Abstract

Hydrogen is an emerging energy source which is known as “The fuel of future". It is extensively used in thermal power plants, hydrogen engines, fuel cells etc. Storage of hydrogen is quite challenging due to its highly inflammable nature even at 4% hydrogen in air. Therefore, for optimum surveillance of hydrogen gas, an energy efficient gas sensors with low operating temperature, high sensor response and selectivity, compact size and radioactive environmental stability are desired. 1- dimensional nanostructures grab all attention as they work as building blocks for miniaturized gas sensors with low power consumption. Nanorods based gas sensors show relatively high response at low working temperature even with minimal gas concentration. Detection at ppm level is achieved due to the availability of large surface reaction area with high surface to volume ratio. ZnO is wide band gap and n-type semiconductor material which have high thermal stability and high conducting electron mobility.

This thesis mainly comprises of deposition of well-aligned ZnO nanorods and nano-crystalline thin films using sputtering technique where deposited ZnO nanorods are highly crystalline and are grown along c-axis with high optical properties and less number of intrinsic defects. Electrical characterization of ZnO nanorods/Si heterojuncton is also studied which shows rectifying behaviour along with strong dependence of barrier height on operating temperature. Deviation in Richardson constant is observed due to presence of barrier inhomogeneities at junction, which was further modified using double Gaussian distribution of barrier height. Then hydrogen sensing mechanism for Ohmic ZnO nanorods/Si heterojunction was proposed that gave fast response time of ~27 seconds at low operating temperature. For further enhancement of sensor response, Schottky contacted Au/ZnO nanorods based sensors were fabricated that showed sensors response varied from 11% to 67% with fast response (9-16 Sec) for 1% hydrogen at operating temperature ranging from 50 ºC to 150 ºC. Pd/ZnO nanorods based sensor further enhanced sensor's response from 13.86% to 91.26% for 7 ppm to 1% hydrogen concentration at operating temperature range from 50 ºC to 175 ºC. Schottky contacted Pd/ZnO nanorods based sensor shows high selectivity towards hydrogen (32% response at 175 ºC) in comparison to other gases like CH_4, H_2S, CO_2. Minimum limit of detection for hydrogen is 7 ppm (32 % at 175 ºC) in comparison to 110 ppm CH_4 (10%), 500 ppm H_2S (12.8%) and 1% CO_2 (11%).

For modification of sensor's response, post deposition technique such as gamma irradiation and swift heavy ion irradiation were used. As a result, gamma irradiation enhances Au/ZnO nanorod based sensor's response about ~14 % for 1% hydrogen concentration at low gamma dose of 1 kGy. Furthermore, Nano-crystalline ZnO thin film sensor's response also enhances from 66.8% to 89.84 % using 120 MeV Au ion fluences.

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