Highly efficient ammonia sensors based on modified single walled carbon nanotubes

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Carbon nanotubes have emerged as a promising alternative for highly efficient gas sensing technologies due to their remarkable properties like high surface to volume ratios and the possibility of doping or functionalization according to a specific application[1]. In this work, the fabrication and response of gas sensing devices based on networks of single walled semiconducting, pristine (unsorted), boron doped and nitrogen doped carbon nanotubes to low concentrations of ammonia at room temperature was investigated. The chemiresistor-type sensors were fabricated using UV-lithography process, and the nanotubes were deposited using a drop casting approach (Fig. 1) followed by electrical and scanning electron microscopy characterization. Then, the sensors were exposed to 1.5, 2.5, 5, 10 and 20 ppm of NH_3, and the change of current at a fixed voltage as the reaction to the gas exposure was measured.

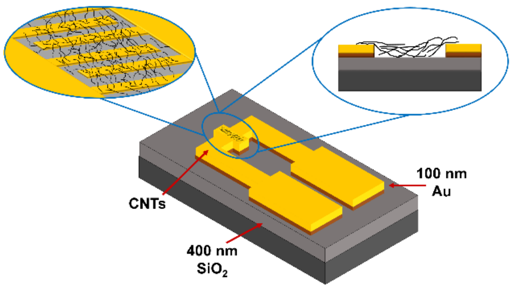

Figure 1. Schematic view of the CNT-based gas sensing device with interdigitated electrodes and SWCNTs on Si/SiO_2 substrate.

The comparison of the detection performance of different devices, in terms of resistance change, combined with the detailed analysis of chemical bonding of dopant atoms to nanotube walls sheds the light on the interaction of NH_3 with CNTs.
Electrical characterization and analysis of the structure of fabricated devices showed a close relation between the amount and quality of distribution of deposited nanotubes and their sensing properties (Fig. 2). Furthermore, sensors based on semiconducting CNTs exhibited the highest sensing responses to all ammonia concentrations compared to other nanotubes. These sensors have 3.5% response to 1.5 ppm of ammonia at room temperature, are able to detect NH_3 at sub-ppm concentrations, and consume only 0.6 µW of power. All this suggest application of these sensors for diagnosis of certain diseases based on the analysis of exhaled breath samples as well as for mobile applications or a remote environment monitoring.

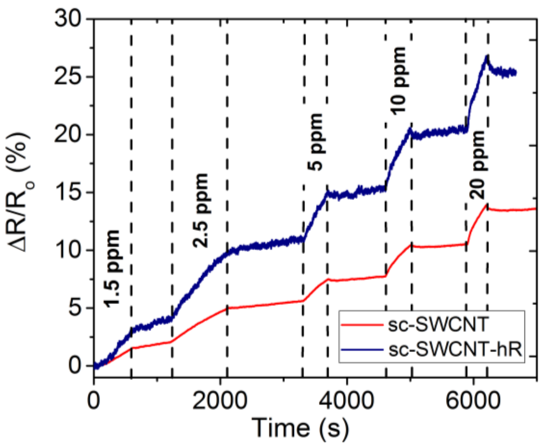

Figure 2. Sensing response $\Delta R/R_0$ of two devices based on semiconducting SWCNTs with different amount of nanotubes under exposure to five different ammonia concentrations. The devices had initial resistance of 268Ω (more nanotubes, red) and 15 kΩ (less nanotubes, blue).

References

[1] Llobet, E. Sensors and Actuators, B Chem. 179 (2013) 32-35.