Device optimization based on electrical and optical simulation of tris(8-hydroxyquinoline) aluminium based microcavity organic light emitting diode (MOLED)

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OLED has emerged as a potential candidate for applications in display devices due to its prominent advantages in size, brightness and wide viewing angle. Following our previous work, where optical analysis of the OLED has been documented[1] we present in this work detailed examination optical and electrical analysis of the performance of an OLEDs based on two organic layers: N,N′-di(naphthalene-1-yl)-N,N′-diphenylbenzidine (NPB) as the hole transport layer and tris (8-hydroxyquinoline) aluminium (Alq3) as the emitting layer, and two metallic mirrors. Our optical model fully takes into account dispersion in glass substrate, organic layers as well as the dispersion in metal contacts/mirrors. Influence of the incoherent transparent glass substrate is also accounted for. Two metal contacts Ag and Cu have been considered for anode and cathode respectively. For the hole transport layer NPB was used. The OLED structure is examined as a function of: thickness of the organic layers, and position of the hole transport layer/Alq3 interface. In order to obtain better agreement with EL experimental data, electrical models was developed in conjunction with the existing optical model to facilitate accurate optimisation of the OLED structure. The electrical model developed considers the metal contact as Schottky contact, the carrier mobility is taken to be field dependent with the Poole-Frenkel-like form and Langevin recombination model is used. The carrier transport was simulated using one-dimensional time-independent drift-diffusion model using device simulation software ATLAS.[2] Finally, the optimised devices were fabricated and characterised and experimental and calculated optical emission spectra were compared together with results obtained from electrical transport model.

The optical emission spectra were modeled using the equation below[3]

$$I_{cav}(\lambda) = \frac{\dfrac{1-R_{bot}}{i}\sum_{i}\left[1+R_{top}+2\sqrt{R_{top}}\cos\left(\dfrac{4\pi z_i}{\lambda}-\varphi_{top}\right)\right]}{1+R_{bot}R_{top}-2\sqrt{R_{bot}R_{top}}\cos\left(\dfrac{4\pi L}{\lambda}-\varphi_{top}-\varphi_{bot}\right)}\, I_{nc}(\lambda)$$

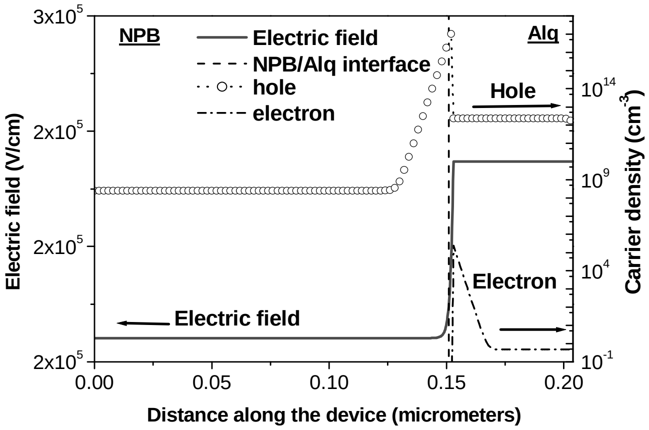

Figure 1 Simulated electric field and carrier density of Quartz (1mm)/Cu (25nm)/NPB (51nm)/Alq (153nm)/ Ag (70nm) device across the organic layers NPB/Alq.

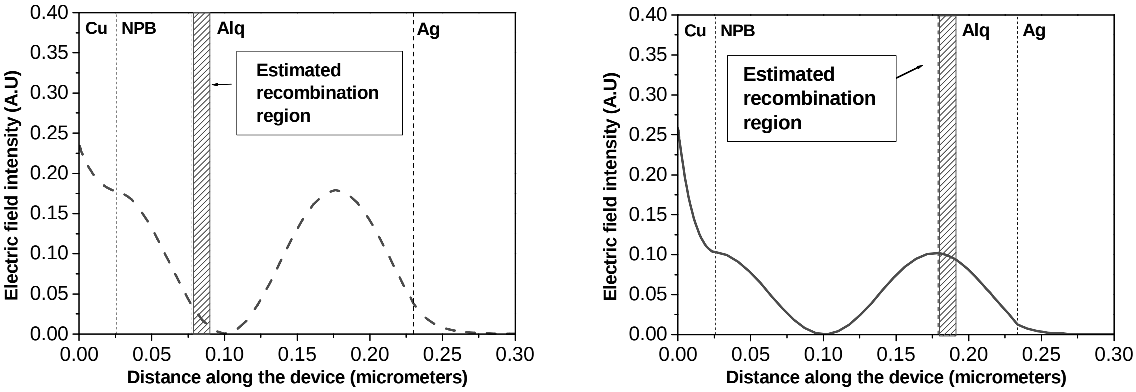

Figure 2 Simulated optical field intensity of device one with different NPB/Alq thickness of Quartz (1mm)/Cu(25nm)/NPB(51nm)/Alq(153nm)/Ag(70nm) (Left) and Quartz (1mm)/Cu (25nm)/NPB(153nm)/Alq(51nm)/Ag(70nm) (Right) respectively .

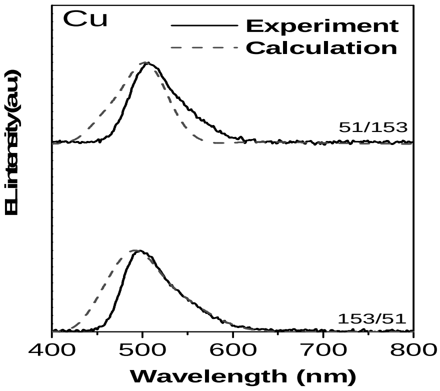

Figure 3 Comparison between the simulated and experimental electroluminance spectra of both devices in figure two.

[1] J.Chan, A. D. Rakic, C Kwong, A B. Djurišić, M L. Majewski and W Chan, Proc. SPIE **5277**, 2004, p.311-319.

[2] Silvaco, ATLAS user's manual, Silvaco, Santa Clara, CA

[3] A. Dodabalapur, L Rothberg, R Jordan,T Miller,R Slusher and J Phillips, J. Appl. Phys. **80**, 1996, p. 6954-6964.