UNIVERSITI TEKNOLOGI MARA

BEHAVIOUR OF BILAYER COMPOSITES TITANIUM DIOXIDE-ZINC OXIDE THIN FILMS RESISTIVE SWITCHING AND THEIR POTENTIAL FOR TACTILE SENSING DEVICE

SHAFAQ MARDHIYANA BINTI MOHAMAT KASIM

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ABSTRACT

This thesis covers the study on behaviour of bilayer composites metal oxide thin films resistive switching and their potential for tactile sensing application. In semiconductor, conduction mechanism is important to be analyzed for fundamental understanding on the device itself to further improve the device performance including the endurance and retention properties as well as identify the relation with resistive switching. Therefore in this work, the dominant conduction mechanisms for single and bilayer composites TiO_2-ZnO thin films resistive switching device were investigated. Furthermore to achieve resistive switching devices which responsive to the touch and pressure, the suitable material, fabrication properties and comprehensive measurement need to be identified. Thus, tactile sensor may require a flexible element of touch and pressure sensitive area in order to have the intense effect during measuring the sensor sensitivity with low temperature of heat treatments as the flexible element itself has very low thermal resistance. Also, this thesis was written to propose parameters and procedure for tactile measurement. As an initial step, bilayer composites thin films metal oxide with two different sequential structures TiO_2/ZnO and ZnO/TiO_2 were fabricated on ITO/glass to finalize the optimal sequential structure to be deposited on ITO/PET for the flexural analysis. Fabrication processes involved were spin-coating, annealing and sputtering. The electrical and physical characterizations comprised I-V measurement with and without flexural effect, film thickness, surface morphology and cross-section. In the beginning, the characterizations were performed to investigate the optimal sequential structure which comes out with TiO_2/ZnO as the significant structure compared to ZnO/TiO_2 by referring to the R_{OFF}/R_{ON} ratio and the consistency of resistive switching pinched hysteresis loop itself. Then the optimal sequential structure TiO_2/ZnO was fabricated on ITO/PET and different size of top electrode were deposited for the flexural I-V measurement preparation. Besides different size of top electrode, flexural I-V measurement with different bending angle was examine as well in order to study on the effect towards resistive switching behaviour. A clamping device was proposed in order to accomplish the flexural I-V measurement process to ensure the samples were bending evenly for precise results and error reduction. The investigation on the effect of different bending angle to resistive switching characteristics show slightly significant results compared to the assessment on different size of top electrode. Overall, the results suggested that composition of TiO_2 and ZnO with appropriate fabrication parameters has the potential to act as a tactile sensor because it is responsive to the bending effect and due to the internal potential that was generated from the mechanical stress which was applied to the sample. For the performance of individual device, sample with 0.3×0.3 cm metal contacts was considered as effective device due to the equality of resistance value at normal state yet it very responsive to the bending effect during convex and concave states.

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CHAPTER ONE
INTRODUCTION

1.1 RESEARCH BACKGROUND

Resistive switching denotes as a physical phenomenon where the resistance across a dielectric solid-state material is changed under the action of a strong electric field or current. Resistive switching is often tied to memristor which is known as the fourth basic passive circuit element which has exclusive properties that cannot be duplicated by any combination of other three elements (resistor, capacitor and inductor) [1]. It has a wide range of potential applications as it associates with memory element which has capability to memorize the last resistance it had after removal of applied bias.

Resistive switching device can be constructed from a simplest structure consists of insulator layer sandwiched by top and bottom metal electrode. Generally, this device can be defined by looking at the current-voltage characteristics having pinched hysteresis loop or "bow-ties" shape. Resistive switching can be classified into three (3) which are occurrence of thermal effect, electronic effect and ionic effect depending on the material that were used for electrodes and the dielectric. The dielectric part can be made using organic compound [2] and several materials but most of researcher extensively selected titanium dioxide (TiO_2) as this transition metal oxide has unique properties [3]–[7] which are highly resistivity in it pure state, wide band gap, compatible with standard complementary metal-oxide-semiconductor (CMOS) technology [5], [7] and the most important is it has potential to eliminate the necessity of electroforming process in resistive switching device . Moreover, because of its structural and optical properties, TiO_2 has been used in variety of applications such as in solar cell, gas sensor, photo-catalysis and biomedical applications [8]–[11]. Other than TiO_2, there are several types of materials that have been considered for resistive switching device study such as silicon dioxide (SiO_2) [12], zinc oxide (ZnO) [13]–[17], nickel oxide (NiO) [18] and so forth.