

# SPECTRUM 1k – Single Pixel Counting Readout Chip with In-Pixel Energy Histogramming

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A new single photon-counting IC prototype called SPECTRUM1k with pixel matrix  $40 \times 24$  and pixel pitch  $75 \mu\text{m}$  is developed by the Microelectronics Group of the AGH University of Krakow as a solution for X-ray color imaging [1, 2]. The chip, produced in CMOS 40 nm technology, is made up of 960 individually configured pixels, each composed of an amplifier, an analog-to-digital converter, and  $64 \times 12$ -bit memory cells that allow one to perform in-pixel energy histogramming. Thanks to the proposed architecture working with the 200 MHz chip clock and 1 Gcps/mm<sup>2</sup> multi energy photon intensities up-to about 23 ms exposition time is feasible (365  $\mu\text{s}$  exposition time whenever monoenergetic photons are used only). In-pixel offset ( $\sigma = 3.5\%$ ) and gain ( $\sigma = 5.8\%$ ) spread, the amplifier performance (ENC = 95 e- rms) and the ADC resolution (ENOB = 5.4 b) allow to convert the incoming photons' energy with FWHM = 3.7 ke @134.2 keV upon 45  $\mu\text{W}$  (high-speed mode) or 12  $\mu\text{W}$  (low-speed mode) per pixel power consumption.

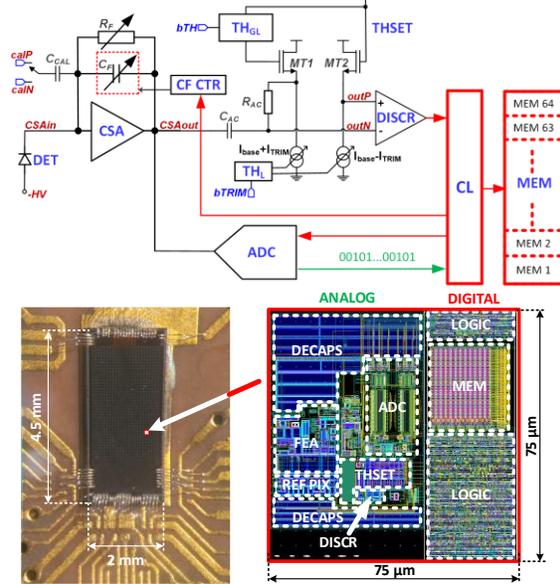


Figure 1. SPECTRUM 1k IC: photo and single pixel layout.

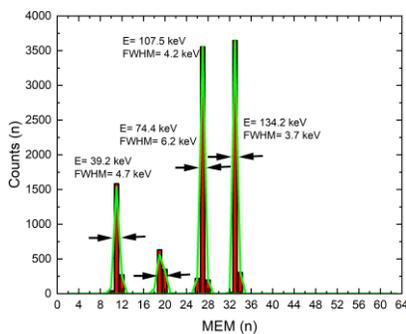


Figure 2. Energy histograms for four photons of different energies and different intensities (generated via calibration input).

We present a description of the ASIC's architecture [3, 4] as well as characterization results. The threshold dispersions, gain spread as well as noise and energy measurement performance of the SPECTRUM1k are presented.

- [1] C. Hansson, K. Iniewski, "X-ray Photon Processing Detectors: Space, Industrial, and Medical applications", Springer, 2023.
- [2] S. Iwanczyk, et al, "Radiation Detectors for Medical Imaging", CRC-Press, 2016.
- [3] P. Kmon et al., "Spectrum1k — integrated circuit for medical imaging designed in CMOS 40 nm", JINST, (2022).
- [4] R. Kłeczek et al., "Single Photon-Counting Pixel Readout Chip Operating up to 1.2 Gcps/mm<sup>2</sup> for Digital X-Ray Imaging Systems", IEEE JSSC, 53 (2018).

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