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Abstract

Graphene‐Coated Spandex Sensors for Composites Health Monitoring

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Abstract:
Internet of Things has been recently evolved by the state-of-the-art piezoresistive nanocomposite strain sensors due to their high sensitivity and flexibility. Such versatile sensors involve a nanoscale percolating conductive network elaborated into a non-conductive, flexible polymeric matrix. Electrically-conductive polymeric composites have attracted increasing attention owing to their prominent capabilities in applications such as structural health monitoring, human motion detection, and traffic monitoring [1]. The study presented here aims at the development of low-cost, sensitive, and stretchable yarn sensors based on spandex (SpX) yarns coated with graphene nanoplatelets (GnP) through a dip coating process: SpX yarns were cut into 50-mm pieces, and coated with graphene nanoplatelets through a multi-step dip coating process. In each step, the yarns were dipped into a 1 wt.% solution of graphene in deionized (DI) water agitated for 3 sec. This was followed by the dehydration process performed by leaving the yarn on a hotplate at 100 °C for 1 min before the next dipping cycle. After the coating cycles were accomplished, the conductive yarns were attached to carbon fiber tow electrodes from their two ends using silver epoxy at 25 mm distance (i.e. the sensor's gauge length).

Wash durability and GnP protection was attained by embedding the SpX/GnP sensors into a stretchable silicone rubber (SR) sheath through spin coating. For this purpose, the GnP-coated SpX yarn along with the carbon fiber electrodes was attached to the back side of a 100 mm diameter petri dish. 3 ml of the rubber base polymer was poured onto the petri dish, covering the sensor through spin coating at 200 rpm for 20 sec. The silicone layer was then cured at room temperature for 24 h (resulting in ~1 mm thick silicone sheath encompassing the conductive yarn). The sensor was cut into 3-mm pieces and then detached from the petri-dish surface.

The relative resistance changes of the SpX/GnP/SR sensors were measured 24 hours after removing them from the boiling water tank to imitate the harsh environment during the washing process. The sensors were immersed in the tank for the duration of 2.5 hours to assess wash durability. The effect of the SR thickness (obtained using different spin coating speeds) on the relative resistance change is shown for SpX coated through 20 immersion times (ImTs). A significant permanent resistance change of 54.2% was measured for the sample with no SR sheath. This value was significantly reduced when the SR sheath was applied; the larger the thickness of the sheath the lower the resistance changes (as low as 1.7% at the 200 rpm spin coating speed).

Biography:

Mina Hoorfar received She received her PhD and MASc degrees in Mechanical Engineering from University of Toronto in 2005 and 2001, respectively, and her BSc from University of Tehran, Iran, in 1998. She is currently Director of the School of Engineering, The University of British Columbia, Canada. She held an NSERC Post-Doctoral Fellowship at Case Western Research University, where she was with one of the earliest centers of fuel cell research. Her current research focuses on the development of portable devices for biomedical applications ranging from DNA purification from saliva, acetone detection from the exhale breath of a diabetes patient, circulating tumor cells detection from the blood of a metastatic patient, and cell patterning on the digital microfluidic platforms for tissue engineering. Another aspect of Dr. Hoorfar's research endeavors involves the design and fabrication of biosensors and nano-biosensors to achieve low detection limits required for environmental and agricultural applications.

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