The unique properties of carbon nanotubes (CNTs) represent a potential for developing a piezo-resistive strain sensor and a resistive heating sheet. Conventional fabrication techniques of CNT nanocomposites such as molding, casting or coating are lack of capabilities of controlling geometries and properties of the fabricated nanocomposites. Digital printing technique is able to fabricate the CNT nanocomposites with precisely controlled geometries with an assistance of computer aided design. Their properties can also be controlled by adjusting the printing parameters. The objective of this study is to investigate the printing-structure-property relationship of the printed CNT nanocomposites having the multi-functionalities of strain sensing and self-heating simultaneously. A spray deposition modeling (SDM) process using multiple inkjet nozzles was used to print the CNT layers in the nanocomposite. The reported CNT nanocomposite strain sensors only have limited stretchability and sensitivity for measuring diverse motions. Strain sensors fabricated by traditional techniques are capable of measuring strain in a single direction. However, in order to monitor the motion with complicated strain conditions, strain sensors that can measure strains in multiple directions are needed. In this study, highly stretchable (in excess of 45% strain) and sensitive (gauge factor of 35.75) strain sensors with tunable strain gauge factors were made by printing the CNT layers onto a polymer substrate using the SDM technique. The cyclic loading-unloading test results revealed that the composite strain sensors exhibited an excellent long-term durability. Due to the flexibility of the printing technique, rosette-typed sensors were printed to monitor complicated human motions. These superior sensing capabilities of the printed CNT nanocomposites offer potential applications in flexible strain sensors.

Resistive heating properties of the printed CNT nanocomposites were also investigated in this study. The electrically resistive heating of the CNT nanocomposites can be a desirable stimulus to actuate shape memory polymers (SMPs). Traditional SMP nanocomposites have a slow heating rate and same shape recovery ratio at different locations, which limit their applications where localized heating and actuation are required. Programmable shape recovery ratio at specified locations are desirable. In this study, the printed CNT nanocomposites have a fast heating rate and controllable maximum surface temperature. Their shape recoverability was approximately 100% taking 30 seconds under a low voltage of 40V. The shape recovery rate was controlled and localized actuation with the desired recovery ratios was achieved through programming the number of printed CNT layers at different locations. The high efficiency of heating coupling with the wide adjustability of surface temperature and shape recovery ratios at specified locations make the printed CNT nanocomposites for localized heating and actuation applications of SMP nanocomposites such as smart skins and smart tooling.

Major: Materials Science and Engineering

Educational Career:
Bachelor’s of Polymer Science and Engineering, BS, 2012, Donghua University
Master’s of Materials Science and Engineering, MS, 2014, University of Central Florida

Committee in Charge:
Jihua Gou, Chair, Materials Science and Engineering
Yuanli Bai, Materials Science and Engineering
Hyoungh Jin Cho, Materials Science and Engineering
Nina Orlovskaya, Materials Science and Engineering
Olusegun Ilegbusi, Mechanical and Aerospace Engineering

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The public is welcome to attend.