Silicon-Scintillator detectors as a novel concept for medical imaging and dosimetry

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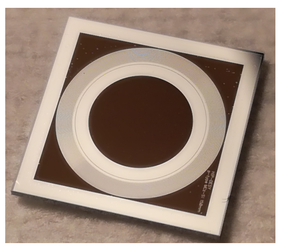
Motivation

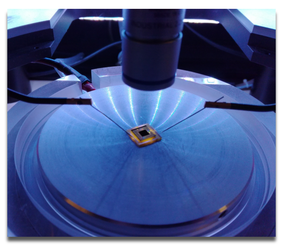
- The concept of Silicon-Scintillator detectors (SiS) combines advantages of two highly developed technologies. It is called to substitute the conventional direct converting detectors (such as CdTe/CdZnTe) in multispectral imaging and dosimetry applications
- Sensors, based on direct converting semiconductor materials, have a merit of high sensitivity to ionizing radiation and provide substantial dose reduction on the patients
- However, expansion of direct converting detectors to the market of medical imaging devices faces significant difficulties due to the limited availability of high-quality sensors

Concept

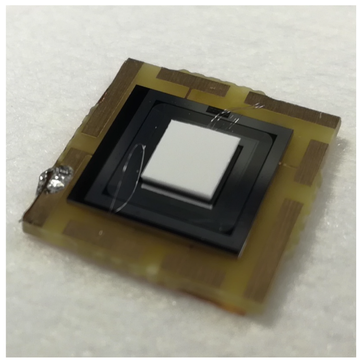
- Main disadvantage of Si detectors is its low effective atomic number (Z_{eff}) for the typical photon energy range of interest in most medical imaging applications (20-200 keV)
- On the other hand, most of the inorganic scintillation materials have a high Z_{eff} and, subsequently, sufficient absorption efficiency for the X-ray photons of stated energy range
- **The core of the concept involves enhancement of Si detector by introducing scintillation light to the optical opening of the sensor and recording separately the signals directly induced in the Si bulk by X-ray photons and the ones from scintillator**

First prototypes



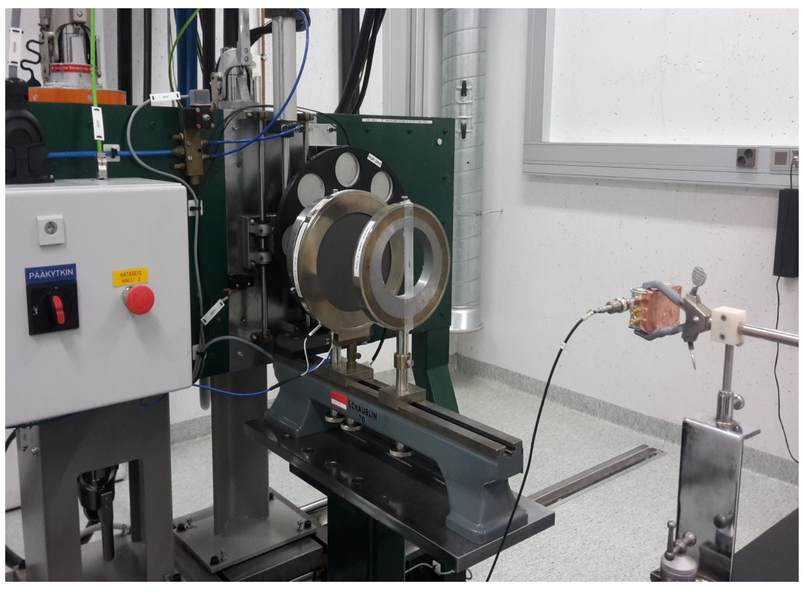


- First prototypes of detectors have the following configurations:
  - Si detectors: 300um thick, p-type bulk p-n diodes
  - scintillation materials: GOS:Tb and GAGG:Ce optically coupled with Si diodes



GOS:Tb scintillator optically coupled with a Si detector

Test in STUK irradiation facility



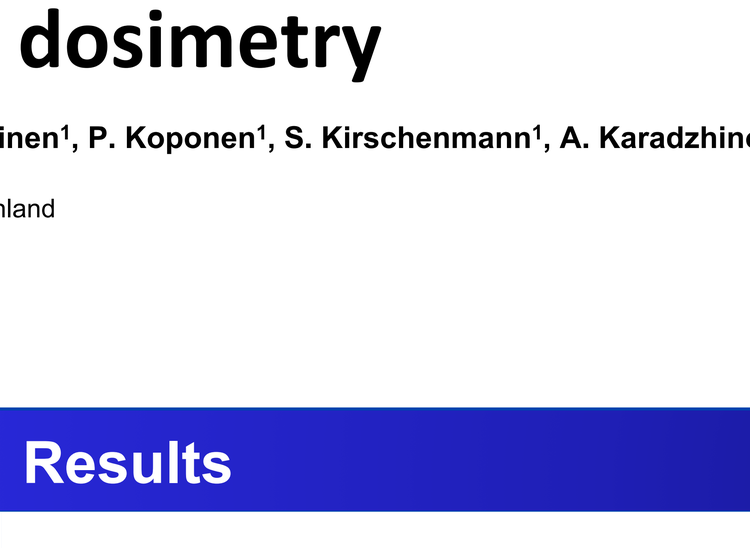
- Irradiation performed with ISOVOLT Titan E160 Series of X-ray Generator within STUK testing facility

Results

- Tests have been performed under several standard radiation qualities (RQR) while detector was fixed in the same position and irradiated with a constant dose rate of 0.57 mGy/s

X-Ray spectra corresponding to different RQRs

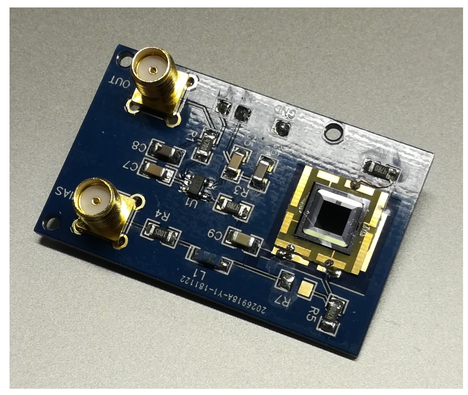
Current through the detector induced by irradiation



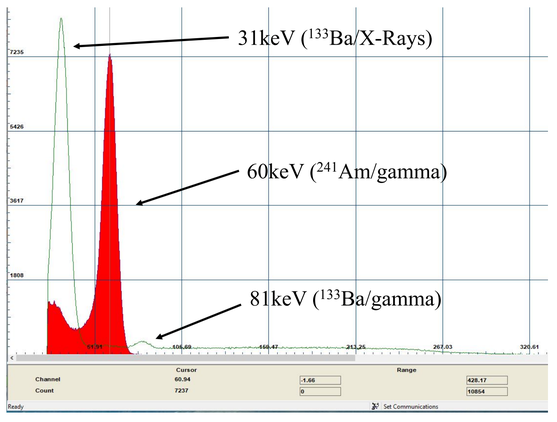
- Current through the bare Si detector decreases with increase of X-ray photon energy
- Scintillator enhanced Si diodes demonstrate substantial increase in the current through the detector (up to 30%)

Read-out electronics

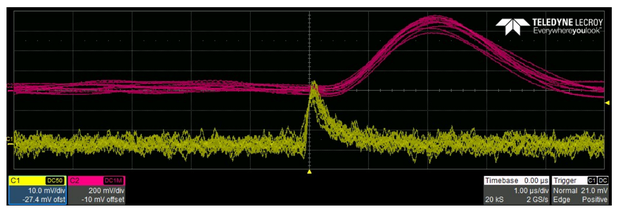
- The directly induced pulses in Si bulk and the ones caused by scintillation light are expected to differ
- Low noise preamplifier board for direct mounting of detectors has been designed in order to improve signal-to-noise ratio
- Pulse-shape discrimination analysis will be applied for separation of the pulses originated by scintillation light



First spectra from ^{241}Am and ^{133}Ba

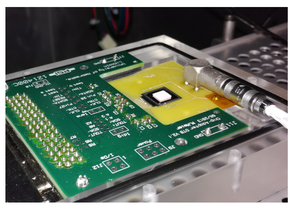


Pulses from ^{241}Am 60keV gamma photons



Further developments

- Further investigation of SiS system: detailed study of signals induced in Si by scintillation light
- Optimization of SiS detectors by advanced simulation
- SiS prototyping with finely segmented pixel detectors
- Development of novel scintillation materials optimized for SiS imaging systems



Segmented pixel detector with GOS:Tb scintillator

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