

Characterization of the CNT Agglomerate Interphase in a Three-Phase Nanocomposite

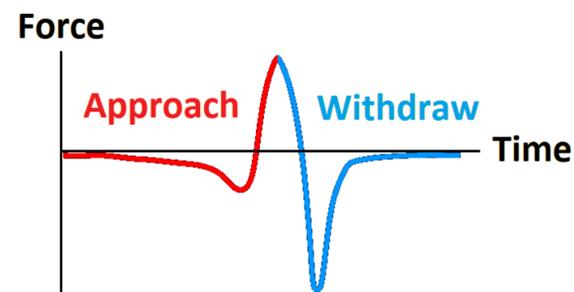
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Research question

How does the addition of carbon nanotubes in polymer composites affect the nanoscale mechanical properties at the interphase? How will this affect composite performance?

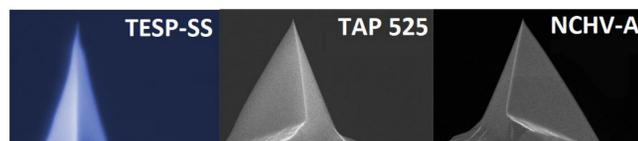
Methodology

AFM techniques use contact mechanics principles to extract a sample's mechanical properties. Peak Force Quantitative Nanomechanical Mapping (PFQNM) is an AFM mode that simultaneously captures properties like viscoelasticity, elastic modulus, roughness, and dissipation in real time.



$$F_{tip} = \frac{4}{3} \cdot E^* \sqrt{Rd^3} + F_{adh}$$

$$E_s = (1 - \nu_s^2) \left[\frac{1}{E^*} - \frac{1 - \nu_{tip}^2}{E_{tip}} \right]^{-1}$$



Results

AFM was operated in the CNT-rich zone of a composite made of epoxy, carbon fiber, and CNT. Fig 2 shows the change in properties from the epoxy-rich zone to the CNT-rich zone. CNT has higher modulus and lower adhesion than pure epoxy. The rapid change in properties corresponds to the interphase. Compare Area 2 with the location of CNT in Fig 1. Consistent readings in Area 2 suggest the presence of few voids in the CNT-rich zone.

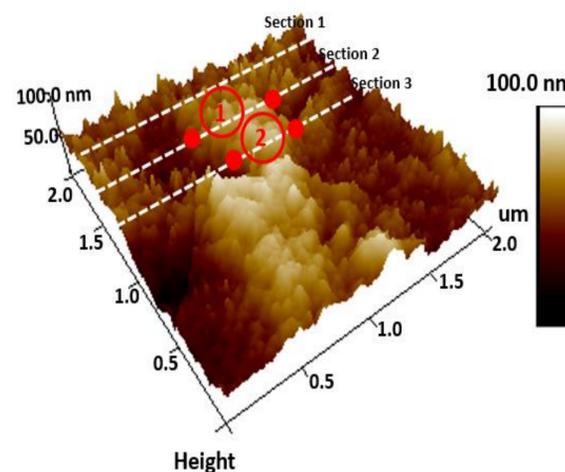


Figure 1: Height profile of CNT-rich region of the sample

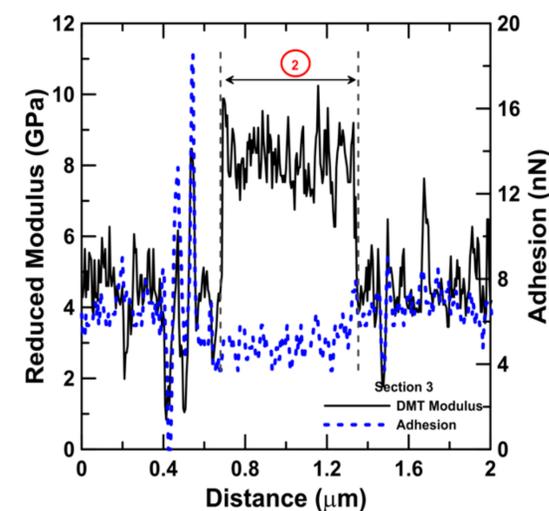
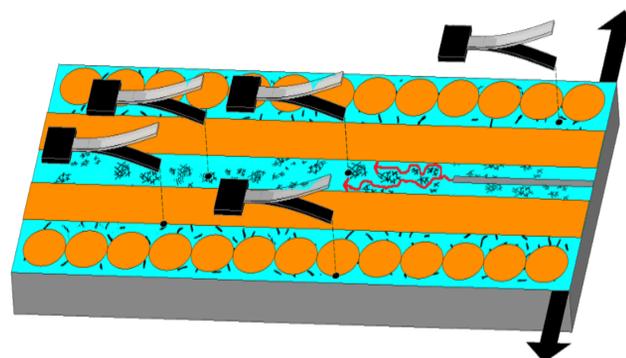


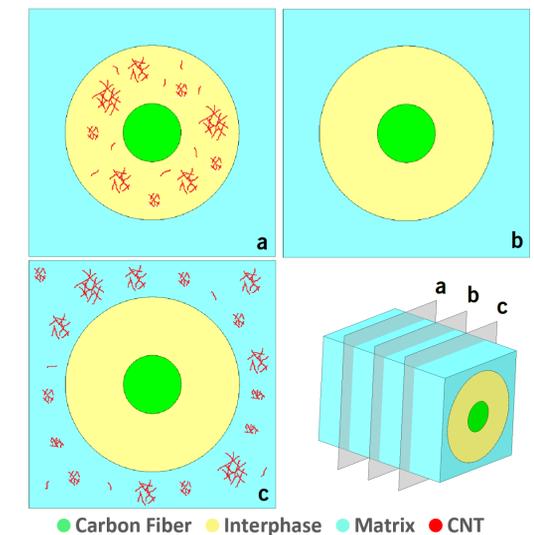
Figure 2: Adhesion and Modulus along Section 3, Area 2



An optical microscope was used to identify potential zones of CNT agglomeration among the carbon fiber, polystyrene stitching, and epoxy of polished samples. Then, AFM probes can extract sample properties.

What is the interphase?

The interphase zone is a 3D region that marks the transition in material properties between the filler and bulk matrix phases.



Future Work

- Field Emission Scanning Electron Microscope (FESEM) to observe CNT orientation
- Atomic resolution AFM scanner to improve interphase clarity

Acknowledgements

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