Characterization of a new photon counting detector with X-ray fluorescences

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General overview of the detector

Comparison of the calibration methods

Measurements of X-ray spectra
A Hybrid Pixel Detector for photon counting

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SPECIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pixel Pitch</td>
<td>220 µm x 220 µm</td>
</tr>
<tr>
<td>No. of Rows</td>
<td>16</td>
</tr>
<tr>
<td>No. of Columns</td>
<td>16</td>
</tr>
<tr>
<td>Sensitive Area</td>
<td>3.52 mm x 3.52 mm</td>
</tr>
<tr>
<td>Sensor Material</td>
<td>Silicon</td>
</tr>
</tbody>
</table>
Dosepix: pixel architecture

- Counting Mode
- Energy binning mode

Single Pixel ASICS block diagram

* W. Wong A Hybrid Pixel Detector ASIC with Energy Binning for Real-Time Spectroscopic Dose Measurements
Dosepix: pixel architecture

- Counting Mode
- Energy binning mode

* W. Wong A Hybrid Pixel Detector ASIC with Energy Binning for Real-Time, Spectroscopic Dose Measurements
Calibration Methods I: Analog Test Pulse method

- Pixel wise calibration
- Analog test pulse

The test pulse is driven in the matrix column wise.

The ToT value for each test pulse is recorded.
The test pulse is driven in the matrix column wise.

The ToT value for each test pulse is recorded.

- Pixel wise calibration
- Analog test pulse
Test Pulse method

- Pixel Wise Calibration
- Test Pulse

Threshold of the pixel:
~ 62.5 mV (~ 2000e−)

* Jan Jakubek, Precise energy calibration of pixel detector working in time-over-threshold mode.
Energy Calibration with Fluorescence Lines

Outline

Dosepix  Calibration Methods  X-ray Spectra  Conclusion

Set-up
Response of one pixel at XRF-lines of different elements

\[ W(L) \bar{E}_{\text{dep}} = 9.67 \text{ keV} \]

\[ \text{Sn}(K) \bar{E}_{\text{dep}} = 25.07 \text{ keV} \]
Fitting of the response of one pixel

![Graph showing the relationship between deposited energy and time-over-threshold (clock ticks).]

<table>
<thead>
<tr>
<th>Element</th>
<th>Deposited Energy * (keV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sn</td>
<td>25.07</td>
</tr>
<tr>
<td>Ag</td>
<td>22.10</td>
</tr>
<tr>
<td>Pb</td>
<td>11.41</td>
</tr>
<tr>
<td>W</td>
<td>9.67</td>
</tr>
<tr>
<td>Cu</td>
<td>8.06</td>
</tr>
</tbody>
</table>

*T. Gabor, Personendosimetrie mit einem pixelierten Halbleiterdetektor, Diploma Thesis, Erlangen University
Fitting of the response of one pixel

\[ \text{Tot}(E_{\text{dep}}) = a + b \cdot E_{\text{dep}} + \frac{c}{(E_{\text{dep}} - t)} \]

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</tr>
<tr>
<td>Cu</td>
<td>8.06</td>
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</table>

*I. Ritter, Characterization of the Dosepix Detector with XRF and Analog Test pulses, IWORID 2013*
Comparison between test pulse and fluorescences lines calibration

Threshold: $7.1 \pm 1.6$ keV

Future work:
Pixelwise test pulse calibration
Overlapping Method for Energy Binning

![Energy Spectra Graph]

- Pixel 1: Bin 0, Bin 1, Bin 2
- Pixel 2: Bin 0, Bin 1, Bin 2

Number of entries for different energies (40 KV, 60 KV, 80 KV):

- X-Ray tube, Erlangen University
Detector Characterization:

- Threshold: $7.1 \pm 1.6$ keV
- Proportionality between Test Pulse (DAC Value) and Energy (keV)
- Energy Resolution: 10 % in the range of 8-25 keV

Future Work

- Analysis of impinging spectra in order to use the detector in medical application
Thank you very much for your attention

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Energy Resolution

<table>
<thead>
<tr>
<th>Element</th>
<th>Energy (keV)</th>
<th>Energy Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sn</td>
<td>25.07</td>
<td>10.91%</td>
</tr>
<tr>
<td>Ag</td>
<td>22.10</td>
<td>5.9 %</td>
</tr>
<tr>
<td>W</td>
<td>9.67</td>
<td>11.3 %</td>
</tr>
<tr>
<td>Cu</td>
<td>8.06</td>
<td>8.5%</td>
</tr>
</tbody>
</table>