Superlattices and Microstructures 83 (2015) 367–375

Contents lists available at ScienceDirect

Superlattices and Microstructures

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

Temperature-dependent field-effect measurements method to illustrate the relationship between negative bias illumination stress stability and density of states of InZnO-TFTs with different channel layer thickness

Chuan-Xin Huang [a], Jun Li [a,b,*], Xing-Wei Ding [a], Jian-Hua Zhang [b], Xue-Yin Jiang [a], Zhi-Lin Zhang [a,b]

[a] *School of Material Science and Engineering, Shanghai University, Jiading, Shanghai 201800, People's Republic of China*
[b] *Key Laboratory of Advanced Display and System Applications, Ministry of Education, Shanghai University, Shanghai 200072, People's Republic of China*

ARTICLE INFO

Article history:
Received 4 September 2014
Received in revised form 18 January 2015
Accepted 23 February 2015
Available online 18 March 2015

Keywords:
Transistor
Illumination stability
Temperature-dependent field-effect measurements method
DOSs

ABSTRACT

We investigate the stability of thin film transistors incorporating sputtered InZnO as the channel layer under negative bias illumination stress. The transfer characteristic for various active layer thicknesses is shifted toward the negative direction under negative bias illumination stress and the device with thicker channel layer shows a slighter V_{TH} negative shift than another device under negative bias illumination stress. In order to investigate channel layer thickness can have a great effect on the trap density and thus affect the V_{TH} shift caused by charge trapping; we use temperature-dependent field-effect measurements method to accurately calculate their trap density. The results show that thicker InZnO channel layer has fewer DOSs, resulting in the decrease of charge trapping and the decrease of photoexcitation generated electron carrier. So the device with thicker channel layer shows a slighter V_{TH} negative shift than another device under negative bias illumination stress.

* Corresponding author at: School of Material Science and Engineering, Shanghai University, Jiading, Shanghai 201800, People's Republic of China.

E-mail address: lijun_yt@163.com (J. Li).

http://dx.doi.org/10.1016/j.spmi.2015.02.043
0749-6036/

1. Introduction

Amorphous oxide thin film transistors have received considerable attention in novel active-matrix (AM) display, such as a transparent and bendable AM display because they have several advantages in many ways, for example, low-temperature and low-cost process, transparent (wide band gap), good electric properties (high field effect mobility), high stability, and good uniformity [1,2]. In particular, metal oxide semiconductor thin films with wide energy bandgap materials such as ZnO, InGaZnO and InZnO (IZO) enable the transparent electronic or display to be realized. So far, although researchers have conducted a lot of research to improve performances of thin film transistors [3–7], there are still some issues need to be resolved. Such as how to control the threshold voltage for circuit design and power consumption, the mechanism of device instability and how to improve the stability under various stresses for example, bias, illumination and temperature. In particular, since most of the proposed uses of the IZO TFTs will expose the TFTs to a backlight or ambient light during operation, the stability of IZO TFTs under light illumination is a important issue for the practical applications. In previous report, the instability of TFTs under light illumination is attributed to the following three mechanisms, including the oxygen photo-desorption model [8], the hole trapping model [9,10] and the photo-transition model from $[V_O]$ to $[V_O^{2+}]$ [11,12]. The channel thickness of IZO TFT is an important parameter to control device performance. Specifically, as reported previous [13–15], it can effectively adjust the stability of TFTs. However, the channel thickness effect on the stability under bias and light illumination is not very clear.

Moreover, amorphous oxide semiconductors have tail states and subgap density of states (DOSs) originated from structure disorder and defects [16]. Therefore, the investigation of DOSs in IZO has to be carried out in respect of the stability. Many methods have been used to extract DOSs such as simulation-based fitting [17], the optical response method [18], temperature-dependent field-effect measurements method [19], and multifrequency method [20]. In this study, for the first time, we introduce the temperature-dependent field-effect measurements method to establish the relation between DOSs and the instability under negative bias illumination stress with different channel thickness of IZO thin film transistor. The negative bias illumination stress stability with different channel thickness of IZO thin film transistor was investigated, using DOSs and falling rates in IZO thin film transistor. In addition, it is investigated that the instability under negative bias illumination stress and thermal stress can be attributed to excitation behavior and charge trapping mechanism.

2. Experimental details

Top-contact-type TFTs with different thicknesses IZO channel layer and 120 nm SiO_2 dielectric layer were fabricated. Fig. 1(a) shows the schematic structure of the device. Initially, SiO_2 film was

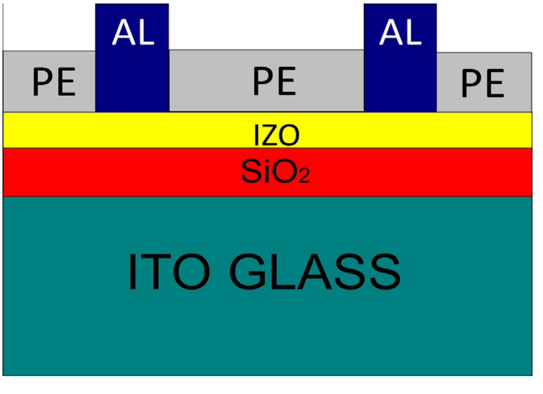

Fig. 1. Schematic structure of the IZO-TFTs.