

Abstract

Sharp metal tips with a radius of about 50 nm can be made by electrochemical etching. In our probe station, up to six probes can be independently manipulated with a joystick with about 1 nm resolution. The probes can be used to make electrical measurements or force measurements. They can be used to modify the sample by scratching or pushing structures, small particles or carbon nanotubes around. By bringing a tip very close to a conducting surface it is also possible to generate a spark that ablates material away. Craters with diameters between 200 nm and 5 microns can be made. These probes are being used to construct and to measure the characteristics of nanodevices.

Micromanipulator Probe Station



Fig. 1: Micromanipulator installed in a FEI Quanta 200 (photograph taken by Kleindiek)

Electrical Probing

The micromanipulators can be used for electrical probing without the need to fabricate contacts.

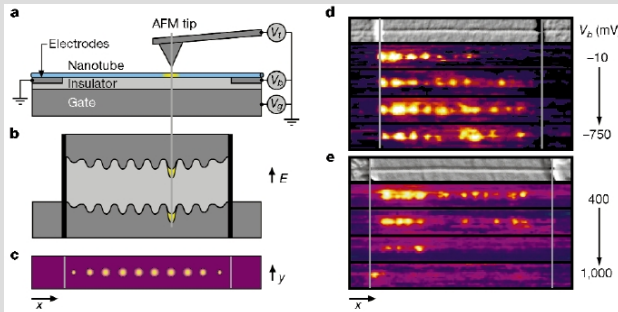


Fig. 2: Scanning-gate potential imaging along a semiconducting carbon nanotube [Tans and Dekker, *Nature* **404**, 834-835 (2000)]

Force Measurement System

A force measurement system expands the versatility of the micromanipulators. With a tip radius smaller than 20 nm and a maximum tip force of 360 μ N, force measurements or nanoindentation can be performed with this system.



Fig. 3: Micromanipulator with force measurement plug-in tool (photograph taken by Kleindiek)

Electrical Discharge Machining

EDM is a method of removing material by electric arcing discharges between an electrode (the cutting tool) and a conducting work piece, in the presence of an energetic electric field.

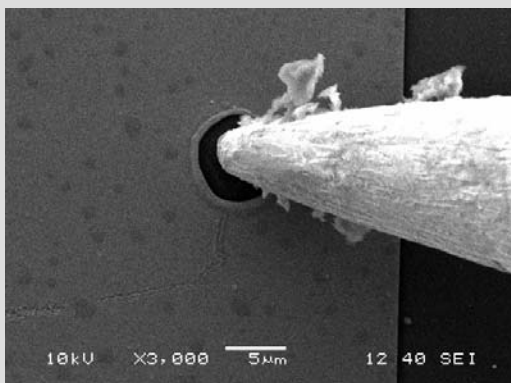


Fig. 4: Electrical discharge machined hole with a diameter of about 7 μ m in an aluminum film (thickness: 30 nm). Applied voltage at the tip was $U_{tip} = -1$ V.

Microassembly

With micromanipulators it is also possible to manipulate micro- and nanocomponents like carbon nanotubes. Attached to the tip, they can be used for probing, but they can also be used for larger nanotube assemblies.

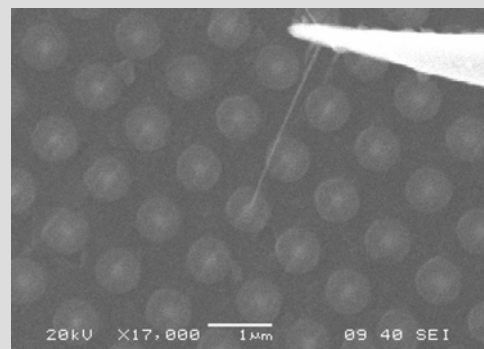


Fig. 5: A better probing resolution was achieved through attaching a multiwalled carbon nanotube to the tip with e-beam assisted carbon deposition.