DC lifetime of encapsulated organic light emitting diodes

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Organic light emitting diodes (OLEDs) are ideal sources for chemical and biological optical sensors [1], due to their simplicity, low cost (disposable applications) and possibility to be integrated on chip and fabricated in the form of large 2D arrays (microarray fluorescence [2]) even on flexible plastic substrates. OLEDs with lifetimes of a few hundreds of hours at initial luminance values in the range (500÷1000) cd/m^2 are suitable for the above applications, but these lifetimes can be achieved only by a proper encapsulation. Fast, simple and inexpensive encapsulation methods are highly desirable to keep the low cost profile and for this reason we report two different encapsulation structures and compare their effectiveness in increasing device lifetime of bilayer green emitting OLEDs based on *Tris (8 idroxyquinoline) aluminum* (Alq3) as emitting material.

The OLEDs structure is shown in Fig. 1 and full fabrication details are reported in [3]. The encapsulations are performed straight after the OLEDs samples are taken out from the vacuum chamber. The first structure (package A, Fig. 2) is assembled in ambient atmosphere and consists of a layer of polydimethylsiloxane (GELEST, Inc.) deposited by spinning on a glass slide cover that is then applied to the device-side sample surface by a light pressure. The resin is allowed to fully cure at room temperature for 12 h. The second structure (package B, Fig. 3) is assembled in a glove box under an overpressure of high purity dry N_2. It consists of an Al cap placed on top of the device-side sample surface using a thin bead of UV-curing resin applied around the edge of the cap. To absorb residual molecules of water vapour, a desiccant (Dryflex®, SAES Getters) is inserted into the package B. Finally the resin is cured under an UV lamp for 1 min.

Accelerated lifetime tests are performed at fixed DC current corresponding to an initial luminance L_0 of 1070 cd/m^2 and 1023 cd/m^2 for nominally identical OLEDs, respectively, in package A and in package B. Fig. 4 shows normalized luminance and voltage vs. time. As expected, in both cases a decay of luminance and a simultaneous voltage increase with time is evident, but the package B is much more effective than package A in increasing device lifetime. This is 230 h for OLED in package B, corresponding to a projected lifetime of 2350 h at an initial luminance of 100 cd/m^2. At the end of the lifetime test, the OLED in package B do not show dark spots, demonstrating excellent barrier properties of package B against oxygen and water vapour. Both OLEDs exhibit a strong luminance decay within the first hour of operation that we ascribe to filling of deep electron traps in the Alq3 emitting layer [3].

References

[1] J. Shinar et al., "Organic light-emitting devices (OLEDs) and OLED-based chemical and biological sensors: an overview", J. Phys. D: Appl. Phys., Vol.41, 2008, 133001
[2] A. Marcello et al., "A deep-blue OLED-based biochip for protein microarray fluorescence detection", Biosensors and Bioelectronics, Vol. 46, 2013, pp.44-47
[2] P. Cusumano, "Study of voltage decrease in organic light emitting diodes during the initial stage of lifetime", Solid State Electronics, Vol.116, 2016, pp.30-32

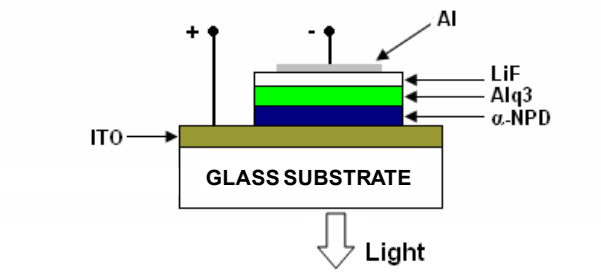
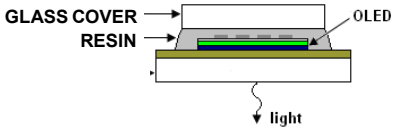
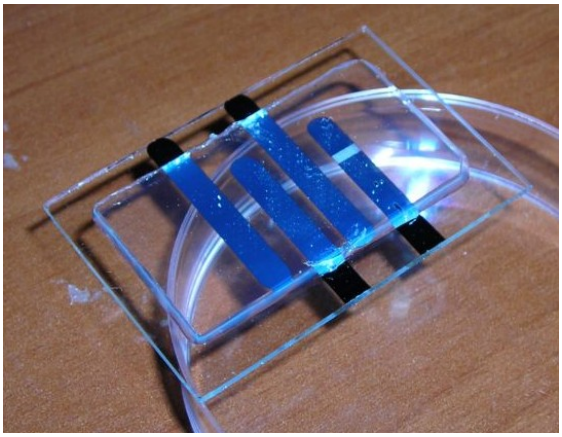


Figure 1: Bilayer Alq3-based OLED structure.

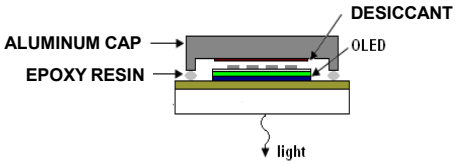


(a)

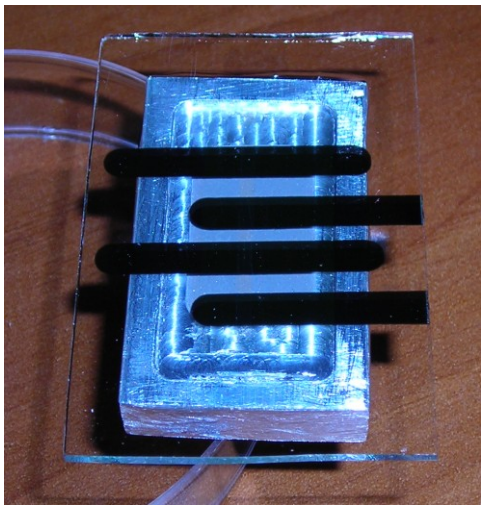


(b)

Figure 2: (a) schematic and (b) photo of package A.



(a)



(b)

Figure 3: (a) schematic and (b) photo of package B.

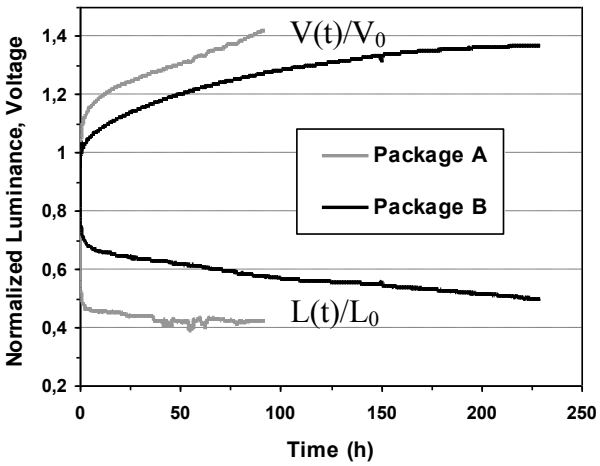


Figure 4: Normalized luminance and voltage vs. time for OLEDs in package A (L_0 = 1070 cd/m^2) and in package B (L_0 = 1023 cd/m^2).