Numerical simulation of charge transfer in SrS:Ce AC thin-film electroluminescent devices

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Abstract

A simple model which includes HSPICE Fowler-Nordheim diode for the creation of external charge in blue emitting SrS:Ce ACTFEL display device is presented.

I. Introduction

SrS:Ce based all-solid-state, high-contrast blue color AC Thin film electroluminescent (ACTFEL) flat panel display are becoming the potential for multifunctional avionic and consumer displays [1].The AC TFEL display's thinness, compactness, low weight, moderately low power requirements and durability are its prime advantages. In this ACTFEL device, an active layer, doped with cerium (SrS:Ce) is sandwiched between the two dielectric layers followed by conductive layers. All the layers are transparent except the back conductive layer. Luminescence behavior of SrS:Ce device is substantially different from that of typical ZnS:Mn devices and it is very difficult to explain its luminescent and electrical properties by the models developed for ZnS:Mn devices. Several preliminary , qualitative models for SrS:Ce device have been reported [2], but still no comprehensive model is developed to exactly explain the luminescent property of this device.

In this paper a simple numerical model is proposed for the calculation of charge transfer and light emission,.Physical processes are described in terms of rate equations and field, current and luminescence waveforms are calculated for one set of device parameters. The shape of the calculated waveforms is similar to the

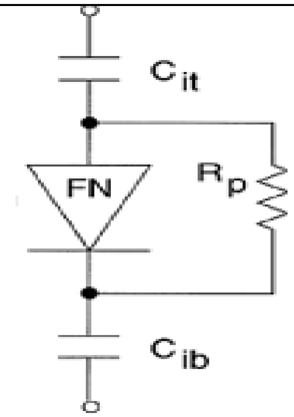

Fig 1 ACTFEL equivalent circuit using the SPICE Fowler-Nordheim diode model. Notice that the diode conducts under both applied voltage polarities

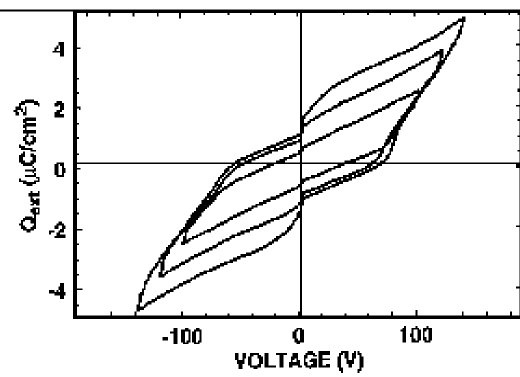

Fig.2 External charge versus applied voltage (Q_e-V_{app}) family of curves for an *ALE deposited SrS:Ce ACTFEL device taken at 20,40, and 60 V above threshold. Solid – experimental, dotted blue corresponds to simulated*

shape of the experimentally observed waveforms [3].

TABLE 1
DEVICE PARAMETERS

Parameter	***value***
Material	*ALE SrS:Ce*
Frequency	*100 Hz*
Thickness	*500 nm*
Trap depth	*0.58*
Dielectric constant	*9.4*
Threshold voltage	*77.8 Volt*
Carrier effective mass	*0.25* m_0
Series resistance	*100 Ohm*
Insulator capacitance	*39.8* nF/cm^2
*Phosphor Resistance**	*0.65 M Ohm*

II. RESULT & CONCLUSION

When a typical trapezoidal waveform applied to the ACTFEL device, the measured Qe–V_{app} curve of SrS:Ce ACTFEL device, which is operated at 100 Hz frequency for 20, 40, and 60 volts above threshold is obtained as shown in Fig.1. The SrS: Ce ACTFEL display device exhibits non-ideal characteristics and HSPICE Fowler-Nordheim tunneling diode (basically developed for ideal ZnS:Mn device) cannot be used to simulate the SrS:Ce device. Through this paper an approach has been made to simulate the Q_e–V_{app} characteristics of the ALE SrS:Ce device. Device parameters are listed in Table 1.

The circuit topology of the basic Fowler- Nordheim diode is shown in Fig. 2. The two capacitors, C_{it} and C_{ib}, represent the capacitances of the top and bottom insulators, respectively. In series with and sandwiched between these capacitors is a Fowler-Nordheim tunneling diode, which accounts for current transport across the phosphor. A "phosphor resistance," R_p, is added in parallel with the diode to account for charge leakage across the phosphor. [4].

In the simulated curve considering the Fowler-Nordheim tunneling (Fig.2) ,it is obvious that leakage charges are accurately simulated. The negative differential resistance could not be simulated using this model which means some modifications are required in the basic formulas used in the SPICE Fowler-Nordheim diode model. The model is able to simulate the dominant features of the experimental luminance and current waveforms Further proper optimization of the device parameters of SrS:Ce device may enhance the accuracy of modeling efforts. The appropriate device physics of SrS:Ce phosphor is still not known which is also a problem in getting good simulation results.

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