

Thin-film transistors and circuit-design styles for scalable control and access functionality over sensor arrays on plastic.

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Abstract

Large Area Electronics based on amorphous silicon thin-film transistors (a-Si:H TFTs) has enabled the development of “systems-on-plastic”. Thin-film transducers, processed at low temperatures on polyimide sheets, have been proposed for inexpensive and conformal sensor arrays capable of covering large surfaces [1] [2]. Access and control over such arrays requires integrated large-area circuits based on TFTs. For scalable control circuitry with low static power dissipation and large logic swings, despite single-carrier a-Si TFTs, we develop a logic style employing dynamic circuit techniques and capacitive bootstrapping. We implement this and demonstrate two passive integrated large-area platform components: (1) an a-Si TFT circuit for control logic and (2) a low-impedance sensor-access switch. These components enable circuits for controlling many sensors using a minimal number of interface signals.

For the logic style, we develop key thin-film components on polyimide: (1) a-Si TFTs matched to appropriate circuit requirements, (2) a-Si diodes for efficient dynamic node charging, (3) integrated capacitors for dynamic operation and bootstrapping, (4) vias and metal-layer crossovers. The dynamic control circuit employs blanket-passivated (Silicon Nitride, SiN_x), back-channel etched TFTs (deposited by PECVD at 180°C). TFT gate dielectrics are optimized for minimal gate leakage (0.1pA at V_{gs}=10V), essential for maintaining in-circuit dynamic nodes. Etching processes are chosen for minimal source-drain leakage at V_{gs}=0V (1pA), sufficient uniformity in threshold voltages as well as large on-off ratios [10⁷ at 15V/0V]. TFTs are thus sufficiently off with 0V control signals. These TFT improvements are important for developing reliable SPICE models for dynamic circuit design. For the sensor readout circuit, interdigitated access TFTs are developed with large W/L [60000/6um] to enable low-impedance readout of sensors. a-Si Schottky diodes are engineered to provide low-voltage drop and good forward/reverse characteristics. In-circuit metal-dielectric-metal capacitors are formed with the TFT gate dielectric used as insulator. In-circuit TFT terminal connections are designed to minimize interconnect and via resistance (<10Ω) by careful choice of layer deposition sequences and via metals. Interconnect cross-over shorts are avoided by retaining selective portions of the TFT stack in between metal layers to provide adequate isolation. For wiring, Cr/Al/Cr metal layer stacks are chosen for fabrication on plastic (e.g. better-matched coefficients of thermal expansion), avoiding interconnect cracking and peeling, whilst still maintaining good TFT electrical properties.

We will emphasize device- and circuit-level design choices that enable uniform device characteristics and good operation of the circuits we have implemented for a sensing system-on-plastic.

[1] Someya et al. MRS Bull. 33, p. 690, 2008

[2] Wagner et al. Phys. E, vol. 25, 2-3, p. 326, 2004

Keywords: a-Si TFTs, sensing, system-on-plastic, multiplexing, circuit reliability, dynamic logic, integration, sensor readout