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Metal Oxides Hetrostructure: A Potential to detect NO_2 Gas

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Abstract:

ZnO/CuO hetrostructure was successfully deposited on glass substrate by using simple catalyst free thermal evaporation technique followed by annealing at different atmosphere. The surface morphology of hetrostructure film was analyzed by scanning electron microscopy (SEM). The gas sensing outcome established the hetrostructure sensors are highly responds towards toxic NO_2 gas as compare to other analyte gases. The hetrostructure sensor exhibits a maximum response of 175 % to NO_2 gas with very squat response / recovery time and outstanding reproducibility and stability also. Furthermore, the hetrostructure sensor responds to an enormously minute exposure of NO_2 gas i.e. 1 ppm. The interaction of hetrostructure sensor with NO_2 gas has effectively measured by employing an impedance spectroscopy measurement.

Key words: Gas Sensor, ZnO/CuO hetrostructure, Response, SEM, NO_2 gas.

Experimental

The CuO nanoparticles (NPs) –ZnO nanowires (NWs) hetrostructure were arranged by thermal evaporation technique on glass substrate. The deposition process was done in vacuum condition at a pressure of 5×10^{-5} mbar. Initially, Cu metal was stuck in a high power joined molybdenum boat, a dirt free glass substrate hold on substrate possessor. The Cu metal was allocated to evaporate as increasing the current and settle down on glass substrate. For the formation of CuO, the films were annealed at 600ºC in tubular furnace for 1 hr in continued existence of argon gas and air atmosphere. For the configuration of ZnO/CuO hetrostructure, zinc metal was evaporating on as prepared CuO thin film in a vacuum state.

Morphogical study

The surface morphology of ZnO/CuO hetrostructures is observed by the SEM as shown in fig.1 (a-b). The morphological analysis clearly shows that, the ZnO nanowires are formed on the surface of CuO nanoparticles developing the ZnO/CuO hetrostructure. The formation of nanowires is encouraging for the gas sensing importance due to of its immense surface area and lofty surface to volume ratio are attract to gas sensing applications [1].

Gas sensing Measurements

The selectivity investigation of ZnO/CuO hetrostructure sensors were checked for various oxidizing/reducing such as NO_2, H_2S, CO, Cl_2, SO_2 and methanol gases @ 150°C and is illustrated in fig 2(a). From the selectivity histogram it is confirms that the hetrostructure sensors are highly selectivity to oxidising NO_2 gas. The rate of reaction in between ZnO/CuO hetrostructure sensors and NO_2 gas molecules could be greater. Therefore such sensors show highest response towards NO_2 gas than other analyte gases.

The response values of sensor was deliberated by the using relation as [2-3],

$$Response(\%) = (Ra - Rg) / Ra * 100 \quad ...(1)$$

Here, R_g and R_a are resistance values in analyte gas and air respectively.

The dynamic response curve of ZnO/CuO hetrostructure sensors on treatment of diverse concentrations (1 ppm to 100 ppm) NO_2 gas at most favorable temperature of 150°C as shown in fig 2(b-c). The ZnO/CuO hetrostructure sensor prepared in argon atmosphere exhibits a highest response of 175% on exposure of 100 ppm oxidizing toxic NO_2 gas; also sensor acquires a response of 11% on the coverage very quiet concentration NO_2 (1 ppm), while ZnO/CuO hetrostructure sensor prepared in air atmosphere acquires a maximum response of 71% & 8% on coverage of 100 ppm & 1 ppm NO_2 gas correspondingly. At upper NO_2 gas concentration i.e. 100 ppm, NO_2 gas molecules wrap more surface area of the sensor and there can be numerous reactions due to accessibility of additional active sites on sensor surface. While on the other hand, at small concentration i.e. 1 ppm NO_2 gas molecules wrap partial surface area of sensor due to which a little surface reaction are probable on sensor surface and therefore, sensor exhibits a lesser response [4].The gas sensing script expose that the as prepared ZnO/CuO hetrostructure sensors aspects a superior selection to NO_2 gas along with its elevated response, rapid response/recovery time, and spectacular reproducibility & stability.

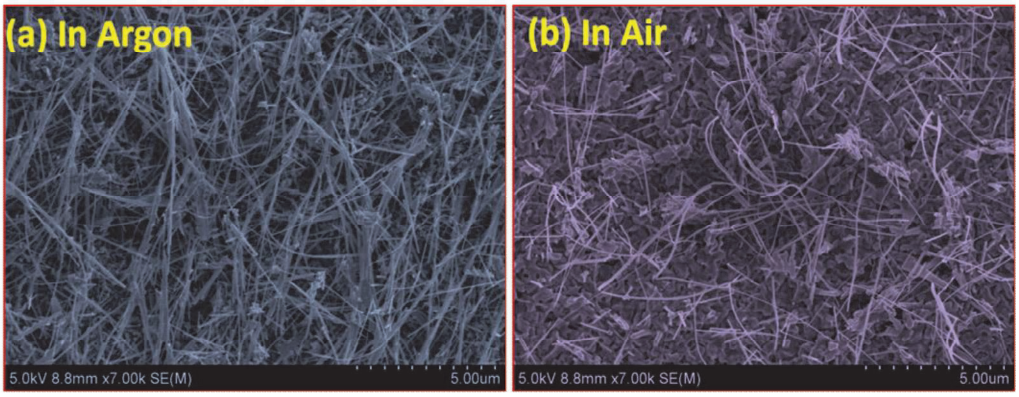

Fig.1. SEM micrographs CuO/ZnO hetrostructure sensors (a) Prepared in argon gas and (b) Prepared in air atmosphere.

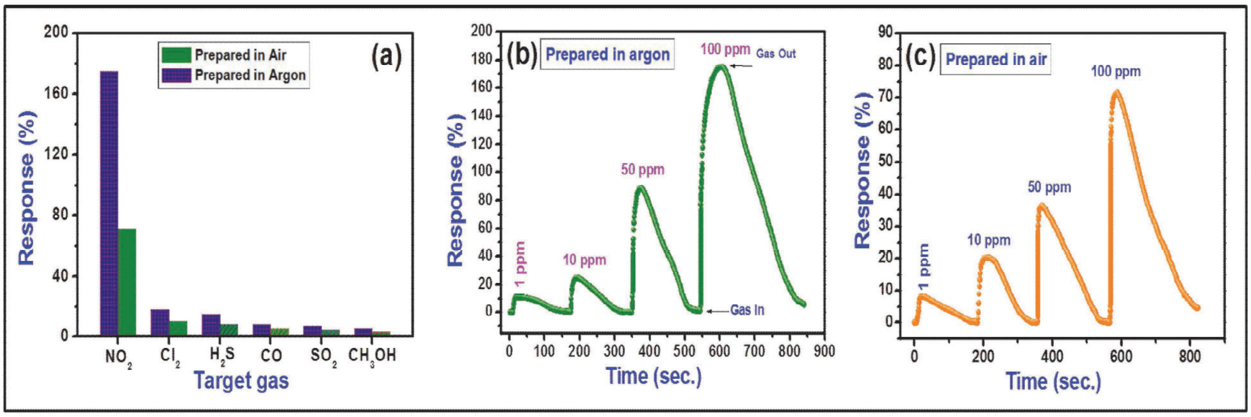

Fig.2 (a) Selectivity histogram of CuO/ZnO hetrostructure sensors, (b-c) Dynamic response curve of CuO/ZnO hetrostructure sensors.

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