Self Aligned Attachment of Carbon Nanotubes to Surfaces

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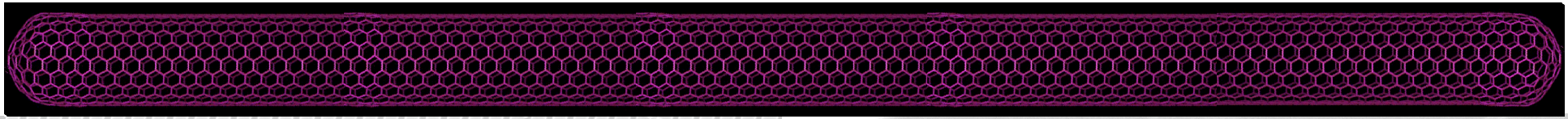
CNS subcontractors working with collaborative support from members of the CNS.

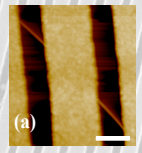


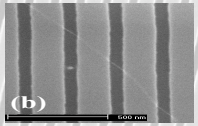
Motivations

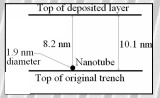
Researchers continue to make advances in understanding carbon nanotubes, but are limited by the difficulty in isolating specific nanotube species, physical placement of nanotubes in relation to other structures and devices, and electrical contact to these materials. Advances in patterning and placement of specific chirality nanotubes combined with advances in tube contacts to metal and semiconductor surfaces will be essential in enabling the development of viable nanotube based sensors, actuators, and electronic devices. We are working primarily with undergraduate research students both at Pomona College and Brigham Young University. Undergraduate students travel to work with collaborators at the CNS during the summer.

Attachment of Nanotubes

A self-aligned thin-film deposition technique was developed to mechanically attach carbon nanotubes to surfaces for the fabrication of structurally robust nanotube-based nanomechanical devices. Single-walled carbon nanotubes were grown by thermal chemical vapor deposition (CVD) across 150 nm wide silicon dioxide trenches. The nanotubes were mechanically attached to the trench tops by selective silicon tetraacetate based silicon dioxide CVD. No film was deposited on the nanotubes where they were suspended across the trenches.







Background: 150 nm wide trenches in silicon substrates supporting nanotubes.

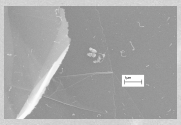
Pomona College students, James Mefarland ('07), Elena Scire ('04), and BYU student Jed Whittaker ('03) working on CVD of nanotubes in Dr McEuen's laboratory at Cornell.

An SEM image of a 1.5 micron long carbon nanotube growing out from a shard of silicon.

Maskless Photolithography System

We have developed a new maskless photolithography tool based on a combination of an ultralight DLP computer projector and an optical microscope. This tool allows for rapid prototyping in photolithography directly from any image created in software. Eliminating the mask fabrication allows custom photolithographic patterns to be created in less than ten minutes. Multilevel alignment has been demonstrated. This tool is being used to define catalyst pads and metal contacts for nanotubes.

Brett Close ('07) images HOPG by STM.



CVD nanotubes on cleaved HOPG.

Carbon Nanotubes and Graphite Surfaces

It has been shown (Superfine, et. al.) that carbon nanotubes on graphite surfaces bond much more strongly when the nanotubes atoms align along the three axes of symmetry on the graphite surface. We are working to combine this selective bonding with lithographic patterning techniques to locate nanotubes of a predetermined chirality on planar surfaces. Templates for growth and individual graphene segments are being fabricated at the CNF.

Undergraduate Research Students

Our research program focuses on using undergraduate students. Five Pomona College students, Brett Close ('07), Matthew Ferguson ('03), David Musgraves ('03), Elizabeth Smith ('06) and Alan Tarr ('07) were supported by the CNS grant this year. Two more Pomona College students are starting this summer working at Cornell. BYU student Jed Whittiker ('03) is beginning his second year of work supported by the CNS, and another BYU student is starting in the CNS REU program this summer.

Pomona College student, Emily Tenenbaum ('04), and one of the workshop participants on the AFM simulation to detect a molecule.

Curriculum and Outreach

We are actively integrating nanoscale science into our undergraduate curriculum, both in lectures and in teaching laboratories. This year we have added STM experiments to our lower division courses. At Pomona a new Freshman Seminar on Nanotechnology will be offered this fall.

Both Dr. Davis and Dr. Tanenbaum have a significant commitment to outreach beyond undergraduate students. We are working to establish programs that both bring pre-college students onto our campuses, as well as preparing educational programs that we can take out to local schools. In collaboration with Dr. Monica Plisch from the CNS both Pomona College and BYU hosted new workshops for local area high school teachers in Southern California and Central Utah this year. The workshops were very popular and we plan to continue this collaborative program next year.

Prof. Davis gives a laboratory tour and demonstration using the AFM to science teachers attending the workshop held at BYU.

Science teachers attending the workshop held at Pomona College work together in to build a Cloud Chamber that they can take home to show sub-atomic particles to their students.

Background: Carbon nanotubes grown from catalysts in thermal CVD on Graphite.