ARTICLE IN PRESS

Materials Today: Proceedings xxx (xxxx) xxx

Contents lists available at ScienceDirect

Materials Today: Proceedings

journal homepage: www.elsevier.com/locate/matpr

Effects of channel length and gate dielectric material on electrical properties of an IGZO TFT

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ARTICLE INFO

Article history:
Available online xxxx

Keywords:
Threshold voltage
Transconductance
Channel length

ABSTRACT

In this paper, the variation of threshold voltage, transconductance, and on/off current ratio of bottom-gate InGaZnO (IGZO) thin-film transistors (TFTs) with different channel lengths and gate dielectric substrate has been investigated. Bottom gate configuration was simulated using SILVACO TCAD Software. Electrical parameters such as threshold voltage, transconductance, and on/ off current ratio were analyzed with an active layer thickness of 30 nm and the variation of length of channel from 5 µm to 25 µm and gate dielectric substrate of high dielectric constant. Threshold voltage increased and transconductance decreased with the increase of the channel length but there was no big change in I_{On}/I_{Off} ratio. The threshold voltage around 0.64 V, transconductance around 44.2 µs, and On/Off current ratio around $8.13x10^8$ were observed at a channel length of 5 µm. When the dielectric material SiO_2 was replaced by Si_3N_4, the threshold voltage was 0.76 V, transconductance was 85.64, and On/Off current ratio was $1.58x10^9$ and for Al_2O_3 threshold voltage was 0.77 V transconductance was 199.8 µs and On/Off current ratio was $4.3x10^9$.Transconductance, Threshold voltage, and On/Off current ratio were increased for high K gate dielectric materials.

Selection and peer-review under responsibility of the scientific committee of the 3rd International Conference on "Advancement in Nanoelectronics and Communication Technologies".

1. Introduction

Transparent display technology has been fast progressing in recent years. As a consequence of high optical transparency in the visible region, oxide semiconductors have been considered as potential options for thin-film transistors (TFTs). Based on this, amorphous oxide thin-film transistors (OxTFTs) have been used in active-matrix liquid crystal displays (LCDs) and organic light-emitting diode displays (OLEDs), which combine the benefits of traditional amorphous Si (a-Si) and polycrystalline Si(p-Si) TFTs while avoiding the disadvantages of both. [1–5]. When utilised for channel layers, InGaZnO is the most appealing material among most oxides because to its excellent channel mobility, minimal subthreshold swing, and great area uniformity. Because of the overlap of the spherical s-orbital of the heavy transition metal cations, *a*-IGZO possesses high mobility [6–8]. An analytic problem is to improve the electrical properties of TFT by selecting gate dielectric materials that suit the thin film of semiconductor materials [9,10]. The impact of channel length on electrical characteristics of IGZO-based TFTs was investigated in this research using 2-D device modelling. In addition, the author examines the electrical properties of TFTs using various gate dielectric materials such as Si_3N_4, Al_2O_3, and SiO_2.

2. Device structure and simulation method

Fig. 1 depicts a simplified two-dimensional cross-section of the bottom-gate *a*-IGZO TFT device structure utilised in this study. The *a*-IGZO TFT's functioning is simulated using a SILVACO ATLAS simulator on a two-dimensional grid made up of multiple finite element grid points called nodes. ATLAS solves a set of differential equations (Poisson's and continuity equations) on this grid in order

Abbreviations: TFT, Thin Film Transistor; I_{On}, On Current; I_{Off}, Off Current; V_{TH}, Threshold Voltage; DOS, Density of States; *a*-IGZO, amorphous InGaZnO.

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https://doi.org/10.1016/j.matpr.2022.07.037

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Please cite this article as: A. Jain, Vivek Kumar Jain, Lalit Kumar Lata et al., Effects of channel length and gate dielectric material on electrical properties of an IGZO TFT, Materials Today: Proceedings, https://doi.org/10.1016/j.matpr.2022.07.037