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Influence of high-*k* dielectric material on the electrical performance of a-IGZO Thin Film Transistor

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ABSTRACT

Here, the electrical performance of an amorphous Indium Gallium Zinc Oxide (a-IGZO) Thin Film Transistor (TFT) is examined using the Silvaco Atlas tool. The effects of several factors such as drain current (I_d), Sub threshold Swing (SS), $\frac{I_{on}}{I_{off}}$, threshold voltage (V_{th}), on voltage (V_{on}) are closely examined. When SiO_2 was replaced by high-*k* HfO_2, TFT shows low SS of 0.17 V/decade, high $\frac{I_{on}}{I_{off}}$ ratio of ~10^{18} and V_{on} of 0.13 V. Effect of channel length is also analysed for high-*k* Al_2O_3 dielectric. This analysis might be useful for researchers to realize future TFT related applications.

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1. Introduction

As a result of people's dependence on semiconductors in their daily lives, the semiconductor industry has seen significant growth. Rapid growth in the industry requires the development of faster, more flexible, more powerful, cheaper, and smaller devices. As a result of this demand, new materials and technologies have been created to meet the demands of the burgeoning semiconductor industry. Thin film technology has now advanced to widespread use in optics, electronics, aircraft, defense etc. [1,2]. For the projection year of 2021–2026, the TFT market is estimated to grow at a CAGR of 17.34% [3]. TFTs are a form of transistor with a dielectric, semiconductor, and contact layer placed on a supporting substrate. As channel layers, A-Si, Poly Si, Semiconducting Metal Oxides (SMOs), and other materials are used. In recent years, SMOs such as ZnO, GaZnO, IGZO, ITZO, and others have gained a lot of attention and are used to replace A-Si and Poly-Si [4]. Researchers are interested in IGZO because of its many desirable properties, including better mobility, low temperature processing, low cost, non-toxicity, band gap of 3.05 eV, etc. [5]. Nomura et al. announced the Ist a-IGZO TFT at ambient temperature, and it is believed that it could be employed in future electronic products [6]. According to Lee et al., IGZO base TFT provides both high electric mobility and good optical transmittance [7]. Yabuta et al. demonstrated IGZO TFT with mobility (μ_{fe}) of ~10 and an $\frac{I_{on}}{I_{off}}$ ratio of ~10^8 [8]. So, to see if a-IGZO could be used as a channel layer in a TFT, we used the Silvaco TCAD ATLAS programme to simulate a TFT and got outstanding results. For decades, SiO_2 was the most often utilized dielectric in TFT technology. As the technology advances, transistor sizes are reducing and it can be reduced by reducing SiO_2 gate dielectric thickness, which enhances gate capacitance per unit area and hence improves transistor performance. The tunneling gate leakage current rises as the SiO_2 gate dielectric thickness lowers and it may no longer be able to guarantee appropriate reliability. This results in increased power consumption and, as a result, decreased transistor performance [9,10]. Enhancing the gate dielectric's physical thickness (PT) without increasing the effective thickness is a promising strategy to this problem. This is known as the equivalent oxide thickness (EOT), and it lowers the gate leakage current while maintaining optimal gate capacitance. This can be accomplished by substituting a low-*k* dielectric with a high-*k* dielectric [11]. The main goal here is to investigate the effect of PT and equivalent thickness (ET) on the electrical properties of an a-IGZO TFT using a variety of dielectric materials such as Si_3N_4, Al_2O_3, and HfO_2. The properties of a-IGZO TFT is also investigated by variation in channel length. A 3D

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