Oxide TFT Backplanes for Large Area Circuits and Systems

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The growing maturity of thin film transistor (TFT) technology coupled with newly emerging materials and processes are enabling integration of systems for a family of new applications ranging from active matrix OLED displays, and augmented human-machine interactivity, to sensing systems [1]. In particular, the oxide semiconductor (see Fig.1) is becoming a key technology for these applications. It exhibits high transparency as well as high electron mobility at low fabrication temperature (see [2] and references therein). This paper will discuss the development of oxide TFTs for displays, including interactivity (see Fig.2), and present a contrasting study with LTPS backplanes (see Fig. 3) from the standpoint of system design and compensation techniques for V_T instability and OLED degradation [4]. Besides pixel circuits and display systems, TFT-based analog and digital circuitry for signal processing and wireless power transmission are required for realization of heterogeneously integrated systems that can be realized using a combination of oxide and other technological routes on disposable/recyclable substrates (see Fig.4). Such systems place great demand for expedient CAD tools to accurately and to reliably predict system behaviour. We review physically based CAD models, taking into account the relative dominance of the carrier transport mechanisms (see Fig.5) in the TFT, along with circuit examples.

References:

[1] R. Chaji and A. Nathan, Thin Film Transistor Circuits and Systems, Cambridge University Press, 2013.

[2] S. Lee, S. Jeon, R. Chaji, A. Nathan, “Transparent semiconducting oxide technology for touch free interactive displays,” Proc. IEEE, in press.

[3] S. Jeon, S.-E. Ahn, I. Song, C. J. Kim, U-I. Chung, E. Lee, I. Yoo, A. Nathan, S. Lee, J. Robertson, K. Kim, “Gated three-terminal device architecture to eliminate persistent photoconductivity in oxide semiconductor photosensor arrays,” Nature Materials, Vol.11, No.4, pp. 301-305, Feb. 2012.

[4] R. Chaji and A. Nathan, AMOLED panel design considerations for LTPS and MOx backplanes, SID Display Week, 2014.

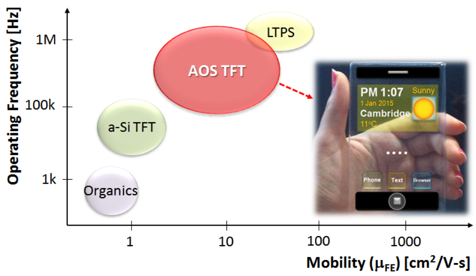

Fig.1 Materials for TFTs showing frequency capability.

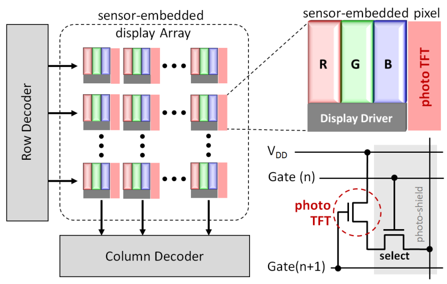

Fig.2 Oxide TFT backplane with image sensor [3].

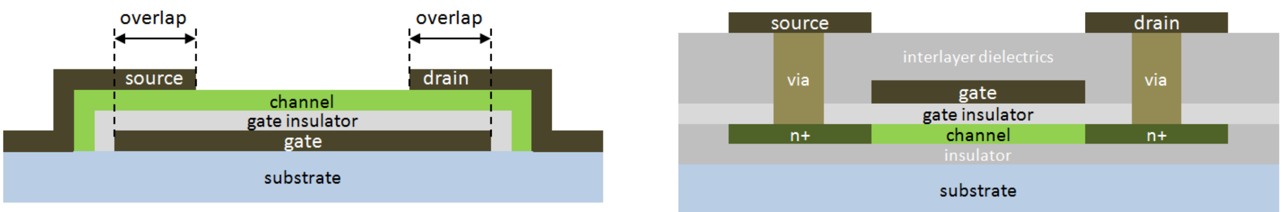

Fig.3 Cross-sectional views of oxide and LTPS TFTs illustrating parasitic capacitances.

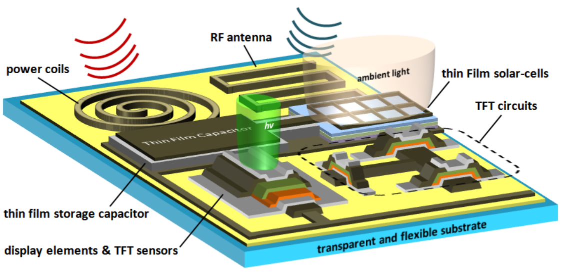

Fig.4 Architecture of heterogeneously integrated system.

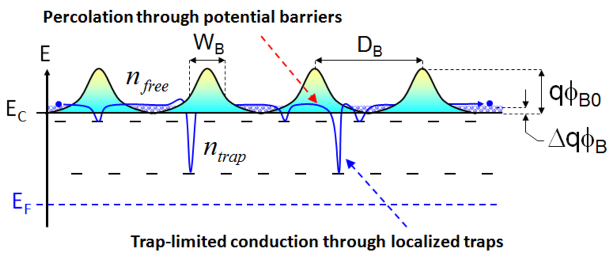

Fig.5 Illustration of transport mechanisms in oxide TFTs.