NANO HIGHLIGHT
New Platforms for Advanced Nanoscale Mechanical Testing

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In recent years arrays of vertically aligned multi-walled carbon nanotubes (MWCNTs) have been synthesized with plasma-enhanced chemical vapor deposition. Such arrays are promising for the development of nanoscale devices such as field-emission displays and sensors. A full understanding of their mechanical properties is a critical step for future applications of these materials.

The fracture mechanics of the vertically aligned MWCNTs was studied with a home-built nanomanipulator inside an SEM. The free end of a CNT was clamped to an AFM tip with our recently developed *rapid electron beam induced deposition method*, [2] (Figure 1a). The CNT was then loaded in tension and eventually fractured near the base (Figure 1b) at low stress (~10 MPa), indicating a relatively weak attachment to the substrate. For some applications this level of bonding will be sufficient, but for applications that call for a mechanically robust linkage with the substrate, our measurements suggest that stronger nanotube/substrate bonding is necessary.

The exceptional mechanical properties of CNTs combined with their high aspect ratios make them excellent candidates as a reinforcing phase in polymer composite systems. To realize the true potential of these nanocomposites a fundamental understanding of the nanotube/polymer interaction and load transfer needs to be developed.

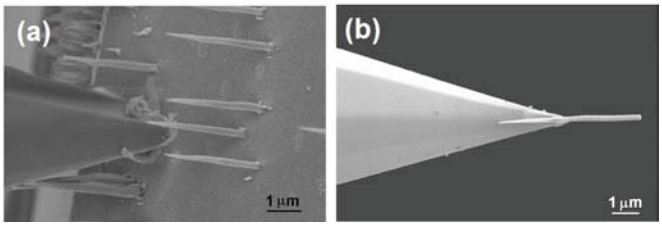

Figure 1. (a) AFM cantilever approaching a CNT; (b) MWCNT being pulled away from the substrate.

To obtain qualitative information about the load transfer characteristics of CNTs in polymer matrices we developed a novel micro-electromechanical (MEMS) platform (Figure 2) that enables the simultaneous high-resolution imaging (by AFM, SEM, or TEM) and driving of a crack in a CNT-PMMA composite sample. The behavior of the MEMS platform has been characterized by *in-situ* tests in an AFM. Test results indicate that a crack can be driven large distances (~500 nm) in a 200 nm thick PMMA film.

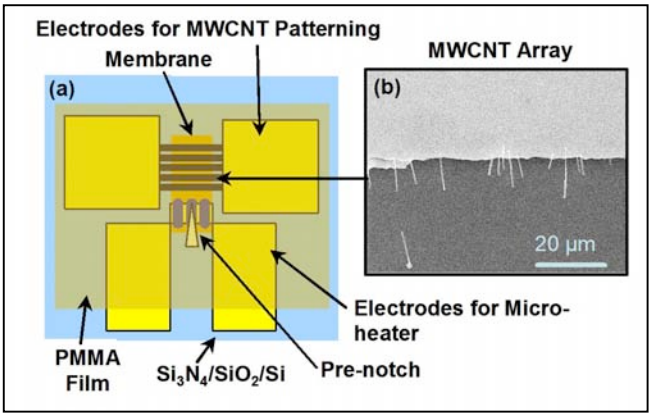

Figure 2. (a) Schematic of the MEMS platform design and (b) SEM image of an array of MWCNTs deposited on the edge of a metal electrode by dielectrophoresis.

References

[1] For further information about this project link to **<http://www.me.udel.edu/chou/nirt>**

[2] Ding, W., et al., "Mechanics of hydrogenated amorphous carbon deposits from electron beam induced deposition of a paraffin precursor," *Journal of Applied Physics*, 2005. **98**: 014905.