Analytical modelling of sensing performance of carbon nanotubes for gas sensing

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Abstract: Carbon nanotubes as a new variety of quasi one-dimensional (1D) materials belong to the family of carbon-based nanostructures, which have recently ignited tremendous research interest. The latest discoveries of the outstanding properties of carbon nanotubes (CNTs) in terms of their electronic and structural behaviours such as, large surface-to-volume ratio, tunable band gap, high mechanical strength, high mobility and extreme sensing capability make them a great candidate for nanoelectronic devices of the future. Due to the importance of nanoscale sensors and biosensors in various areas of our lives, using promising materials such as carbon nanotubes has widely captured the attention of researchers to achieve better sensitivity and accuracy in these devices. Up until now, the majority of investigations have focused on experimental studies for sensors. Therefore, there is a lack of analytical models in comparison to experimental investigations. In order to model the transport parameters of a CNT-based gas sensor, the field effect transistor (FET)-based structure has been employed as a primary model for a gas detection sensor. The conductance of the carbon nanotube has been affected under exposure to the target analyte – NH_3 gas molecules. The absorption of NH_3 gas concentration on the CNT surface follows a chemical reaction between CNTs and the NH_3 gas. Therefore, it modulates the current-voltage (I-V) characteristics and conductance of the proposed CNT-based gas sensor. The I-V characteristics of the CNT-based sensors have been proposed as a criterion to detect the effect of gas absorption. Finally, the accuracy of the proposed models were validated by benchmarking them on existing experimental works.

Keywords: carbon nanotubes; sensors; I-V characteristics; conductance.