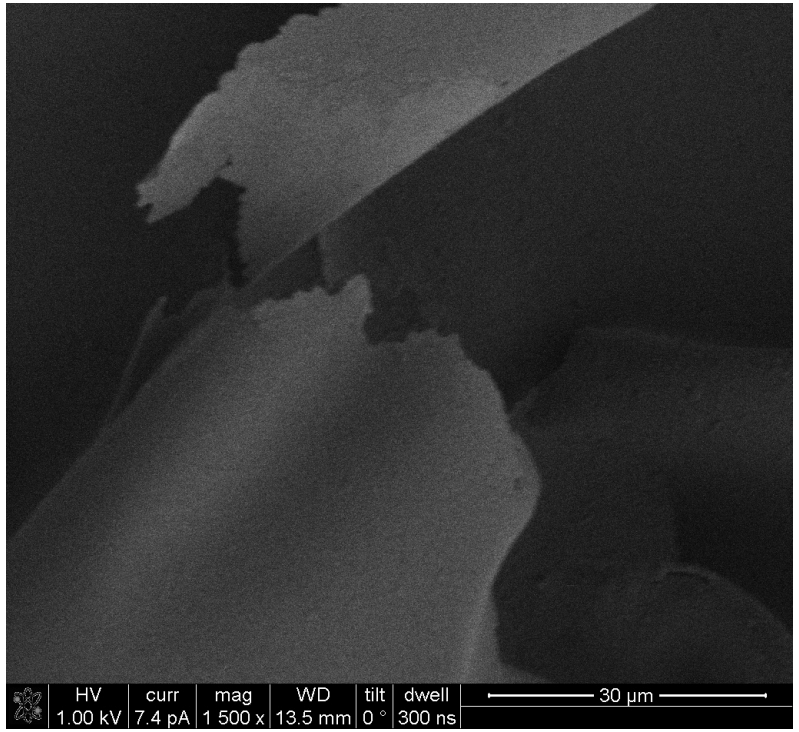


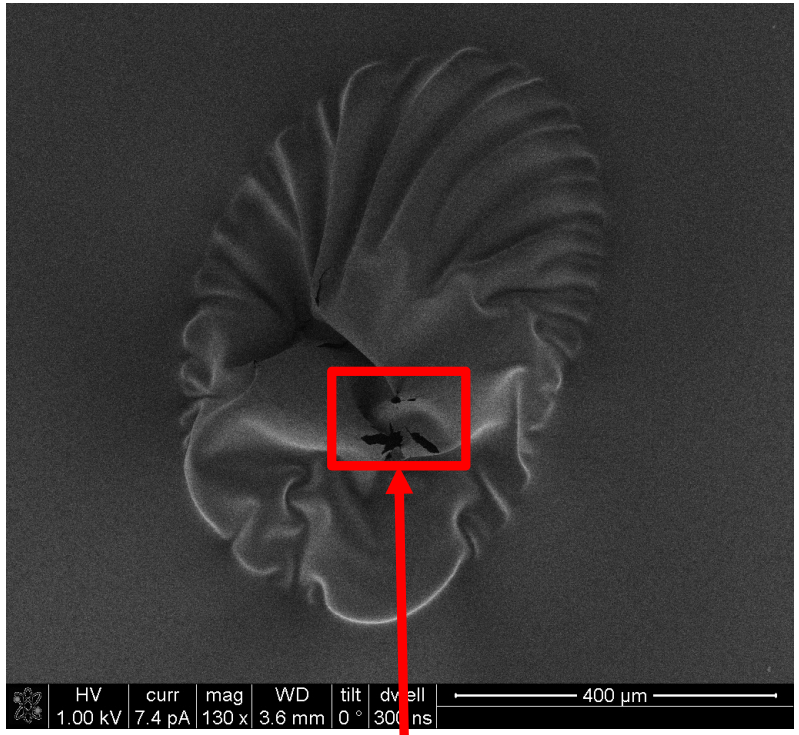
- Electron gun Emission current and faraday cup current should scale with one another if no thinning or hole formation occurs.

SEM Imaging

- Post mortem SEM imaging can give insight into whether holing occurred due to mechanical stress or sublimation.

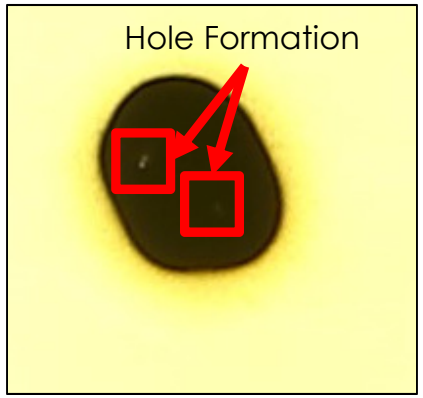


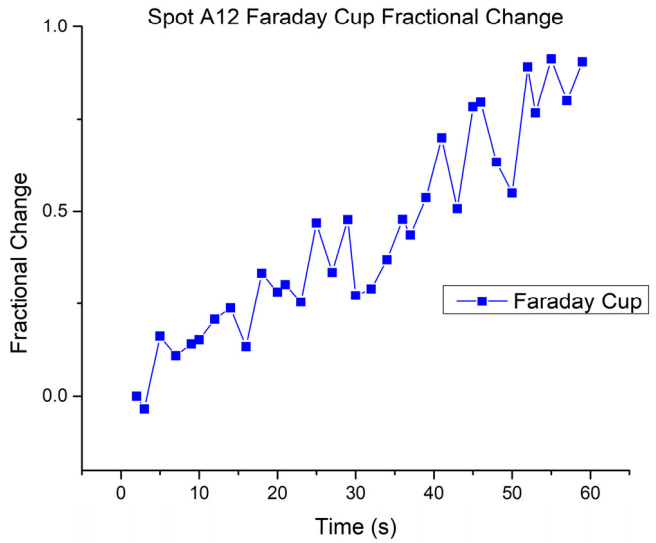




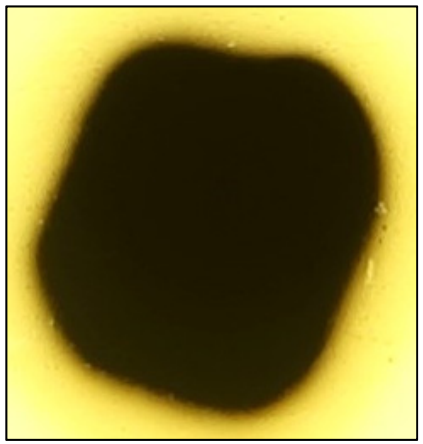
Conditioning

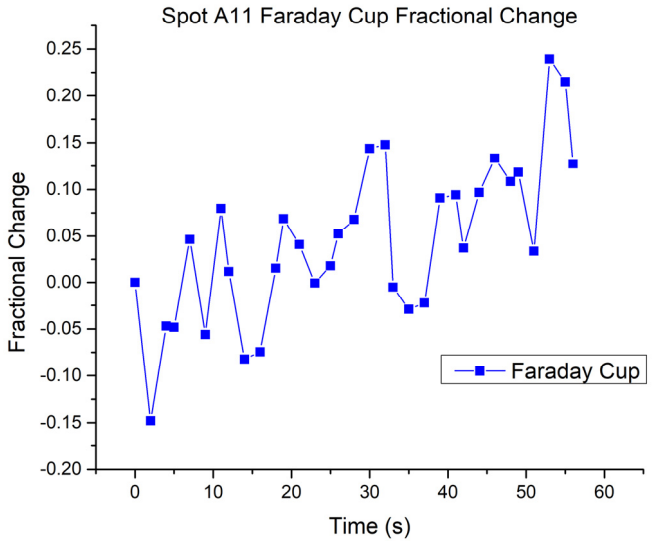
Spot A12 Non Conditioned Spot





Spot A11-3 Pre Conditioned Spot

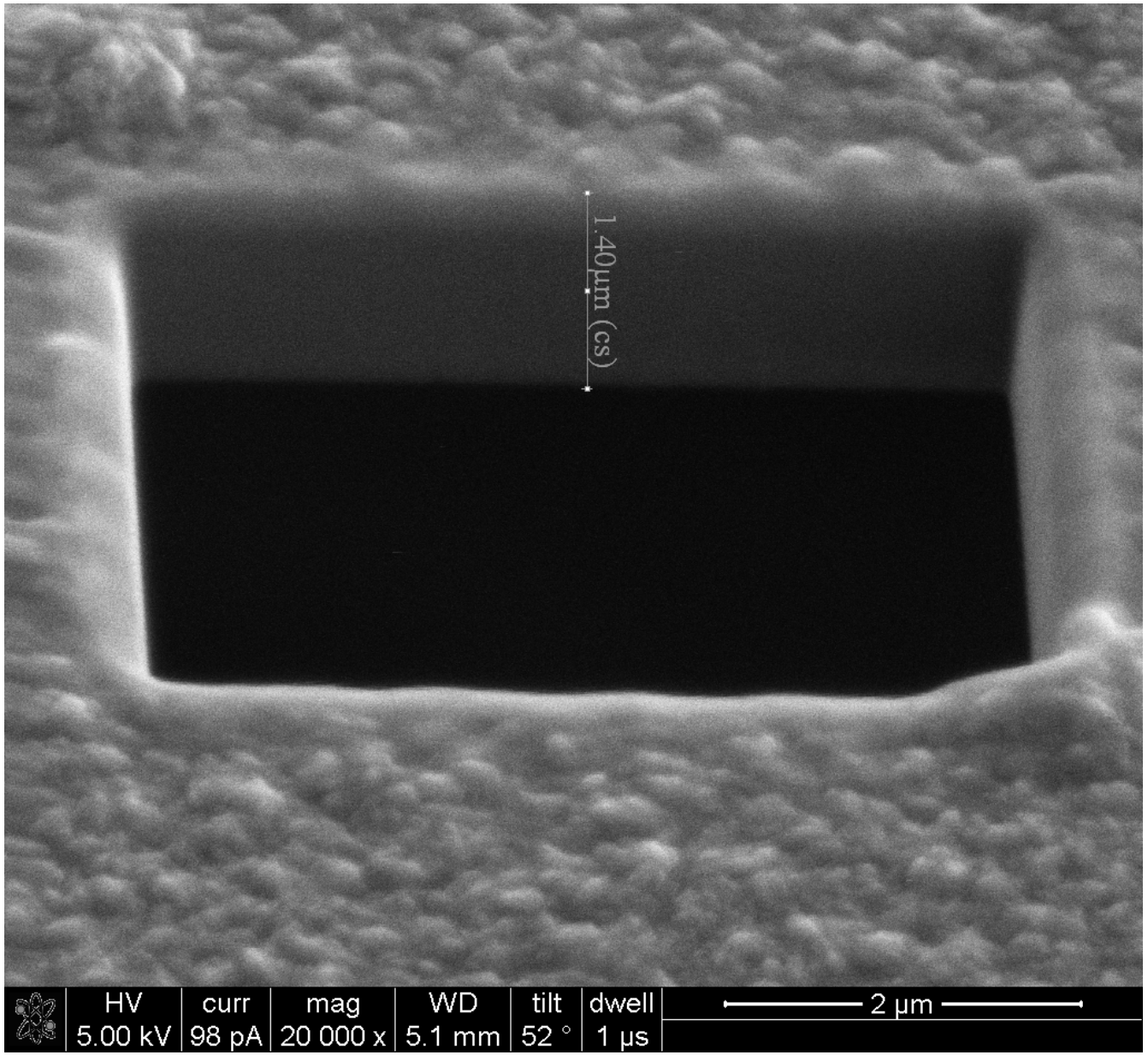




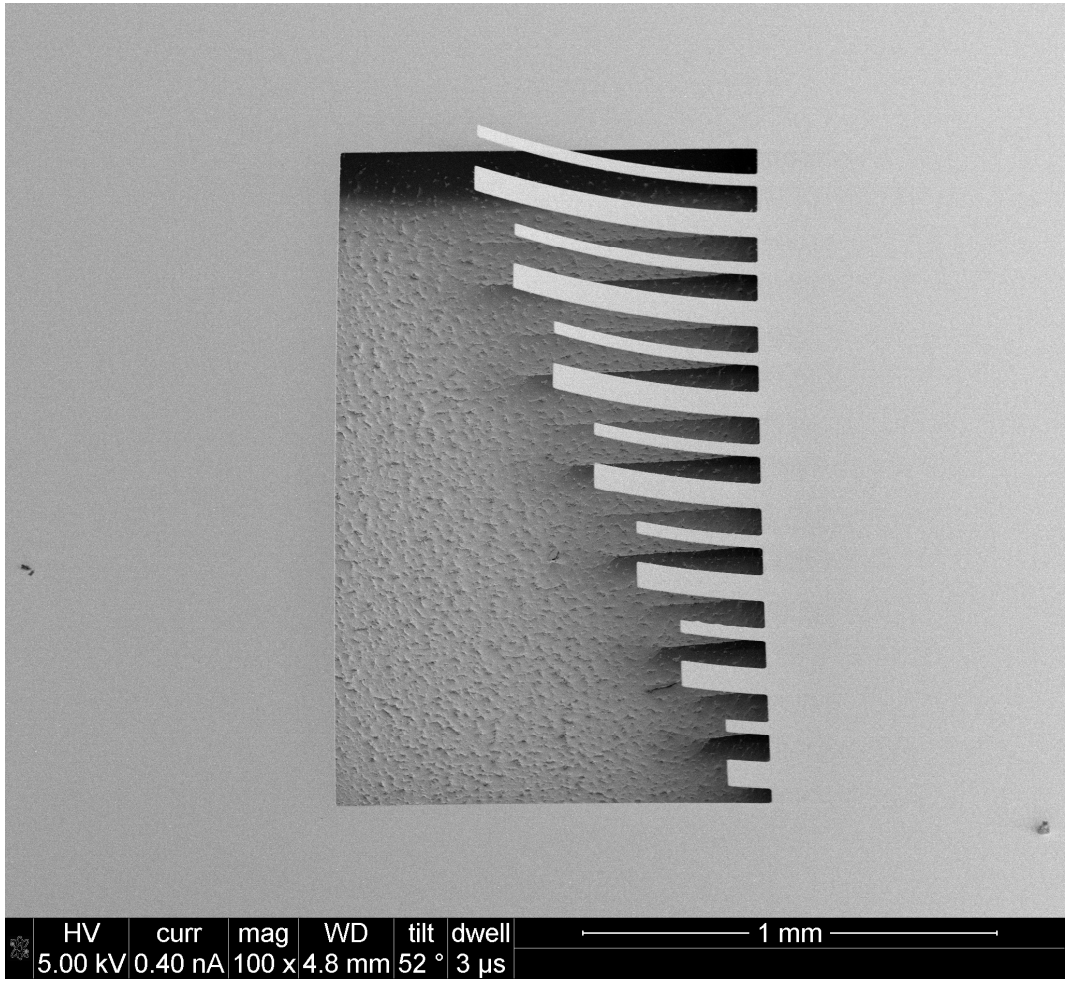
- Conditioned spots see less hole formation than the non conditioned spots.
- The graphitized area believed to act as a heat sink.
- Stress due to "graphitization" is also a concern for inducing mechanical failure.

Post Mortem Testing

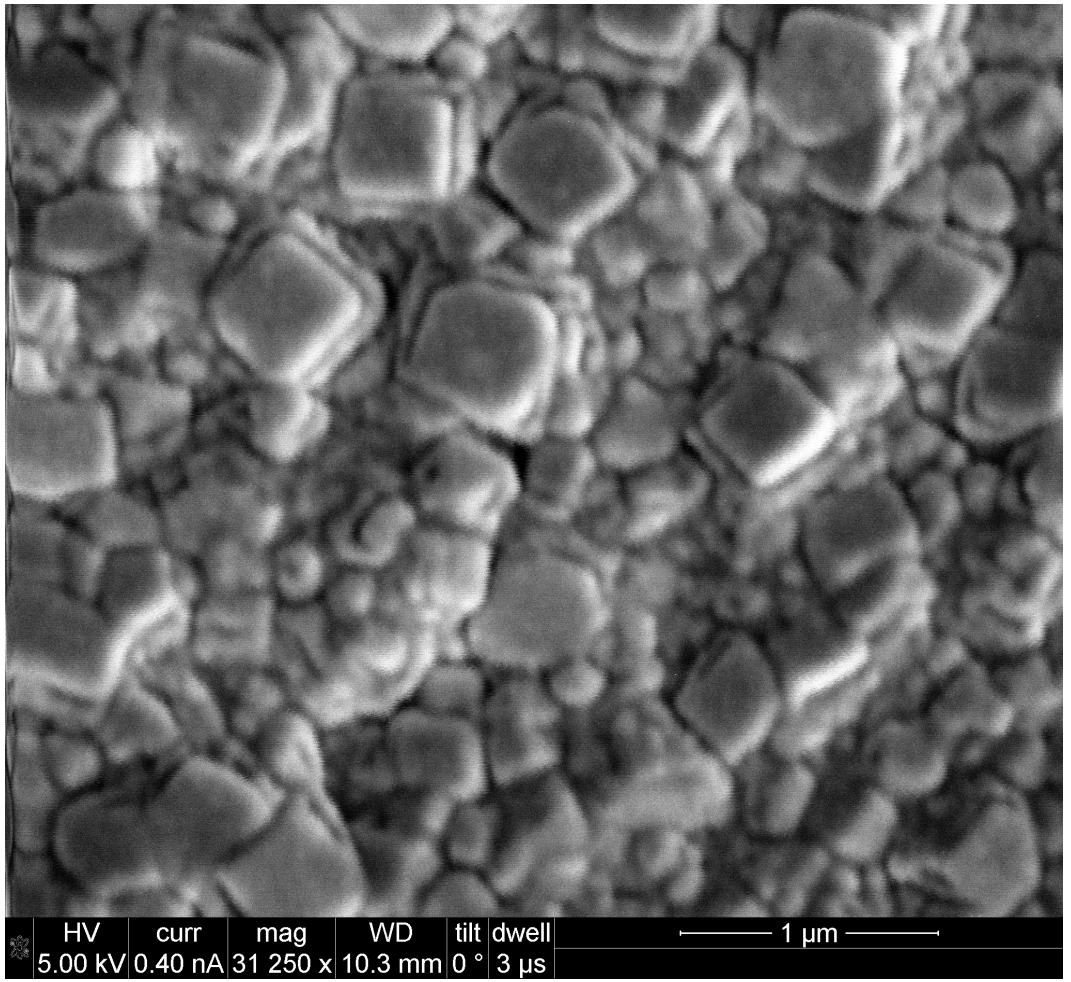
- Ion beam milling can give thickness measurement of exposed areas.
- This will help to measure both density changes due to graphitization and thickness changes due to sublimation.
- This gives a direct method to measure thickness and link to sublimation.



Foil Improvement Research



- Bilayer cantilevers used to measure thermal conductivity.



- Microcrystalline diamond surface structure with a layer of gold on top. Roughly 40x higher thermal conductivity.

Acknowledgements

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