

HIGH SENSITIVITY METHANE SENSOR BY CHEMICALLY DEPOSITED NANOCRYSTALLINE ZNO THIN FILM

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Abstract –Nanocrystalline n-ZnO thin films were deposited on SiO₂-coated (0.45 μm) p type Si substrates (10-20Ω-cm) by a low cost chemical deposition technique to fabricate ZnO-based resistive sensors for methane detection. The nanocrystalline ZnO needle like structures were grown on RCA cleaned p-Si<100> substrates by successive immersion (100-200 times) into a Sodium Zincate bath (0.125M) kept at room temperature and DI water maintained at 90 °C . The Sodium Zincate was prepared by reacting Zinc Sulphate and excess Sodium Hydroxide in aqueous solution. The film thickness of 1.5 μm (approx.) for 75 dippings was obtained. The dipping time is 1 second. The annealing was done at a lower temperature (150 °C) for 30 minutes in air. Structural characteristics were studied by FESEM and EDAX to indicate the formation of ZnO with vertical orientation. The hexagonal needle like structures of 0.3-0.5μm diameter and 1-1.5μm length were formed. The resistance of the ZnO films in ambient air (zero level for gas sensing) was found to be stable and reproducible after several thermal cyclings. Surface modification with palladium (0.01% PdCl₂ for 5 seconds) was done to enhance sensitivity; so that the ZnO thin films can give significant response to target gases at the operating temperature of as low as 130°C, compared to the normal operating temperature range of 200–400°C for zinc oxide resistive gas sensors. The planar gold contacts were deposited by vacuum evaporation technique. The device was then tested for its methane sensing property at different operating temperatures (150,175,200,250,300,350°C) and at 5 different methane concentrations (0.01,0.05,0.1,0.5,1%) taking N₂ as a carrier gas. The response magnitude, response time and recovery time were studied in detail for both Pd modified and unmodified ZnO film. The maximum response of 99.76% and the lowest response time of 39 seconds were obtained at 200°C for Pd modified sensor. A high sensitivity to methane even at low temperature (130°C) was observed comparable to those obtained by more sophisticated and expensive deposition process e.g. MOCVD.

Indexterms : Nanocrystalline zinc oxide, Methane sensor, Pd modified, Fast response.