Electrical and Mechanical Properties of Magnetic-Field Aligned Single-Walled Carbon Nanotube Buckypapers

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Introduction

Carbon nanotube (CNT) is fascinating lightweight material recognized for its low dimensionality with high electrical and thermal conductivity and excellent mechanical properties. Sheets of nanotubes or nanofibers, known as buckypaper (BP), provide a promising medium to control the properties of CNT. Several methods, such as alignment under magnetic [1] or electric fields, e-beam or ion beam irradiation [2], are under investigation to improve the electrical and mechanical properties of BP to produce high-performance nanocomposites. In this research, magnetically aligned BPs up to 10” × 10” were produced and tested to determine their electrical and mechanical properties as a function of magnetic field.

Experimental

Purified Hipco SWCNT (Carbon Nanotechnologies Inc., TX) was dispersed in an aqueous solution. To align the CNTs, BPs were produced under different magnetic fields up to 17.3 T. The aligned BP samples were cut in rectangular shapes for electrical and tensile tests. Polarized Raman with 785 nm excitation (0.5 mW) was used to check alignment. Electrical conductivity was measured using a conventional four-probe method. Tensile strength and modulus were measured in a dynamic mechanical analyzer (DMA 2980, TA instruments).

Results and Discussion

Figure 1 shows normalized G band intensities of aligned BPs from polarized Raman indicating alignment increased as the magnetic field increased. As shown in Fig. 2, electrical conductivity was enhanced by more than four times for BP produced in higher magnetic fields. Conductivity anisotropy, $\sigma_{//} / \sigma_{\perp}$, also increased along with magnetic field strength. Mechanical properties improved as a result of magnetic alignment. Figure 3 shows tensile modulus and strength of aligned BPs increased by more than factor of two.

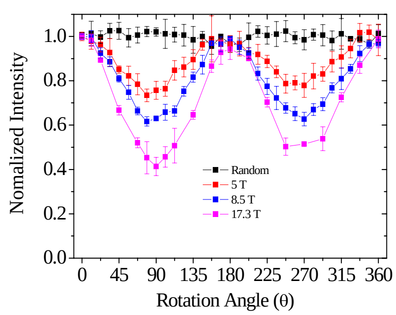

Fig. 1. Normalized G band polarized Raman intensity along with rotation angle

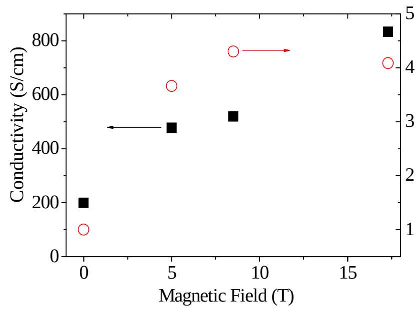

Fig. 2. Electrical conductivity and its anisotropy of aligned BP as a function of magnetic field

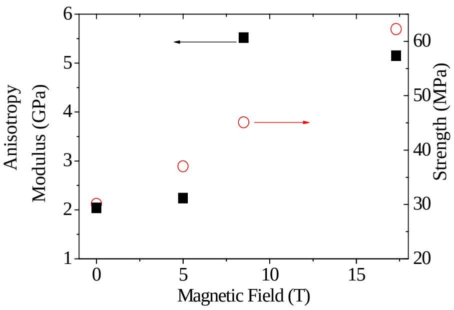

Fig. 3. Tensile modulus and strength of aligned BP as a function of magnetic field

Conclusions

BP production under magnetic fields enhances the CNT alignment, which improves the electrical and mechanical properties. CNT alignment improves as a function of the magnetic field strength, enhancing electrical and mechanical properties of BP by more than factor of two-four. These improvements should facilitate producing high performance composites.

References

[1] Fischer, J. E., *et al.*, J. Appl. Phys. **93**, 2157 (2003).
[2] Krasheninnikov, A. V., *et al.*, Nature Mat., **6**, 723 (2007).