DECTRIS

New Photon-Counting High Energy Resolution ASIC For Laboratory Diffraction

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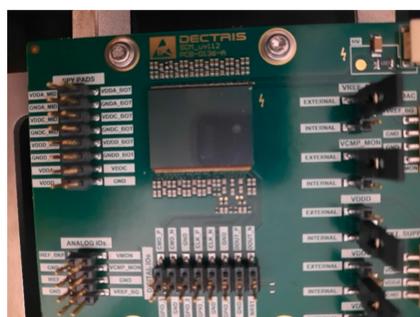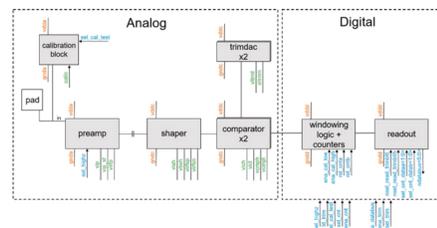
Introduction

The novel ASIC **ERMINE** is one of the latest developments of the R&D at DECTRIS: a photon counting chip that is specifically designed for laboratory X-Ray Diffraction (XRD) applications.
ERMINE is a 192 x 256 pixels array with an active area of 14.4 mm x 19.2 mm and a pixel pitch of 75 µm. The ASIC's two-side buttable design allows for larger sensitive areas with wider angular coverage.
The readout electronics allows for both positive and negative signal polarity, making it compatible with standard silicon sensors (hole collection) and most high-z sensors (electron collection).
The signal readout is a typical design in terms of photon counting detectors. It includes an analog signal chain with a charge sensitive amplifier and a shaper, followed by a comparator stage with two 12-bit counters that can be operated independently, allowing for dead-time-free operation. ERMINE is optimized for excellent energy resolution while still providing high count rates at low power consumption. It achieves better than 600 eV (FWHM) energy resolution at 8keV while providing >1Mcts/px/s and consuming <1.2 W of power.
The chip can be fully operated using simple serial protocols. All needed analog bias current and voltages are generated on chip. Available readout modes include single threshold and windowing between two thresholds, both at a framerate of at least 400 frames per second in continuous readout.

ERMINE ASIC Pixel Block and Specifications

Preamp and shaper (AC coupled), gain can be adjusted (in shaper independently for the two polarities).

2 comparators/pixel: only one threshold or windowing.
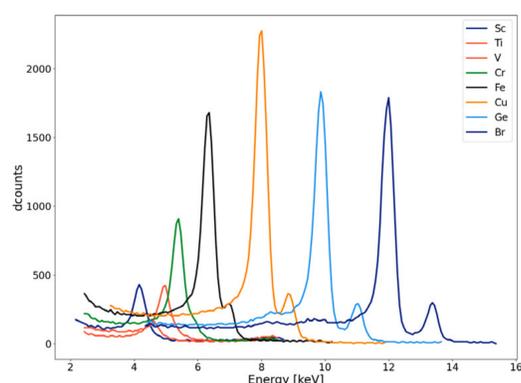
Trimming: 6 bits for each threshold.

The ERMINE ASIC mounted on our single chip test board

Technical Specifications

Pixel size	75µm
Array size	192 x 256 pixels (14.4 mm x 19.2 mm)
Geometry	2-side buttable
Input polarity	Pos / Neg
Thresholds	Single threshold or windowing
Counters	2 counters 12 bit, ~0 dead time
Frame rate	> 400 fps
Count rate	> 1 Mcps with Cu radiation
Threshold range	Si: 4 – 11 keV, High-Z: 8.7 – 25 keV
Energy resolution	< 600 eV @8 keV, < 900 eV @17 keV

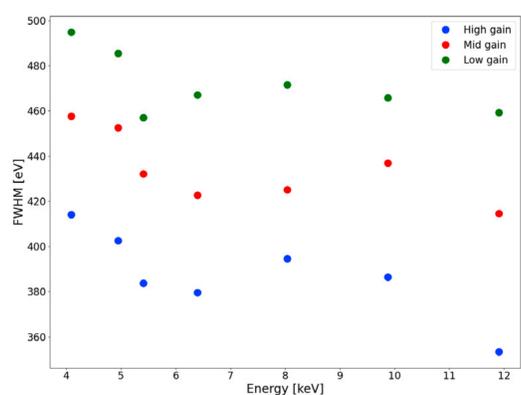## Energy Resolution

Calibrated Spectra

Counts are median value of the full matrix.

Fluorescence samples from Sc (4.09 keV) to Br (11.9 keV).
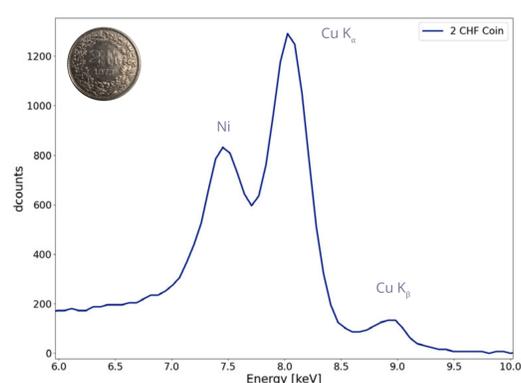
Silicon sensor, 320 µm thickness.

Energy Resolution

FWHM of fluorescence peaks.

Tested different readout settings, high gain shows the best performance.

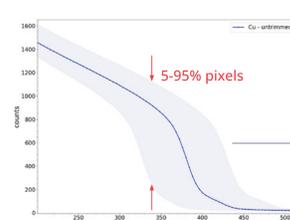Better than 500 eV in all conditions.

A Little Experiment

Spectrum of a 2 CHF coin, made of Cu-Ni alloy.
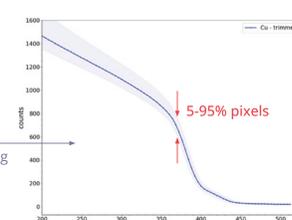
Coin irradiated with W X-ray tube, 45 kV.

Peaks of Ni and Cu (both K_α and K_β) are recognizable.

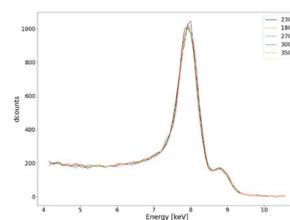## Trimming and Temperature Stability
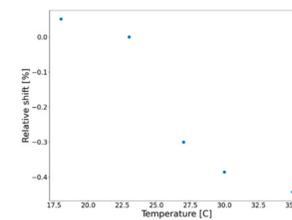
Before Trimming

After Trimming

Treshold scans of Cu sample: effect of the trimming.

The blue shadow is the distribution of the 5-95% of the pixel counts in the full matrix.

Differential Spectra

Peak Centroid Relative Shift

Chip trimmed and calibrated at 23°C.

Cu spectrum collected in a temperature range from 18°C to 35°C, using the calibration and trimming done at 23°C.

The peak centroid moves in a range <0.5%.

The chip is very stable with temperature.

Count Rate at 8 keV

Measurements done at BAM beamline at BESSY synchrotron.

Chip count rate depends on the analog frontend settings.

Higher gain makes the readout slower.

There is a compromise between count rate (speed) and energy resolution (noise).

We can reach 1 Mcts/px/s with count rate correction in the mid and low gain settings.