Characterization of n-on-p devices fabricated at ITC-irst

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History

SMART collaboration

End 2003 finalized the layout

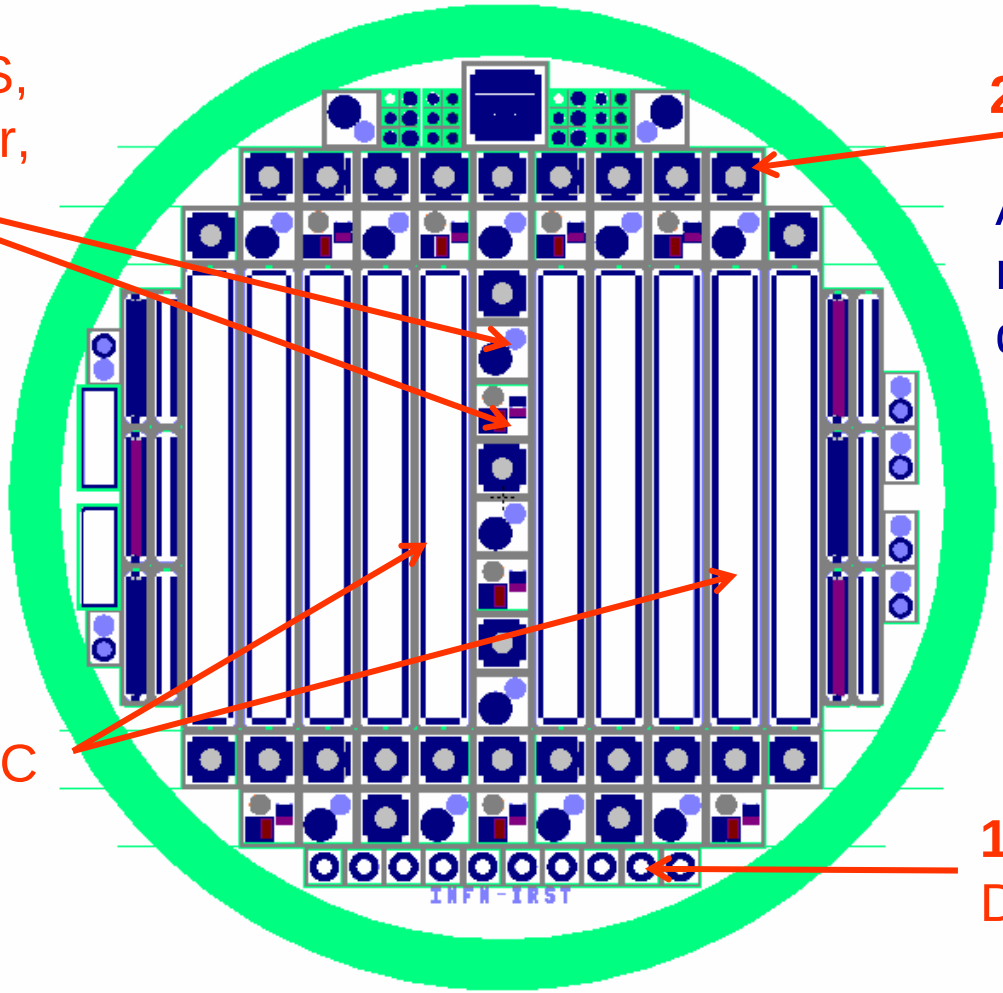
May 2004 first batch of p-on-n devices on different substrates (FZ, MCz, Cz, EPI)
Various samples sent for irradiation.

August 2004 first batch of n-on-p devices with same layout
Some samples sent for irradiation.

January 2005 irradiated samples available for test

Layout

14 + 9 + 6 Test pads including diode, MOS, gated diodes, resistor, etc.



27 MG diodes

Area 13.6 mm^2
die 6x6mm^2

5 (pitch 50µm)
+ **5** (pitch 100µm)
Microstrip detectors AC coupled, poly-resistor biased

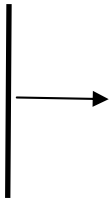
die 6x47mm^2

10 Small MG Diodes

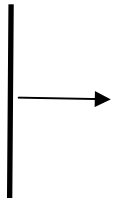
Area 2.3 mm^2
die 4x4mm^2

n-on-p batch

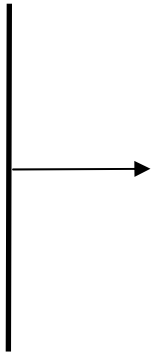
#	sub-type	comments
3	FZ 525	p-spray 3E12
3	FZ 525	p-spray 5E12
3	FZ 200	p-spray 3E12
3	FZ 200	p-spray 5E12
6	MCz	no OG; p-spray 3E12
5	MCz	no OG; p-spray 5E12



FZ <100>
p-type
>5000Ωcm
525µm



FZ <100>
p-type
>5000Ωcm
200µm



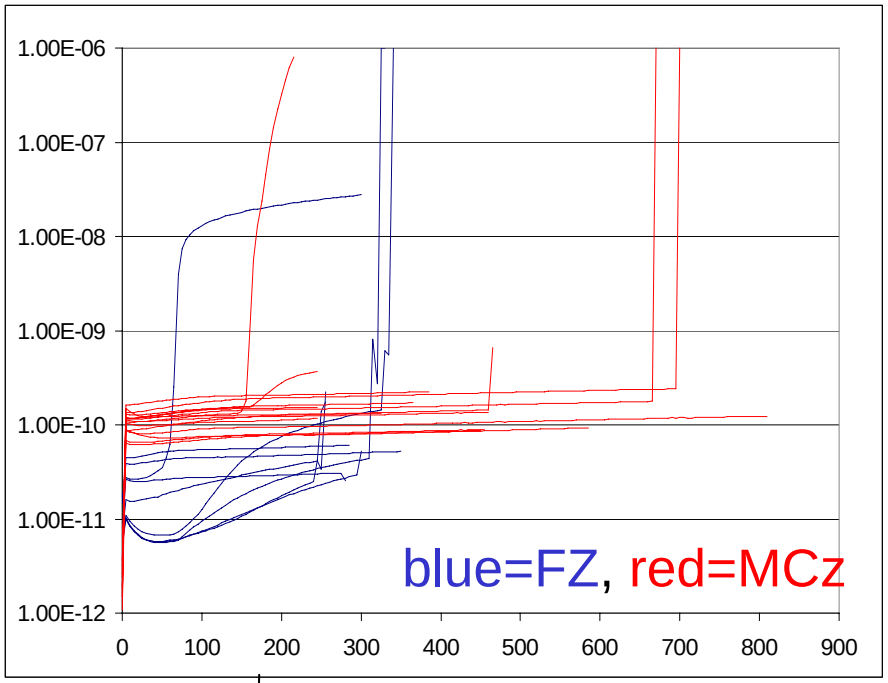
MCz <100>
p-type
>1.8kΩcm
300µm

n-on-p – IV on MG diodes (1)

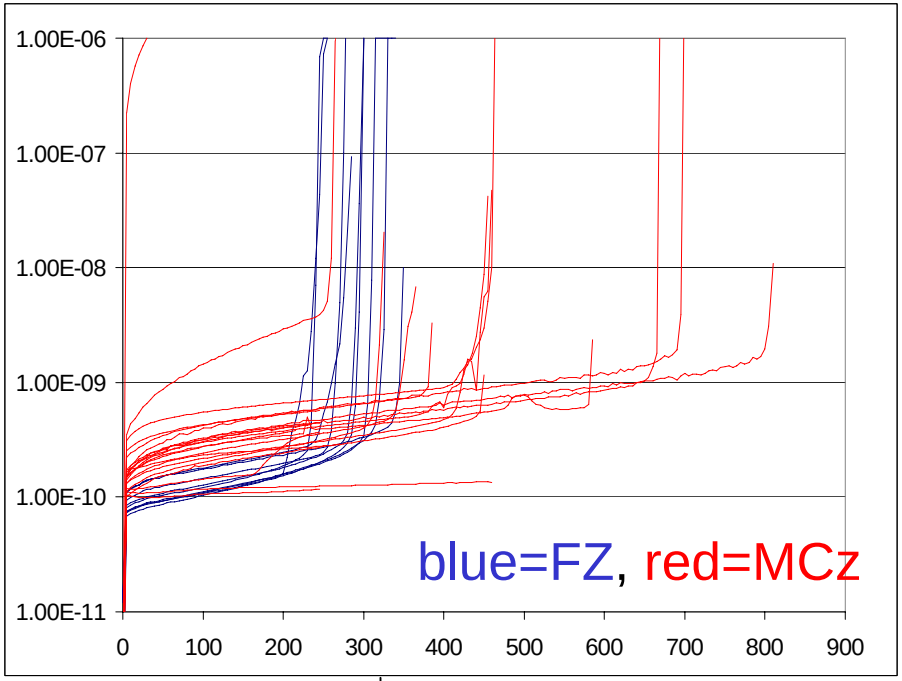
High dose p-spray

Measurements on 3 diodes per 8 wafers

Diode current (A) vs Voltage (V)



GR current (A) vs Voltage (V)



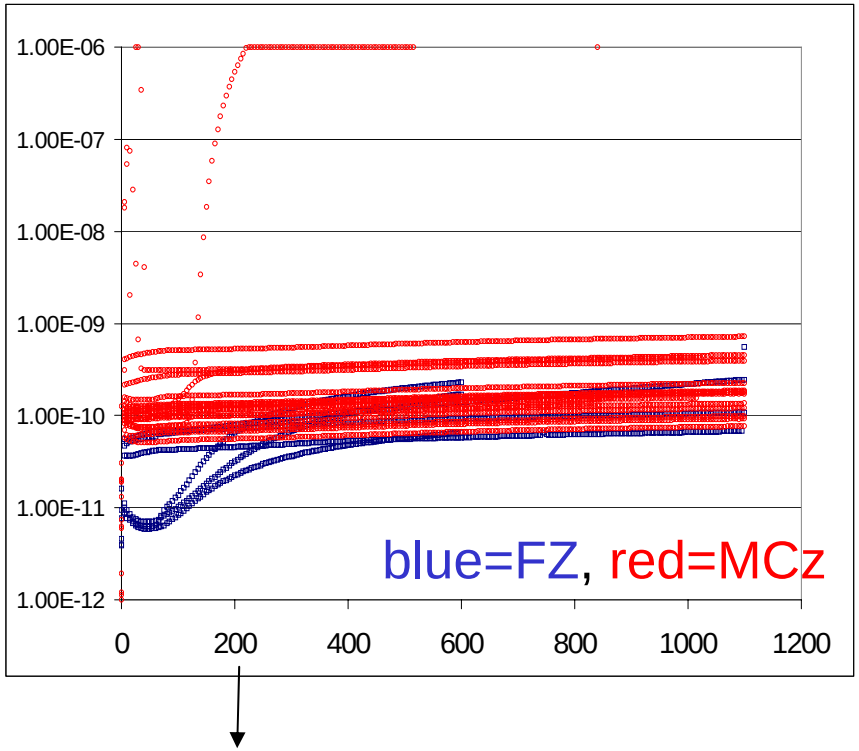
Leakage current ~ **10nA/cm²** Breakdown voltage **~200-300V**

n-on-p – IV on MG diodes (2)

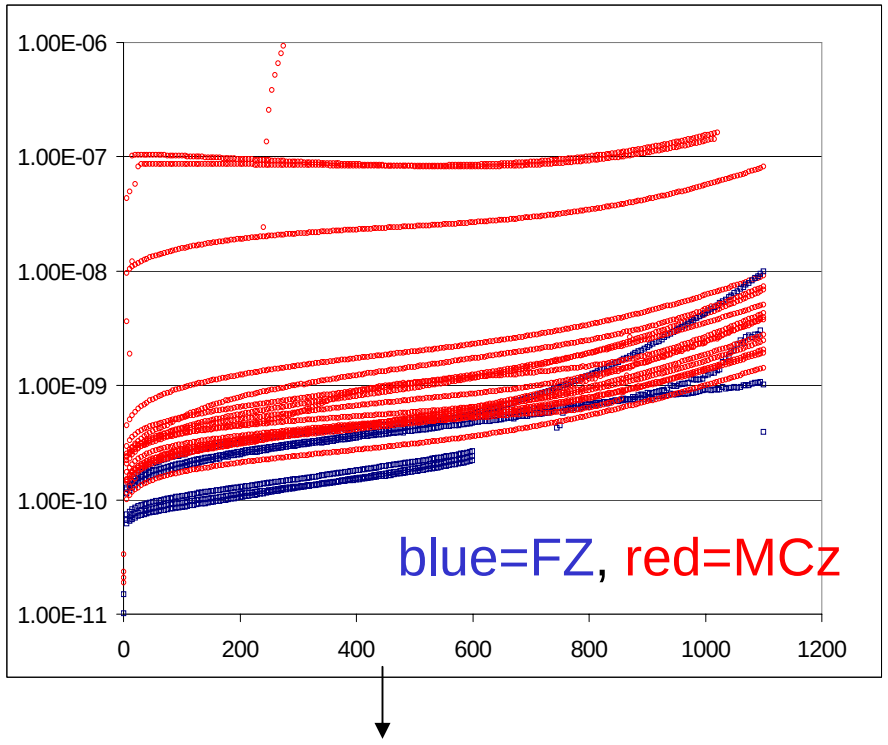
Low dose p-spray

Measurements on 3 diodes per 9 wafers

Diode current (A) vs Voltage (V)



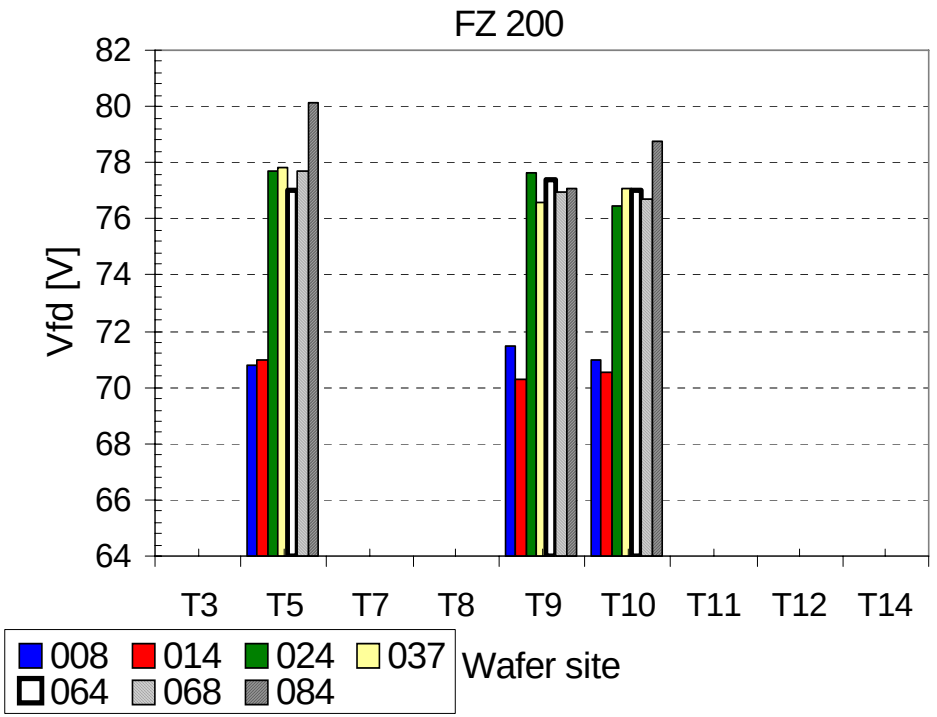
GR current (A) vs Voltage (V)

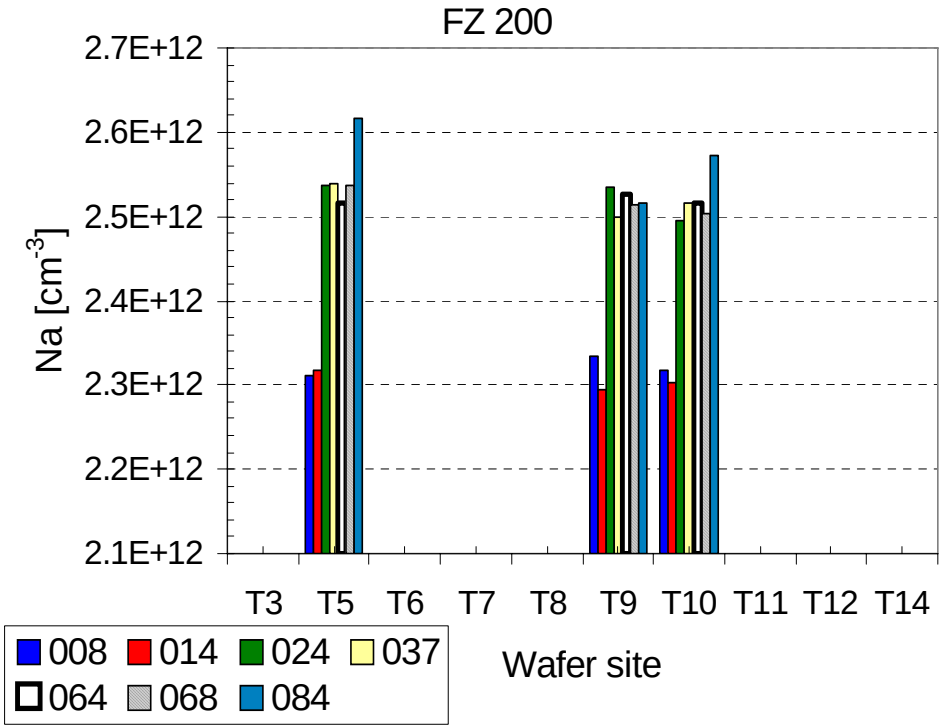


Leakage current ~ **10nA/cm²** Breakdown voltage **>1000V**

n-on-p – CV on diodes (1)

Measurements on **FZ wafers**





Depletion voltage very uniform at the wafer level.

n-on-p – CV on diodes (2)

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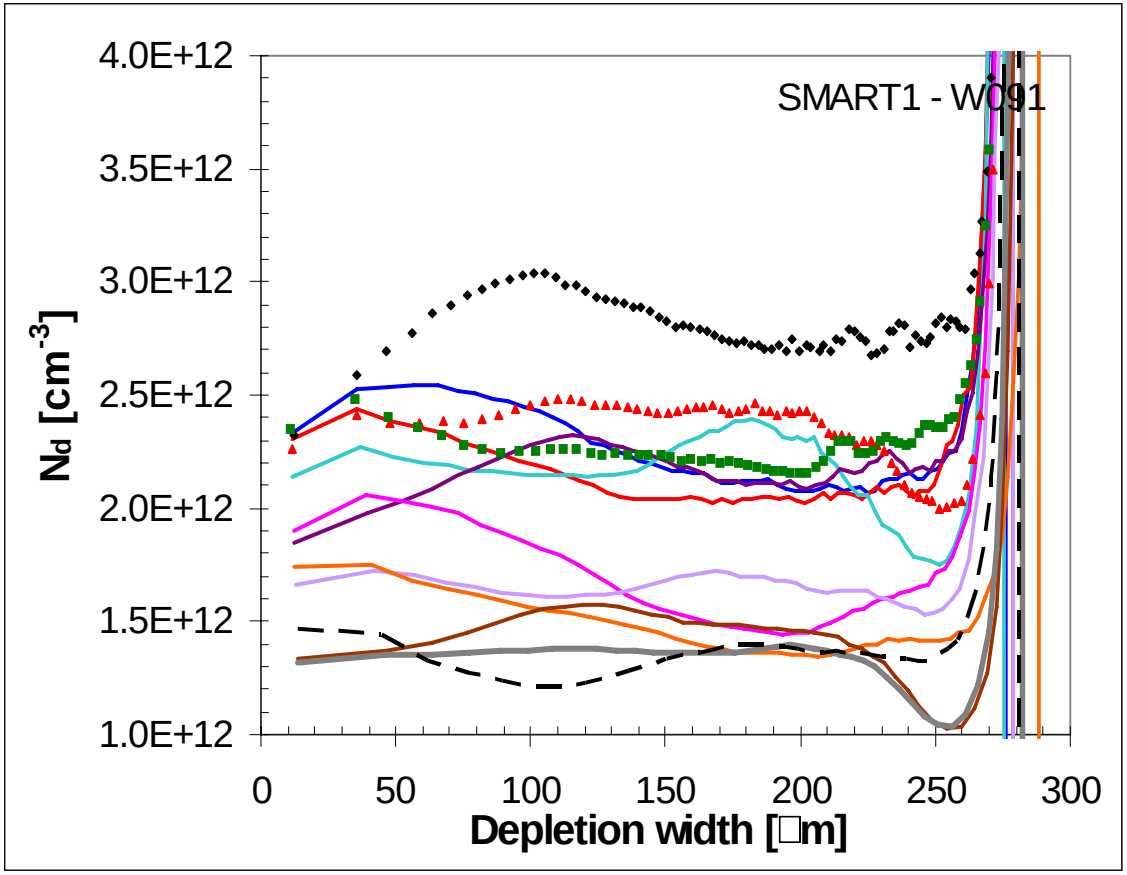
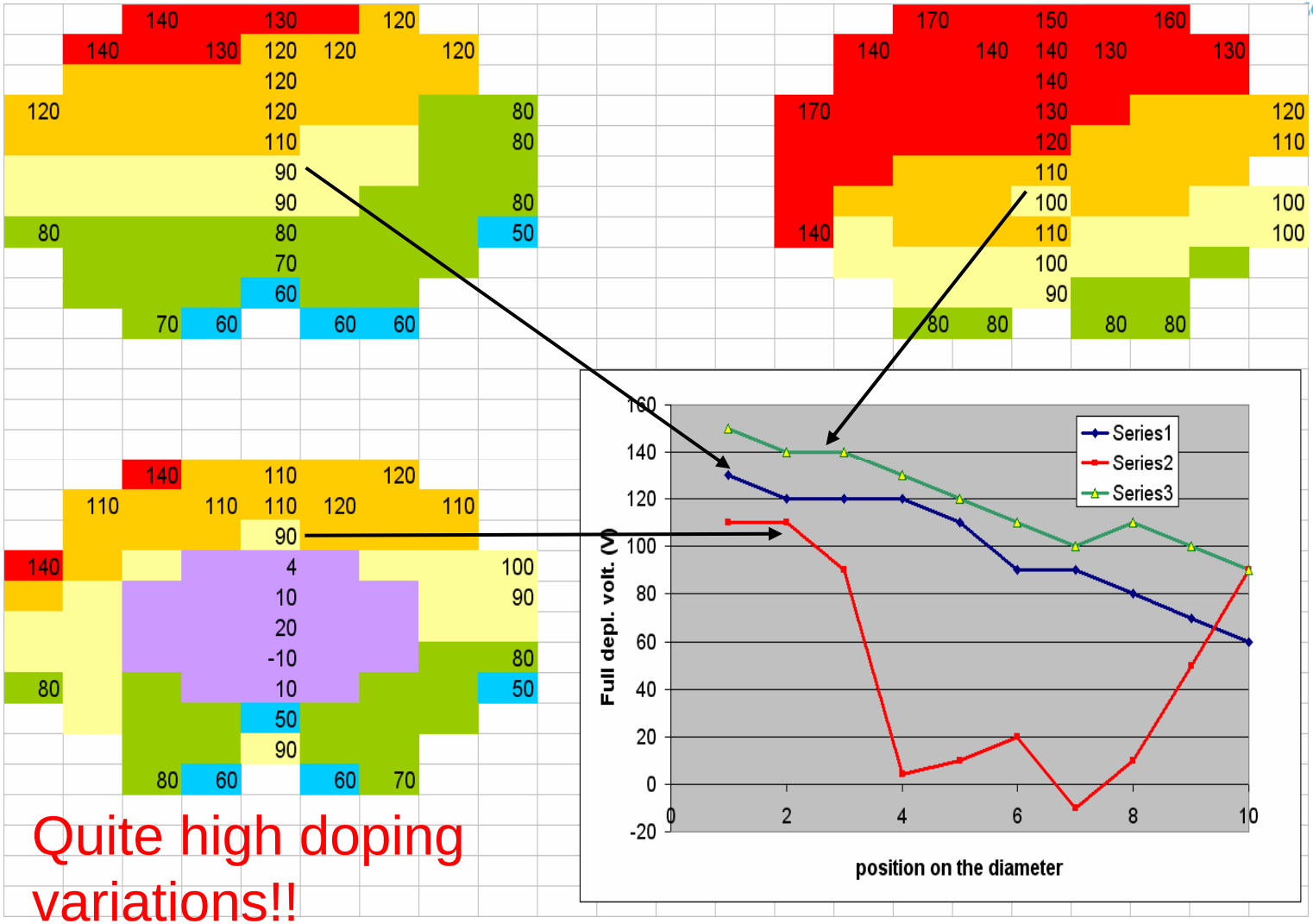
Measurements on **MCz wafers**

Example of Doping profile from CV measurement



Doping concentration lower than n-type MCz (~2e12 against 7e12) but fluctuations of the same order

n-on-p – CV on diodes (3)

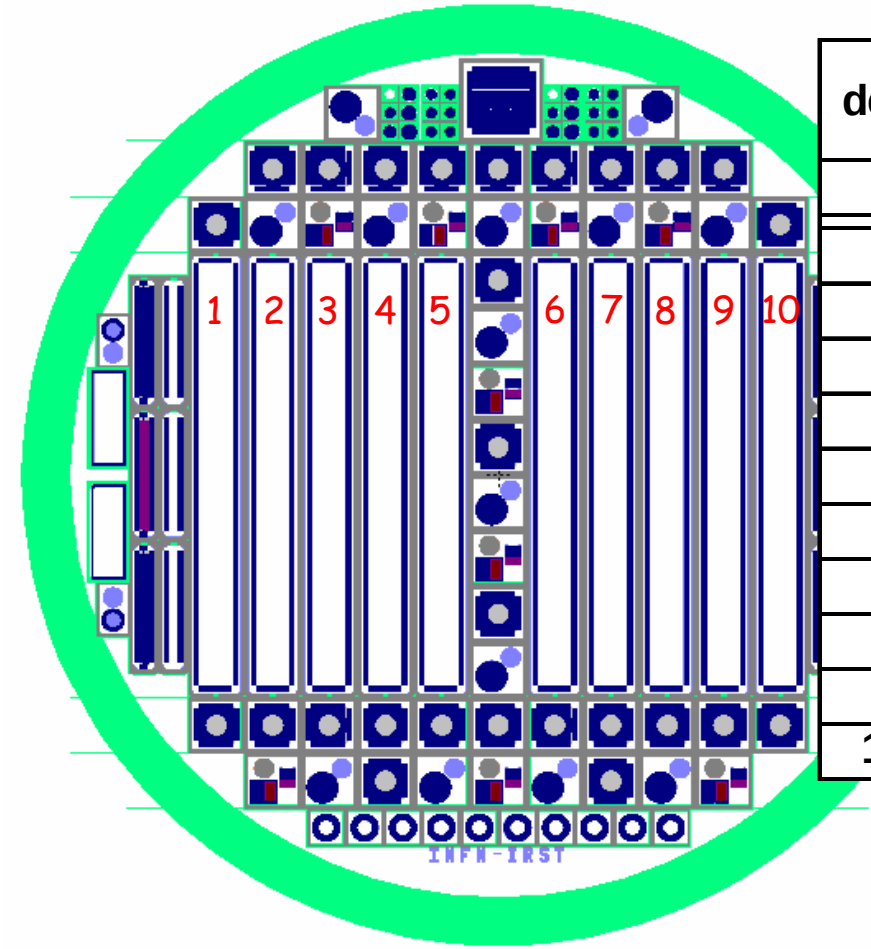


Quite high doping variations!!

Probably due to fluctuations of the oxygen concentration.

Microstrip minisensors

- AC coupled
- poly resistor biased



det#	pitch	p^+ implant width	polysilicon width	metal width
	[um]	[um]	[um]	[um]
1	50	15	10	23
2	50	20	15	28
3	50	25	20	33
4	50	15	10	19
5	50	15	10	27
6	100	15	10	23
7	100	25	20	33
8	100	35	30	43
9	100	25	20	37
10	100	25	20	41

die ~6x47mm^2

Microstrip minisensors measurements

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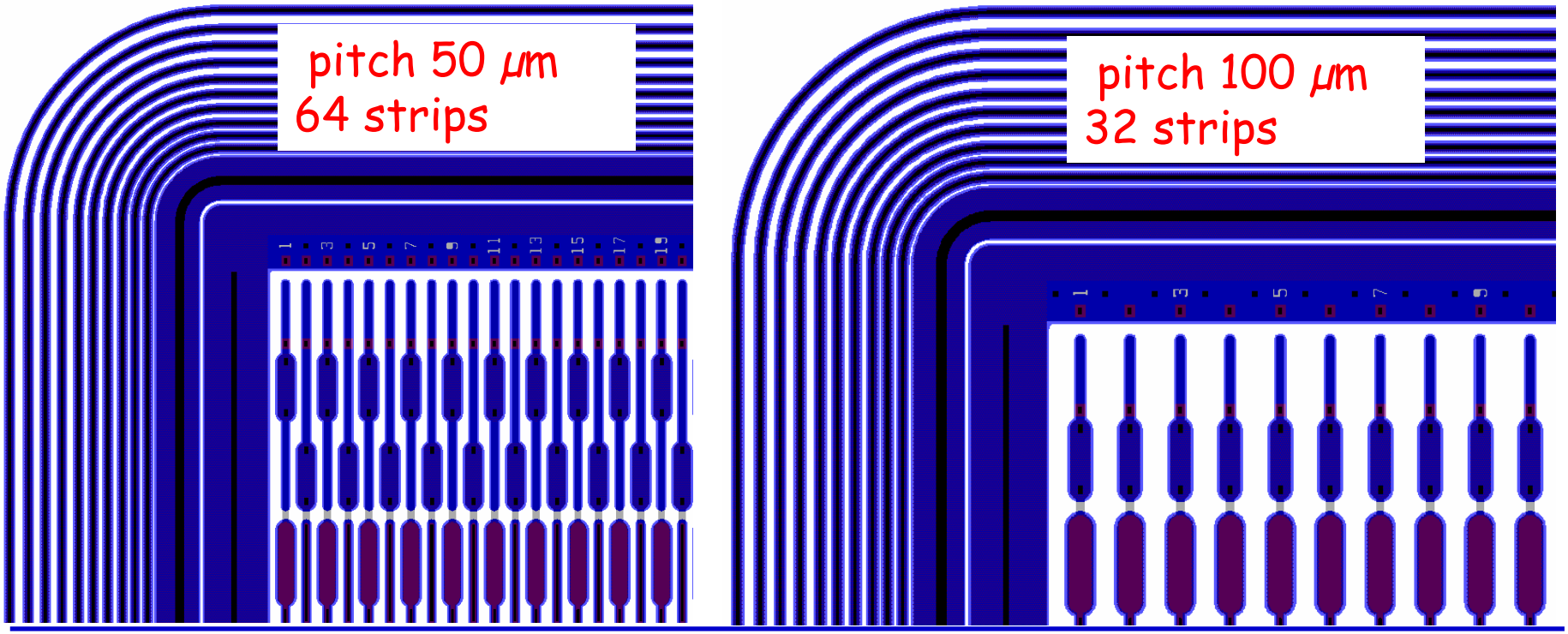
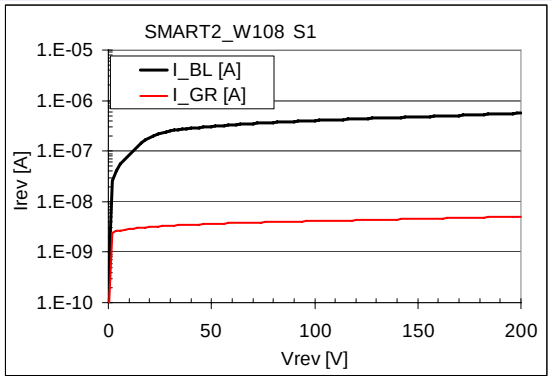
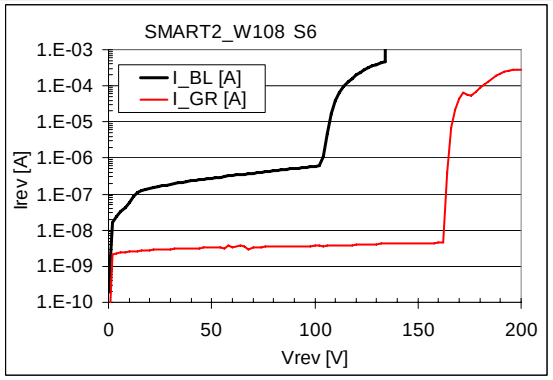
probe-card + automatic prober

- BL&GR reverse IV
  (I_tot, V_{rev} 0÷200 V)
- Strip current scan
  (I_strip @ 100V V_{rev})
- Bias resistors scan
  (R_bias @ 100V V_{rev})
- Capacitors scan
  (I_AC @ 20V V_{cap})

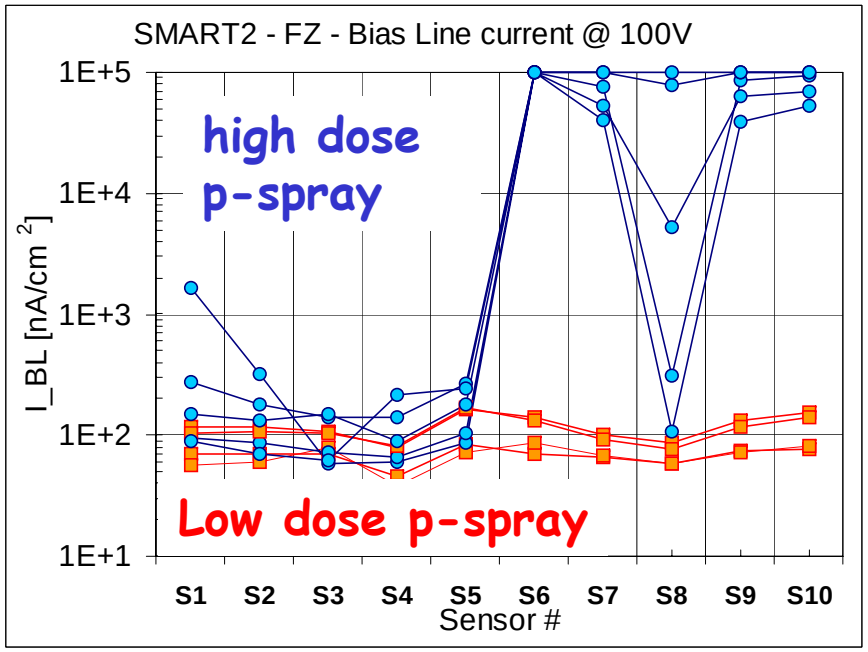


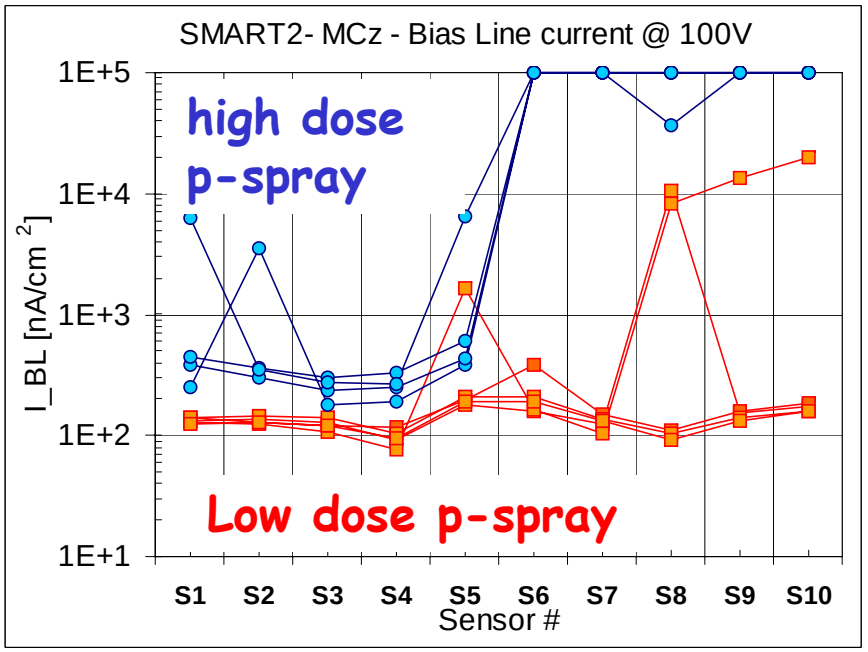
BL & GR *I-V* reverse currents (1)





Bias-line currents @ 100 V





FZ wafers

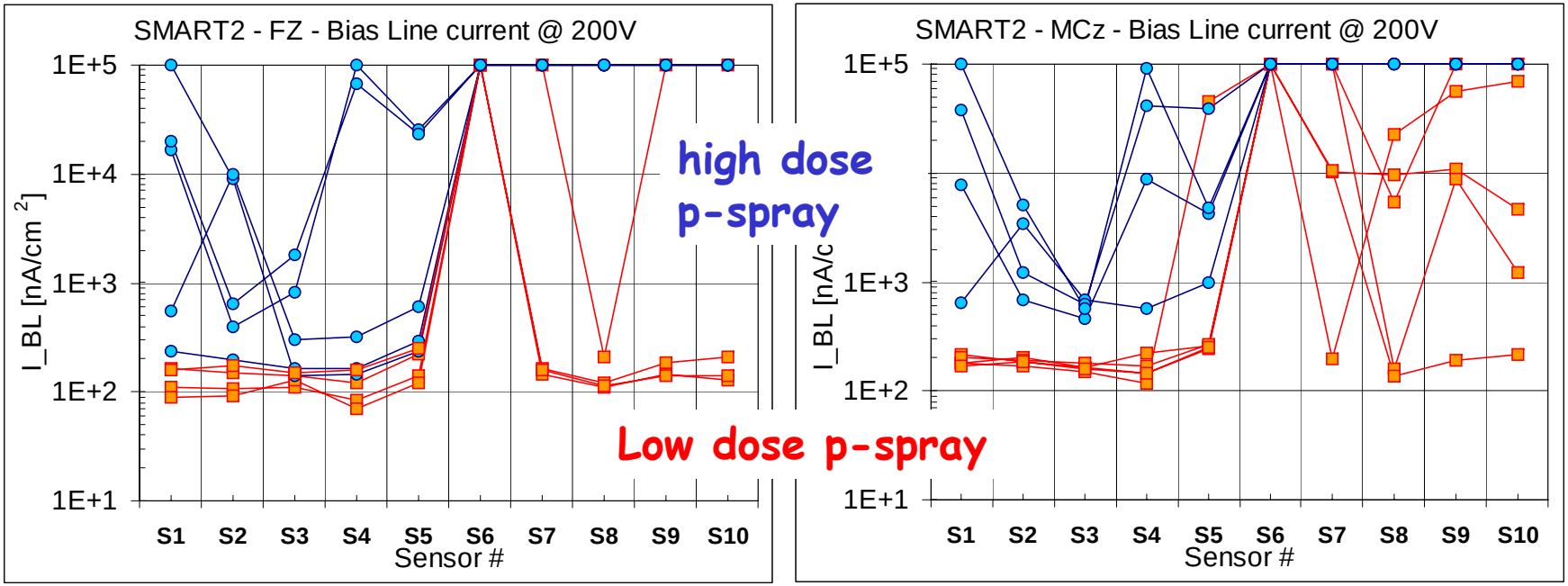
MCz wafers

BL & GR *I-V* reverse currents (2)

Bias-line currents @ 200 V

FZ wafers

MCz wafers

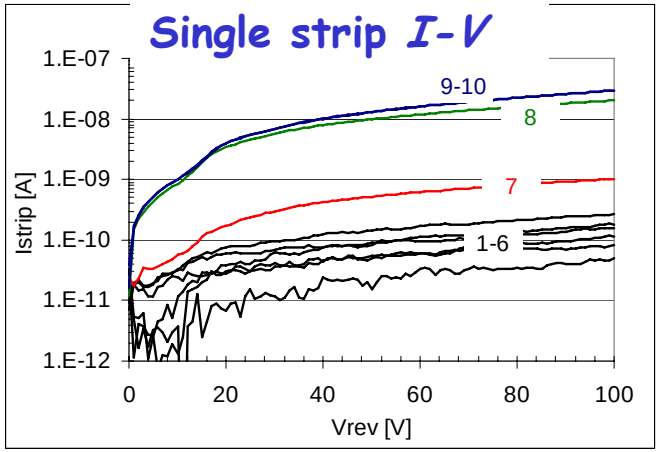


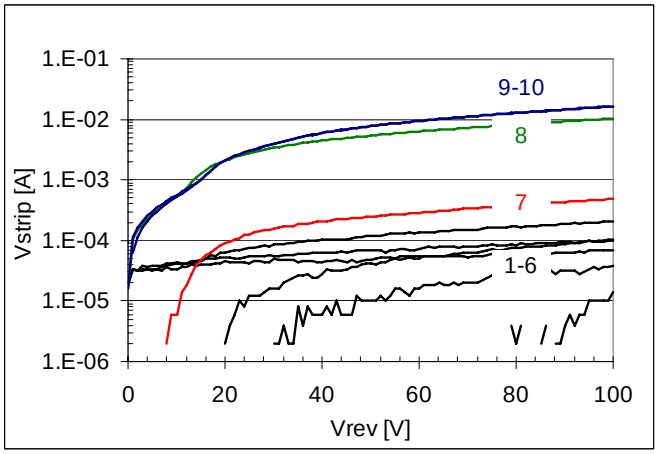
- design dependence of voltage handling capability (pitch and …);
- low "break" voltage for high-dose p-spray;
- substrate dependence?

Strip current scan (100V)

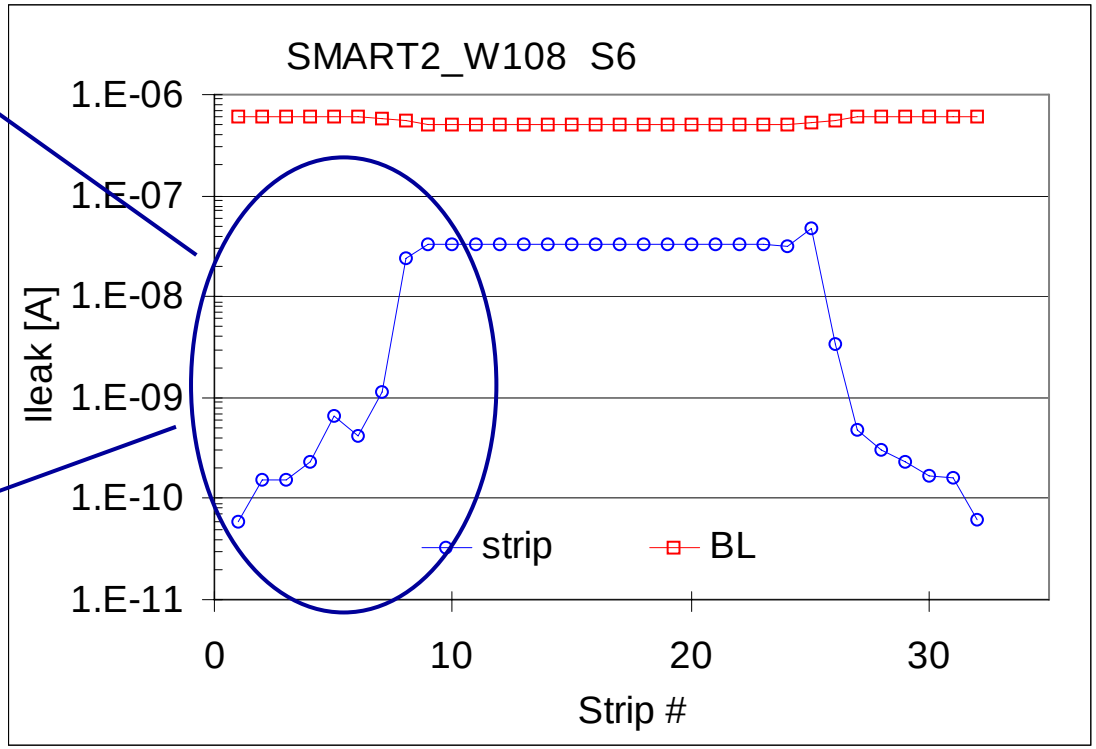
Low current values on border strips

- high- and low-dose p-spray
- 50μm and 100μm pitch
- p and n substrates





Floating strip potential



Bias resistor scan (100V)

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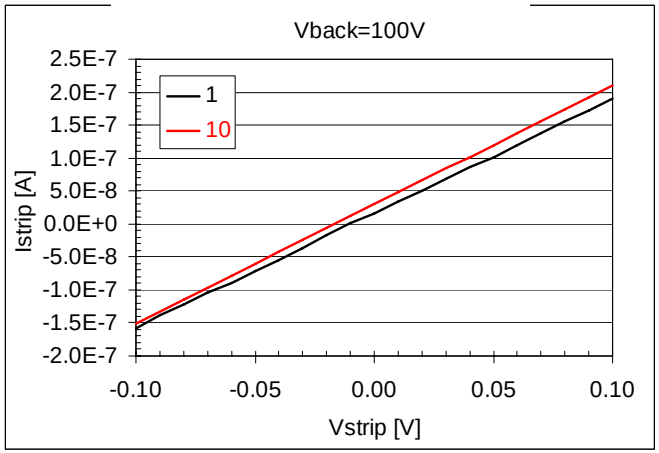
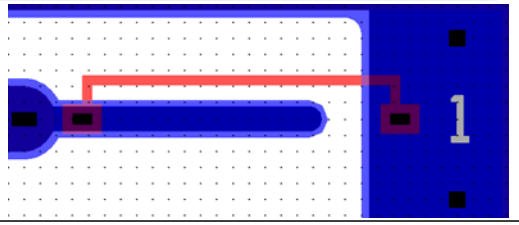
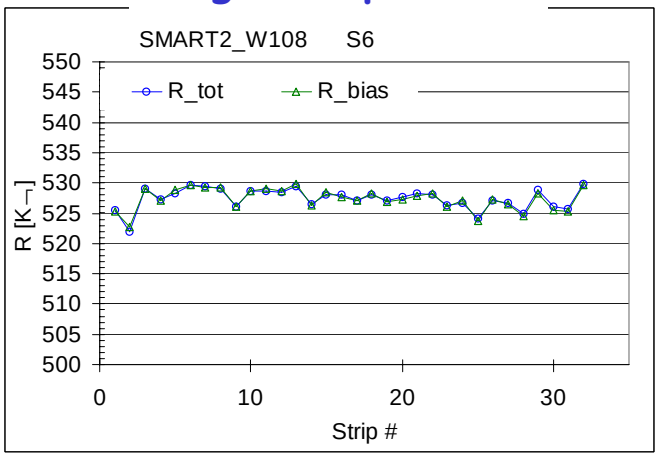
Single strip *I-V*

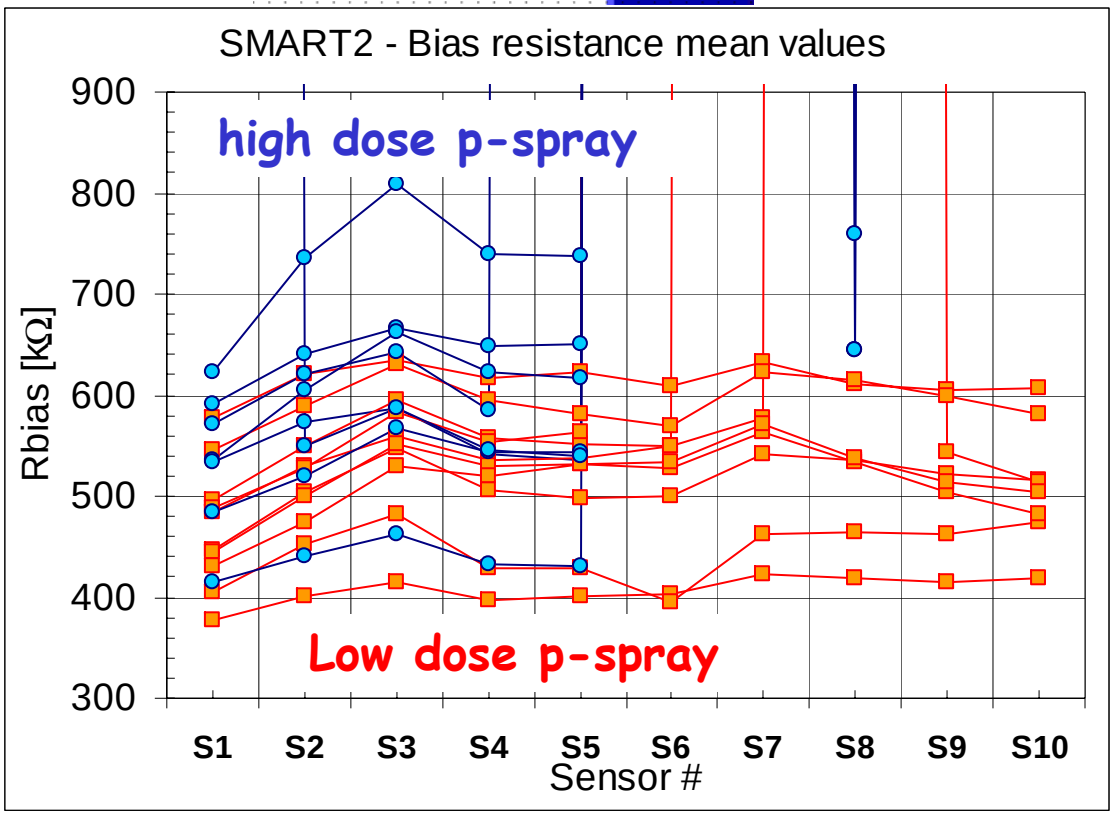




37 squares
width=6 μm

Single strip scan





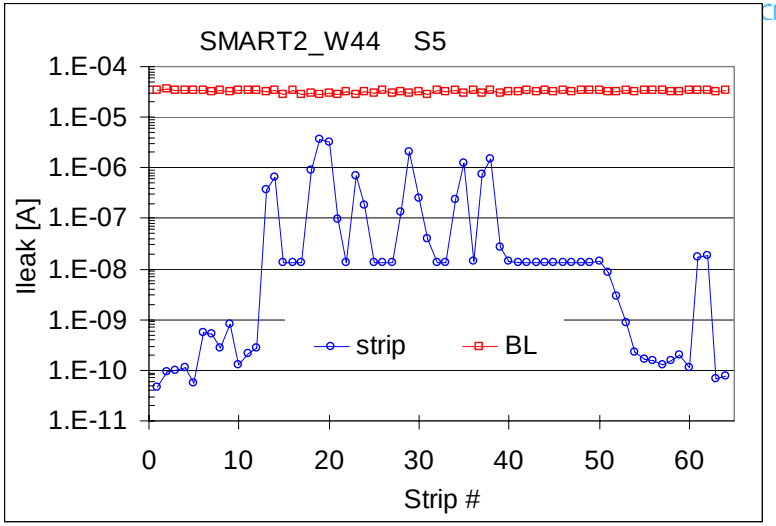
Single scan uniformity: 0.2% ÷ 2%

No results available for sensors with low breakdown values

Defects

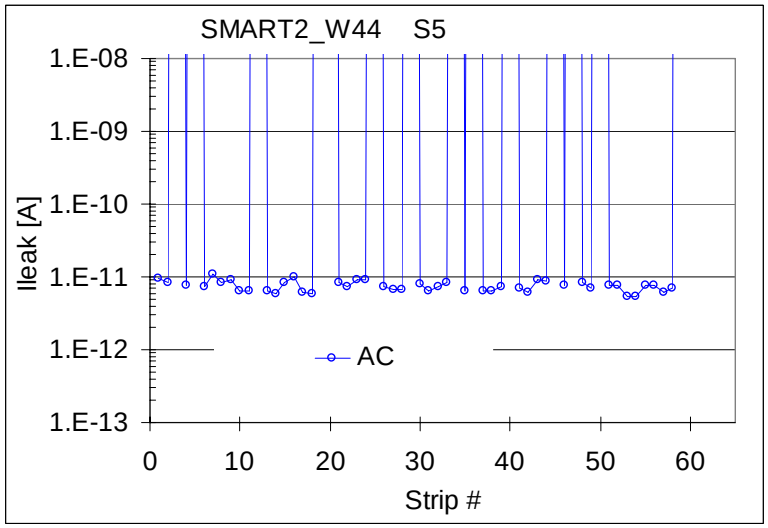
current-scan:
only few sensors

AC-scan:
~23% sensors have broken capacitors
(mainly 50μm pitch devices)



Sub type	Split	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
FZ 525	low p-spray										
FZ 525	low p-spray										
FZ 525	low p-spray										
FZ 525	high p-spray										
FZ 525	high p-spray										
FZ 525	high p-spray										
FZ 200	low p-spray										
FZ 200	high p-spray										
FZ 200	high p-spray										
MCz	low p-spray										
MCz	low p-spray										
MCz	low p-spray										
MCz	low p-spray										
MCz	low p-spray										
MCz	high p-spray										
MCz	high p-spray										
MCz	high p-spray										
MCz	high p-spray										

batch or sub problem?



No AC-defects are present for p-on-n devices

Conclusion

Problems on n-on-p production:

- non-uniformity of the depletion voltage (MCz subs)
- design/p-spray-dose interaction (→p-stop…?)

To be verified:

- effectiveness of actual p-spray

Samples available for the collaboration.