CARBON NANOTUBE AND GRAPHENE PAPERS AS FLEXIBLE HEATING ELEMENTS

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ABSTRACT

As possible technological applications of graphene and its related materials are further extended to more areas, the transfer of their impressive properties from the nanoscale to the macroscale becomes an important issue. Such properties are particularly pronounced when it comes to the electrical and thermal conductivities of graphene related materials. Although carbon nanotubes and graphene have been widely combined with polymers in small weight ratios, the dielectric nature of polymeric matrices and interface resistance limit the electrical and thermal conductivity [1] of composites. Free-standing paper-like structures which consist solely of CNTs and 2D nanomaterials seem to bypass this issue as they can reach good amounts of strength [2], while providing excellent electrical and thermal properties [3].

In this work, CNT and graphene papers that work as Joule heaters are fabricated through simple and accessible techniques. The papers display a hierarchical microstructure that ensures compliancy to various shapes, mechanical robustness and reduced or zero binder content. The inherent conductivity of consisting nanomaterials combined with the near or total absence of polymeric materials ensure the good conductivity of the papers making them good candidates for flexible joule heaters. Like actual papers they can be folded, applied to irregular surfaces and cut to various shapes with the added benefits of increased electrical conductivity and ultrafast heating response. Preparation was based on simple dead-end filtration of inks consisting of CNTs and 2D nanomaterials. The inks contained combinations multi-walled CNTs (MWCNTs) or oxidized MWCNTs (OMWCNTs) and commercially procured graphene nano-platelets (GNP), graphene oxide (GO) or thermally reduced graphene oxide (trGO). Thermal testing was conducted in a stage that allows the direct measurement of the temperature either via a thermal camera or a micron-thick k-type thermocouple. Electrical contacts with direct current source are formed using adhesive copper tape. Current and temperature measurements are collected simultaneously and show a near instantaneous heating response to applied voltage from source. Along with heating rates, maximum temperature and power draw are measured at discrete applied voltage values.

KEYWORDS: Joule heaters, buckypaper, resistive heaters

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