MACROSCOPIC MULTIWALLED CARBON NANOTUBE ROPES AS NITROGEN DIOXIDE GAS SENSORS

[1] J. Rodriguez, J.R. Morante,
[2]E. Mendoza, ,S.R.P Silva,
[3]Y. Li and Y. Q. Zhu

[1]Departament d'Enginyeria Electronica. Universitat de Barcelona
Marti i Franques 1 08028 Barcelona, Spain
[2]Advanced Technology Institute, University of Surrey
[3] Advanced Materials, School of Mechanical,
Materials and Manufacturing Engineering,
University of Notthingham
e-mail: jordi_rodriguez@ub.edu

Carbon nanotubes have attracted a wide interest due to their extraordinary electrical and mechanical properties. These, in combination with a good chemical stability, high surface area and the fact that the conduction properties are modified when molecules adsorb on their surface, makes them ideal candidates for being used for the design of sensors. In this work, NO_2 gas sensors based on macroscopic multiwalled carbon nanotube (MWCNT) ropes are presented.

The MWCNTs ropes (Fig.1) were prepared using the floating catalyst chemical vapour deposition within a quartz tube in a horizontal furnace [1]. A mixture of ferrocene and thiophene was used as catalyst and carbon source for the synthesis of carbon nanotubes. The mixture was dissolved in a xylene solution. The solution was injected into the pre-heated zone (200ºC) of the quartz tube using a syringe. The pre-heated low temperature zone will sublimate and vapourise the solution. The vapour was then transported by a mixture of argon and hydrogen into the high temperature reaction area (1150ºC) where the CNTs form. The ropes are collected from the inner wall of the quartz tube.

Structural and electrical characterisation shows that these ropes constitute bundles of MWCNTs. The electrical resistance of these ropes decreases upon exposure to NO_2 , showing a high response even at room temperature. The electrical response increases with the temperature and the signal recovery is partial revealing a complexe nature of the absorption sites. This is shown to be an effect of the bundled nature of these ropes in comparison with individual MWCNTs [2]. The adsorption sites created in within the bundles of carbon nanotubes are more stable requiring higher desorption energy.

The surface of the MWCNTs ropes is functionalised with a low temperature (≈ 80ºC) HNO_3 acid treatment during 12 hours. This functionalisation process introduces hydroxyl and carboxyl groups on the surface of the MWCNTs [3]. The presence of these chemical groups has a strong effect on the gas adsoption properties. The response to NO_2 molecules (Fig.2) is increase by a factor 100 % at room temperature. This is attributed to the polar interaction between the NO_2 molecules and the carboxyl and hydroxyl groups. These results demostrate a strategy to increase the response of carbon nanotube gas sensors.

References

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Figures

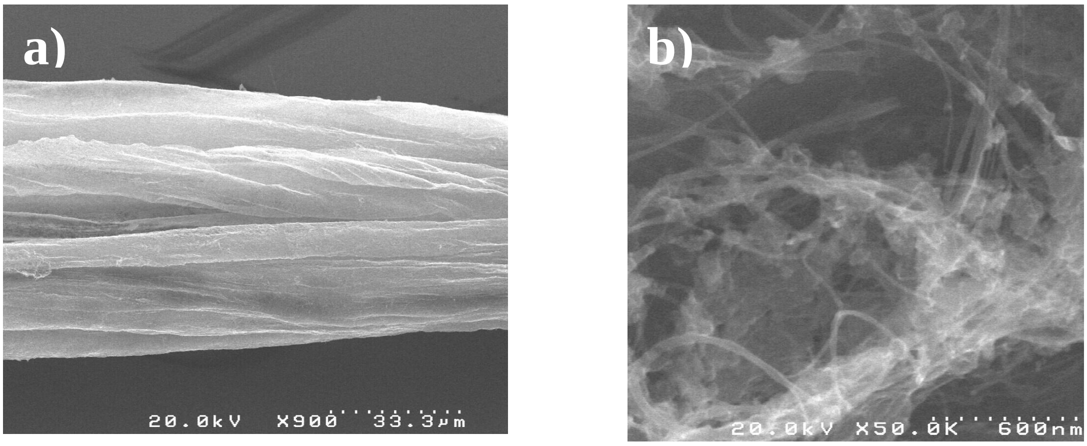

Figure 1: (a) Low magnification SEM micrography showing a MWCNT rope (b) High magnification SEM image showing the MWCNTs form which the MWCNT rope is constituted.

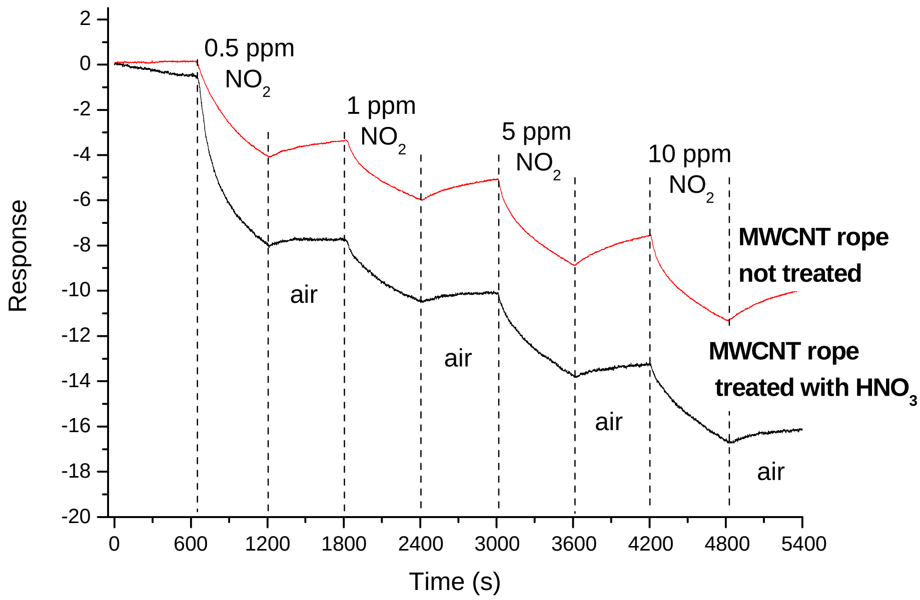

Figure 2: Dynamic responses at room temperature of a pristine MWCNT rope and a rope after acid treatment for different concentrations of NO2 .