ON-PIXEL AMORPHOUS SILICON AMPLIFIER FOR DIGITAL FLUOROSCOPIC IMAGING

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INVITED

This work extends amorphous silicon (a-Si) TFT technology from traditional switching applications to on-pixel small signal amplification for digital fluoroscopy. The reported a-Si amplified pixel interface circuit (Fig. 1) offers improved signal-to-noise ratios, lower cost, and less off-panel circuit complexity compared to its (traditional) a-Si switch counterpart. An in-house test array of 250 μm^2 amplified pixel readout circuits based on MOS active pixel sensors is presented with measurement results that indicate excellent linearity, programmable gain, and real time readout. The amplified a-Si pixel advances the state-of-the-art by offering a large area real-time imaging solution for low-noise fluoroscopic medical imaging that is not viable with current a-Si switch based pixels. More significantly, the pixel (because of its circuit gain) offers potentially reduced patient x-ray doses for all diagnostic medical imaging modalities, hence improving the safety standards associated with current x-ray imaging practices.

The characteristic threshold voltage shift (ΔV_T) of the a-Si READ and RESET TFTs in the pixel is minimized by appropriate TFT biasing voltages in the ON and OFF states since the duty cycle is typically 0.1% in large area fluoroscopy. Like CMOS APS circuits, the saturated AMP transistor causes V_T non-uniformity related FPN in our a-Si pixel. This FPN can be reduced by standard offset and gain correction techniques used in addition to CMOS-like off-chip double sampling. Also, TFTs in fluoroscopic arrays are typically clocked at <100 kHz and hence, off-chip low-jitter clocks can alleviate jitter issues.

A 3 x 3 amplified pixel test array (Fig. 2), consisting of an integrated a-Si TFT amplifier circuit in a 250 x 250 μm^2 pixel area, was fabricated. The pixel demonstrates small signal linearity and increasing the readout time increases the gain. Investigations of noise added by the a-Si amplified pixel to the input (adapted from CMOS APS literature) indicate that this noise is minimized for small C_{PIX} implying the feasibility of low capacitance detectors (e.g. an a-Se photoconductor).

The results demonstrated here, including its scalability to state-of-the-art a-Si technology (Fig. 3), provide the impetus to expedite development of amplified pixel arrays for fully integrated, large area, real-time fluoroscopic medical imaging.

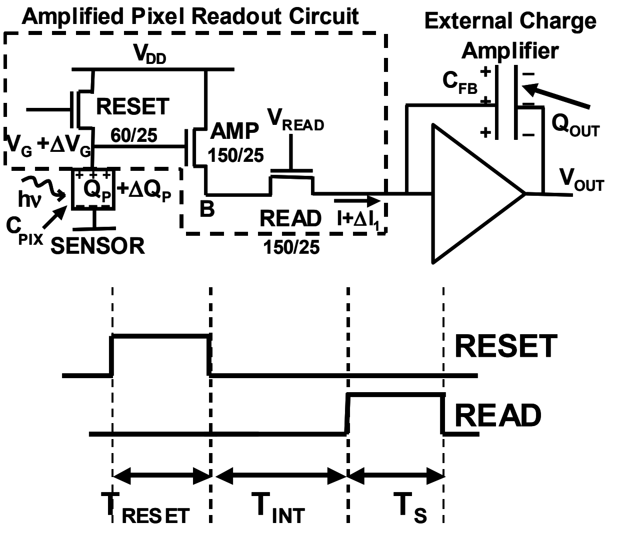

Figure 1. Amorphous silicon on-pixel amplifier circuit connected to an external charge amplifier and associated timing diagram

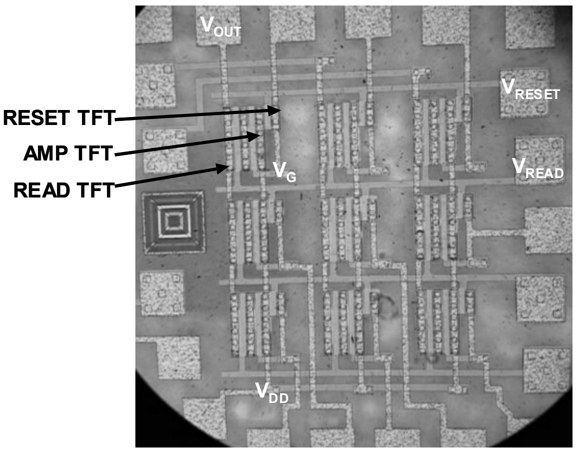

Figure 2. Die micrograph of fabricated 3 x 3 amorphous silicon amplified pixel array

	18 μm a-Si TFT process (implemented)	5 μm state-of-the-art a-Si TFT process (projected)
Parameters	$(W/L)_{RESET}$ = 60/25 $(W/L)_{AMP}$ = 150/25 $(W/L)_{READ}$ = 150/25	$(W/L)_{RESET}$ = 40/5 $(W/L)_{AMP}$ = 100/5 $(W/L)_{READ}$ = 100/5
Supply Voltage	20 V	20 V
Feedback capacitance	10 pF	5 pF
Reset (C_{PIX} = 1 pF)	< 30 μs	< 3 μs
Readout	60 μs	30 μs
Gain	2.75	18
Pixel area	250 x 250 μm^2	125 x 125 μm^2

Figure 3. Performance summary of fabricated a-Si TFT APS readout circuits and their projected performance using state-of-the-art a-Si technology