SINGLE WALL CARBON NANOTUBE (SWCNT) NO_2 GAS SENSOR

Jyoti[1], Khushbu[1,2], Daya S. Sharma[3], Mandeep K. Bairwa[1], T. Eshwar[1], Pankaj B. Agarwal[1,4], Prateek Kothari[1], Arvind K. Singh[1], Anil Kumar[1,4]

[1]*CSIR-Central Electronics Engineering Research Institute, Pilani, Rajasthan*
[2]*Modi University of Science and Technology, Laxmangarh, Rajasthan*
[3]*Maulana Azad National Institute of Technology (MNIT), Bhopal*
[4]*Academy of Scientific and Innovative Research (AcSIR), New Delhi*

ABSTRACT

Nitrogen dioxide (NO_2) gas sensors are important for the safety of environment and living beings. NO_2 gas is a filthy-smelling air pollutant from fossil fuel combustion, road traffic, etc and is one of the cancers causing pollutants [1]. Gas sensors based on Carbon Nanotubes (CNTs) are used for improving the gas sensitivity due to high surface area to interact with target gas molecules [2].

Basically, in CNTs based gas sensors, resistance changes when a particular gas molecules are adsorbed on the surface from the surroundings [3]. CNTs gas sensors are classified as chemi-resistive, chemi-capacitive and chemi- field effect transistor [4]. The simplest sensor architecture is the chemiresistor, which consists of two metal electrodes connected by a SWCNT film. Here, we report fabrication and characterization of SWCNT chemiresistive sensor for NO_2.

Functionalization of SWCNTs is performed by oxidation in nitric acid (HNO_3) for 3 hours. To confirm the attachment of -COOH group on SWCNTs, FTIR spectroscopy (Bruker optic tensor 37) was carried out. A SWCNT-COOH dispersion of 3mg/mL was prepared in DI water by using horn type sonicator (model VCX 750). A thin film of functionalized SWCNTs dispersion was drop-cast over fabricated gold micro electrode structure on silicon substrate with the help of 1.5µL micropipette. The SWCNT chemiresistor was kept at room temperature until the DI water evaporates, followed by drying at a temperature of 100 °C.

The fabricated gas sensor was exposed to NO_2 in an enclosed chamber and the response was measured at concentrations up to 50 ppm at room temperature. Sensitivity of fabricated chemiresistor was measured at different concentrations from 10 ppm to 50 ppm. Initially sensor was purged with dry air for 15 minute and initial resistance was measured 4.24 kohm. Exposure time of dry air and NO_2 gas was 5 minute each. Resistance of chemiresistor decreases in presence of NO_2 gas at 10 ppm and recovers partially to its original value after removal NO_2. Variation of sensor resistance with NO_2 concentration (10ppm-50ppm) is shown in Figure I.

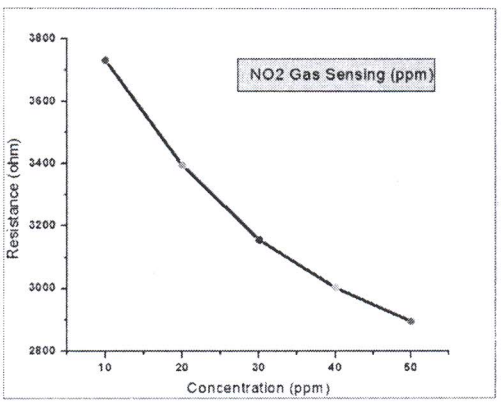

Figure I. Variation of sensor resistance with different concentrations (10ppm-50ppm).

SWCNTs chemiresistor shows resistance variations from 4.24 kohm to 2.89 kohm when exposed to NO_2 concentration from 10 ppm to 50 ppm. Corresponding calculated sensitivities are 12.16% at 10 ppm and 31.88% at 50 ppm. This study shows the potential of SWCNTs for room temperature NO_2 sensor applications in environmental monitoring.

Acknowledgement: Authors would like to acknowledge Director, CSIR-CEERI, Pilani for his continuous support and encouragement. Authors also thankful to Group Leader, SNTG and In-charge, clean-room facilities (NB), for their help and support.

References:

1 Y. S. Kim, S.C. Ha, K. Kim, S.Y. Choi, H. Yang, J. T. Park, C. H. Lee, J. Choi, J. Paek, and K. Lee, Appl. Phys. Lett. 86 (2005) 213105.

2 Claus-Dieter Kohl, Thorsten Wagner, Springer ISBN 978-3-642-54519-1 (2014) 125-132.

3 C. Cantalinia, L. Valentinib, I. Armentanob, J.M. Kennyb, L. Lozzic, S. Santuccic, Journal of the European Ceramic Society 24 (6) (2004) 1405–1408.

4 E.S. Snow, F.K. Perkins, E.J. Houser, S.C. Badescu, T.L. Reinecke, Science 307 (2005) 1942–1945.