Low Temperature Scanning Probe Microscopy

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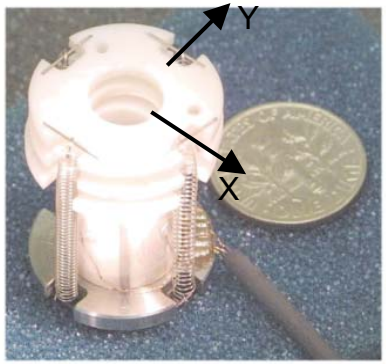
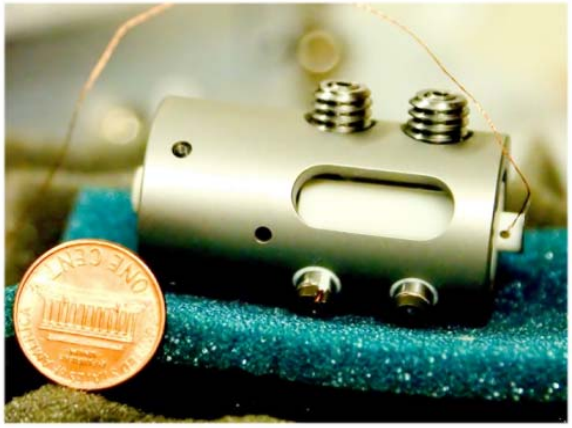
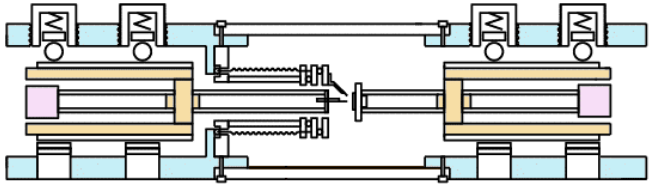
- Double-tip STM with 11 degrees of freedom.
- **TEST**: scan one tip against the other. The image is obtained by electrons tunneling from one tip to the other at a distance of one nanometer.
- Compact design, ideal for low temperature experiments with carbon nanotube tips.



X-Y stage



Z stage



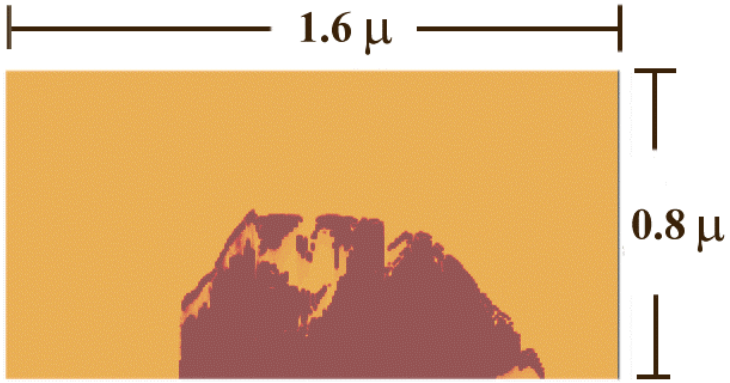


Image of one tip against the other

The scanning tunneling microscope (STM) works by rastering a sharp metallic needle over the surface of a sample. The gap between the needle and the surface is only about 1 nm, which allows electrons to tunnel from one side to the other. This is purely a quantum mechanical process since the electrons do not have enough energy to overcome the barrier presented by the gap. The STM has been an invaluable tool in our study of surfaces down to the atomic scale and has even been used to make patterns with single atoms.

Our contribution has been to design and build a new STM with two tips. The first tip perturbs the surface by pumping electrons into or out of it, and the second tip measures the effects of this perturbation. The technical difficulty is that the two tips must be very close to each other, within about 100 nm. The positioning and scanning of two tips and a sample result in the design shown here, featuring 11 different kinds of motion or degrees of freedom. This sophisticated instrument has passed a number of initial tests before it is cooled down to near zero absolute for its final tests.

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Education

Undergraduates:
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Societal Impact

The art of designing and building sophisticated instruments must be nurtured to ensure our continued leadership in science and technology. The two-tip tunneling microscope developed here will probe materials in a new way by using one tip as a perturbation and the second tip as a probe to measure the effects of that perturbation.