

Over the past decade there has been rapid development of real-time active matrix flat-panel imagers (AMFPI) to replace the x-ray image intensifiers (XRII) in fluoroscopy and angiography. The major advantages of AMFPI compared to the conventional XRII are: (1) compact and light weight; (2) free of distortion; (3) use of lower-z material for detector window, which increases the quantum absorption efficiency of the detector; (4) free of veiling glare. Depending on the materials used for x-ray detection, AMFPI are divided into two main categories: *direct* and *indirect* detection. Direct detection AMFPI employ a uniform layer of x-ray sensitive photoconductor, e.g., amorphous selenium (a-Se) to directly convert incident x-rays to charge, which is subsequently read out by a two dimensional array of amorphous silicon (a-Si) thin film transistors (TFTs). In indirect AMFPI, a phosphor such as structured cesium iodide (CsI) is used to convert x-ray energy to optical photons, which are then converted to charge by integrated photodiodes at each pixel of the TFT array. The principle of operation, and advantages and disadvantages of both direct and indirect AMFPI will be described. The imaging performance of both approaches, and their comparison with the XRII will be presented. The evaluation of imaging performance includes: (1) the spatial frequency (f) dependent detective quantum efficiency (DQE); (2) DQE(f) as a function of x-ray exposure; (3) temporal performance, i.e. lag and image persistence; and (4) veiling glare. Despite their differences in detector structure, the direct and indirect AMFPI have comparable imaging performance. The DQE(f) of AMFPI compares favorably to XRII except at the lowest exposure encountered in fluoroscopy (< 5 nGy), where the electronic noise of AMFPI degrades the DQE. To improve the DQE at low dose is the focus of many recent developments of both direct and indirect AMFPI. For direct AMFPI, photoconductors of higher z and x-ray to charge conversion gain, e.g. lead iodide (PbI_2) and mercuric iodide (HgI_2), have been developed. The x-ray to charge conversion gain for these new photoconductors is seven times higher than that of a-Se. For indirect AMFPI, a thin layer of a-Se avalanche photoconductor is being investigated as a replacement for a-Si photodiodes. Under electric field of > 80 V per micron, avalanche multiplication occurs in a-Se, which can amplify the signal in low dose applications. Sophisticated pixel structures (by incorporating more than three TFTs at each pixel) are also being proposed, which provide signal amplification at each pixel to reduce the electronic noise. This approach can be applied to both the direct and indirect AMFPI. The principle of operation, feasibility and advantages of each new AMFPI concept will be discussed.

Educational Objectives:

1. To understand the principle of operation and imaging performance of different AMFPI, and their advantages and disadvantages compared to XRII.
2. To understand the limitation of existing AMFPI in low dose performance, and learn about the current development and advancement in AMFPI design to overcome this limitation.