Circuits Unusual

by Ken Gilleo, PhD

March 1, 2007

The Real Printed Electronics

Our industry has become very skilled at printing circuits, but we've had about 80 years of practice actually printing conductors and dielectrics. In the 1920s, circuit pioneers printed conductive inks made with graphite and, later, powdered metals such as copper and silver. But a visionary dream of many who worked on printing conductors was to print all of the electronics, including components. Printed passive devices, like resistors and capacitors, were relatively simple, and methods were developed during WWII. The idea of printing active devices was not even a consideration until the advent of solid-state electronics. Printing active electronics components would prove to be a greater challenge that would require special and complex materials, and newer printing processes for commercial viability.

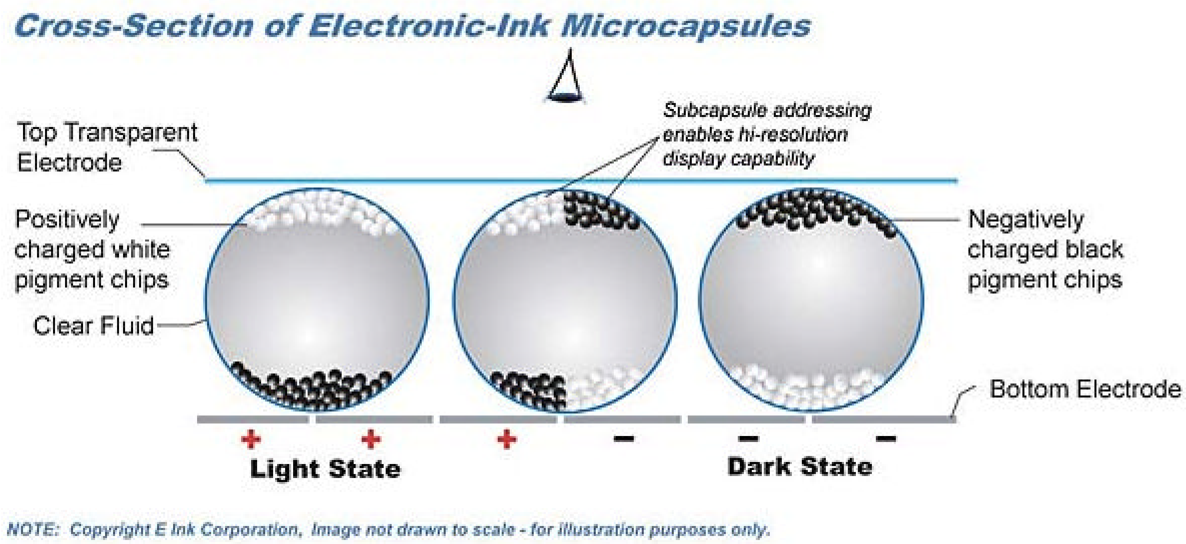

Figure 1 E Ink Imaging Film

The polymer thick film (PTF) industry, a rather small niche in the PCB industry, relies heavily on screen printing to apply most anything. PTF researchers, long familiar with printing conductors, dielectrics, adhesives, light panels, and even sensor electrodes, believed that diodes, and probably transistors, might be screen printed in the future. But only small steps were made in this emerging field called "printed electronics." We were able to print crude diodes, using doped intrinsically conductive polymers, but not much else. The distant hope of printing integrated circuits continued, however, but neither the PCB nor membrane switch industries were in a position to finance such a high-challenge and high-risk endeavor. But 1994 held an important breakthrough when the French National Center for Scientific Research reported the first all-organic transistor [1]. The literature indicates that organic transistors were demonstrated in the mid-'80s, however, but with help from solid metal components and non-printing methods. While early organic transistor fabricators used vacuum deposition and laminating, the ultimate goal was to *print* electronic components [2].

Figure 2 Sony book reader.

Where is *printed electronics* today? Four technologies appear to be coming together to produce the right mix for success. The three somewhat obvious areas are nano-particles, micro-fluid jetting, and advanced organic semiconductors. But a fourth area, and one that is less technically related, is providing economic incentive to bring printed electronics into commercial reality soon. This important fourth ingredient has been called "electronic paper," or e-paper: electronic paper display. Although developments span many decades, with dozens of companies playing a role, E Ink (an MIT spinout start-up) has emerged as an important leader today. The technology has the elegance of simplicity, making it a potentially powerful contender in the fast-paced flat panel display sector. The display film is essentially an array of "light valves" consisting of microencapsulated "ink" (electrically controlled opacity) that responds to an electrical charge.

Figure 1 shows the concept from E Ink. So far, so good, but how do we add the driver circuitry, the control matrix to turn pixels on and off? Fortunately, there is a profusion of active matrix technology in the flat panel display industry. We can just bond a glass thin film transistor (TFT) active matrix back panel onto the plastic imaging film because no direct electrical contact is required. This is what E Ink did, and the system seems to work just fine. Sony's new book reader (Figure 2) and Motorola's MOTOFONE are recent design wins, but expect to see many more in 2007. Because the display sheet is flexible plastic, wouldn't it be neat to apply a flexible backplane driver?

Imagine a practical flexible roll-up display? What a grand idea, but where do you find a flexible active matrix? Now enter printed electronics. Just apply the TFT to plastic film. Many have been working on flexible active device substrates for a considerable length of time and a few companies have had enough success to stay in the game. One of these companies is Plastic Logic, which is in partnership with E Ink. Plastic Logic, a start-up spun out of

Cambridge University, recently announced they would build a plant in 2007 to produce flexible printed electronics the following year [3]. This is exciting, especially to us old screen printers who have been telling everyone that printed electronics is just around the corner—well, maybe it was 20 corners. But finally, it's happening, and we sure hope to see high-volume printed electronics in 2008 and beyond. And while the launch is for TFT driver arrays, it's a beginning where the end cannot be predicted, even by those involved. Just think about how long it took solid-state semiconductors to go from the transistor to powerful CPUs. What is especially noteworthy is that two companies separated by an ocean, and each launched by two different universities, are literally merging their technologies to produce an important and unusual display technology that will enable a plethora of new products. So when you read e-paper print, keep in mind that behind the scene is "printed electronics." (Next time, we'll look at materials and methods.)

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References

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2.. Gilleo, K., Polymer Thick Film, Kluwer Academic Publishers Group (first printing 1994, by Van Nostrand Reinhold). See Chapter 6 - Printed Components.

3.. Plastic Logic announcements; see http://www.plasticlogic.com