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Modification of Carbon-Based Gas Sensors for Boosting Selectivity

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Abstract : Gas sensors that utilize carbonaceous materials as sensing media offer numerous advantages, making them the preferred choice for constructing chemical sensors over those using other sensing materials. Carbonaceous materials, particularly nano-sized ones like carbon nanotubes (CNTs), provide these sensors with high sensitivity. Additionally, carbon-based sensors possess other advantageous properties that enhance their performance, including high stability, low power consumption for operation, and cost-effectiveness in their construction. These properties make carbon-based sensors ideal for a wide range of applications, especially in miniaturized devices created through MEMS or NEMS technologies. To capitalize on these properties, a group of chemoresistance-type carbon-based gas sensors was developed and tested against various volatile organic compounds (VOCs) and volatile inorganic compounds (VICs). The results demonstrated exceptional sensitivity to both VOCs and VICs, along with the sensor's long-term stability. However, this broad sensitivity also led to poor selectivity towards specific gases. This project aims at addressing the selectivity issue by modifying the carbon-based sensing materials and enhancing the sensor's specificity to individual gas. Multiple groups of sensors were manufactured and modified using proprietary techniques. To assess their performance, we conducted experiments on representative sensors from each group to detect a range of VOCs and VICs. The VOCs tested included acetone, dimethyl ether, ethanol, formaldehyde, methane, and propane. The VICs comprised carbon monoxide (CO), carbon dioxide (CO2), hydrogen (H2), nitric oxide (NO), and nitrogen dioxide (NO2). The concentrations of the sample gases were all set at 50 parts per million (ppm). Nitrogen (N2) was used as the carrier gas throughout the experiments. The results of the gas sensing experiments are as follows. In Group 1, the sensors exhibited selectivity toward CO2, acetone, NO, and NO2, with NO2 showing the highest response. Group 2 primarily responded to NO2. Group 3 displayed responses to nitrogen oxides, i.e., both NO and NO2, with NO2 slightly surpassing NO in sensitivity. Group 4 demonstrated the highest sensitivity among all the groups toward NO and NO2, with NO2 being more sensitive than NO. In conclusion, by incorporating several modifications using carbon nanotubes (CNTs), sensors can be designed to respond well to NOx gases with great selectivity and without interference from other gases. Because the response levels to NO and NO2 from each group are different, the individual concentration of NO and NO2 can be deduced.

Keywords : gas sensors, carbon, CNT, MEMS/NEMS, VOC, VIC, high selectivity, modification of sensing materials
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