World Academy of Science, Engineering and Technology
International Journal of Materials and Metallurgical Engineering
Vol:10, No:07, 2016

Study of the Hysteretic I-V Characteristics in a Polystyrene/ZnO-Nanorods Stack Layer

Authors : You-Lin Wu, Yi-Hsing Sung, Shih-Hung Lin, Jing-Jenn Lin

Abstract : Performance improvement in optoelectronic devices such as solar cells and photodetectors has been reported when a polymer/ZnO nanorods stack is used. Resistance switching of polymer/ZnO nanocrystals (or nanorods) hybrid has also gained a lot of research interests recently. It has been reported that high- and low-resistance states of a metal/insulator/metal (MIM) structure diode with a polystyrene (PS) and ZnO hybrid as the insulator layer can be switched by applied bias after a high-voltage forming process, while the same device structure merely with a PS layer does not show any forming behavior. In this work, we investigated the current-voltage (I-V) characteristics of an MIM device with a PS/ZnO nanorods stack deposited on fluorine-doped tin oxide (FTO) glass substrate. The ZnO nanorods were grown by a hydrothermal method using a mixture of zinc nitrate, hexamethylenetetramine, and DI water. Following that, a PS layer was deposited by spin coating. Finally, the device with a structure of Ti/ PS/ZnO nanorods/FTO was completed by e-gun evaporated Ti layer on top of the PS layer. Semiconductor parameters analyzer Agilent 4156C was then used to measure the I-V characteristics of the device by applying linear ramp sweep voltage with sweep sequence of 0V → 4V → 0V → 3V → 0V → 2V → 0V → 1V → 0V in both positive and negative directions. It is interesting to find that the I-V characteristics are bias dependent and hysteretic, indicating that the device Ti/PS/ZnO nanorods/FTO structure has ferroelectricity. Our results also show that the maximum hysteresis loop height of the I-V characteristics as well as the voltage at which the maximum hysteresis loop height of each scan occurs increase with increasing maximum sweep voltage. It should be noticed that, although ferroelectricity has been found in ZnO at its melting temperature (1975℃) and in Li- or Co-doped ZnO, neither PS nor ZnO has ferroelectricity at room temperature. Using the same structure but with a PS or ZnO layer only as the insulator does not give and hysteretic I-V characteristics. It is believed that a charge polarization layer is induced near the PS/ZnO nanorods stack interface and thus causes the ferroelectricity in the device with Ti/PS/ZnO nanorods/FTO structure. Our results show that the PS/ZnO stack can find a potential application in a resistive switching memory device with MIM structure.

Keywords : ferroelectricity, hysteresis, polystyrene, resistance switching, ZnO nanorods
Conference Title : ICMET 2016 : International Conference on Materials Engineering and Technology
Conference Location : Stockholm, Sweden
Conference Dates : July 11-12, 2016