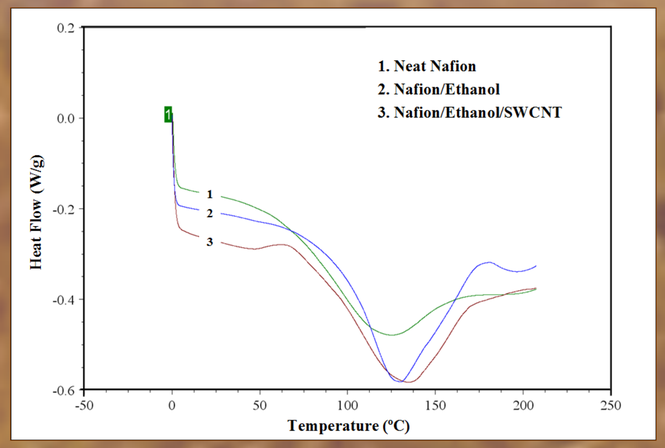
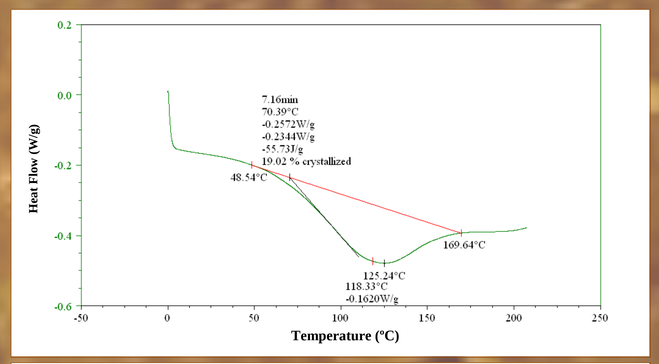
Investigating Nanoparticle Reinforced Polymers for Improved Detection of Trace Explosive Vapors

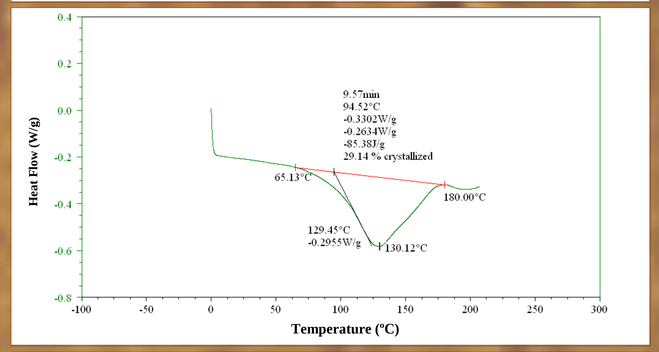
Funded By NAVSEA

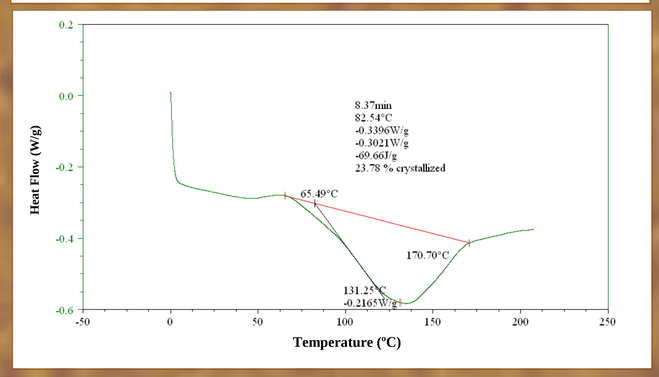
Charles Davis, Florida Atlantic University, Ocean & Mechanical Engineering Department
Dr. Hassan Mahfuz, Florida Atlantic University, Ocean & Mechanical Engineering Department
Jonathan Reynolds, Tennessee State University, Engineering & Computer Science Department
Dr Keith Hargrove, Tennessee State University, Engineering & Computer Science Department
Dr Tye Langston, PoC NSWC-PCD, Intelligent Sensing Branch

DSC Studies









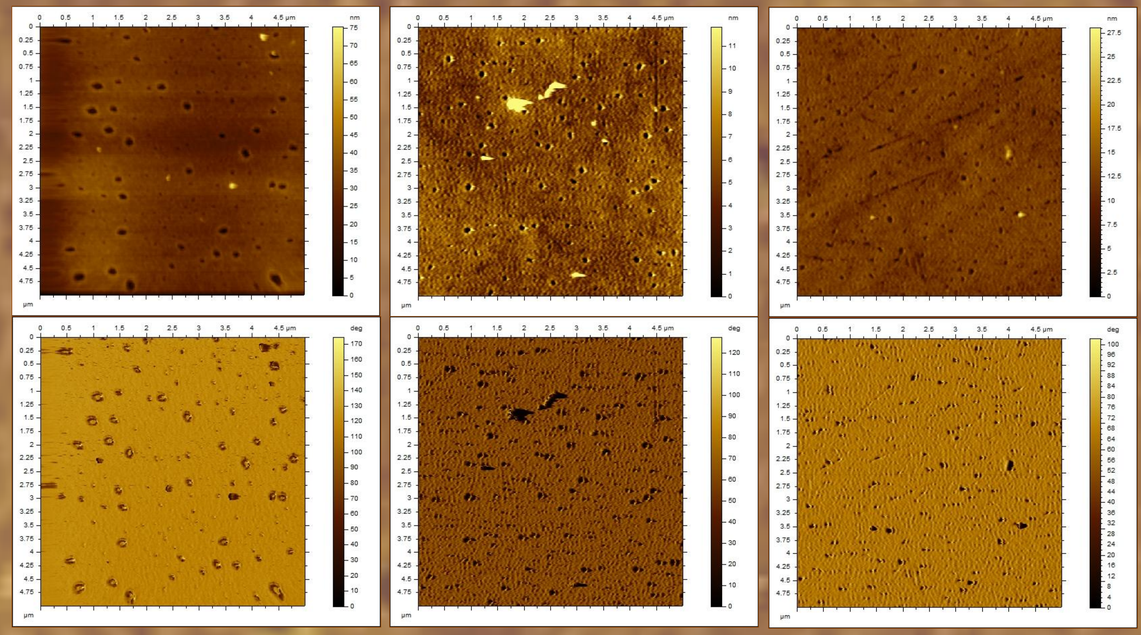
Objectives

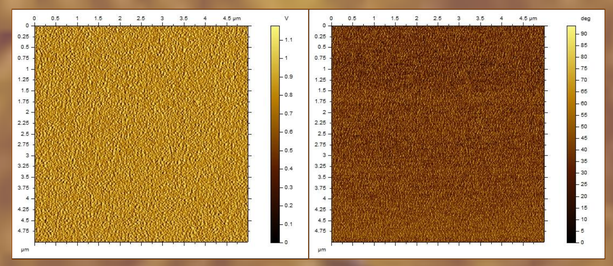
- Selectively Detect volatile organic compounds on a micro-scale platform
- Achieve a high level of sensitivity, stability, and reversibility
- Investigate composite coatings appropriate for application to micro-cantilever style gas detection to compliment efforts underway at NSWC-PCD

Composite Material Composition

- **Nafion** – An ionic polymer developed by DuPont that is acidic, capable of selectively transporting cations, and has an affinity for polar molecules
- **Single walled carbon nanotubes functionalized with carboxylic acid groups**– High surface area for increased adsorption sites, acid groups to attract more basic ammonia particles.

AFM Studies

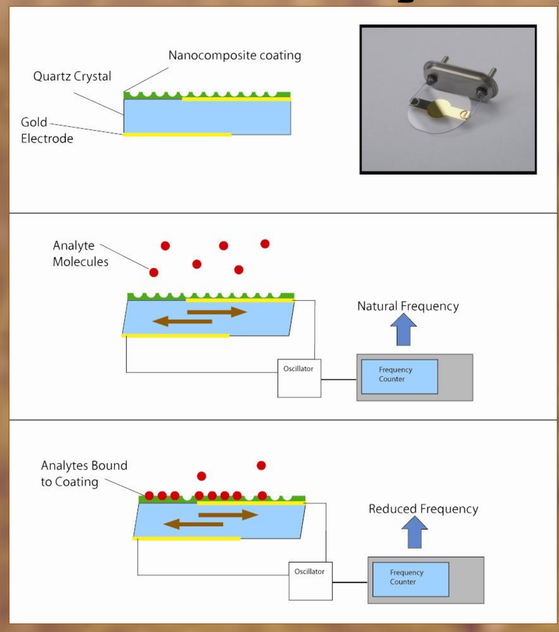




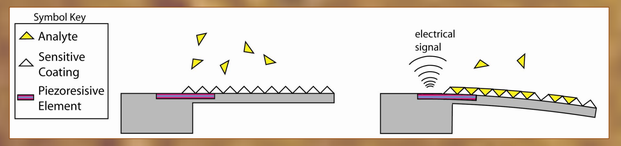
Above: AFM Topography of composite coated QCMS. From left to right: 2 coats at 1000 RPM, 1 coat at 900 RPM, 1 coat at 800 RPM

Left: AFM Topography of gold electrode with no coating for comparison.

Theory



A quartz crystal microbalance (QCM) undergoes shear oscillation when activated by an AC current to it's electrodes. When coated, the frequency of this oscillation becomes a function of the surface stress generated by the adhesion of the coating to its surface. If another compound then binds to this coating, it will apply a different amount of stress to the crystal. This will in turn change the frequency in proportion to the amount of foreign material bound to the coating.



NSWC-PCD is interested in a similar application using mico-cantilevers which directly measure deflection via an internal piezoresistive element. A sensitive coating, such as our composite material, applied to the surface of the cantilever would induce a deflection of the beam in the presence of analytes, again due to the change in surface stress.

Summary

- Nano-Particles are binding to the polymer.
- Stability of the compound is improved by nano-particles.
- Displayed ability to control layer thickness qualitatively.