LOAD TRANSFER IN ALIGNED NANOTUBE COMPOSITES

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Introduction

Load transfer in carbon nanotube (NT) composites is difficult to characterize due to the scale of the NT and the intractability of the composite manufacture. Polarized Raman Spectroscopy is used to separate the mechanical response of the matrix material and the reinforcing NT as each material has distinct response spectra. A further difficulty is due to the alignment of NTs within the polymer matrix material. Without alignment the loading environment is not completely known and modeling efforts cannot be legitimately undertaken. By applying a strong magnetic to a thermotropic liquid crystal polymer (TLCP)-NT composite the polymer chain is aligned parallel to the magnetic field and subsequently aligns the non-magnetically susceptible nanotube reinforcement.

Experimental

TLCP (Vectra A950) was melt mixed with nanotubes of varying length and concentrations. These samples were subsequently compression molded to produce ASTM V tensile specimens. The compression molded samples were placed within a stainless steel holding plate for magnetic processing. The composite samples were placed (while in the SS holding plate) into a magnetic field of 30T for 10 minutes while being held at 325°C (T_m LCP is 279°C). The samples were thus removed and allowed to cool. For a control, samples were created and aligned using a PC matrix (non -LC).
Raman load transfer measurements were taken at strain increments of 0.025% strain for samples of different length and loading of NT reinforcement.

Results and Discussion

The results from samples prepared with surface alignment were tested using Raman spectroscopy. These samples showed significant strain response and were able to be used for the determination of the ineffective length in polycarbonate (figure 2)[1]. The samples also showed a significant increase in load transfer and load carrying capacity for the single wall nanotube as compared to the multi wall nanotube (see figure 3) which can be seen by the steeper slope (indicating greater bond stretch).

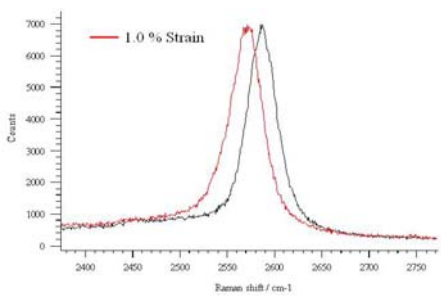

Figure 1 – Raman shift with applied strain

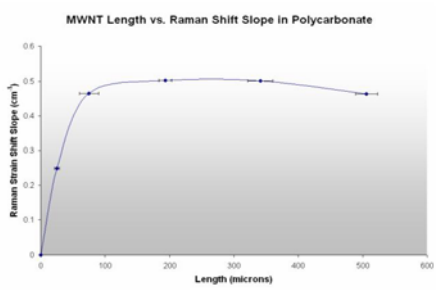

Figure 2 – Raman strain shift with NT length

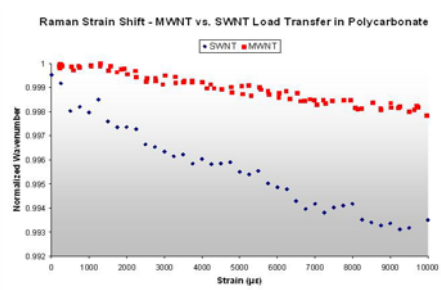

Figure 3 – SWNT vs. MWNT strain shift

Conclusions

Through the use of a high magnetic field a new technique for the alignment of nanotubes within a LCP matrix has been investigated. Using surface aligned (shear) it was found that nanotube strain response is less at low length allowing for the determination ineffective length and load transfer efficiency with multi wall nanotubes as compared to single wall nanotubes.

Acknowledgements

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References

[1] Bult, J.B. et *al*., Materials Science and Technology Conference (TMS), Cincinnati, OH; October (2006).