AMOLED TFT VGA DISPLAY ON FLEXIBLE METAL FOILS WITH INTEGRATED ROW DRIVERS

Matias Troccoli*, Themis Afentakis, Ta-Ko Chuang, Abbas Jamshidi, Yu-Lin Chang, Miltiadis K. Hatalis,
Display Research Laboratory,
Department of Electrical and Computer Engineering
Lehigh University, Bethlehem, PA

Apostolos T. Voutsas, Masahiro Adachi, John W. Hartzell
Sharp Laboratories of America Camas, WA

Active Matrix Displays on flexible substrates present a novel and exciting application of Thin Film Transistors (TFT) microelectronic processing. This new technology has the potential of producing displays and similar active matrix arrays with large resolutions and considerable cost savings over the established processes (amorphous Silicon a-Si:H or silicon on Insulator SOI) on quartz or glass substrates, especially if fabrication is performed in a roll-to-roll fashion. Other advantages include lower display weight, higher versatility and increased ruggedness. Numerous applications have been targeted such as electronic paper, electronic textiles and tablet PC displays, to name just a few.

Polymers have been the basic contender for theses applications, and have received a growing research interest in the past few years. However, they are found to be the reason for a number of drawbacks, the most important of which is their reduced compatibility with standard CMOS processing, and the resulting low device stability. Although NMOS devices with mobility values around 100cm^2/Vs are feasible, the lack of high temperature steps compromises device stability, which becomes evident under higher voltages. This might not be a serious issue with Liquid Crystal Displays, since the active pixel element has to operate mainly as a digital switch, in which case the ON and OFF values of drain current are more important, and even low mobility devices can switch fast enough to comply with display timing specifications. On the other hand, Organic Light Emitting Diode (OLED) displays require pixel TFTs that operate as current sources passing current throughout the operation cycle, so stability is more critical and stressing more severe.

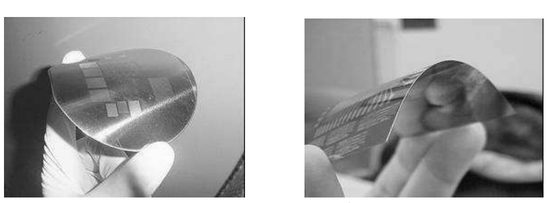
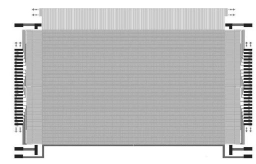


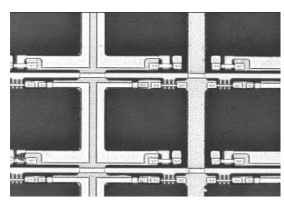
Fig.1: Generations 1 and 2 flexible arrays

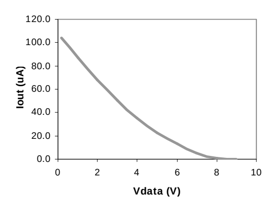
It should also be mentioned that the integration of driver circuitry with the display architecture may pose additional challenges for polymer substrate implementations, tightening the acceptable limits for stability variations (mobility and threshold voltage) with time. Finally, plastic substrates have to be isolated from the rest of the process line in a micro fabrication facility, to protect against chemical contamination. Thus, it is obvious that some of the advantages of plastic substrates are balanced –at the time of this writing– by certain serious drawbacks.

Thin metal foils represent an excellent alternative to polymers for use as flexible substrates, for a variety of applications. They offer superior chemical resistance in a number of environments compared to plastics, and they are compatible with high temperature processing. This is especially important in both fabrication and finished product use. The ability to utilize higher temperature processing on a substrate that allows higher thermal budgets is shown to increase device stability. In the case of stainless steel for example, high temperature steps such as thermal oxide growth, thermal dopant activation, silicide growth etc at temperatures as high as 1000^{o}C pose no problem. This also ensures that the finished product will work adequately at temperatures higher than room temperature without considerable performance degradation.



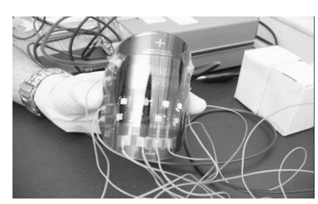
The display array presented in this paper consist of 480 by 640 125um pixels forming a full VGA display with a 4in. diagonal (above). The standard 2 TFT pixel circuit is implemented with PMOS transistors. (250 micron pixel showed below with its output characteristics)





The integrated row drivers are implemented with Static Shift Registers that were selected based on stability, reliability and yield from a variety of tested designs. The operation speed of the Shift registers ranges from a few Hertz to several MegaHertz, which puts them well within the operational range for VGA row driving speeds of approximately 50Khz.

Both n-channel and p-channel excimer laser re-crystallized poly-silicon devices with effective mobility values in the region of 350cm^2/Vs and 150cm^2/Vs respectively, and ON vs. OFF current ratios of at least seven orders of magnitude have been fabricated.



Due to the opaque nature of the stainless steel substrates, the light emitting devices are top-emitting OLED's. We are adopting Polymer OLED's, with a PEDOT Hole transport layer and a PPV light emitting layer and to reflect the light from the anode gold is sputtered or evaporated before forming the OLED. The light passes through the cathode which consists of thin ITO and aluminum layers. (Passive OLED's showed above)

The finalized array will be presented in the final paper and study results on power consumption, light efficiency, display flexibility and driving schemes will be discussed.