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Title : NANOSTRUCTURED TUNGSTEN TRIOXIDE ON INTERDIGITATED MICRO-ELECTRO-MECHANICAL PLATFORM FOR ETHYLENE GAS SENSOR APPLICATIONS

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In this study, tungsten trioxide (WO_3) nanostructure material is integrated onto interdigitated (IDE) Micro-electro-mechanical (MEMS) platform to form a gas sensor targeting to detect ethylene gas. Traditionally, ethylene gas detection requires the sample of the gas to be collected and measured offline due to the complexity of the measurement system. Even though a newer detection technology which enables for in-situ detection has been developed, the size of the sensor is relatively bulky and very expensive hence it is not suitable for mass outdoor applications examples in the agriculture industry. Therefore, this research explores a different approach to detecting ethylene gas utilizing WO_3 nanostructure as the sensing element of the sensor. This n-type metal oxide family were recognized for its excellent in sensitivity, ruggedness, versatility and relatively low cost to fabricate compared to other gas sensing material technology. The early work in this research is focused on producing one-dimensional WO_3 nanostructure through hydrothermal method. Design of experiment (DOE) technique is used to identify the effect and relationship of the variables in producing WO_3 nanostructure morphology. Field Emission Scanning Electron Microscopy (FESEM) reveals one dimensional, two dimensional and three-dimensional nanostructures have been produced by this facile process. Since the response of the gas sensor is highly dependent on the surface area, the analysis of DOE was focused on defining parameters that will produce one-dimensional nanostructure because it will give the biggest surface to volume ratio compared to the other structures. This type of morphology is also suitable to create the electrical interconnection in between the IDE electrodes to functionalist the sensor. To fabricate the sensor, the synthesized WO3 nanostructures were deposited on IDE platform to create the conduction network between the electrodes. Three deposition approaches have been explored namely in situ growth, drop cast and spin coating process. A dedicated test rig system is employed to perform the functionality testing for the sensor. The changes of sensor resistance value upon exposed to a certain concentration of ethylene gas at room temperature were then recorded to determine sensor performance. It was concluded that the density and the morphology variations of nanostructure network play a major role in sensitivity, response and recovery time of the sensor. The best sensitivity calculated based on the resistance ratio before and after the sensor exposed to ethylene gas was 1.23 at 20 ppm obtained from sensor fabricated by spin coat fabricated sensor. At the same ethylene concentration value, the sensitivity for drop cast and in situ fabrication process are much lower at 1.05 and 1.04 respectively. In terms of response behaviour, spin coat sensor exhibits fastest response and recovery (7 minutes and 13 minutes) as compared to spin coat process (14 minutes and 28 minutes) and in situ process (10 minutes and 16 minutes). This study contributes the knowledge of controlled hydrothermally synthesis of WO_3 and at the same time proves that the fabricated NANO/MEMS sensor platform are able to detect ethylene gas. This finding is significant in developing ultra-sensitive, small in size and requires low power consumption ethylene gas sensor, especially for precision agricultural applications.