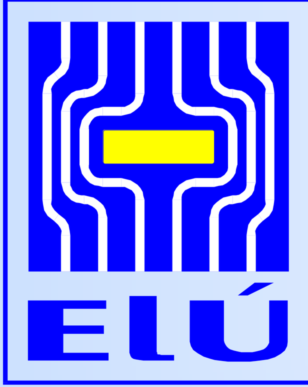
From single silicon carbide detector to pixelated structure for radiation imaging camera



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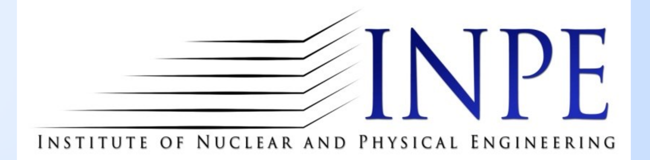


INTRODUCTION

Detectors based on 4H-SiC (Silicon Carbide) are very perspective due to:

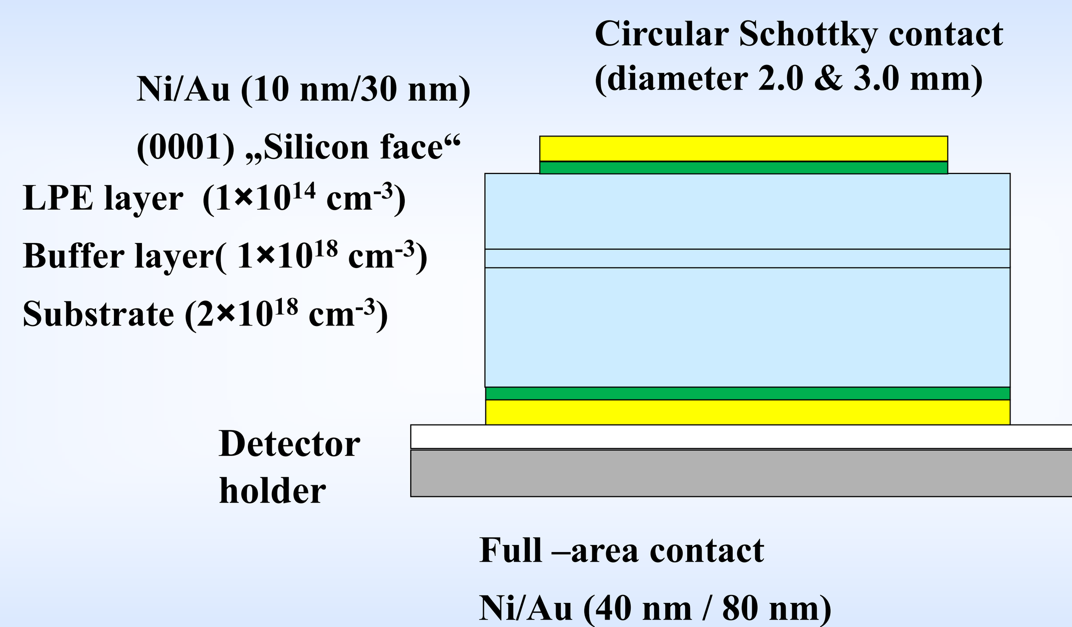
- high breakdown voltage (4×10^6 V/cm)
- electron mobility of about 900 $cm^2V^{-1}s^{-1}$
- high electron saturation drift velocity (2×10^7 cms^{-1})
- band gap energy of 3.26 eV
- operation at increased temperature up to 500 °C
- good radiation hardness

DETECTOR MATERIAL

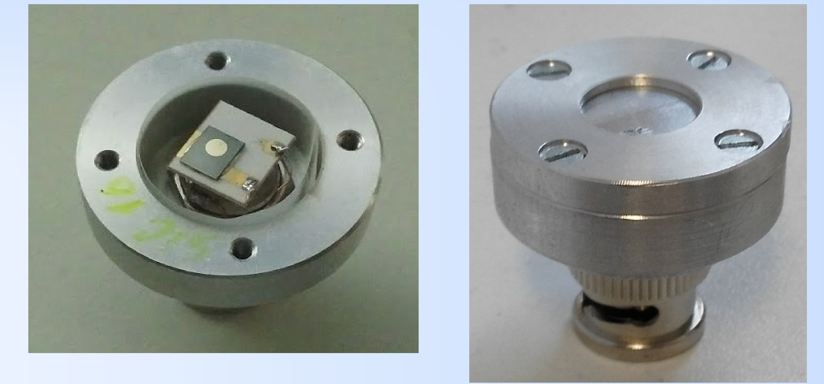
Base material parameters:

- 25, 50, 70 µm thick nitrogen-doped 4H–SiC layer grown by LPE
- Doping concentration about 1×10^{14} cm^{-3}
- 4H-SiC n^{++} substrate (350 µm thick)
- 0.5 µm buffer layer n^+-SiC with concentration 1×10^{18} cm^{-3}

CROSS-SECTION OF DETECTOR



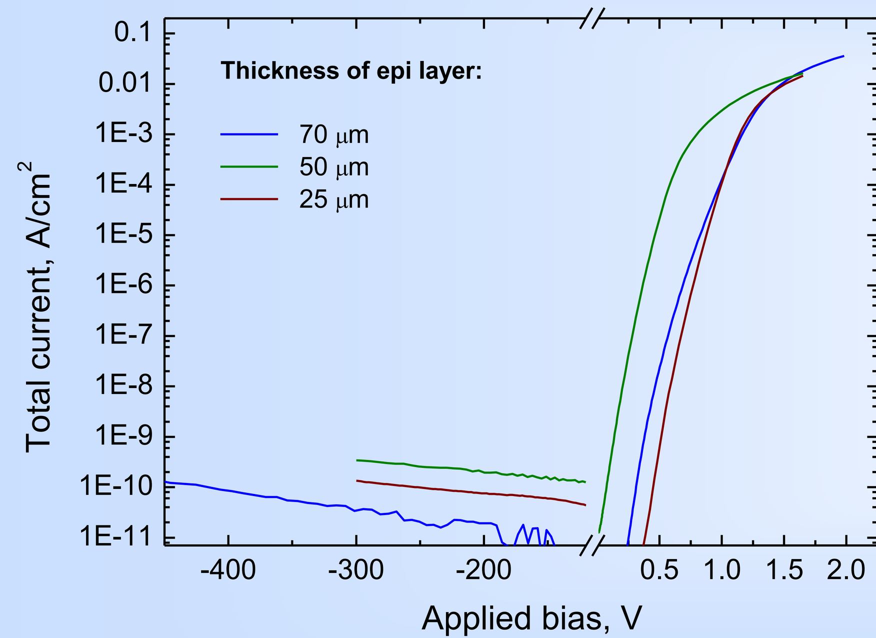
PHOTOGRAPH OF DETECTOR

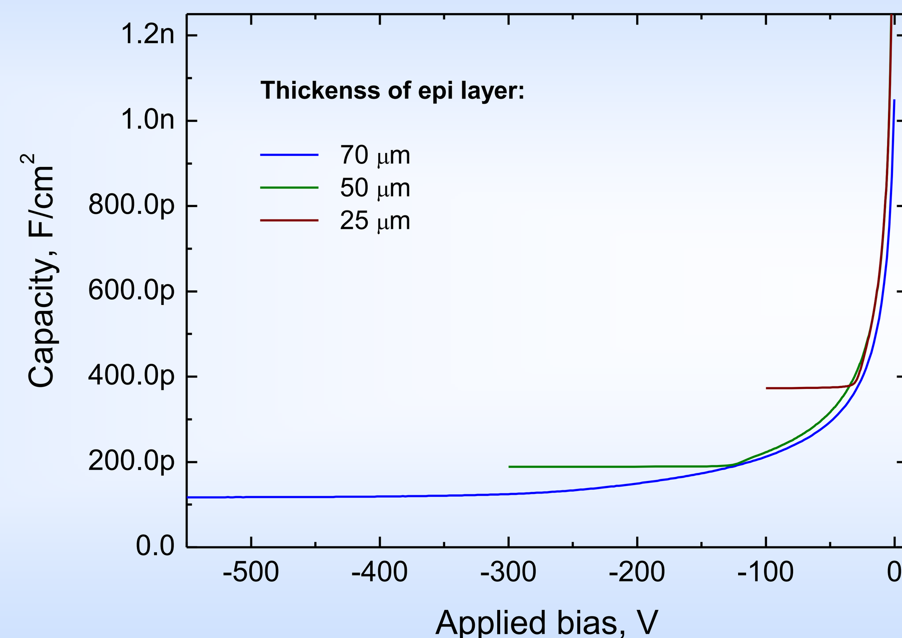


EXPERIMENTAL METHODS

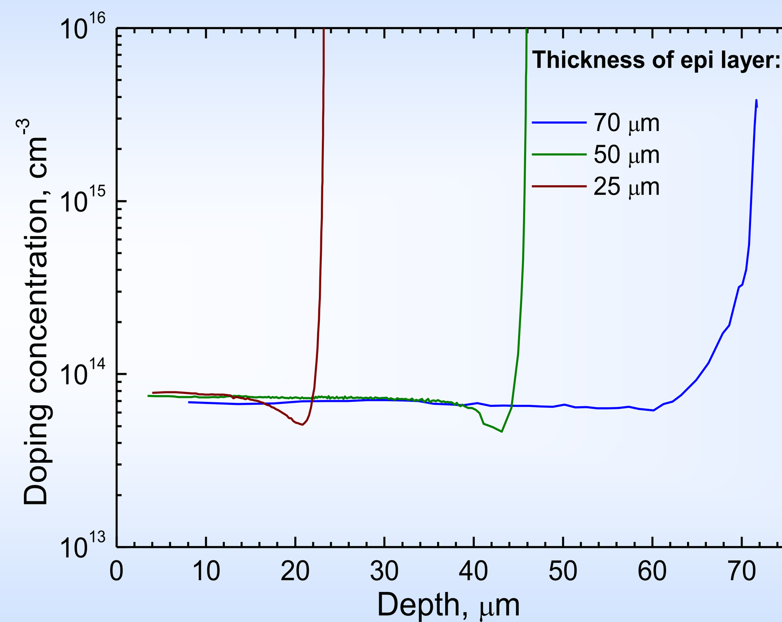
- Current-voltage measurements up to 1 kV;
- Capacitance-voltage measurements up to 600 V;
- Measuring system: Keithley system consisted of 4200A-SCS Parameter Analyzer completed by 4200A-CVIV Multi-Switch

CURRENT-VOLTAGE & CAPACITANCE-VOLTAGE MEASUREMENTS

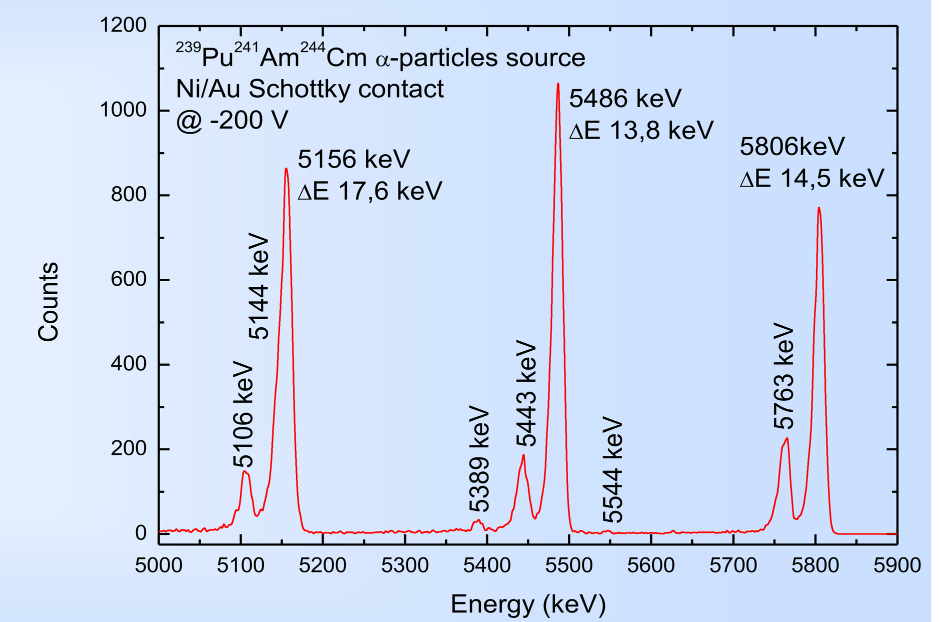




DEPLETION THICKNESS



ALPHA PARTICLE SPECTRUM



PIXEL STRUCTURES

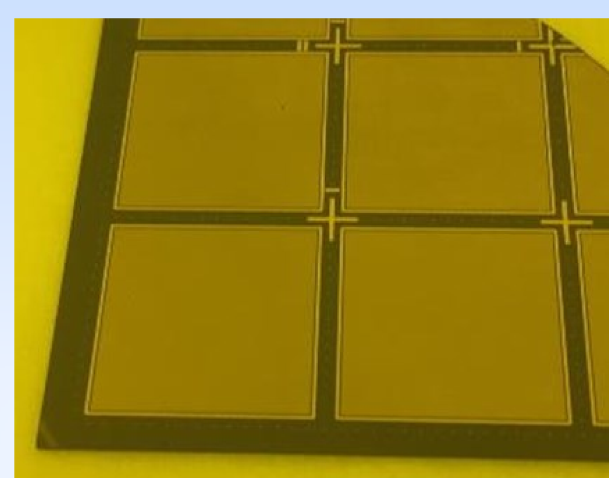
Base material parameters:

- 80 µm and 100 µm thick nitrogen-doped 4H–SiC layer grown by LPE
- Doping concentrations about 7×10^{13} cm^{-3} and 3×10^{14} cm^{-3}
- 4H-SiC n^{++} substrate (350 µm thick)
- 0.5 µm buffer layer n^+-SiC with concentration 1×10^{18} cm^{-3}

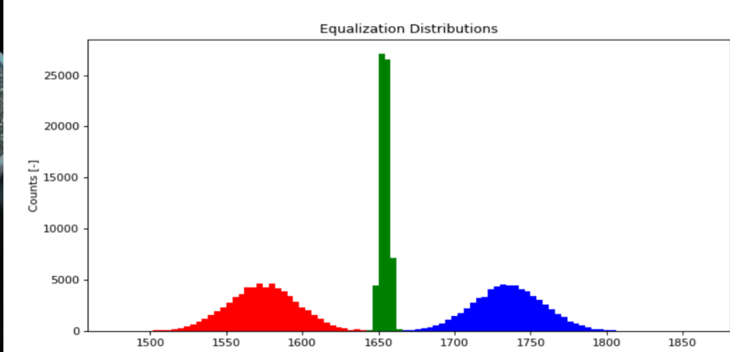
Contacts preparation:

- Ni/Au (70/100 nm) Schottky contact
- Ti/Pt/Au (10/30/50 nm) Ohmic contact

PREPARED PIXELATED STRUCTURES

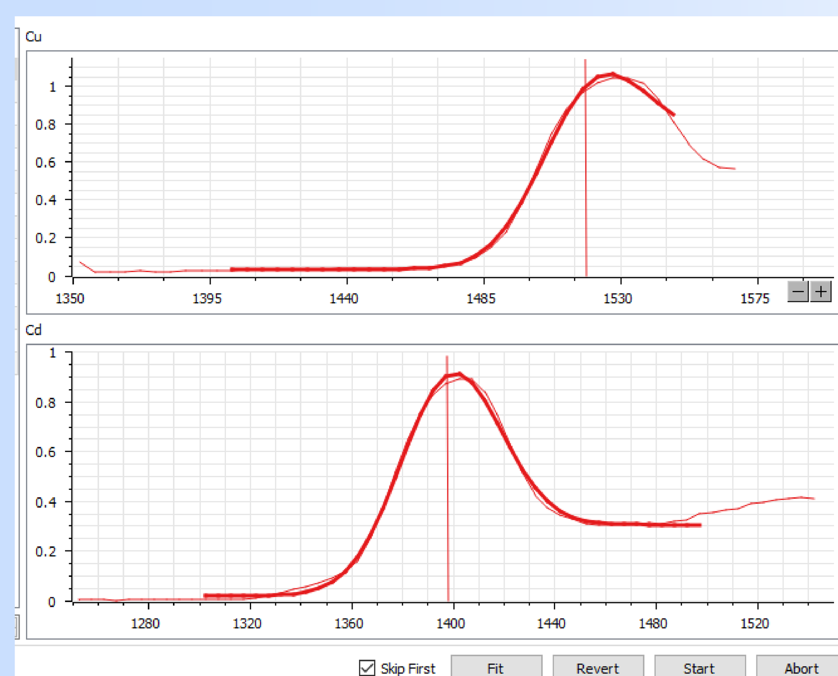


TIMEPIX3 DETECTOR BASED ON 4H-SIC

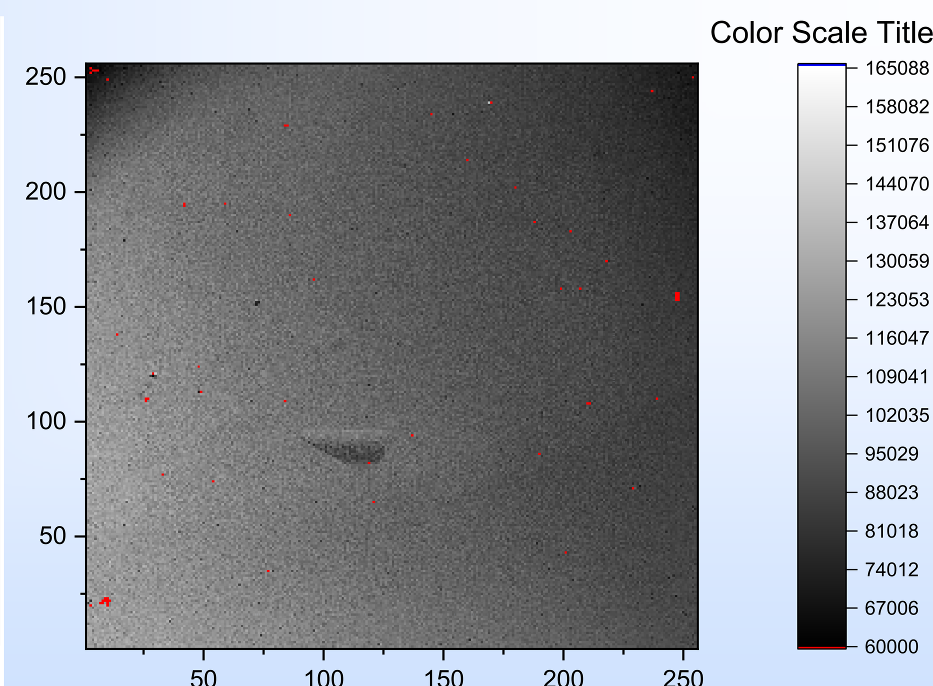


Parameter	Value
Mean THL	1654.224
Std. Dev	7.813
Masked Pixels	73
Final THL	0

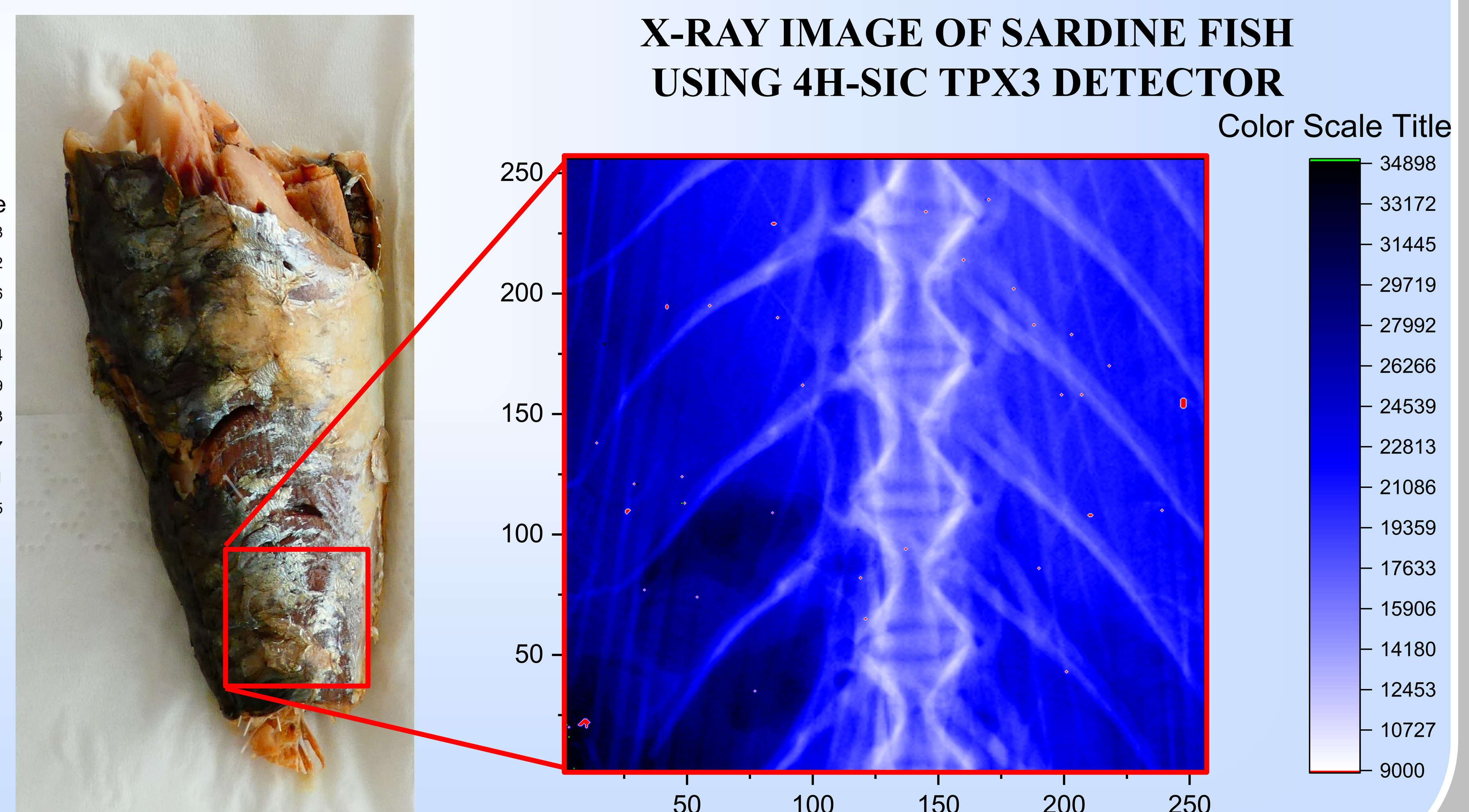
THRESHOLD SCAN OF X-RAY PEAKS OF Cd AND Cu MATERIALS



X-RAY BACKGROUND IMAGE OF 4H-SIC TPX3 DETECTOR



X-RAY IMAGE OF SARDINE FISH USING 4H-SIC TPX3 DETECTOR



SUMMARY

- **We fabricated semiconductor detectors based on 4H-SiC epitaxial layer.**
- **Active layer consists of 4H-SiC LPE with thickness up to 100 µm.**
- **The lowest doping concentration is below 7×10^{13} cm^{-3}.**
- **The detector size was defined by circular Schottky contact with the diameter up to 3.0 mm.**
- **Detectors can obtain high energy resolution comparable to silicon detectors.**
- **We fabricated pixelated structures based on high-quality 4H-SiC epitaxial layer.**
- **Structures were bump-bonded to Timepix3 readout chips.**
- **We performed threshold equalization of new SiC Timepix3 detectors**
- **The threshold scan of Cd and Cu X-ray peaks shows good energy resolution of SiC Timepix3 detector.**
- **X-ray image of Sardine fish shows homogeneity of pixels and excellent quality of X-ray image.**

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