Metal (Cu, Al) CNT Composite Wires for Energy Efficient Motors

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Project Period: 05/01/2017-04/30/2020 (pending)

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Project Objective

- To investigate fundamentals related to manufacturing processes of copper (Cu) and aluminum (Al) composites integrated with carbon nanotubes (CNTs) able to increase the thermal/electrical conductivities by >50%
- Cu and Al are widely used conductors but their inherent resistances consume significant amount of electricity by producing unwanted resistive (Joule) heat
- CNTs and metals (Cu,Al) are dissimilar materials therefor challenges of making composites with desired properties have remained unsolved.

This project will make breakthrough in manufacturing Cu/CNT and Al/CNT composites with the potential to meet the application needs on conductors in motors.

Technical Innovation

- Carbon Nanotubes (CNTs) are ideal fillers to increase metals' conductivities due to CNTs' exceptional conductivities. However, the poor dispersion and the weak interfacial bonding have remained as unsolved challenges.
- The approach is to disperse CNTs completely in an electrolyte and encapsulate CNTs by metal deposition/encapsulation thus retain the separation permanently. Moreover, the encapsulated metal will act as the interface to form strong interfacial bonding and the conductive interface thus significantly increased conductivities are expected.
  - Due to small CNT addition, the cost is less than 5% more than that of the pure metal.

Technical Approach

- The technical approaches include 1) fabrication of metal encapsulated CNT powders, 2) investigate the fabrication process of metal/CNT composites via power metallurgy method, 3) investigate the fabrication process of metal/CNT wires by continuous powder metallurgy process, 4) study the fabrication process of metal/CNT composite via casting, 5) study the fabrication process of metal/CNT composite wires via continue casting method.
- Dr. Quanfang Chen (PI), study the material design and fabrication. Dr. Yuanli Bai, investigate the wire fabrication.
- Oxidation will be addressed by using inert gas protection as well as coating metal/CNT powders with a thin silver layer.
- Dr. Bai has worked in GE before joining UCF, and Dr. Chen has worked closely with the International Copper Association, California Fine Wires and Siemens.

Transition

- Copper and aluminum are mostly used conductors for electricity, and lower resistance is desired to reduce the material cost and the energy consumption.
- The potential end users will be motor companies that conductors are used as the windings in the motors. The use of metal/CNT wires will increase the energy efficiency and increase the reliability.
- The success of this work will enable private wire fabrication companies develop the technology further and bring it to the market eventually.
- The technology will enable high performance to meet high expectations and/or reduce the cost of materials by using less amount of materials than the pure metals.

Measure of Success

- Metal/CNT wires' resistivity and the Joule heating produced will be measured against the associated pure metal wires. If successful (conductivities increase by 50% and Joule heating reduced by 33%), future motors will carry greater current thus produce higher performance and consume less energy.
- The success of this project will significantly reduced the Joule heating thus energy consumption by motors could be significantly reduced due to the reduced waste on electricity usage plus the reduced energy required for cooling of motors.

Project Management & Budget

- The project duration is 05/01/2017 to 04/30/2020
- **Milestone 1**: Identify ideal CNTs in term of size and nature (metallic or semiconductor). Year 1
- **Milestone 2**: CNT treatment processes. Year 1
- **Milestone 3**: Fabrication of Cu/CNT and Al/CNT via powder metallurgy approach, Year 1, 10% increase in conductivities.
- **Milestone 4**: >50% increase in conductivities Year 3

Total Project Budget	
DOE Investment	$1,000,000
Cost Share	$367,440
Project Total	$1,367,440

Results and Accomplishments

- The project has just started due to the lengthy award negotiation, there no results are presented here.
- Work to be completed by the end of the project:
  - Material selection on carbon nanotubes
  - Surface treatment of carbon nanotubes
  - Fabrication of metal encapsulated CNT powders
  - Fabrication study of metal(Cu,Al)/CNT composites with powder metallurgy process
  - Fabrication of metal/CNT wires via powder metallurgy process
  - Fabrication of metal/CNT wires via casting process
  - Characterization study of materials and wires