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A Novel Printable Process for Fabricating Large Size OLED Display

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The current method for organic optoelectronic device fabrication, small molecule-based organic light emitting diode (OLED) for example, is vacuum-thermal deposition using a shadow mask to locally pattern the individual layers.[1] For relatively small devices such as cell phones, tablets, and small displays these techniques work very well. However, shadow mask technology cannot provide the required uniformity over the large areas required for large displays. Additionally the vacuum-thermal process is expensive and wasteful. Thus, fabrication processes other than thermal evaporation are required. For several years there has been a large effort in developing solution printing processes [2,3,4,5]. However there is still not a commercial solution printing process. Materials limitations have been a barrier; but the ink-jet process has thus far been unable to deliver the required display quality. In particular pixel uniformity has been problematic.

We have developed a novel method of manufacturing OLED display devices by digital printing techniques. The light-emitting layer is produced in four steps:

1) A polymerizable/crosslink-able dopant emitter-receiving base layer is coated over a pre-coated hole-transporting layer. This layer has a glass transition temperature (T_g) below 80ºC.

2) A digital printing technique, such as ink-jet, is used to pattern emitter dopants on the surface of the light-emitting base layer.

3) The coated layers are heated to a temperature below 80ºC to diffuse the patterned dopant emitters into the base emitter layer to form the light-emitting pixels.

4) The organic light emitting layer is then subjected to actinic light to crosslink/polymerize the layer and improve its thermal properties.

This process eliminates the need for a shadow mask, provides efficient dopant diffusion at relatively low temperature and restores layer thermal properties for excellent device stability.

In this paper we demonstrate the feasibility of this novel process. An "ink", using Coumarin-6 as the emitting dye, was formulated with low boiling solvents and loaded into the ink cartridge of an Epson C88 ink-jet printer. The dopant ink solvent is chosen to be a non-solvent for the polymerizable/crosslink-able dopant emitter-receiving base layer. The base layer was a dope formulation of molaicular™ AMBI-120[6], a bipolar host material dissolved in acetone containing a photosensitizer and a plasticizing cross-linking agent. The dope was blade-coated on an aluminized substrate, using a 1 mil knife and dried on the coating block at 50ºC. The coated layer was ~2 microns. The aluminized substrate/base layer was fed through the Epson C88 ink-jet printer and the Coumarin-6 dye ink printed in rectangular patterns. Figure 1 (left) shows the as-printed dye illuminated with 360nm light. The printed fluorescent dye is clearly observable. The printed coating was then heated to 50ºC to effect diffusion of the dye into the base layer. The T_g of the base layer was slightly above room temperature. Emission spectra of the Coumarin-6 in the as-printed and dye-diffused emitter layer demonstrated that the spectral characteristics were essentially unchanged.

The Coumarin-6 ink was also printed on a control base layer of molaicular™ AMBI-120 (without crosslinker and photosensitizer). The Coumarin-6 fluorescence in this case, Figure 1 (right), is clearly visible but less intense than the dye-diffused sample. We interpret this difference to Coumarin-6 being on the film surface (right) or diffused into the film (left).

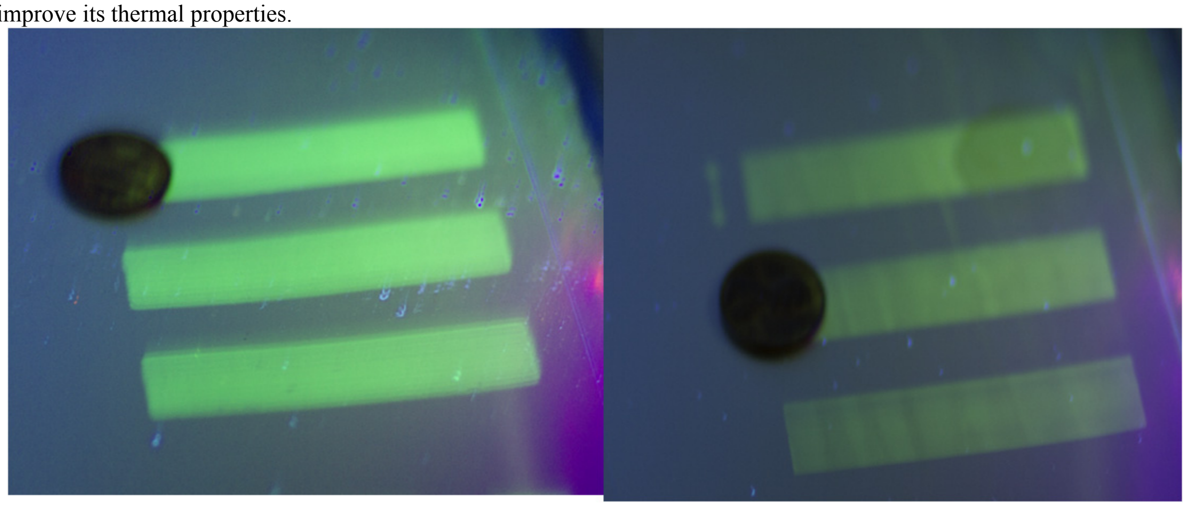

***Figure 1**. The picture on the left is of ink-jet printed rectangles of Coumarin-6 on a cross-linkable base layer of molaicular™AMBI-120 containing cross-linking agent and photosensitizer under 350nm illumination. The printed film was subsequently heated to effect diffusion of the dye into the film. The picture on the right is of the illuminated ink-jet printed Coumarin-6 on a neat molaicular™AMBI-120 base layer. (The penny was used to distinguish the two samples in the photographs.)*

Keywords
Crosslinkable Dopant-Receiving Layer, Ink-jet Printed Dopant Layer, Large OLED Display

Biography
Michel (Mike) F. Molaire is the Founder, President and CTO of Molecular Glasses, Inc. He received a BS (chemistry), M.S. (polymer science), and MBA from the University of Rochester. He retired from the Eastman Kodak Company as a Senior Research Associate in 2010. He has over 40 years of interdisciplinary experience in materials research and process development, project leadership, OEM technology sales, business analysis and planning. Molaire has been recognized for scientific research and reporting (the Eastman Kodak C. E. K. Mees Award) and for being a prolific inventor with 58 U. S. and over 120 international patents (Eastman Kodak Distinguished Inventor's Gallery). He is also the recipient of an African Scientific Institute Fellowship.

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