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FABRICATION OF NANOSTRUCTURED ZnO/MgO BILAYER WITH PVDF-TrFE LAYER FOR METAL-FERROELECTRIC-INSULATOR-METAL (MFIM) CAPACITOR APPLICATION

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ABSTRACT

The nano-MgO films, nano-ZnO films and nanostructured ZnO/MgO bilayer films were synthesized using sol-gel spin coating method. The uniform and smooth nano-ZnO film was utilized as the oxide dielectric template to produce nanostructured ZnO/MgO bilayer films. The nano-MgO films and nanostructured ZnO/MgO bilayer films were deposited at various deposition parameters (solution concentration, number of layer and annealing temperature). The effect of deposition parameters towards morphology and dielectric properties of nano-MgO films and nanostructured ZnO/MgO bilayer films was investigated. The variation of solution concentrations revealed that nano-MgO film and nanostructured ZnO/MgO bilayer film with 0.4M concentration produced improvement in the electrical properties as seen by the uniform particle distribution. The 0.4M nanostructured ZnO/MgO bilayer film showed an increment in dielectric constant, k (5.71) in comparison to 0.4M nano-MgO single layer film. Hence, 0.4M concentration was the optimized solution concentration utilized for both nano-MgO films and nanostructured ZnO/MgO bilayer films, for investigating the number of deposition layers of these films. For both films, 10 layers of MgO were found to give significant improvement in the surface properties. Most importantly, an enhancement in k value (9.70) for nanostructured ZnO/MgO bilayer film annealed at 475°C. This study has produced a novel metal-ferroelectric-insulator-metal (MFIM) capacitor configuration of ZnO/MgO/PVDF-TrFE by utilizing optimized nanostructured ZnO/MgO bilayer film as dielectric layer, with the integration of PVDF-TrFE as polymeric ferroelectric. With this novel MFIM capacitor configuration, a high electrical strength of polarization-field (P-E) hysteresis loop was obtained. In addition, the enhancement in k value (19.42) for ZnO/MgO/PVDF-TrFE film was caused by the increased in β-phase crystals in the film. This contributed to an improvement in the spontaneous polarization of ZnO/MgO/PVDF-TrFE film. Ultimately, the capacitance value obtained for ZnO/MgO/PVDF-TrFE film was significantly enhanced (35 pF) with the addition of PVDF-TrFE co-polymer film in the capacitor configuration.

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CHAPTER ONE
INTRODUCTION

1.1 RESEARCH BACKGROUND

A capacitor is a passive component that is commonly used in electronic devices. It consists of two parallel plates that are separated by an insulator layer known as a dielectric film. The dielectric film is vital as it influences the capacitor performance. Material with high dielectric properties (high dielectric constant, k) will typically have high capacitance value. This material is suitable for storing charges due to its high polarizibility in an electric field.

Researchers have reported on a wide use of silicon as substrate in device fabrication [1-4]. The utilization of silicon dioxide, SiO_2 as dielectric layer (k~3.9) produced by thermal oxidation of silicon wafer was quite common. However, the use of SiO_2 as dielectric film is unfavourable due to its thickness limitation. Typically, SiO_2 with thickness less than 5 nm suffers from leakage current of 10^{-5} A.cm^{-2} [5-7]. Recently, researchers explore alternative dielectric materials with high dielectric constant value (high k) to replace the SiO_2 dielectric layer. Amongst these high k oxide materials were titanium dioxide (k~100), tantalum oxide (k~23), magnesium oxide (k~9.8) and zinc oxide (k~4). Though titanium dioxide (TiO_2) and tantalum oxide (Ta_2O_5) have high k value (above 20), these oxides consistently suffer from high leakage current. High leakage current is an indication of imperfection in dielectric material for which passage of electrons may channel through the dielectric film. In addition, the deposition process for these oxides is complex.

Oxide such as magnesium oxide (MgO) is dielectrics utilized in fabrication of devices due to its bulk properties such as high band gap (7.8 eV), high dielectric constant than SiO_2 which was 9.8 and high dielectric strength (12 MV/cm). Some studies have reported high dielectric constant value of MgO thin film in the range of 9.45 to 11.5 deposited using complex methods such as PLD and e-beam [8-11]. There are also reports on the deposition of MgO thin films via a simple technique such as spin coating method with the dielectric constant value of 7 [12]. In addition, MgO film was found to provide a chemically stable buffer layer for ferroelectrics due to its