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Design and initial X-ray characterization of active-pixel CMOS imaging detectors using different scintillators for digital mammography and breast tomosynthesis

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In recent years, digital mammography with advantages of high sensitivity to low-contrast masses, wider dynamic range and lower radiation dose has been introduced as a new alternative to conventional X-ray film-screen mammography. At the present time, both indirect X-ray conversion approach using a combination of a-Si:H with thin film transistors(TFT), CCD(Charge coupled device) and suitable scintillators and direct X-ray conversion approach using amorphous selenium(a-Se)/TFT-based detector are widely used for clinical digital mammography. However, expensive manufacture process and bulky reduction optics, special cooling systems are required in a-Si based flat panel detector and CCD technology respectively. Recently, CMOS (complementary metal oxide semiconductor)-based X-ray imagers with low power consumption and compactness have been used for high resolution and real-time X-ray imaging such as mammography, fluoroscopy and CBCT application. The CIS has many benefits such as the higher readout speed, low noise, smaller pixel size and high system integration for superior spatial resolution.In this work, the small CMOS detector with 94x24 pixel array of 100um x100um pixel size was fabricated using a 0.35um 1poly/4metal standard CIS process. The 14-bit extended counting ADC and different frame rates with 30/60fps mode were used to reduce the area and simultaneously improve the image resolution. We used a thallium-doped CsI(CsI:Tl) scintillation film of 150m thickness and Gd2O2S:Tb scintillation screen with different thickness for the X-ray imaging characterization and comparison. Additionally, the fiber optic plate (FOP) with 6m diameter and 2mm thickness was used in order to improve the signal to noise ratio by minimizing direct X-ray induced noise from photodiode surface and its effect was investigated in terms of X-ray imaging quality. Furthermore, we investigated the initial X-ray imaging performance of our small-field CMOS-based detector such as the signal response to X-ray exposure dose, modulation transfer function (MTF), signal-to-noise-ratio (SNR) and image lag for mammographic and tomosyntheis systems.

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