ITO-free transparent top electrode for top emitting OLEDs

I. Verboven[1], G. Vandevenne[1], K. Gilissen[1] ,J. Manca[1,2] and W. Deferme[1],

inge.verboven@uhasselt.be

1) Institute for Materials Research (IMO-IMOMEC), Hasselt University, Diepenbeek, Belgium
2) IMEC vzw – Division IMOMEC, Wetenschapspark 1, B-3590 Diepenbeek, Belgium

Abstract: Organic light emitting diodes (OLED) are promising to be the next generation in lighting with a wide range of applications. When applied on a non-transparent substrate the OLED has to be top emitting through a transparent top electrode. For this electrode the use of a thin semi-transparent metal layer or a metal grid embedded in PEDOT:PSS could be suggested. This report shows that the latter has a higher transmittance and conductivity. The metal grids are ink jetted on the substrate. This non-contact deposition technique is well suited for maskless patterning and roll to roll production.

Keywords: e.g. OLED, ITO-free electrodes, metal grids, transparent electrodes, printed electronics

Introduction

The basic structure of an OLED consists out of an organic layer sandwiched between two electrodes. [1] When a voltage is applied across the OLED the organic layer will emit light. One of the two electrodes has to be transparent to perceive the emitted light.

In bottom emitting OLEDs on glass or PET, Indium Tin Oxide (ITO) is mostly used as a bottom transparent electrode. ITO however is becoming more and more expensive due to low indium reserves and causes crack formation on the surface because of his high rigidity. [2][3] Furthermore it cannot be used as a top electrode as the sputtering process to apply the ITO uses a temperature that would disintegrate the organic layer. [4] Two possible candidates to serve as transparent contacts were investigated: a thin semi-transparent metal layer and a metal grid.

Results and Discussion

Thin gold layers from 1 to 15 nm were thermally vaporized on glass. Silver grids (figure 1) with different shapes, hexagon and triangle, and different sizes were ink jet printed on glass.

To determine the conductivity the sheet resistance of each layer or grid was measured with the Van der Pauw set-up. With an UV-VIS measurement the transmittance could be obtained. The sheet resistance of the gold layers was typically between 3,2 and 123,7 Ω/□ and the transmittance between 25 and 68 %. The grids showed a better result in both conductivity with a sheet resistance between 0,82 and 2,7 Ω/□ and transmittance between 68 and 90 %.

Obviously the silver grids are the better choice. However they have to be sintered at a temperature of at least 130 °C that can cause damage to the organic layers. Additionally the grids have to be embedded in PEDOT:PSS which will decrease the transmittance with about 5 %.

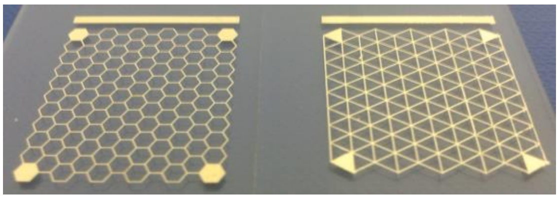

Figure 1: Silver grids.

Conclusions

As an ITO-free transparent top electrode both thin semi-transparent metal layers or metal grids can be used. Ink jetted silver grids show a better conductivity and transmittance than vaporized thin gold layers and are suitable for roll to roll production. The sintering temperature of the grids could cause the disintegration of the organic layers of an OLED. Therefore OLEDs with these silver grids will be produced to conduct more tests.

References

[1] A.Rockett, The Materials Science of Semiconductors, (Springer Science+Business Media, Urbana, 2008), 395-453

[2] M. Neophyto, G. Efthymios, M.M. Fyrillas and S.A. Choulis, Two step sintering process and metal grid design optimization for highly efficient ITO free organic photovoltaics, *Solar Energy Materials and Solar Cells* **122**, 1-7 (2004)

[3] Y.C. Han, M.S. Lim, J.H. Park and K.C. Choi, ITO-free flexible organic light-emitting diode using ZnS/Ag/MoO3 anode incorporating a quasi-perfect Ag thin film, *Organic electronics* **14**, 3437-3443 (2013)

[4] H.H. Yu, S.-J. Hwang, M.-C. Tseng and C.-C. Tseng, The effect of ITO films thickness on the properties of flexible organic light emitting diode, *Optics Communications* **259**, 187-193 (2006)

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