Novel photon counting detector and method for very high resolution X-ray and gamma radiography with spectral sensitivity

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The novel photon-counting imaging detector for hard X-ray and gamma radiography with very high spatial resolution of 9 micrometers (pair 17D for duplex IQI) will be presented along with its brand new version for ultra high dynamic range imaging reaching SNR of 2000. Energy discrimination, multichannel or even fully spectroscopic imaging is inherent property of these detectors. The common imaging detectors suitable for hard X-ray or gamma ray radiography with radioisotopes such as Ir-192 are traditionally based on structured scintillating layer attached to photodetector (e.g. film). Since the gamma rays to be detected are very penetrating the scintillator has to made of thick high-Z materials. The thick scintillator suffers of phenomenon called light-sharing which limits its spatial resolution to hundreds of micrometers. In this contribution we will present the hybrid photon counting detectors of Timepix family (Timepix2 and Timepix3) with thick CdTe sensors which, thanks to advanced signal processing, can determine the impact point of every gamma photon with precision of 9 micrometers. The Timepix3 chip records not only position of every single photon interacting with sensor but also its energy (spectrum) and time (with step of 1.56 ns). The hybrid pixel detector of Timepix3 type with thick CdTe sensor enables novel list-mode imaging methods based on processing of each detected event independently. Each Timepix3 pixel registers the deposited energy and detection time for each ionizing particle such as gamma ray photon. Single particle often deposits its energy in form of ionization charge in several adjacent pixels forming well defined cluster or several pixels. Performing very fast cluster shape analysis the precise impact point and energy can be calculated. There are also other advantages of Timepix3 technology: Gamma rays interacting with sensor material produce secondary radiation such as internal X-ray fluorescence, Compton scattered gamma rays or combination of both. Therefore, multiple pixels grouped to multiple clusters can react to single primary gamma ray. The integrated image and spectra formed by all these pixels suffers of some distortions and artifacts: presence of background signal in the images, blurring of images, false peaks in spectra etc. The main motivation of this work is to use complete information recorded for each interacting gamma quantum for maximal enhancement of spatial resolution and for suppression of image background improving signal-to-background ratio. The illustrative radiographic images of iron sheets with newest wire-type duplex image quality identifier (IQI) will be shown demonstrating that all wire pairs including 17D are clearly recognized.