

Purpose: To investigate the feasibility of a new concept of indirect flat-panel detector with avalanche gain and field emitter array (FEA) readout to improve the imaging performance at low dose with high resolution.

Method and Materials: The proposed detector is made by optically coupling a structured scintillator (CsI) to a uniform layer of avalanche amorphous selenium (a-Se) photoconductor called HARP (High Avalanche Rushing amorphous Photoconductor). The HARP layer absorbs the visible photons emitted from the scintillator and generates electron-hole pairs. These carriers undergo avalanche multiplication under a sufficiently high electric field E_{Se} and form an amplified charge image. A two-dimensional FEA, which is essentially a flat electron source, is proposed as a new method to read out the charge image. The proposed detector is called SAPHIRE (Scintillator Avalanche Photoconductor with High Resolution Emitter readout). Experimental and theoretical methods were developed to study the factors affecting the x-ray response and spatial resolution of SAPHIRE.

Results: The avalanche gain in the HARP layer depends on both its thickness and E_{Se} . The avalanche gain for an 8- μm -thick HARP layer is 46 under an E_{Se} of 110V/ μm . The gain can be turned off in high dose applications (e.g. radiography) by decreasing the E_{Se} . Our electron optics simulation of SAPHIRE shows the dominant source of blur is the lateral spread of the electron beams from the FEA, which depends on the geometry and bias potentials of different electrodes in the detector. With proper electron optics design a pixel size of 50 microns is achievable.

Conclusion: The avalanche gain of SAPHIRE can provide x-ray quantum noise limited images down to a single x-ray photon. The gain is programmable by changing E_{Se} , which ensures wide dynamic range for SAPHIRE. The FEA can potentially provide a smaller pixel size and higher readout speed than existing flat-panel detectors.