Study of Detection Performance of Silicon Strip Sensors for ATLAS ITk Upgrade Project

Věra Latoňová

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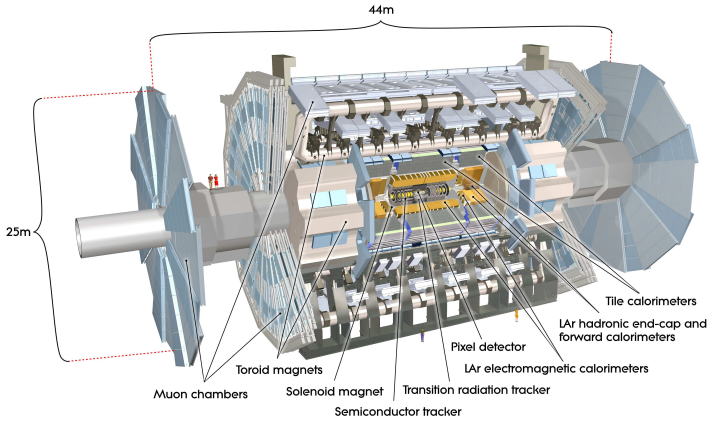
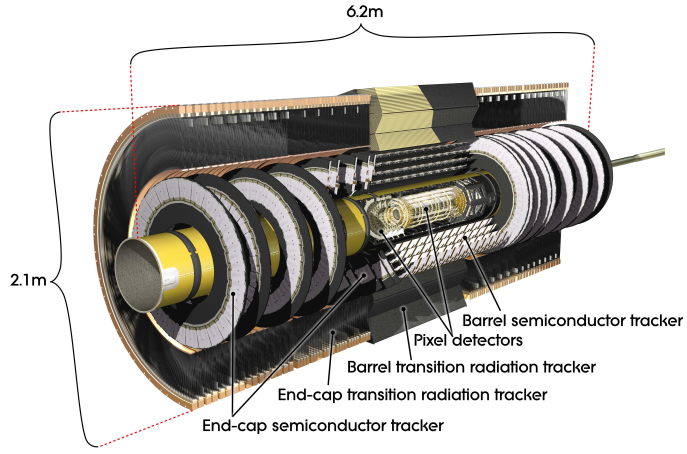
Consultant: doc. RNDr. Zdeněk Doležal, Dr.

Outline

- ATLAS Inner Detector and its upgrade
- Semiconductors and p-n junction
- Strip detectors
- Testing detectors
- Future work

ATLAS Inner Detector (ID)





Three sub-systems

- Pixel detector
- SemiConductor Tracker (SCT)
- Transition Radiation Tracker (TRT)

Designed for:

- peak $L = 10^{-34}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$
- 23 pile-up events per 25 ns bunch crossing
- level-1 trigger rate of 100 kHz

Motivation for the upgrade (ID $\rightarrow$ ITk)

- LHC $\rightarrow$ HL-LHC (2024)
- Occupancy
- Bandwidth saturation
- Radiation damage

	ID	Phase I	Phase II
$L[10^{-34}\mathrm{cm}^{-2}\mathrm{s}^{-1}]$	1	2.2	5-7
$L_{\mathrm{int}}[\mathrm{fb}^{-1}]$	75	300-400	3000
μ	23	55	140-200

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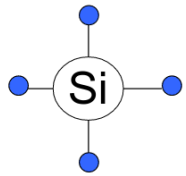
Semiconductors and p-n junction

- Si, Ge, GaAs
- Their properties can be improved by dopping
  - n-type semiconductors
  - p-type semiconductors
- PN-junction
  - diffusion until equilibrum
  - potential barrier $\rightarrow$ deplation layer
  - increase of the depletion width by applying negative voltage – reverse bias



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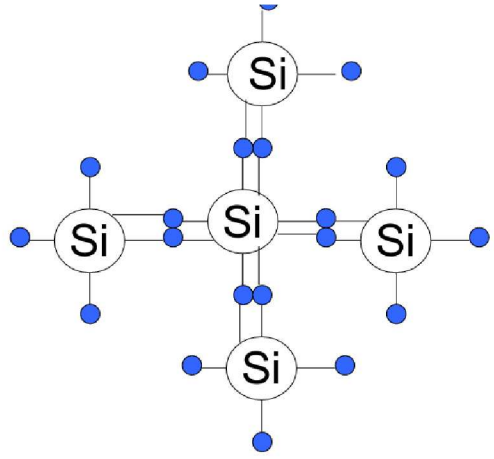

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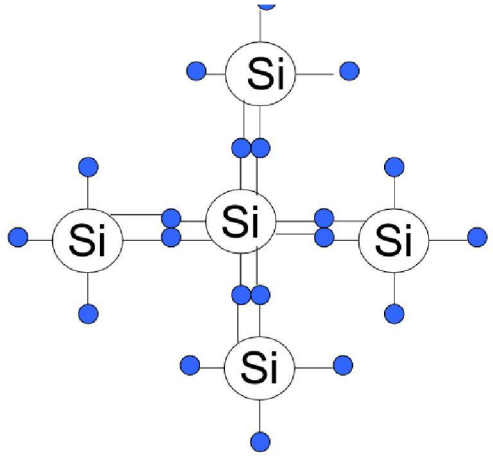

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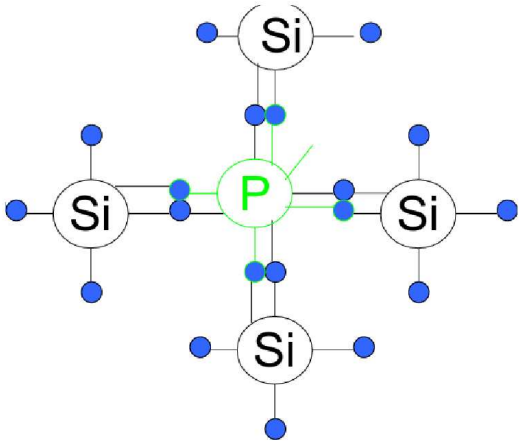

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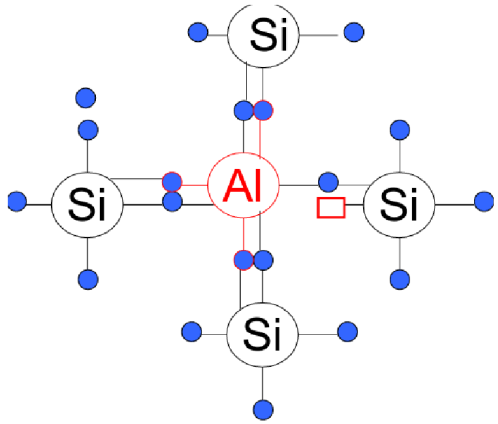

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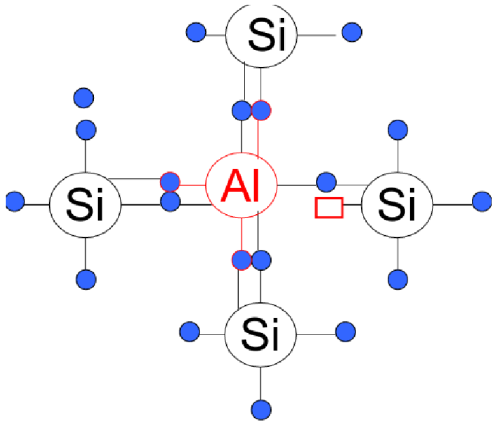

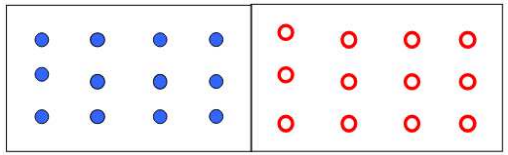

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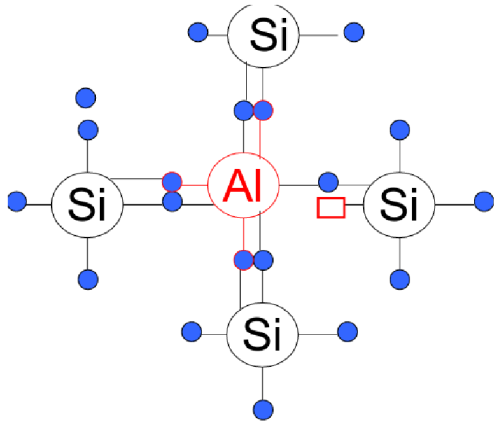

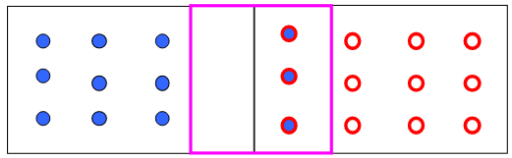

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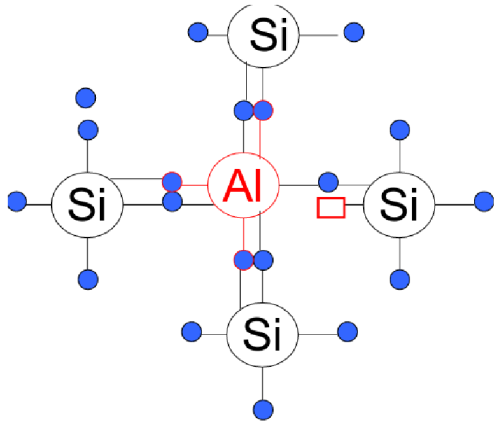

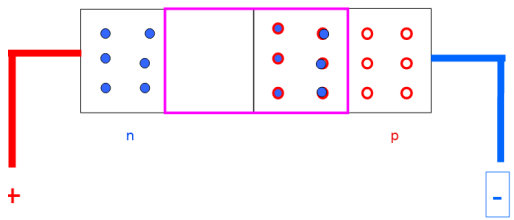

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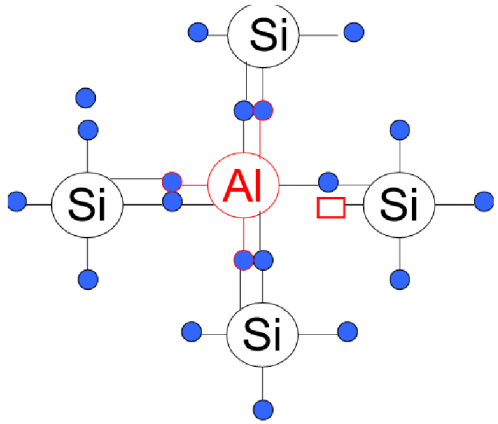
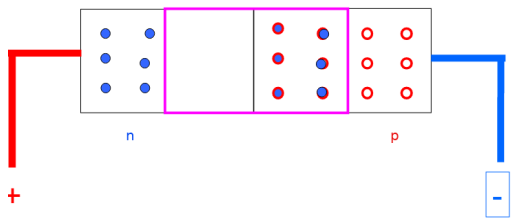
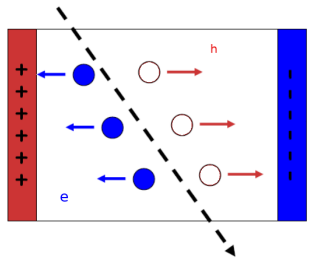
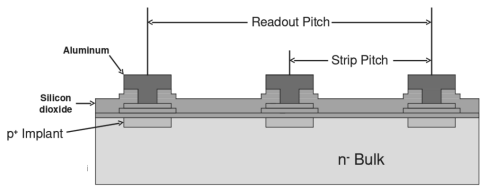
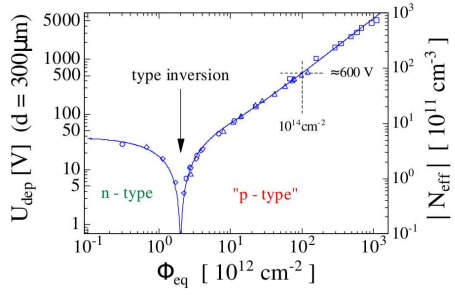


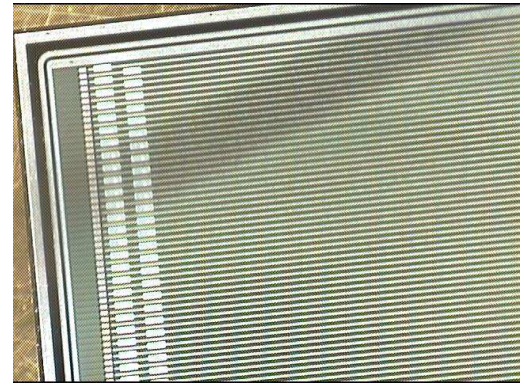




Silicon strip detectors







Why silicon

- Low ionization energy $\approx 3.6\,\text{eV}$
- Long mean free path $\approx 100\,\text{nm}$
- Large energy loss per distance $\approx 3.8\,\text{MeV/cm}$ (MIP)
- High carrier mobility at room temperature
- Possible electronics integration

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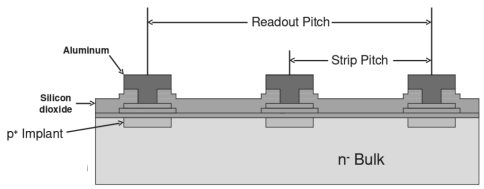

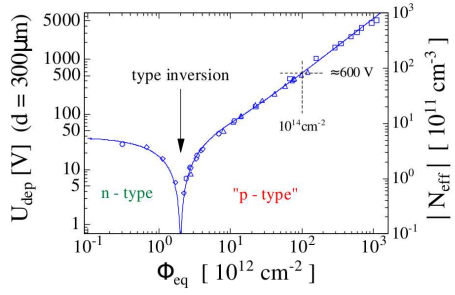

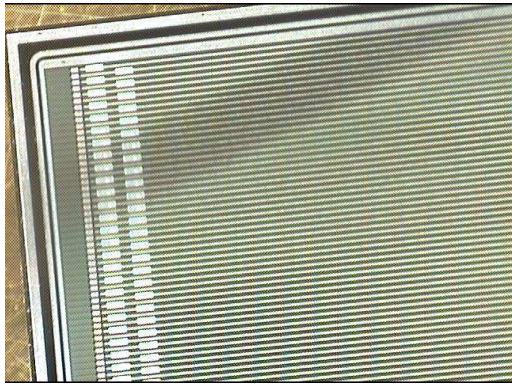

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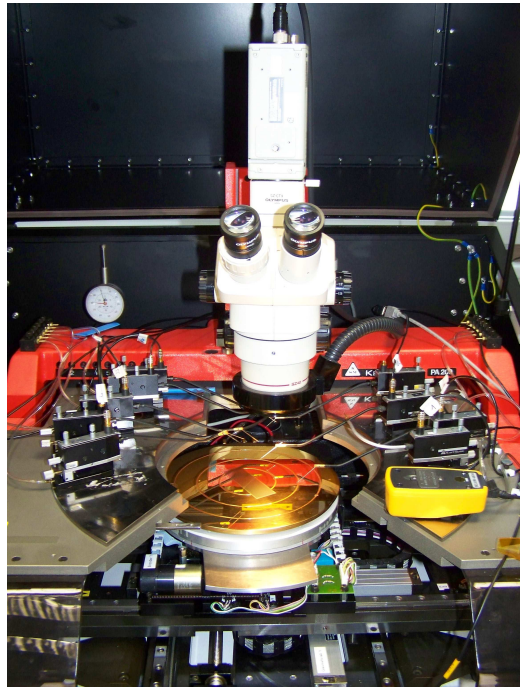
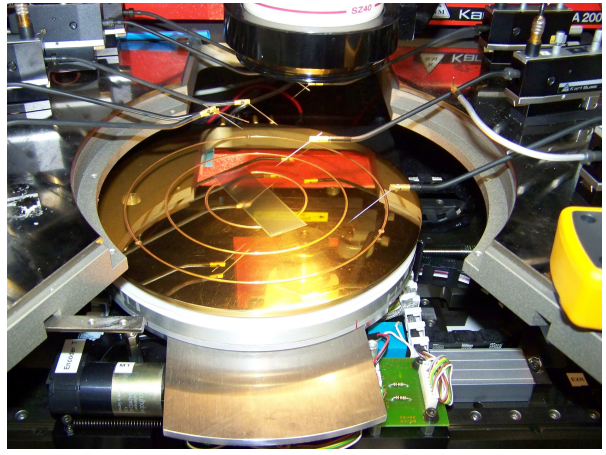
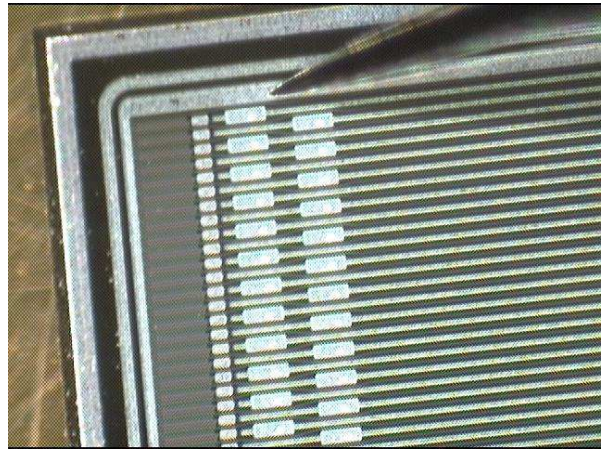
Testing detectors

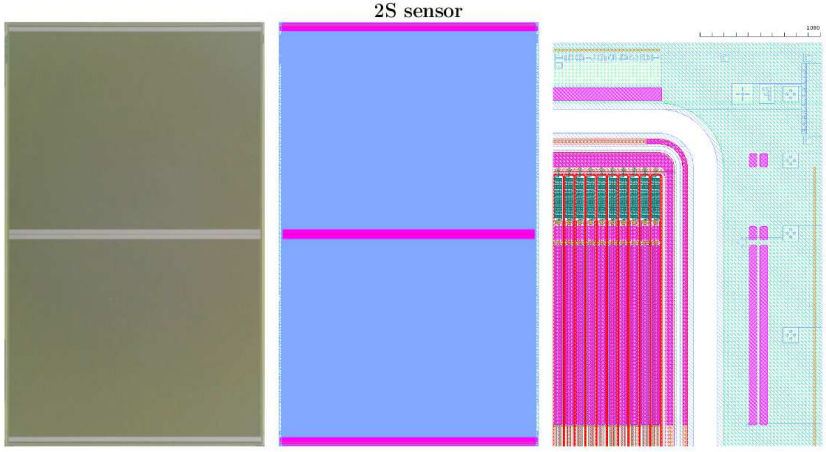
- Visual inspection
- Metrology
- IV, CV
- Full strip tests
- C_{int}, R_{int}
- Current stability
- PTP

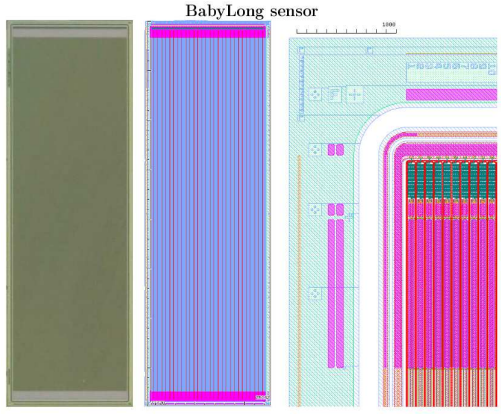


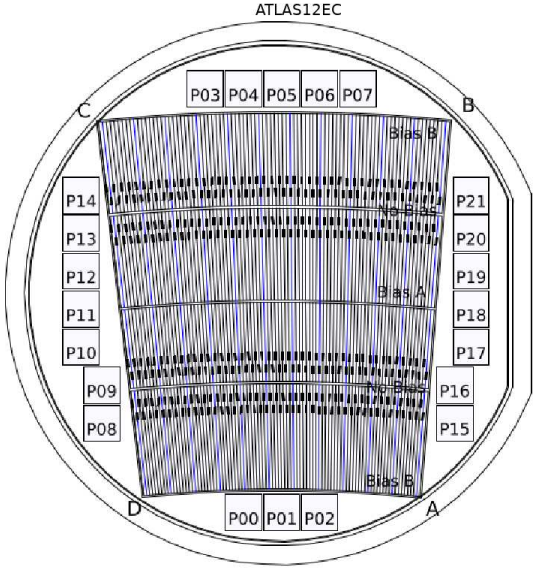


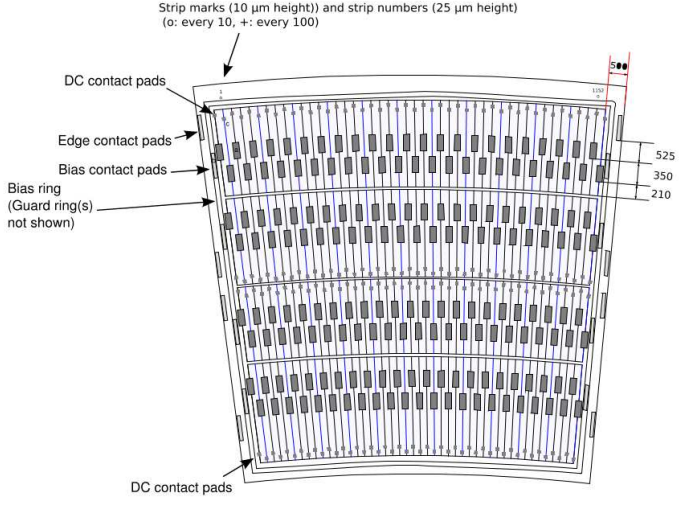


Tested sensors

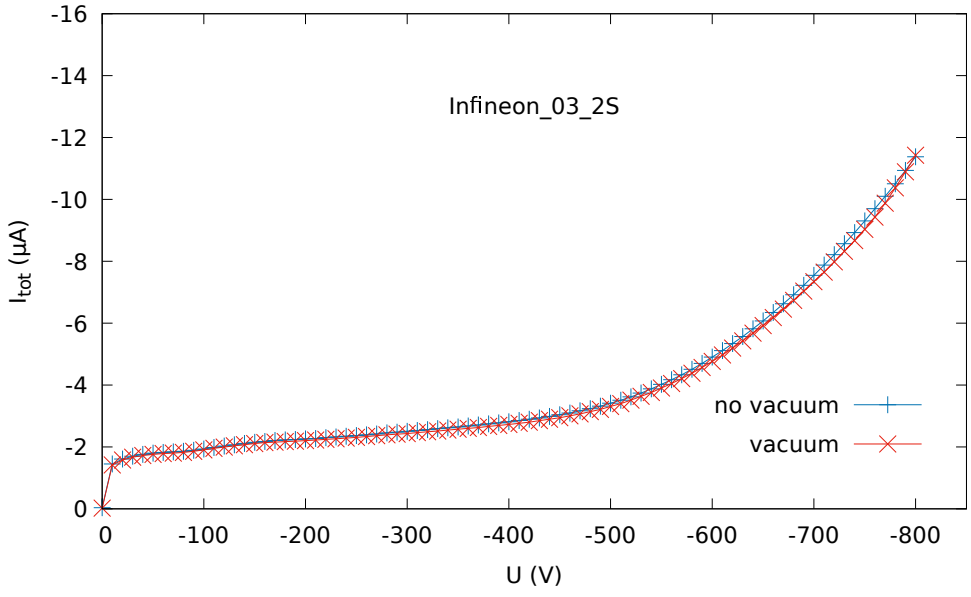


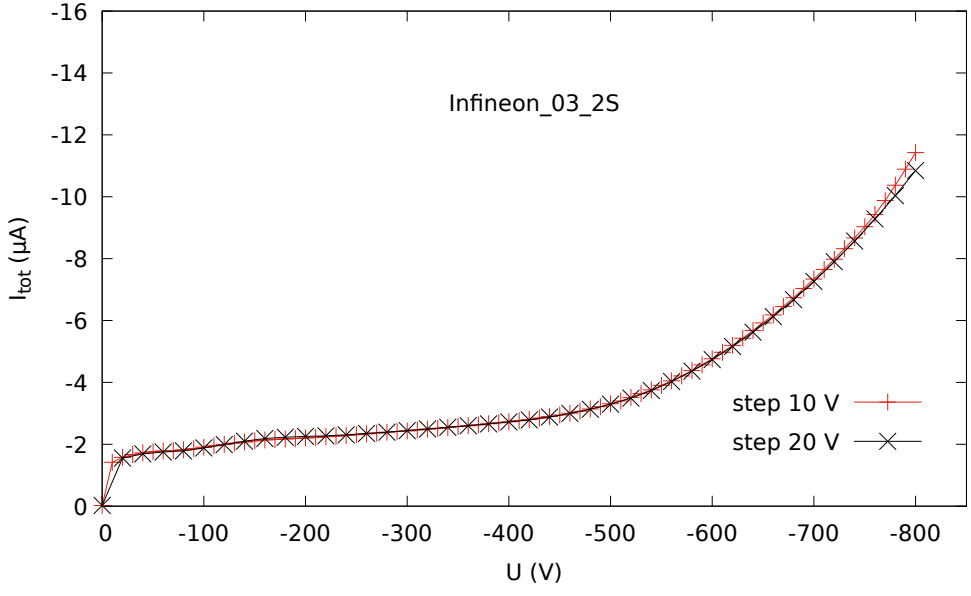






First tests


Infineon_03_2S
no vacuum
vacuum
I_{tot} (µA)
U (V)
-16
-14
-12
-10
-8
-6
-4
-2
0
0
-100
-200
-300
-400
-500
-600
-700
-800


Infineon_03_2S
step 10 V
step 20 V
I_{tot} (µA)
U (V)
-16
-14
-12
-10
-8
-6
-4
-2
0
0
-100
-200
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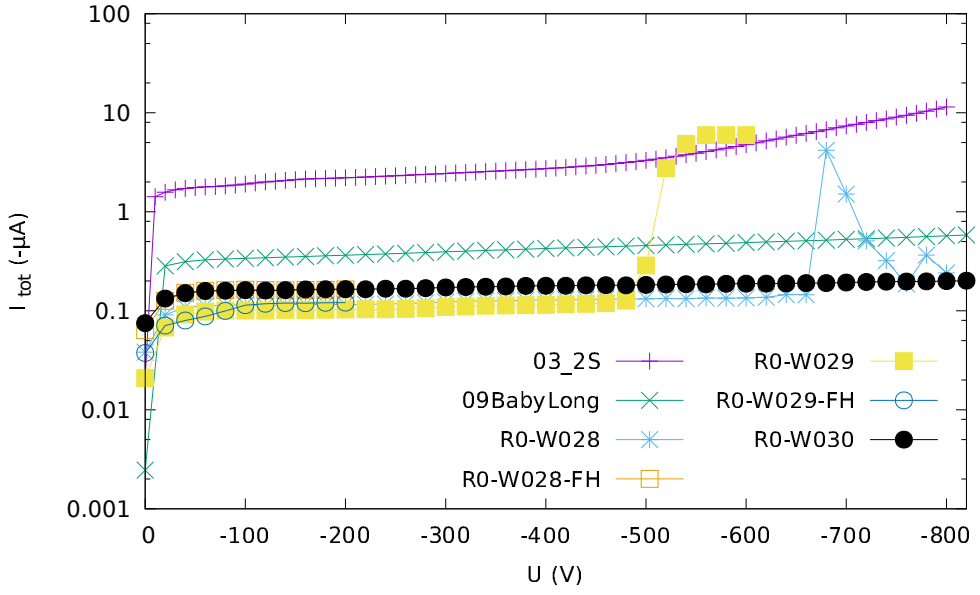
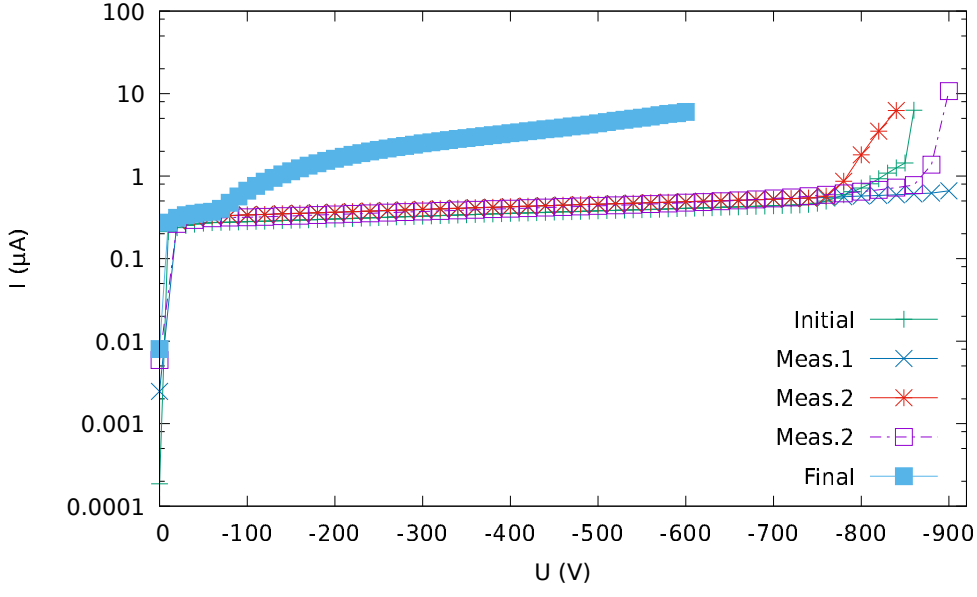
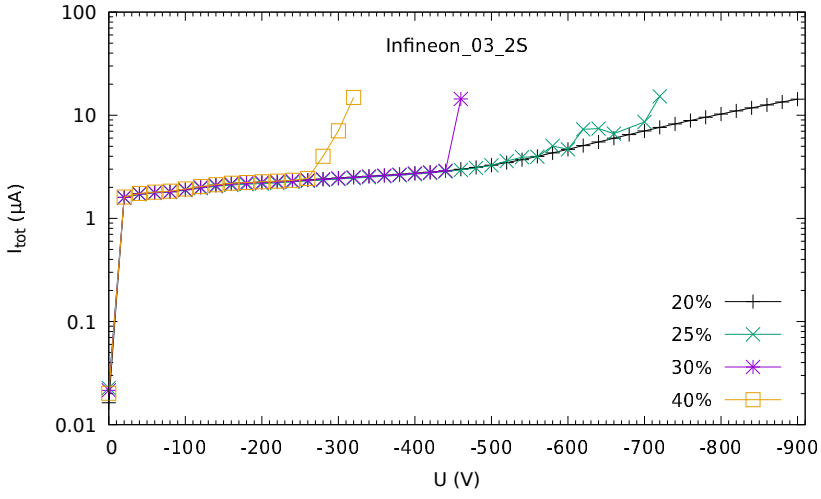
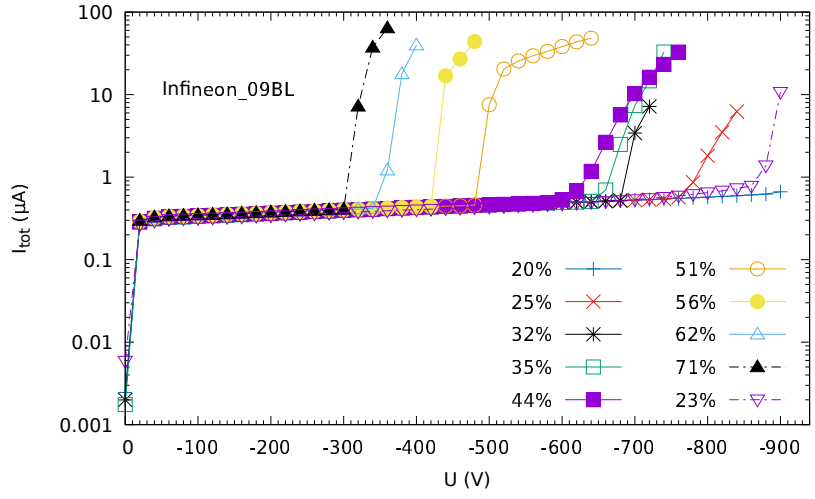
IV-Characteristics

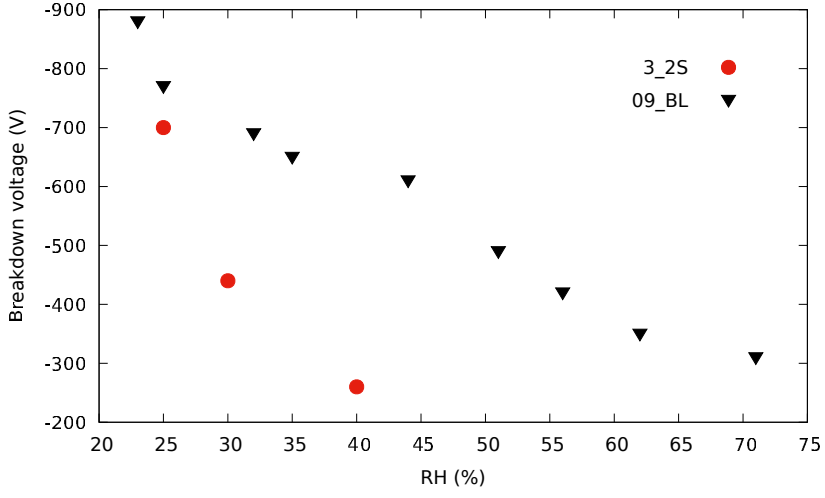




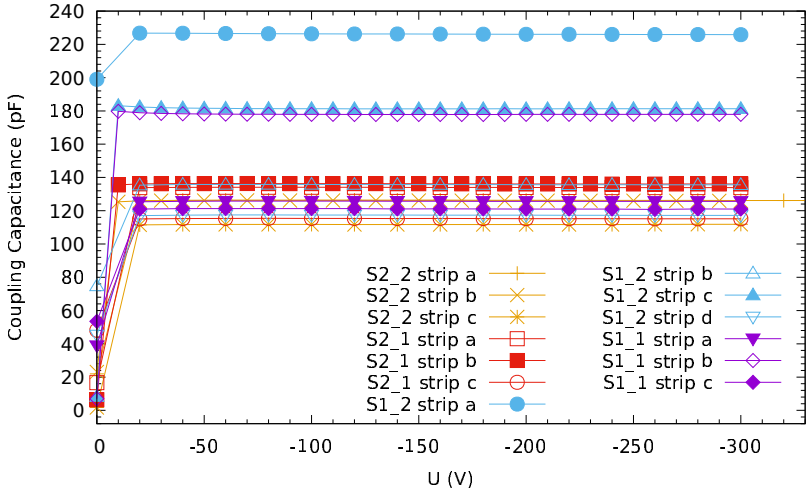
Humidity tests

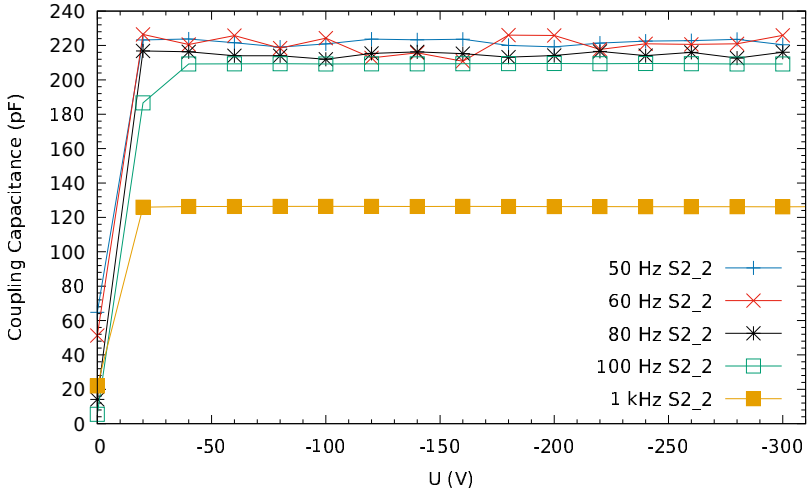


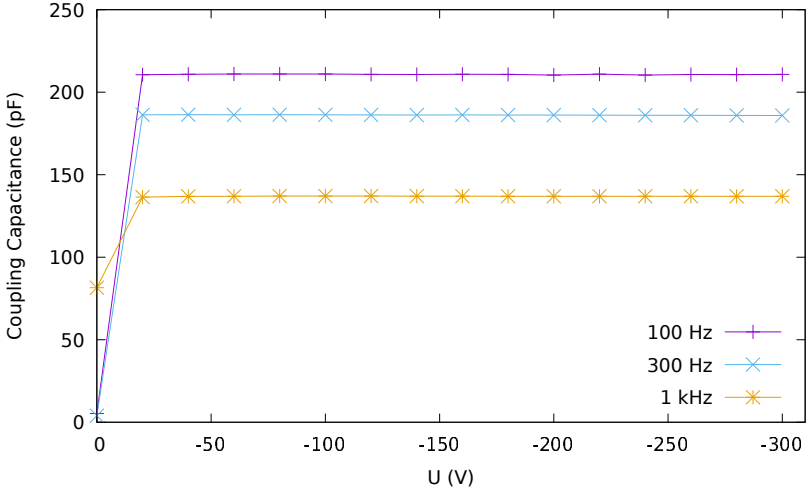


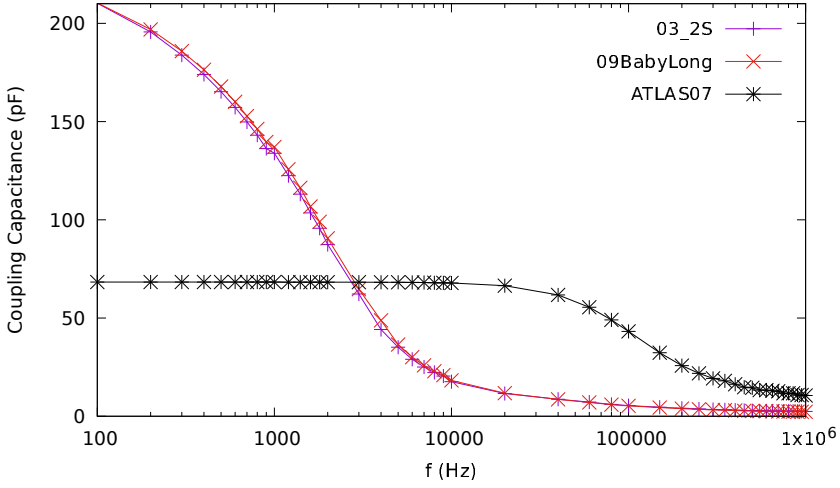


Coupling capacitance

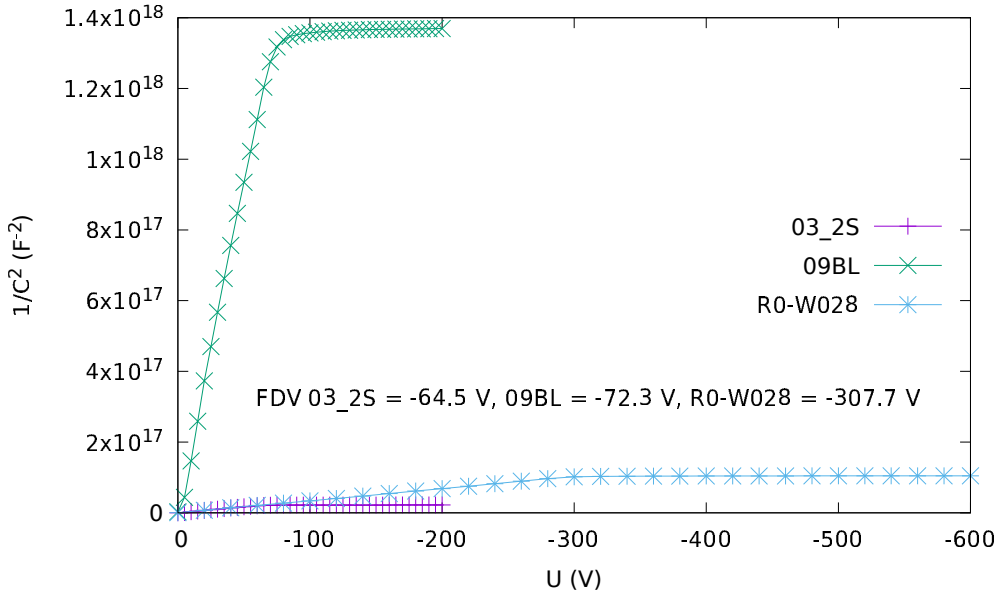


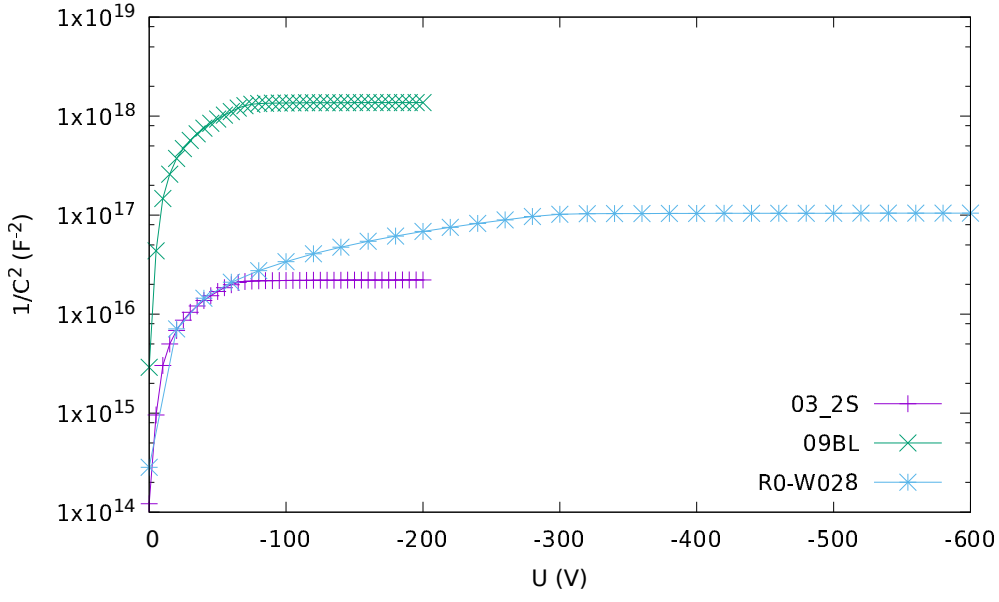






Full Depletion Voltage





Future work

- Run all the remaining tests on the sensors
- Compare the results with the requirements listed in "Technical Specification"
- Improve the testing procedure in order to become:
  - faster
  - more efficient
  - more automatic

Thank you for attention!

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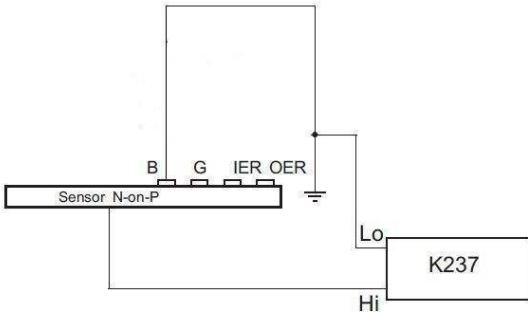
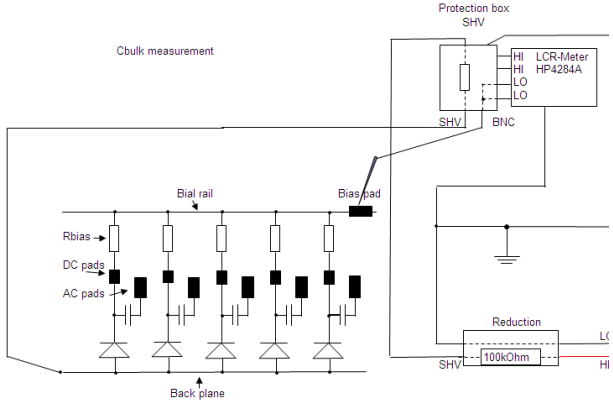
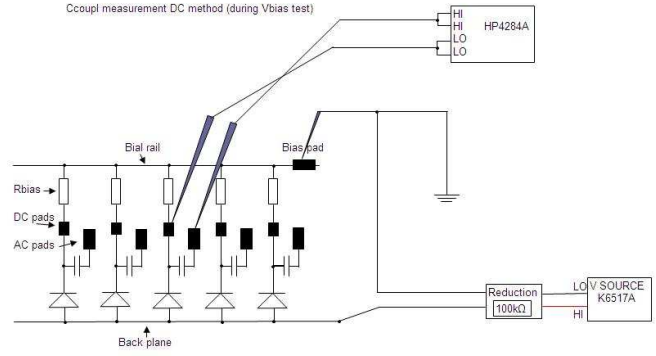




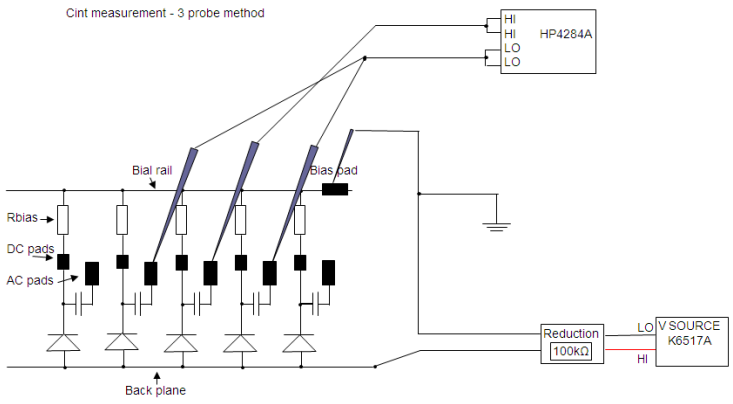
HP4284 - precise capacity meter, CR in Serie, 1kHz, level 2V

K6517 Vsource 0 to -1000V



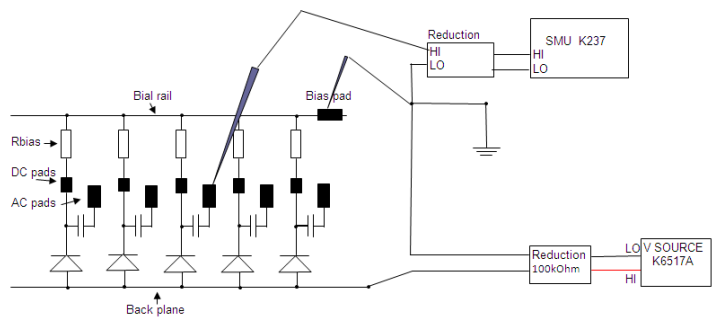
HP4284 - precise capacity meter, CR in parallel, 1kHz

K6517 Vsource 0 to -600V



HP4284 - precise capacity meter, 1MHz, CPRP

K6517 Vsource 0 to -1000V



K237 Source Measure Unit, Vappl =100V, I measured
K6517 Vbias -50V,