

Polymer-Carbon Nanotube Composites

Carbon Nanotubes:

One-dimensional structure (small diameter of ~ 1 nm and long length of many microns), high thermal and chemical stability, high heat conduction, high mechanical strength (elastic modulus comparable to that of a diamond), high current density, metallic or semiconductor type electrical conductivity.

Composites:

Extremely low percolation threshold ($\sim 0.01\%$)

Dispersion is not easy

Interaction with the matrix is important

Alignment of nanotubes is possible with external fields

Applications:

Transparent electrodes

High performance electrodes in batteries and fuel cells

Electromagnetic interference shielding

Nano-electronic devices

Prospects for printed electronics

Sensors and actuators

Nanotube bundles. Dispersion of nanotubes.

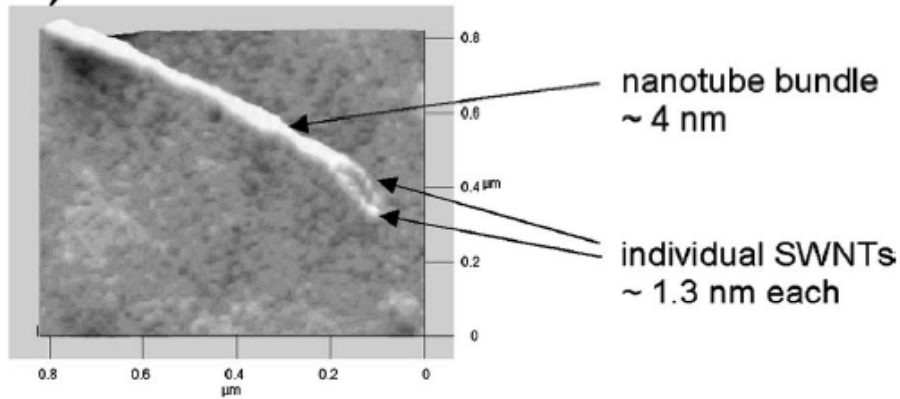
CNT atomically smooth surface and high polarizability ($\alpha \sim 1.39 \text{ \AA}^3$ for unit cell of (10, 0) SWNTs).

Significant van der Waals interactions.

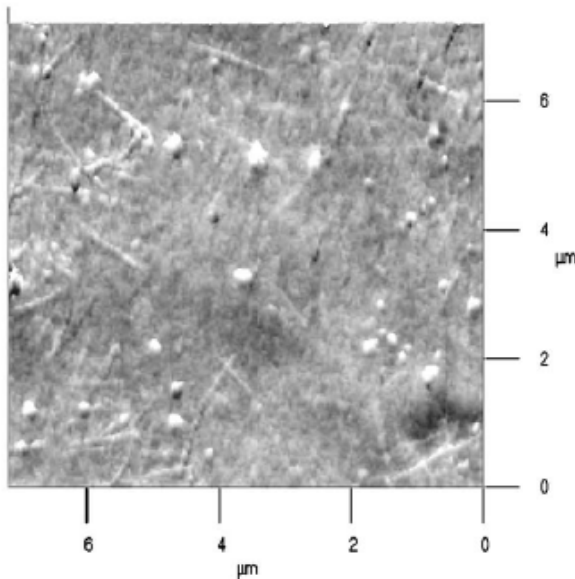
The energy of attraction is estimated to be 0.537 eV per molecule of (10, 10) nanotubes.

Therefore, nanotubes are bundled as shown below.

a)

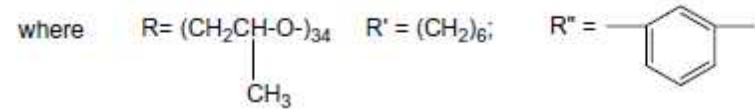
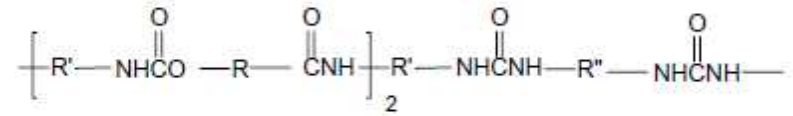


b)



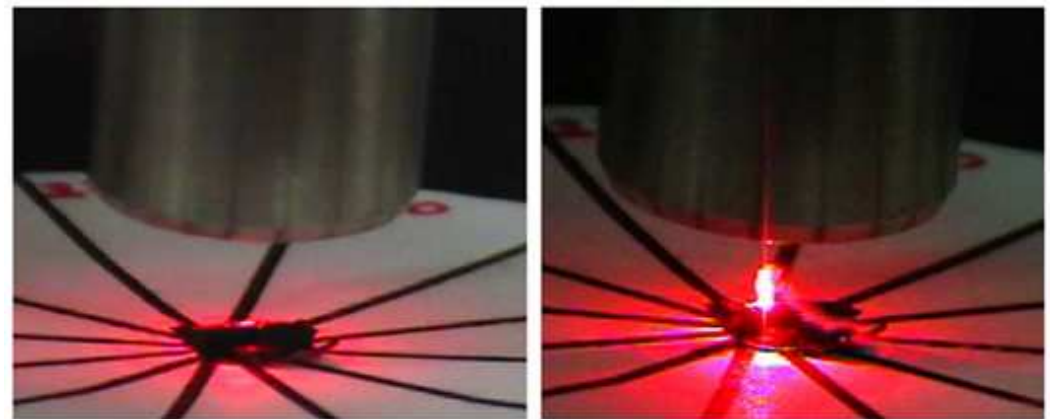
Polyurethanes (PU) can be used for better dispersion of CNTs

Polyurethane urea



Proof of CNT dispersion in PU matrix:

Ignition of PU/CNT composite under low power semiconductor laser is observed because of insulation of individual nanotubes by polymer matrix with low thermal conductivity.

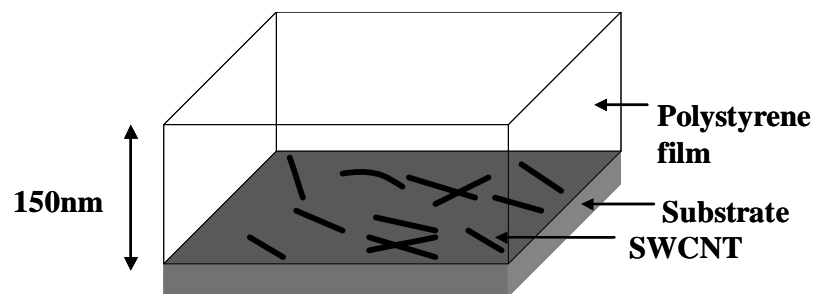
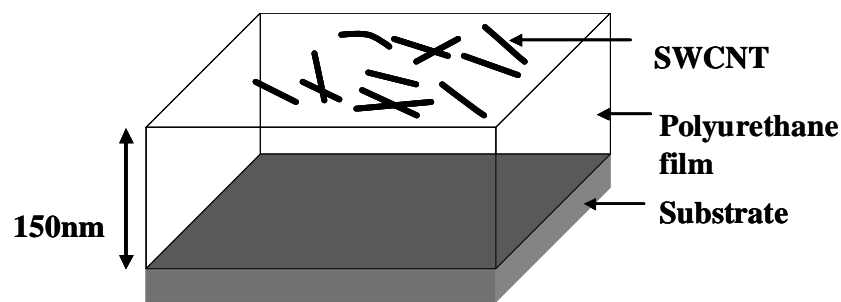
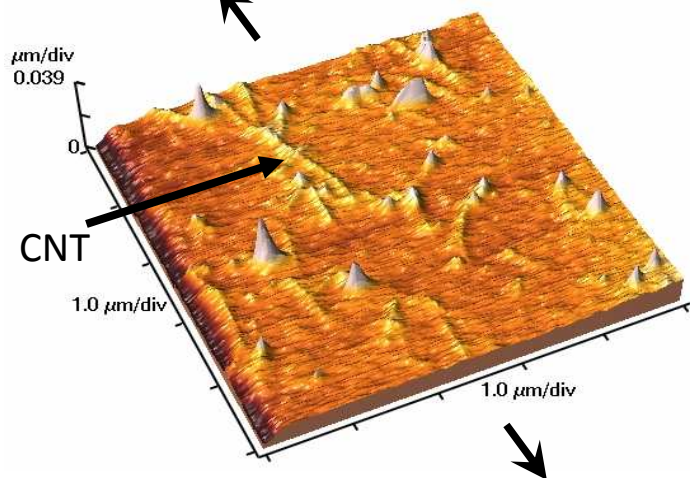


S. Singamaneni, V. Shevchenko, V. Bliznyuk, *Carbon*, 2006, v.44, pp.2191-2195.

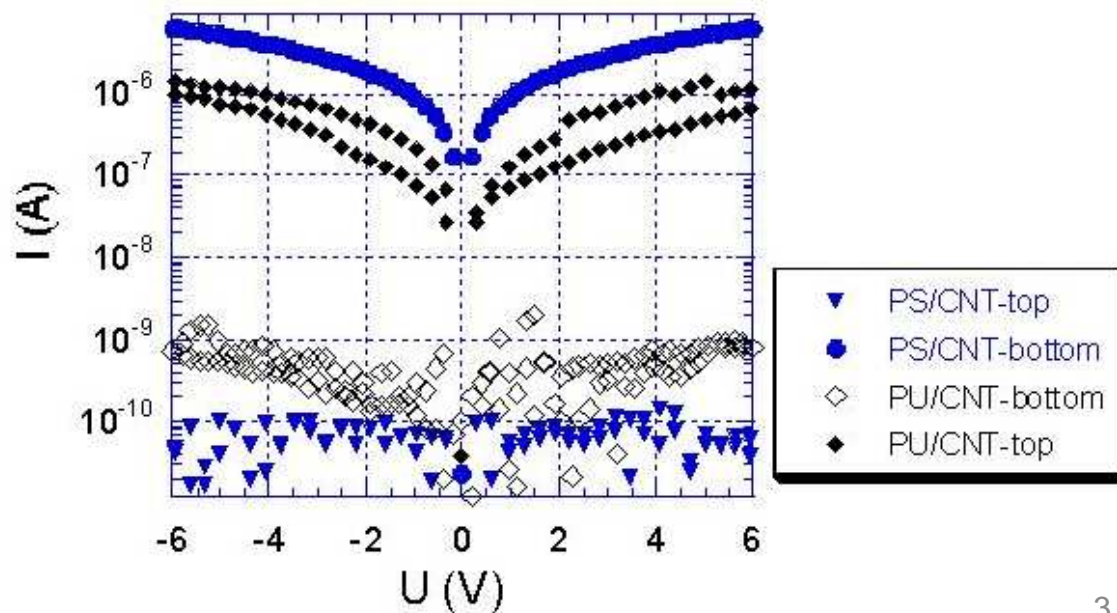
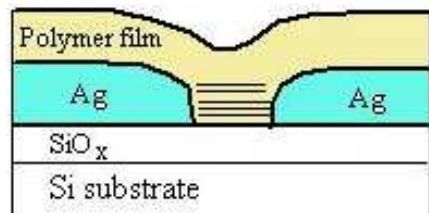
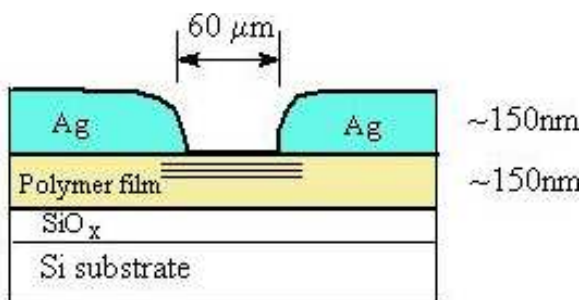
V. Bliznyuk et al., *APL*, **88**, 164101 2006

Nanotubes and nanocomposites

Vertical phase separation and anisotropy of electrical properties

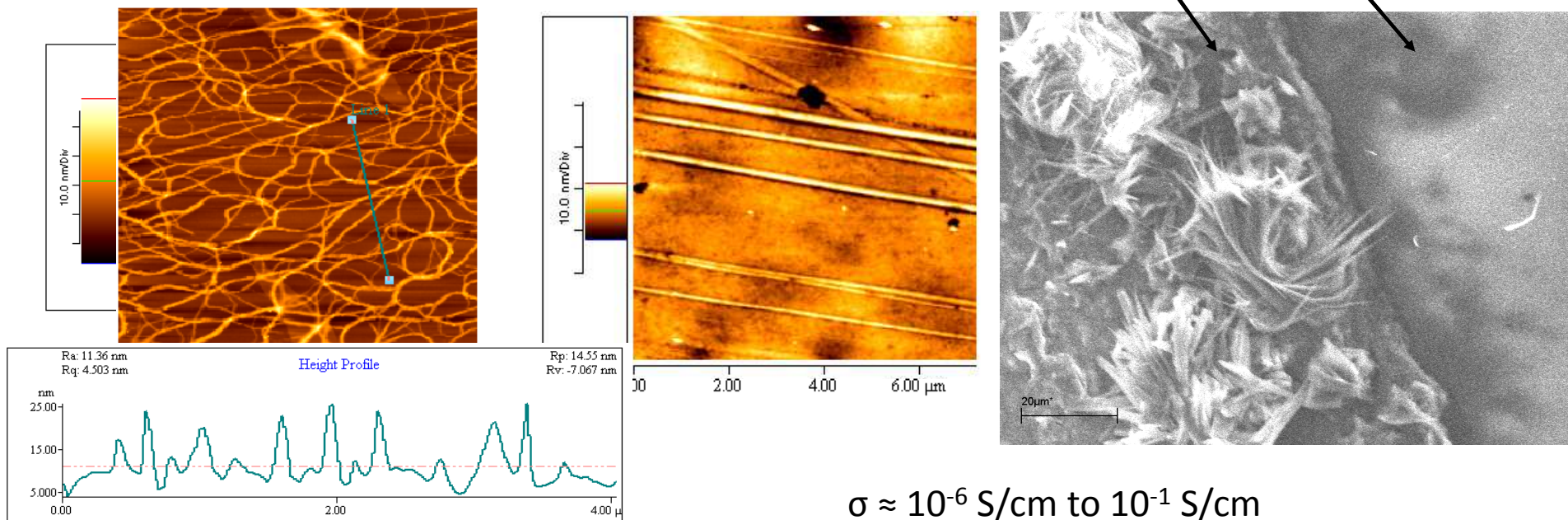


$$\sigma \approx 2 \times 10^{-6} \text{ S/cm to } 1 \times 10^{-5} \text{ S/cm}$$



Alignment of nanotubes with LC polymer matrix. Anisotropy of conductivity.

V. Bliznyuk, S. Singamaneni, R. L. Sanford, D. Chiappetta, B. Crooker, P.V. Shibaev, Micro Orientation of Liquid Crystalline Polymer Films Filled with Carbon Nanotubes, *Journal of Nanoscience and Nanotechnology*, 2005, 5 (10), pp. 1651-1655.



$$\sigma \approx 10^{-6} \text{ S/cm to } 10^{-1} \text{ S/cm}$$

