High speed imaging and spectroscopy with X-rays

Lothar Strüder, PNSensor GmbH, München, Germany and University of Siegen, Germany

Counting, imaging and spectroscopic measurements of X-rays at energies between 50 eV and 30 keV require detectors with challenging properties. As the penetration depth of low energy X-rays in the above energy range is only 100 nm, special attention must be given to the properties of the radiation entrance window. For the higher energies the depleted thickness must be large. As the number of generated electron-hole pairs is low (for X-rays of e.g. 100 eV about 27 signal charges) the detector systems must be operated with very low electronic noise, especially if not only imaging shall be performed but simultaneously spectroscopy. For experiments requiring spectroscopic information the "system energy resolution" should be Fano-limited, i.e. at 300 eV X-ray energy the system noise should be lower than 3.5 electrons (rms) and at 4 keV the requirement would be below 10 electrons. As the photon intensities per unit area can be as high as 10^8 X-rays per second and pixel, long term stability, especially radiation hardness is an important requirement. In case of imaging experiments with analog signal integration the dynamic range, the charge handling capacity, plays a major role. As many experiments require the proper detection of single X-rays per pixel and readout frame, as well as more than 10.000 X-rays per pixel in the same image frame, special mechanisms have to be implemented to keep the spatial and amplitude information intact.

We will report about two different types of X-ray detectors:

- High speed pnCCDs for X-ray imaging and spectroscopy
- High dynamic range active pixel sensors for X-ray imaging and spectroscopy

Measured results from all three types of detectors will be given. Experiences at synchrotrons, free electron lasers and PIXE experiments will be shown. Future development strategies beyond the present capabilities will be highlighted.