Investigation of Charge Carrier Transport and Charge Sharing in X-Ray Semiconductor Pixel Detectors such as Medipix2

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Motivation

Medipix2 Simulation

Geometry
Spectra
Settings
Experiment
Threshold scans
Image
Other information
Charge Sharing / Spreading

- Diffusion
- Spatial spreading
- Energy distribution
- Efficiency
Diffusion

\[ \sigma^2 = 2Dl \]
\[ D = \frac{k_BT}{e\mu} \]
and
\[ l = \int_0^z dz \frac{1}{\mu(E)E(z)} \]
**Simulation of interaction**
Gives location and energy deposition of interactions inside the sensor layer.

(x,y,z,E) of interaction

**Simulation of diffusion**
Each e-h pair is Gaussian distributed with \( s = s(z) \) and projected in x,y plane.

(x,y) single charge 3.6 eV

**Simulation of electronics**
The energy in a spatial interval (Pixel) is also blurred Gaussian (electronic noise). The resulting energy per pixel is discriminated by the threshold and counted.
Experimental setup

- Bragg reflections as monoenergetic sources
- Threshold scans with Medipix2.

**Tungsten Kα1 and Kα2 line**

**Diagram:**
- Tungsten tube
- Silicon crystal
- Detector
25.5 keV monoenergetic
59.3 keV monoenergetic
Backscattering

Silicon sensor

Bump bonds, Sn-Pb alloy

Silver-filled glue

γ

Spatial spreading

Energy distribution

Efficiency
Implementation of the assembly

- Sensor, 700 μm silicon.
- Bump bonds, Sn/Pb alloy, cubics 25 μm.
- ASIC, 700 μm Si layer.
- Silver-filled glue 7 μm.

But: Simulation time up to a factor of 100.
59.3 keV

Counts per bin

E in keV

Simulation, sensor only
Simulation, incl. backscattering
Measurement Kα1 59.3 keV
Conclusion

- For energies below 30 keV the energy response can be described by a convolution of a Gaussian charge distribution and the pixel aperture.
- For energies higher than 30 keV fluorescence of the assembly becomes significant (Silicon sensors) and the assembly as a whole has to be considered.

Energy response of the Medipix2 detector can be described by our simulation.

Thank you, for your attention