Staggered Probes for Integrating Nano Machining and Metrology

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This proposal was received in response to Nanoscale Science and Engineering Initiative, NSF 01-157, category NIRT. Our interdisciplinary team is investigating a new process for nanoscale machining employing field emission of electrons from carbon nanotubes. High-precision nanomachining will be obtained by the concentrated thermal power transmitted by electron beams to a thin-film workpiece. In order to investigate the nanomachining process, we will develop a staggered probe that integrates multiple carbon nanotubes on a single probe for integrated nanometrology by scanning probe microscopy and nanomachining by field emission. Such probes will enable the experimental demonstration and investigation of nanomachining with field emission from nanotubes.

This research will demonstrate a new high-precision manufacturing process for producing nano-scale patterns that will impact many disciplines such as nanoelectronics, nanoscience, biology, and energy. The research will foster a multi-university, interdisciplinary partnership in the areas of precision manufacturing, nanoscale thermal sciences, solid-state physics, and material science. A broad set of educational and outreach activities will include nanotechnology workshops chemistry and pre-engineering students at Kentucky State University (KSU) and a summer microscopy fellowship for KSU minority students at the University of Kentucky's microscopy facility.

During the first year of this project,we established the numerical simulation tools and apparatuses necessary for experimental work. For instance, we are able to numerically simulate the heating of metal films by electron beams, and we can fabricate tools and workpieces that will be used for demonstrating nanomachining using field emission from nanotubes. We are poised to conduct a variety of nanomachining experiments during year 2, in which we will test the conditions suggested by the numerical simulations of heating.

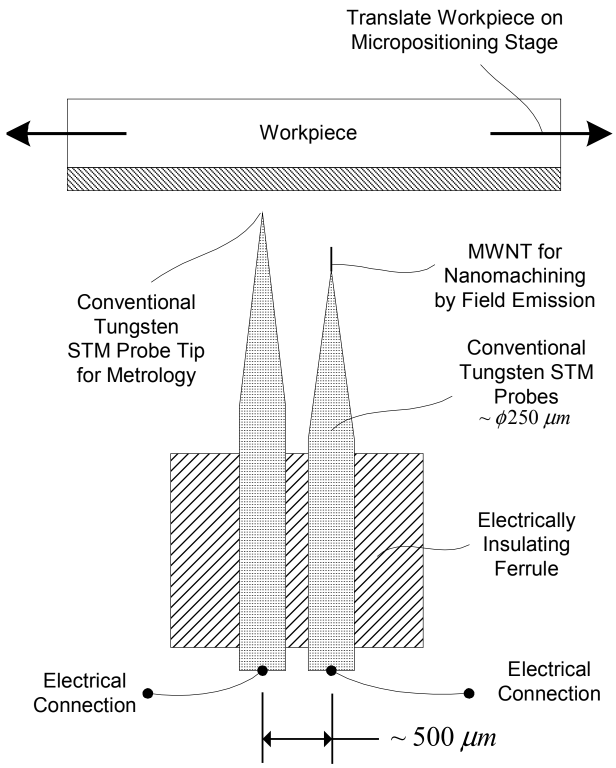

Fig 1: Proposed staggered probe using two electrochemically etched tungsten (W) wires. A CNT on the tip of an etched W wire emits electrons for nanomachining. A second etched tip, with or without a CNT, can be used for measuring material removal by scanning probe microscopy.

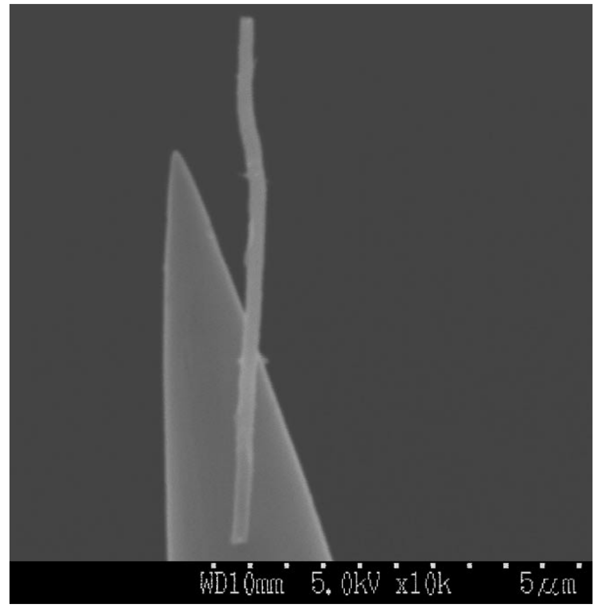

Fig 2: A MWNT, synthesized by CVD, is attached to an electrochemically etched tungsten wire using a nanopositioning stage under an optical microscope

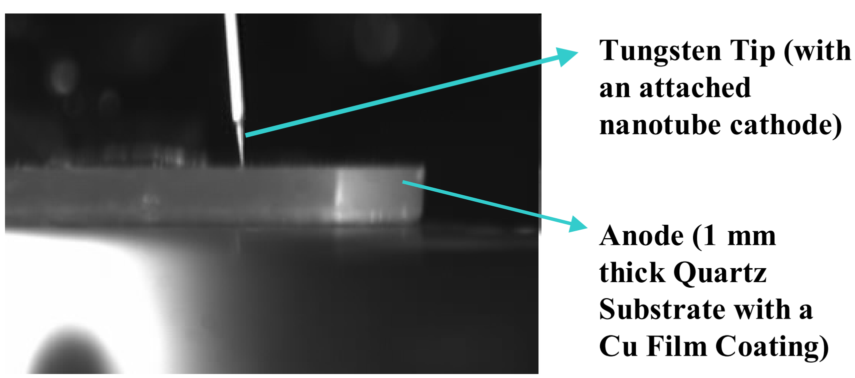

Fig 3: Set-up for initial field emission experiments using a MWNT attached to the end of a tungsten tip and positioned many microns above a Cu anode substrate.

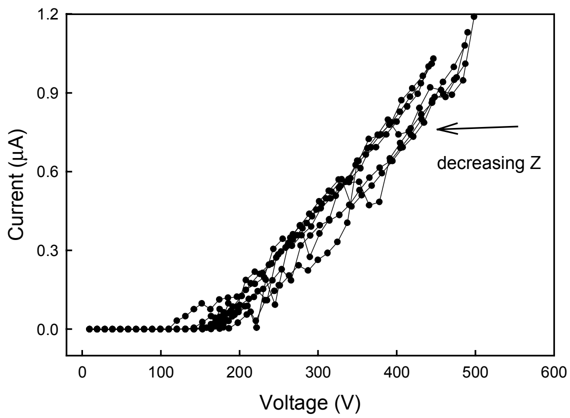

Fig 4: I-V Curve for the Nanotube on Tungsten Tip

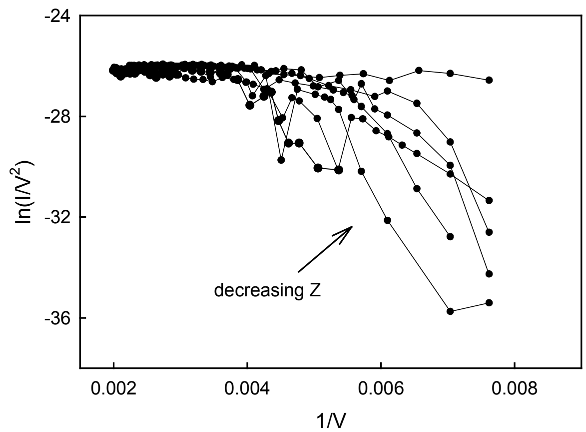

Fig 5: Plot of log(I/V2) vs. 1/V

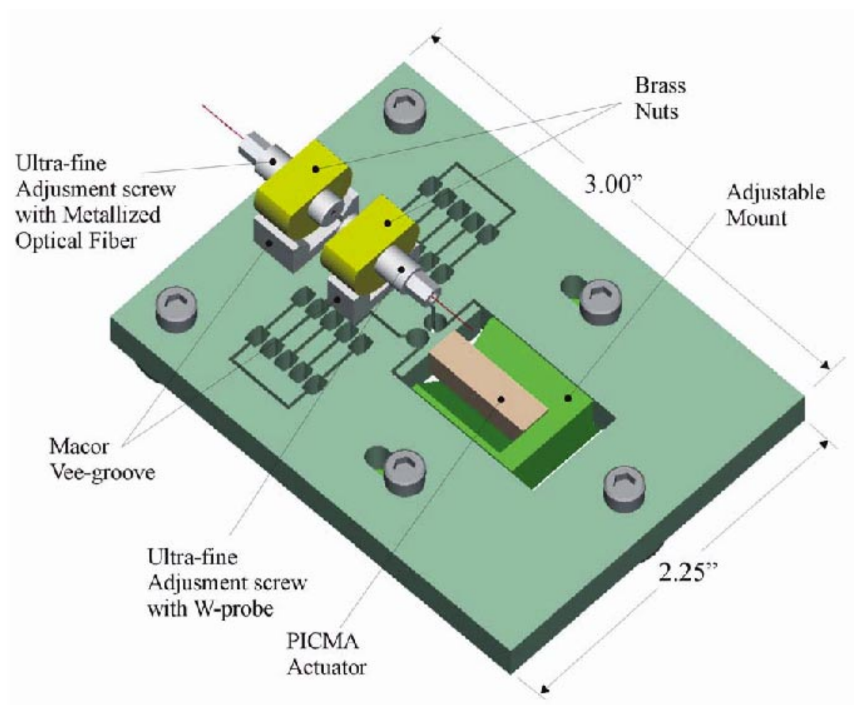

Fig 6: New instrument for conducting high-precision field-emission experiments to measure I-V curves at small gaps (< 20 microns) and fine positioning increments

References

[1] For further information about this project email **vallance@gwu.edu or menguc@engr.uky.edu.**