Functional Imaging and Detection at the Single-Molecule Scale Using Carbon Nanotube Probes

Charles M. Lieber
Department of Chemistry and Chemical Biology
Harvard University, Cambridge, MA 02138

Abstract
Carbon nanotubes (NTs) represent ideal materials for the probe tips used in many scanning probe microscopies, such as atomic force microscopy (AFM). In addition to the high aspect ratio of NTs, which allows for probing deep crevices, their unique ability to buckle elastically makes these tips very robust and limits the maximum force applied to delicate biological samples. Both multi-wall (MWNT) and single-wall (SWNT) carbon nanotubes have been attached to the ends of single crystal silicon cantilever-tip assemblies. The resolution of NT tips has assessed through studies of well-defined chemical and biological structures, and in the case of SWNTs, found to be significantly better than conventional tips. Both MWNT and SWNT probes have been covalently-modified to present acidic, basic, hydrophobic and biological functionality. For example, NT tips modified with biotin have been used to measure the binding force between single streptavidin-biotin pairs and single pairs of oligonucleotides. In addition, functionalized nanotube tips have been used to map chemical functionality (functional imaging) with nanometer resolution. Because individual SWNTs have radii on the order of 0.5 nm, these new AFM probes provide a clear pathway for achieving molecular resolution, functionally sensitive imaging and detection of chemical and biological systems.