

Purpose: Active matrix flat-panel imagers (AMFPIs) – based on amorphous silicon thin-film transistors (TFTs) – have been developed for a wide variety of x-ray imaging applications at diagnostic energies. However, under conditions of low exposure or small pixel sizes, the additive electronic noise associated with readout of the pixel signal of these imagers leads to relatively low levels of signal-to-noise ratio – resulting in significant loss of detective quantum efficiency (DQE) and image quality. An increasingly promising approach for overcoming such limitations involves the incorporation of in-pixel amplification circuits, referred to as active pixel (AP) architectures, based on low-temperature polycrystalline silicon (poly-Si) TFTs.

Methods: Theoretical performance limits for additive noise and DQE for large area imagers employing various AP designs have been explored. The methodology involves SPICE simulations of pixel circuits in an array environment employing realistic inputs for signal, as well as noise derived from individual poly-Si TFT test devices. Pixel circuit noise performance derived from these simulations, along with other imaging parameters, are input to cascaded systems models for calculations of the corresponding DQE performance.

Results: For large area imagers employing architectures comprising one- and two-stage in-pixel amplification, the calculations suggest that the effect of additive noise can be significantly diminished, leading to substantial improvement in DQE compared to that of conventional AMFPIs, especially at the low exposures associated with fluoroscopy. Such improved performance is largely maintained even for more sophisticated pixel designs incorporating additional features such as higher frame rate and selectable amplification gain.

Conclusions: Active pixel imagers based on poly-Si TFTs offer a potential alternative to conventional AMFPIs for overcoming the decline of DQE at low exposures in fluoroscopy. The combination of detailed circuit simulations and cascaded systems modeling provides a powerful tool for guiding the development of future generations of ever more sophisticated imagers.

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