Nanocomposite Strain Sensors

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Motivation

• To introduce a lighter, lower cost strain sensor.
• Versatility – a wide range of applications from aerospace to structural
• To take a fresh look at strain sensors and see where there is opportunity for alteration.
Measuring Strain

- Measure conductivity
- Apply strain
- Conductivity decreases
- Strain can be interpreted as a function of conductivity
Outline

• Introduction
  ▫ Literature review and comparative analysis

• Materials overview
  ▫ Fabrication process

• Data & Results
  ▫ Examination of past and recent data
    • Issues and trends

• Conclusions
Introduction

The research is on strain sensors that are:

- Lighter
- Less expensive
  - Carbon Nanotubes (CNTs) vs. Vapor-grown Carbon Fibers (VGCFs)
    - SWCNTs cost ~$80/gram vs. $5-6/gram\(^1\)

1. [http://www.cheaptubes.com/carbon-nanotubes-prices.htm#Multi_Walled_Nanotubes_Prices](http://www.cheaptubes.com/carbon-nanotubes-prices.htm#Multi_Walled_Nanotubes_Prices)
Carbon nanotubes (CNTs) vs. Vapor Grown Carbon Fibers (VGCFs)

- Similar mechanical and electrical properties
- Sizes of VGCFs can vary from a few nm (similar to CNTs) to about ten microns.²
- Comparable geometry
  - High aspect ratio
  - ‘Nanofiber’ designation for VGCFs (diameter is between 10 and 100 nm) and the presence of a central hollow core.²

Materials Overview

- Vapor-grown carbon fibers (VGCF)
- Polydimethylsiloxane (PDMS)
- Curing agent

Effect of Strain on Conductivity for 10:1, 4% VGCF

Possible Solutions

- Change the ratio of base to curing agent
- Past research was with 10:1, with varying percentages of VGCF from 1.5 – 4 wt. %.
  - 10:1
  - 10:1.5
  - 10:2
    - 3 and 4 wt. % VGCF
Testing

• Tensile testing (Dynamic mechanical analysis)
  ▫ Dimensions: 20 mm x 6 mm x 1.75 mm
  ▫ Samples strained at 1%/min
  ▫ Max 25%

• Conductivity testing
  ▫ Strain applied and conductivity is measured
Tensile Modulus Data

Effect of Curing Agent and VGCF concentrations on Tensile Modulus (E)
Effect of VGCF concentration on Electrical Resistance For 10:1 Monomer:Curing Agent Ratio

- 3% VGCF, Loading
- 3% VGCF, Unloading
- 4% VGCF, Loading
- 4% VGCF, Unloading
Effect of Curing Agent Ratio on Electrical Resistance for 3% VGCF

Resistance (Ohms)

Strain (%)  0  1  2  3  4  5

10:1, Loading
10:1, Unloading
10:1.5, Loading
10:1.5, Unloading
10:2, Loading
10:2, Unloading
Conclusions

• Higher ratios show better recovery of conductivity upon unloading
• Long term trends need to be tested
  ▫ Initial stain may cause a fundamental change in fiber alignment.
  ▫ Fatigue tests will be performed
• Compare fiber alignment hypothesis with SEM images.
• Formulate a quantifiable calibration curve
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Questions???