Carbon Nanotube Transistors: Nanotube Growth, Contact Properties and Novel Devices

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Abstract

Carbon nanotubes (CNTs) are envisioned to be used as the basic building blocks in future electronics due to their excellent electronic properties such as high mobility, compatibility with high-k dielectrics and small diameters resulting in advantageous electrostatics. This thesis is divided into three separate topics related to increasing the fabrication yield and performance of CNT field effect transistors (CNTFETs).

The first part describes a method to control the orientation of CNTs during chemical vapour deposition (CVD) using an electric field. Under certain experimental conditions, deformations in the SiO_2 substrate are formed in the vicinity of the CNTs. An explanation based on field emission from the growing CNTs and Marangoni convection and capillary waves in the molten SiO_2 underneath agrees well with the observed structural changes.

In the second part, CNTFETs that employ CNTs as gate electrodes are described. Devices have been fabricated both by combining electric field directed growth with dielectrophoretic deposition and by a technique with two successive CVD steps. The use of a CNT gate gives an improved inverse subthreshold slope compared to using a back gate and a gate delay of 5 ps. The measured characteristics agree well with theoretical modeling which also asserts that the gate delay can be lowered to 2 ps by reducing the thickness of the gate dielectric.

The final part describes a study of the Schottky barriers between Pd contacts and semiconducting CNTs measured using temperature dependent electrical characterisation. It is found that the barrier heights are close to those expected without Fermi level pinning and inversely proportional to CNT diameter.

Keywords: Carbon nanotube, chemical vapour deposition, field effect transistor, Marangoni convection, Schottky barrier.