Fabrication of Nanoscale Sensors Using Divining Rod Carbon Nanotubes

CNF Project # 1192-04
Principal Investigator: Michael J. Naughton

Abstract:
This is a project to develop scanned probe sensors using branched nanostructures, such as Y-junction carbon nanotubes (YCNTs). The goal is to improve SPM sensing, including magnetic (i.e. MFM), by employing intrinsically nanoscale sensing elements. As the dimensions of these are smaller than the wavelength of light, conventional optical sensing is precluded. We’re using piezoresistance sensing, in “divining rod” geometries.

Summary:
Our branched YCNTs have a mostly non-crystalline structure. Previously, we fabricated devices using samples of diameter 20 to 50 nm, and several microns in length. The typical electrical resistance of such YCNTs is of the order of 100 kΩ/µm. The YCNTs are both theoretically estimated and experimentally proven to have a significant piezoresistive effect. However, we found that the ductility of our YCNTs is low, and they broke rather easily, such as via electrostatic shock or under AFM manipulation.

To address this, we report here another round of fabrication process using larger diameter YCNTs, ~ 100 nm, with lengths easily exceeding 10 µm. These are anticipated to be much stronger in structure than our previous samples, yet still have substantial piezoresistive effect, which means they could probably survive the shocks that previously broke the thin YCNTs, and live to tell us the story of nanoscale displacement sensing.

With that, we designed Cr/Au nano-wires placed via e-beam lithography (we used CNF’s Leica VB6) across two branches of the new Y-junction CNT, and make the 3rd branch suspended over a trench etched by BOE (see figure for the new sample fabricated). We’re presently working on measurements of these new YCNT samples, including magnetically-driven piezoresistivity.
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Figure 1: SEM picture of a Y-junction CNT (diameter ~ 100 nm) suspended above a trench (~ 400 nm deep, etched by BOE); the nanotube is contacted by 4 metal leads (50 nm Cr + 30 nm Au). Substrate underneath the structure is Si with 1 μm of thermally-grown silicon oxide. This structure will be used to sense nanoscale displacement via piezoresistive effect.