Modeling of transient photocurrent and lag signal in amorphous selenium X-ray Detectors

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Direct conversion Flat-panel imaging (FPI) detectors (e.g., using stabilized amorphous selenium, a-Se, as a photoconductor) are widely used today in Mammography and general radiology because of their superior image quality and relative convenience of use that digital systems deliver compared to traditional analog systems. In direct conversion detectors, the X-ray radiation is directly absorbed in the photoconductor layer and creates many electrons and holes there. These electrons and holes then drift in the presence of an applied electric field and eventually become collected through the bias electrodes. However, some of the drifting carriers are trapped in the energy distributed defect states of the photoconductor layer (e.g., a-Se has many defects in its mobility gap) and these trapped carriers are released later depending on their energy depths from the mobility edges [1]. As a result, a transient decaying current has been detected for several hundred/thousands seconds in X-ray detectors even after the excitation is taken away [2], which constitutes a lag signal [3]. This is an undesirable phenomenon because when a part of the current from a previous exposure combines with the next one, the resulting image can be inaccurate and misleading. Though this is a known phenomenon, an accurate quantitative mathematical model has not been established in the literature.

In this paper, we have developed an analytical model for the transient photo and residual decay currents in a-Se detectors by solving the time and space dependent continuity equations for both holes and electrons. The release current is modeled considering thermal release event and Shockley-Ramo theorem. We analyze the dependences of the residual current on various factors such as density of states (DOS) distributions, applied electric field, and temperature. The magnitude and duration of the residual current are highly sensitive to the DOS distribution in the mobility gap. The residual current decreases with increasing applied field and decreasing temperature. The model calculations are compared with the published experimental data and found a very good agreement.

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