Sample Preparation of TiO_2 Added ZnO Using Powder Metallurgy Route and its Characteristics

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Abstract:
Metal oxide semiconductor gas sensors have been widely utilized in a variety of different roles and industries. They are relatively inexpensive, robust, lightweight, long lasting and benefit from high material and quick response time compared to other sensing technologies. However, there are major challenges need to overcame by developers in order to construct a semiconductor metal oxide gas sensor that is efficient, and durable and most importantly can work at lower temperature. Therefore, in this research, TiO_2 dopants was introduced into conventional high purity ZnO gas sensor whereby the samples were prepared in pellet form using powder metallurgy route. The improvement in the mechanical properties as well as the electrical properties of the samples was wished to be observed through this research. The density measurement showed that the adding of TiO_2 was efficient to promote the densification of ZnO sample in which 9 wt% TiO_2 doped ZnO sample showed the highest density. The XRD results showed that the diffraction pattern was basically attributed to the wurtzite structure of ZnO. This was proven by the plane (1 0 1) had the highest intensity in all the samples except 6 wt% TiO_2 and 9 wt% TiO_2 doped ZnO sample. SEM showed that the grain size of ZnO decreased with the addition of TiO_2. This was caused by the formation of the new phase which was Zn_2TiO_4. The smaller the grain size, the higher the specific surface area and oxygen adsorption quantity, and therefore the higher the gas sensitivity is. UV-Vis showed that the wavelength of all samples was located around 380 nm. Therefore, the calculated exitonic energy was around 3.20 eV which was nearly matched with the theoretical band gap of ZnO (3.37 eV). The measurement of the resistivity using four point probe showed that the electrical resistivity of the samples decrease up to addition of 9 wt% TiO_2. This was attributed to increased carrier concentration. Vickers hardness test showed that the doping of TiO_2 had increased the hardness of the sample whereby the 9 wt% TiO_2 doped ZnO sample showed the highest value of hardness. The addition of TiO_2 into high purity ZnO has influenced the mechanical and electrical properties of ZnO. From observing the microstructural and density measurement to the measurement of the surface resistivity as well as the determination of the Vickers hardness value, it was found that 9 wt% TiO_2 doped ZnO was predicted as a candidate for substituting a conventional high purity ZnO as the gas sensor.

Keywords: Powder Metallurgy; Semiconductor; Sensor; TiO_2; ZnO

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