Template based fabrication of size tunable single-walled carbon nanotube single electron transistors

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Single electron transistors (SETs) have attracted considerable attention because of their potential as a building block for future quantum based nanoelectronic devices. However fabrication of reproducible and controllable quantum dot sizes that can operate at high temperature is challenging. We developed a novel technique for the fabrication of size tunable and controllable quantum dot using single-walled carbon nanotube[1]. Our technique is based on the formation of two tunnel barriers of controllable separation by naturally bending SWNT at the edges of a electron beam lithographically patterned local Al/Al_2O_3 gate of length L. A SWNT is placed on top of the local gate, and then contacted with Pd source and drain electrodes of 1 μm separation on Si/SiO_2 substrates. The aluminum gate serves three purposes: (i) it acts as a "mechanical template" to define two tunnel barriers at the edges by naturally bending the nanotube due to van der Walls interactions with the substrate, (ii) the width of the gate defines the size (L) of the quantum dot, and (iii) it acts as a local bottom gate to control the operation of the SET device. Using this approach we fabricated SETs of different sizes from 500 nm down to 50 nm. We present detailed fabrication procedures and low temperature transport studies of these SET devices.

[1] Paul Stokes and Saiful I. Khondaker, Appl. Phys. Lett. 92, 262107 (2008).

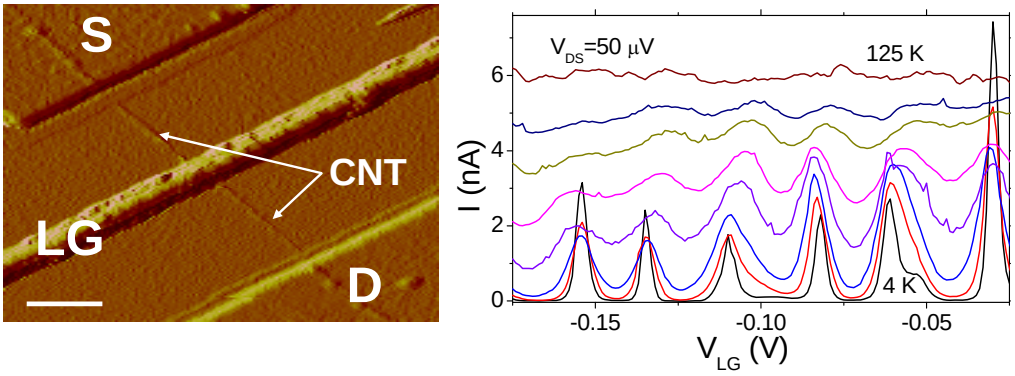

Figure 1. (left) Tapping mode atomic force micrograph of the carbon nanotube (CNT) single electron transistor (SET) device. The CNT was placed on top of 100 nm wide Al/Al_2O_3 local gate (LG) and was connected between Pd source (S) and drain (D) top contacts (scale bar is 200 nm). The gate defines the quantum dot and controls its operation. (Right) Current versus local gate voltage showing several reproducible peaks for several temperatures (bottom to top: 4.2, 12, 20, 35, 50, 75, 100, and 125 K). Peaks begin to wash out around 125 K, for which $k_BT \sim 11$ meV.