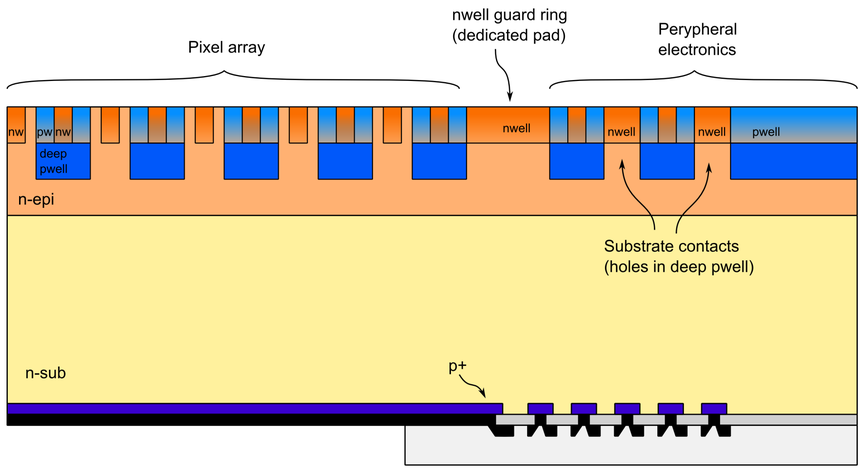
A 110nm CMOS process for fully-depleted pixel sensors

L. Pancheri[1,2], J. Olave[3,4], S. Panati[3,4], A. Rivetti[3], F. Cossio[3,4], M. D. Da Rocha Rolo[3], N. Demaria[3], P. Giubilato[5,6], D. Pantano[5,6], S. Mattiazzo[5,6]

[1]Università di Trento, DII, Trento, Italy
[2]TIFPA, Trento, Italy
[3]INFN Torino, Torino, Italy
[4]Politecnico di Torino, DET, Torino, Italy
[5]Università di Padova, Padova, Italy
[6]INFN Padova, Padova, Italy

Concept

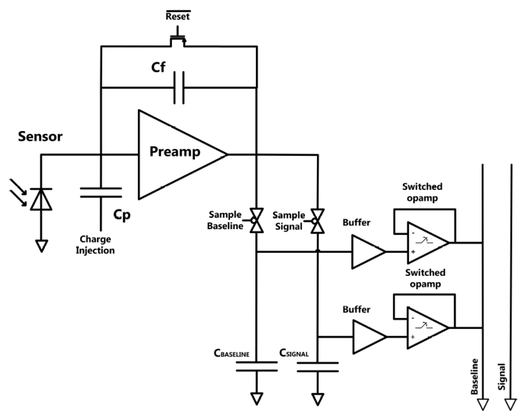


- Modified 110nm CMOS process
- 1.2V thin-oxide transistors for high radiation resistance
- Fully-depleted n-type High Resistivity substrate with 300µm thickness
- Backside processing: p+ implantation, metal and passivation
- Depletion region extending from the backside

Implementation

Chip 1: pixel array MATISSE:

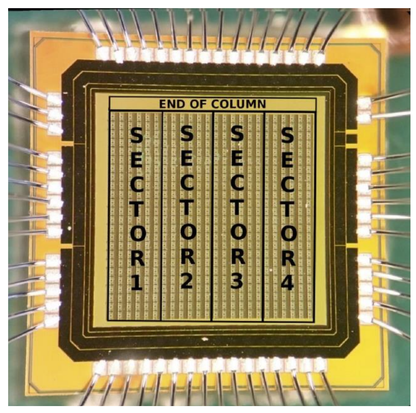
- 24 x 24 pixel array
- Pixel size: 50µm x 50µm
- In-pixel charge integrating amplifier
- In-pixel Sample-and-Hold and buffer amplifiers



MATISSE pixel schematic diagram

Chip 2: test structures:

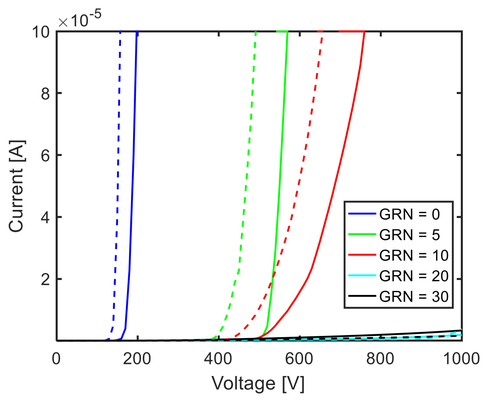
- **Backside diodes** with different terminations
- **Pseudo-pixel structures**: arrays of collection diodes with the same geometry and doping of MATISSE pixels, but without electronics



MATISSE chip micrograph

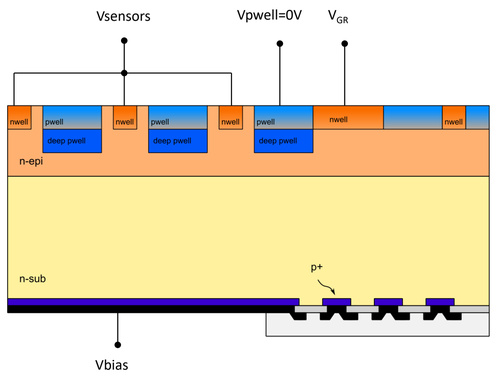
Characterization – Test structures

Current-Voltage curves of backside diodes with different Guard Ring Number (GRN)
Continuous lines: unirradiated diodes
Dashed lines: irradiated diodes (1Mrad)

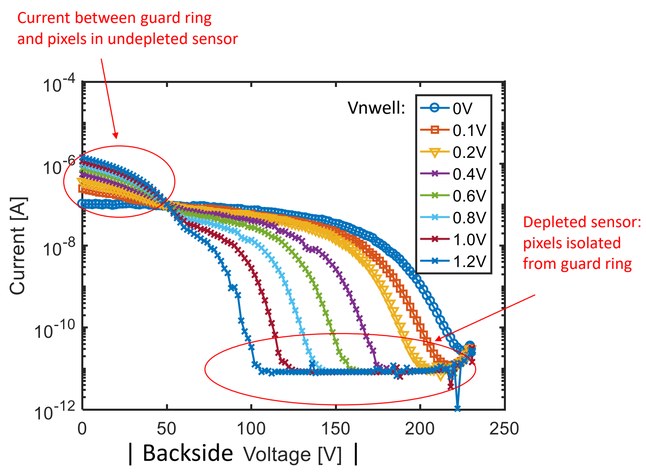


Pseudo-pixels: 8x8 array of **50µm x 50µm pixels** with 20µm x 20µm sensor size. All the sensor nodes are connected together.

- DC measurements: readout with SMU
- Dynamic characterization: fast transimpedance amplifier

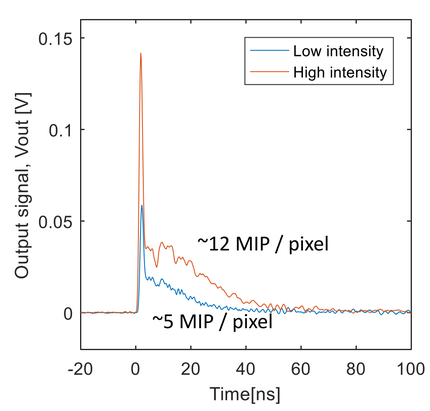


Dark current flowing in pseudo-pixels:
backside depletion voltage depends on the voltage applied to the sensors at the frontside



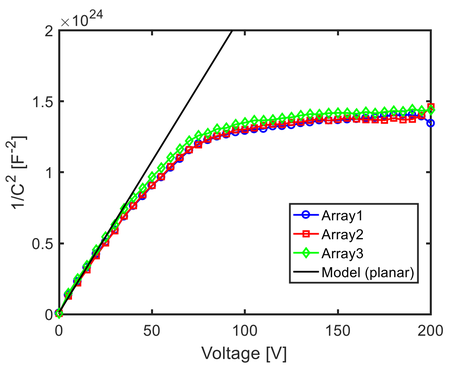
Signal collection:

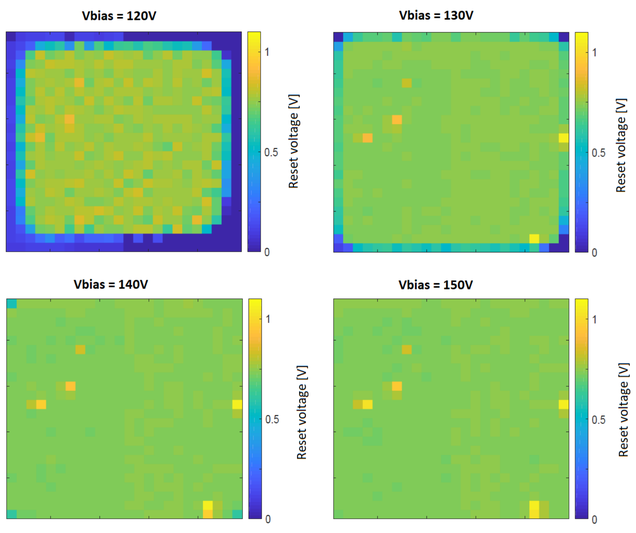
- Sensor node current read out with wideband (1GHz)amplifier
- Flood illumination (unfocused laser)
- Wavelength: 1060 nm.



Characterization – Pixel array

Capacitance-Voltage curves of the **array backside diodes**: capacitance is constant above 140 – 150V



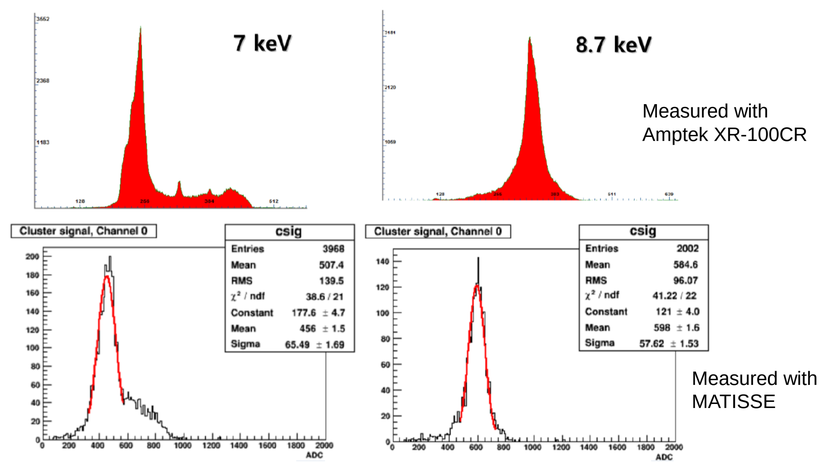


Map of the pixel reset voltage:

120 – 130V: high leakage at the border of the array: incomplete depletion

140 – 150V: low leakage: complete depletion

Measurement of monochromatic **X-ray spectra**



Measured with Amptek XR-100CR

Measured with MATISSE

Work in progress

- New run with **different thickness**:
  100µm for particle tracking
  400µm for photon science
- Full characterization of radiation damage effects with ionizing and non-ionizing radiation
- Design of a large-area pixel sensor for efficiency studies

Acknowledgements

The research activity presented in this poster has been carried out in the framework of the experiment SEED (Sensor with Embedded Electronics Development) funded by Istituto Nazionale di Fisica Nucleare (INFN).

Authors would like to thank LFoundry for the support in the process customization