Stretchable and Highly Conductive Carbon Nanotube-Graphene Hybrid Yarns for Wearable Systems

(Invited Paper)

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ABSTRACT

Carbon Nanotubes (CNTs) have emerged as potential candidates for replacement of conventional metals due to their significant mechanical, electrical, thermal properties and non-oxidizing abilities [1, 2]. The density of CNT composites is about five times lower than copper and around half that of aluminium. Moreover, their thermal conductivity is about ten times that of copper. With the above mentioned distinguishing features, CNTs have been of interest in medical, electronics and antenna applications [3]. CNTs are drawn into yarns by pulling and twisting them from CNT forests. Previously we have presented microwave characterization of CNT yarns [4]. Our results have shown that the CNT yarns exhibits frequency independent resistive behavior and is beneficial for wide-band applications such as ultra-wideband (UWB) and wireless body area networks [4].

Electrical conductivity of a CNT yarn depends on the properties, loading and aspect ratio of the CNTs. It also depends upon the twist angle and the characteristics of the conductive network. By doping or adding materials, such as gold, silver or NiCr, electrical conductivity of CNTs can by varied. In [5], highly conductive carbon nanotube-graphene hybrid yarns are reported. They are obtained by drawing vertically aligned multi-walled carbon nanotubes (MWCNT) into long MWCNT sheets. Then graphene flakes are deposited onto the MWCNT sheet to form a composite hybrid structure that is transformed into yarns by twisting. The electrical conductivity of these composite MWCNT-graphene hybrid yarns is over 900 S/cm. In this work, we have modeled this hybrid material as a potential data transmission line and compared it with a transmission line made out of copper on the same substrate. The results are tabulated in Table-I. They show a good agreement between copper based and composite MWCNT-graphene hybrid material based transmission lines.

The hybrid material is high conductive, flexible and stretchable. This makes it suitable to use as transmission lines and connecting wires in systems that require stretching and flexibility, such as wearable systems.

Keywords

Carbon nanotube, Graphene, Carbon nanotube-Graphene, Yarns, Hybrid yarns, Stretchable yarns, highly conductive yarns, Wearable.

BODYNETS 2015, September 28-30, Sydney, Australia

DOI 10.4108/eai.28-9-2015.2261421

Table I. Results of a hybrid CNT-Graphene yarn and copper wire at 2.5GHz when placed on a substrate to form a transmission line.

Structure	Impedance (Ω)	Phase of the transmission coeff. (Deg)
Copper strip-line	50	68.6
Hybrid CNT-Graphene strip-line	50	66.6
Copper Wire	130.5	103.4
Hybrid CNT-Graphene Yarn	131.8	101.7

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