

TFT-Based Calibration Circuit for Thin-Film Photoconductors

T. Moy, W. Rieutort-Louis, J.C. Sturm, S. Wagner and N. Verma

Department of Electrical Engineering, Princeton University, Princeton, NJ, 08544, USA

email: tmoy@princeton.edu

Experimental large-area electronics (LAE) sensors, such as thin-film photoconductors, have inherent processing variability and defects. This variability makes analyzing sensor data challenging, as it is difficult to determine whether fluctuations in outputs are due to detected physical changes or variations in the sensors themselves. In this work, we present a calibration circuit, which provides both amplification and the ability to individually tune the outputs derived from thin-film photoconductors, to overcome these challenges imposed by sensor variability.

Since a photoconductor can be modeled as a variable resistor (i.e. due to changes in illumination), it is typically configured as a leg of a voltage divider, with the sensor output provided as a voltage (Fig. 1a). However, the presented calibration circuit incorporates a thin-film transistor (TFT) to tune the voltage-response generated by a connected photoconductor (Fig. 1b). That is, varying the gate bias of the TFT proportionately changes the current, I_{Out} , through the photoconductor, as seen in the linear transfer curves simulated using a Level 61 SPICE amorphous silicon (a-Si) TFT model (Fig. 1b). These calibration biases are programmed into the a-Si TFTs by exploiting controlled threshold-voltage shifts based on nitride charge trapping (1). Thus, for a fixed bias, V_{Bias} , the programmed threshold-voltage shifts, V_{Shift} , change the effective gate biases on the TFTs. As previously demonstrated (1), with a gate-source voltage of 80V and programming times of 1ms to 100s, it is possible to achieve a V_{Shift} between 0-30V. When programming, the drain and source must be held at known voltages to control the programming condition (i.e., electric field across the nitride). Accordingly, during programming, the node normally used to supply V_{DD} is switched to ground (Fig. 1c), causing both the drain and source to be held at ground. This ensures no drain-source current, and thus, no voltage drop across the resistors in the circuit, when the programming voltage, $V_{Program}$, is applied to the gate.

To demonstrate the effect of this calibration circuit, we apply the simulated transfer curves to sensor data obtained from displaying images of shapes onto a 5x6 array of a-Si undoped photoconductors (1). The substantial variation in the photoconductors is best observed when only light is shined on the sensing array (Fig. 2a). We calibrate the photoconductors by normalizing the sensor outputs under this condition (i.e. no shaped displayed) (Fig. 2b). As seen in comparing Fig. 3b and 3c, performing calibration makes analyzing the sensor data considerably easier, since after calibration, it is possible to visually determine the shape displayed on the image sensor (i.e. circle or rectangle (Fig. 3a)). Furthermore, before calibration, the variations in sensor outputs make it difficult to determine an effective threshold between 'light' and 'dark'. However, after calibration, an appropriate threshold can be easily determined and applied to the data, further improving the ability to discern the sensed image (Fig. 3d).

1. W. Rieutort-Louis, T. Moy et al., *International Solid-State Circuits Conference* (in press) (2015)

Acknowledgments: This work was supported in part by Systems On Nanoscale Information fabriCs (SONIC), one of the six SRC STARnet Centers, sponsored by MARCO & DARPA.

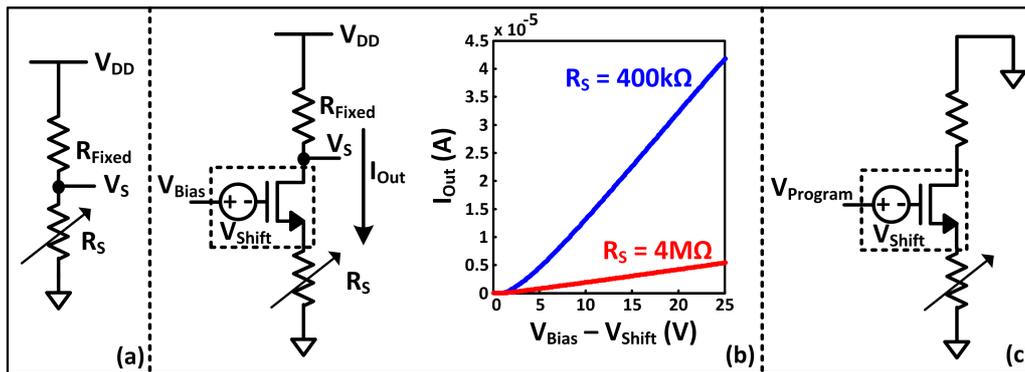


Fig. 1 (a) Typical voltage divider configuration of photoconductor, R_S , with output voltage, V_S . (b) Calibration circuit and transfer curves (simulated with Level 61 SPICE a-Si TFT model, $R_{Fixed} = 750k\Omega$, $V_{DD} = 30V$) incorporating a programmable a-Si TFT to amplify and tune photoconductor current I_{Out} . (c) Configuration when programming TFT threshold-voltage shift.

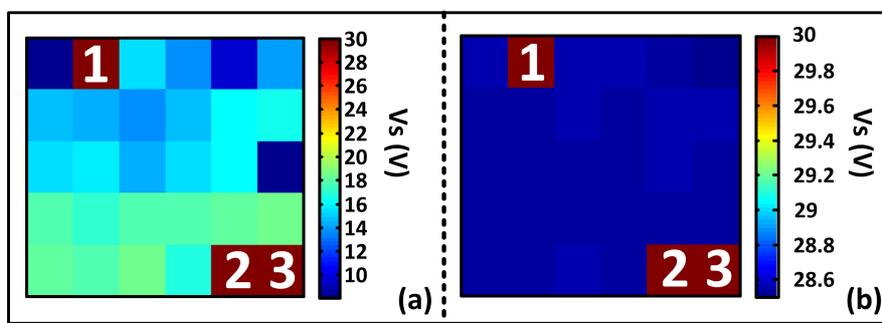


Fig. 2 Spatial diagram of voltage outputs, V_S , with no shape image displayed on a 5x6 array of a-Si photoconductors (a) before calibration and (b) after calibration. '1', '2', and '3' refer to broken photoconductors.

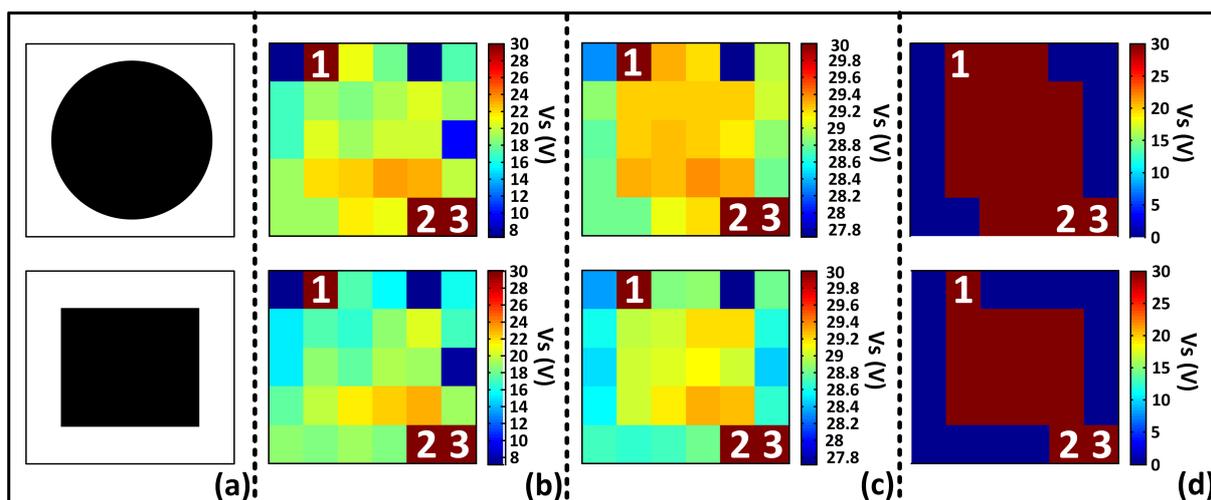


Fig. 3 (a) Shapes (circle or rectangle) displayed onto 5x6 array of a-Si photoconductors and their corresponding voltage outputs, V_S , (b) before calibration, (c) after calibration and (d) after calibration and thresholding. '1', '2', and '3' refer to broken photoconductors.