

# Manipulating and Measuring Carbon Nanotubes inside SEM Using a Probe System

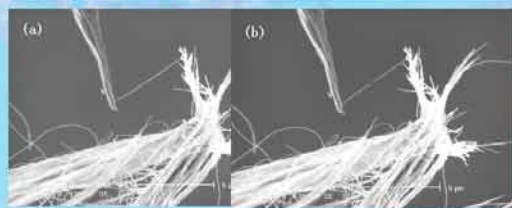
Qing Chen, Xian-long Wei, Sheng Wang and Lian-mao Peng

Key Laboratory for the Physics and Chemistry of Nanodevices, Department of Electronics, Peking University, Beijing 100871, P. R. China

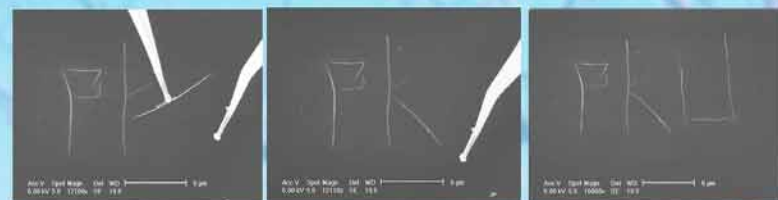
The ability to measure and manipulate at the nanometer scale is crucial to the progress of nanoscale science and technology. Traditionally, scanning electron microscope (SEM) is basically a passive tool in which one can only observe objects but cannot do much to change it. A probe system such as an SPM may be used in many ways to manipulate and perceive objects actively. It is therefore highly desirable to integrate the probe system inside the SEM. In this work, four nanoprobe systems from Kleindiek company were installed in a FEI SEM and carbon nanotubes (CNTs) were manipulated and measured.

## Manipulating CNTs

Using the probe systems, CNTs were cut, moved and placed on a substrate.

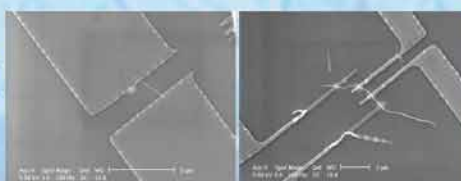


CNT was picked up and cut by a large current



CNTs were moved and placed on a substrate to form a "PKU" pattern

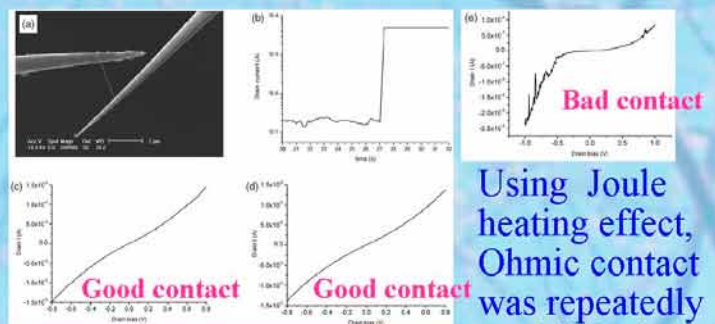
CNTs were placed onto electrodes for device fabrication



## Measuring CNTs---Establishing Ohmic contacts

CNTs samples usually contain both metallic and semiconducting nanotubes. To measure the electronic property of the CNTs before they are built into nanodevices is very important. Using the probe system inside SEM, the CNTs on the substrate as well as that suspended can be measured.

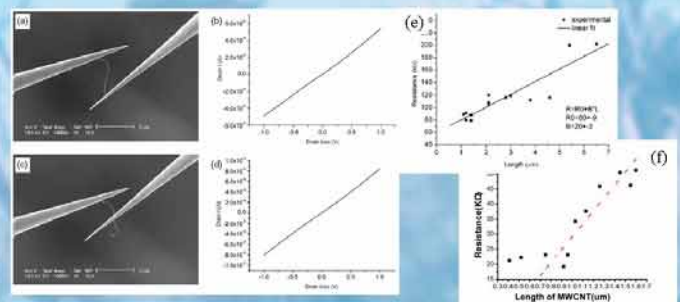
The first problem is to establish reliable contacts between the CNTs and the electrodes. Methods for establishing Ohmic contacts on a CNT were developed using the Joule heating effect.



Using Joule heating effect, Ohmic contact was repeatedly established

## Measuring CNTs---resistance vs. length

The resistance of CNTs were measured as a function of length.



The resistance of CNTs reduced linearly with length (e & f). Ballistic transport was also observed when the length is short (f).

## References:

- [1] Peng L.-M., Chen Q., et al. *Micron* **35** (2004) 495-502
- [2] Chen Q., Wang S., Peng L.-M., *Nanotechnology* **17** (2006) 1087.
- [3] Wei X. L., Chen Q., et al., 2006, unpublished.