

Industrial Production of Large-Area Si-Detectors

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About the collaboration HEPHY-Infineon

- › HEPHY Vienna and Infineon Technologies cooperate since 2009 on the development of Si-sensors for HL-LHC-experiments
- › Responsibilities
 - HEPHY: Layout-design, characterization, test-beams, irradiations, device-simulations
 - Infineon: Process-engineering, processing, establish series testing at Infineon
- › Focus
 - Planar AC-coupled Strip-sensors and DC-coupled Pad-sensors on large area wafers 6" and 8" on high-resistive FZ wafers 3..8 kOhm.cm
- › Following measurements were done by HEPHY/Vienna

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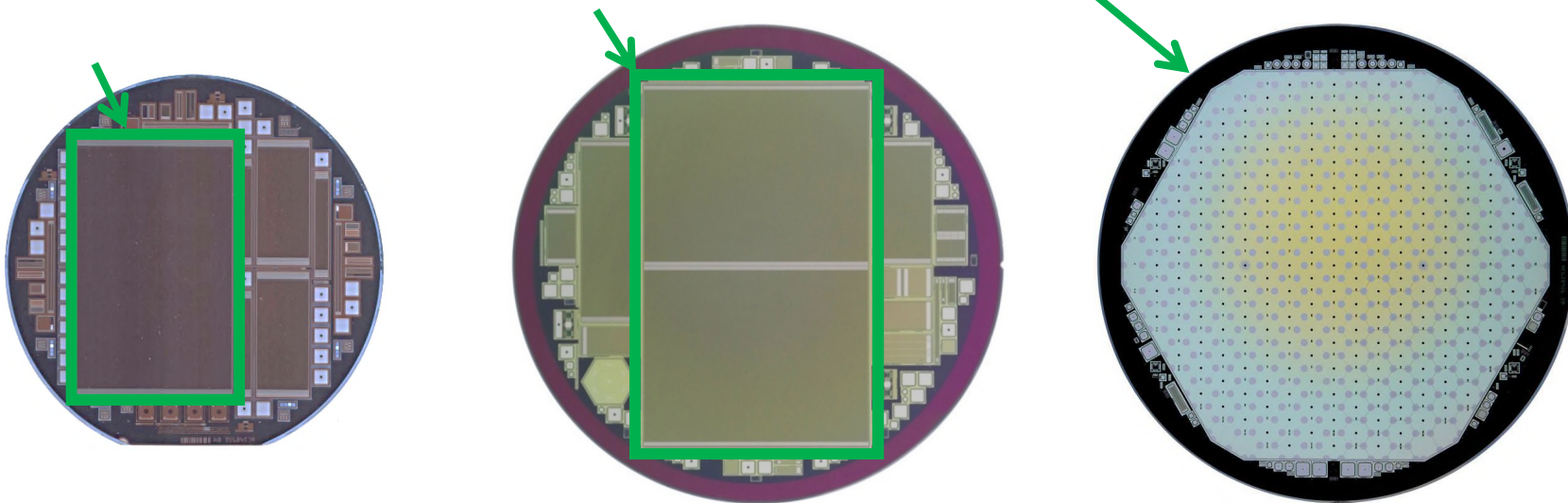
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Outlook

Achievements Overview

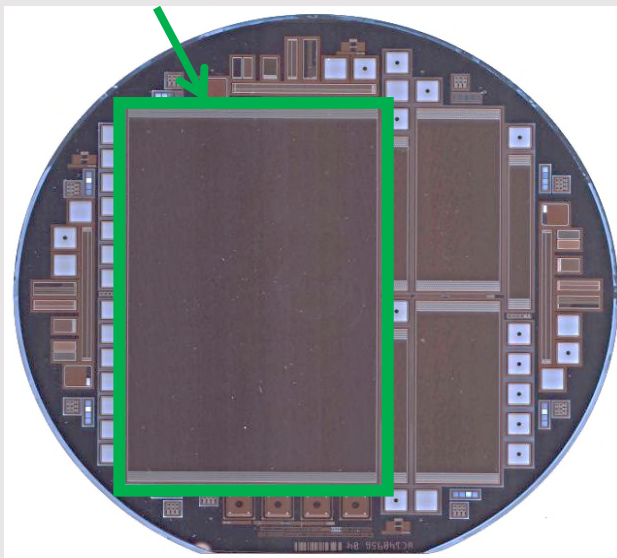


Wafer size	Polarity	Layout	Chipsize [cm ²] main sensor	Thickness [μm] physical ≈ active
6"	p-in-n FZ	AC-Strip	10 x 7	200, 300
8"	n-in-p FZ	AC-Strip	15 x 10	200
8"	n-in-p FZ	DC-Pad	18 x 16 hexagonal	140, 200, 300, 350

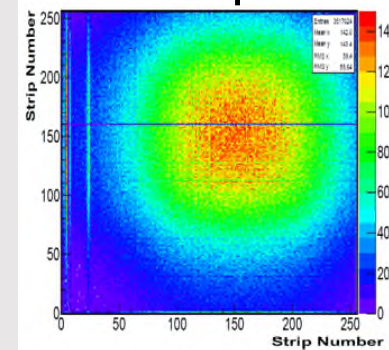
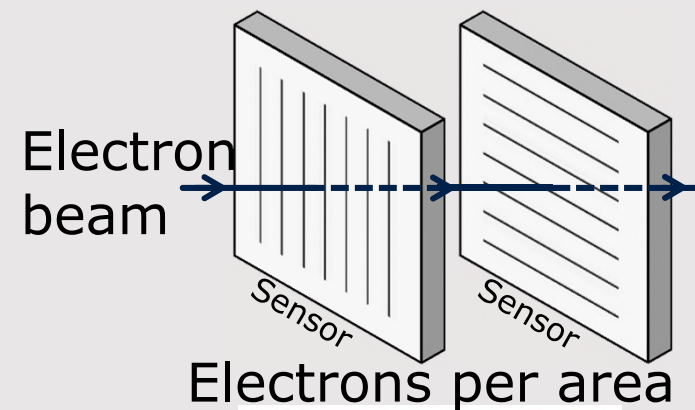


6" AC-coupled Strip-Sensor, p-in-n

- › The aim was to re-produce the current CMS tracker sensors
- › Sensor STL: $\sim 10\text{ cm} \times 7\text{ cm}$
- › 512 strips á $10\text{ cm} \times 20\text{ }\mu\text{m}$
- › 300 μm and 200 μm thickness
- › Resistivity FZ, 1.3 kOhm.cm

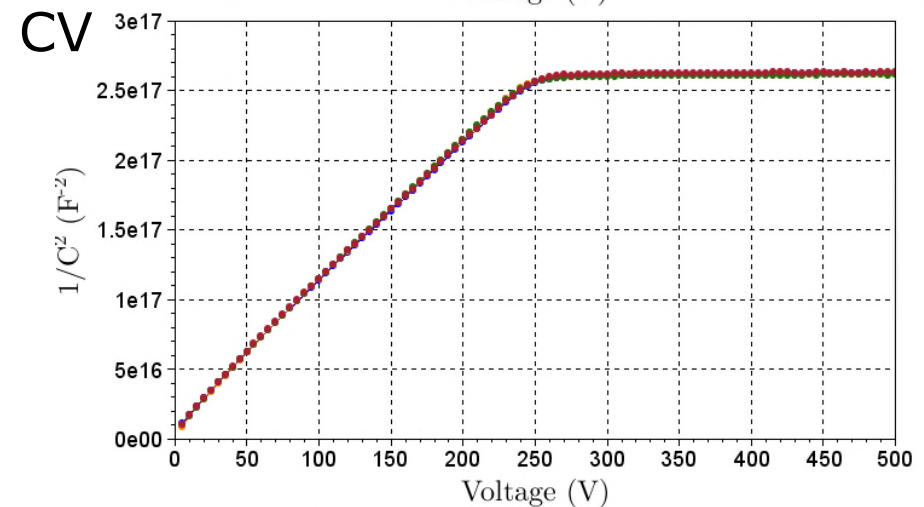
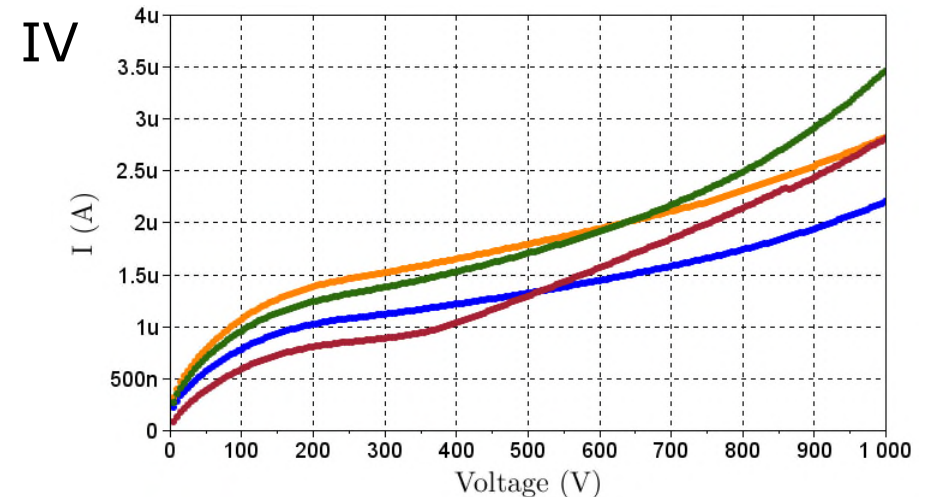


- › Testbeam at DESY, readout with APV25 chip (analogue CMS chip)
- › Performance: very good



6" AC-coupled Strip-Sensor, p-in-n

- › Typical IV and CV curves of STL sensors of batch 1
- › Full depletion voltage at approx. 250 V
- › Global current @ 300 V between 0.7 μA and 1.5 μA for a $10 \times 7 \text{ cm}^2$ sensor



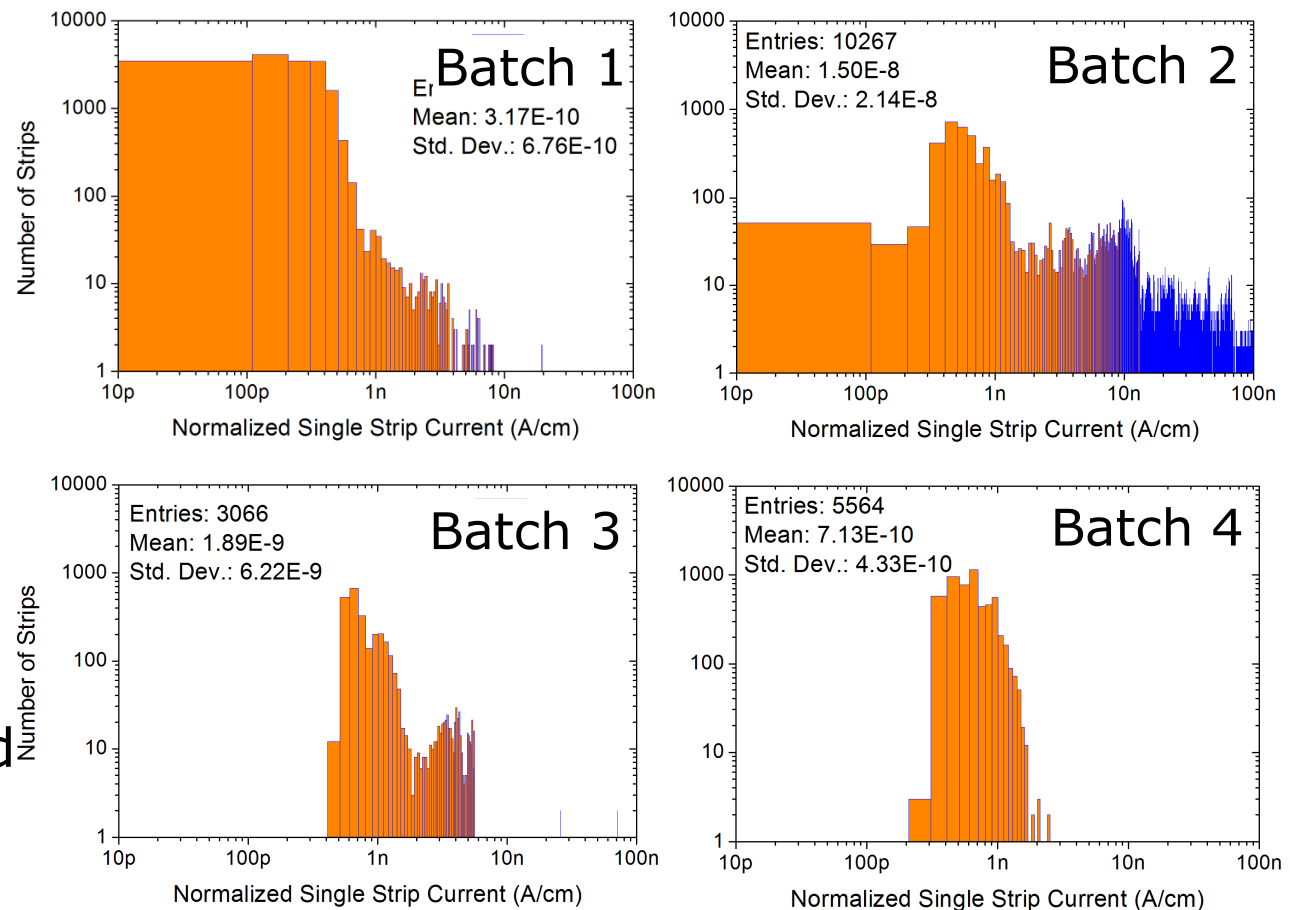
Measurements by HEPHY/Vienna

6" p-in-n Strip-Sensor Summary of Electrical Characterization



- › Continuous improvement clearly visible throughout the 4 batches
- › Formation of an irregular area is understood
- › Improvements at Infineon: Sawing
- › Improvements at HEPHY: Optimized sensor design

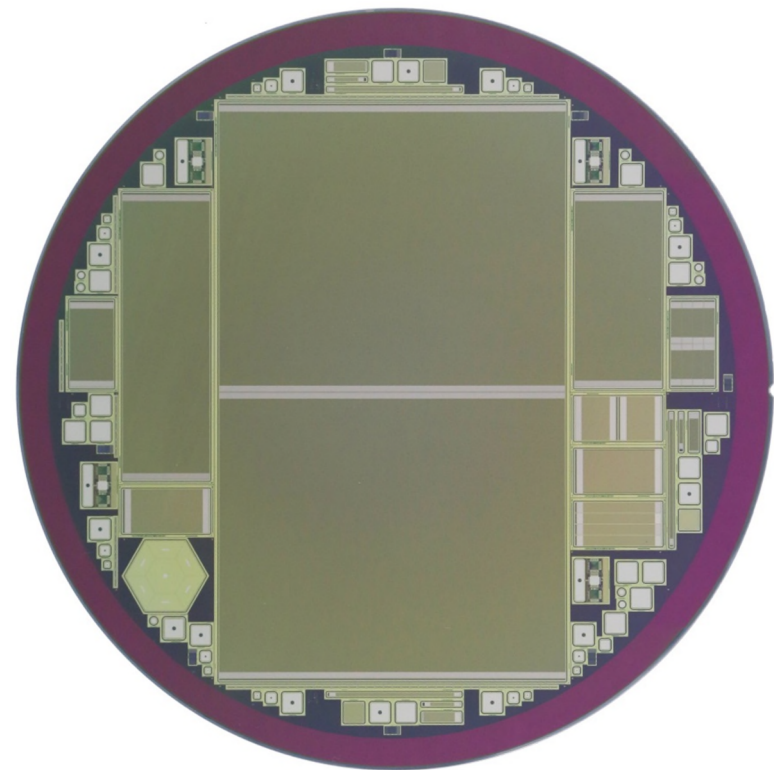
Histograms of I_strip vs. batches



Measurements by HEPHY/Vienna

8" p-in-n, AC-coupled Strip-Sensor

- › Wafer for CMS-Phase II-Upgrade-Strip-Tracker
 - Wafer diameter (8" wafer): 200 mm
 - Forbidden margin 10 mm -> 180 mm usable
 - Resistivity $\sim 7 \text{ k}\Omega\text{cm}$, n-on-p float zone, orientation $\langle 100 \rangle$
 - 200 μm physical thickness $\rightarrow V_{fd} \sim 60\text{V}$
- › Main Sensor
 - Size: 94.183 x 153.4 mm²
 - Strips: 2032, Strip length: 75.6 mm
 - Strip Pitch: 90 μm , P-stop: Atoll
- › Split groups for runs:
 - p-stop / p-spray, Dose, Profile
 - Different R_poly doping
 - Backside activation

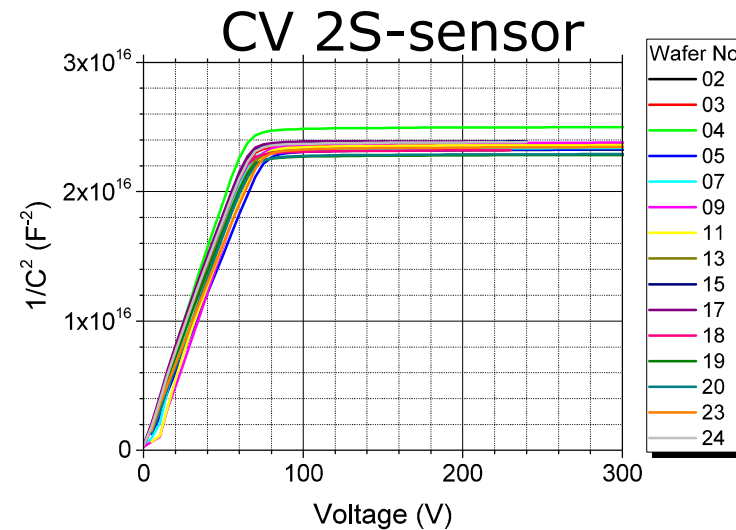
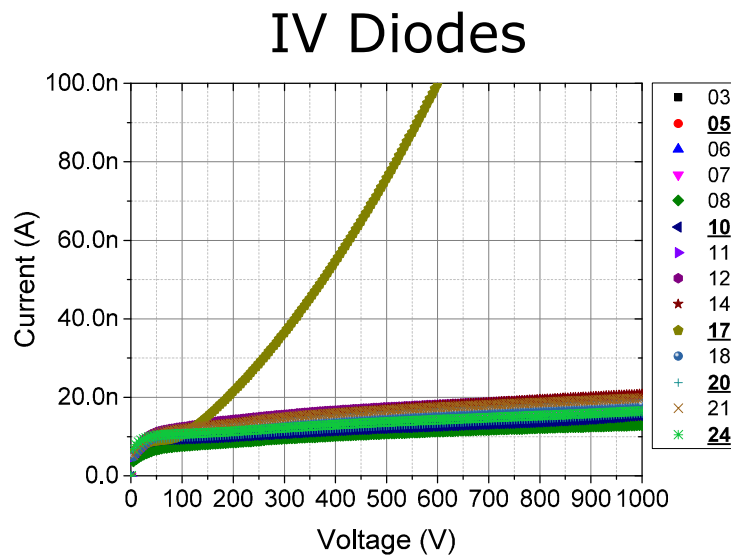
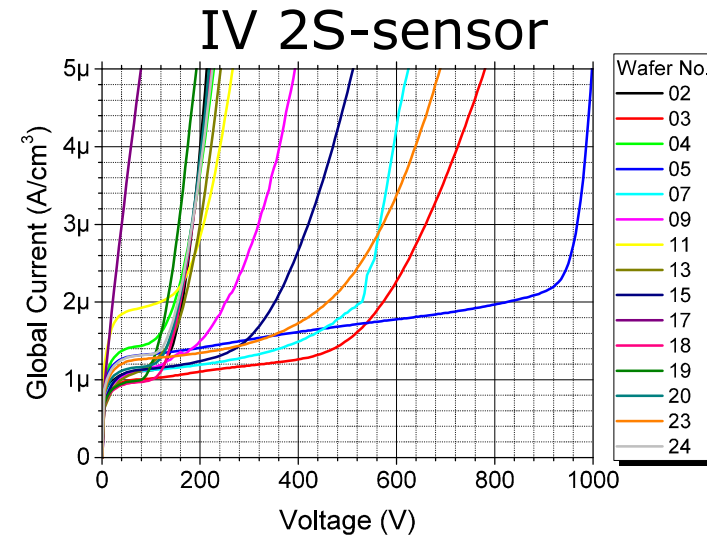


8" p-in-n, AC-coupled Strip-Sensor

Global parameters IV and CV



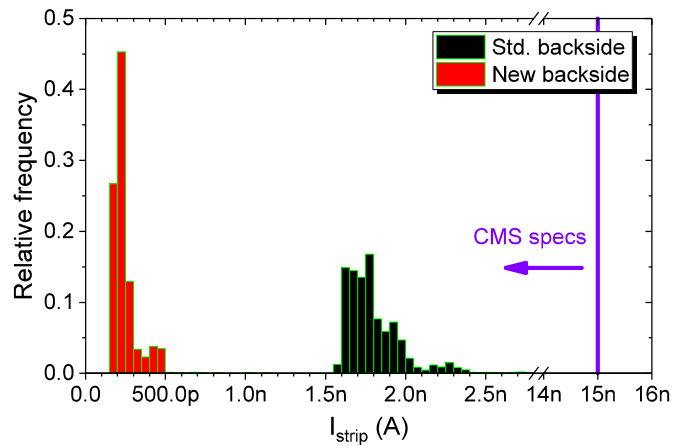
- › Full depletion voltage of ~ 75 V
- › Sensor-HV-stability to be improved
- › Diodes are HV-stable



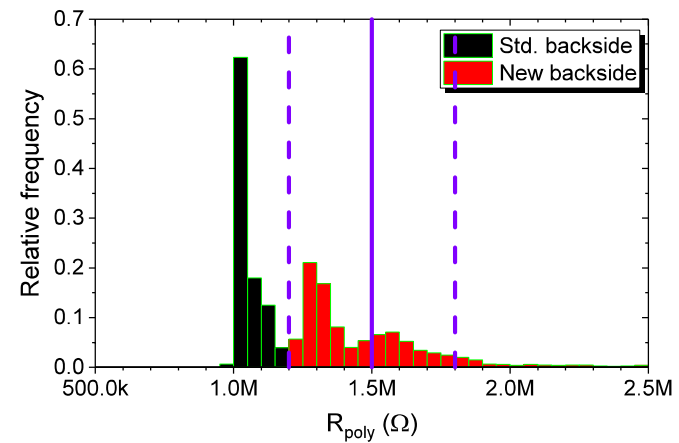
8" p-in-n, AC-coupled Strip-Sensor Strip-Parameters Batch 2



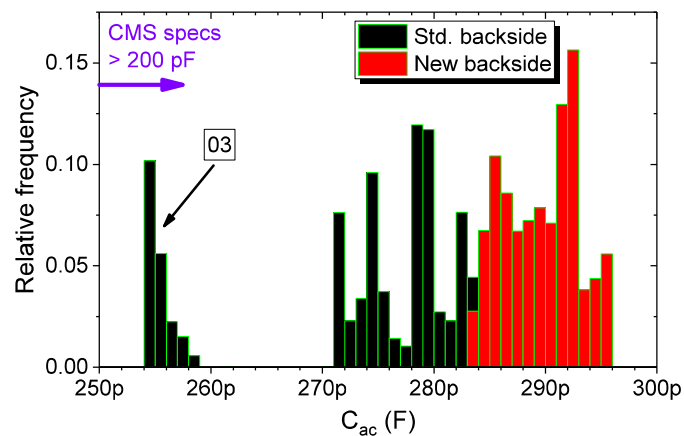
I_{strip}



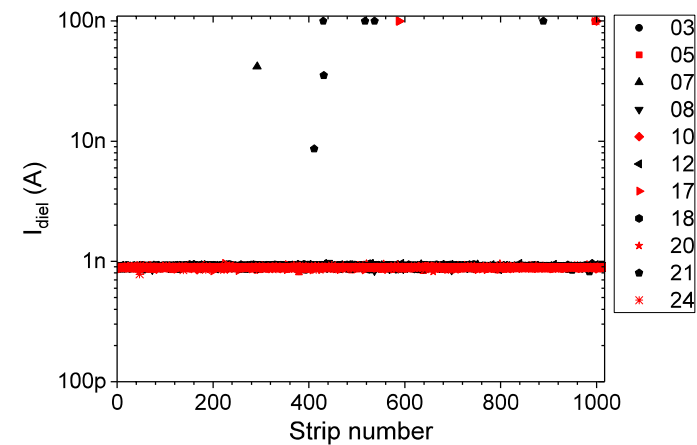
R_{poly}



C_{ac}



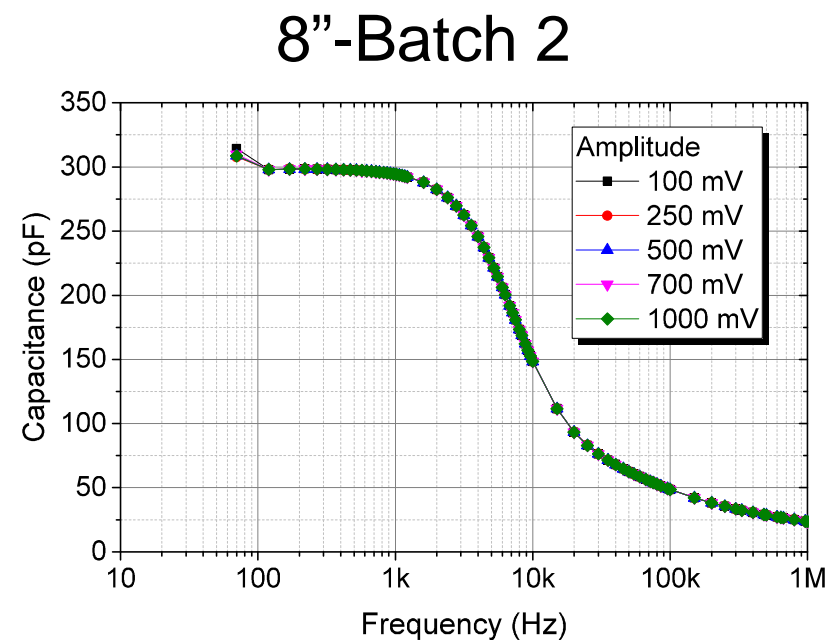
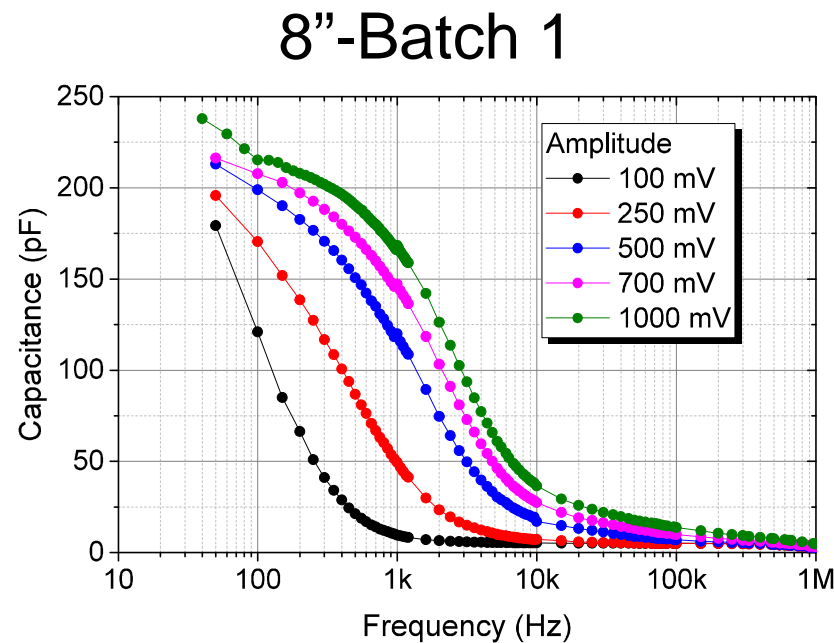
I_{dial}



8" p-in-n, AC-coupled Strip-Sensor C_{ac} f- and V-dependence is solved



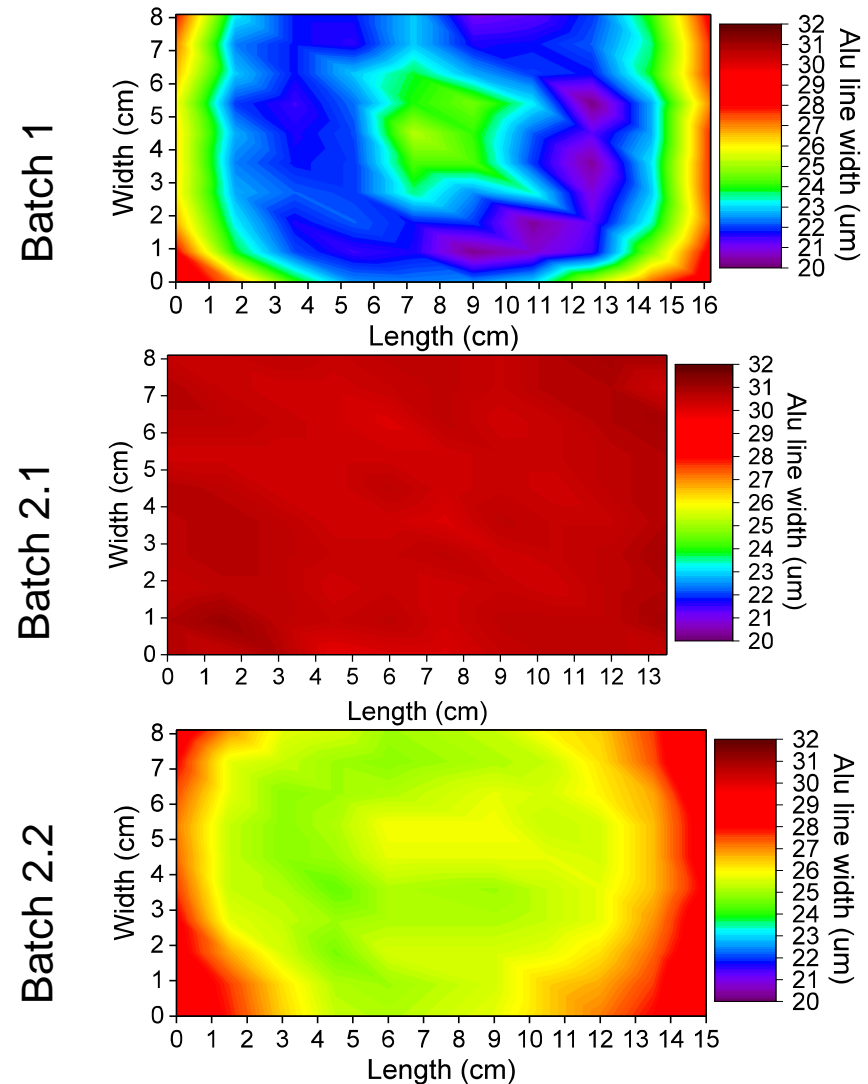
- › At 8"-batch 1, a coupling capacity (C_{ac})-frequency and amplitude dependence was observed
- › At 8"-batch 2 this topics is solved



8" p-in-n, AC-coupled Strip-Sensor Aluminum line accuracy improved

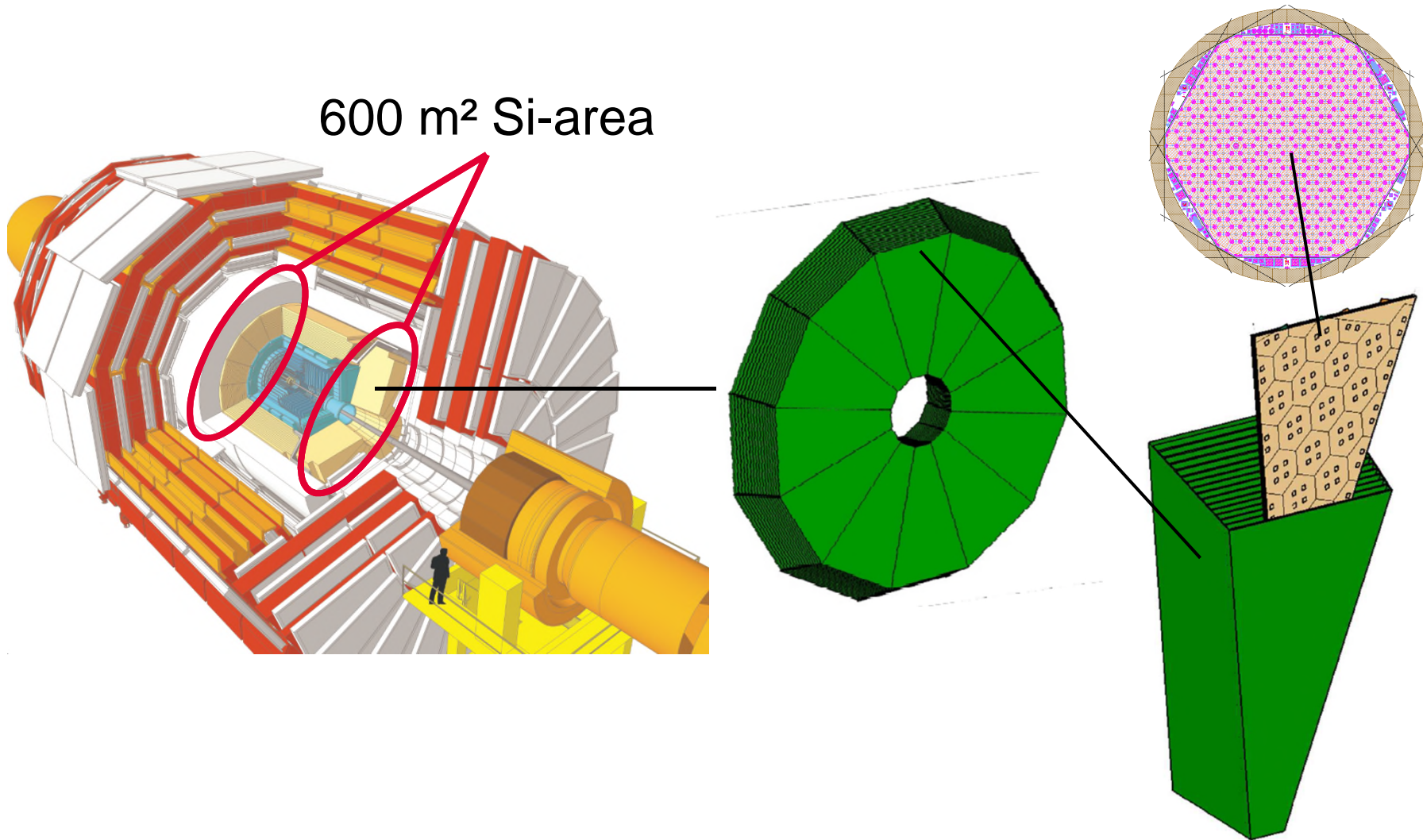


- › The width of the strip aluminum was measured on 2S long sensors
- › Alu width in layout = 32 μm
- › Sensor of batch 1 shows line widths of 20..30 μm
- › Sensor of batch 2.1 shows very homogeneous aluminum line width \sim 29..30 μm because of lithography in thick wafer-state
- › Sensor of batch 2.2 with std. backside activation-flow wafer-thickness: 200 μm
- › Work to improve is ongoing

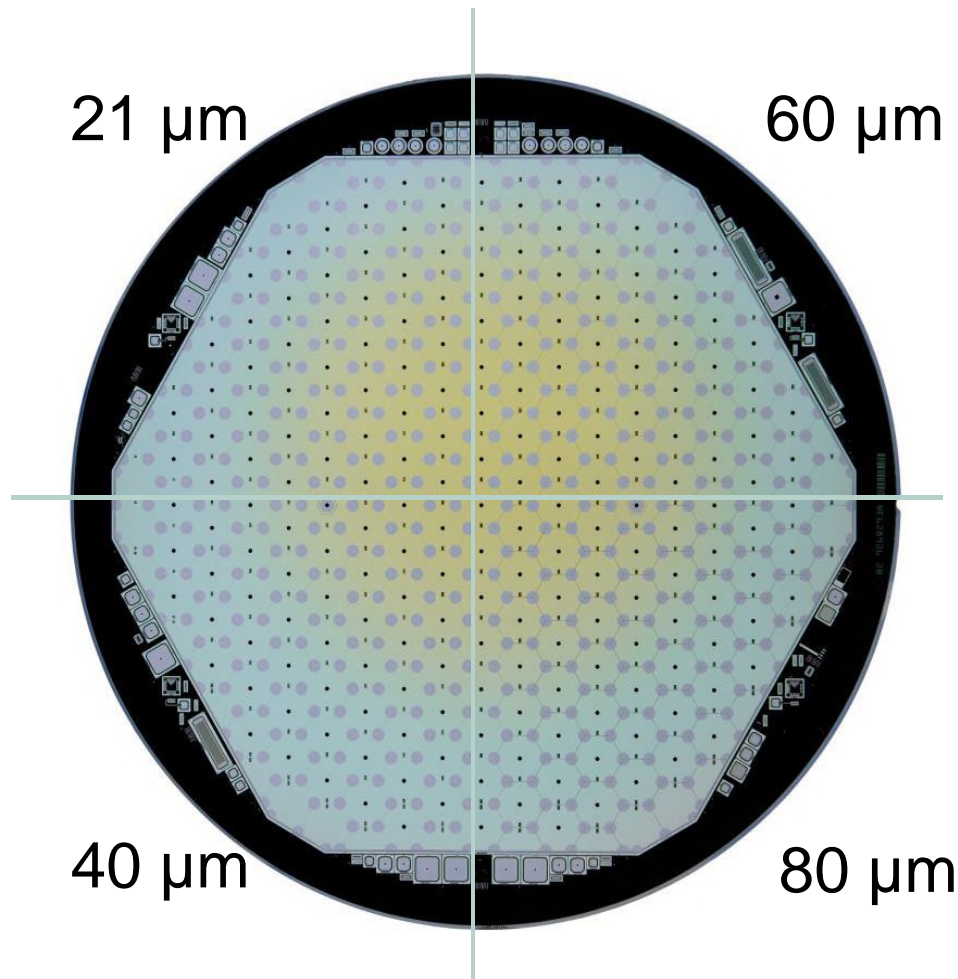


CMS-Phase II Upgrade Endcap Calorimeter

600 m² Si-area



8" p-in-n, DC-coupled Pad-Sensor for CMS-High Granularity Calorimeter

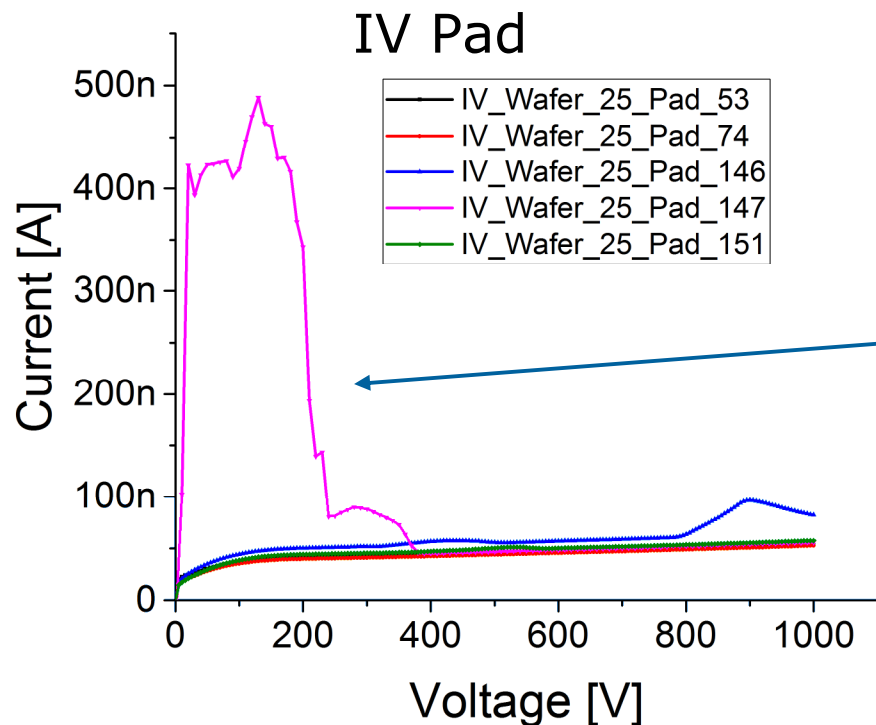
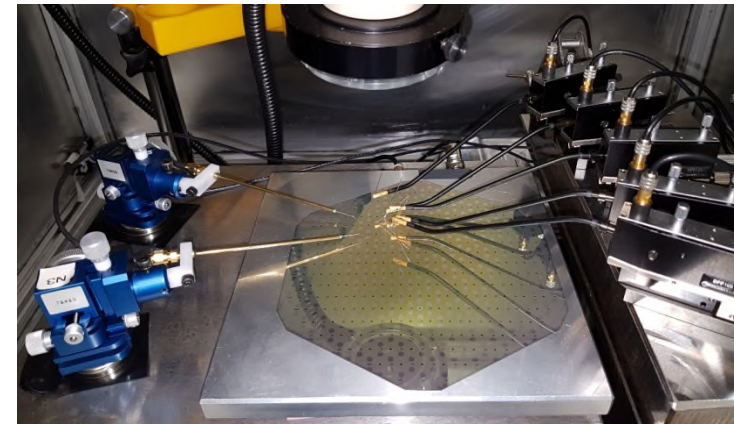


- › ~ 235 usable Cells
- › ~1 cm² pad size
- › 4 Quadrants with different Pad distances
- › Wafers with physical ~ active thicknesses were produced:
140, 200, 300, 350 μm

8" p-in-n, DC-coupled Pad-Sensor Electrical Characterization



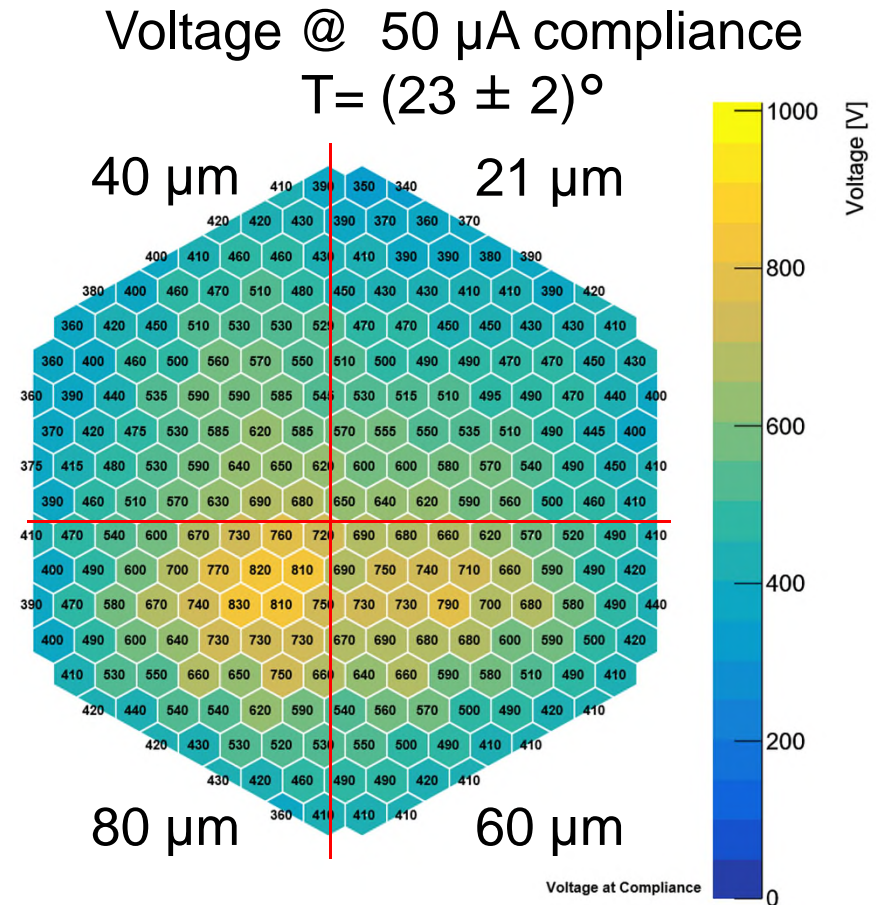
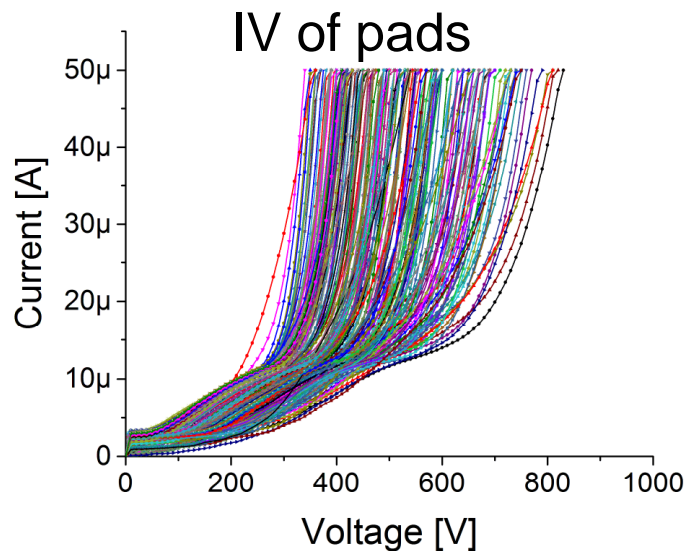
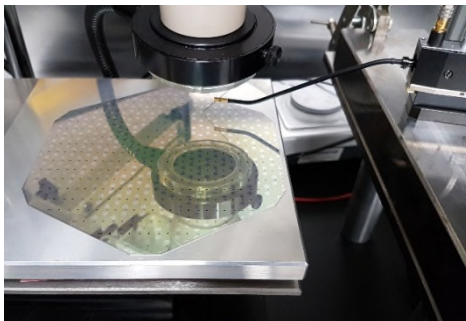
- › IV-measurement of one pad with all neighbour pads on the same potential by 7 needles vs backside
- › Humidity 40-45%, Temp: 22-23°C
- › Batch 1 Wafer 25: 350 μm thickness



- › Initial contact problems with positioners
- › Resolved with new contacting
- › Current of pink curve: 55 nA @ 1000 V, $\sim 1 \text{ cm}^2$, 350 μm

8" p-in-n, DC-coupled Pad-Sensor Single Needle Measurement

- › IV with one needle only
- › Batch 1 Wafer 6: 350 μm



- › Probecards to contact all pads at once are in development

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6"	n-in-p FZ	AC-Strip	10x10 + 10x5	200, 300	ATLAS, CMS Trackers
8"	n-in-p FZ	DC-Pad	18 x 16 Dodecagonal	140, 200 300	CMS HGC

	CMS-Tracker	CMS-HGC	ATLAS-Tracker
6"			
8"			



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