Charge collection measurements of CdTe pad detectors using IBIC imaging method

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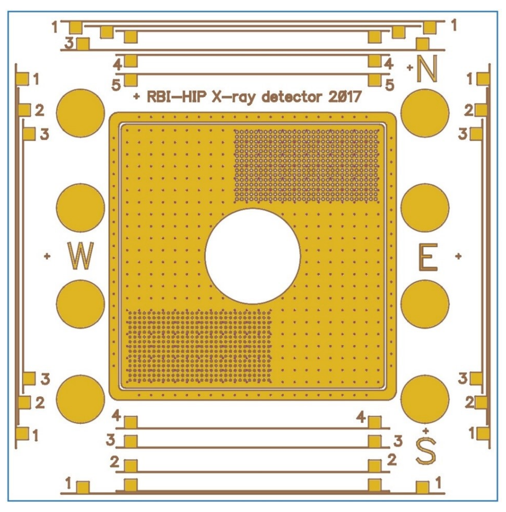
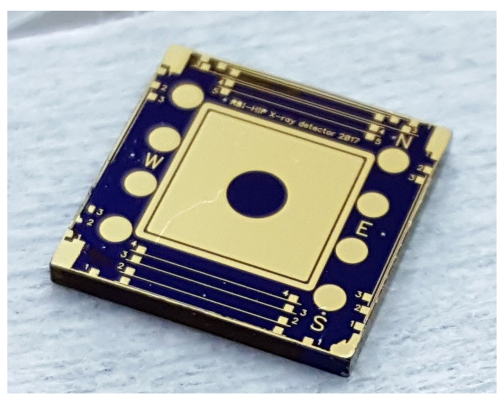
Introduction





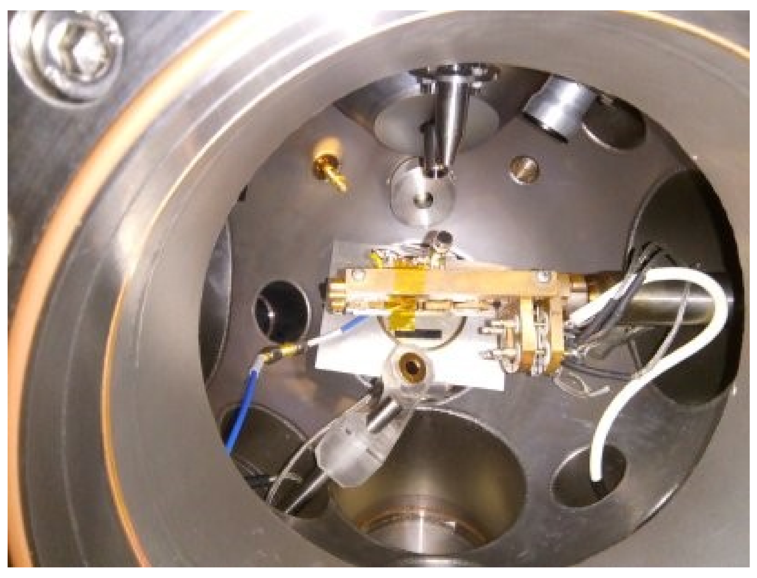
CdTe pad detectors used in this study[1][2]:

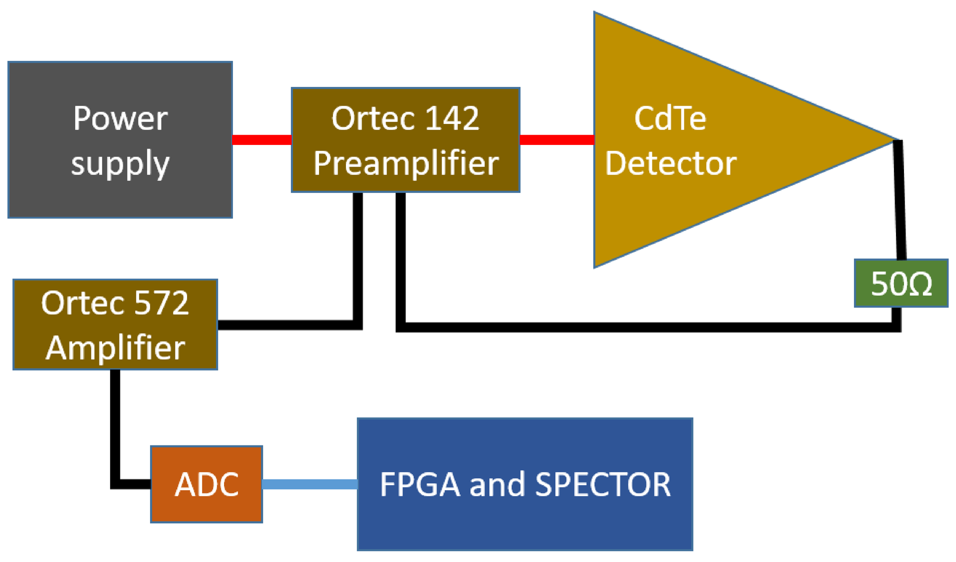
- Dimensions of 1×1×0.1 cm^3
- Aluminium nitride (AlN), or aluminium oxide (Al_2O_3) as field insulator material
- Array of Schottky barrier contacts of 20 nm thick titanium tungsten (TiW) adhesion layer, and around 200 nm thick layer of gold
- Pad has a surface area of 5.5 × 5.5 mm^2

Measurements

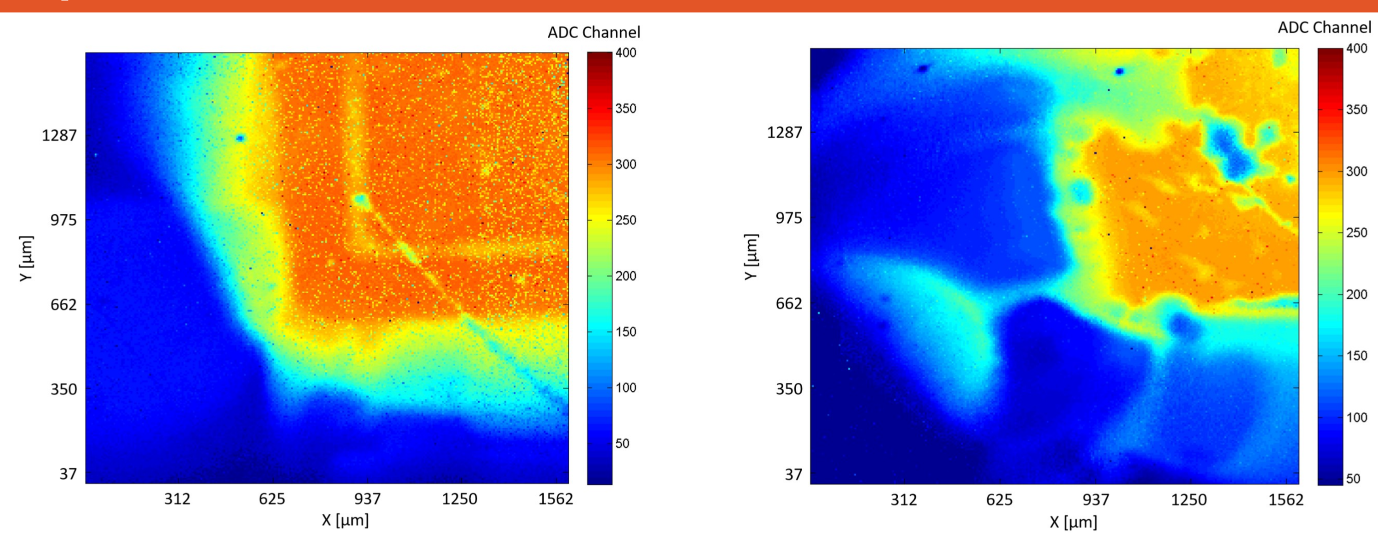
Charge collection of the CdTe detectors was analysed by using scanning microbeam of the Accelerator laboratory of the Ruđer Bošković Institute[3]

- 2 MeV protons provide penetration depth of around 40 µm
- Beam frequency around 1-2 kHz
- Beam current 20 pA
- Detectors were mounted inside a vacuum chamber





Comparison of Passivation Materials

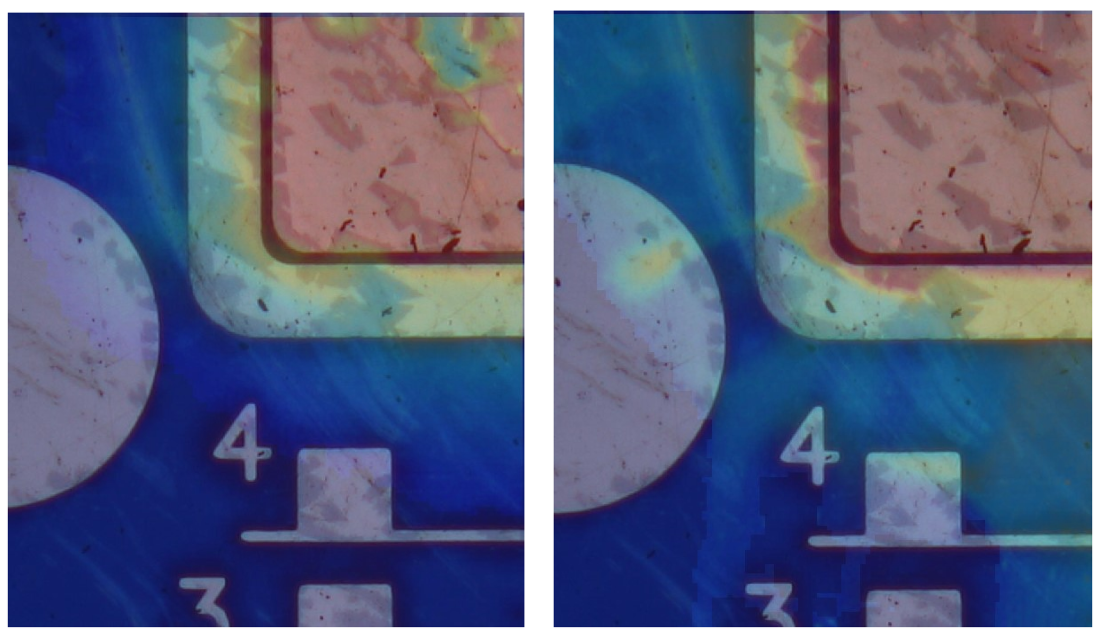


Comparison of the IBIC maps of AlN Al_2O_3 passivated detectors. In the measurements the bias was applied to the backside of the detectors. The guard ring of the AlN detector in these measurements was shorted to the pad and thus appears visible in the maps.

- AlN passivation provides more uniform charge collection area
  - Suffers from surface discharge under high bias voltage
  - Does not leak the field into passive elements on the surface
- Al_2O_3 passivated detectors have higher surface granularity
  - Clear edge is not visible at the boundary of the metalization in the IBIC maps

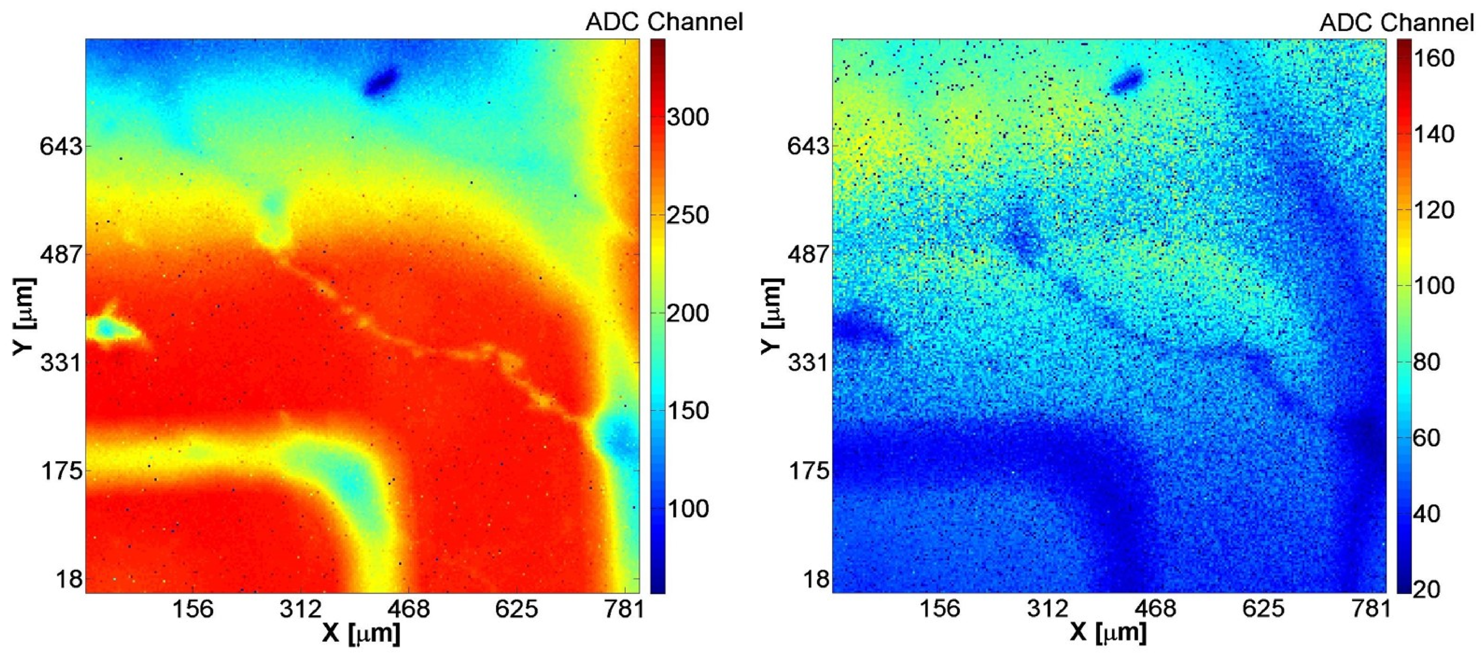
Effects of Surface Granularity

- Surface granularity has notable effects in the field uniformity of the detectors at low bias values
- At pad area the effect decrease with higher bias voltage
- On the edges the grains extend the field lines



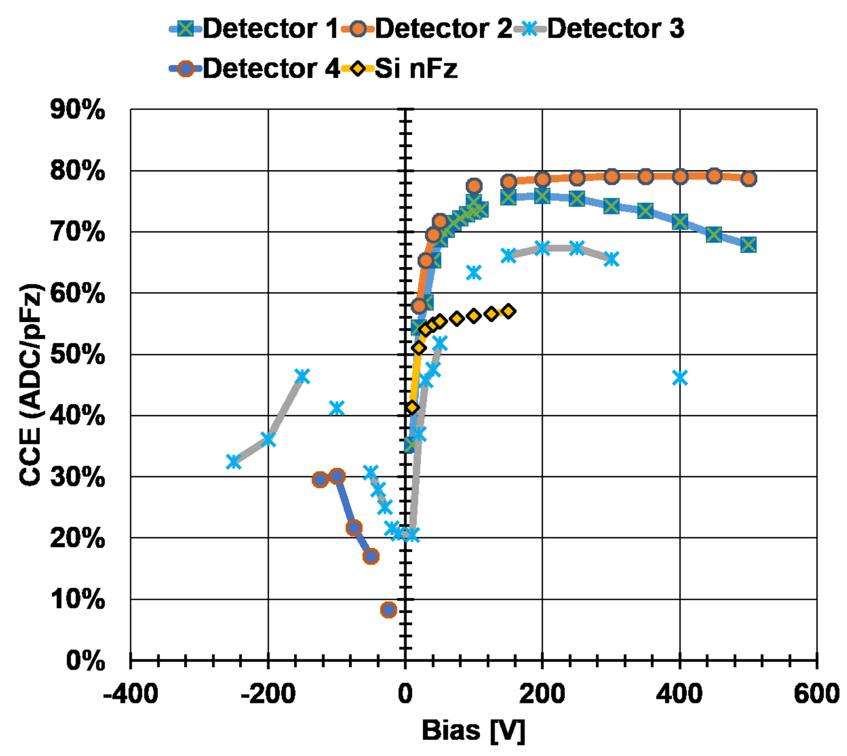
Comparison of two IBIC maps overlaid on top of an image taken with a microscope. The left one is biased with +50 V and the right one with +500 V. The impact of the surface grains on the pad seem to decrease while the grains at the boundaries seem to exted the field lines.

Forward and Reverse Biasing



- By changing the bias voltage from positive to negative, or vice versa, different details of the detectors can be studied
- Defects close to surface, such as dislocations and cracks seem to be highlighted with reversed biasing
- Also the metal boundaries appear more clearly

Charge collection efficiency



Comparison of CCE of the detectors used in this study. Detectors 1 and 3 are AlN passivated and Detectors 2 and 4 are Al_2O_3 passivated. The reference detector in measurements was pCz silicon detector. Detectors 3 and 4 had micromesh pattern on the surface pad.

- By ramping the bias voltage and by selecting an uniform area on the pads, the CCE of the detectors can be compared in relation to CCE of pCz silicon diode
- Although Al_2O_3 can suffer from the effects of the surface grains, the CCE is more stable than for AlN passivated detectors
- For AlN the surface charging and discharging disturbs the CCE

[1] A. Gadda et al., Advanced processing of CdTe pixel radiation detectors, Journal of Instrumentation 12(12) C12031. 2017.
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[3] M. Jakšić et al., New capabilities of the Zagreb ion microbeam system, Nuclear Instruments and Methods in Physics Research Section B, 260 (1):114-118, 2007.

This research has received funding from the European Union's Horizon 2020 ERA Chair research and innovation programme under grant agreement No 669014, project PaRaDeSEC.