A new generation of fast X-ray and particle imagers with single-quantum analysis for applications non-destructive testing and space

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Semiconductor pixel detectors, originally developed for high energy particle tracking at the CERN Large Hadron Collider, have demonstrated very interesting properties for applications out of the field of accelerator physics. After 3 decades of development the principle of "quantum counting" or "photon counting" imaging detectors became well established. This technology was elaborated and modified for a range of practical applications such as medical imaging, nondestructive testing, computed tomography, electron microscopy, mineral analysis, dosimetry or even space weather forecasting. The principle of the single quantum tracking detectors is a direct detection and digitization of the complete information for each quantum (e.g. X-ray photon). The incident quanta generate signals in a cluster of pixels, from which one can recognize characteristics of the quantum including its energy (calibrated in keV), time of arrival (~100 ps), precise impact position (subpixel). Different particle types such as X-ray or gamma photons, electrons, ions, etc. produce distinctive patterns allowing very effective suppression of unwanted background in images. Identification of coincidences (e.g. Compton scattering or XRF) improves the image quality even further. The full suppression of the electronic noise brings outstanding image quality in radiographic applications. The ultrahigh dynamic range enabled by excellent signal to noise ratio (>thousands) is limited only by intensity of radiation and exposure time. The multichannel or even fully spectroscopic energy information helps to resolve a material composition of samples. The parallel signal processing in pixels and the data-driven, multi-port readout enable fast imaging, including observation of sub-ms dynamic processes. Examples will be presented for use in non-destructive testing.