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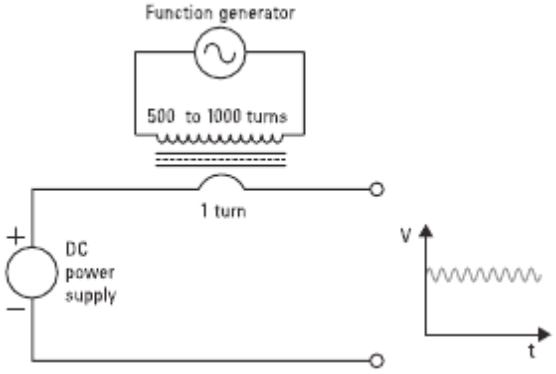
# Headquarters Innovation Fund 2010 “Embedded Carbon Nanotubes for Stray Light Suppression”

- Background
  - Improvements in stray light suppression are important to Scientific Observations: simplification of design, higher observational efficiency in high contrast regions and enabling observations of dim objects.
  - The Goddard team has demonstrated order of magnitude improvements from state of the art paint using aligned multiwalled carbon nanotubes grown in a 750 degree furnace. This process is not amenable to certain materials and large sizes, therefore this work was geared towards finding an alternate process to address these limitations.
- Approach
  - Create thin film embedded carbon nanotubes that can be applied to larger surfaces using an electric field to align the nanotubes during the setting process. Three materials were chosen to embed the nanotubes in; aerogel, epoxy and Z306 paint. The steps required to perform this procedure were mixing of powdered carbon nanotubes in ethanol and then dispersion by ultrasonic mixing. The mixture was then introduced to the embedding agent and cured while in the presence of an electric field to align the nanotubes. The aerogel solution was then placed in a supercritical dryer to create the voided matrix. In the alternate approach the epoxy surface was atmospheric plasma etched to expose the nanotubes or mixed in paint.

***E-field applied to epoxy solutions***




***Circuit for AC/DC E-Field***

***Nanotube clumps in solution***

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- Results: Aerogel embedded Multi-walled Carbon Nanotubes (MWCNTs)

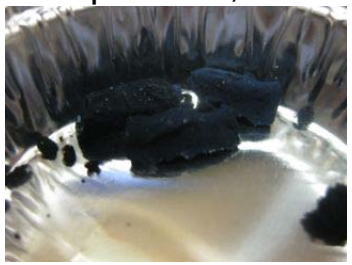
  – Although the aerogel samples were extremely black, all tests with thin aerogel were compromised due to collapse of the silicate matrix after supercritical drying. This resulted in fractured, shrunken samples that could not be measured.

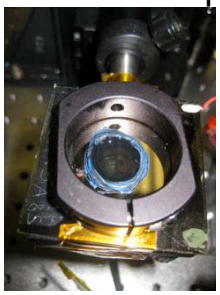
  – It was decided to focus on thick aerogel samples that could be used for calibration references or other applications that required bulk absorbers. In this case we were successful with initial silicate aerogel growth with multwalled carbon nanotubes. Since it was observed that nanotubes clump in bulk, no electric field was applied during curing or drying.

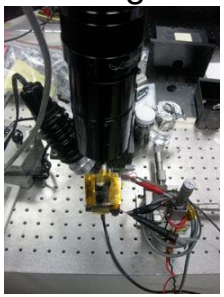
***Aerogel embedded nanotubes***

***Nanotube solution***

***Nanotube solution in e-field with video monitoring***







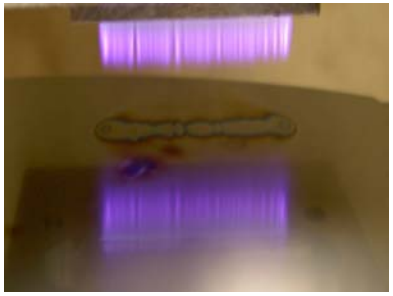
- Results: Epoxy embedded MWCNTs

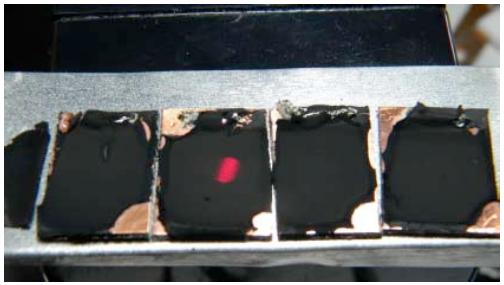
  – Mixing of the aerogel in epoxy resulted in a black finish that was atmospheric plasma etched to release the tips of the nanotubes to provide a usable black finish. Demonstration of nanotube alignment in the presence of an electric field was made for low concentrations of nanotubes. Atmospheric plasma etching successfully exposed the nanotubes. Hemispherical reflectance improved by 57% over Z306 paint. These results appear in the next slide.

***Epoxy embedded nanotube sample with plasma etched area***

***Atmospheric plasma etch***

***Epoxy embedded nanotube samples with variety of e-field alignment***





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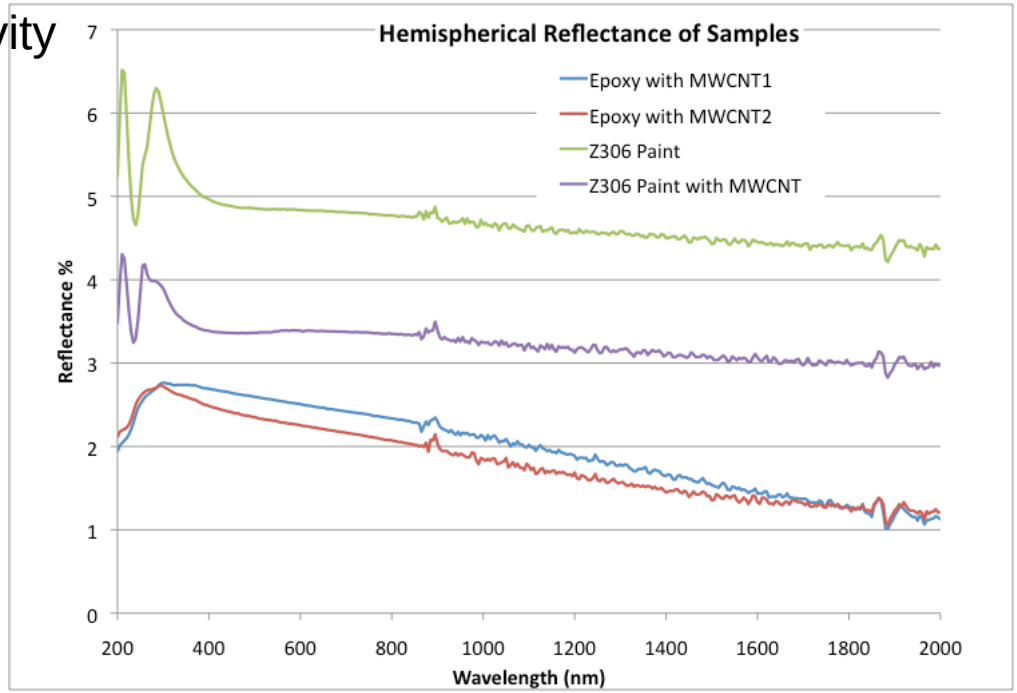
- Results: MWCNT additive to Z306 paint
  - 30% improvement over Z306 paint by adding MWCNT’s and applying E-Field for 10 minutes, believe that this process could be further optimized.
- Technology Readiness, NTR’s
  - The epoxy and paint embedded carbon nanotubes are currently at TRL 4 and present a significant advantage over existing Z306 formulations.
  - NTR’s were submitted on both epoxy and aerogel embedded carbon nanotubes, a third NTR on nanotube alignment in E-fields is in process.
- Expectations for follow on activity

  - Moderate success at both nanotube dispersion and electric field alignment of epoxy and paint embedded nanotubes has raised expectation that improvement to existing surface treatments is achievable. Team will continue this with work with infrastructure developed during innovation fund efforts with awarded FY 2011 GSFC IRAD manpower.