Functional Electronic Screen-Printing – Electroluminescent Lamps on Fabric

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Summary

A planar electroluminescent (EL) lamp has been screen-printed directly on to woven fabric to create a smart fabric lamp. The EL lamp consists of six printed layers and has been produced in colours: light blue, dark blue, and orange. The printed structure has high durability whilst maintaining the flexible properties of the fabric. The lamp developed in this work is only printed in the desired area thus maintaining the breathability and comfort of the overall woven fabric. The printing process relies on an 'interface' layer developed at the University of Southampton [1] to smooth the woven fabric surface where required, presenting a more homogenous surface than the underlying fabric for the subsequently printed functional layers. Distinct printed layers are produced with layer thickness ranging from 10 µm to 170 µm depending on the number of deposits and the paste used.

Motivation and results

Better integration of electronics into everyday life has been an aim for many years, particularly in relation to wearable electronics [2]. We present a novel method of fabricating electroluminescent lamps by screen-printing directly onto woven fabric. Woven fabrics are already used widely in clothing, as they are comfortable, flexible, and washable. We have previously developed a method allowing screen-printing of conductive tracks directly onto fabric [1]. This work has now been expanded to allow screen-printed electroluminescent lamps on fabric. Screen-printing allows any pattern to be printed in any orientation with respect to the fabric warp and weft directions. It also allows paste to be placed directly on top of the fabric so properties next to the skin are unaffected.

The printed lamps have been produced in three colours, shown in Figures 1 and 2. The changes in colour are controlled through varying the phosphor particles used in the printing process. Fabric flexibility properties are maintained as shown in Figure 2, allowing a range of wearable applications without restricting movement. The printed lamps are fabricated in a capacitor structure using six individually printed layers as shown in Figure 3 and described below:

- Interface layer: reduces the surface roughness of the fabric.
- Bottom electrode layer: provides one side of the capacitor structure.
- Dielectric layer: prevents short circuits across capacitor structure and acts as a reflector.
- Phosphor layer: the phosphor emits light under the influence of an electric field.
- Top/bus electrode layer: provides connection to the top electrode.
- Semi-transparent electrode layer: provides an even distribution of charge across the phosphor layer for improved light distribution.

Curing requirements were considered when selecting the pastes, as printing onto fabric places constraints on the maximum achievable temperature. The lamps in this work were printed on a 65% Polyester 35% Cotton blend; a similar fabric is used in much of the clothing industry and could be used in applications such as warning workwear. The fabric began to discolour above 140ºC, therefore all of the pastes used were either UV curable or cured below 130 ºC.

An SEM micrograph cross-section of an EL lamp is shown in Figure 4 to highlight the multilayer structure of the device.

References

[1] K. Yang, R. Torah, S. Beeby, and J. Tudor, Flexible and washable conductive textile achieved by screen printing for smart fabric applications, *13th AUTEX World Textile Conference 2013*.
[2] X. Tao, Smart Fibres, Fabrics and Clothing: Fundamentals and Applications, Woodhead Publishing, 2001.

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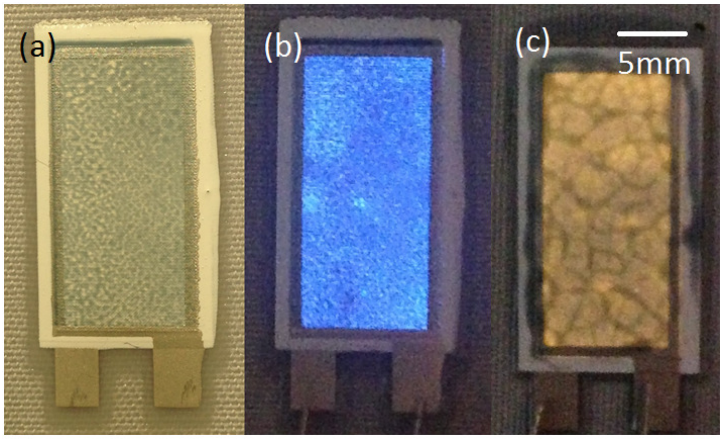

Figure 1: Screen-printed EL samples on fabric (a) Unpowered, (b) Dark blue powered, (c) Orange powered.

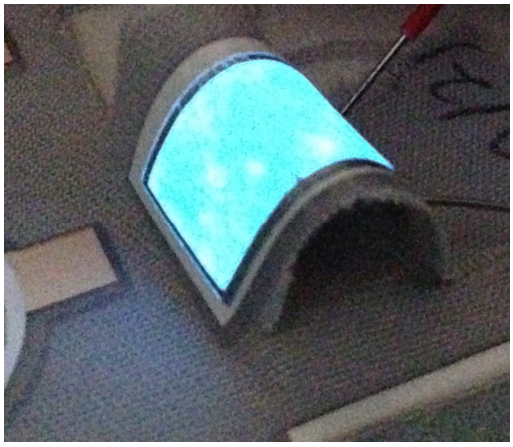

Figure 2: Screen-printed light blue EL lamp on fabric showing maintained fabric flexibility.

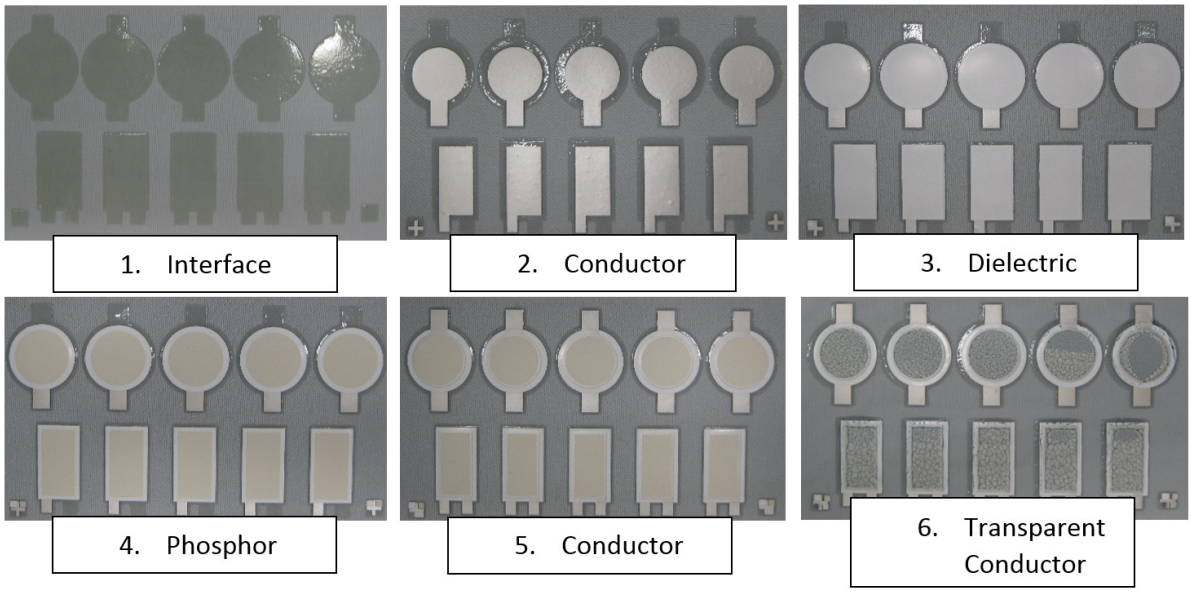

Figure 3: 6 individually printed layers built up to produce EL display.

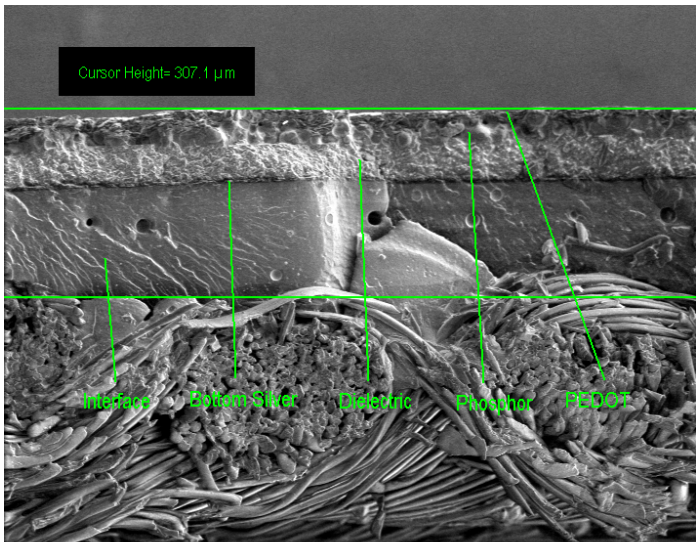

Figure 4: SEM micrograph showing EL lamp cross-section.