Sensors and Materials, Vol. 21, No. 5 (2009) 265–280
MYU Tokyo

S & M 0767

Chemical Modification of Carbon Nanotubes for NO_2 Detection

Takeshi Hashishin* and Jun Tamaki

College of Life Sciences, Department of Applied Chemistry, Ritsumeikan University,
1-1-1 Nojihigashi, Kusatsu, Shiga 525-8577, Japan

(Received April 6, 2009; accepted June 2, 2009)

Key words: carbon nanotubes, oxides, chemical modification, NO_2, p-n junction

Multiwalled carbon nanotubes (MWNTs) were oxidized by nitric acid in order to simultaneously induce defects and hydrophilic (carboxyl) groups on the surface of MWNTs, on the basis of the concept that defects and carboxyl groups could contribute to the increase in the number of adsorption sites of gas molecules such as NO_2. It was observed by transmission electron microscope (TEM) that oxidized MWNTs had a rough sidewall surface. The sensor response to dilute NO_2 (R_a/R_g) of an oxidized MWNT-based sensor was 50% higher than that of an as-grown MWNT-based sensor, suggesting an increase in the number of NO_2 adsorption sites with an increase in the density of defects on the surface of MWNTs. On the other hand, the p-n junction of a semiconductor generally contributes to increasing electric resistance by forming a space charge layer. A space charge layer could be expected to enhance NO_2 gas adsorption. Thus, MWNTs as p-type semiconductors were modified with an n-type semiconductor such as WO_3 and SnO_2 nanoparticles, which generally exhibit an excellent sensor response to dilute NO_2. MWNT-WO_3 and MWNT-SnO_2 composite sensors showed a fairly good sensor response (R_a/R_g) to dilute NO_2, compared with that of the MWNT-based sensor. The addition of an n-type oxide to MWNTs contributes to the formation of a large depletion layer within MWNTs by the p-n junction on contact points between MWNTs and oxides, resulting in an increase in resistance in air and the enhancement of NO_2 adsorption.

*Corresponding author: e-mail: hasisin@sk.ritsumei.ac.jp