*Proc. of the Intl. Conf. on Nanotechnology for Better Living, 2016*
*Editors* K. K. Kar, A. Shah and R. Sharma
Vol. 3, No. 1, p. 216
doi:10.3850/978-981-09-7519-7nbl16-rps-216

NBL-2016

# SWCNTs/$Al_2O_3$ composite thin film temperature sensor

Poonam Sehrawat, Mohammad Aftab Alam, Nivrith Mandayam Gomatam, Zuhaib Khan, Shivani Patel, Shima Shabbir, Sharad Singh, Sumayah Shakil Wani, Kehkasha Parveen, Fauzia Afzal and S.S. Islam*

Centre for Nanoscience and Nanotechnology, Jamia Millia Islamia (A Central University), Jamia Nagar, New Delhi-110025, India.
*Email: sislam@jmi.ac.in

Temperature quantification is at the heart of every thermal management system. Excellent thermal and electrical properties are implicit requirements for a material to be suitable for temperature sensor fabrication. Carbon nanotubes, CNTs, are one such material; exhibiting extraordinarily high electrical, mechanical as well as thermal properties. Since their discovery, they are being profusely investigated for their remarkable physical properties. In this work, we illustrate the synthesis of single-walled carbon nanotubes (SWCNTs)/alumina ($Al_2O_3$) composite using sol-gel process for different concentrations of SWCNTs and its potential use as a temperature-sensing element.

Alumina sol was prepared by following the sol-gel route using aluminum-sec-butoxide (95% pure) as precursor. Varying concentrations of SWCNTs were ultrasonically mixed in alumina sol to prepare different composites, Table I consolidates the parameters of the various composite samples prepared. The composite was obtained in the form of a paste, which was then coated on alumina substrate (1cm x 1cm) using dip coater. All the samples were annealed at 450 °C for 30 minutes. Temperature sensors were fabricated from the annealed samples by patterning parallel electrodes at both the ends of the samples using highly conductive silver paste.

Table I: Various sensor parameters used for investigation.

| SWCNTs concentration (wt %) | Sample Code | TCR (-%/°C) |
|---|---|---|
| 1 | S1 | 0.314 |
| 2 | S2 | 0.372 |
| 3 | S3 | 0.495 |
| 3.5 | S4 | 0.571 |
| 4 | S5 | 0.432 |

The surface morphology of the sensors was investigated using FESEM revealing good dispersion of the nanotubes in the alumina matrix (Figure 1a). Temperature dependent resistance was monitored in order to evaluate the temperature coefficient of resistance (TCR) of the sensors. The TCR was found to be highly sensitive with the concentration of SWCNTs in the composite (Figure 1b). Initially, with increasing SWCNTs content the TCR increases and reached a maximum value of -0.571 %/°C at 3.5 wt%. However, after 3.5 wt%, TCR decreased with further increase in the nanotubes concentration. This behavior has been ascribed to poor dispersion of nanotubes in the alumina matrix at higher concentrations; leading to the formation of ropes/bundles and entanglements creating large number of metal–metal, metal–semiconductor, and semiconductor–semiconductor junctions within the network mess. These result in large electron-phonon scatterings at higher temperatures, thereby controlling the TCR. The maximum value of TCR achieved is -0.571 %/°C at 3.5 wt% concentration which is quite high vis-à-vis other materials used for the temperature sensor fabrication.

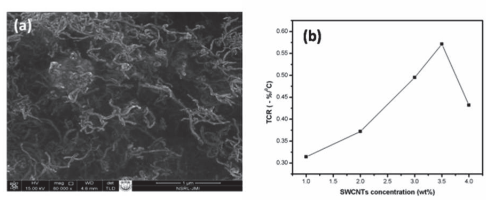


Figure 1: (a) FESEM image of S4 sample and (b) TCR variation with SWCNTs concentration in the SWCNTs/Alumina composite.