Abstract

Rapid expansions of industrialization and growing population in cities have caused tremendous air pollution. Therefore, there is an urge for clean air supply to maintain our ecosystem. However, leakage of explosive and flammable gases is extremely dangerous for human beings and their belongings. Hence, accurate real-time gas monitoring devices are essential to protect the environment and human beings timely. A cost-effective, reliable, low power consuming, highly sensitive, and small size gas sensor is the most effective candidate to avoid unexpected situations caused by toxic and explosive gases. Among all sensors, metal oxide (MO_x) semiconductor-based gas sensors are more popular due to their low cost, good sensing response, easy fabrication, and good chemical stability. There are however some difficulties with MO_x based sensors like inability to detect extremely low concentration, poor selectivity and high operating temperature. Thus, the Thesis summarizes proposal of few efficient techniques which enable escalation of sensing response at low operating temperature with high selectivity.

In the initial part, the Dissertation demonstrates the growth of TiO_2 and ZnO nanostructures using RF magnetron sputtering techniques, and TiO_2 nanoplates (anatase phase) have been used for hydrogen sensor. The Schottky barrier height between metal and TiO_2 is modulated by different metal electrodes (Ag, Ni, and Au) on TiO_2 nanoplates, which enhances the sensing response towards hydrogen gas. Highest effective barrier height is observed for Au electrode which corresponds to large change in relative response ~77%. For Au electrode, fast response time (~7 s) and moderate recovery time (114 s) is observed. In another study, Ni-doped ZnO nanostructures revealed higher relative response and selectivity towards hydrogen as compared to pure ZnO. Moreover, surface morphology transformed with Ni doping. Excellent relative response is observed for 4% Ni-doped ZnO sensor, caused by large surface sites for adsorption of oxygen on nanoplates and lowest activation energy ~6.47 KJ/mol. The Thesis further highlights improvements in sensing response towards hydrogen gas based on rGO (0-1.5 wt%) decorated 4% Ni-doped ZnO nanostructures. Hydrogen gas sensor exhibited maximum relative response of ~63.8% to 100 ppm at 150°C with 0.75 wt% of rGO decorated on Ni doped ZnO nanostructures, and showed excellent selectivity towards hydrogen gas in comparison to CH_4 and CO_2. Thus, the relative response enhanced by formation of p-n heterojunction between rGO and ZnO. On the other hand, in case of rGO decorated V_2O_5 thin film, the sensor showed higher relative response (~61%) to NO_2 gas as compared to pure form of V_2O_5 and rGO under same conditions.

Thereafter, hydrogen sensing has been performed on PAN/PAN-b-PMMA derived electrospun nanoporous CNF (0.1-0.5 wt%) loaded on ZnO nanostructures. Maximum relative response is observed for 0.2 wt% CNF/ZnO nanostructures as compared to all sensors for 100 ppm hydrogen at 150°C. The study presented in the Thesis focuses on elaborate description of various gas sensing enhancement mechanisms using MO_x based gas sensors. This will further shed light on several other proposals of highly sensitive gas sensors, even at low operating temperature.

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