

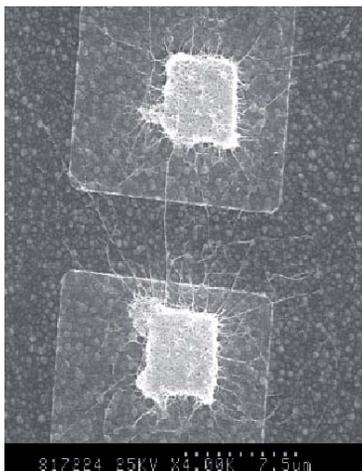
(8) Measurements and Characterization



Characterization equipment in SNF, including microscopes and surface topography measurement tools



A scanning electron microscope (SEM) used to image nanoscale features



SEM image of carbon nanotubes that have been grown across two electrodes.

After you build a nanostructure, or even while you are partway through the fabrication process, you usually need to measure and characterize it. This can be difficult when you are making such tiny things. **SNF has many tools for looking at and measuring nanostructures.**

Optical microscopes are common tools to observe micro- and nanostructures, such as to inspect lithography processes and measure linewidths. SNF has several of these, including two that can be accessed over the internet. However, with optical microscopes one can only see features that are on the scale of micrometers or larger. **To observe smaller features, scanning electron microscopes (SEMs) can be used**, which have resolutions down to the nanometer scale. Instead of light, these use a focused electron beam which scans across the sample surface. This causes surface electrons to be emitted which are collected and used to form an image of the surface on a CRT screen. **Another tool to image and measure very small surface features is the Atomic Force Microscope (AFM).** This uses an extremely small and sharp stylus (or tip) which scans over the sample surface. Its vertical deflection is measured very accurately using a laser, and a 3D image map of the surface is obtained on the atomic, or sub-nanometer, scale. **SNF also has tools to measure the thickness of thin films** using reflective light techniques and tools to measure surface profiles or topographies using light and interferometry. There are also tools to measure film stress. **Electrical measurements**, such as transistor characteristics, can be made on the equipment in the room behind you.

Characterization equipment is also available for SNF users at the Stanford Nano-characterization Lab in another building. These include transmission electron microscopy, focused ion beam, x-ray diffraction, and XPS.