Computational Analysis on Recombination Rate for Organic Light Emitting Diodes

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ABSTRACT

We report our numerical study on the carrier injection and exciton transport for organic light emitting diodes (OLEDs) structure with material basis on tris (8-hydroxyquinolinato) aluminum (Alq3). Since the charge accumulation at the interfaces between emission layer (EML) and transport layer is considered to raise the recombination rate, which also increases the exciton density, we numerically investigated the effect of inserting the EML in the bilayer structure.

DEVICE STRUCTURE

In Fig.1 is shown the multilayer OLED structure in this work. The device comprises ITO (Anode) / NPB (HTL) / EML / Alq3 (ETL) / Al (Cathode). The thickness of ITO and Al is 100nm, respectively. Emission layer (EML) is BAlq (aluminum (III) bis (2-methyl-8-quninolinato)-4-phenylphenolate) which is emitting cool blue color [15]. We investigated the effect of inserting the EML in bilayer structure. In this article, we investigated 9types of device presented in Table1.

SIMULATION RESULTS AND DISCUSSION

Referring to Fig. 2(a), in basic bilayer device A, the electric field peaks at the interface between electron transport layer and hole transport layer. In case of device B and C, a trilayer with emission layer, a change of electric field occurs between interfaces of each layer. Device B contains a high band gap in the EML, which causes the charges to accumulate on either interface and hence enhance the electric field across the EML. On the other hand, Device C represents an ideal structure in terms of both current balance and recombination since electrons and holes can enter the EML without overcoming the energy, this is shown Fig. 2(b). We also simulate transient response of Device A, B, and C to know which device structure is more efficient, this is shown Fig. 3. For a quantum efficiency of device, we define the current balance factor. Numerically, the factor can be evaluated using the electron, hole, recombination current. The current balance factor b is defined as follows:

$$b = \frac{\int_0^L eR(x)dx}{J} = \frac{J_{e,cathode} - J_{e,anode}}{J} \qquad (1)$$

It is important for recombination kinetics to figure out how many excitons are generated for each device structure. In Fig. 4 is shown the exciton density as a function of carrer injection barrier height in Device C

CONCLUSION

We investigated the design parameters which influence the efficiency or optical properties such as alignment of LUMO and HOMO of EML, thickness of each layer, injection barrier height, and doping concentration for optimization of OLEDs. As trade-off relationship of design parameters considered, engineer can choose electrical and optical properties.

ACKNOWLEDGEMENT

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REFERENCES

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Device Structure	Layer	HOMO (eV)	LUMO (eV)
Device A	HTL	2.8	5.3
	ETL	3.0	5.6
Device B	HTL	2.8	5.3
	EML1	3.0	5.3
	ETL	3.0	5.6
Device C	HTL	2.8	5.3
	EML2	2.8	5.6
	ETL	3.0	5.6

Table. 1. Energy level parameters for the materials of trilayer devices in our simulations.

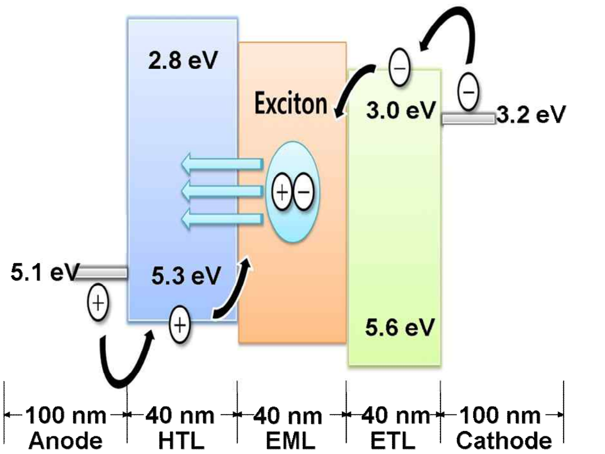

Fig. 1. A schematic diagram of a 3-layer OLED structure which comprises ITO (Anode) / NPB (HTL) / EML / Alq3 (ETL) / Al(Cathode).

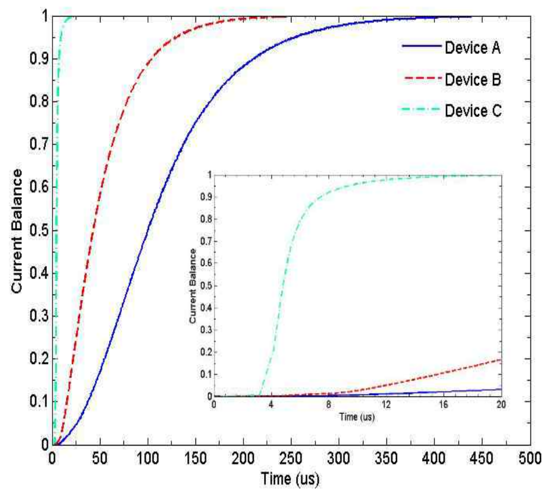

Fig. 3. A plot of the transient current balance which uses measure of recombination efficiency of device A, B, and C.

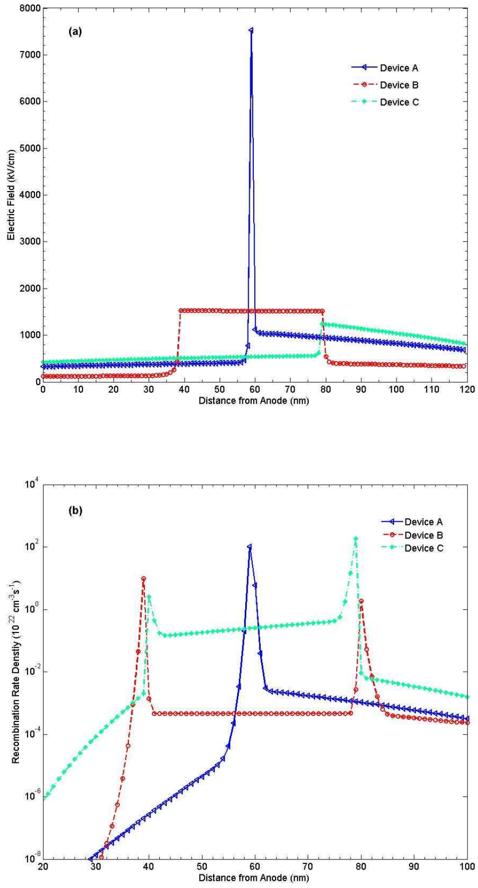

Fig. 2. Polts of calculated distribution of (a) electric field and (b) recombination rate density in basic bilayer device A, trilayer charge-blocking device B, and trilayer charge-confining device C.

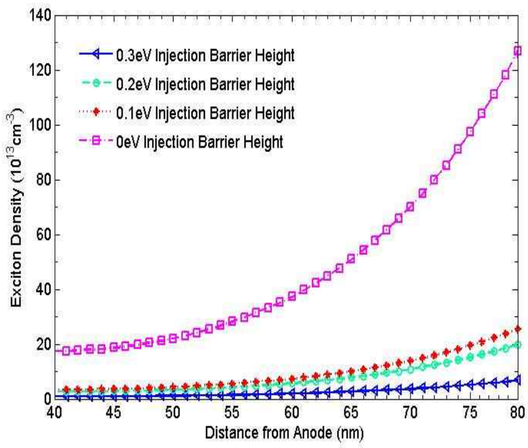

Fig. 4. A plot of exciton density distribution as a function of carrer injection barrier height in Device C.