Nanotube and nanowire devices

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Abstract

The microelectronic revolution has spawned many fields that take advantage of the incredibly small size devices that can be made. However, the limits of photolithography and even electron beam lithography are fast approaching. Future progress in miniaturization of electronics, mechanical devices and optical structures will require new processes and materials.

The work presented in this thesis is an investigation into the possibilities of using new nanomaterials to fabricate simple devices. It is a challenge to integrate these materials with traditional microfabrication techniques. The processes commonly used to make electronics can damage or destroy some nanomaterials. Also, it is difficult to place and orient these novel substances. Finally, at the nanometer scale, different physical properties emerge due to confinement effects and the large surface-area-to-volume ratio.

We have fabricated devices out of carbon nanotubes and electrodeposited nanowires. The nanowires have been fabricated in gold, platinum, silver and nickel. For all the nanowires except silver we have measured the temperature dependence of the resistance and found that it is consistent with bulk metals. We have created and tested crossed nickel nanowires for magnetoresistive effects and found none.

From the platinum wires we have fabricated and tested the first doubly clamped resonator fabricated out of "bottom-up" materials. This resonator has much lower Q than comparable devices made by traditional techniques. The resonator also exhibits non-linear behavior well described by the Duffing oscillator.

From carbon nanotubes we have created a doubly-clamped beam. In addition, we have created a novel carbon nanotube field emission device with integrated grid. Work is ongoing to achieve experimental results from these devices.

The appendix describes photonic crystal defect cavity lasers, which offers interesting potential for integration with nanotubes and nanowires.

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