A Hybrid Pixel Detector ASIC with Energy Binning for Real-Time, Spectroscopic Dose Measurements

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Abstract

Hybrid pixel detectors have been demonstrated to provide excellent quality detection of ionising photon radiation, particularly in X-ray imaging. Recently, there has been interest in developing a hybrid pixel detector specifically for photon dosimetry. This thesis is on the design, implementation, and preliminary characterisation of the Dosepix readout chip.

Dosepix has 256 square pixels of 220 mm side-length, constituting 12.4 mm^2 of photo-sensitive area per detector. The combination of multiple pixels provides many parallel processors with limited input flux, resulting in a radiation dose monitor which can continuously record data and provide a real-time report on personal dose equivalent. Energy measurements are obtained by measuring the time over threshold of each photon and a state machine in the pixel sorts the detected photon event into appropriate energy bins. Each pixel contains 16 digital thresholds with 16 registers to store the associated energy bins. Preliminary measurements of Dosepix chips bump bonded to silicon sensors show very promising results. The pixel has a frontend noise of 120 e^-. In low power mode, each chip consumes 15 mW, permitting its use in a portable, battery-powered system. Direct time over threshold output from the hybrid pixel detector assembly reveal distinctive photo-peaks correctly identifying the nature of incident photons, and verification measurements indicate that the pixel binning state machines accurately categorise charge spectra. Personal dose equivalent reconstruction using this data has a flat response for a large range of photon energies and personal dose equivalent rates.

Keywords: Hybrid pixel detector, low power readout chip, photon counting, time over threshold (ToT), energy binning, personal dosimeter