Plasma treatment of slot die coated polymer layers for OLEDs

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Organic light emitting diodes (OLEDs) have been widely explored in previous years due to their benefits compared to other light sources, such as light weight as well as possible transparency, flexibility and foldability. These devices consist of a certain number of stacked organic layers sandwiched between two electrodes. Organic layer deposition starts on top of a transparent anode in case of bottom emitting devices. ITO is typically used as anode layer for the preparation of bottom emitting OLEDs on rigid substrates. Silver grid structures or diffuse distributed nanowire films in combination with polymer overcoating are examples for anode layers which can be used for the preparation of flexible devices. The thickness of the organic stack hardly exceeds several 100 nm. Therefore, the anode has to be very smooth to prevent shorts due to ITO peaks into the organic layers.

The combination of liquid phase deposition and vacuum thermal evaporation appears to be a promising route for the preparation of reliable and efficient devices. A thick solution processed polymer layer between anode and evaporated organic layers is an approach for smoothing the anode surface. [2] The hole injection is heavily influenced by choice of the conductive polymer material. In the present work, the pH neutral polymer material Clevios™ HIL 1.3N SD is applied on rigid ITO substrates as hole injection layer (HIL). The coating process is done with a table slot die coater, providing 200 mm die width.

Oxygen plasma treatment of polymer HILs can improve device performance as shown by Chen *et. al*. [3] Herein we explore the influence of different plasma treatment procedures on the performance of OLED devices. The plasma process removes organic residues and activates the surface of the used polymer layer. Three procedures are compared: oxygen plasma, argon/oxygen plasma and no application of any plasma. The treatment was done in a vacuum tool immediately before the deposition of the hole transport layer.

First, plasma treated HIL's on ITO substrates were prepared for single layer characterization. Second, OLED devices were prepared on a separate set of plasma treated samples. All OLEDs were encapsulated under nitrogen conditions after finishing the evaporation process.

The single layers are characterized by atomic force microscopy, surface energy and spectrophotometer measurements. As expected, the oxygen plasma treatment increases the polar part of the surface energy up to 40% (Fig.2).

Fig.2: Sideviews of droplets of DI water, diiodmethane, and ethylene glycol (from left to right), on oxygen treated polymer layer.

OLEDs prepared on oxygen plasma treated polymer layers showed improved performance. Increased luminance as well as decreased leakage currents are observed in comparison to the argon/oxygen plasma treated and untreated polymer layers. The effect on the spectral radiance is discussed based on light out-coupling simulations.

Table 1: Lifetime determination.

Plasma	LT70 [h]	LT50 [h]
O_2	1111	3971
Ar/O_2	185	587
None	281	856

Initial luminance: 1000 cd/m².

The most significant difference is shown in the lifetime (LT) results, shown in table 1. The initial luminance was 1000 cd/m². LT50 (time for 50% luminance reduction) is almost improved by a factor of 5 for OLEDs consisting an oxygen treated HIL layer compared to OLEDs with an untreated HIL layer.

References

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