Carbon Nanotubes Based Nano-Electro-Mechanical Sytems

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Nanotubes are very promising as core elements of nano-electro-mechanical systems (NEMS). Understanding the interplay between the physical, geometrical and electrical parameters of the system is crucial to accurately design nanotube NEMS [1,2]. We present a combined theoretical and experimental (AFM based) study [3] which shows that these parameters and the deflection efficiency of MWNTs are related through a scaling law of general validity. It allows, the quantitative determination of the electrostatic deflection efficiency of suspended MWNTs as well as their Young's modulus with very high accuracy. A generic method for properly designing and scaling actual devices is deduced from these results.
As an example of nanotube NEMS devices, we present two-terminal nanotube electromechanical switches based on singly clamped, self-assembled and suspended MWNTs. The self-assembly techniques relies on the chemical modification of a patterned substrate. This local functionalization guides the selective deposition of MWNTs from an organic solvent. The switches show extremely sharp transitions (pull-in) between an Off-state (no physical contact between the tube and the actuating electrode) and an On-state (tube in physical contact) with the current changing by several orders of magnitude within a 100mV change of the actuating electrode bias [4].
These results will be discussed in the broader perspectives of the development of High Frequency NEMS based on nanotubes and of the use of carbon nanotubes for contacting single molecules.

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[1] Duquesnes et al., Nanotechnology 13, 120 (2002).
[2] Kinaret et al., APL 82, 1287 (2003) and JAP 96, 629 (2004).
[3] Lefèvre et al, PRL.95 185504 (2005)
[4] Dujardin et al, APL 87, 193107 (2005)

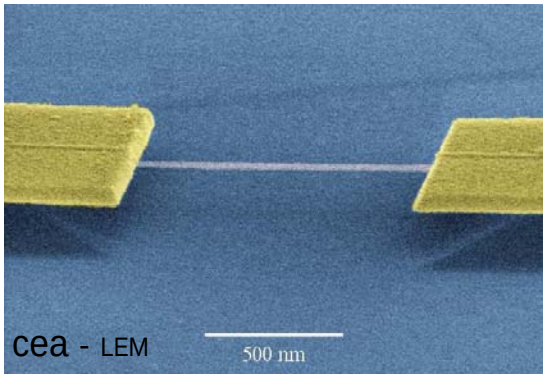

Fig: Doubly clamped suspended MWNT. The doped silicon wafer is used as a gate to deflect electrostaticaly the nanotube.