CONTROL ID: 2040937 SAND2014-15205PE
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Abstract Details

PRESENTATION TYPE: Invited Speaker
CURRENT SYMPOSIUM: K. Graphene and Graphene Nanocomposites
KEYWORDS: Synthesis & Processing/Chemical Reaction/chemical synthesis, Performance/Functionality/devices, Performance/Functionality/microelectro-mechanical (MEMS).
Abstract

TITLE: Graphene Nanocomposites
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ABSTRACT BODY:
Abstract Body: The outstanding mechanical properties and high surface area of graphene presents a real opportunity to improve a large number of composite materials, structures and devices. Here, we will focus on graphene nanofiller reinforced carbon based micro-electro-mechanical systems (C-MEMS) and composites for marine hydrokinetic (MHK) power applications and advanced mechanical energy storage systems (i.e. flywheels). For example, graphene-based materials blended into a photo-resist prior to pyrolysis allow for fine-tuning of the electro-mechanical properties and response of C-MEMS devices. As a first step towards developing novel C-MEMS, nano-composite carbon cantilevers were fabricated for testing using 3 different lengths with fixed 10:1 length to width ratios. The devices investigated contained increasing amounts (from 0 wt. % to 2 wt. %) of reduced graphene oxide (RGO) blended into Novolac photo-polymer. An increase in conductivity, from 900 S/cm to 1700 S/cm, was observed. A piezoelectric actuator was used to randomly excite the substrate and a Laser Doppler Vibrometer (LDV) recorded the response for the first three bending modes of each beam. Increasing RGO wt. % was found to increase the natural frequency of the beam, indicating an altered stiffness. A model was generated to estimate the change in Young's modulus of the material. 2 wt. % RGO was found to increase the modulus from 41 GPa to 68 GPa, a factor of ~ 1.65. In the case of graphene reinforced epoxy composites, LDV data on test coupons indicates that as little as 1 wt. % loading increases the modulus from 15-35%, depending on the type of graphene nanofiller used. The effect that graphene can have on water uptake, important in MHK applications, and how water content effects the mechanical properties of the composite will also be discussed. Finally we will address our ongoing efforts to build graphene-reinforced carbon fiber (CF)/epoxy composites as well as build and test small industry relevant prototype mechanical flywheels utilizing these composite systems. Flywheels are rotating mechanical devices used to store rotational energy where the amount of energy stored is proportional to the square of the rotational speed. Stronger composites with increased inter-laminar strength are needed. To date, three point bend tests on arc samples indicate a 13% to 17% increase in ultimate strength for CF/epoxy/graphene nanofiller composites, when using a graphene filler material at 1 wt. % or 3 wt. % filler, respectively.

This work was supported by the Department of Energy's Office of Electricity Delivery and Energy Reliability, Office of Energy Efficiency & Renewable Energy and Sandia National Laboratories: Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under Contract DE-AC04-94AL85000.
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