NANO HIGHLIGHT
Enhanced Resolution SQUID Microscopes

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The scanning Superconducting QUantum Interference Device (SQUID) microscope images magnetic fields above a sample with high sensitivity but modest spatial resolution. Scientists at the IBM Research Division in Yorktown Heights and the University of Twente in the Netherlands have recently improved the spatial resolution of SQUID microscopes using field-ion-beam etching and advanced fabrication techniques to construct SQUIDs as small as 0.5 microns in diameter. The enhanced resolution of these new sensors can be applied to various applications such as imaging the magnetic fields from current passing through single walled carbon nanotubes (CNTs) containing loops [1].

Images of the loop regions of CNTs are a way to probe the properties of nanotube-nanotube contacts. Bipolar light emission (indicating recombination of electron-hole pairs) is localized at the loop bridges over a range of gate voltages. This result is surprising because current transport along CNTs is thought to be ballistic at low energies, while nanotube-nanotube contacts have relatively high resistances [2]. High-resolution scanning SQUID microscopy detects a finite unipolar current flowing around the loop, suggesting that nanotube-nanotube junctions at the base of the loop pin the ambipolar emission through inter-tube electron-hole interactions.

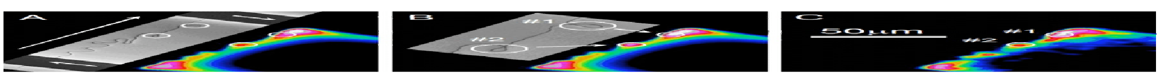

Figure 1: Scanning SQUID microscopy of nanotube loops. (**A**) Modeled SQUID image under the assumption of 100% current tunneling through the nanotube-nanotube junctions. An SEM image of the entire device is shown as an inset. (**B**) Modeled SQUID image under the assumption of 100% current flowing through the loops. A magnified view of the two loops is shown as an inset. (**C**) Experimental SQUID image from the CNTFET. The 1kHz, AC source-drain currents detected by the SQUID were between 1 and 2 A, and the devices operated as p-type devices with a negative V_d and negative time varying V_g's.

References

[1] Marcus Freitag, James C. Tsang, John Kirtley, Autumn Carlson, Jia Chen, Aico Troeman, Hans Hilgenkamp, and Phaedon Avouris, "Electrically-excited, localized infrared emission from single carbon nanotubes", submitted to *Nature Materials*.
[2] M. S. Fuhrer, J. Nygård, L. Shih, M. Forero, Young-Gui Yoon, M. S. C. Mazzoni, Hyoung Joon Choi, Jisoon Ihm, Steven G. Louie, A. Zettl, Paul L. McEuen ; "Crossed Nanotube Junctions", *Science* 288, 494-497 (2000).