

Abstract

Extensive usage of toxic, flammable, and explosive Volatile Organic Compounds (VOCs)/ gases in industry induces tremendous environmental pollution leading to a threat to living organisms. Therefore, there is a requirement for continuous monitoring of VOCs/gases using cost-effective, highly selective, sensitive, environmentally stable sensors. So, our work focuses on different approaches to modify the SnO_2 for developing low-temperature operable humidity tolerant VOCs/gases sensors. NO_2 , the most common toxic gas, induces various respiratory diseases even for short-term exposure at a low concentration of 5 ppm. Thus SnO_2 -rGO is synthesized at optimized conditions by the solvothermal method. In the SnO_2 -rGO nanohybrid device identified through a combinatorial approach, optimum morphology and structure along with the intrinsic Sn-C bond exhibited a significant response of ~ 3 to a low concentration of 80 ppm NO_2 at room temperature operation and fluctuating humidity (20-50% RH) at much faster speeds ~ 5.6 s and recovered quickly in 14.1 s without heating. Xylene, one of the components of cigarette smoke, is a major contributor to indoor pollution and induces various respiratory diseases. We synthesized Sn- SnO_2 as a sensing material with unique mesoporous nano-spherical morphology, providing a high specific surface area for Volatile Organic Compounds (VOCs)/gases adsorption. The sensor exhibits a repeatable response of 255% at 60 ppm xylene at room temperature with unprecedented ultrafast response and recovery time of 1.5 s and 40 s, respectively. The concentration of NH_3 in the exhaled breath of healthy persons is about 0.4–1.8 ppm, while that in end-stage renal disease patients is around 0.8–14.7 ppm. Hence, disease state monitoring and environmental exposure assessment applications demand highly sensitive, faster, and more selective NH_3 sensors that can operate under various environmental conditions. In our study, we synthesized SnO_2 nanosheets using a solvothermal method and carefully optimized the pH conditions of the precursor solution for tuning the size, crystallinity, and thickness. The sensors fabricated using these samples exhibited a selective response to ammonia at 25 °C and relative humidity (RH) of 70%. The pH 14 device demonstrated the highest sensitivity to ammonia (150% at 100 ppm) with fast response (8 s) and recovery kinetics (55 s). A theoretical LOD of 64 ppt implies superior sensitivity to all previously reported SnO_2 -based chemiresistive sensors. Triethylamine becomes explosive at concentrations above 10 ppm in the air and can induce headaches and difficulty breathing as well. The optimized substitutional fluorine doping in SnO_2 film results in high conductivity, hydrophobicity, transparency, reduction in oxygen defects, and excellent electrochemical stability. Consequently, the fabricated F- SnO_2 sensor showed a humidity-resistant nature with the highest response of 52% towards triethylamine at a relatively low operating temperature. Thus, the gas and VOC sensors developed in this work can be deployed for real-time sensing after miniaturization and integration with the AIoT platform.

