HIGHLY CONDUCTIVE AND FUNCTIONAL ELECTRODE COATINGS

DEVELOPMENT OF AN OPTIMIZED DEPOSITION PROCESS

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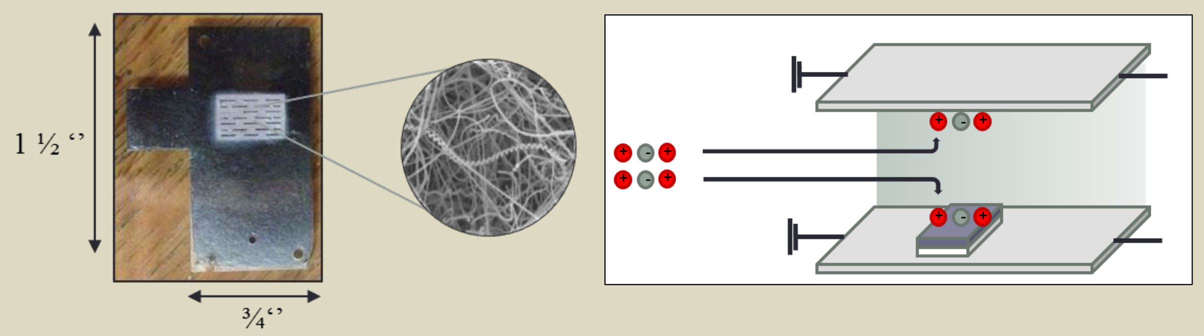
The research focus is to optimize the Graphitic material from the University of Idaho Thermolyzed Asphalt Reaction (GUITAR) deposition recipe to create a commercially viable electrode coating process. Our work includes ongoing optimization of the GUITAR deposition recipe and film characterization.

BACKGROUND

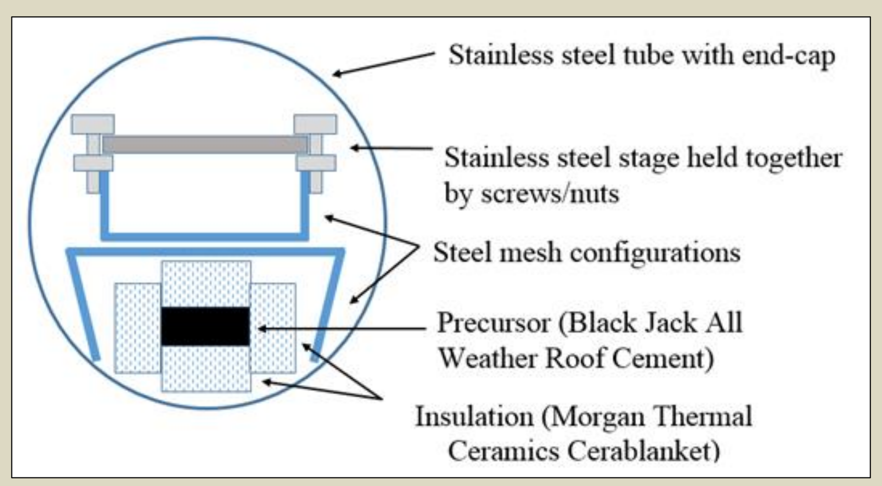
Oregon State researchers are currently developing an ion removal device at the Microproducts Breakthrough Institute in conjunction with the University of Idaho. The device consists of two graphite electrodes, with a microchannel between them. Silicon dioxide (SiO_2) nanosprings are grown on each electrode, and a graphitic film is deposited on the nanospring beds using the Graphitic material from the University of Idaho Thermolyzed Asphalt Reaction (GUITAR) deposition process. The graphitic films are electrically conductive, and attract ions from the solution when a voltage is applied to the device.



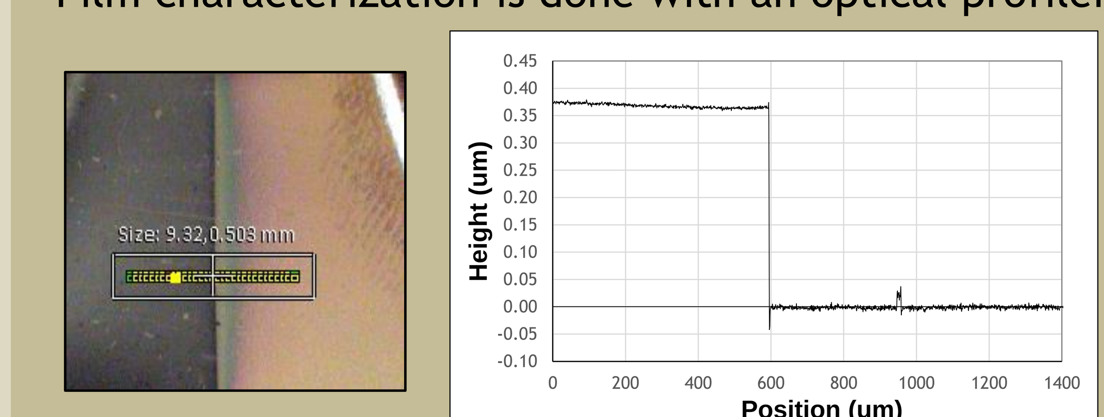
Due to the scale of the nanospring beds, the thickness of the deposited graphitic film is crucial to proper device function. Our research has focused on optimization of the GUITAR deposition process to repeatedly produce a uniform film layer on the order of 10 nm.

METHODS

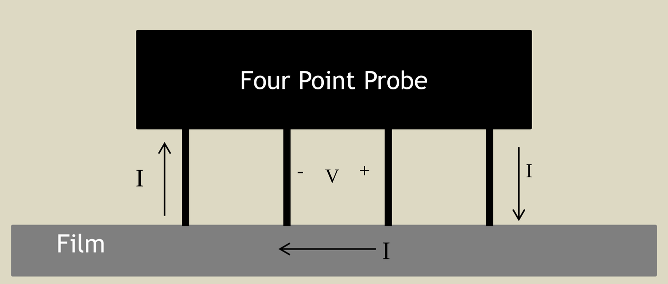
Deposition experiments are performed in a Rapid Temp Furnace. Silicon wafers are used as our substrate.



Film characterization is done with an optical profiler.



Electrical properties tested with a four point probe. Current is passed through outside probe tips and potential is measured between two inner probe tips.



OBJECTIVE

Optimize the recipe for depositing a thin, uniform, repeatable layer of conductive film.

Deposition Variables

- Temperature
- Dwell Time
- Precursor Mass
- Ramp Rate
- Substrate Orientation

Film Characterization

- Thickness
- Uniformity
- Conductivity
- Mechanical Stability
- Surface Wetting

Device Characterization

- Hardness Removed
- Pressure Drop

RESULTS

Effect of temperature, dwell time, and precursor mass on film properties have been characterized and are summarized by the plots below.

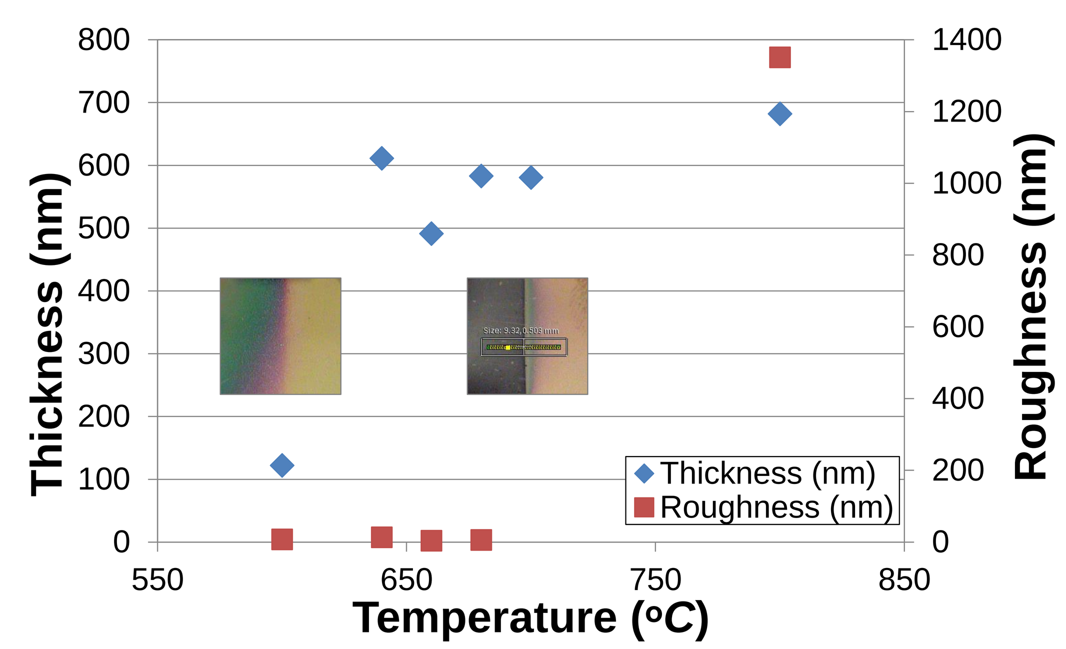


Fig. 1: Temperature effect on film thickness and uniformity shows that lower temperatures are desirable both for the lower thickness and better uniformity. Images shown correspond with deposition temperatures.

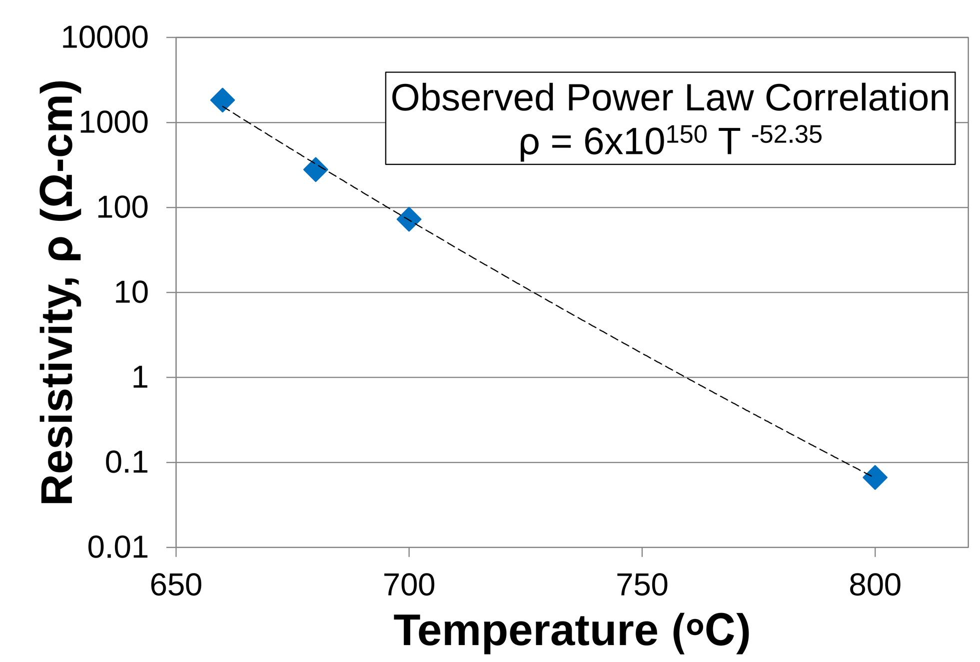


Fig. 2: Decreased deposition temperature results in a large increase in resistivity. Thermal decomposition of organic species may be occurring at higher temperatures, giving the film better electrical properties.

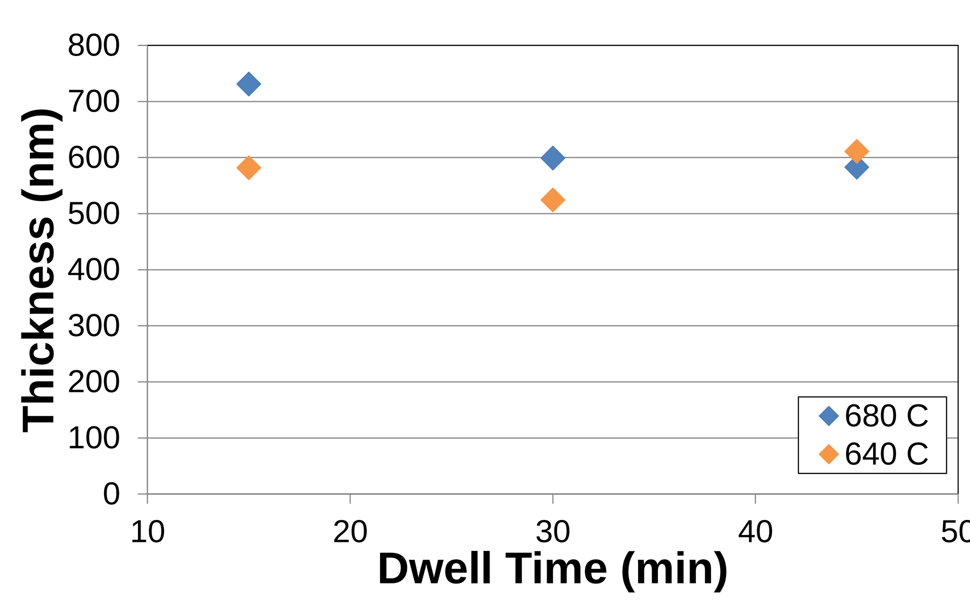


Fig. 3: Film thickness was not substantially affected by changes in the dwell time at the reaction temperatures, suggesting that most of the deposition occurs within the first few minutes of the dwell.

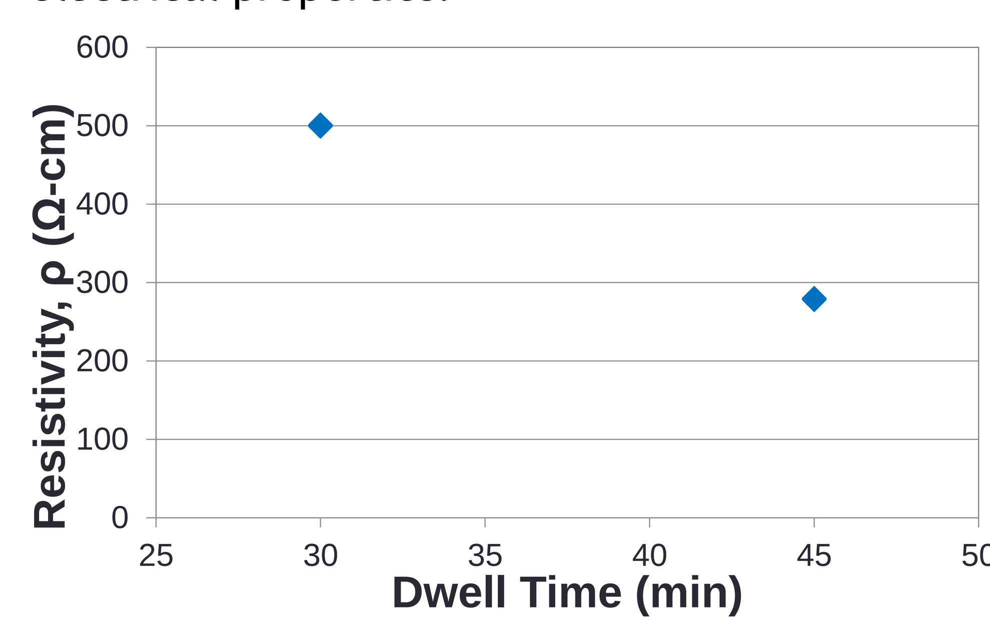


Fig. 4: Resistivities of films deposited at 640 °C. Longer dwell times result in a less resistive film. Thermal decomposition of the organics in the film may require sufficient time to reduce their concentrations.

Investigation of substrate orientation showed that films deposited on a face-down substrate were more uniform. This is likely due to precipitate forming and falling onto the upper face.

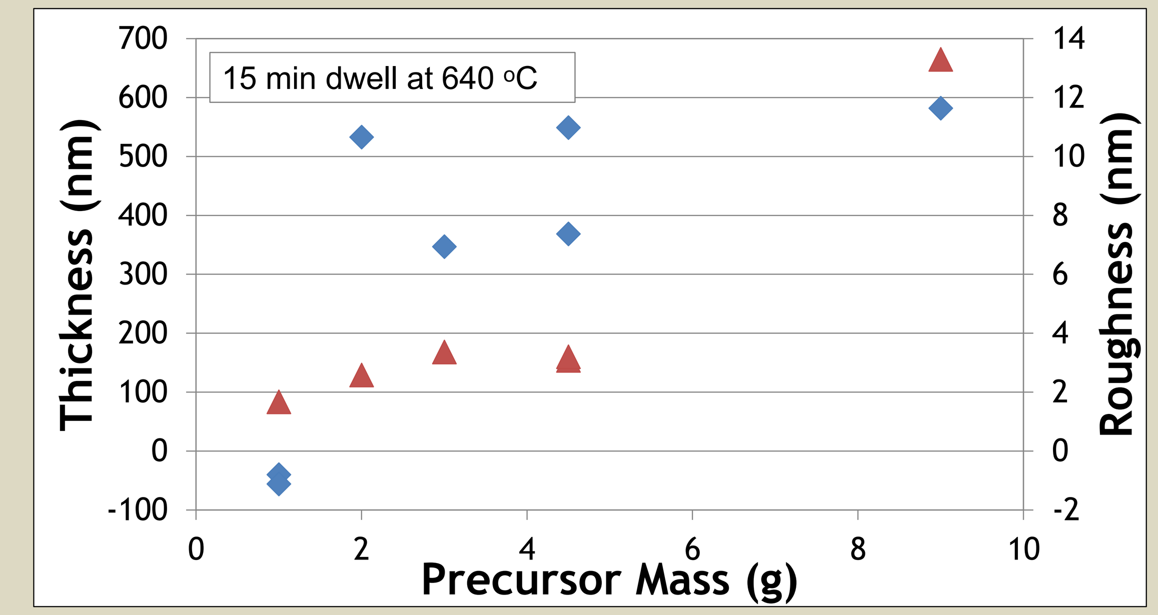
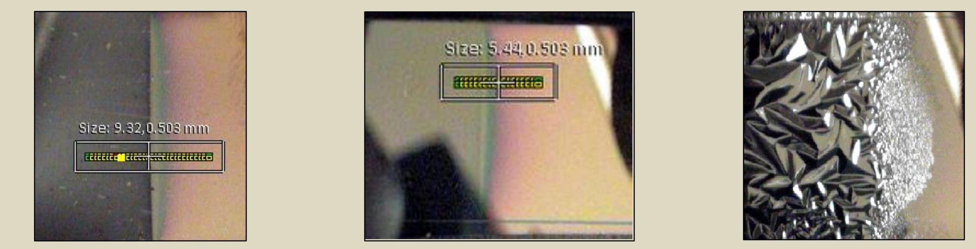


Fig. 5: The effect of precursor mass on film thickness and uniformity. This was expected to have yielded a linear relationship. More testing is necessary to solidify this trend.

Higher ramp rate appears to yield a foil-like film compared to dull grey film at similar deposition temperatures. Wrinkling is due to rapid thermal expansion of the film.



Low ramp rate 11 °C/min | Medium ramp rate 20 °C/min | High ramp rate 30 °C/min

CONCLUSIONS

The GUITAR process has been characterized and partially optimized for application in an ion removal device. The most optimized deposition recipe follows:

- Precursor: 3 g Black Jack Roofing Cement
- Ramp rate: 11 ˚C/min
- Operating temperature: 640 ˚C
- Dwell duration: 15 min

FUTURE RESEARCH

- TGA/MS on precursor and deposited films to investigate chemical composition
- Perform statistical analysis on current data by testing deposition repeatability
- Continue to develop trends in order to fully optimize deposition recipe to 10 nm
- Investigate surface wetting
- Deposit on nanograss electrodes and analyze film performance in ion removal device

ACKNOWLEDGEMENTS

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Microproducts Breakthrough Institute

Oregon State UNIVERSITY

Reference: Cheng I.F., et al. "Synthesis of graphene paper from pyrolyzed asphalt". *Carbon* 49 (2011): 2852-2861. Web. 13 Feb 2014.