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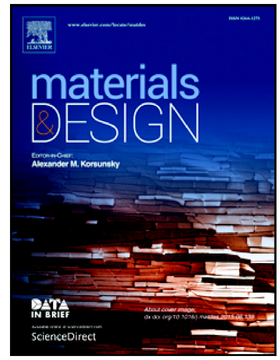


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PII: S0264-1275(18)30083-2
DOI: https://doi.org/10.1016/j.matdes.2018.02.006
Reference: JMADE 3673

To appear in: *Materials & Design*

Received date: 12 December 2017
Revised date: 1 February 2018
Accepted date: 2 February 2018

Please cite this article as: Tao Yan, Zhe Wang, Yi-Qi Wang, Zhi-Juan Pan , Carbon/graphene composite nanofiber yarns for highly sensitive strain sensors. The address for the corresponding author was captured as affiliation for all authors. Please check if appropriate. Jmade(2017), https://doi.org/10.1016/j.matdes.2018.02.006

# Carbon/Graphene Composite Nanofiber Yarns for Highly Sensitive Strain Sensors

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**Abstract**: In this work, flexible strain sensors were fabricated using carbon/graphene composites and nanofiber yarn (CNY)/thermoplastic polyurethane (TPU). These flexible strain sensors exhibit excellent sensitivity and stability because of the continuity, brittleness, and high conductivity of the CNYs. When the number of yarns and substrate thickness were 4 and 129 μm respectively, the average gauge factor value was more than 1700 under an applied strain of 2%. Meanwhile, the strain sensor showed a high level of stability during 300 stretching–relaxation cycles. Moreover, the strain sensor could accurately detect subtle deformations. The working mechanism of the strain sensor was also analyzed during stretching using a resistance network model; there was very good agreement between the experimental and simulation results. Such flexible strain sensors can be easily incorporated onto the surfaces of textiles, and within electronics, for use in applications such as smart textiles and health monitoring.

**Keywords:** strain sensor, carbon nanofiber yarns, sensitivity, stability

## 1. Introduction

Recently, carbon-based nanomaterials such as carbon nanotubes (CNT), graphene, carbon nanofibers, and carbon black nanoparticles have been comprehensively investigated for use as potential lightweight, high-strain, flexible strain sensors, which could be applied in the fields of human motion detection, health monitoring, smart textiles, and smart garments[1-8]. The working mechanism of these applications is based on the formation of a conductive network of polymers with carbon-based nanomaterials[9,10]. However, owing to their tiny size and noncontinuous characteristics, it is difficult to use these nanomaterials as strain sensors. In addition, they have a complex fabrication process[11]. Such nanomaterials have been generally combined with an elastic polymer matrix consisting of polymers such as thermoplastic polyurethane (TPU), polydimethylsiloxane, and polypropylene, which could significantly increase the strain range and stability of the sensors[12-15]. To date, a variety of