First production of Resistive AC-Coupled Silicon Detectors (RSD) at FBK

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for the RSD group (**FBK** and **INFN Torino**)

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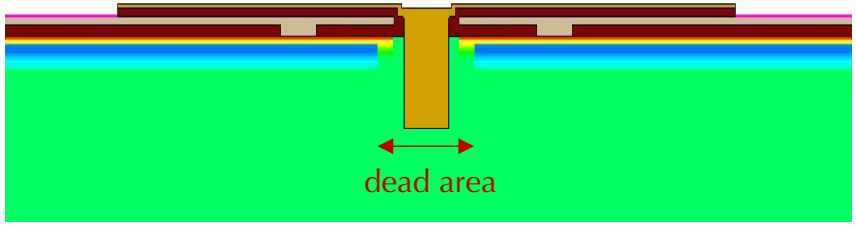
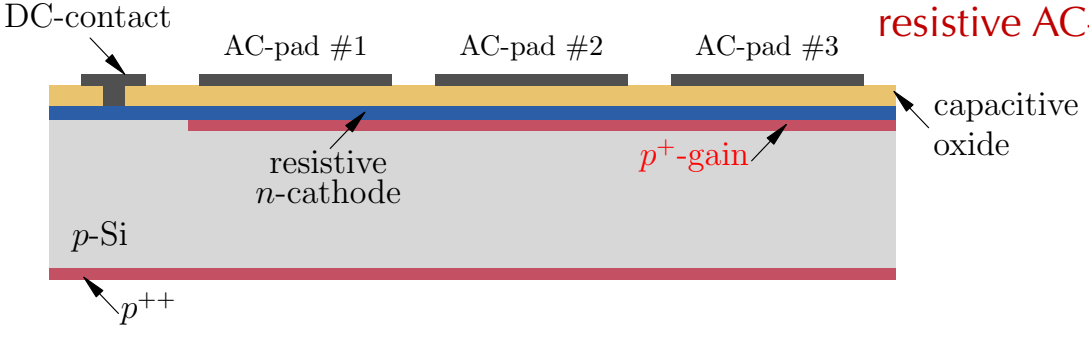
Motivations

- Possible solutions to increase the fill-factor:

trenches isolation (HD-LGAD)
(see G. Borghi presentation)



resistive AC-coupled readout (AC-LGAD)

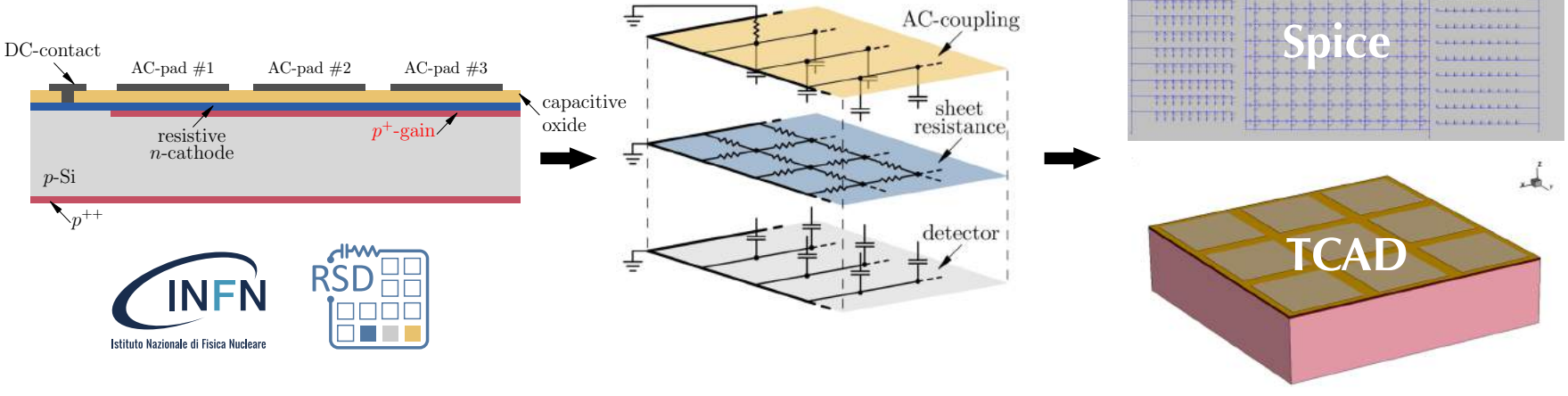


The RSD1 simulation and design

numerical implementations

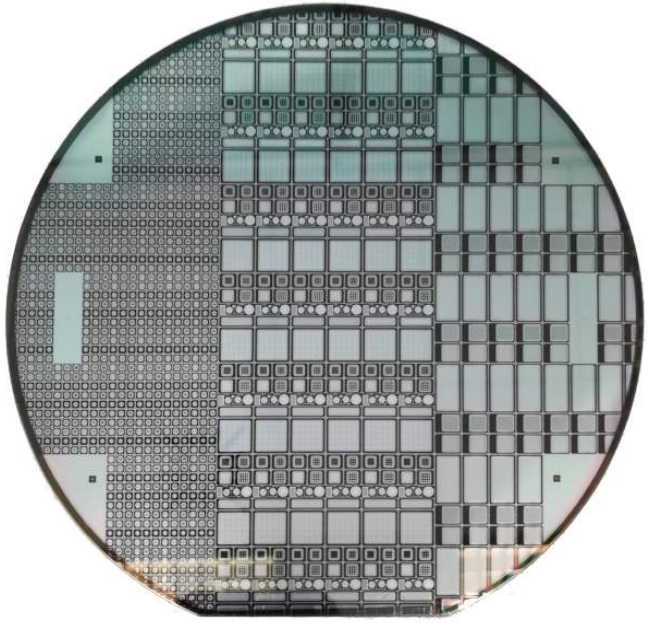
conceptual cross-section

simplified model



The RSD1 production

55 µm thick **6″** wafers
stepper lithography



Si-Si **FZ** from **IceMOS**
Epi from **Addison**

wafer	*n*-plus dose	*p*-gain dose	dielectric thickness	*p*-stop dose	substrate
1	A	0.92	L	B	Si-Si
2	A	0.94	L	A	Si-Si
3	A	0.94	L	B	Epi
4	A	0.94	H	B	Si-Si
5	A	0.96	H	B	Si-Si
6	B	0.92	L	B	Epi
7	B	0.94	L	A	Si-Si
8	B	0.94	L	B	Si-Si
9	B	0.96	L	B	Si-Si
10	B	0.96	H	B	Si-Si
11	C	0.92	L	B	Si-Si
12	C	0.94	L	B	Epi
13	C	0.94	L	B	Si-Si
14	C	0.96	H	B	Epi
15	C	0.96	H	C	Si-Si

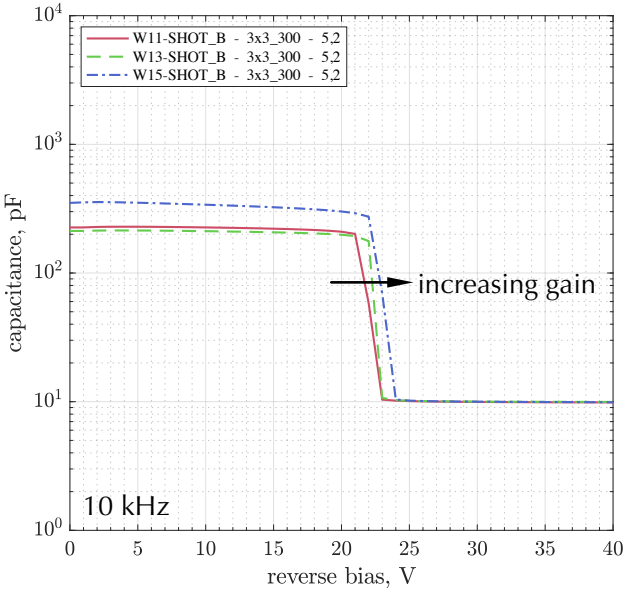
Static characterization

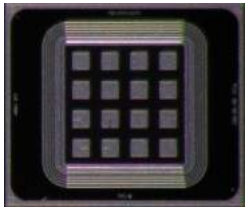
p-gain dose split

PRELIMINARY

4×4 matrix sensor
300×300 μm² pad **size**
500×500 μm² pad **pitch**

C(*V*)

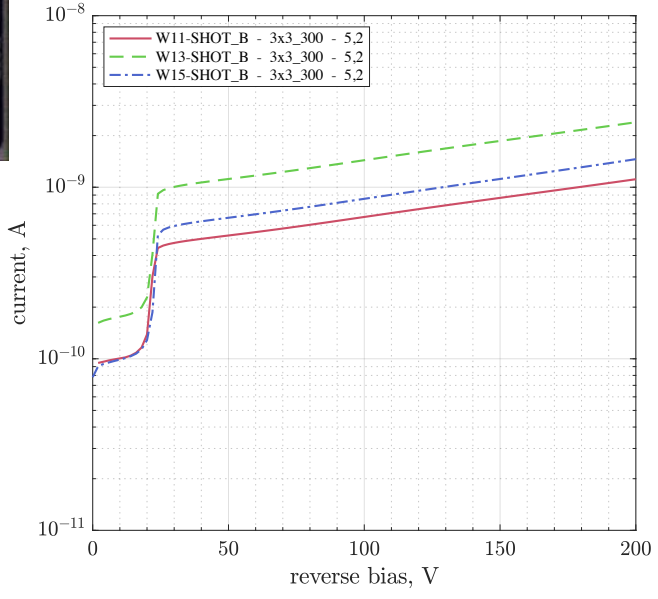




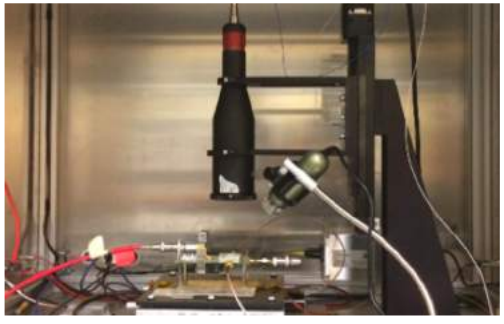
***p*-gain**

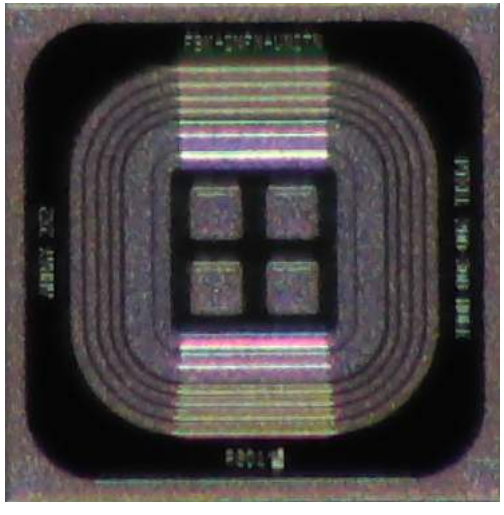
W11: 0.92
W13: 0.94
W15: 0.96

I(*V*)



Dynamic characterization at TCT





Readout setup:

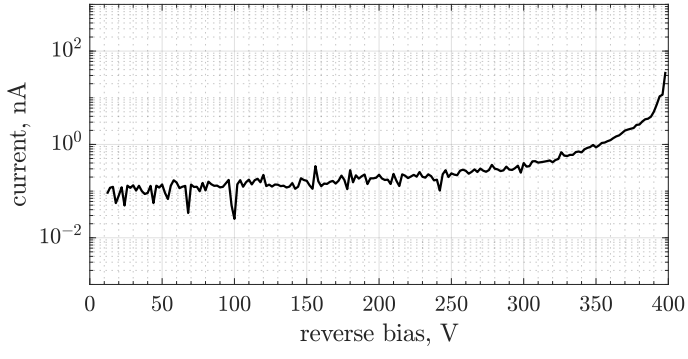
- TCT laser (1064 nm) @ ~10 MIP with FWHM ~15 nm
- INFN-Torino 3-channel board
- CIVIDEC 40 dB ampl. for each channel
- V_{bias} = 200 V (I ~ 5 nA)

Tested sample:

- 2×2 matrix, 200-300 μm
- W04

gain dose:	0.94
n^+ dose:	A
p-stop dose:	B
t_{diel}:	High
substrate:	Si-Si

- V_{bd} = ~400 V



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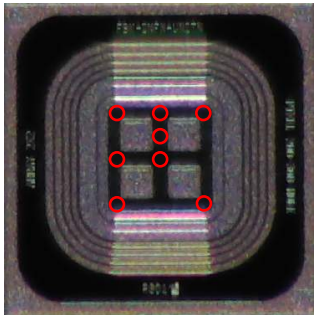

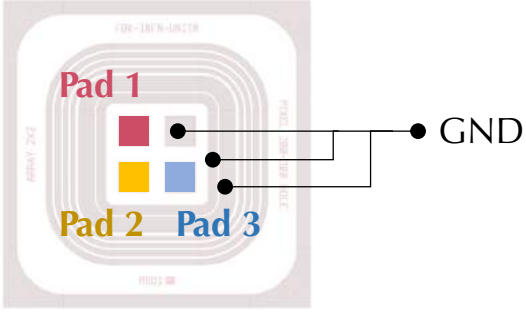

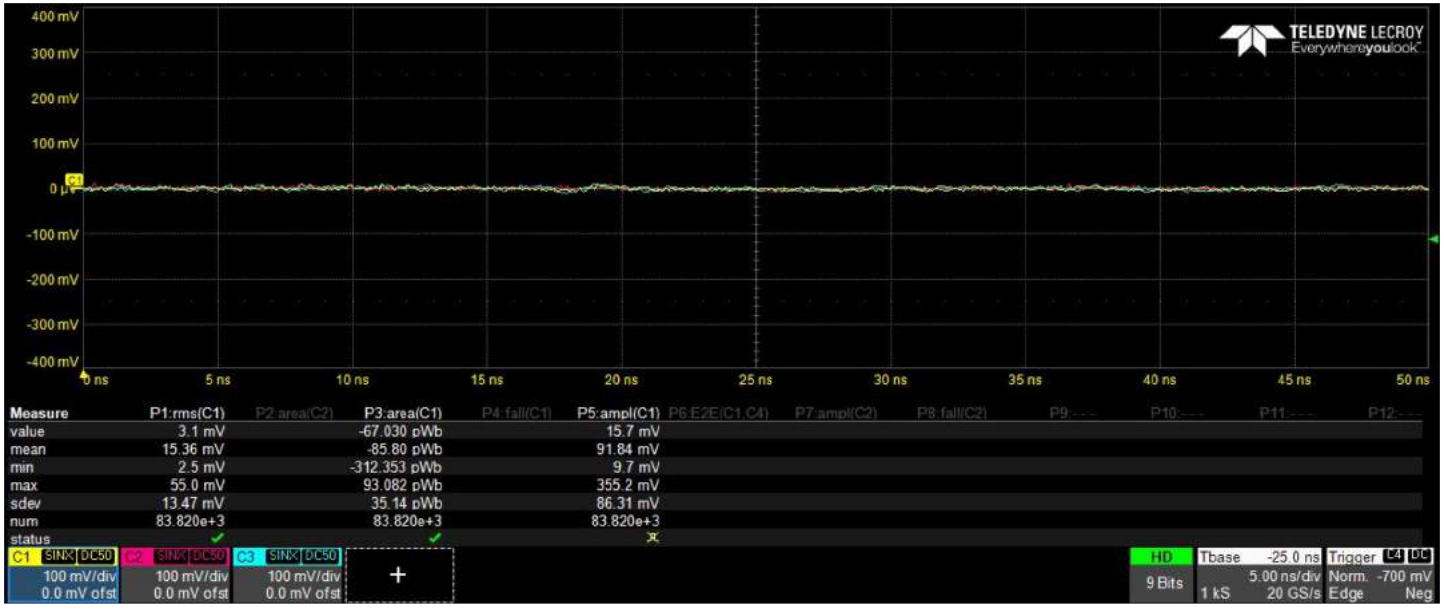

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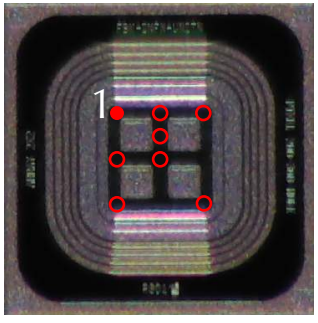

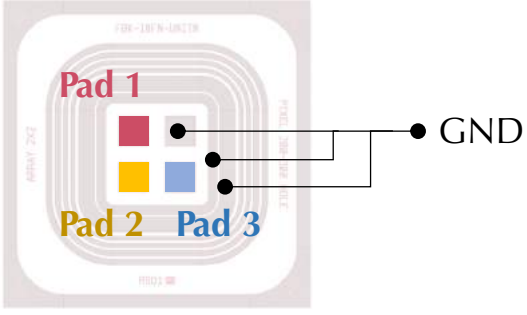

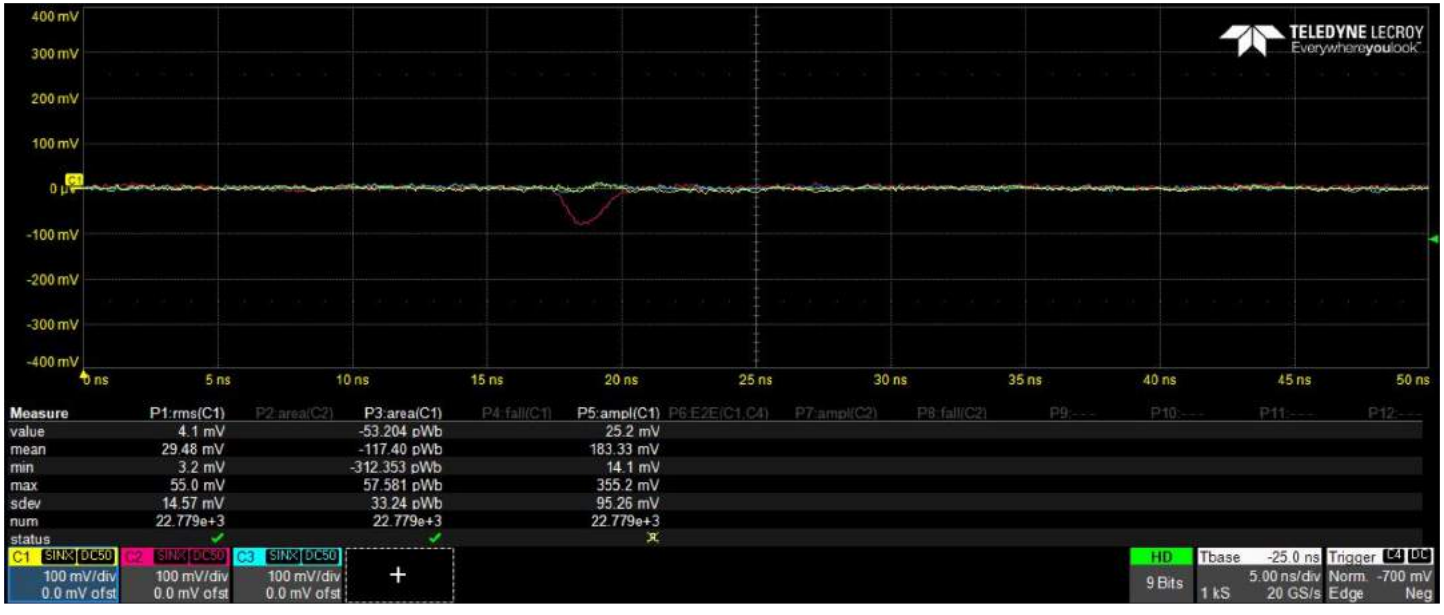

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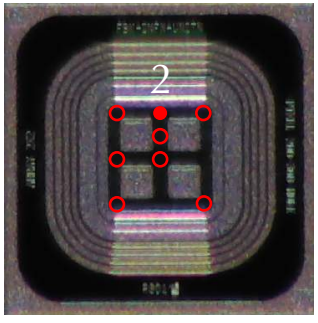

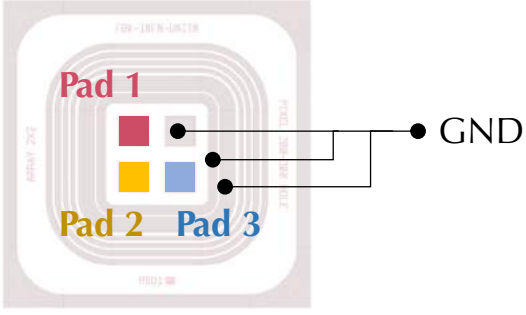

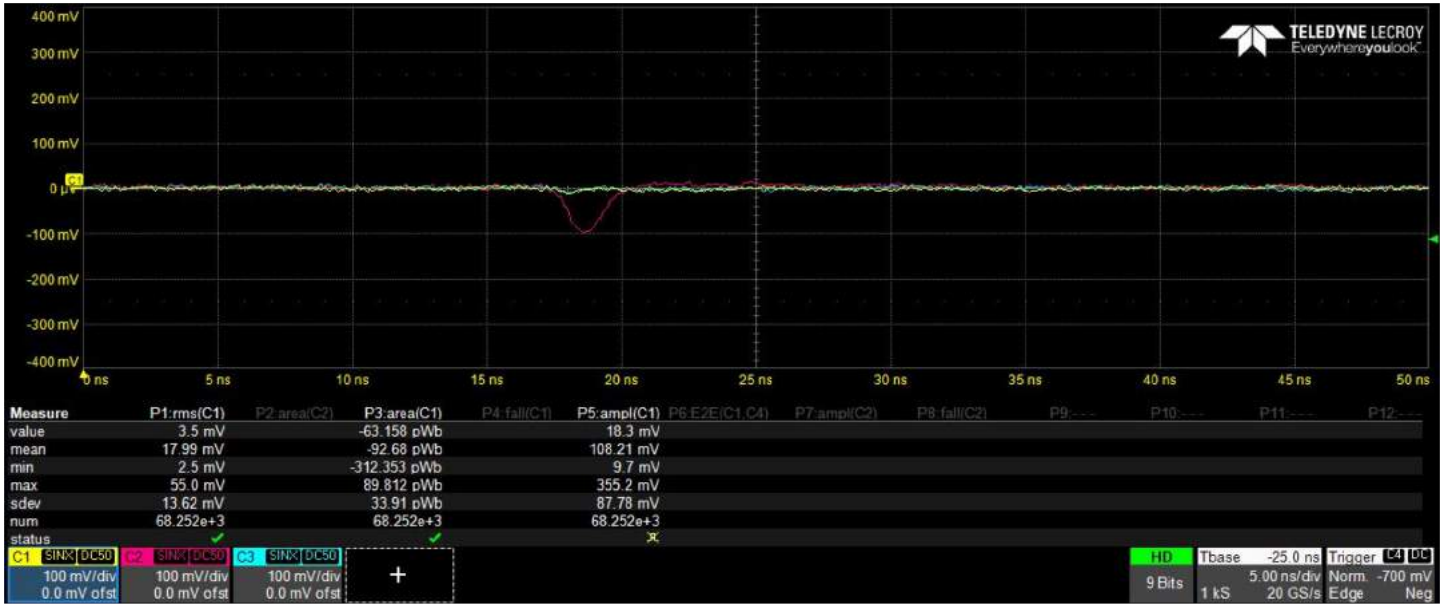

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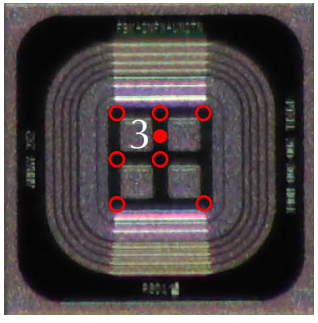

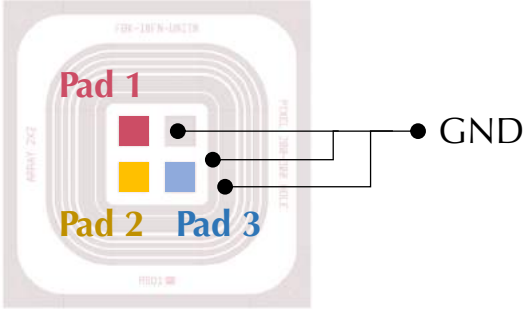

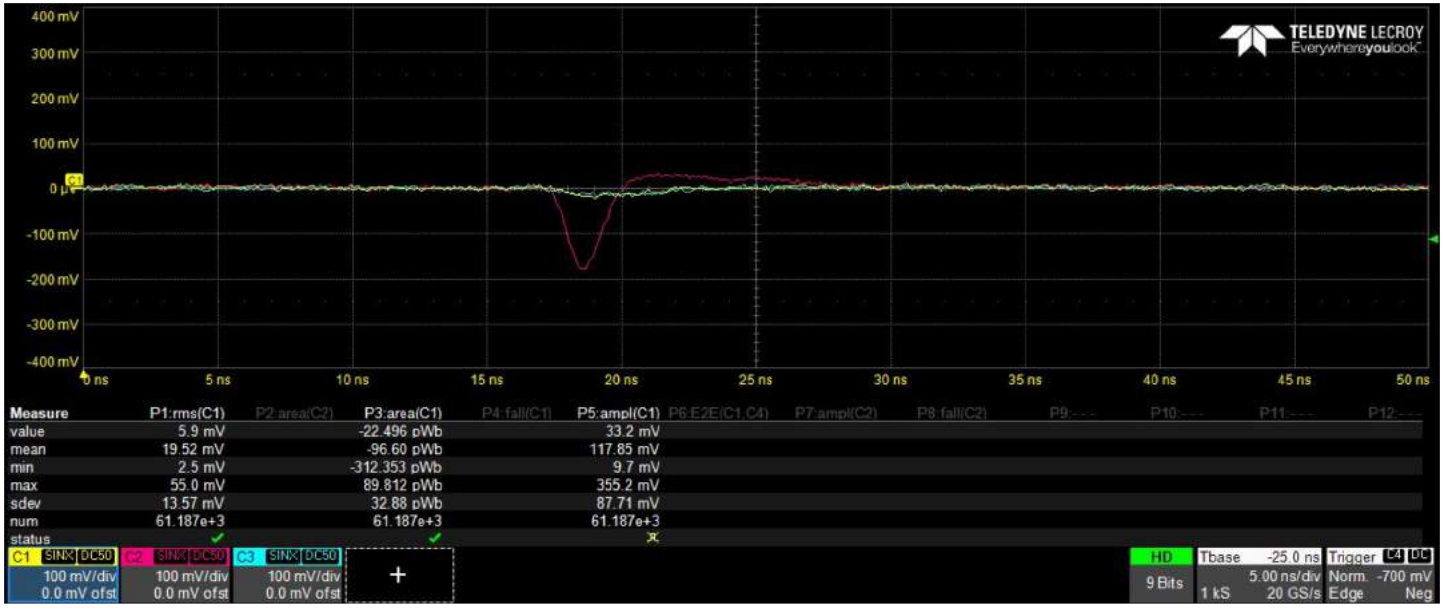

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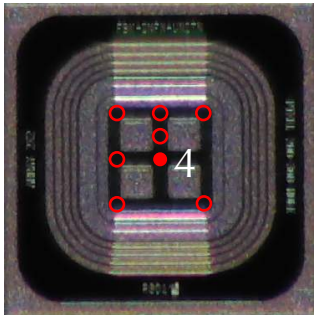

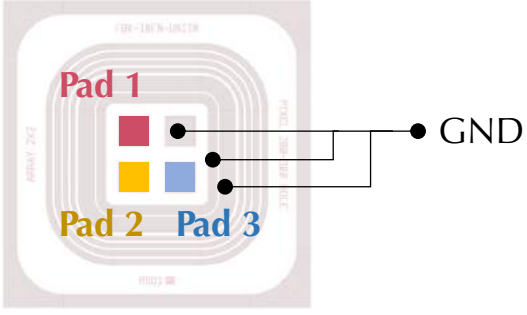

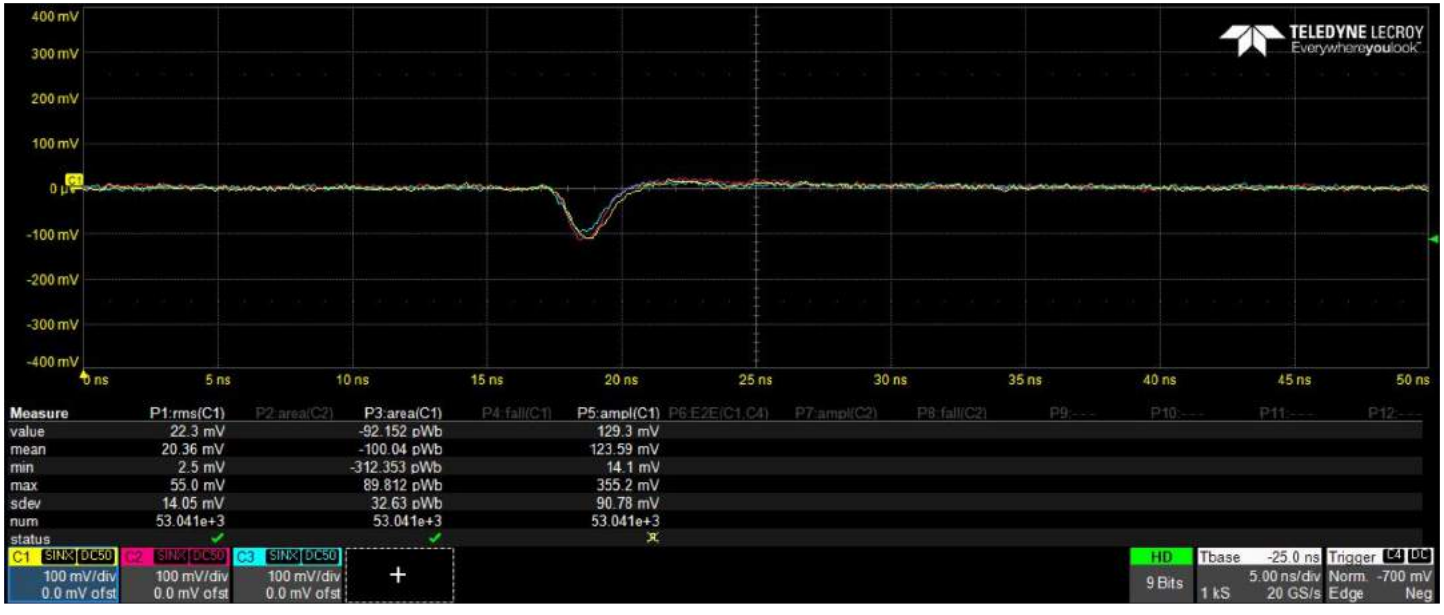

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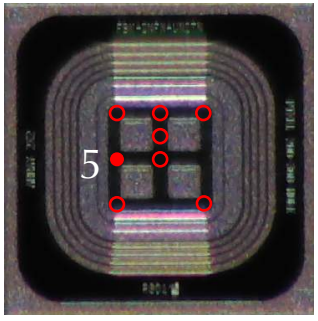

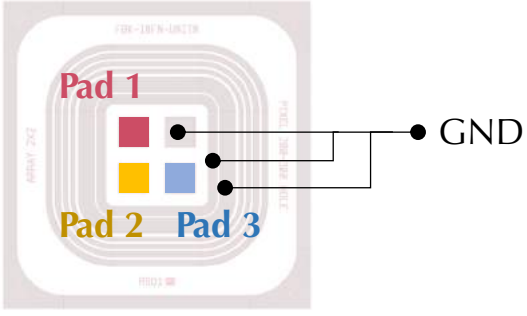

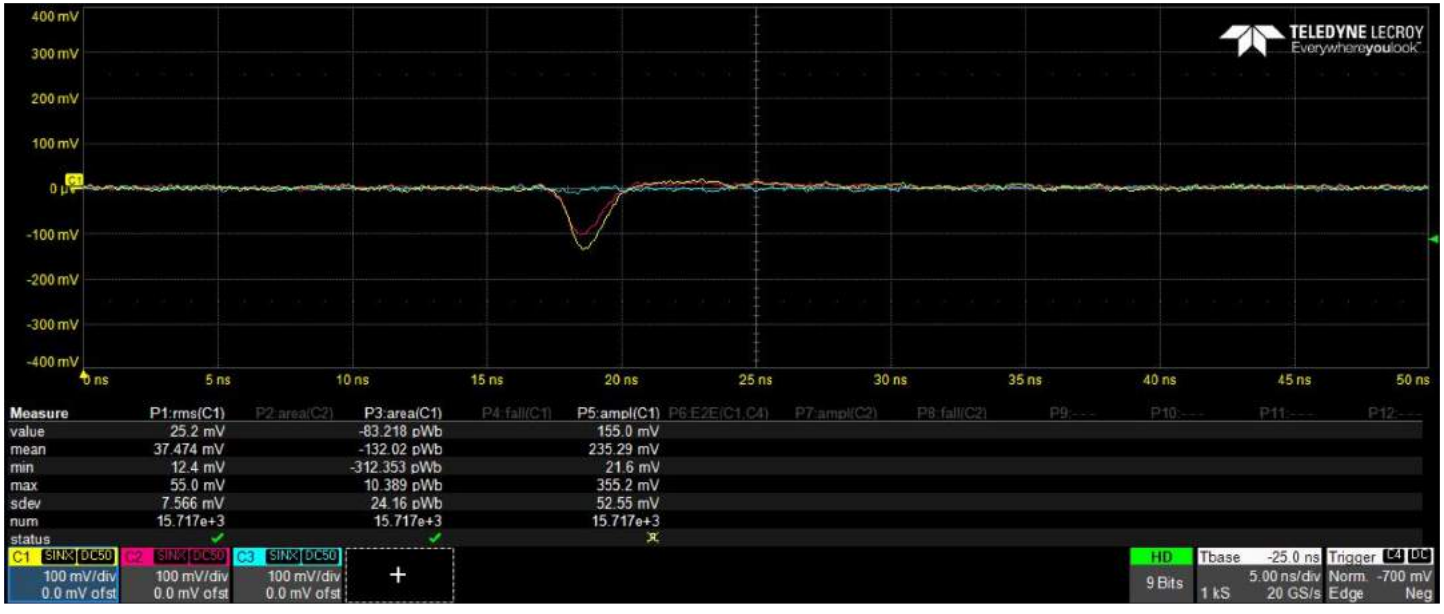

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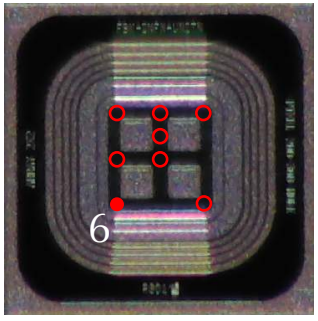

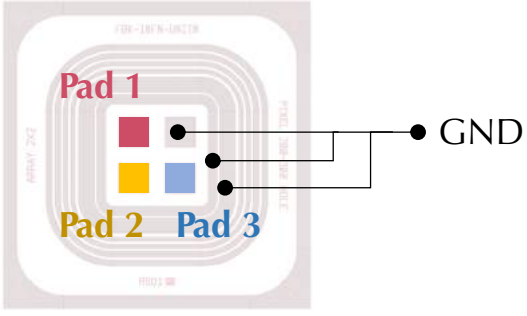

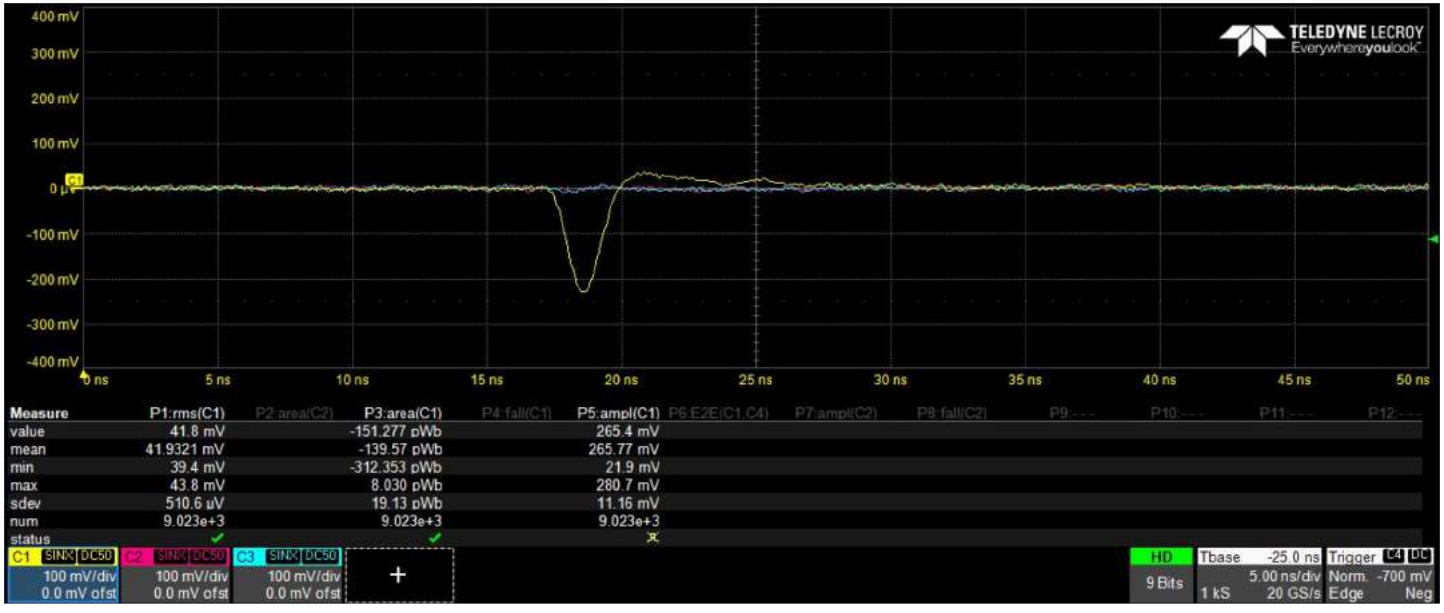

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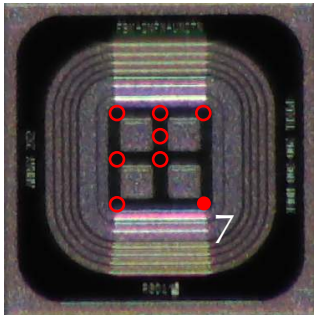

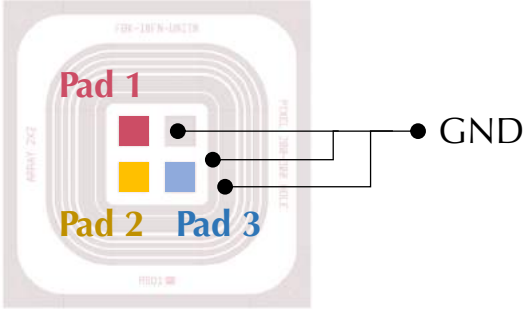

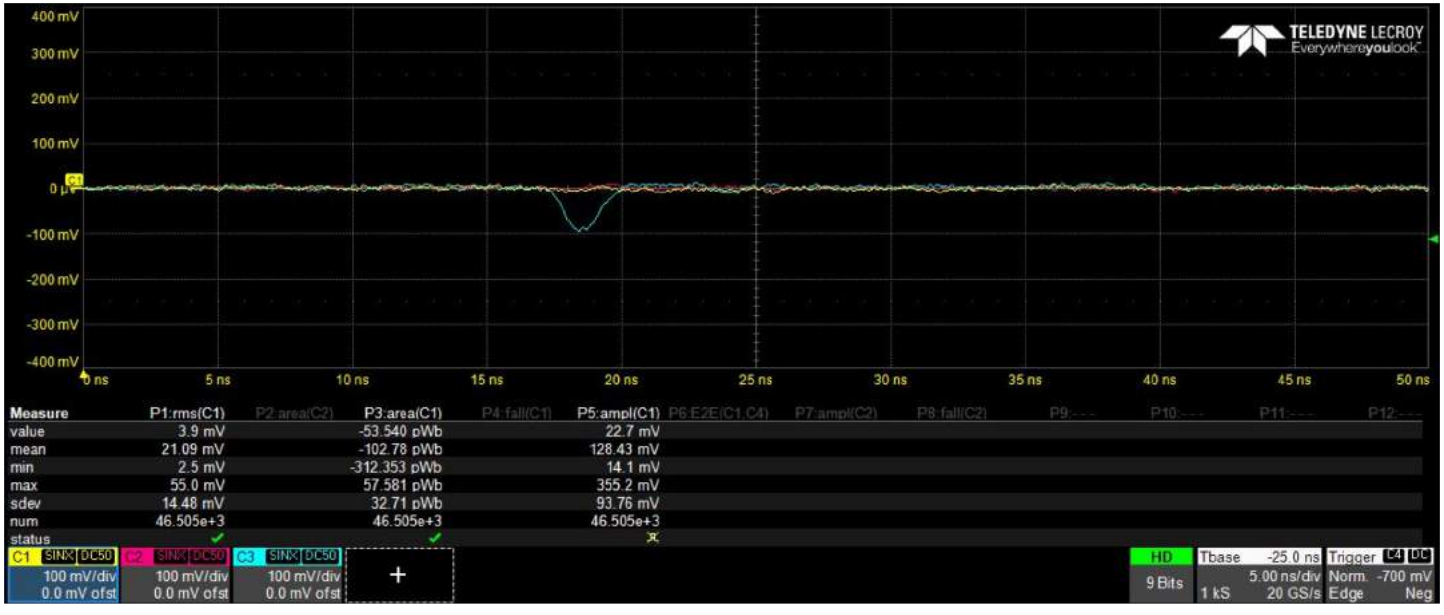

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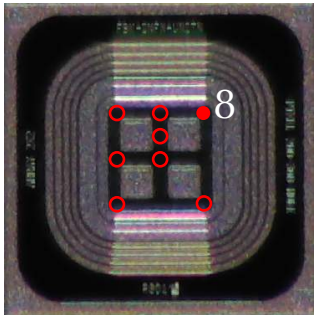

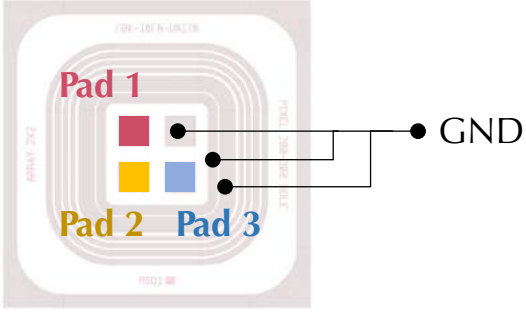

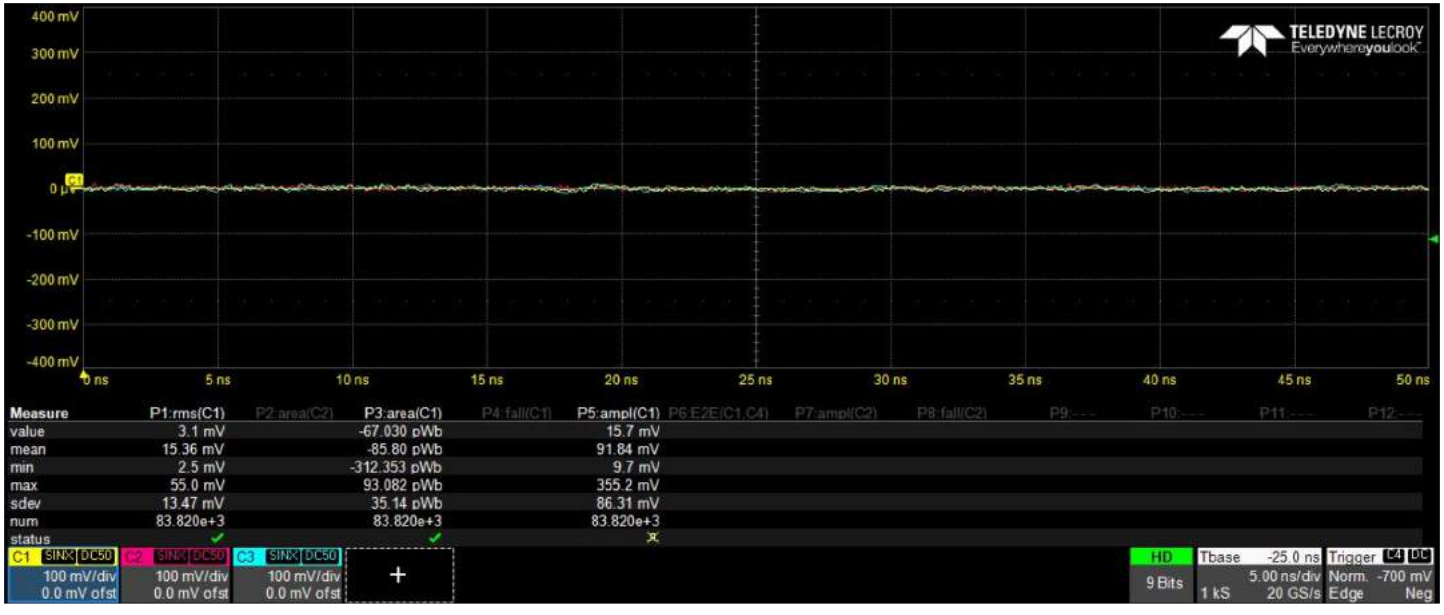

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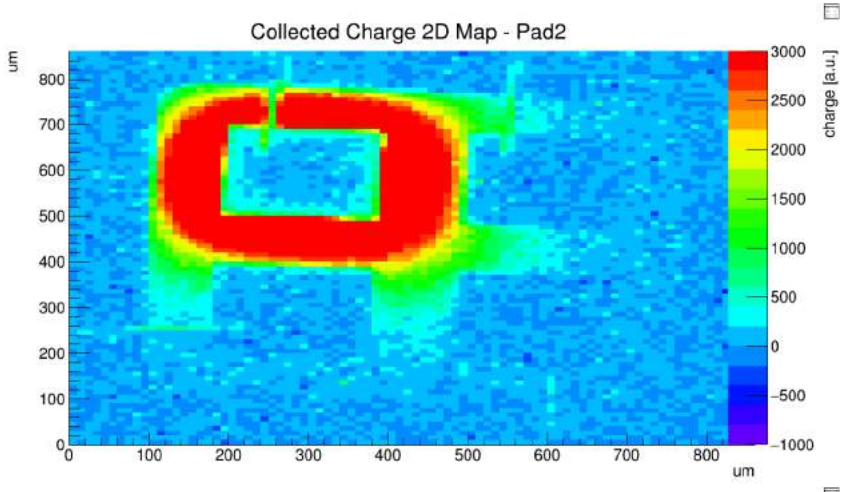
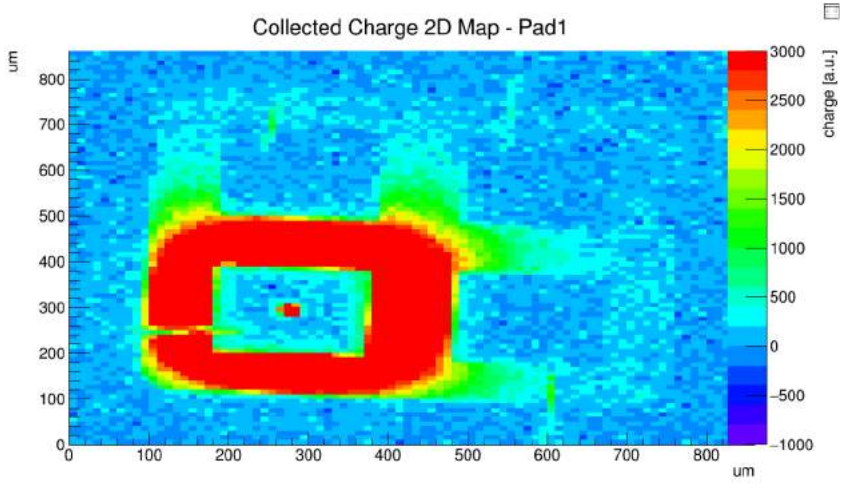
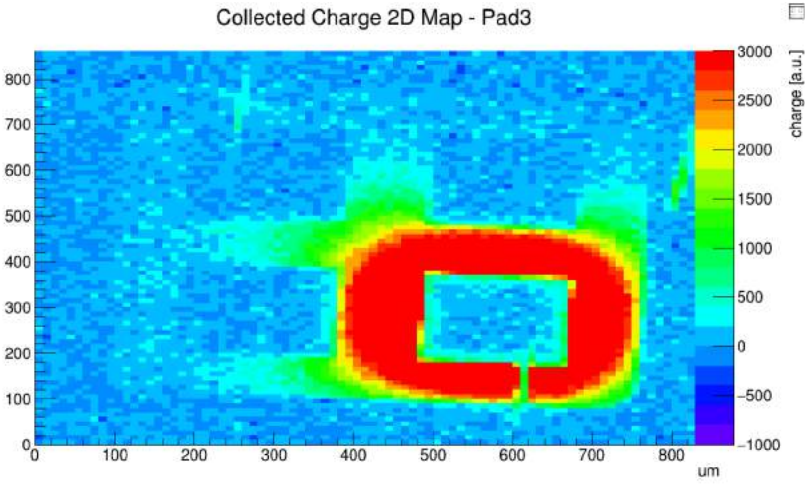


Pads 1, 2, 3

Integration time: 5 ns
Signal sensitivity to position: ~1% each µm





Summary

- A first run of **Resistive AC-Coupled Silicon Detectors** (RSD) has been produced at **FBK**
- Two **substrates** and several split of **resistive**, **gain** and ***p*-stop** implants have been used
- Preliminary **static measurements** before dicing seem to be indicative of a very **homogeneous run**
- First signals seen with the **TCT** setup on a small-pitch RSD matrix demonstrate that RSD are alive and produce **very promising signals**, both in terms of **shape** and **dynamic response** with respect to the laser hit position
- The signal shape is dominated by a **large negative lobe** followed by a **small positive overshoot**. The various **splits** will identify how to **control the shape**

Acknowledgements

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- **INFN - Gruppo V**
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- **U.S. Department of Energy** grant number DE-SC0010107
- **Dipartimenti di Eccellenza**, **Univ. of Torino** (ex L. 232/2016, art. 1, cc. 314, 337)

Many thanks also to the **Silicon lab** in Torino, to the whole **UFSD group** and especially to **F. Ficorella**, **G. Paternoster**, **N. Cartiglia**, **M. Ferrero**, **F. Siviero**, **M. Tornago**, **R. Arcidiacono** and **F. Lenta**

Thank you for your attention!

Backup

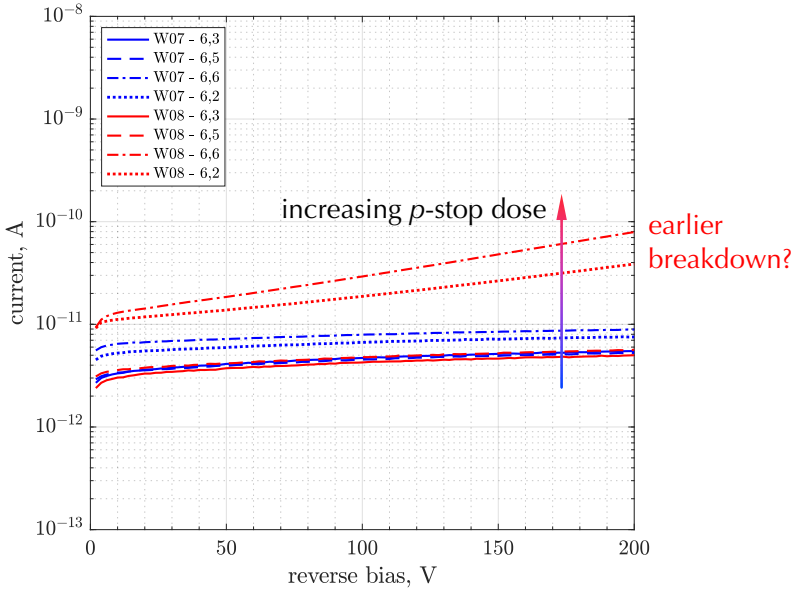
Static characterization

p-stop dose split: *pin*

PRELIMINARY

3×3 matrix sensor
40×40 μm² pad **size**
80×80 μm² pad **pitch**

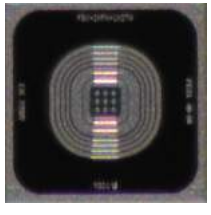
I(*V*)



***p*-stop**

W07: 0.05
W08: 0.10

***pin* diodes**



Example: ALTIROC device

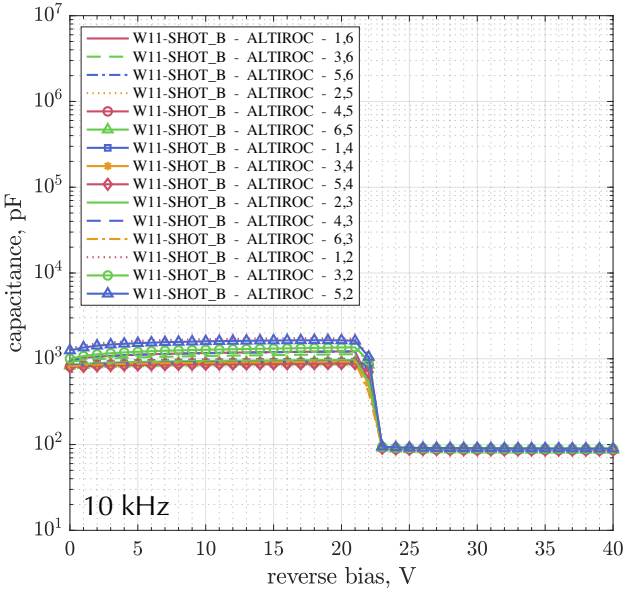
Wafer homogeneity

W 11

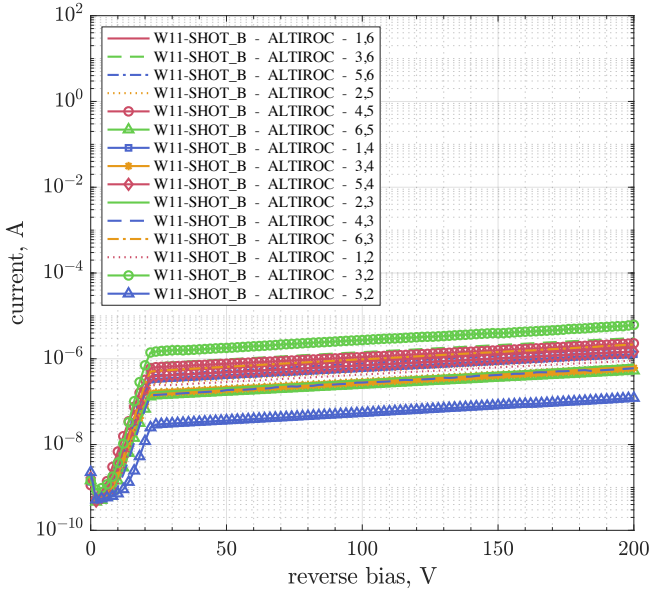
5×5 matrix sensor
1.27×1.27 mm^2 pad **size**
1.30×1.30 mm^2 pad **pitch**

PRELIMINARY

C(*V*)



I(*V*)

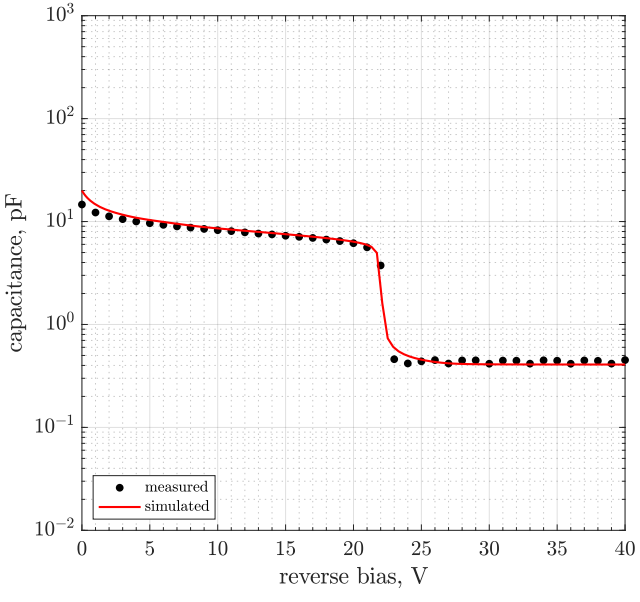


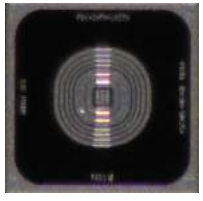
Measurements and simulations

3×3 matrix sensor
45×45 μm² pad **size**
50×50 μm² pad **pitch**

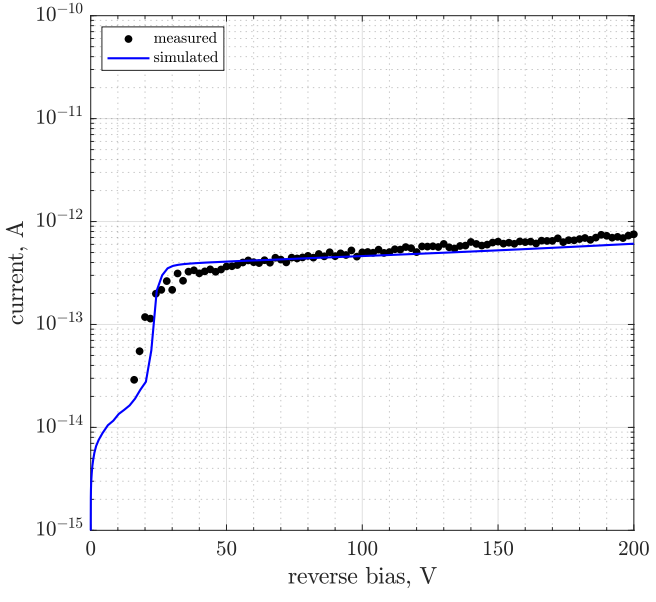
PRELIMINARY

C(*V*)

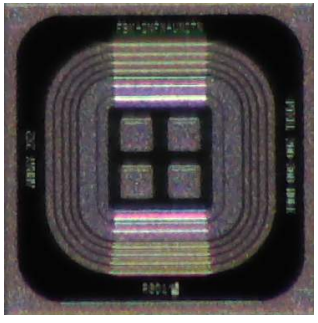


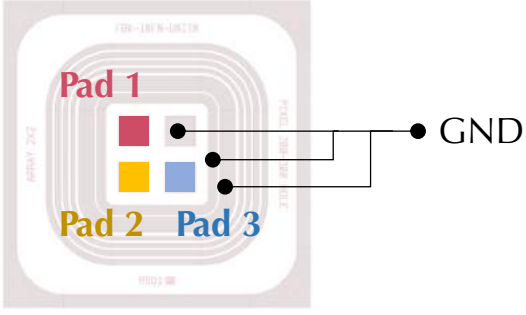


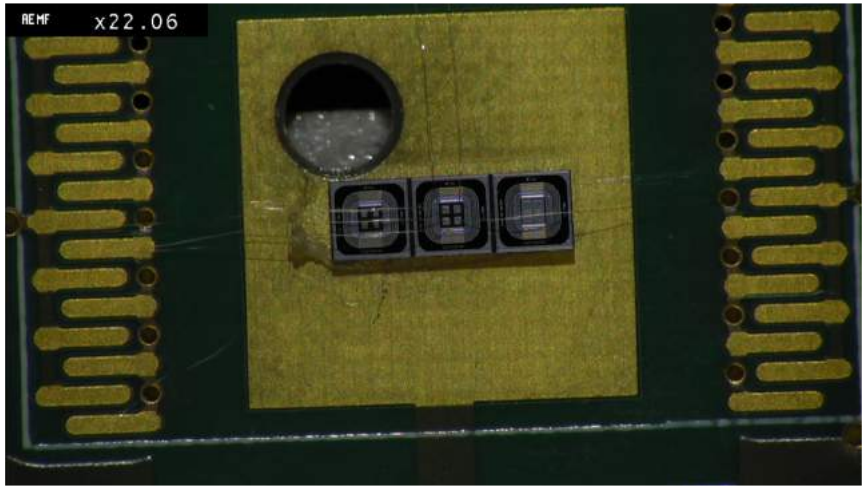
I(*V*)

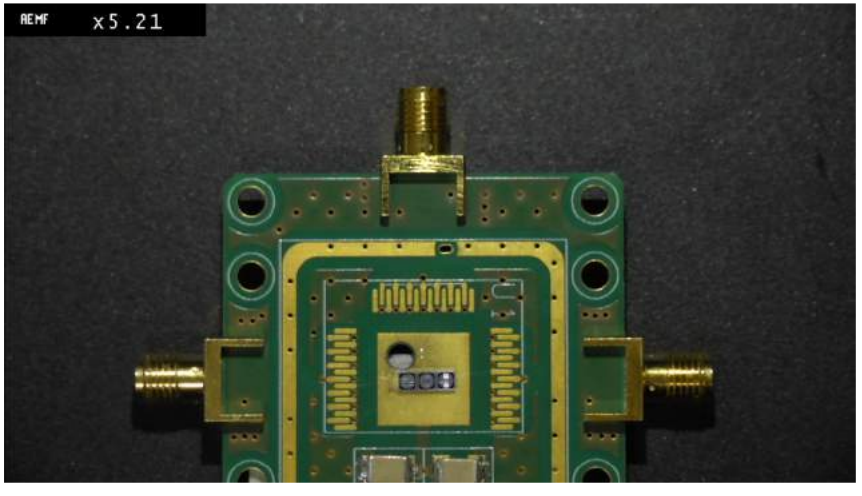


Dynamic characterization at TCT









Dynamic characterization at TCT