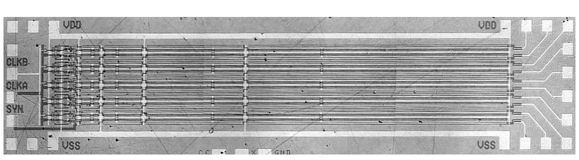
HIGH PERFORMANCE TFT CIRCUITS FOR ALL-INTEGRATED SYSTEMS ON STAINLESS STEEL FOILS

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

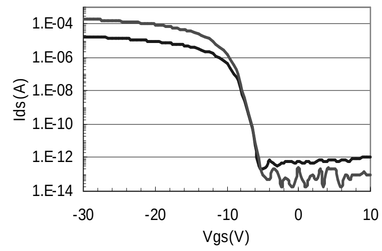
Apostolos T. Voutsas, Masahiro Adachi, John W. Hartzell
Sharp Laboratories of America Camas, WA

In an attempt to fabricate all inclusive systems we are presenting a study on several circuits that would be used as building blocks for all-on-board integrated applications on stainless steel foils. These systems would include in the same substrate all or many of the components of a modern day communication device such as PDA or cellular phone. We are reporting results on both digital and analog circuits on stainless steel foils. An extensive study on shift registers running at speeds greater than 10MHz is shown as well as oscillators operating at over 40Mhz (both speeds are an order of magnitude faster than previously reported results). Converters, decoders and amplifiers are also shown.

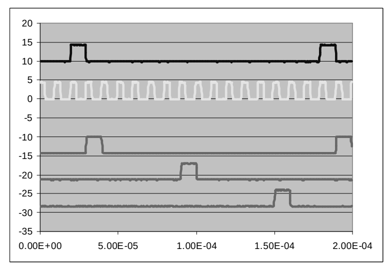
The device technology of choice is that based on poly-silicon TFT technology as it has the potential of producing circuits with good performance and considerable cost savings over the established processes on quartz or glass substrates (amorphous Silicon a-Si:H or silicon on Insulator SOI). Flexible substrates offer additional properties over silicon or glass that make them more attractive to these brand of products (roll-to-roll processing, lower weight, higher versatility and increased ruggedness to name a few). Polymers substrates 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. 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.



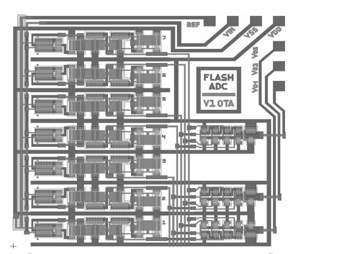
Thin metal foils represent an excellent alternative to polymers for use as flexible substrates, for a variety of applications (Shift register on stainless steel shown above). They offer superior chemical resistance in a number of environments compared to plastics, and they are compatible with high temperature 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.



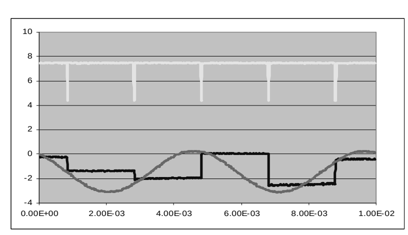
High-speed polycrystalline silicon thin film transistor digital circuits, including ring oscillators and various shift register architectures have been fabricated. Both n-channel and p-channel (above) excimer laser re-crystallized poly-silicon devices with effective mobility values in the region of 300cm^2/Vs and 100cm^2/Vs respectively, and ON vs. OFF current ratios at least seven orders of magnitude have been fabricated, and their characteristics are presented in this paper.



Ring oscillators running at frequencies above 40MHz are described, along with static and dynamic shift registers, with maximum clock frequency exceeding 10MHz. Effects of channel length and design architectures on speed are evaluated. The presented results (above) indicate the potential of this circuits for possible row a column driving for displays or memory addressing.



For those systems with sensing and communication capabilities, mixed signal circuits are required. To that purpose, we developed several analog circuits including operational amplifiers, sample and hold circuits for data buffering, D/A and D/A converters, and decoders. (ADC shown above, Sample and Hold readings below)



REFERENCES

[1] T. Afentakis et al, 2003 SPIE Fall Meeting ‘ Polysilicon TFT AM-OLED on Thin Flexible Metal Substrate’

[2] S. Wagner et al., 1997 Symposium on Amorphous and Microcrystaline Silicon Technology, pp.843-849, (1997)