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Full Length Research Paper

A new approach for optimized an analytical mobility model basing on genetic algorithm

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Abstract

Pentacene thin film transistors, owing to their potentially low-costs, low-temperature fabrication process and fast detection are used as a DNA hybridization sensor. In this paper a new approach for optimized an analytical mobility model has been proposed to drain current basing on genetic algorithm. The optimized analytical results show an excellent agreement with measured data and it can be used into numerical device simulators or to obtain other characteristic of DNA sensor.

Keywords: Pentacene thin film transistor, Mobility modeling, Genetic algorithm DNA hybridization sensor, disposable sensor.

INTRODUCTION

The evolution of modern electronics has led to the realization of devices with different conception in order to fulfill different requirements. For instance DNA hybridization sensors have a great importance in many applications, such as medical diagnostics, forensic science, genotyping, and pathogen detection (Simone et al., 2007; Patolsky et al., 2001; Nam et al., 2004; Ramsay, 1998; Marshall and Hodgson,1998; Pividori et al., 2000).

In the past DNA methods detection are based on radio labeled system or optical detection using fluorochrome tagged oligonucleotides witch have a complications in sample preparation with expensive and complex usage of optical systems.

Electrical mobility is an important parameter characterizing the organic thin film transistor, it was considerable interest for many research for several years.

For these reasons, in the present work, we present a new approach mobility model in DNA hybridization sensors which provides an optimized analytical model for drain current basing on genetic algorithm.

Modeling of mobility and current -voltage characteristics

The performance of the pentacene TFT devices was measured in terms of their output and transfer characteristics. In order to find the output characteristics of devices, the channel current (IDS) was measured as a function of the drain–source voltage (VDS) under a constant gate voltage (VGS). Evaluation of transfer characteristics was carried by measuring the IDS between the source and drain as a function of the VGS

Table 1. Parameters used for GA computation

Parameters	Values
Population size	20
Maximum number of generations	5000
Fitness scaling	Proportional
Selection type	Roulette
Crossover type	Scattered
Mutation rate	10-2

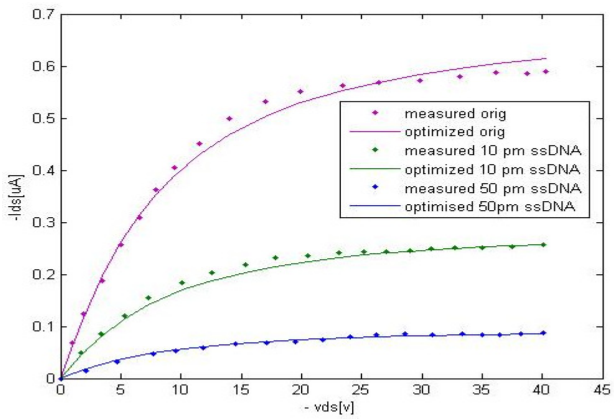

Figure 1. Measured and modeled of the pentacene TFTs output characteristics with 10 and 50 pmoles DNA immobilized on pentacene surface

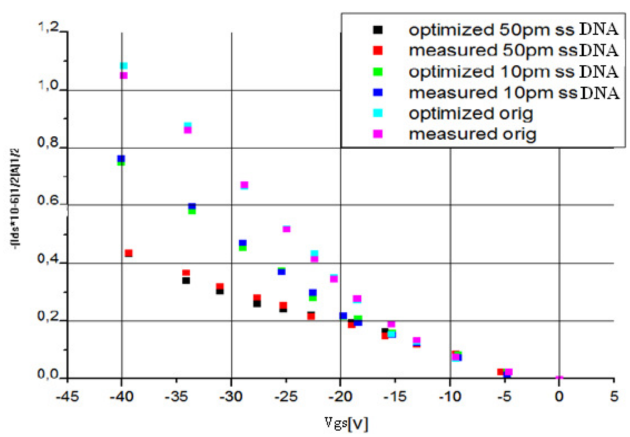

Figure 2. Measured and modeled of transfer characteristics of a pentacene TFTs with 10 and 50 pmoles DNA immobilized on pentacene surface

under a constant VDS. One of the important parameters of OTFT was the field-effect mobility of carriers in its channel region. The field-effect mobility (µFET) was determined using gate voltage and given by equation (1) (Jung-Min et al., 2010):

$$\mu_{FET} = \mu_0 [V_{GS} - V_T]^{\gamma} \quad (1)$$

Where: µ0 is the value of mobility for low perpendicular and longitudinal electric field, VT the threshold voltage and γ is the fitting parameter.

In this paper we suggest a new approach model for organic TFTs based in concentration of DNA hole through the expression:

$$\mu_{FET} = \mu_0 \left[V_{GS} - V_T\right]^{\gamma} \left[\frac{ff}{ff + (dd * N(i))^{0.93}}\right] \qquad (2)$$

Where: Ni is the concentration of DNA, ff and dd are fitting parameters used to adjust µ0 to the experimental value of the low field mobility for the device being modeled. Parameter γ is related to the conduction mechanism and can describe both an increase and decrease in mobility with VGS.

$$I_{DS} = \frac{W\, C_{diel}\mu_{FET}(V_{GS} - V_T)}{\left(1 + R\frac{W}{L}C_{diel}\mu_{FET}(V_{GS} - V_T)\right)} \frac{V_{DS}(1 + \lambda V_{DS})}{\left(1 + \left(\frac{V_{DS}}{V_{Dsat}}\right)^m\right)^{\frac{1}{m}}} + I_0 \qquad (3)$$

Drain current in the linear and saturation regions is modeled

where W is the channel width, L is the channel length, Cdiel is the gate capacitance, R is source plus drain resistance, I0 is the leakage current, m and λ are fitting parameters related to the sharpness of the knee region and to the channel length modulation respectively.

Parameter λ describes the variation of conductance with VDS in the saturation region.

The saturation voltage is defined through the saturation modulation parameter as:

$$V_{Dsat} = \alpha_s(V_{GS} - V_T) \qquad (4)$$

According to the equations (2), (3), and (4) we have nine variables to be optimized using genetic algorithm.

RESULTS AND DISCUSSIONS

Optimization process was conducted for 20 population size and maximum number of generations equal to 5000 for witch stabilization of the fitness function was obtained. GA parameters were varied and the associated optimization error was recorded.

Table.1 shows the GA parameters used in this study of DNA sensor. For this configuration, the fitness function was 0.5 and almost 100% of the submitted cases were learnt correctly. After the optimization process, the obtained fitness function value is equal to 10-2 and almost all cases have been correctly studied. In order to validate the predictive property of the optimized GA configurations, a measured result was compared to the GA optimized drain current model.

The optimized parameters of drain current model in this study are given in Table1.

Figures 1 and 2 shows a comparison of the measured variation and modeled output characteristics of the DNA transistor described. As can be seen, all devices characteristics analyzed in this work can be very well modeled using GA. However, we can see that the proposed model provide a good agreement for different applied voltages (Vgs, Vds). Hence, the optimized analytical model can be used to predict other combinations of input variables in full range. This last observation shows the applicability of GA technique to study the DNA sensor using pentacene TFT.

CONCLUSION

In this paper; organic thin film transistor has been modeled by the genetic algorithm to obtain the optimal drain current model using a new approach mobility model. Extracted variables can be used to predict other parameters.

The simulation results shows that the developed approach can enrich both the physical insight and the engineering in the field of organic electronics and can also be incorporated in electronic simulators tools.

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