CNTFETs fabricated using an
Original Dynamic Air-Brush technique for SWCNTs deposition :
Application to gas sensing and perspectives for other carbonaceous materials

Bondavalli P.*, Gorintin L*., Legagneux P., Simonato J-P+ , Cailler L.+

*Nanocarb Lab, Thales Research and Technology, Palaiseau 91767, FranceOrganization
+ LITEN / DTNM / LCH, CEA-Grenoble, Grenoble 38054, France

paolo.bondavalli@thalesgroup.com

Summary

This contribution deals with Carbon Nanotubes Field Effect transistors (CNTFETs) based gas sensors fabricated using a completely new dynamic air-brush technique (patented) for SWCNTs deposition. The extreme novelty is that our technique is compatible with large surfaces, flexibles substrates and allows to fabricate high performances transistors exploiting the percolation effect of the SWCNTs networks achieved with extremely reproducible characteristics. This technique is extremely interesting considering that it is suitable for industrial transfer. More precisely, we have developed a machine which allows us the dynamic deposition on heated substrates of SWCNT solutions (Fig.1), improving dramatically the uniformity of the SWCNTs mats.

The CNTFETs have been developed for gas sensing applications. Indeed we have fabricated arrays of CNTFETs achieved using different metal electrodes [1,2] (patented approach [3]) to exploit the change of metal/SWCNTs junction characteristics as a function of the gas detected (Fig.2) in order to identify a sort of lectronic fingerprinting. This phenomenon is related to the change of the metal work function and so of the Schottky [1] barrier and seems to be extremely selective (see Tab.1).

Although the deposition technique has been developed to fabricate CNTFETs, this technique is extremely versatile and can be used for other kinds of applications such as fabrication of bolometers (e.g. nanotubes) [4], replacements of ITO layers (e.g. nanotubes, graphene) [5], in OLED (e.g. graphene) [6], for light and cheap ultracapacitors on flexible substrates (e.g. using carbon nanotubes or nanohorns) [7]. This technique could really allow these nanomaterials to strike the market on these applications. During the presentation examples, for all these applications, will be shown.

Results for gas sensing

We have fabricated CNTFETs using interdigitated electrodes. The distance between the fingers was 15µm. Our technique has allowed us to fabricate transistors in a reproductible way with high On/Off current ratio and on large surfaces (Fig.3). We have performed measurements of CNTFETs array before and after exposure to NH_3, NO_2, CO at concentrations, of 50ppm for Ti, Au, Ti, Pt as electrodes. The results demonstrate our concept (Fig.4). The CNTFETs permit to identify a sort of electronic fingerprinting of each gas.

This work has been performed in the frame of the ANR6 Project NANOSENSOFIN [11] for CO selective sensing, and it is a joint effort of Thales Research and Technology and CEA-LITEN teams.

References

[1] P.Bondavalli, et al., CNTFET based gas sensors : State of the art and critical review, Sensors and Actuators B, 140, 1, pp 304-318, (2009)
[2] P. Bondavalli, CNTFETs based gas sensors : patent review, Recent Patents on Electrical Engineering, 3 (2010)
[3] P.Bondavalli et al Conductive nanotube or nanowire FET transistor network and corresponding electronic device, for detecting analytes., 2008 WO/2006/128828
[4] M. Tarasov, J. Svensson, J. Weis, L. Kuzmin and E. Campbell' Carbon nanotube based bolometer, JETP Letters, 84, 5 (2006)
[5] http://www.touchuserinterface.com/2008/06/graphene-possible-replacement-for-ito.html
[6] J. Wu, M Agrawal,H. A. Becerril, Z. Bao, Z. Liu,_Y. Chen_ and P. Peumans, *ACS Nano*, 4(1), 2010.
[7] Printable Thin Film Supercapacitors Using Single-Walled Carbon Nanotubes, Martti Kaempgen, Candace K. Chan, J. Ma, Yi Cui, and George Gruner, Nanoletters, Vol.9 n.5 (2009)

Figures

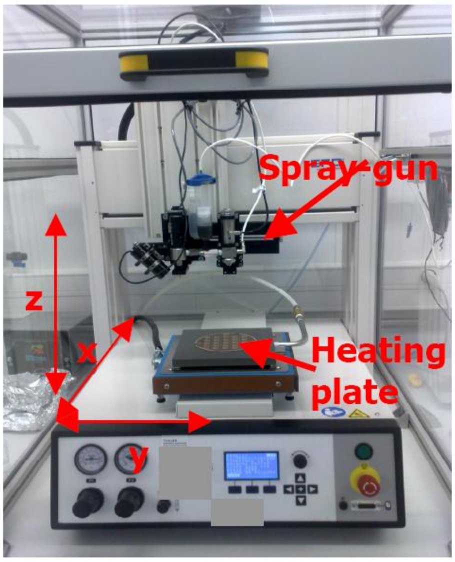

Fig. 1: Machine for Dynamic Air-Brush deposition of SWCNTs.

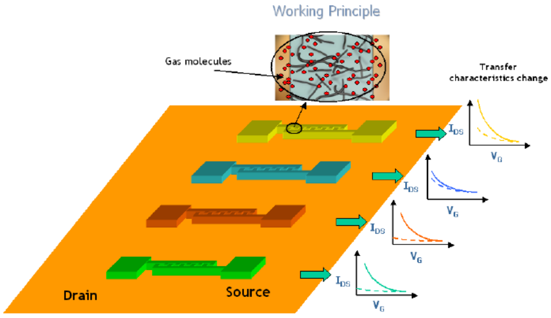

Fig.2 : Gas fingerprinting concept. CNTFETs array composed by transitors with different metal electrodes (each colour). On the right : the transfert characteristics relative change after gas exposure (before, solid line and after exposure, dash line) is specific for each metal for one targeted gas.

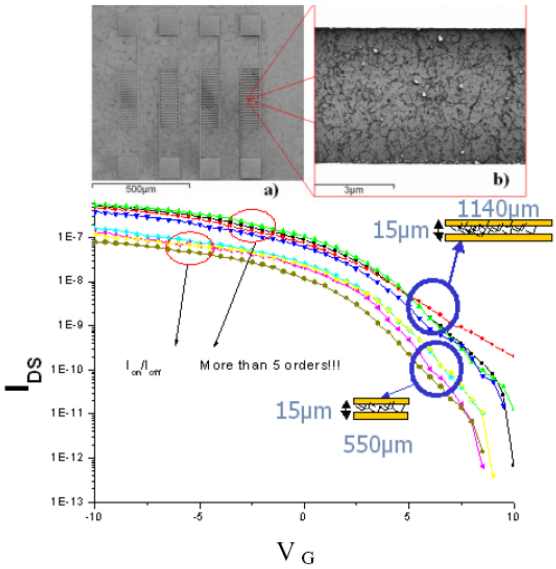

Fig. 3: On the top: array of four CNTFETs with Interdigited finger configuration and a detail (AFM picture) of the CNTs mat. On the bottom : on/off current ratio for CNTFETs with finger distance

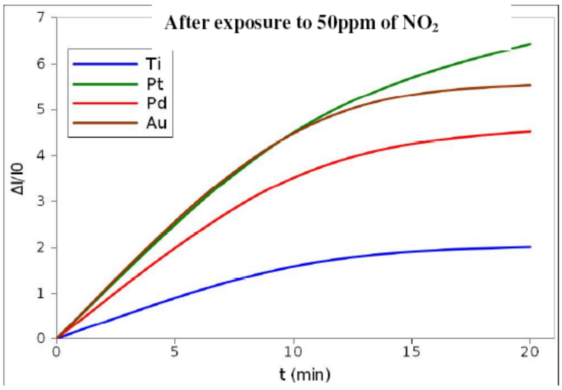

Fig. 4 : Current change as a fucntion of Time, after exposure to 50ppm of NO_2 of four CNTFETs achieved using different metal as electrodes

	CO	NH3	NO2
Au	65%	-30%	6600%
Ti	15%	-50%	4400%
Pd	45%	-35%	38000%
Pt	-5%	-45%	84000%

Tab.1 : Relative change of the current after 20 minutes of exposure to 50ppm of NO_2, NH_3 and CO for CNTFETs achieved using Au, Pd, Ti, Pt as electrodes