First evidence of the Photoconductivity of Single Wall Carbon Nanotubes films deposited on Silicon surface by Time Resolved Microwave Conductivity

Sébastien Sorgues[1], Claire Costa-Coquelard[2]

1- Laboratoire de Chimie Physique, Université Paris-Sud 11, bât 349 91405 Orsay Cedex, France
Sebastien.sorgues@u-psud.fr

2- Service de Physique de l'Etat Condensé CEA/DSM/IRAMIS/PEC, 91191 Gif/Yvette Cedex, France

Nowadays, semiconductors, such as silicon, are the most convenient materials employed for the photovoltaic cell production. To be efficient, these materials should (i) absorb the maximum of photons of the sun and (ii) exhibit the highest conductivity by preventing the charge carrier recombination. These performances should be reached at a minimum financial cost which is often associated with the simplicity of the employed methods. Besides, it is well known that Carbon Nanotubes, especially Single Wall Carbon Nanotubes (SWNT) are interesting candidates for the photovoltaics[1]: semiconductors SWNT exhibit low gap, extended absorption spectrum in the visible range, strong molar extinction coefficient and reduced carrier scattering.

The aim of this work is to graft SWNT on a surface of silicon in order to benefit of the SWNT properties, as well as the properties of silicon surfaces. We will present the preliminary results concerning the preparation of dense SWNT film on hydrophilic n-doped silicon surface by the bubble deposition method (BDM method, see for example ref[2]). The method consists in confining SWNT in two layers of surfactant via a bubble. This bubble is deposited on the treated silicon surface. The time of drainage enable us to control the quantity of SWNT which is deposited. The last step consists to remove the surfactant. An AFM image is presented in Figure 1. The BDM is an efficient and nevertheless simple and scalable method without being a time and solution consuming method.

In a second step, we studied for the first time the photoconductivity of these surfaces by a non-invasive method such as the Time Resolved Microwave Conductivity (TRMC) method[3]. This transient absorption technique is based on the microwave absorption of samples containing mobile charge carries. In this transient experiment, a nanosecond laser excitation of the semiconductor induces a charge separation via a transition from the valence band to the conduction band. The fate of the species created is probed by microwave absorption. It has been demonstrated that the signal measured is proportional to the conductance change and consequently to the number of charge carrier and to their mobility. We demonstrated by this method that at surface SWNT-modified surface, the lifetime of the charge carrier is 100 times longer compared to non-modified surface (Figure 2). These first results are very encouraging for the preparation of surfaces of solar cells and their characterization.

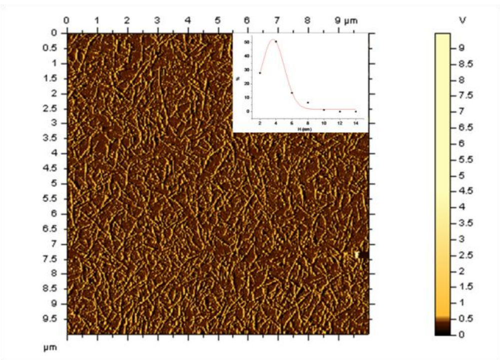

Figure 1

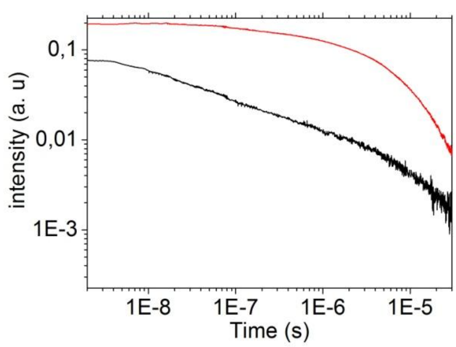

Figure 2

---

[1] J. U. Lee, Applied Physics Letters, 87 (2005), p. 073101

[1] G. Tang, X. Zhang, S. Yang, V. Derycke, and J.-J. Benattar, Small, 14(6) (2010), p. 1488

[3] C. Swiatkowski, A. Sanders, K.-D. Buhre and M. Kunst, Journal of Applied Physics, 78(3) (1995), p. 1763

Figure Caption

Figure 1: AFM image of SWNT film on Si substrate. Insert: Height distribution of the film

Figure 2: Amplitude of the TRMC signal in arbitrary unit of (–) Si Surface (–) Si-OH/ SWNT Surface