Fully Solution Processed Blue Colour Organic Light Emitting Electrochemical Cells (OLECs) with Silver-Nanowires (AgNWs) as Cathode for Top Illumination

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Abstract

Organic light emitting polymers can be formulated into solutions, that can be printed in ambient atmospheres and cured at low temperature process <120 ºC. the deposition techniques can be spin coating, spray coating and ink jet printing. This provides the possibility of fabricating OLECs onto to a range of flexible substrates including textiles, hence enabling wearable electronics. In addition, the utilization of different polymers could produce light emitting textiles in a range of colors. This work details the optimization steps and challenges involved in the fabrication of OLECs on Indium Tin Oxide (ITO) glass followed by the transfer of the process onto a textile. A blue emitting polymer Merck (NCMP) is used for the active layer and the device fabrication process is carried out at low temperatures in an ambient atmosphere. Working devices have been created on ITO to achieve the top illumination with the next phase being the transfer onto textile.

Introduction of OLECs

- Organic light emitting electrochemical cells (OLECs) are thin film devices fabricated to emit any colour based on the functional character in the organic semiconductor active layer at low voltage. There are commercially available light emitting polymers available and this work uses a Merck Blue emitting polymer.

- The mobile ions are blended internally or externally with the organic semiconductor in the OLEC active layers and will redistribute across the junction in the active layer when the device is biased. The electrons and holes formed can be efficiently injected into a single layer of the LEC active material from the top (cathode) and bottom (anode) electrodes to emit bright light.

OLECs Architecture and Fabrication

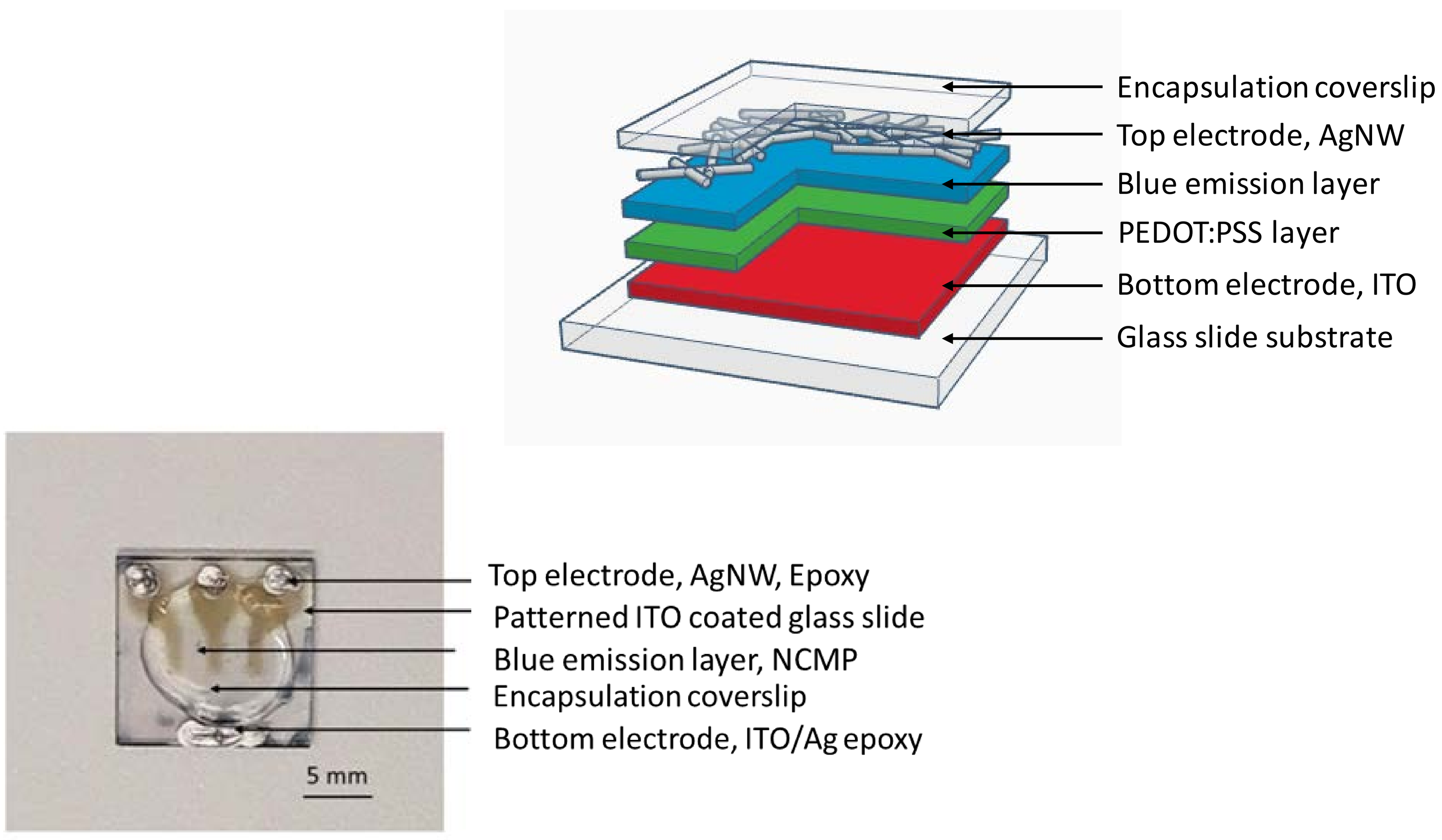

Figure 1. *Pictorial representation of the solution processed OLECs on glass slide (bottom left), and isometric view of the schematic OLEC architecture (top right).*

- Figure 1 shows the schematic OLEC architecture and the device fabricated in this research work. The optimisation work is carried out on a pre-coated ITO glass substrate prior to being transferred to a textile. As can be seen from the image most of the layers are transparent, however, when the device is produced on the textile all the layers including the top electrode will need to be transparent for top emission of light from the cell.
- Fabrication involves using a pre-coated ITO glass slide as the substrate and bottom electrode. Both PEDOT:PSS and active layers were spin coated and dried on hotplate in ambient environment. For some of the optimisation work sputter silver electrode is used, although, in the image above AgNWs were spray coated with a shadow mask; as part of the investigations into a transparent top electrode. Finally the whole device was encapsulated in a glovebox with a UV curable materials with a thin coverslip to protect them from oxygen and moisture during measurement.

Result and Discussion

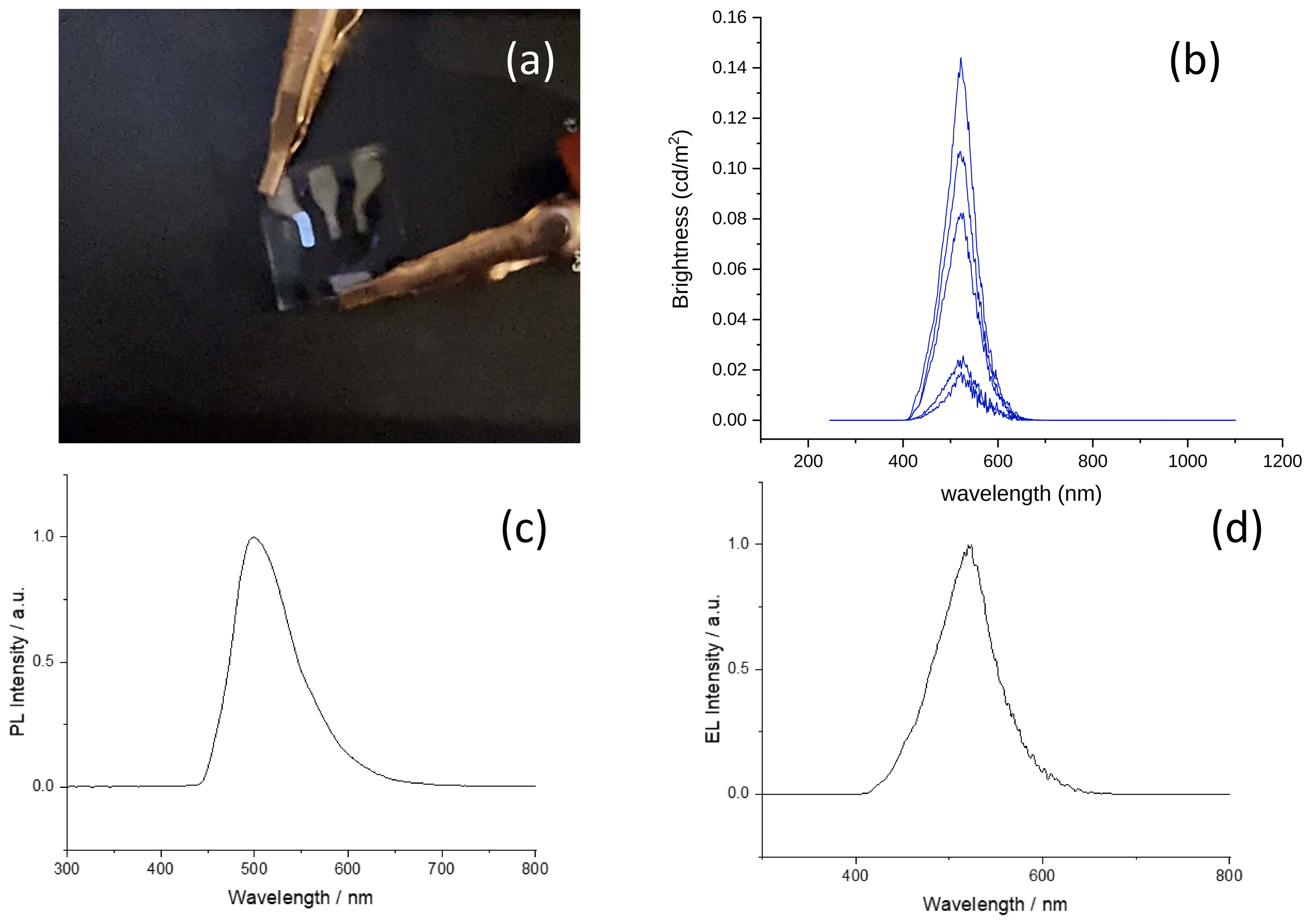

Figure 2. *(a) Merck (NCMP) device with Silver top electrode lit up, (b) Brightness captured in 2mm^2 electrode, (c) Photoluminescent (PL) intensity spectrum obtained by laser excitation on the Merck NCMP in cyclohexanone solution, (d) Electroluminescent (EL) intensity spectrum obtained by electrical biased at 6 V on the NCMP OLEC (Spectrometer integration time of 500 µs),*

- Each layer of the LEC fabrication process was optimized. This has so far included, optimizing the coating and drying of the PEDOT:PSS layer; testing different concentrations of the three components in the active layer formulation; optimizing the spin coating and drying of the active layer formulation; and testing different post fabrication process steps and encapsulations.
- Optical properties of blue emitter were also assessed, using the ultraviolet/visible (UV/Vis) spectrophotometer and photoluminescence (PL) by laser excitation, as shown in Figure 2 (c) whereas, (d) shows the EL spectrum of the biased OLECs, indicating the peak of 520 nm within the blue region.

Conclusions and Further Work

- Blue emitting OLEC devices have been successfully fabricated, in an ambient atmosphere, on ITO pre-coated glass substrates. A commercially available blue emitting polymer was utilized as the active layer. The PEDOT:PSS and blue emitter layers are around 100nm each to get bright light emission devices and good junction resistance. AgNWs top electrode was used to achieve the translucent cells for potential migration to textile substrate, although other more transparent electrodes will be investigated.

Acknowledgement

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