An Aging Current Model for OLED Degradation

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ABSTRACT

This work presents a new aging current model of organic light-emitting diode (OLED). It can predict the OLED current with different stress time under some aging conditions, which can be used in related simulation software to describe the degradation of OLED.

1 INTRODUCTION

Organic light-emitting diode (OLED) displays have received significant attention from the electronics industry in recent years. Although OLED displays have many advantages, like being more energy-efficient and having better visual-enjoyment, compared with liquid crystal displays (LCD) [1], there are still some problems that can impede the OLED displays' development. The degradation of OLED devices is one of the most concerned issues, especially in large-size OLED displays. The aging phenomenon influences the device lifetime greatly, which has attracted many concerns before its widely adopted. This work proposes a current-time model to characterize the OLED degradation. The model consists different aging conditions (voltage, temperature, working time, device parameter). According to that, we can simulate the circuit transient performance more accurately, which is beneficial to studying OLEDs' performance.

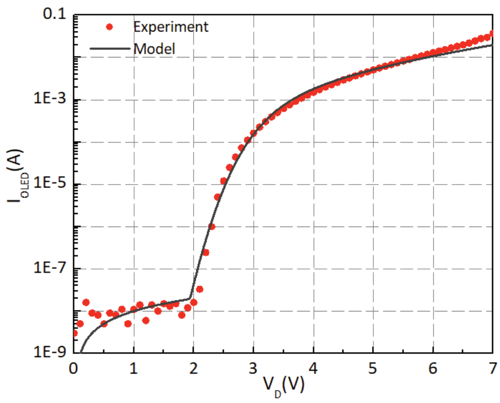
2 Proposed Current Model

The aging current is calculated as equation (1) and (2) in this model. I_0 is the initial OLED current without degradation. L_t is lifetime parameter and β is related coefficient during the aging process. Noticeably, L_t is a significant variable, which is expressed as a function of materials and technique parameter of OLED device (τ), aging temperature (T_A) and aging voltage (V_A). θ_1 and θ_2 are dependence coefficients. From (1), the OLED lifetime can be estimated during various situation.

$$I_{OLED} = I_0 * \exp(-(\frac{t}{L_t})^{\beta}) \quad (1)$$

$$L_t = \tau * T_A^{\theta 1} * V_A^{\theta 2} \quad (2)$$

The proposed model introduces a new parameter



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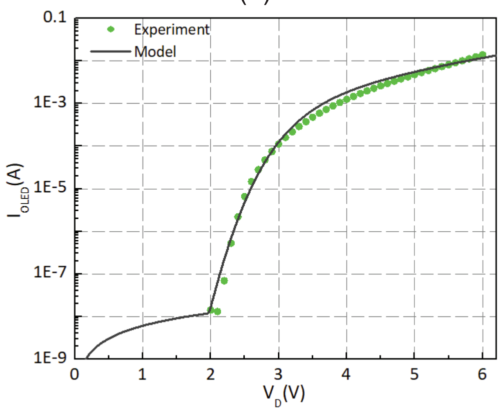

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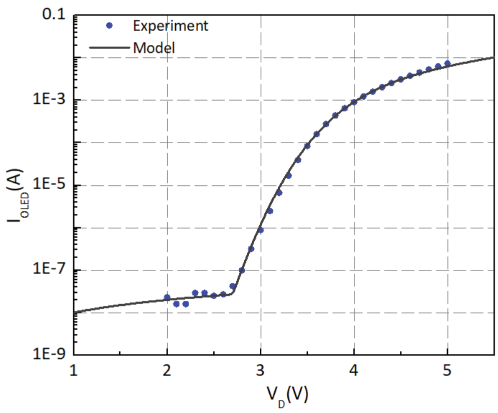


(c)

Fig. 1 The current-voltage characteristic without aging of red(a), green(b), and blue(c) OLEDs.

(aging time), which is useful in characterizing the OLED performance. Furthermore, the aging conditions are also in consideration. The lifetime parameter is influenced by aging temperature, aging voltage and material property. In this work, we discuss temperature's role in OLED degradation based related aging test data.

3 EXPERIMENT & RESULTS

To verify the proposed model, we have test some different experimental OLEDs with the same size under diverse aging conditions.

Firstly, we test the OLEDs' initial characteristic performance. As shown in Fig.1, they are current-voltage characteristic curves of red(a), green(b), and blue(c) OLEDs without aging. And the model can describe current-voltage characteristic precisely of different OLEDs [2].

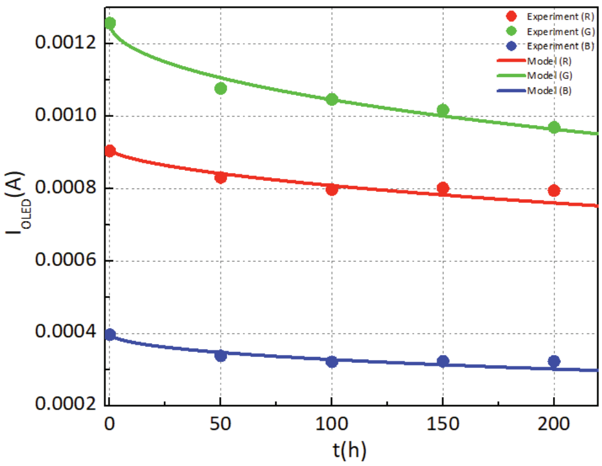
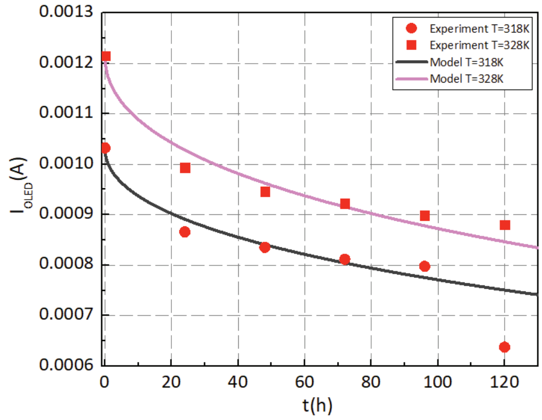


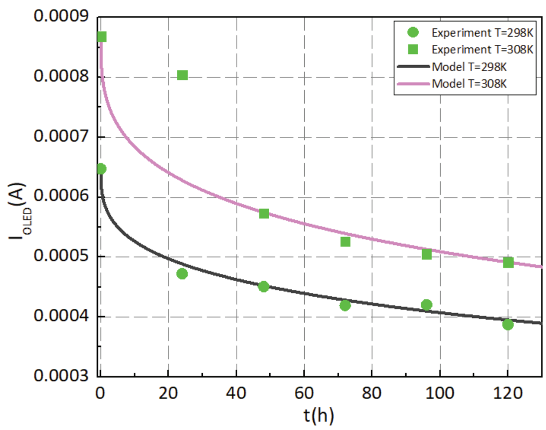
Fig. 2 The current aging with stress time of red(a), green(b), and blue(c) OLEDs.

Secondly, we put three devices under the same aging setting, in which the temperature is 298K, the constant voltage is 4V (T_A=298K, V_A=4V). Fig.2 describes current curves aging with stress time of red(a), green(b), and blue(c) OLEDs under the same aging condition. Currents have different degrees of reduction over working time. The model fits the experiment data even with a limited-hour aging test.

Then, we test devices in groups to study the aging temperature influence. We put the same OLEDs in different aging temperature and record their current variation with time changing. The Fig.3 shows red(a), green(b), blue(c) OLED's aging current curves with stress time under disparate tests. The two red OLEDs have the same aging voltages of 3.5V, the two green and two blue OLEDs' are the same of 4V. But the most striking difference is two aging temperatures 10K apart, which cause different variations. The comparison of model data and experiment data illustrates the model is applicable to different aging conditions. After that we compile the model into SPICE. We set aging voltage to 4V



(a)



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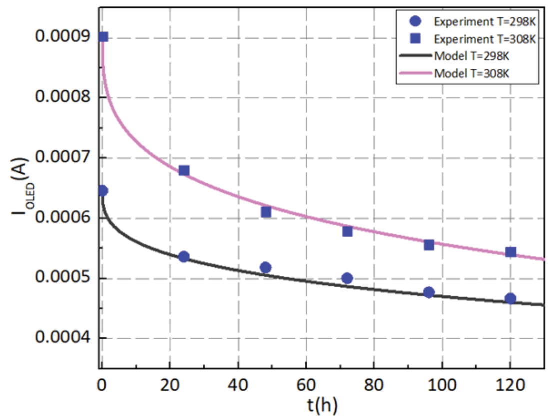

(c)

Fig. 3 The red(a), green(b), blue(c) OLED's current with stress time under different aging temperature.

and aging temperature to 300K in this model. Fig.4 is the simulated OLED's current results by Cadence under given aging conditions (TA=300K, VA=4V). It has a good agreement with the experimental data, which demonstrated the model's feasibility.

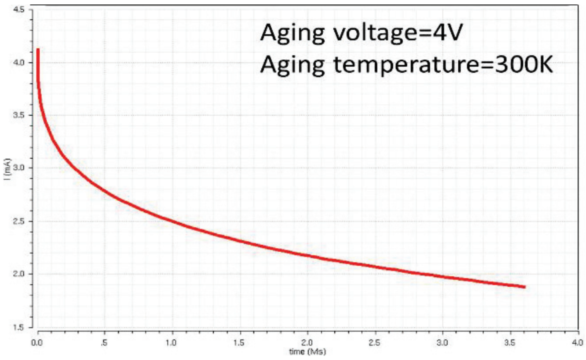

Fig. 4 The simulated OLED's current results by Cadence using the aging model.

4 SUMMARY

This model is beneficial to some work which needs to consider the OLED detailed performance, especially when its aging phenomenon can't be ignored. Like the device lifetime prediction, the OLED degradation compensation and the transient analysis of display circuits [3]. By comparison with experimental data, the model has shown its accuracy to a certain degree. As for the different aging conditions, this model contains aging temperature, aging voltage and material property. However, we admit more test data are required to support and improve this model in various aging conditions. And our following work is getting more detailed data to perfect this model.

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