Passive CMOS Strip Detectors Response with Alpha Particles

Marta Baselga[1], Jan-Hendrik Arling[2], Naomi Davis[2], Leena Diehl[3*], Jochen Dingfelder[4], Ingrid M. Gregor[2,4], Marc Hauser[3], Tomasz Hemperek[4], Fabian Hügging[4], Karl Jakobs[3], Michael Karagounis[5], Kevin Kröninger[1], Fabian Lex[3], Ulrich Parzefall[3], Arturo Rodriguez Rodriguez[3**], Birkan Sari[1], Niels Sorgenfrei[3*], Simon Spannagel[2], Dennis Sperlich[3], Tianjang Wang[4], Jens Weingarten[1], Iveta Zatocilova[3]

1 TU Dortmund University, 2 Deutsches Elektronen Synchrotron (DESY), 3 University of Freiburg, 4 University of Bonn, 5 FH Dortmund

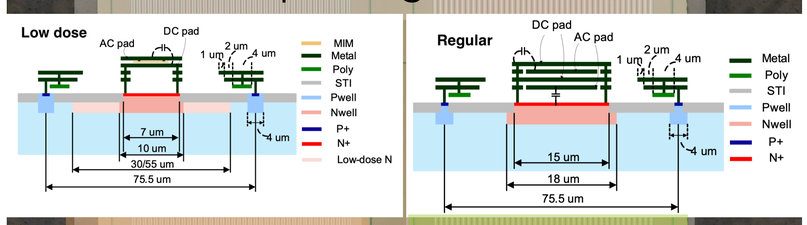
* now at CERN, Esplanade des Particules 1, Meyrin, Switzerland, ** now at Littelfuse, Edisonstraße 15, 68623 Lampertheim, Germany

Motivation

* Passive CMOS strip detectors were fabricated stitching 2 different reticles
* They show excellent performance in different setups and irradiations [1-5]
* Here we want to show that they give excellent results with alpha particles

Sensors

* Fabricated at LFoundry [6], 150 nm CMOS process
* 150 µm thick FZ wafer with 3-5 kΩ resistivity
* Strips 4.1 cm and 2.1 cm long, with 75.5 µm pitch
* Passive technology, no electronics included
* Two strip designs:



Low dose:

- 20 strips with 30 µm implant
- 20 with strips 55 µm implant

Regular

Similar to ATLAS design

- 40 strips

Stitching line (junction between two reticles)

1 cm² reticle

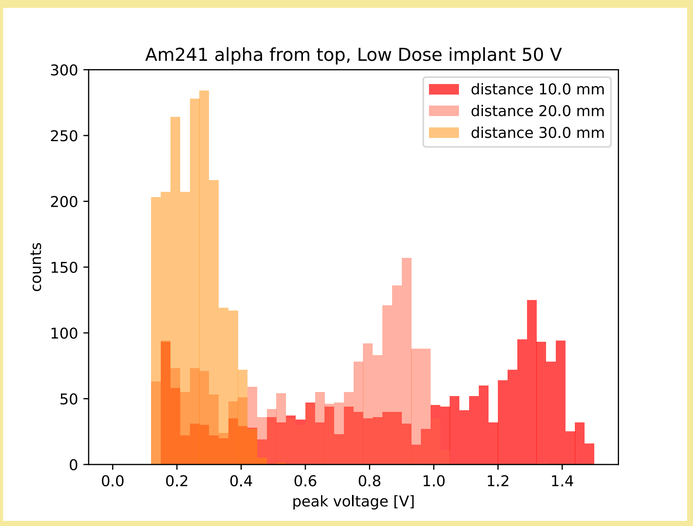
Stitching line (junction between two reticles)

Setup

* Measurements taken with Am241 source on top of the detector, located at different distances
* All strips bonded and connected to a CIVIDEC [7] spectroscopic amplifier
* Data taken with a fast oscilloscope

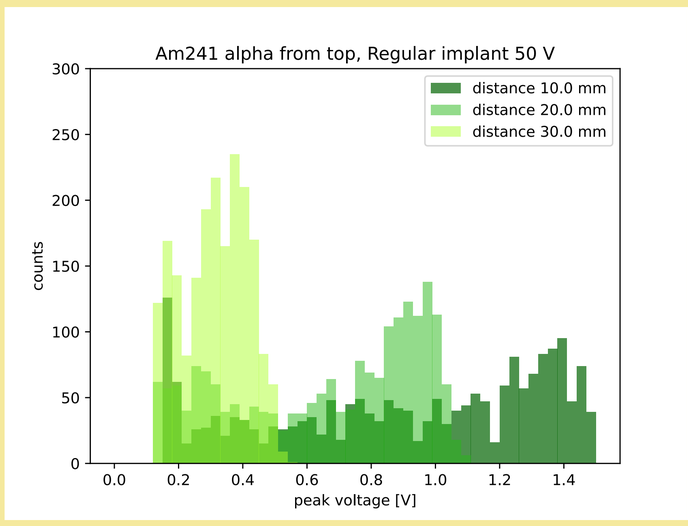
Results Low Dose implant

* Alpha peak amplitude for different distances, 2000 waveforms each
* Sensor biased at 50 V (depleted)



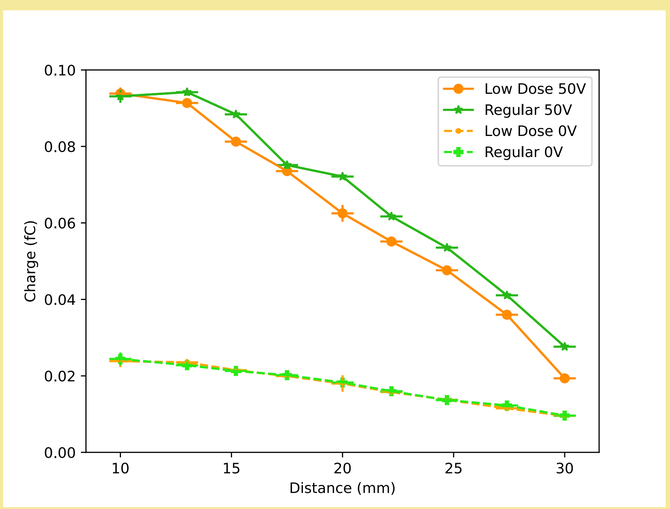
Results Regular implant

* Alpha peak amplitude for different distances, 2000 waveforms each
* Sensor biased at 50 V (depleted)



Analysis

* As expected, the closer the source is from the detector more charge is deposited (less interaction with air)
* Calibration from CIVIDEC, using the literature value 12.5 mV/fC
* Data peaks fit with Landau curves



* Low dose and regular implant design do not show significant difference
* Depleting or not biasing the detectors change the collected charge, although still some charge is collected at 0 V
* The missing energy for the depleted measurements due to the air and the uppermost inactive layers of the detector

Conclusions

* Passive CMOS stitched strip detectors work with alpha particles
* Different energy detected at different distances for the two strip designs
* Stitching does not affect the strip performance
* Future plans:
  * Fabricate active strips
  * Full CMOS wafer strip detector

Acknowledgements

This work has been partially funded by the BMBF grant Verbundproject 05H2021 - R&D DETEKTOREN (Neue Trackingtechnologien): Entwicklung von aktiven und passiven mikrostrukturierten CMOS-Sensoren

References

[1] NIMA 1033 (2022) 166671

[2] NIMA 1039 (2022) 167031

[3] M. Baselga et al. 38th RD50 online 2021

[4] M. Baselga et al. 41st RD50 Sevilla 2022

[5] I. Zatocilova et al., IWoRiD Oslo 2023

[6] LFoundry, Lfoundry s.r.l. Landshut, ludwig-erhard-Strasse 6a, 84034 Landshut, Germany, 2023

[7] CIVIDEC Instrumentation, Schottengase 3A1/41, 1010 Wien, Austria 2023