Tuning transport and two-state noise in carbon nanotubes using precisely controlled electron beam

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Electron beam lithography has proven to be quite the versatile tool in semiconductor technology. In this work, we expose carbon nanotubes to precisely controlled low energy (30kV) electron beam to observe interesting phenomena. First, we show that reversible tuning of transport in carbon nanotubes is possible by electron beam exposure *in situ* to an applied back gate. A partial n-type behavior is obtained by exposing an electron beam on a device with negative gate bias. The tunable transport behavior is relatively stable in time. An electron beam lithography system was used to precisely control dosage of the electron beam. Stepwise tuning of the transport behavior was performed and analyzed. In addition, we show that electron beam irradiation induces discrete current switching in carbon nanotubes at room temperature. Relative switching amplitude remains constant as the bias voltage varies, suggesting that current fluctuation is dominated by mobility fluctuations.

Preliminary experiments have shown that graphene may also have interesting results when exposed to a controlled electron beam. We have observed structural damage caused by electron beam on graphene via Raman spectroscopy. The effect of electron beam on graphene transport are under study.

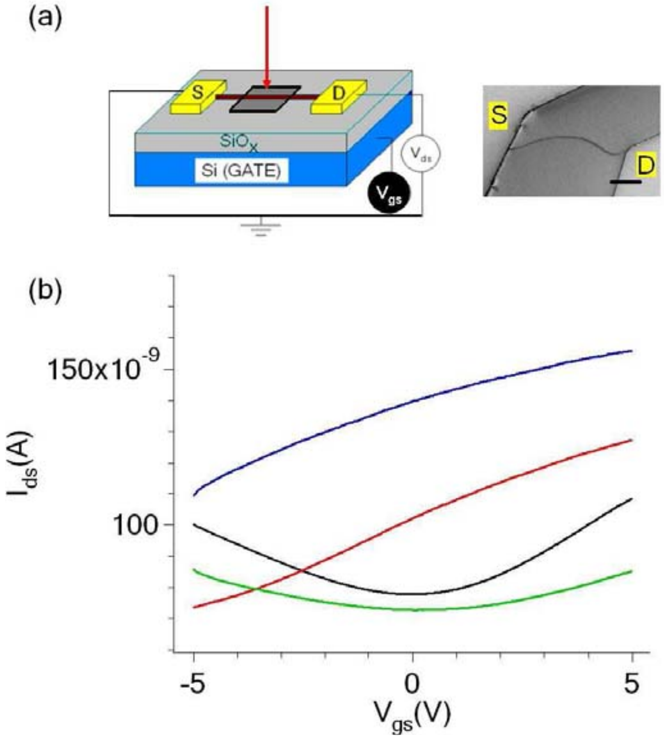

Figure 1: **(a)** Schematic drawing of CNT-FET and SEM image of a contacted CNT, scale bar is 4 μm. **(b)** Transport measurements of the device in vacuum (black curve); after ebeam exposure without applied bias (red curve); after ebeam exposure on a device with positive back gate $V_{gs} = 5V$ applied (blue curve); after ebeam exposure on a device with negative back gate $V_{gs} = -5V$ applied (green curve). All transport measurements were performed under a source drain bias of $V_{ds} = 10mV$.

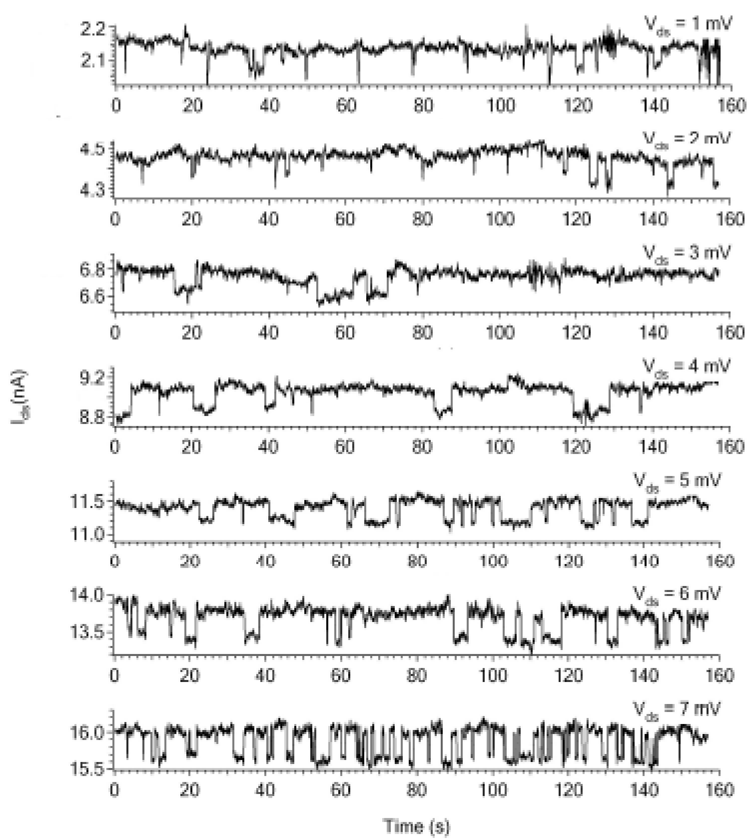

Figure 2: I_{ds} vs. Time (s) measured at fixed V_{ds} from 1mV to 7mV and $V_{gs} = 0$. Current switching becomes more frequent at higher $V_{ds.}$ At $V_{ds} = 7ms$, the current spends about half of its time in both the upper and lower levels.