Blue organic seven segment display based on poly (9,9-dioctyfluorene) with β-phase emission

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In this work, organic seven segment displays based on poly(9,9-dioctyfluorene), PFO, have been fabricated. PFO has consolidated as an attractive material for PLEDs due to its efficient blue emission [1] and high hole mobility. Additionally, PFO has a particular conformation, called β-phase associated to extended PFO chain conformation, which is of great interest for potential device applications because, among all others, it has the highest photoluminescence quantum efficiency [2] and the best colour stability [3].

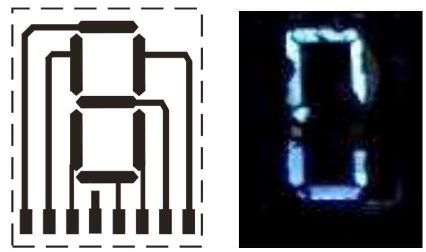

Fig.1: Shadow mask used for anode patterning (left) and final device lighting (right).

The structure fabricated uses Indium Tin Oxide (ITO) as anode, Poly(3,4 -ethylenedioxythiophene) /poly(4-styrenesulfonate) (PEDOT:PSS) as hole transport layer and Ba:Al as cathode. After thoroughly cleaning the substrates (covered with ITO) a photolithography process is carried out in order to pattern the anode. Next, the organic layers (PEDOTT:PSS and PFO) are spin casted. Finally, metals (Ba~30 nm and Al~100 nm) are thermally evaporated in an atmosphere of $6x10^{-6}$ Torr. PFO is dissolved in toluene at 1 % wt. A detailed description of the fabrication process can be found in [4]. Finally, the device is encapsulated (using an epoxy and a glass tap) and contacts are indium soldered on the pads. In figure 1, we can observe the shadow mask used for the anode photolitography process (left) and the final device lighting in a zero configuration (right).

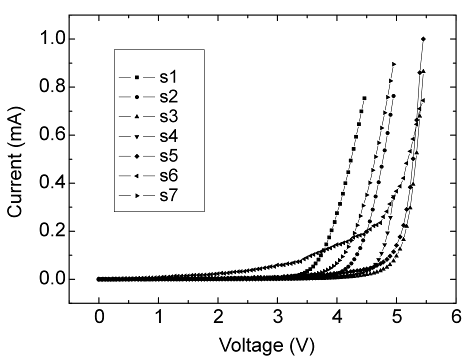

Fig.2: Current-voltage characteristics of the displays seven segments. Threshold voltage ranges between 3.5 V and 5 V

Current-voltage (I-V) characteristics were recorded using an Agilent 4155C semiconductor parameter analyzer and an Agilent 41501B SMU pulse generator. Samples were pulse biased for electrical measurements in order to prevent device degradation.

Figure 2 shows the electrical behaviour of the seven segments of the display. Dispersion of the data can be attributed to several facts: i) different series resistance of each segment due to the different track lengths, ii) non uniformity of the spin- casted organic layers (both PEDOT:PSS and PFO) and iii) non uniformity of the evaporated metals.

EL spectra were recorded using a CS-2000 Minolta Spectroradiometer. Samples were current driven with i) a pulse train and ii) under constant current (DC). Figure 3 shows the normalized electroluminescence spectra of a segment at different bias current levels, ranging from 0.5 mA to 1.9 mA for pulse biasing (left) and for DC biasing (right). The spectra show well resolved peaks at 440, at 467 nm and at 500 nm, corresponding to the well know β-phase of PFO. From the figures it can be concluded that the devices show good current stability, i.e. CIE coordinates remain almost constant with current (x= 0.22, y= 0.24 for pulse biasing and x= 0.22, y= 0.26 for direct current).

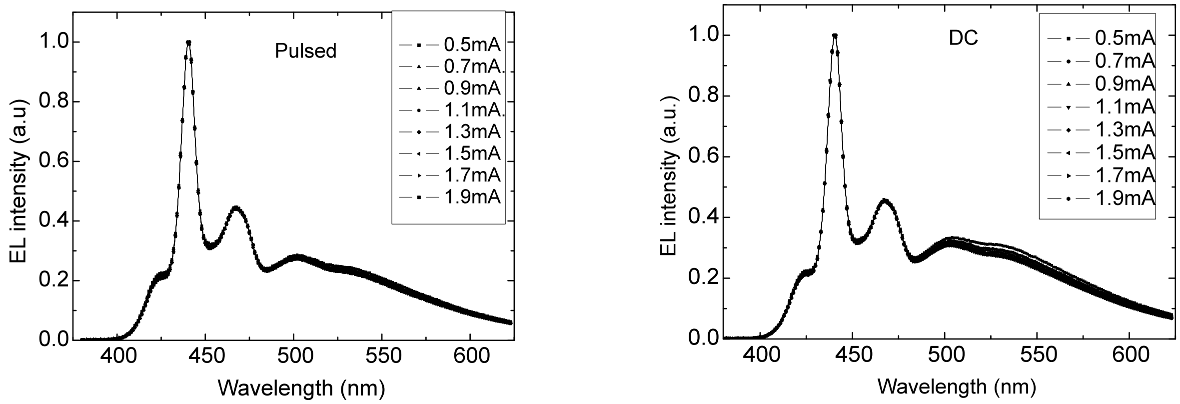

Fig.3: Normalized electroluminescence spectra at different bias current levels, ranging from 0.5 mA to 1.9 mA, for pulse (left) and for direct current (right) biased PFO based devices.

Finally, luminance has been measured and efficiency has been calculated at different driving currents. Figure 4 shows the total luminance and efficiency vs. current for a pulsed bias segment. Since the spectroradiometer measurement is an average during a longer time than the time the display is in ON, luminance values have been corrected. Figure 5 shows the total luminance and efficiency vs. current for a direct current biased segment. The maximum efficiency achieved is 0.6 cd/A, lower than expected when compared with pulse biasing, probably due to device heating and degradation. However, this value is in good agreement with values reported in the literature for similar devices [5].

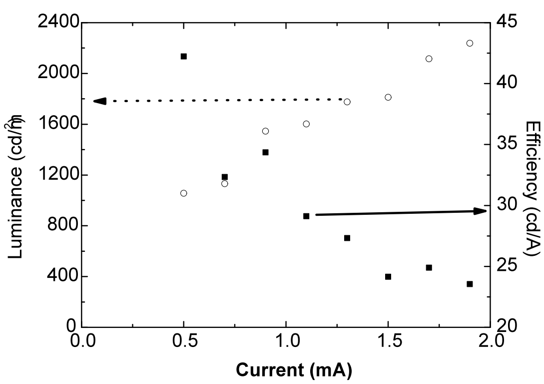

Figure 4. Luminance and efficiency vs. bias current for a PFO based device under pulsed bias conditions.

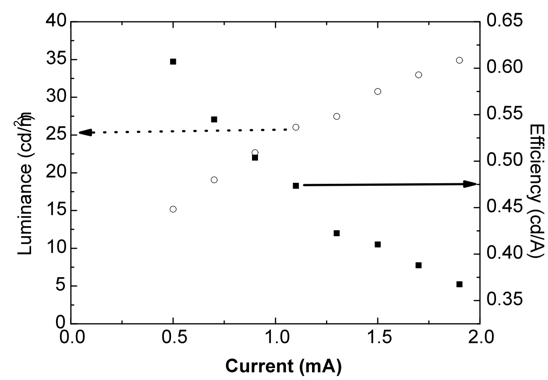

Figure 5. Luminance and efficiency vs. bias current for a PFO based device under direct current.

In conclusion, we have fabricated a PFO based device, 7 segment display, using spin coating technique for polymer deposition. The devices show β-phase emission under electrical excitation and EL spectra show good current stability. Maximum efficiency of 0.6 cd/A is obtained under direct current polarization.

References

[1] S. F. Lim, R.H. Friend, I.D. Rees, J. Li, Y. Ma, K. Robinson, Adv. Funct. Mater., 15, 981, 2005
[2] K. Asada, T. Kobayashi, H. Naito, Jpn. J. Appl. Phys. 45, L247, 2006
[3] J. Morgado, L. Alcacer, A. Charas, Appl. Phys. Lett, 90, 201110, 2006
[4] B. Romero, B. Arredondo, A. L. Álvarez, R. Mallavia, A. Salinas, X. Quintana and J. M. Otón, Solid State Electrón. 53, 211, 2009.
[5] M. Misaki, Y. Ueda, S. Nagamatsu, M. Chikamatsu, Y. Yoshida, N. Tanigaki and K. Yase Appl. Phys. Lett, 87, 243503, 2005.