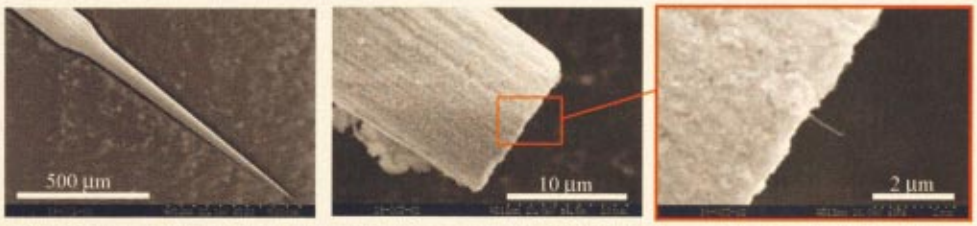

Fig. 1: Structure of probe tips and mounted carbon nanotubes (CNTs) for demonstrating the feasibility of nanoscale machining. (a) Tungsten probe fabricated using electro-chemical etching; (b) Tungsten probe with mounted single CNT; (c) Enlarged view of the mounted CNT on the probe.

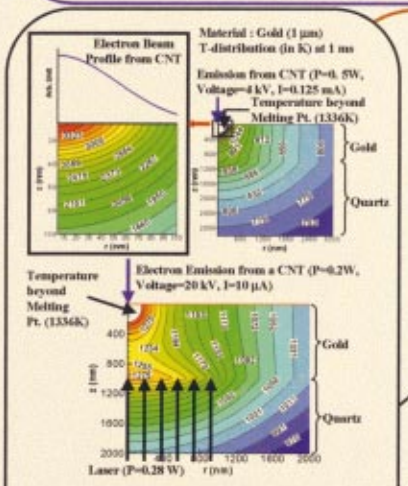

Fig. 2: Numerical modeling of the heat transport using a Monte Carlo method for electron transport, Fresnel equations and heat conduction equation.

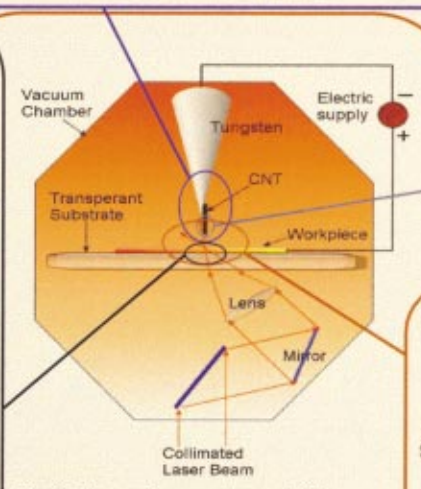

Fig. 3: Proposed nanoscale machining uses energy delivered by an electron beam emitted from CNTs and a collimated laser beam.

Fig. 4: Concentric walls in a MWNT

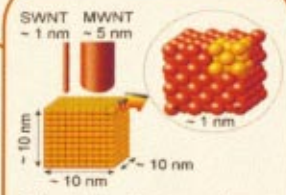

Fig. 5: The size comparison between CNTs and workpiece

Thermal Transport During Nanoscale Machining by Field Emission of Electrons from Carbon Nanotubes

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We are investigating a new process for nanoscale machining called Threshold Heating and Emission from Nanotubes (THEN). THEN is a hybrid process in which the total thermal energy necessary to remove atoms from a workpiece surface will be applied from two sources: (1) localized energy from a laser beam focused to a micron-scale spot and (2) a high-precision electron beam emitted from the tips of carbon nanotubes. Computational simulations of the process suggest that the thermal energy is sufficient to elevate the temperature of nanoscale regions on a gold film to well above melting "temperature." To experimentally validate the process and simulations, we are fabricating nanotools, similar to those used in scanning tunneling microscopy, that consist of multi-walled nanotubes (MWNTs) deposited by chemical vapor deposition on etched tungsten probe tips. This work is supported by an NSF Nanoscale Interdisciplinary Research Team (NIRT) award from the Nano Manufacturing program in Design, Manufacturing, and Industrial Innovation (DMI-0210559).