COMPARATIVE ANALYSIS OF THICKNESS VARIATION OF GATE ON SINGLE & MULTIPLE GATES ORGANIC THIN FILM TRANSISTOR USING SILVACO

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ABSTRACT

In last decades Organic thin film transistors(OTFT) have shown a great improvement on existing technologies and expanded the scope of potentially realizable applications on large-area and flexible devices. This research paper represents the comparative analysis of thickness variation of gate in Single,Dual and Tri-Gate Organic Thin Film Transistor. All the simulations have been carried out using SILVACO TCAD tool. Its performance have analysed on the basis of parameters, which were extracted from its transfer characteristics. The Tri-Gate-OTFT has shown improved electrical performance such as higher on current as compared to single & dual gate OTFT.

Keywords: ATLAS Simulator, Dual Gate Otfts, Organic Thin Film Transistors, SILVACO, Single Gate Otfts, Thickness Variations, Tri Gate Otfts

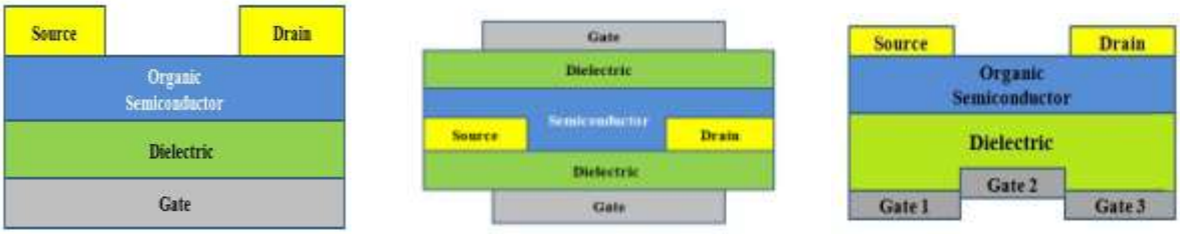
I.INTRODUCTION

THIN-FILM TRANSISTORS (TFT's) using organic semiconductors as the active material have made an impressive progress in terms of light weight, flexibility, and low cost as compared to other semiconductors.Due to above reasons the imposition of organic thin film transistors (OTFT) are increasingly likely.OTFT will find application, not only in displays, but also to integrate logic circuitry and memory arrays into low cost electronic products such as smart cards, smart price and inventory tags, and large-area sensor arrays.[1,2]. This paper deals with comparative analysis of thickness variation in gate of a single, dual and tri-gate OTFT's structures using 2-D ATLAS simulator. It is observed that Tri-Gate based OTFTs under different configurations outperform the single gate and dual gate ones.

The organisation of paper is as follows. The present section introduces the content of paper.SectionII describes about various gate OTFTs structures.Section III deals with the simulation of thickness variations in gate of all the three types of OTFTs and finally result and discussion is drawn in section IV and conclusion is drawn in section V.

II. OTFT DEVICE DESIGN

An organic field-effect transistor (OTFT) is a Field-effect transistor using an organic semiconductor in its channel.Like MOSFETS, OTFT have symmetrical structures that is source and drain are interchangeable.



(a) (b) (c)

Figure-1.Schematic Cross-Section of OTFT Structures

(A)Single Gate Bottom Gate And Top Contact (SGBGTC) (B) Dual Gate Organic Thin Film Transistors (DGOTFT)(C) Tri Gate Organic Thin Film Transistors (TGOTFT)

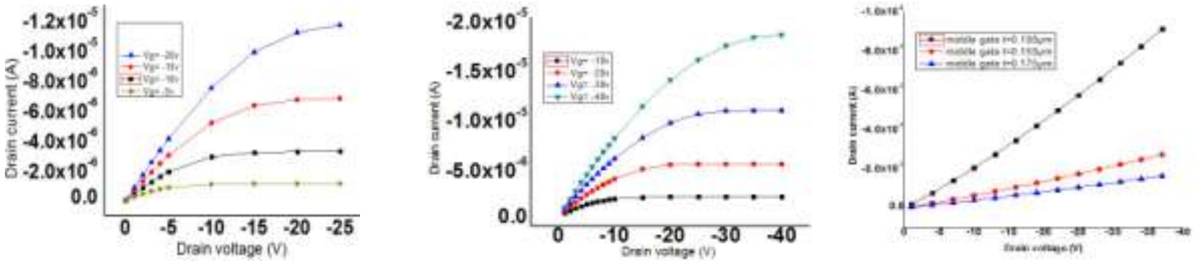
Single gate organic thin film transistors (SGOTFT) have been fabricated with various device geometries depending on position of electrodes and gate with respect to semiconductor and dielectric layer. The most commonly used device in single gate geometry is bottom gate with top drain and source electrodes using thermally grown SiO_2 as gate dielectric.This structure is commonly known as bottom gate top contact(BGTC).However in Dual gate organic thin film transistors (DGOTFT) the active semiconducting layer is sandwiched between two gate electrodes from which it is electrically isolated by two gate insulator.While in Tri-gate organic thin film transistors (TGOTFT) gates three gate may be of different thickness embedded in the bottom of structure with three different contact area. The fundamental principles of the operation of the dual gate organic thin film transistors (DGOTFT) and Tri-gate organic thin film transistors(TFOTFT) do not differ from that of a common OTFT. In OTFT the charges are induced by the gate potential at the semiconductor/insulator interface forming a conducting channel. The formation of the channel creates a conducting path between the source and drain electrodes.It also screens the gate potential similar to the operation of a plate capacitor.The change in the threshold voltage of the gate depends on the gate bias[3,4].

III. DEVICE SIMULATION

A 2-D ATLAS simulator of Silvaco Company is used as a semiconductor simulator. The simulation was carried out on three structures: 1)Single gate BGTC, 2) Dual gate OTFT and 3) Tri gate OTFT. We have used an active layer of pentacene with 50-nm thickness in SGBGTC & 100-nm thickness in DGOTFT and TGTFT respectively. The gate insulator was assumed to be SiO_2 a dielectric constant of 3.9 and a thickness of 400 nm. This material prevents gate leakage currents, acts as an effective capacitor.Also it allows for the accurate measurement of the electrical performance of the organic semiconducting layer. ATLAS is generally used for silicon devices. Poole–Frenkel mobility model was adapted for various organic devices .It is given by

$$\mu = \mu_0 \exp\left(-\frac{\Delta Ea - \beta\sqrt{E}}{kBT}\right)$$

where ΔE_a *is* zero field activation energy, whose value is around 5–50 meV, and β is the Poole–Frenkel constant, whose value is around 1×10^{-5}–5×10^{-4} eV $(V/cm)^{1/2}$ for pentacene. The value of μ_0, activation energy (ΔE_a), and β are 0.62 $cm^2\ V^{-1}\ s^{-1}$, 0.018eV, and 7.7×10^{-5} eV $(V/cm)^{1/2}$, respectively.The channel length was taken as 20 μm and the channel width was assumed to be 200 μm.While in case of DGOTFT and TGOTFT silicon was taken for gate material. SiO_2 of 100nm thickness was again taken as insulating layer.The source and drain electrodes were taken of gold with 52.5nm thickness.The channel width and length were 800 μm & 100 μm respectively[5,6].



(a) (b) (c)

Figure-2.Output Characteristics A) SGOTFT And B)DGOTFT At Different Gate Voltages C)TGOTFT At Different Mid Gate Thickness Variations.

IV. RESULTS & DISCUSSION

Output characteristics of SGOTFT , DGOTFT and TGOTFT are shown in figure-2 which shows that tri gate structure draws more current compared to the other two gated structure of organic thin film transistor.

Table-I. Extracted Parameters

Parameter	SGOTFT	DGOTFT	TGOTFT
I_{on}/I_{off}	6.68458e+06	1.6383e+13	2.23179e+13

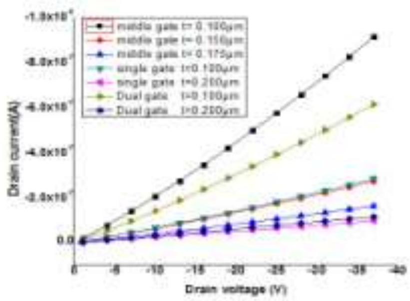


Figure-3 Output Characteristics of Thickness Variations in Gate In All Three Structures.

Figure-3 shows output characteristics of thickness variations in gates from 100nm to 200nm at V_{gs}= -40V(bottom gate in case of DGOTFT and middle gate in case of TGOTFT). Table-1 shows extracted parameters value for both the transistor at 40nm electrode thickness. It has been noted that Tri gate OTFT shows improved switching characteristics (on vs off) compared to earlier transistors. There is decrease in on current with increase in gate width in all three transistors.It consumes far less power than current transistors.

V. CONCLUSION

In this paper performance of SGOTFT,DGOTFT and TGOTFT is analysed by variation of thickness of gate.It can be concluded that tri-gate OTFT has shown superior performance as compared to single gate OTFT such as higher on current which proves to be a better device for switching application.TGOTFT results in higher current due to formation of three conducting channels. Therefore,it can be concluded that Tri-gate is more suitable for applications in large area of electronics.

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