Documentation Project Printed Electronics

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Abstract. The concept of printing electroluminescent pixels is explained. The process of high resolution printing with screen printing and its difficulties are shown.

Keywords: printed electronics, electroluminescence, conductive ink, TDEL, TFEL

1 Introduction

Printed electronics is a recent technology. Olberding, Wessely and Steimle [4] focused their work on the usage of printed electronics for HCI via electroluminescence. The key concept to printed electronics is to use inkjet or screen printing to print conductive ink on some surface. This has some mayor benefits as it is cheap and flexible.

It is also possible to print the layers needed for electroluminescence (EL) foil. The technology to print electroluminescence for displays is known since at least 1983 [5]. Electroluminescence foil works by arranging layers like in a capacitor (two electrodes and a dielectric in between). Between the dielectric and one conductor an electroluminescent material, usually zinc sulfide doped with manganese [6], is added. Once you apply alternating current the material starts to emit light. The electroluminescent material is called phosphor.

2 Current Technology

There are some companies who build displays using EL technology (e.g. iFire Group Ltd and Beneq). iFire Group made big claims for color displays but it is said they stopped production [7], [1] while mono-color-displays by Beneq are available today. The abbreviation $TDEL$ is used for thick-film electroluminescence by iFire [3] while $TFEL$ is used for thin-film by Beneq [2]. A big advantage of EL is that it should be possible to build a curved display. Another advantage of EL displays are that they don't use liquids so they are more robust; however, UV-light degrades the material.

If you find a way to emit blue, green and red color it should be possible to build an RGB display. There exist differently colored phosphors. Problem with using different colors is that the colors are very expensive. By placing the colors

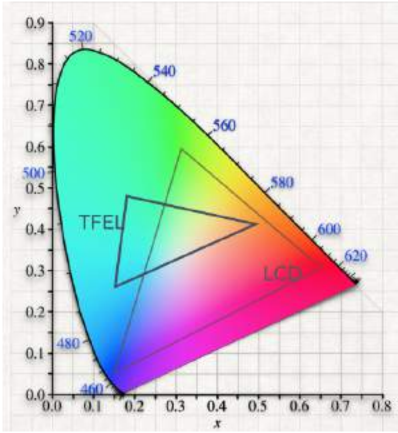

Fig. 1. The color range which is possible with the available colors.

on the CIE color diagram it is possible to identify the range of colors which can be displayed by the display (Fig. 1). The farther the edges of your convex hull of the polygon lay on the diagram the more colors you can perceive. For the colors the company Gwent Group can deliver the triangle is smaller then for usual LCD displays. According to iFire, they use frequency shifting materials to shift the bright blue color to red and green.

3 What I Tried

I wanted to know what sizes of EL are possible to print. The resolution of a display should be determined by the size of the pixels. I printed differently sized pixels on paper using a hand bench (Fig. 2). The edge lengths of the phosphor squares were 10 mm, 5 mm, 3 mm, 2.5 mm and 1.25 mm. The screen, a 100 yarns/cm, was lit with photosensitive material. Because the development room for the exposure was improvised the resulting screen had some minor flaws. Some threads had some material left in the gaps.

Because the prints needs such a high precision one print was misaligned by some millimeters, but I printed the layer on top at a better position. It not easy too aligh the print by looking through the screen, but it is possible.

Half of the prints have two layer of dielectric because they looked as if the printed results were too thin.

4 Results

Surprisingly it is hard to access single pixels. In theory if you light a row and a column only the intersection should ignite; however, cells ignite which should stay dark (Fig. 8). Even attaching the poles to two columns or two rows light up

Fig. 2. The used printing bench

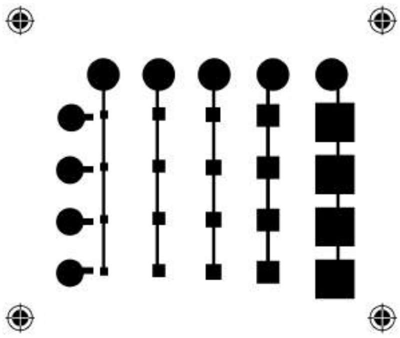

Fig. 3. Top electrode layout

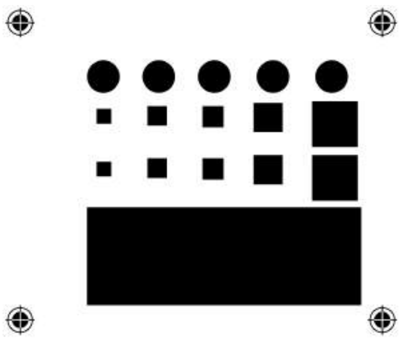

Fig. 4. Dielectric layer

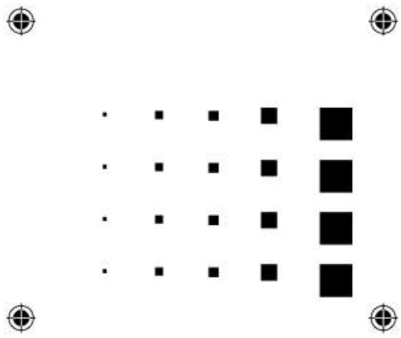

Fig. 5. Phosphor (luminescent material) layer

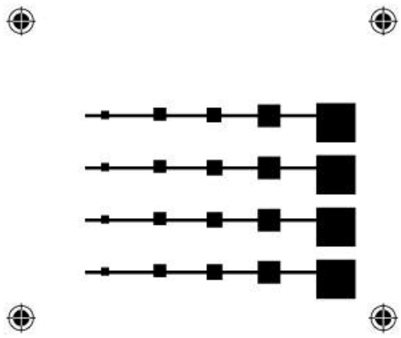

Fig. 6. Translucent Electrode Layer

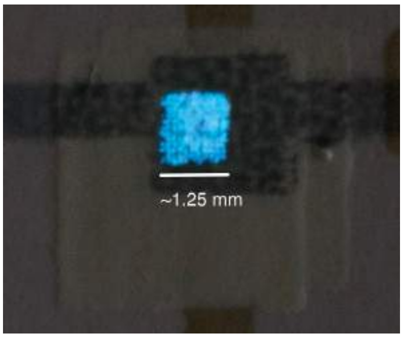

Fig. 7. One of the smallest pixels. A pattern of the threads can be seen. Other pixels had not such a pattern, so this may be caused by the exposure of the screen.

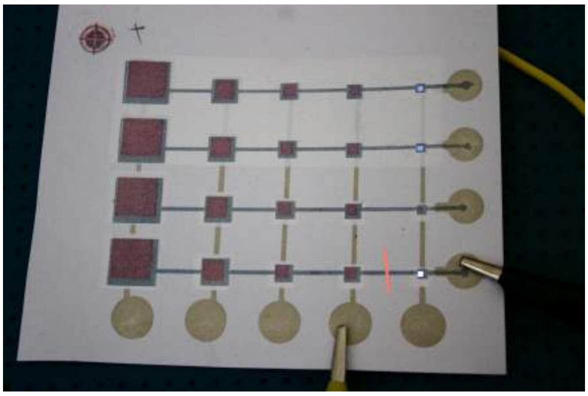

Fig. 8. Some pixels light up, but they should not. The connection with the red mark on it is broken.

some cells. Reason for this must be that the current flows from the bottom to the top layer or vice versa. I could not measure a resistance below 2000 kOhm with a multimeter or detect connectivity with the connectivity test, so I could not locate or confirm this hypothesis. Prints with a double dielectric layer did not behave different from singe layer prints.

Printing a bigger area of the dielectric had no effect (big area can be seen at Fig. 4).

Some pixels created some sparks and burned after power was applied. This is another indicator that the problem lays in the dielectric. Attaching one pole to the transparent ink burned the lines so that the current flow stopped. Reducing the resolution may also cause more problems with this layer because the layer is less homogenous.

All pixels worked as intended. Differences in brightness were mostly due to different connections and resistances caused by the problem explained above.

5 Conclusion and Future Work

Printing small pixels down to an edge length of 1.25 mm is possible with a hand bench. 100% of the smallest pixels worked when powered. It should be possible to print even smaller pixels. The space needed between two electrodes of two neighbor pixels remains unclear. Assuming a space of 0.1 mm between the pixels and a pixel size a little smaller then 1 mm it should be possible to have a resolution of 23 ppi. Different surface materials, as tested by the team of Olberding, Wessely and Steimle, may give different results. Because high accuracy is crucial in the process, printing high resolution displays with a different design should give better results: Black background layer, bottom electrode, transparent dielectric layer, luminescent layer, transparent top electrode (Fig. 9). This design needs one printed layer less which favors the accuracy. Using this design may also solve or improve the unwanted current flow.

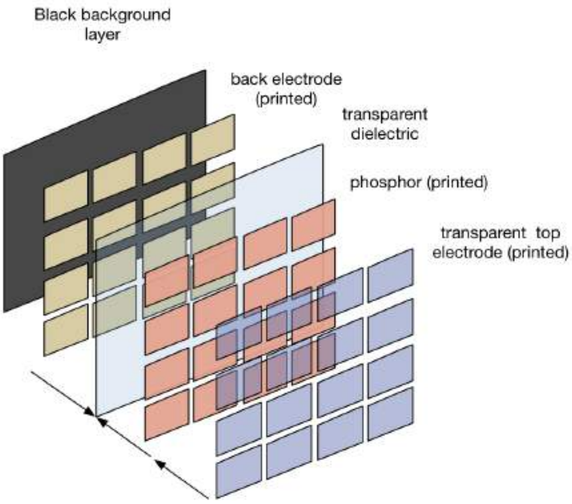

Fig. 9. New design proposal.

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