IR Transparent Si microstrips

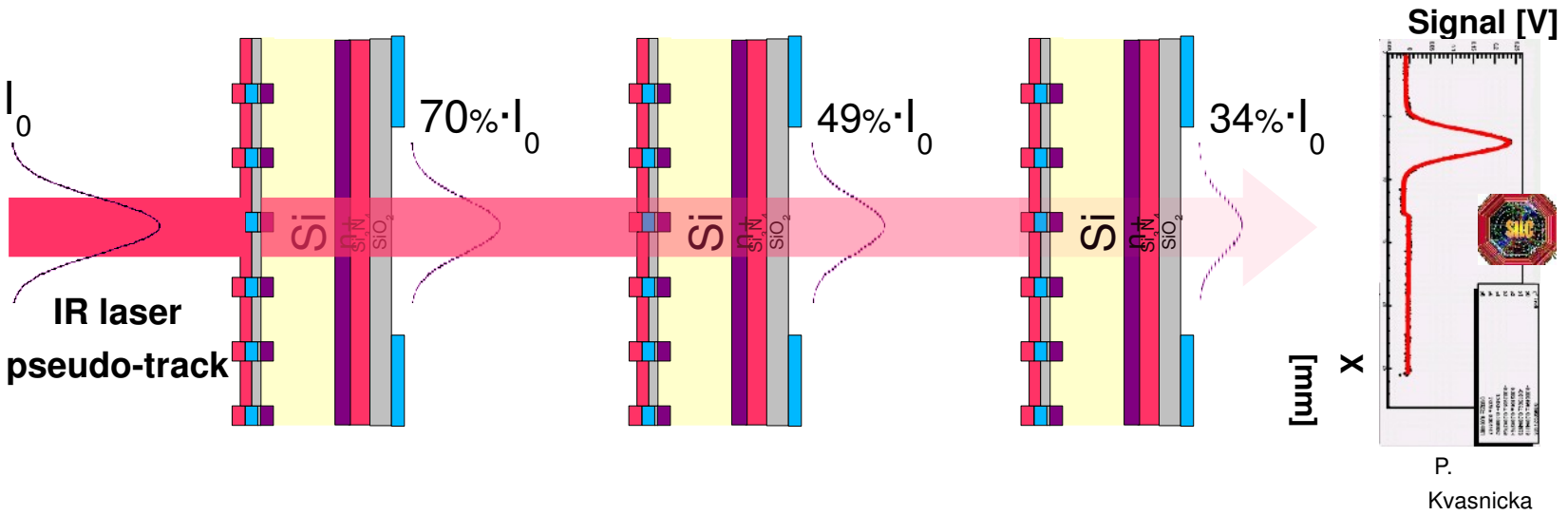
(alignment optimized Si sensors)

IFCA SiLC (a.o.):
Marcos Fernández, Javier González,
Richard Jaramillo, Amparo López,
David Moya, Celso Martínez Rivero,
Francisca Munoz, Alberto Ruiz, Iván Vila

CNM SiLC (a.o.):
Daniela Bassignana, Manuel Lozano,
Giullio Pellegrini, Enric Cabruja,
David Quirion

Microstrips as semitransparent light detectors

Laser tracks can be used by a hardware system to align the tracker

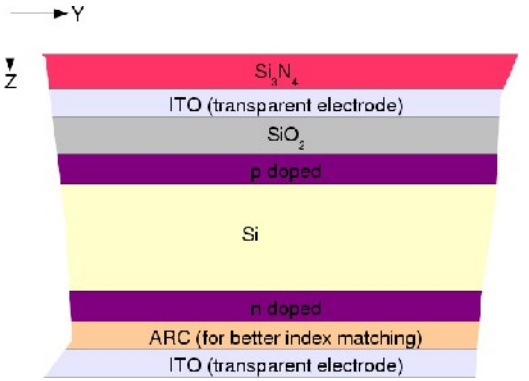


Goal of this project is to improve transmittance to infrared light of microstrip detectors. Main constraint is not to alter the standard production process, and not to include alien materials

Once pitch is fixed, the key to increase transmittance is the thickness of top&bottom passivation layers. Note: The passivation consists of a double layer of Si_3N_4 on SiO_2. The sensors are passivated from the top and from the bottom.

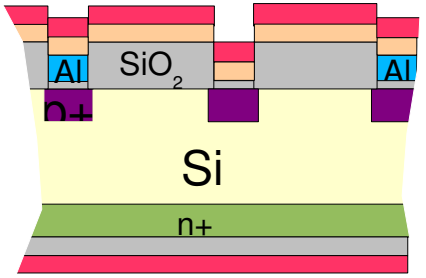
Highlights of this project within EUDET framework

1st year: conceptual design, proposals and perspectives

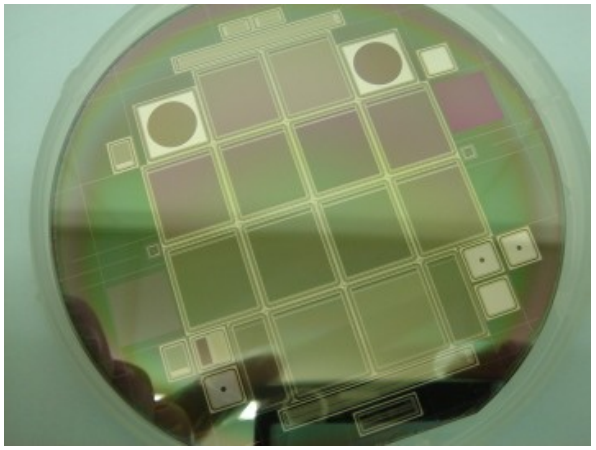


2nd year: Simplified simulation of μstrips as plane-parallel layers.
Validation of plane parallel simulation
Beginning of realistic study (segmented strips)

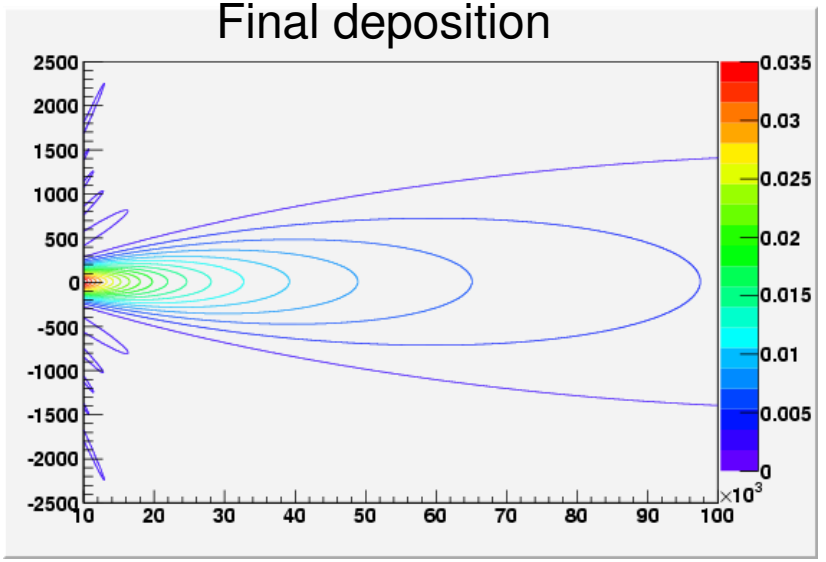
3rd year: Full simulation of μstrips (interefence and diffraction)



4th year: Production of prototype transparent microstrip detectors



5th year: Validation of realistic simulation:
Far field calculations
Final deposition



Main results achieved

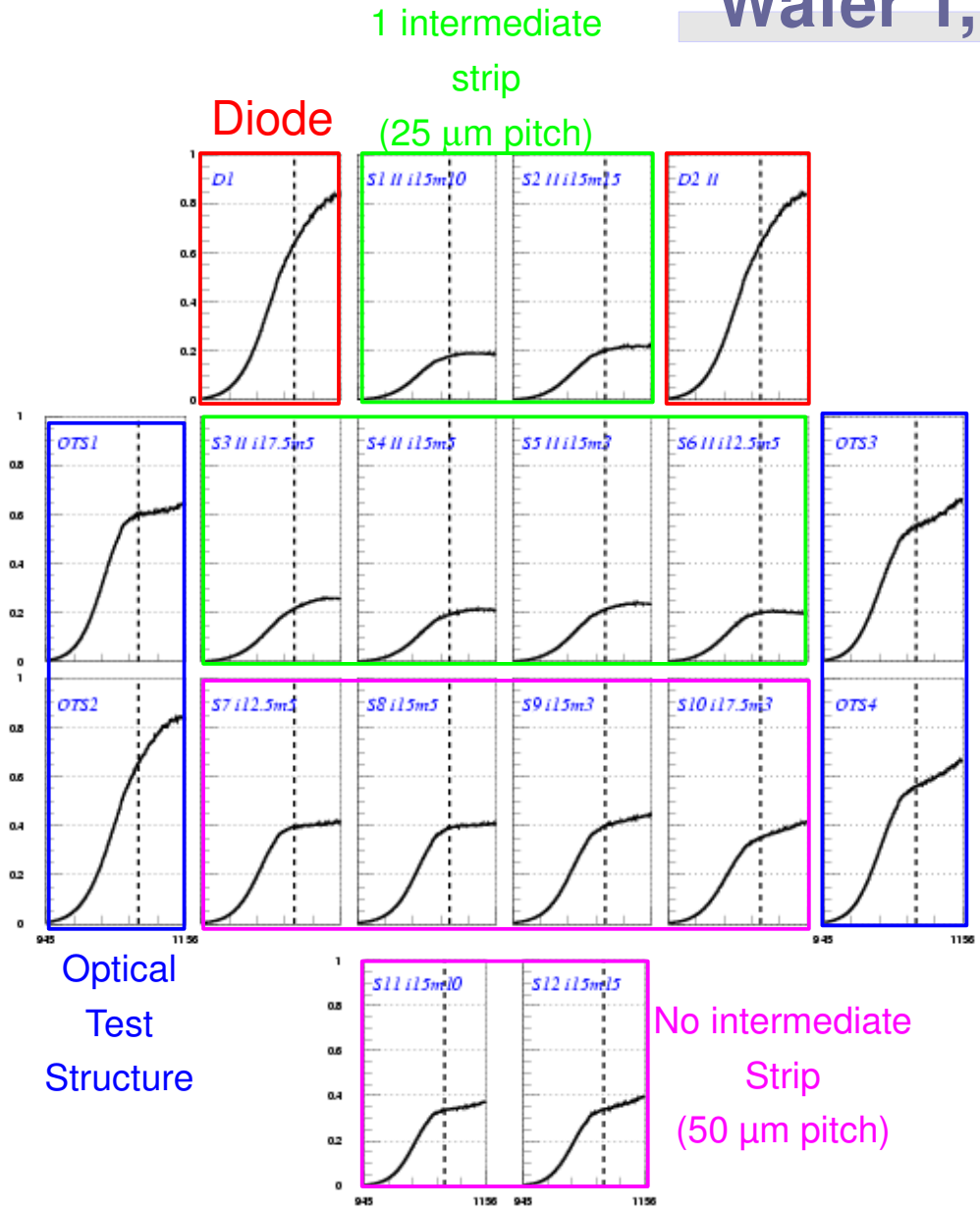
— Strips (having metal or not) behave as a diffraction grating. Sensors with intermediate are more “efficient” gratings.

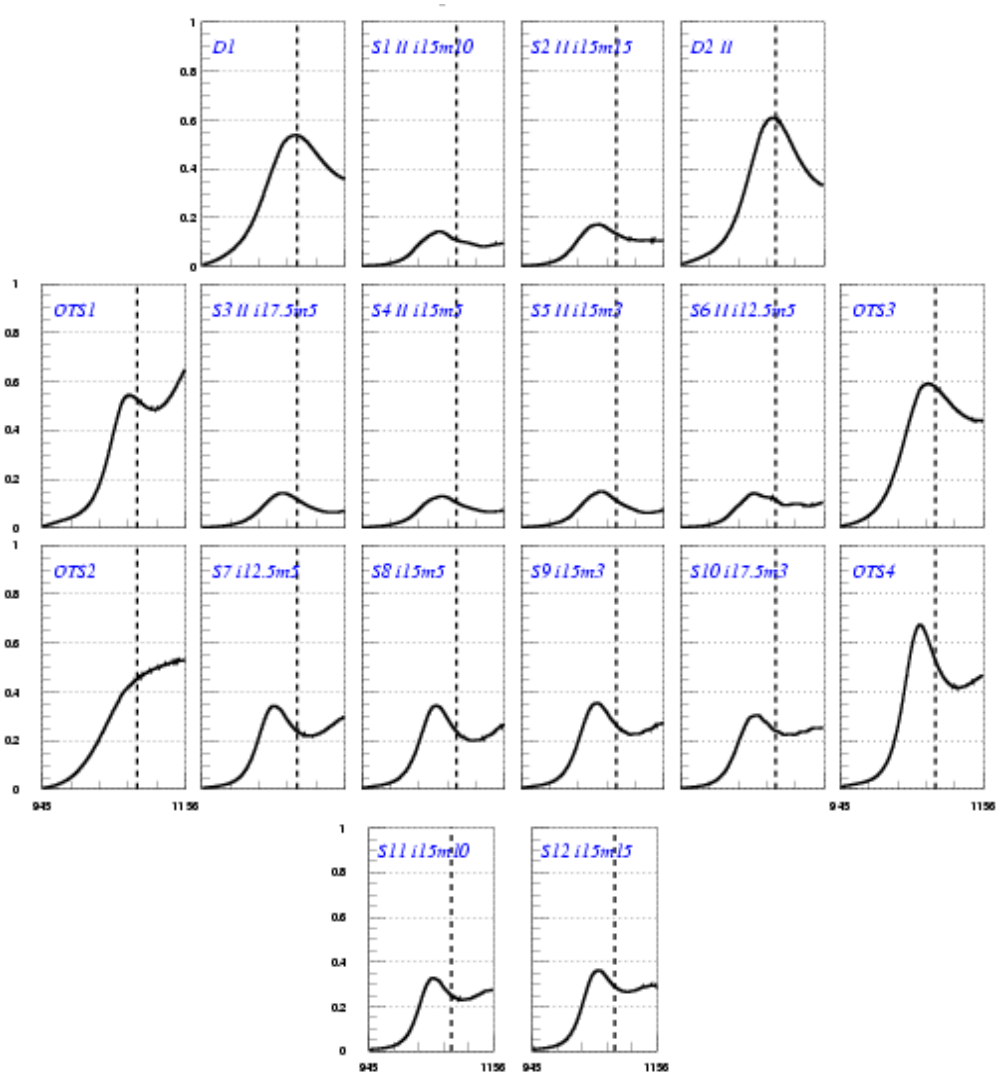
— Pitch reduction (=closer strips) decreases transmittance (1^{st} order effect) and increases reflectance (2^{nd} order).

— Strip width increases reflectance (1^{st} order), and reduces transmittance (2^{nd} order).

— Top and bottom passivation layers behave as an AntiReflection Coating (ARC)
Top passivation thickness more critical than bottom.

Wafer 1, measured





Uncomplete top&bottom passivation

Transmittance~40%

Complete top&bottom passivation

Transmittance~20%

Wafer 1&2, finished

— First 2 wafers were finalized in 2 steps.

— First step was the deposition of SiO2 (top and bottom)

Good news: transmittance of selected sensors ~40%

Measurement differs from simulation by a constant scale factor

The scale factor is different from sensor to sensor

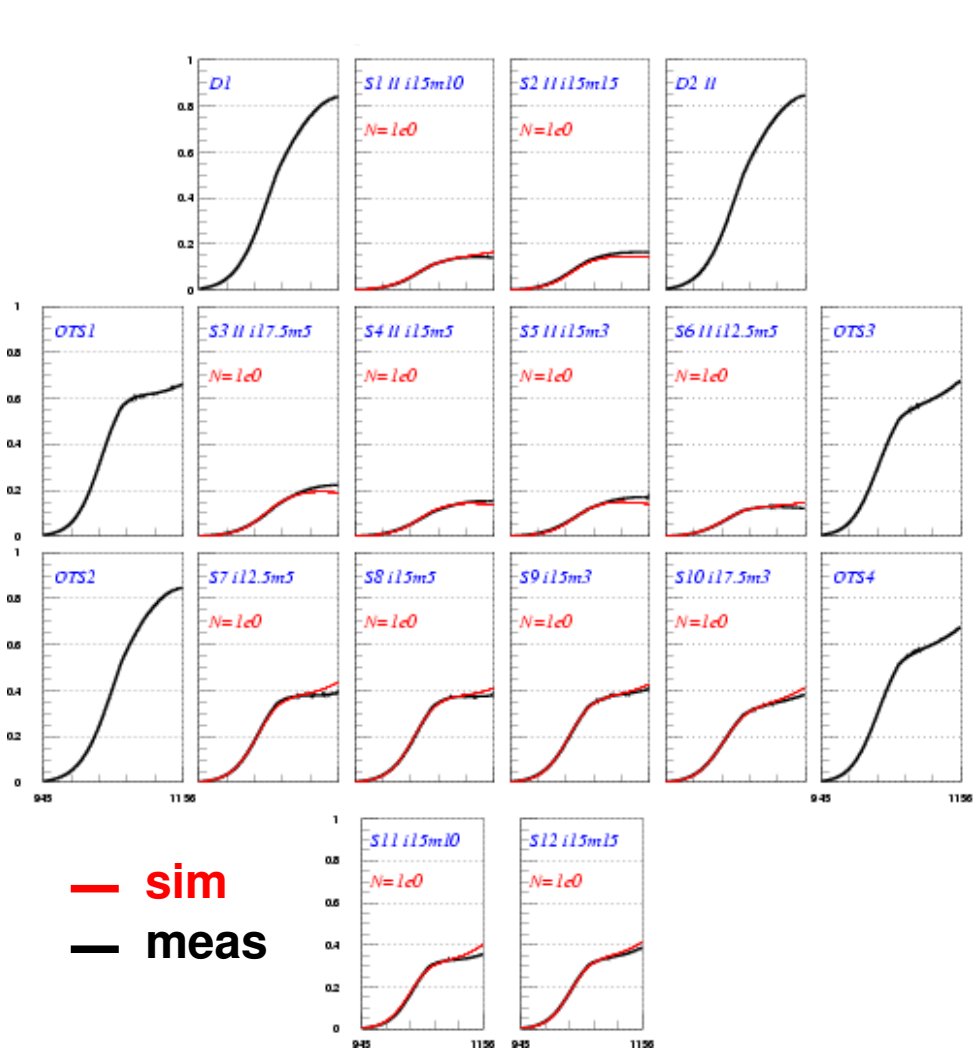
— Deposition of Si3N4 (2^{nd} step) had to be done before end of year 2009

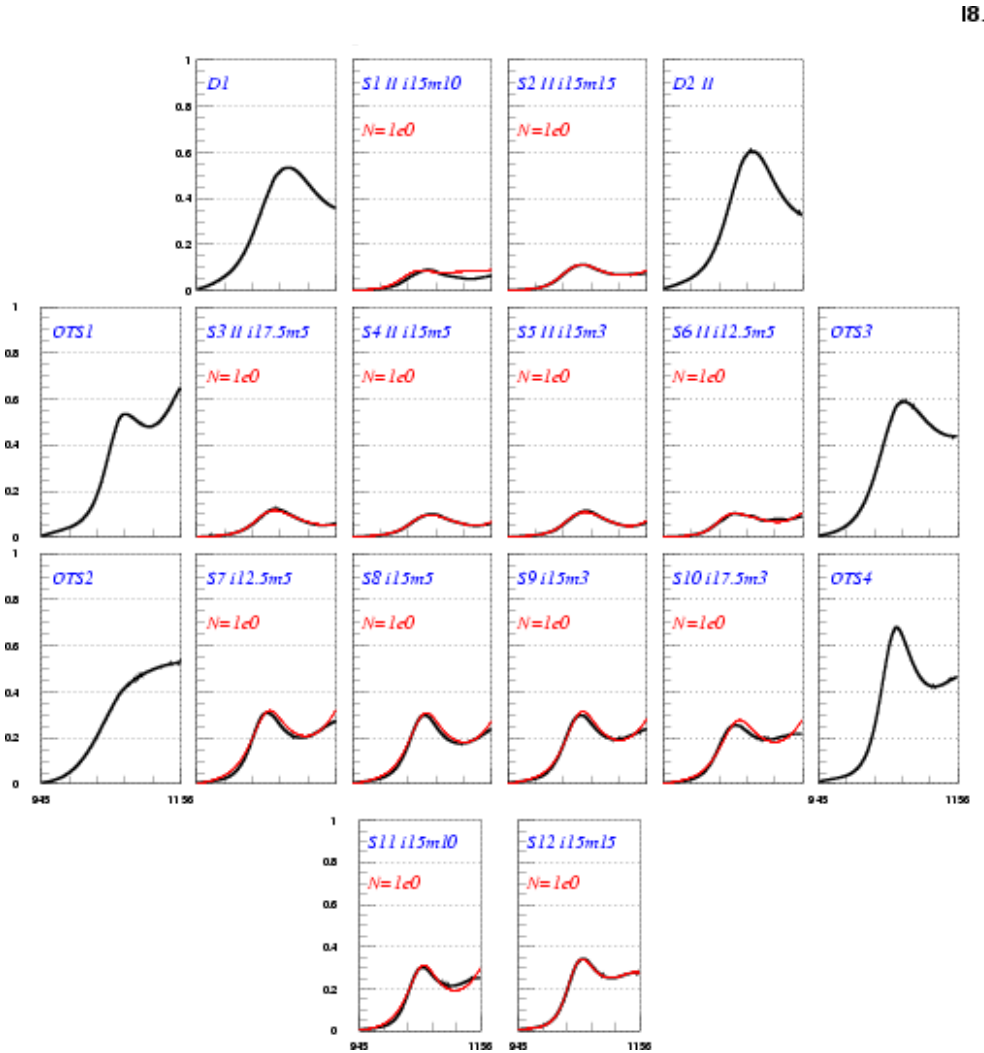
Finalized wafers had lowered transmittance

We realized that transmittance depends on measurement distance.

We need to propagate the calculated fields to far distance

Wafer 1, far field fits





— sim
— meas

Simulation is validated !!

Final step for the last 3 remaining wafers

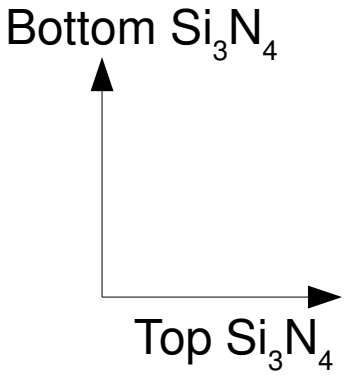
- Three wafers left
  - Conservative approach: deposit desired thickness of Si3N4 in few steps
  - Measure after each step

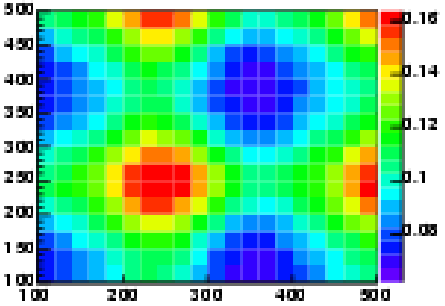
- We have calculated the expected transmittance using the measured thickness of the deposited materials

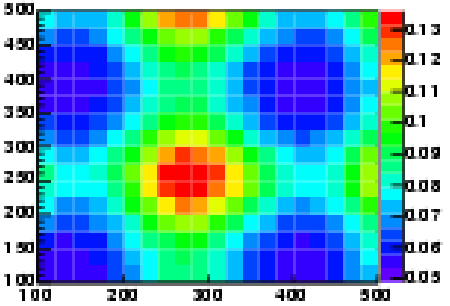
- Next 3 pages show T=T(top Si_3N_4 thickness , bottom Si_3N_4 thickness)

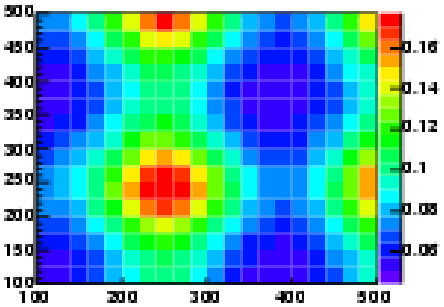
Wafer 3: Sequential deposition of Si3N4

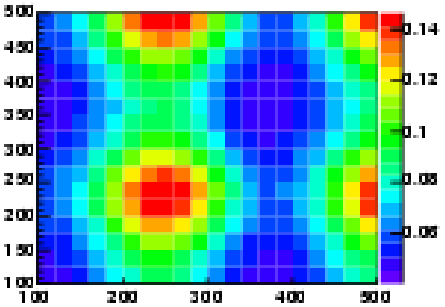
(using measured thickness)

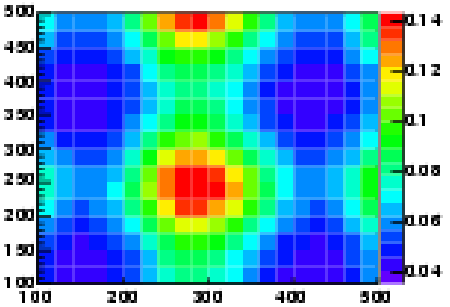


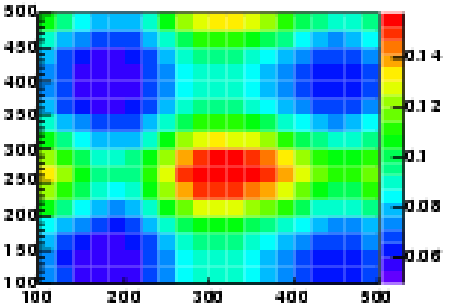


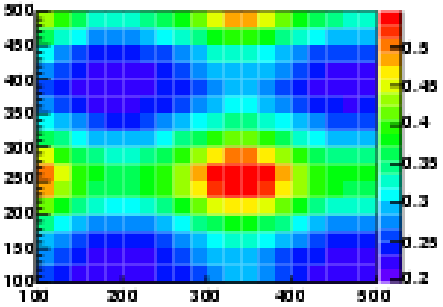


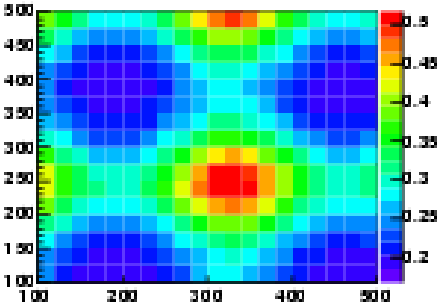


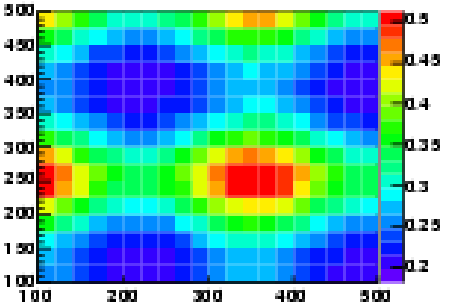


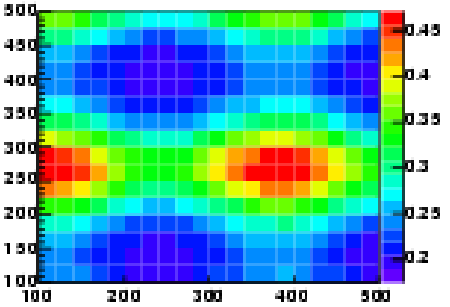


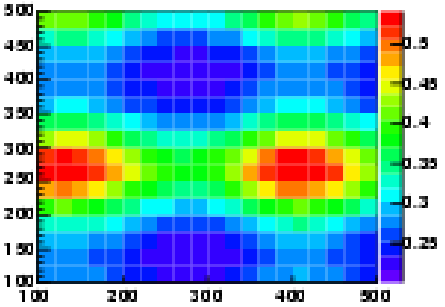


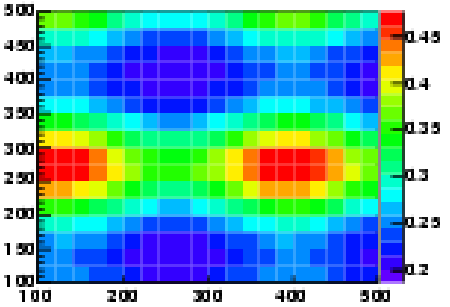






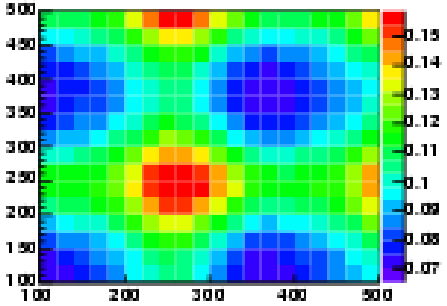
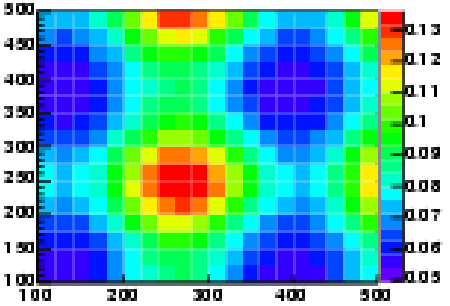
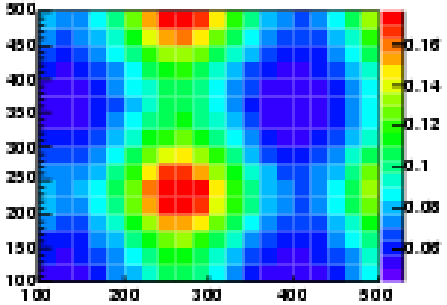
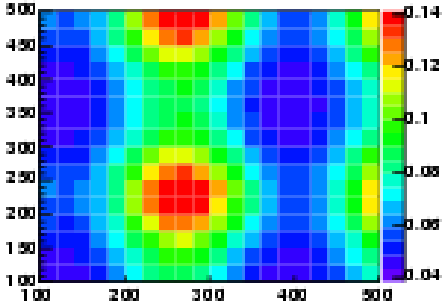
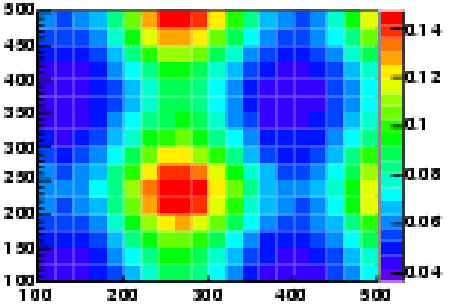
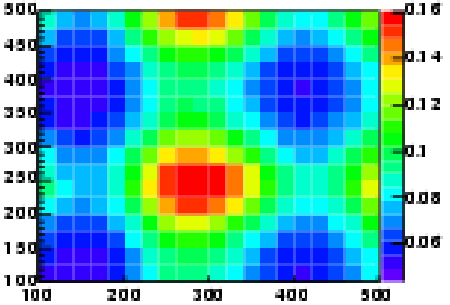
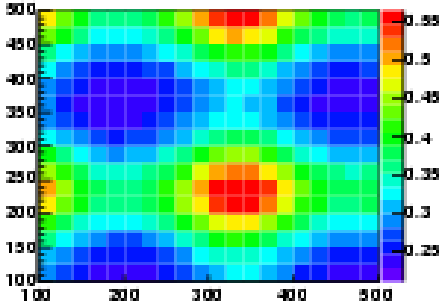
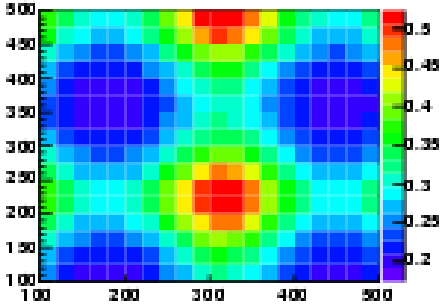
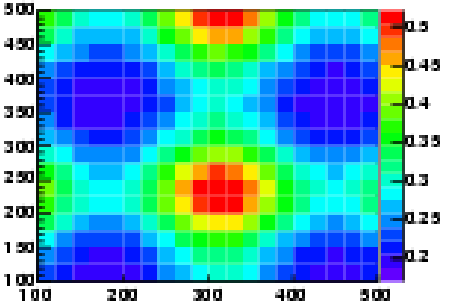
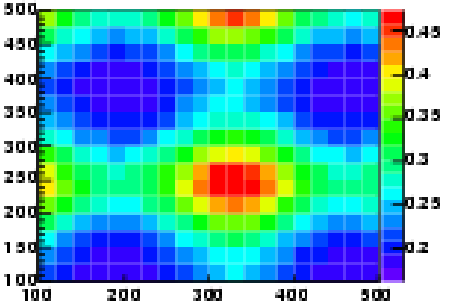
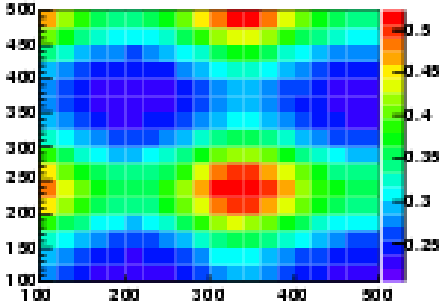
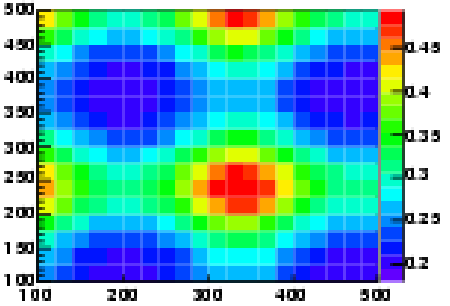






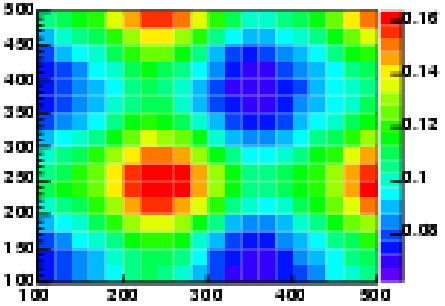
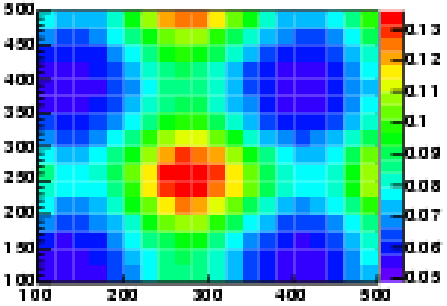
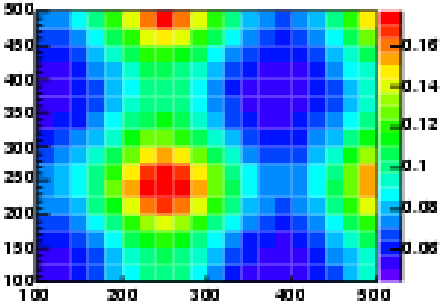
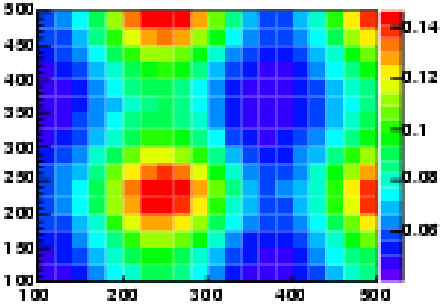
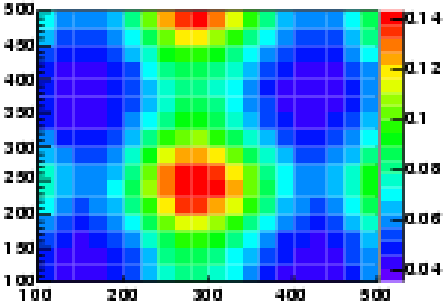
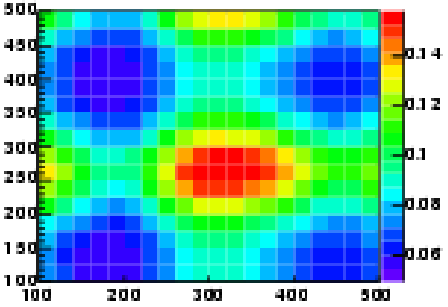
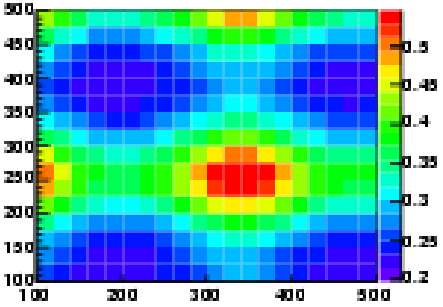
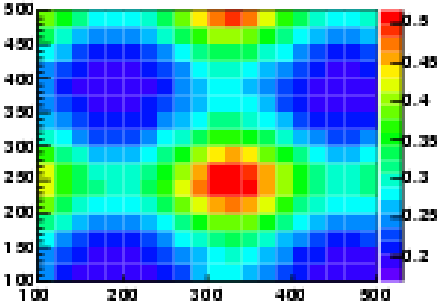
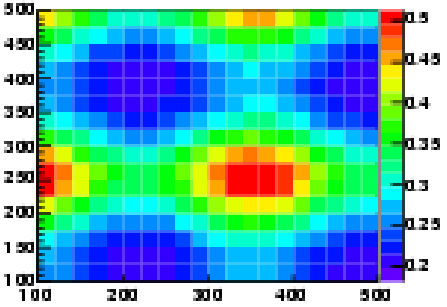
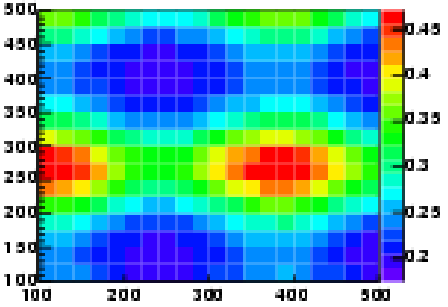
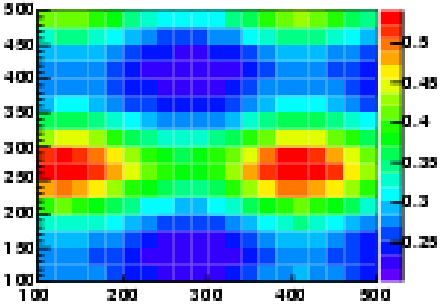
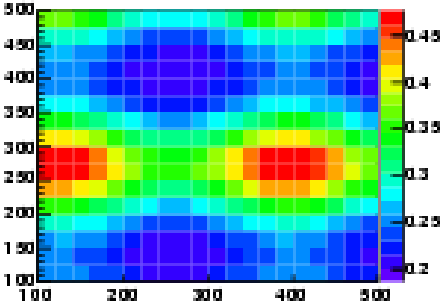
Wafer 4: Sequential deposition of Si3N4

(using measured thickness)

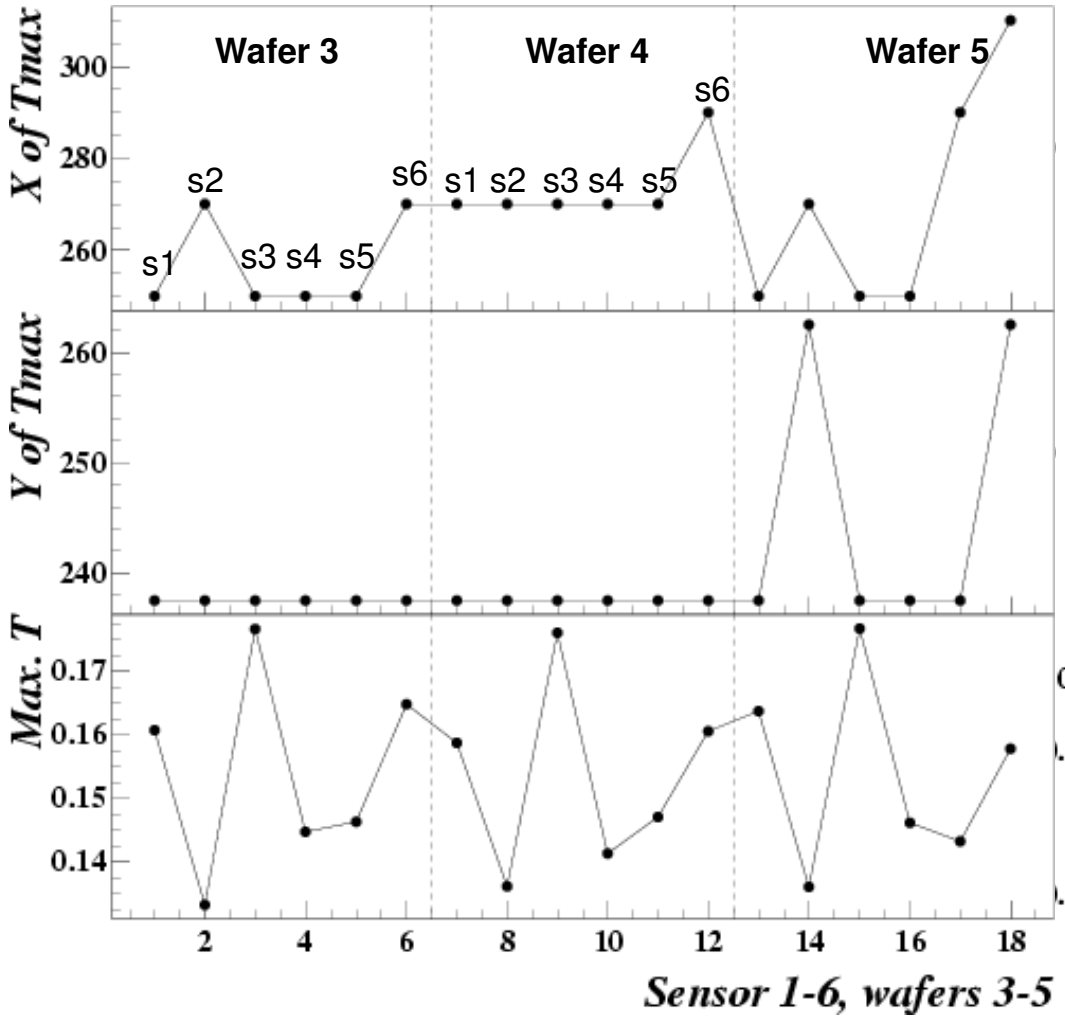













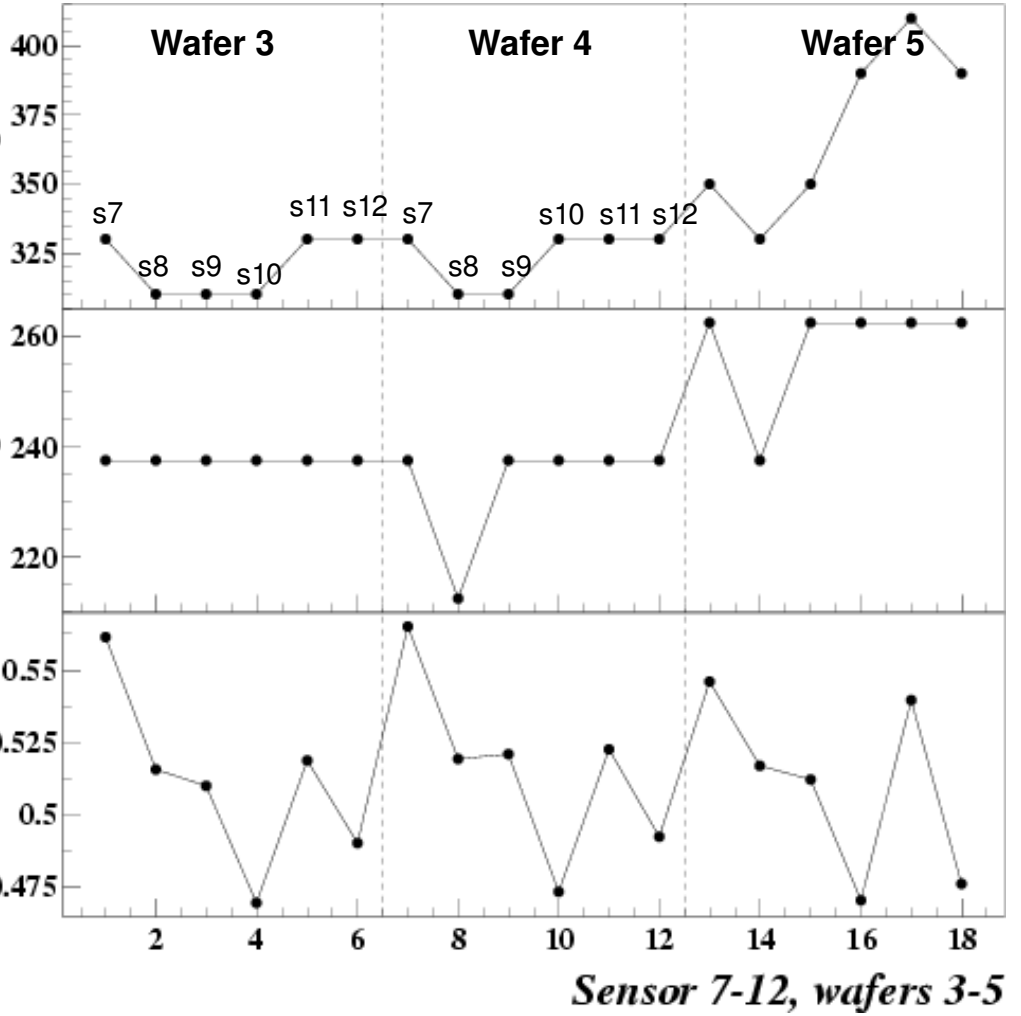
Wafer 5: Sequential deposition of Si3N4

(using measured thickness)

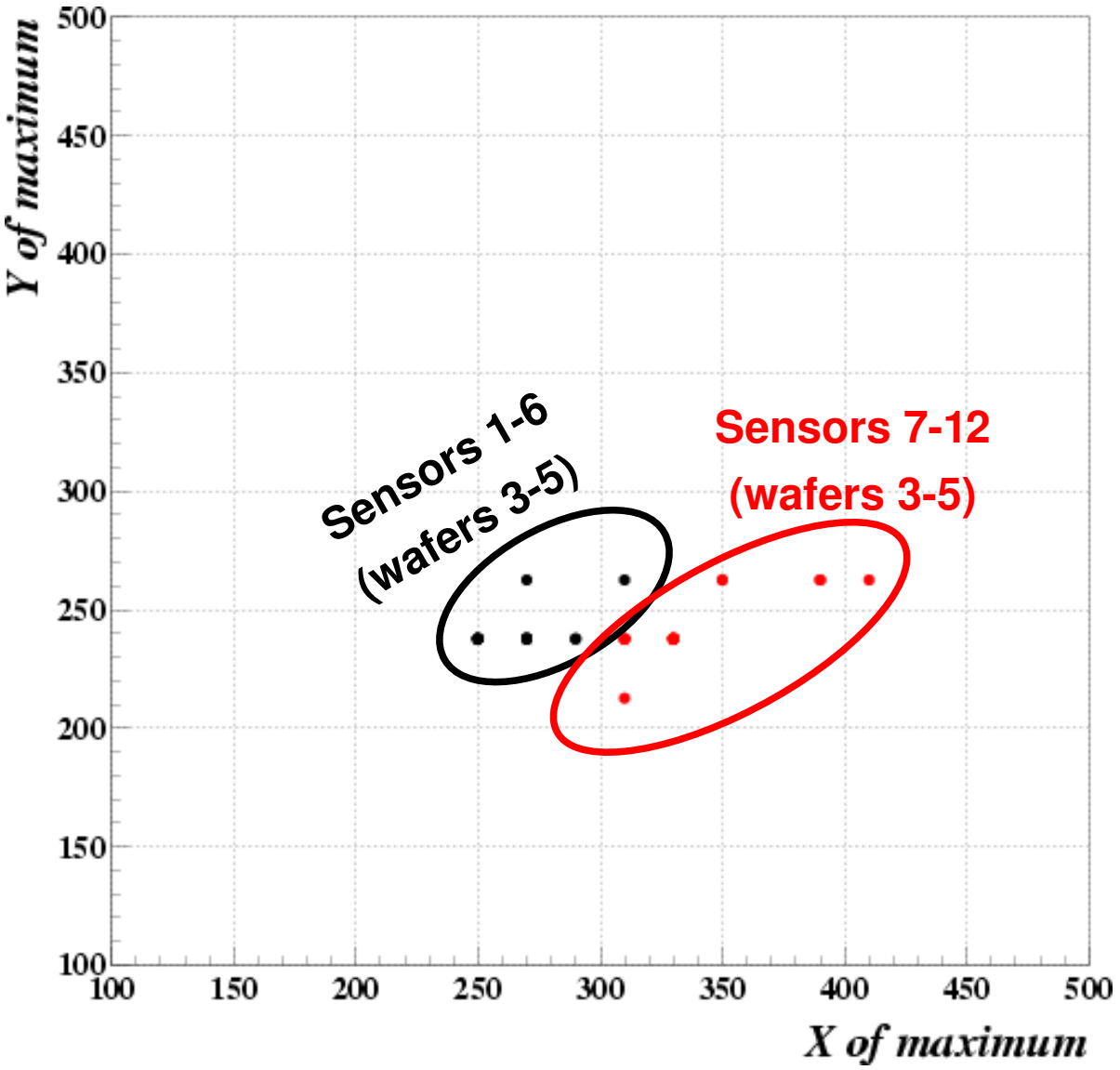













(x,y) of first maximum vs sensor id in wafers 3, 4, 5





Scatter plot of (x,y) of first maximum for wafers 3, 4, 5



Note: Each ellipse contains 18 entries (6 sensors × 3 wafers) showed in the former slide

Conclusions

Sensors with intermediate microstrips have lower %T

Thickness of bottom Si3N4 passivation layer does not depend on the sensor type

Upper Si3N4 layer is thicker for sensors without intermediate strip

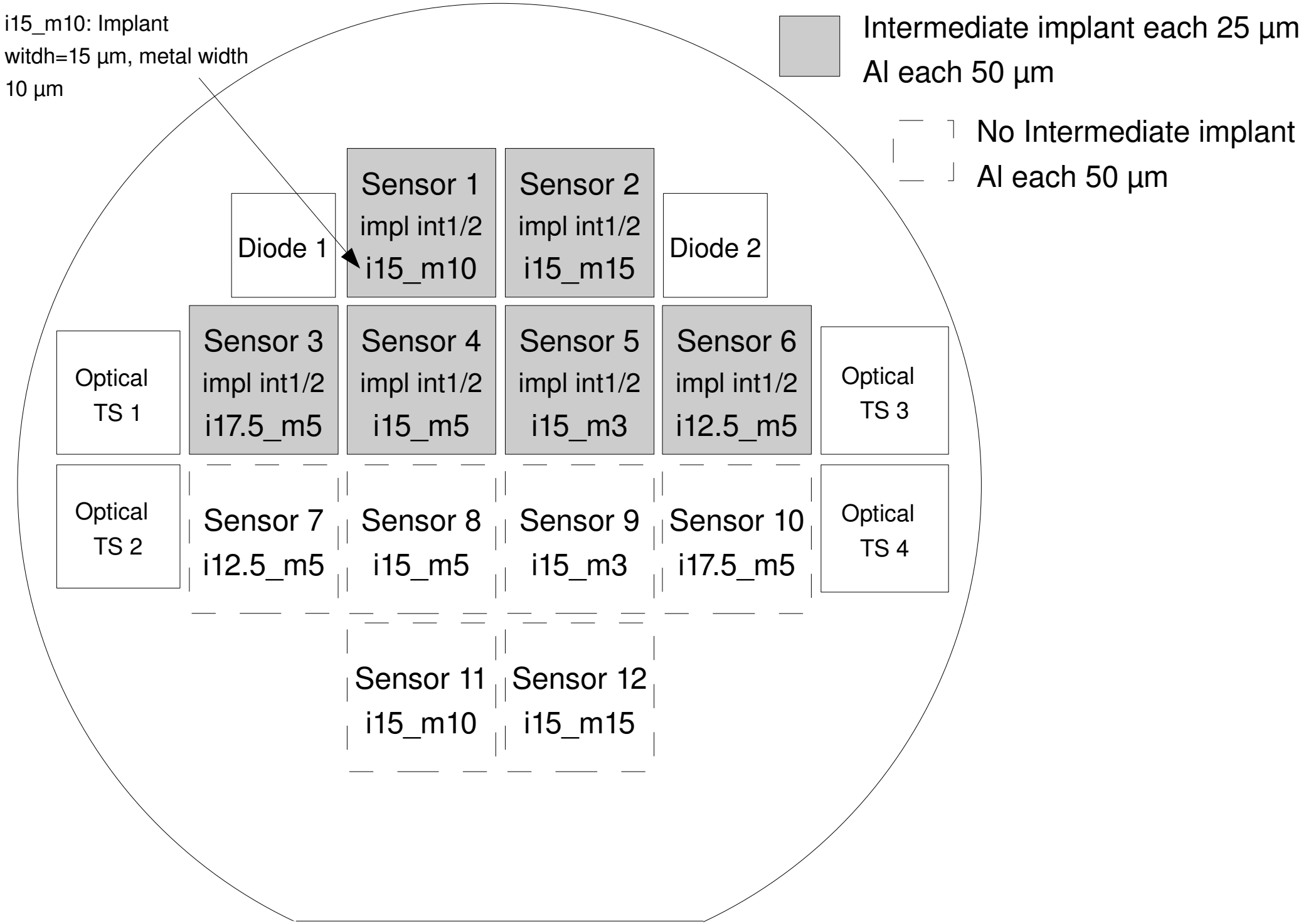
Therefore, thickness does not depend on the wafer but on the sensor

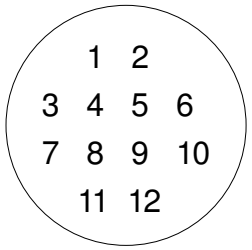
Deposition of last Si3N4 (2 layers/sensor) has been agreed with CNM

Run will be finalized in October.

Final results of this project will be reported in the EUDET annual memo

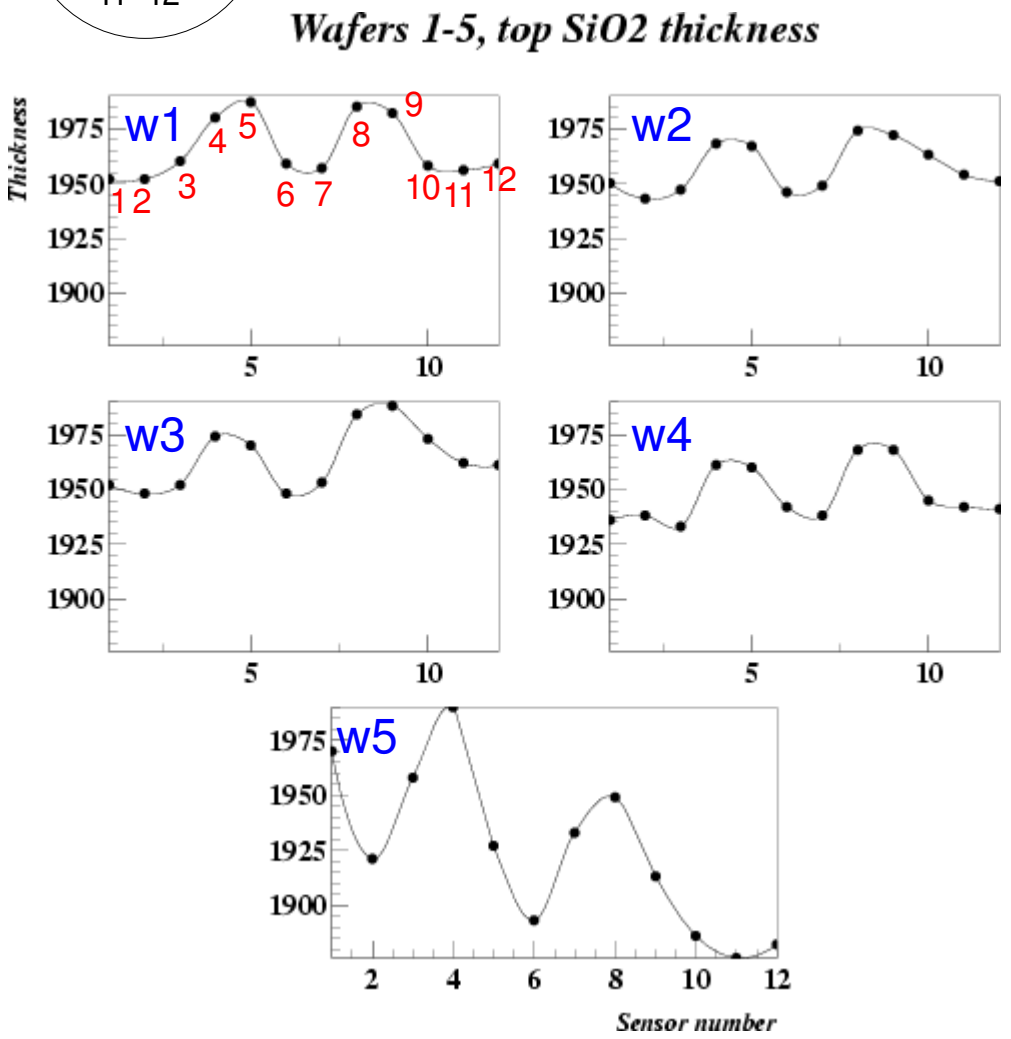
BACKUPS

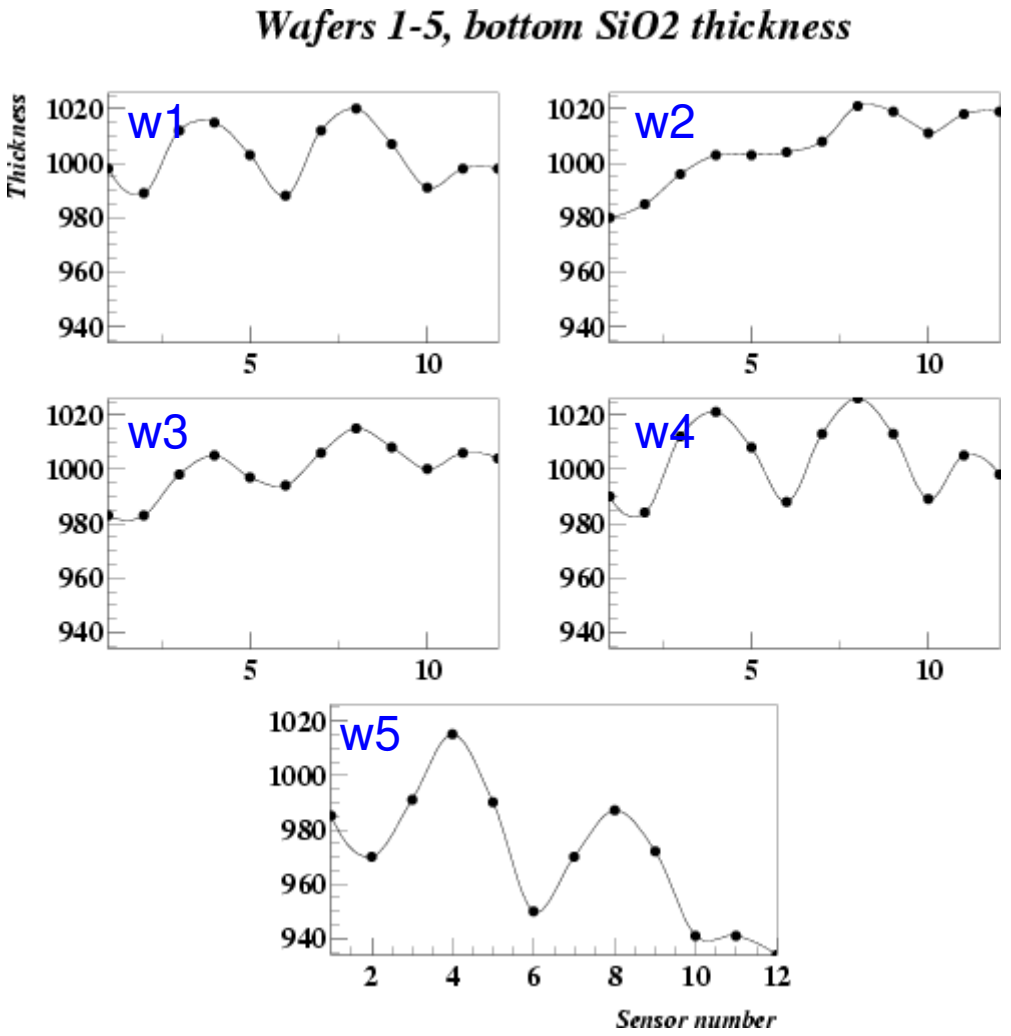

i15_m10: Implant
witdh=15 µm, metal width
10 µm
Intermediate implant each 25 µm
Al each 50 µm
No Intermediate implant
Al each 50 µm
Diode 1
Sensor 1
impl int1/2
i15_m10
Sensor 2
impl int1/2
i15_m15
Diode 2
Optical
TS 1
Sensor 3
impl int1/2
i17.5_m5
Sensor 4
impl int1/2
i15_m5
Sensor 5
impl int1/2
i15_m3
Sensor 6
impl int1/2
i12.5_m5
Optical
TS 3
Optical
TS 2
Sensor 7
i12.5_m5
Sensor 8
i15_m5
Sensor 9
i15_m3
Sensor 10
i17.5_m5
Optical
TS 4
Sensor 11
i15_m10
Sensor 12
i15_m15



SiO2 thickness in each wafer

(curves are interpolated)



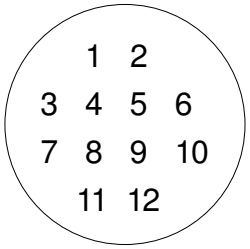


Spread in wafers:

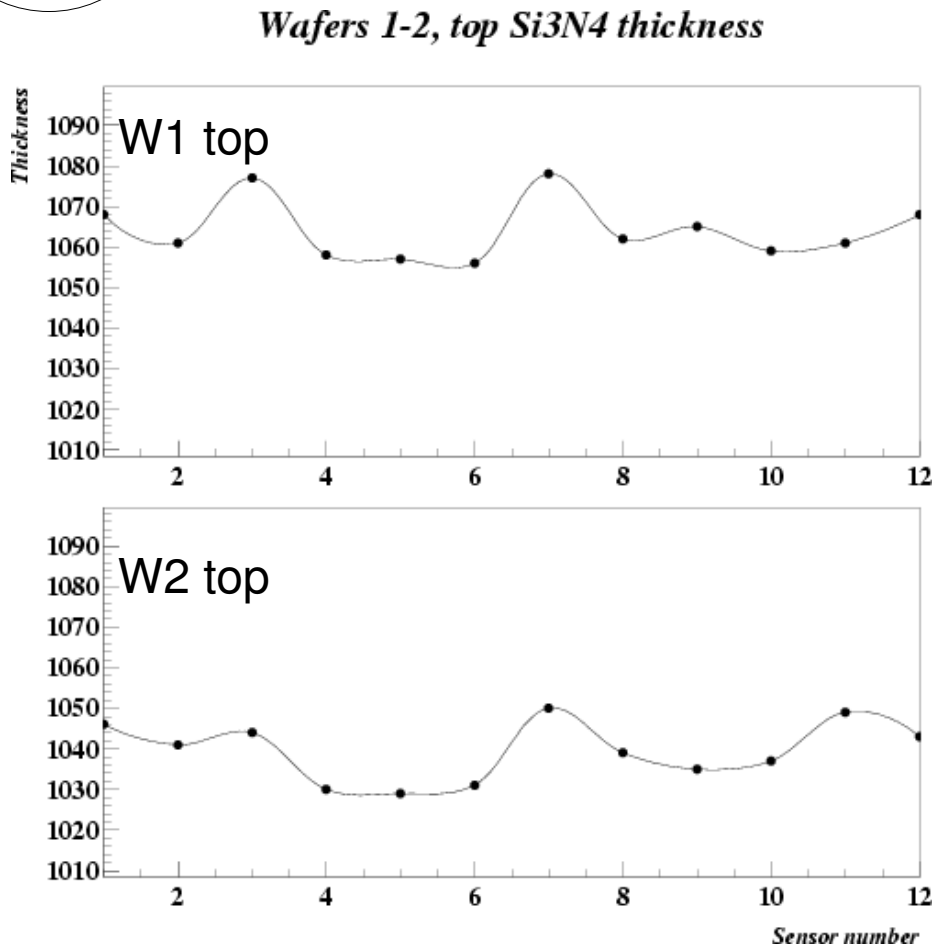
top: 1-4<1%, wafers 5,6 <2% bottom: 1-4<2% wafers 5=3%

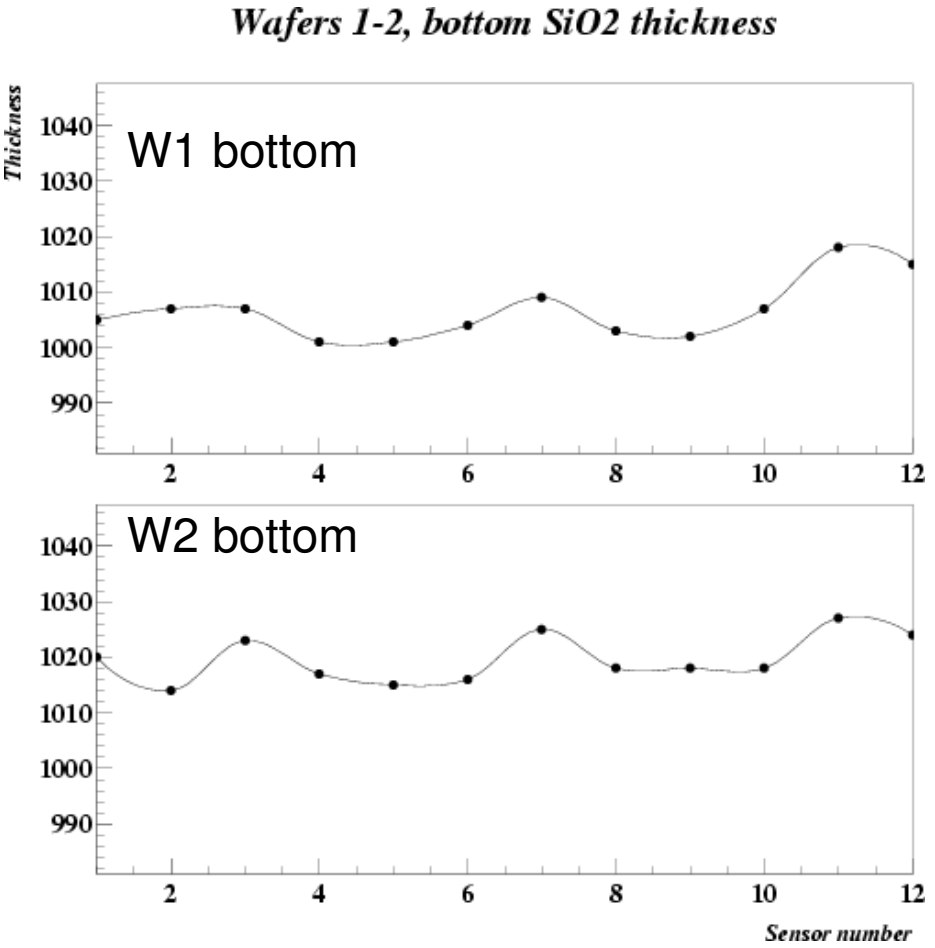
Thickness oscillations of wafer #5 are wider, both top and bottom thickness

Measurements compatible with thicker wafers in the middle, decreasing towards the border: mountain-like profile



Top and bottom Si3N4





Spread < 2%

Measured Gate and Field Oxide

Wafer	Gate Oxide [nm]	Field Oxide [nm]
1	49.5 ± 1.2	1002.7 ± 1.4
2	43.8 ± 1.3	996.5 ± 1.1
3	49.2 ± 1.0	1002.5 ± 1.5
4	49.0 ± 0.7	1002.6 ± 0.4
5	49.0 ± 1.1	1001.3 ± 1.2
6	51.5 ± 0.9	1001.8 ± 0.9

5 measurements/wafer

Measured Aluminum thickness

Wafer	Aluminum [nm]
1	940 ± 37
2	995 ± 42
3	929 ± 39
4	971 ± 36
5	965 ± 46
6	961 ± 41

5 measurements/wafer