Silicon microstrip detectors for future tracker alignment systems

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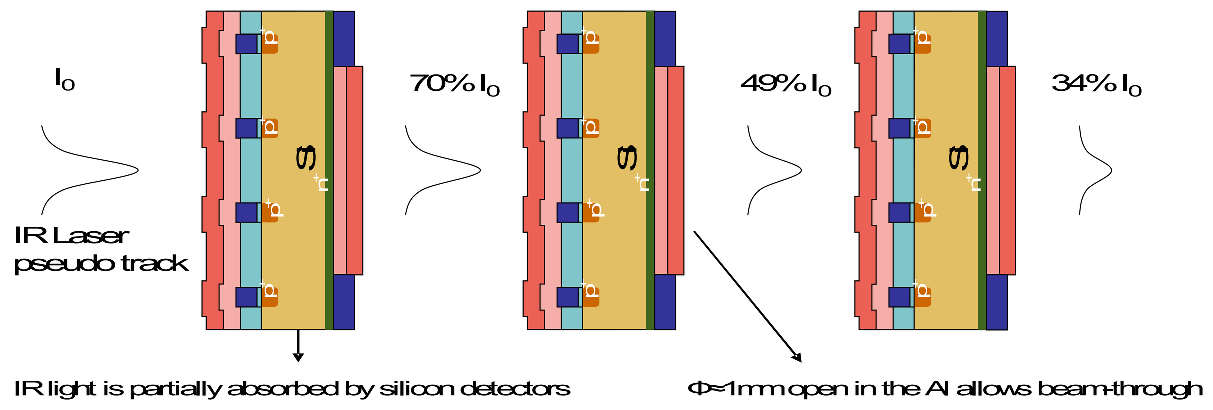
Aim : align Si microstrip sensors using IR laser tracks

Consecutive layers of silicon sensors are traversed by IR laser beams.

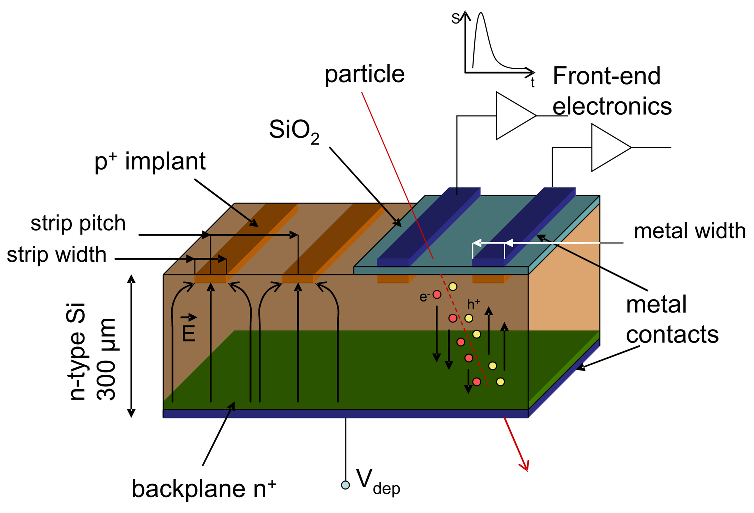
Si is almost transparent to IR light. Still, its absorption is enough to produce a measurable signal.



— Minimum impact on system integration, **no cost in extra material budget**

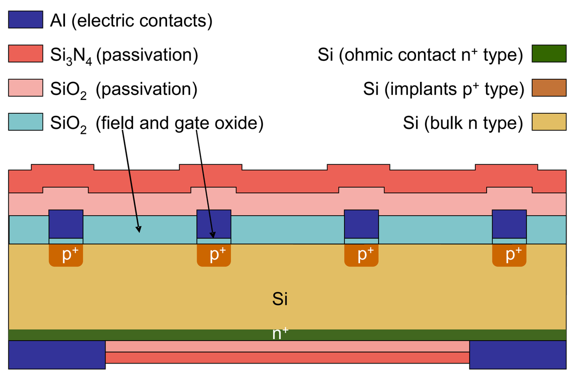
— Straightforward DAQ integration => **Alignment data is read out using Si DAQ**

Starting point : design and technology of the detector



Geometrical factors of optical interest:

- strip width
- metal strip width
- readout strip pitch



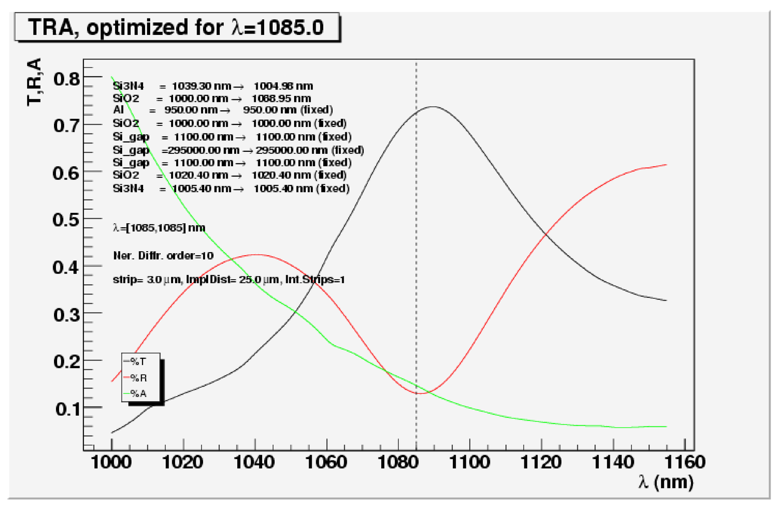
Technological factors of optical interest:

- 10 mm diameter optical window in the back electrode to allow the light pass through
- different materials => different refractive index
- materials thickness

First optical simulations

Tuning the thicknesses of the different material layers and the pitch/metal strip-width ratio of the sensors we optimized transmittance and reduced reflectance for a wavelength of 1085 nm.

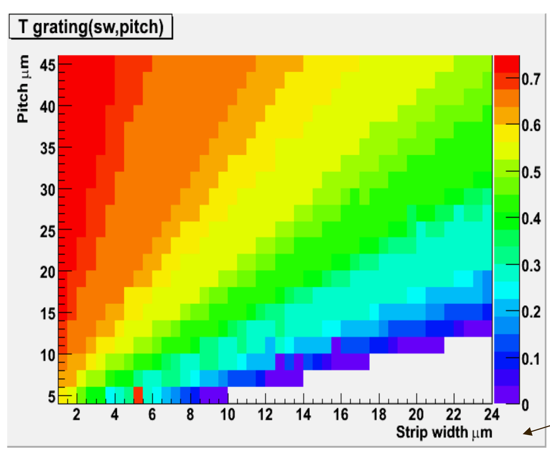
A full optical simulation of the passage of light through a silicon microstrip detector has been developed taking in account the effects of multiple reflections and diffraction by the microstrips, with the use of a rigorous Maxwell's equation solver (RCWA) [1] .



gate oxide 36.5 nm (fixed)

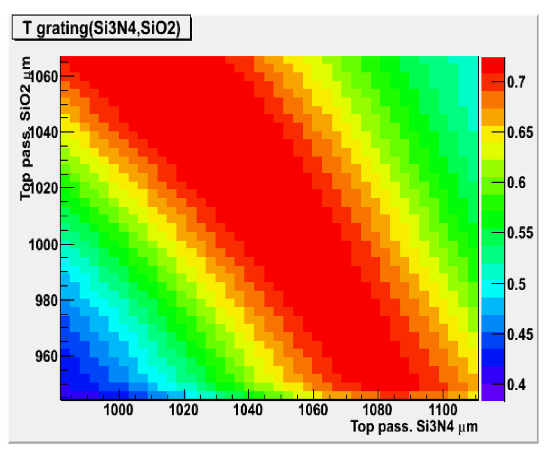
Choose optimal layout (msw/pitch=10%)

pitch 50 μm (fixed)



metal strip width

Use passivation (= SiO_2+Si_3N_4) as an AntiReflection Coating (ARC)

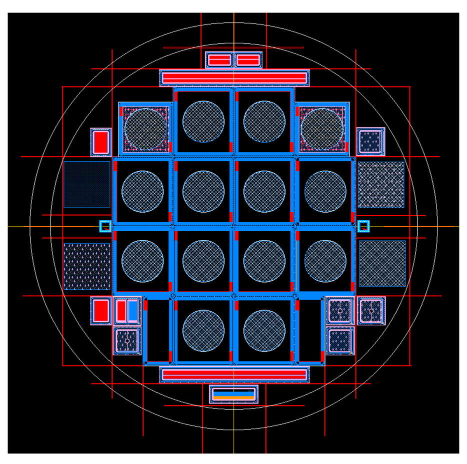


If deposition thickness is better than 5% repeatability of results is granted

Mask design

12 different detectors

- Active area= 1.2x1.5 cm²
- 256 readout strips with 1.5 cm length
- Circular window in the back metal (r=0.5 cm)

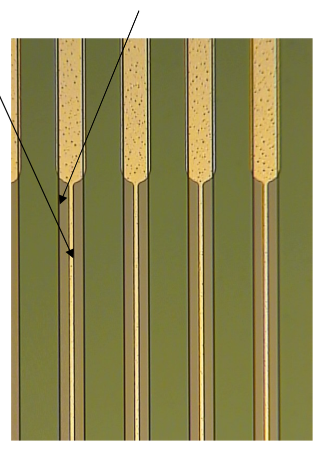


6 detectors with **floating intermediate strips** without metal in order to improve spatial resolution.

	p+ strip width	Metal width	Intermediate strips
1	15um	15um	1
2	15um	10um	1
3	15um	5um	1
4	15um	3um	1
5	12.5um	5um	1
6	17.5um	5um	1
7	15um	15um	no
8	15um	10um	no
9	15um	5um	no
10	15um	3um	no
11	12.5um	5um	no
12	17.5um	5um	no

3 μm metal width

15 μm strip width



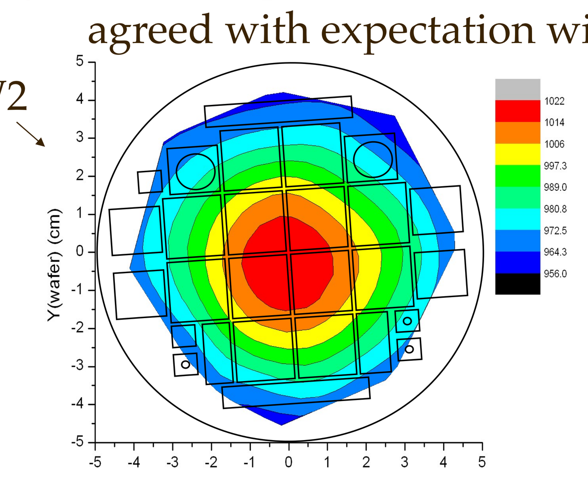
2 trasparent diodes, 4 optical test structures (OTS), more test structures.

Fabrication run

5+1 wafer are in production.

We measured the thickness of each layer after its growth or deposition on all the wafers. Measurements agreed with expectation with a tolerance ~ 5%.

W2

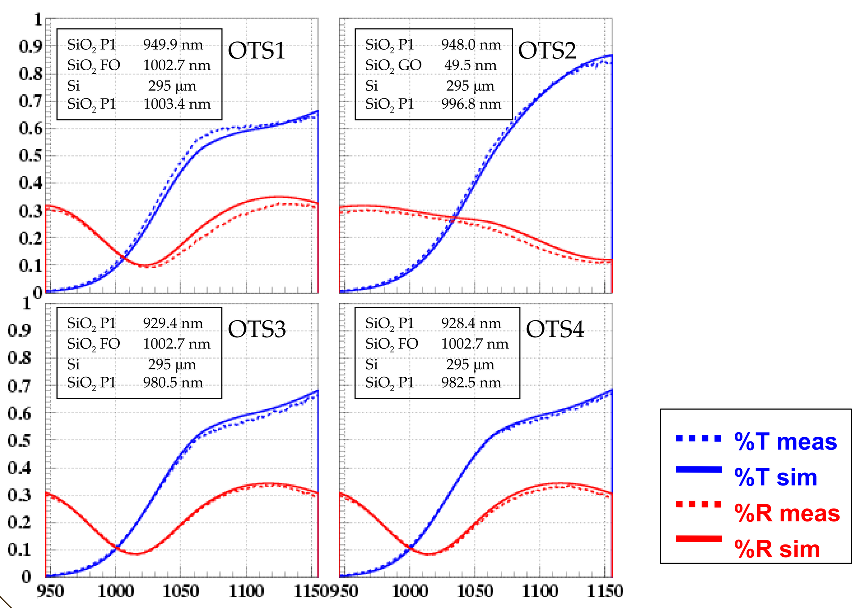


Measurements of SiO_2 passivation layer on the top surface of the wafers

Wafer / Statistics	W1	W2	W3	W4	W5	W6
Mean (nm)	949	980	986	978	955	962
Uniformity (%)	3.3%	3.4%	3.1%	3.2%	3.5%	4.4%

Measured Test structures VS simulated

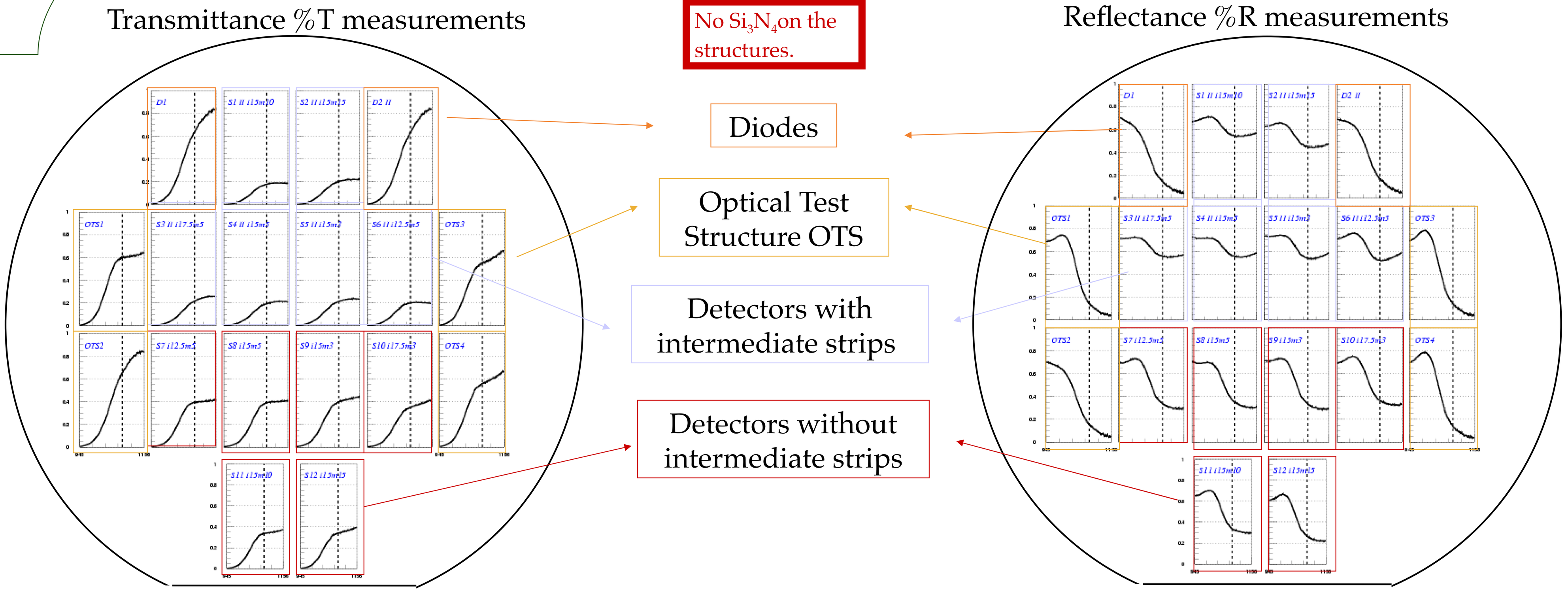
Good agreement in uniform structures



Optical results at intermediate step

We hold the run just before the deposition of the last passivation layer (Si_3N_4).

We measured transmittance and reflectance at this intermediate step.



- T~70% Test structures.
- No intermediate implant ΔT=+20%.
- Metal width [3-5] μm: second order effect.
- Metal width>10 μm: ΔT≤-5%

- R<30% Test structures.
- Metal width>10 μm: ΔR~10%
- No intermediate implant less different than in T case.

%R linked to Al width

%T related to uniformity

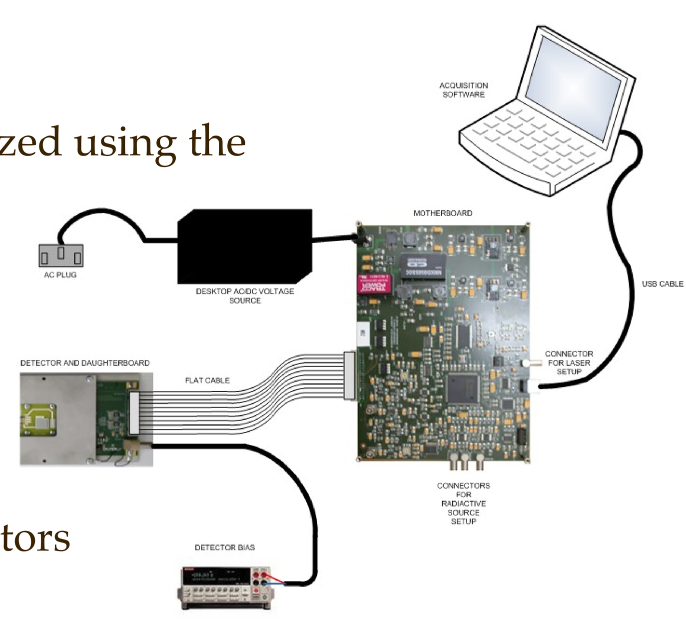
A new simulation is in process to better choose the thickness of the Si_3N_4 layer which would improve the transmittance (ARC).

Conclusions

- We developed a complete study to improve transmittance of silicon microstrip detectors to IR light .
  i. Optimal layout (msw/pitch ratio =10%)
  ii. Passivation =ARC

- 5+1 wafer with multi-geometry sensor in production. Hold just before the last passivation layer deposition.
  i. Deposit tolerance at CNM is remarkable . Better than 5% in almost all layers => repeatability of results granted.
  ii. First optical measurements at intermediate step: results could improve
  iii. New simulation to choose the Si_3N_4 layer thickness to complete the ARC.

The detectors will be characterized using the ALIBAVA[2] readout system



- Up to 256 readout channels
- SNR≈20 in no irradiated detectors

1 “Infrared-transparents microstrip detectors” M.Fernández et al. *Nuclear Instruments and Methods in Physics Reserch A* (2008), Pages 84-85.

2 “A Portable Readout System for Microstrip Silicon Sensors (ALIBAVA)” Marco-Hernandez, Ricardo; Nuclear Science Symposium Conference Record, 2008. NSS '08. IEEE 19-25 Oct. 2008 Page(s):3201 - 3208