Energy selective NanoCT with direct converting CdTe semiconductor detector

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Research Objective
An innovative computer tomograph (CT) is being developed and set up in order to significantly expand the existing analytical methods and to enable cross-scale material characterization. This consists of a spectroscopic detector unit, a high-resolution X-ray source, a probe holder which performs stress and strain on the specimen and a computer system for storing very large amounts of data within short periods of time. This complex CT setup will allow the characterization of different material systems and will be used for in-situ investigation of dynamic processes.

Spectroscopic Imaging with Pixel Detector
With directly converting detectors, the ionizing radiation generates charge carriers directly in the sensor material, see Figure 1 (left). The resulting pulse has a height and a duration correlating to the deposited energy. In time-over-threshold mode (TOT), the length of the pulse is measured above the pixel-specific, defined threshold value.

Concept NanoCT
Figure 2 (left) shows the conceptual design of the nanoCT consisting of a Hamamatsu L10711 (focal spot 250nm), sample stage and detector unit on cross stage. Compared to conventional CT images, the amount of data increases up to 10,000 times for fully spectroscopic images (Timepix3) depending on the energy thresholds used. This places high demands on the interfaces for communication and storage of the resulting amounts of data.

Timepix3 Detector Modul
Figure 3 (left) shows the Timepix3 Hybrid Pixel Detector (HPD). A detector module has a sensitive area of 1.94 cm² consisting of 256 x 256 pixels with a pixel size of 55 μm². Each pixel has an amplifier, a discriminator and a counter. Figure 3 (right) shows the schematic structure of the detector. Different sensor materials like Si, CdTe or GaAs can be bump-bonded to the ASICs.

Figure 4 (left) shows the conceptual design of the nanoCT consisting of a Hamamatsu L10711 (focal spot 250nm), sample stage and detector unit on cross stage. Compared to conventional CT images, the amount of data increases up to 10,000 times for fully spectroscopic images (Timepix3) depending on the energy thresholds used. This places high demands on the interfaces for communication and storage of the resulting amounts of data.

"High-Z" sensor materials such as cadmium tellurite (CdTe) allow an increase in the absorption efficiency of the detector to minimize the duration of CT measurements and to use the energy information of the entire X-ray spectrum, see Figure 4 (right).

Literature