SELF-ASSEMBLING CARBON NANOTUBES FOR ELECTRONICS

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During the last five years, Carbon Nanotubes have been shown to be very promising building blocks for nanoelectronics. Indeed, they exist as semiconducting or metallic wires and have been used to fabricate nm-scale devices like transistors, diodes, NEMs or SET (single electron transistor) for example. The future of SWNT-based devices in nanoelectronics is to a large extent related to the development of bottom-up self-assembly techniques. In this talk, the focus will be on the self-assembled nanotube devices that were developed recently at the LEM.
I will show how carbon nanotubes(NTs) can be self-assembled at predefined location of a substrate using a localized functionalization of the substrate by a patterned self-assembled monolayer[1,2]. Three examples of application of that technique to the realization of devices will be presented:

- Field effect transistors devices prepared in that way prove functional with state-of-the-art performances[3,4]. Their high frequency (GHz) behaviour was investigated and a high frequency equivalent circuit was derived for the first time[5]. The role played by the environment (including that of the self-assembled monolayer directing the deposition of the NTs and that of molecules adsorbed on the NTs) on the CNTFET devices characteristics will also be discussed. It will be shown in particular how a chemical treatment of the devices can be used to drastically improve the performances of the CNTFET[3,4].
- Further elaborating upon the chemical tailoring of the self-assembled CNTFET devices, a new class of devices consisting of optically gated CNTFET or memories has been developed and will be presented[6].
- New nano electromechanical systems(NEMS) based on nanotubes can also be self-assembled with that technique, that function as very efficient switches with the current changing by several orders of magnitude within a 100mV change of the actuating electrode bias[7]. Nanotubes are indeed quite promising as core elements of NEMS. Clearly, the development of such NEMS requires understanding the interplay between the physical, geometrical and electrical parameters of the system. I will show that these parameters and the deflection efficiency of MWNTs are related through a scaling law of general validity that can be used as an efficient dimensioning tool for nanotube NEMS[8].

Finally, the improvements of the self-assembling technique using the recognition properties of biomolecules will be presented[9].

References:

[1] K.H. Choi et al *Surf. Sci*. 462,195 (2000).
[2] E. Valentin et al *Microelectronic Engineering* 61-62, 491 (2002)
[3] S. Auvray et al, *Appl. Phys. Lett*. 84 (2004) 5106;
[4] S. Auvray et al, *Nanoletters* 5 (2005) 451
[5] J.M. Bethoux et al, IEEE trans. Nanotechnol 5(2006)335, IEEE Electron Devices Lett. submitted
[6] J. Borghetti et al, submitted
[7] E. Dujardin et al, APL 87, 193107 (2005)
[8] R. Lefèvre et al, PRL.95 185504 (2005)
[9] L. Goux-Capes, et al CP725, *DNA-Based Molecular Electronics: International Symposium*, edited by W. Fritzsche 2004 American Institute of Physics