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# An Exhaustive Survey and Optimal Controlling of Organic Thin Film Transistors

**Subodh Kumar, Rajeev Kumar Thakur**

Department of Electronics and Communication, NRI Institute of Information Science and Technology, Bhopal, India

**ABSTRACT:** Low-cost, highly flexible devices called organic thin-film transistors (OTFTs) are used in the printing process, detecting, and display purposes. This article presents the literature review of OTFT for the optimal controlling of performance parameters using various methods. The various performance parameters like cutoff frequency, cutoff resistance are used for performance analysis. There were many methods based on intelligent techniques have been used for the optimal control. It has been concluded that improved value of cutoff frequency and cutoff resistance have been attained with intelligent techniques.

**KEY WORDS:** OTFT, contact resistance, cutoff frequency, intelligent, methods

## I. INTRODUCTION

ORGANIC thin film transistor's flexible design, appealing electrical properties, and quick operation make it the best substitute for the conventional MOSFET transistor. For OTFT with charge carriers to function properly, firmly orientated thin films are frequently needed.

Pentacene, polythiophene, and other conductive polymers are examples of organic compounds that are utilized. Charge transport is made possible by the π-conjugated systems found in these substances.OTFTs are appropriate for applications requiring flexibility and bendability since they may be produced on porous substrates like paper, plastic, or textiles.OTFTs can be produced on temperature-sensitive materials at lower temperatures than silicon because organic materials can be treated at lower temperatures. This lowers production costs.Roll-to-roll processing and inkjet printing are two printing techniques that can be used to create OTFTs, allowing for scalable and economical production.Compared to silicon-based transistors, organic materials typically have poorer charge mobility, which restricts their use in high-speed electronics.The stability and performance of organic thin-film transistors (OTFTs) are impacted by environmental conditions such as moisture and oxygen, which can impair organic materials' sensitivity.

## II. GENERAL STRUCTURE OF OTFT

Potential OTFT shapes are determined by the organic interface and gate position. The four distinct forms of possible OTFT constructions are referred to as Top Gate and Top contact, Top Gate and bottom contact, Bottom Gate and Top contact, and Bottom Gate and bottom contact.

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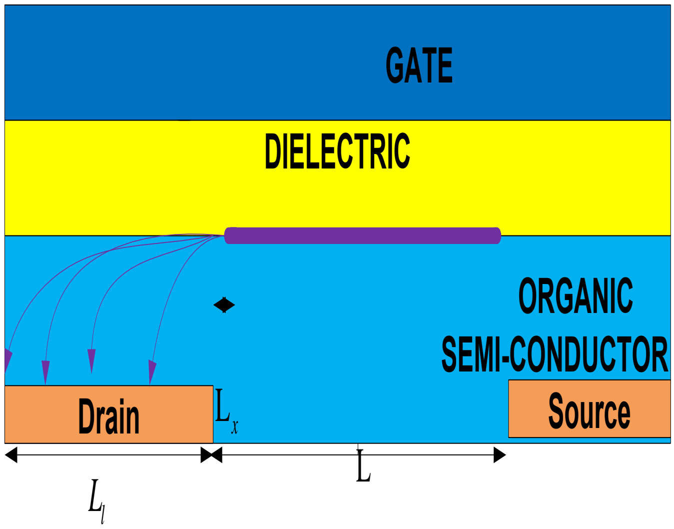


Fig.1 Top gate and bottom contact OTFT Structure

The top perspective of the OTFT construction with the gate at its highest position is shown in Fig. 1, which is unique to this work. A dielectric sits between the gate and the organic semiconductor, and the gate is positioned above the insulator or dielectric. The OTFT's source & drain are located at the bottom. The channel current (Ids) starts to spread at the electrode's edge near the drain link.

Positioned above the gate is the barrier, which is a dielectric, and the hydrophobic is positioned between the barrier and the organic semiconductor. At the bottom are the organic semiconductors' source and drain. The channel's rising current will end up at the drain connector located on the electrode edge. A few standard parameters include L, which stands for channel length, Lx for spread point to drain contact distance, and Ll for contact length (length of source and drain electrode).

## III. INTELLIGENT CONTROLLING OF THE PERFORMANCE PARAMETERS OF OTFT

Transparent organic thin-film transistors (OTFTs) enable concurrent optical imaging, electric sensing, and modulation, they hold great promise for bioelectronics applications. Modern transparent OTFTs, nevertheless, have limitations in their device efficiency because to their high threshold voltage and low mobility. The primary cause of this is the significant contact resistance brought about by an energy level imbalance between the organic semiconductors and transparent electrodes. Here, we present transparent OTFTs that have had the electrode material of indium tin oxide changed by fluorinated silanes to enhance device functionality. The results show that the OTFTs with the electrode modified by fluorinated silanes had a decreased threshold voltage of –2.21 V and enhanced mobility of 0.12 cm2/V·s to 1.58 cm2/V·s[1].

This letter examines the scaling potential of the interface length (the length of the source and drain electrodes) in staggered organic thin-film transistors (OTFTs). We investigated the effects of the Schottky barrier between the source and drain electrodes and the organic semiconductors, channel length, semiconductor film thickness, mobility, material chaos, asymmetry of mobility, and gate-source voltage on contact length scaling down. We discovered that the contact resistance does not increase until the contact length is reduced to less than 500 nm. Crucially, the cutoff frequency (fT) of OTFTs was reported. It was discovered that fT increased as contact length decreased, with the greatest fT possible being attained with contact lengths in the sub-100 nm range with Ohmic contacts[2].

Proximity-sensing surfaces that are adaptable and large-area find utility in several fields such as robotics, control of processes, and work security. Unfortunately, the current systems are limited in their applications since they usually

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require bulky and inflexible electronics. In this article, we describe the creation of a flexible, large-area proximity detecting surface that includes analogue front-end circuitry in each pixel and is made of printed organic materials. Printed organic thin-film transistors and printed thin-film pyroelectric detectors based on poly(vinylidene fluoride-co-trifluoroethylene) co-polymers are used to construct the sensing surface[3].

Flexible electronic devices have shown to have a great deal of promise for improving convenience and enjoyment in human lives. The development of flexible organic field-effect transistor (FOFET) technology for flexible sensors, rollable screens, bendable smart cards, and artificial skins has been the focus of intense attention. Unfortunately, due to a lack of established production techniques and common high-performance materials stacks, numerous uses are still in their infancy. This paper provides a detailed summary of the material selection, device design, and proven applications for FOFET devices and circuits. Additionally, future uses and technological difficulties of FOFETs are explored[4].

Pentacene-activated organic thin-film transistors (OTFTs) were created and examined. Using a modified Y-function approach, the electrical parameters were determined and the threshold voltage was altered. The mobility improvement factor was extracted using the derivative field effect mobility, which is comparable with the typical temperature inferred from the density of states (DOS) calculation. In order to validate the transport system, active layer topologies were also supplied. The electrical characteristics of pentacene thin-film transistors were modeled using the variable range hopping (VRH) mechanism[5].

In this study, we have used two distinct dielectric layers to build pentacene organic thin-film transistors (OTFTs) in the bottom-gate top-contact arrangement. The below the threshold slope (SS) in top-contact pentacene OTFTs was examined in relation to the scale of poly(methyl methacrylate) (PMMA) and cross-linkable poly(4-vinyl phenol) (PVP) polymer dielectric thicknesses. Below the threshold slope considerably improved as both dielectrics' thicknesses were scaled[6].

In recent years, superconductivity generated by an electric field in an insulator was achieved by adjusting the charge carrier to a high density level of 1 × 1014 cm−2. It is a popular topic but a difficult task to raise the highest achievable carrier density for electrostatic tuning of electronic states in semiconductor field- effect transistors. Here, ultrahigh density carrier aggregation has been observed in a ZnO field-effect transistor that is gated by electric double layers of ionic liquid (IL), especially at low temperature. It is discovered that this transistor, known as an electric double layer transistor (EDLT), exhibits extremely high carrier densities and very high transconductance in a quick, reversible, and repeatable manner. Based on Hall-effect studies, the room temperature capacitor of EDLTs is found to be as large as 34 μF cm−2, which is primarily accountable for the carrier density fluctuation in a relatively wide spectrum. It is noteworthy that the IL dielectric, possessing a supercooling characteristic, exhibits the ability to accumulate charges even at low temperatures. At 220 K, it reaches an extremely high carrier density of 8×1014 cm−2, and at 1.8 K, it maintains a density of 5.5×1014 cm−2. The elevated carrier density found in EDLTs holds significant value not only in real-world device implementations but also in basic research endeavors, such as the pursuit of unprecedented electrical phenomena, including superconductivity in in oxide systems[7].

Since small batteries or harvesters of energy will supply electricity for use in many of the uses planned for organic thin-film transistors (TFTs), it will be advantageous if the TFTs can operate at voltages of 1 V or even lower. TFTs ought to have high on/off ratios of current at the identical time, particularly for use in active matrix and digital circuits. Here, we present p-channel and n-channel organic TFTs that, when driven with gate-source voltage between 0 and 0.7 V, have an accurate turn-on voltage of 0 V, a below the threshold slope of 100 mV/decade, and an on/off current ratio of 2 × 105. These TFTs are built on a flexible plastic substrates. At a supply voltage of 0.7 V, complimentary inverter made with these TFTs have an acceptable noise margin of 79% and a small-signal gain of 90. Supply voltages as low as 0.4 V can be used to run parallel ring oscillator[8].

In this work, an innovative generic method that particularly takes into consideration the nonlinear behavior of both source and drain contacts as well as their individual contributions to the current-voltage properties of organic thin-film transistors (TFTs) is presented. An analytical model that explains the behavior of the intrinsic TFT and the source and drain contacts in both the linear and saturation regimes has been developed based on the above extraction technique. The primary aspect of the suggested extraction technique is its independence from any physical events that may

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underlie the electrical properties of the contacts. Rather, it extracts the contacts' current-voltage features, which may subsequently be fitted to any TFT model based on physics. Two distinct small-molecule organic semiconductors have been used to create organic TFTs on malleable plastic substrates in parallel and staggered device designs, utilizing the suggested extraction technique. The transimpedance amplifier circuit based on TFTs with diverse channel lengths and organic TFTs with channel lengths ranging from 4 to 100 µm have been simulated using the compact dc model, and the results show good agreement with the measurements[9].

We have designed, manufactured, and characterized circuits for rectifiers with low threshold voltages and elevated cutoff frequencies using p-channel organic thin-film transistors (TFTs). TFTs and circuitry were created with vacuum-deposited small-molecule organic semiconductors dinaphtho[2,3-b:2',3'-f]thieno[3,2-b] thiophene (DNTT), which was manufactured utilizing shadow-mask lithography on flexible plastic substrates. The TFTs include a channel length of 10 µm and a gate dielectric thickness of 5.3 nm. In this study, single-stage and multistage dynamic-threshold-compensated differential rectifiers—circuit addresses from silicon CMOS technology—are used to analyze the frequency characteristics of diode-connected transistors, or transdiodes. Cutoff frequencies for transdiodes are up to 4.75 MHz at a peak-to-peak input voltage of 3 V, for single-stage different rectifiers they are up to 32 MHz at a peak-to-peak input voltage of 1.5 V, and for two-stage rectifiers they are up to 7.5 MHz at a peak-to-peak feedback voltage of 1.5 V, according to the description of the rectifier circuits. For a load of 10 MΩ, the efficiency is 25%, while for a load of 1 MΩ, it is less than 1%[10].

## IV. CONCLUSION

Organic thin-film transistors (OTFTs) are extremely flexible, low-cost electronics utilized for display, detection, and printing applications. The literature review on OTFT for various ways of optimally regulating performance parameters is presented in this article. Performance analysis uses a variety of performance factors, such as cutoff frequency and cutoff resistance. For the best control, a variety of strategies based on clever tactics were applied. It has been determined that clever procedures have allowed for enhanced cutoff frequency and resistance values.

## REFERENCES

[1] Yilun Zhong,Jiwei Zou,Taoming Guo,Lei Han,Ye Zou,Wei Tang,Yongpan Liu,Huazhong Yang,Yunlong Guo,Chen Jiang, Modification of Indium Tin Oxide Electrodes by Fluorinated Silanes for Transparent Organic Thin-Film Transistors, IEEE Electron Device Letters,vol.45,no.3,2024

[2] Hong Wang, Wei Wang, Pengxiao Sun, Xiaohua Ma, Ling Li, Ming Liu, and Yue Hao, "Contact Length Scaling in Staggered Organic Thin-Film Transistors," IEEE Electron Device Letters, vol. 36, no. 6, pp. 609-611, 2015.

[3] M. Fattori, S. Cardarelli, J. Fijn, P. Harpe, M. Charbonneau, D. Locatelli, et al., "A printed proximity-sensing surface based on organic pyroelectric sensors and organic thin-film transistor electronics", Nature Electron., vol. 5, no. 5, pp. 289-299, May 2022.

[4] K. Liu, B. Ouyang, X. Guo, Y. Guo and Y. Liu, "Advances in flexible organic field-effect transistors and their applications for flexible electronics", NPJ Flexible Electron., vol. 6, no. 1, pp. 1, Jan. 2022.

[5] Peng Zhang,Emmanuel Jacques,Régis Rogel,Laurent Pichon,Olivier Bonnaud, Interpretation of Hopping Transport Based on Pentacene Thin-Film Transistors, IEEE Transactions on Electron Devices, vol.70,no.12,pp. 6364 – 6368, 2023

[6] Praveena Rajput,Hitesh Kumar,Vinay Kumar Singh, Impact of Scaling of Dielectric Thickness on Subthreshold Slope in Top-Contact Pentacene Organic Thin Film Transistor,vol.70,no.5,pp. 2460 – 2464,2023

[7] H. Yuan, H. Shimotani, A. Tsukazaki, A. Ohtomo, M. Kawasaki and Y. Iwasa, "High-density carrier accumulation in ZnO field-effect transistors gated by electric double layers of ionic liquids", Adv. Funct. Mater., vol. 19, no. 7, pp. 1046-1053, 2009.

[8] U. Zschieschang, V. P. Bader and H. Klauk, "Below-one-volt organic thin-film transistors with large on/off current ratios", Organic Electron., vol. 49, pp. 179-186, Oct. 2017.

[9] S. Elsaegh, U. Zschieschang, J. W. Borchert, H. Klauk, H. Zappe and Y. Manoli, "Compact DC modeling of organic thin-film transistors including their parasitic non-linear contact effects based on a novel extraction method", IEEE Trans. Electron Devices, vol. 66, no. 11, pp. 4907-4914, Nov. 2019.

[10] G. H. Ibrahim, U. Zschieschang, H. Klauk and L. Reindl, "High-frequency rectifiers based on organic thin-film transistors on flexible substrates", IEEE Trans. Electron Devices, vol. 67, no. 6, pp. 2365-2371, Jun. 2020.




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