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Effect of dielectric thickness on MgZnO Thin Film Transistor characteristics

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ABSTRACT

From past ten years, low-k dielectric was used as dielectric material in Thin Film Transistors Technology.

Reduction of dimension of device can be done with the reduction the thickness of dielectric material and active layer. Due to reduction in thickness of dielectric material capacitances increases therefore drain current increases. But further more reduction in dielectric material leads to leakage current which effect other parameter like threshold voltage. To enhance performance of transistors without reduction in thickness of dielectric material use high-k dielectric material so overall capacitances increases and decrease leakage current. In this paper the parameters of the Mg_xZn1-_x thin film transistors are compared. Composition of Mg in ZnO used because high direct bandgap (7.7 eV). Due to composition of Mg into ZnO that affects the electrical parameter of a transistor. Mg_xZn1-_x (x = 20% and 1-x = 80%) Thin film transistor's electrical performance with high-k ($Al_2O_3(K \sim 9)$) dielectric materials thickness is measured. Variation in thickness of high-k dielectric is taken as 150 nm, 100 nm, 50 nm, 20 nm. Electrical characteristics are good for 20 nm thickness of Al_2O_3 dielectric material. Optimized electrical parameter of transistor like threshold voltage, mobility, and on/off ratio are 0.59 V, 9.62 $cm^2/V.s$, and 10^{10} observed after simulation on TCAD. Results shows that this type of results for Thin film Transistors are used in photodetector application.

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1. Introduction

In today scenario Thin Film transistors based on ZnO have a great potential in large area and low-cost electronic application like flat panel display because of high mobility, good on/off ratio and most important high optical transparency. ZnO is the compound semiconductor of II-IV group with a direct band gap of 3.34 eV. Bandgap greater than 3.1 eV provides visible transparency in visible range. Therefore, TFT's active channel layer using ZnO are being explored. But the active layer and insulator layer both plays an active role on TFT performance [1–5]. A lot of investigation has been already done on active layer of TFT. Study of the effect of dielectric thickness on TFT performance are very few. ZnO-TFT with SiO_2 dielectric layer suffer from high operating voltage and poor long-term stability. This is because of gate insulator with low-k dielectric constant. Low-k dielectric in TFT increases operating voltage due to lower capacitance. High capacitance can be obtained by the increasing the relatively high-k dielectric material or decreasing the dielectric thickness [6].

Wang et al. [7] fabricated a low voltage $Mg_xZn_{1-x}O$ TFT with Al_2O_3 insulator grown by pulse laser deposition. In this the effect of Al_2O_3 on the crystal quality of the active layer is observed. Jyun -Yi Li et al. [8] reported an $Mg_xZn_{1-x}O$ TFT using high-K dielectric and investigated photo-electrical properties. The main objective is to study the optimum dimension for TFT electrical characteristics. Therefore, an optimum thickness is necessary because by reducing thickness of dielectric material it suffers from low leakage current. So Al_2O_3 dielectric with optimum thickness gives overall improvement in TFT characteristics. In this work Al_2O_3 thickness variation from 150 nm, 100 nm, 50 nm to 20 nm with 30 nm MgZnO active channel layer thickness is done. The electrical characteristics are measured by taking the Al_2O_3 dielectric and measuring the performance by varying the thickness dielectric material.

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