Fabrication of hundreds of field effect transistors on a single carbon nanotube for basic studies and molecular devices

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Due to their unique structure, extraordinary electrical and mechanical properties, and unusual chemical properties, carbon nanotubes (CNTs) are of great interest for many applications. In particular, carbon nanotube field-effect transistors (CNTFETs) can be used both as stand-alone electronic devices and as a basis for other devices such as sensors. For many of these devices, high-throughput fabrication remains an important challenge. In one specifically demanding application, individual CNTFETs are lithographically 'cut' and rejoined with single molecules in the gap, to yield circuits that can be used to study the basic electrical transport properties of single molecules, and can form the basis of multiple types of sensors. Because of the extreme precision required, such devices have a fabrication yield of only a few percent, which severely limits the speed of progress in implementing CNT-molecule devices. In addition, the diversity of nanotube structures provides an additional source of heterogeneity that makes collection of meaningful statistics difficult.

Here, we report a novel fabrication method to produce a chip with over 600 CNTFETs fabricated on a single CNT. This large number of devices ensures high device output, and allows us to study the stability and uniformity of CNTFET properties. In this work, we grow flow-aligned CNTs on a SiO_2/Si substrate by chemical vapor deposition, and locate a single long CNT (as long as 1 cm) by scanning electron microscopy. Two photolithography steps are then used, first to pattern contacts and bonding pads, and next to define a mask to 'burn' away additional nanotubes by oxygen plasma etch. We present the statistics of the transport properties of these devices, which indicate that the 600 CNTFETs share same similar threshold voltage, and similar on-state conductance. These devices are then used to measure DNA conductance by connecting DNA molecules of varying lengths to lithographically cut CNTFETs.