Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG

11th AGIPD Consortium Meeting

Sensor Acceptance and Quality Control

(for the first delivery of the AGIPD sensors)

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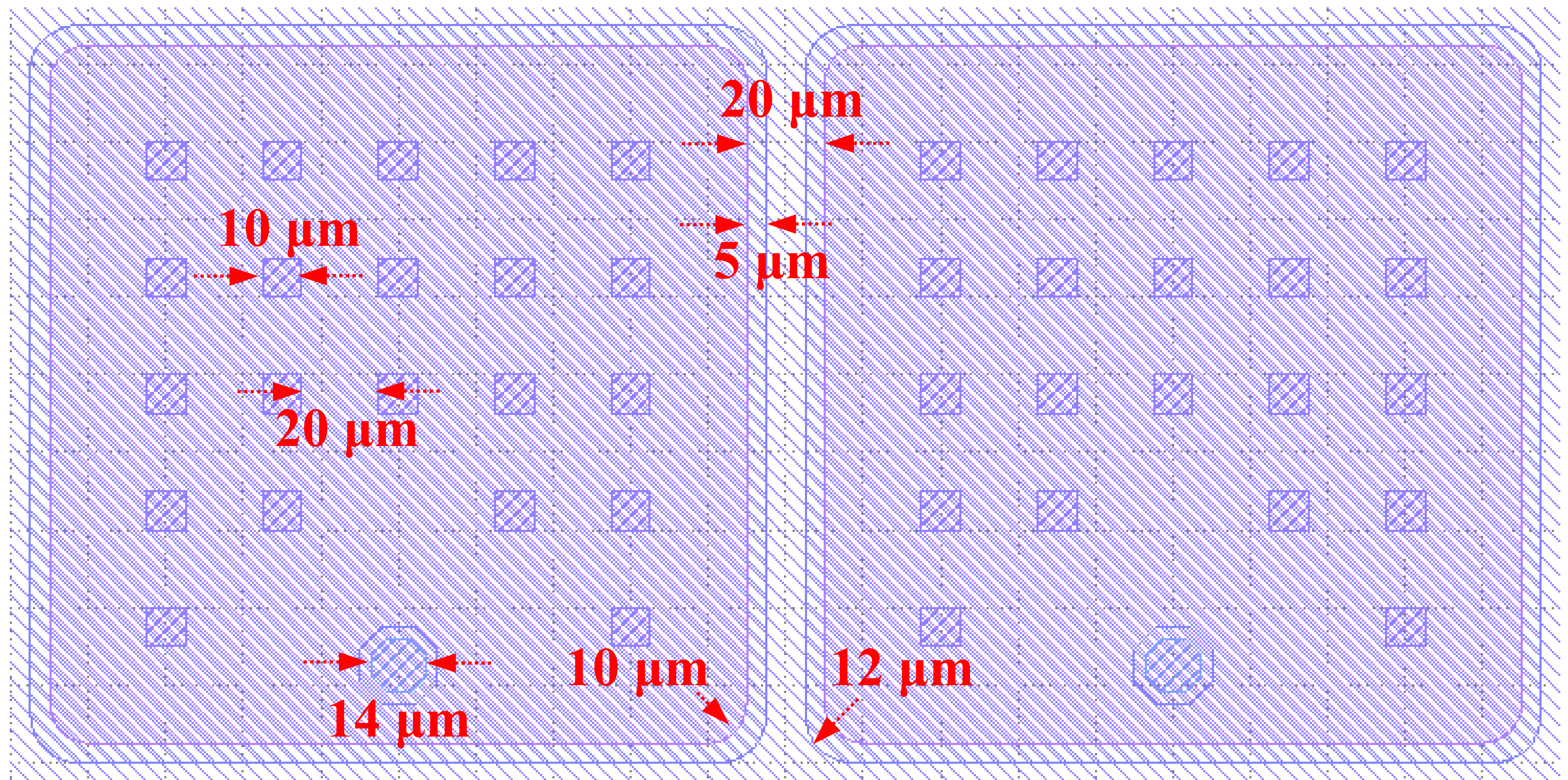
Outline

- Final layout of the AGIPD sensor → changes since April 2012
- The AGIPD wafer → what we have on the wafer
- Acceptance of AGIPD sensors
  - Wafer 1
  - Wafer 2-18
- Measurements for 1st delivery
- Summary

Sensor layout: Pixel

Pixel layout:

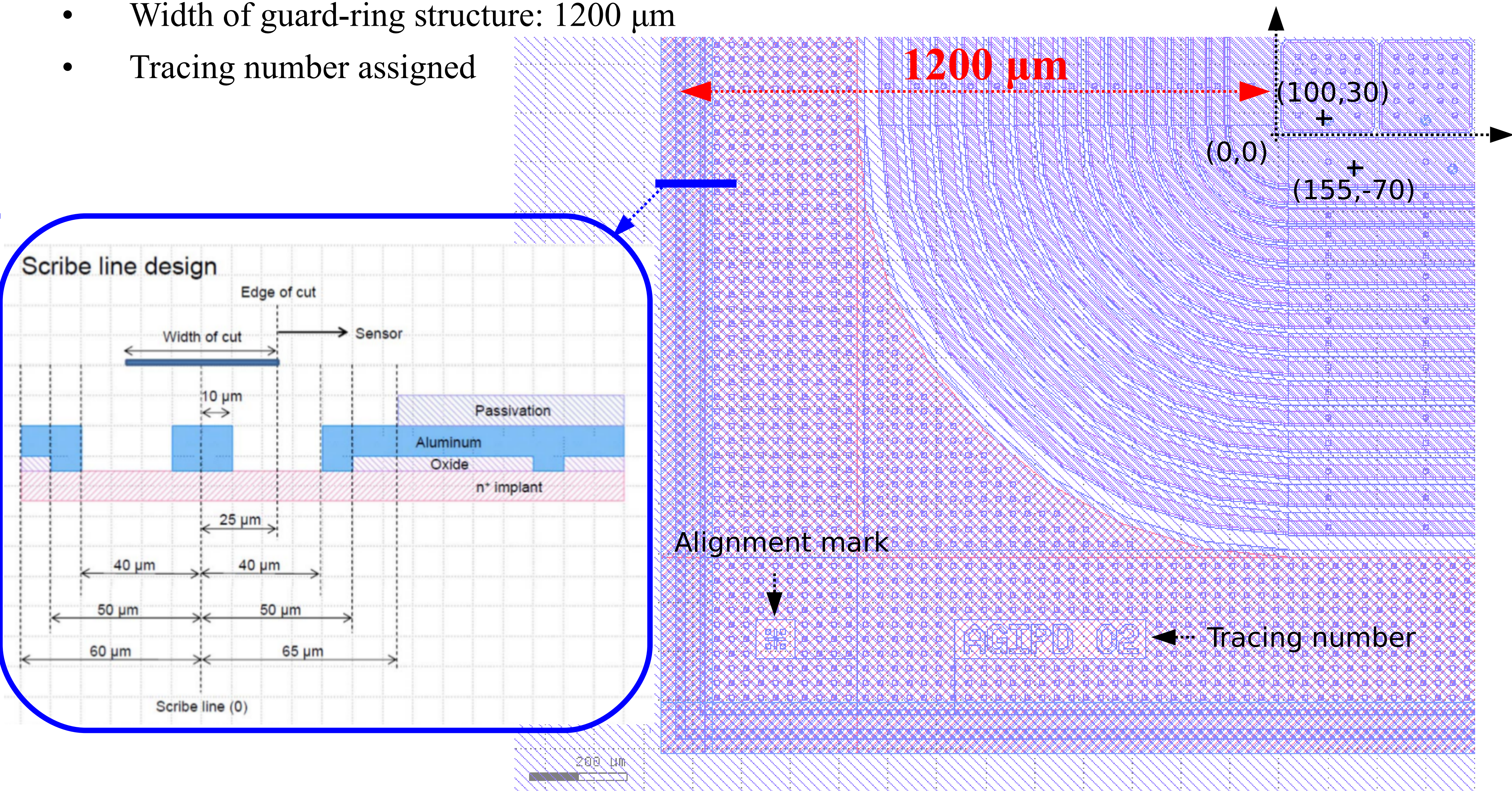
- Gap between implants: 20 μm
- Square vias: 10 μm with 20 μm spacing
- Radius of p^+ corner: 10 μm
- Metal overhang: 5 μm
- Octagon pspad (opening): 14 μm
- Radius of Al corner: 12 μm



Sensor layout: Guard ring

Guard-ring layout:

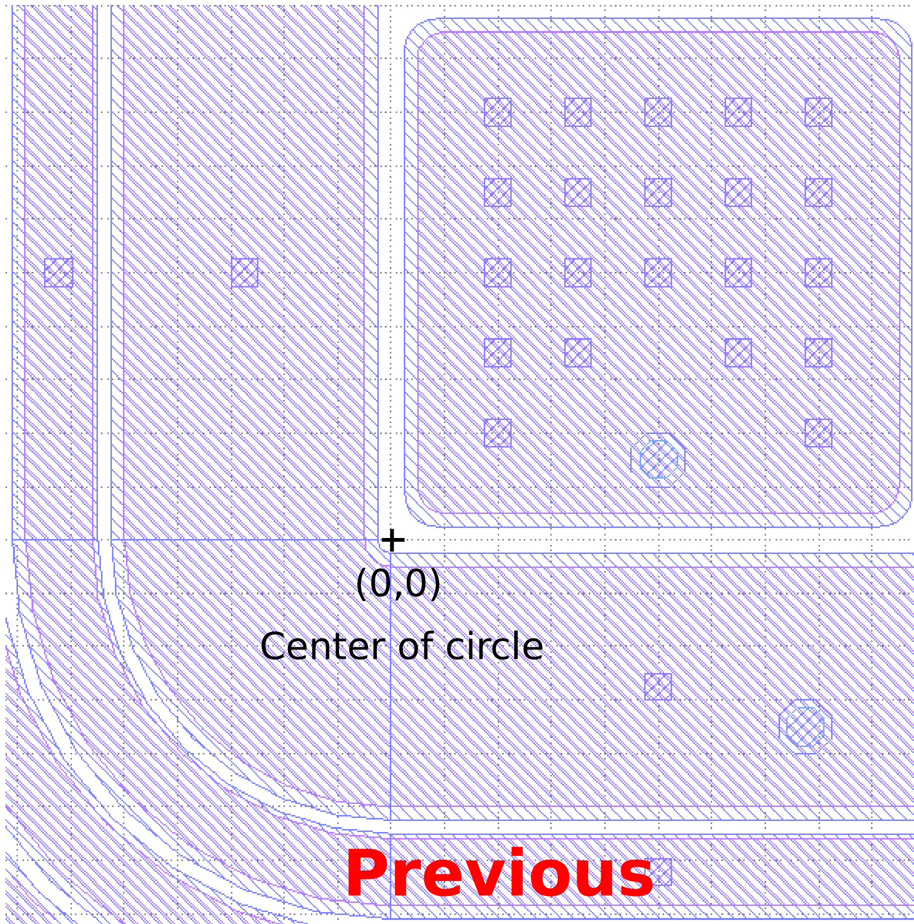
- Width of guard-ring structure: 1200 µm
- Tracing number assigned

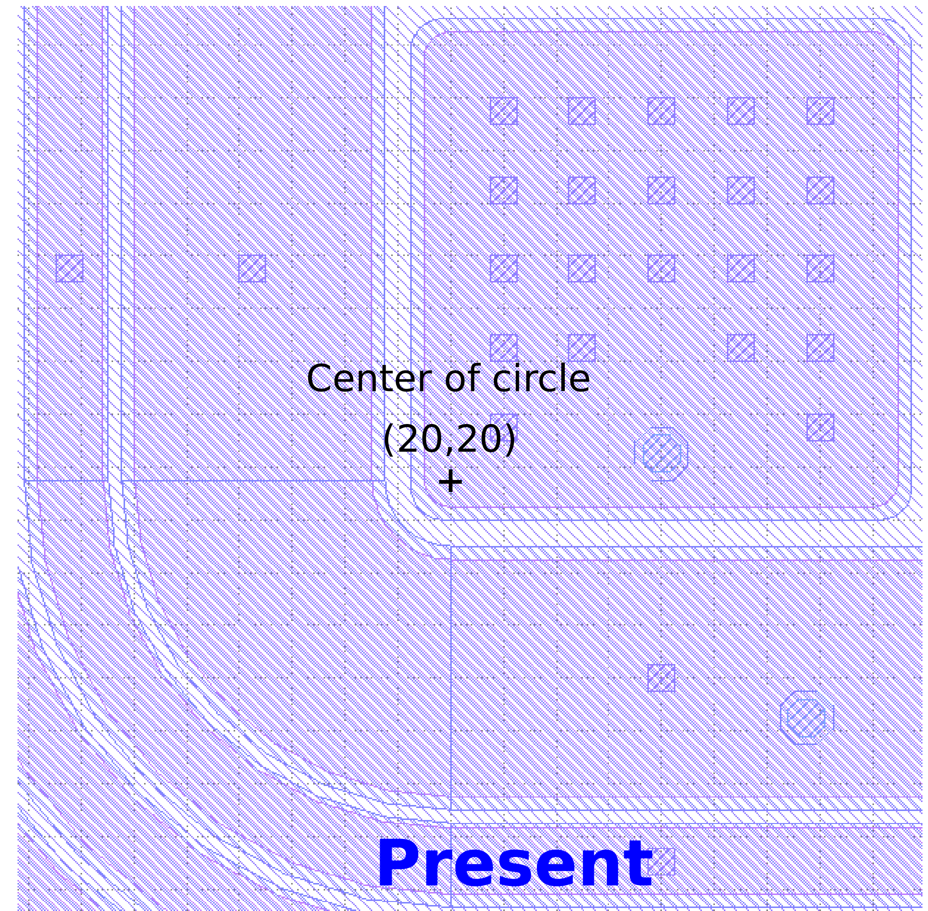


Sensor layout: Guard ring

Change of guard-ring layout since April 2012:

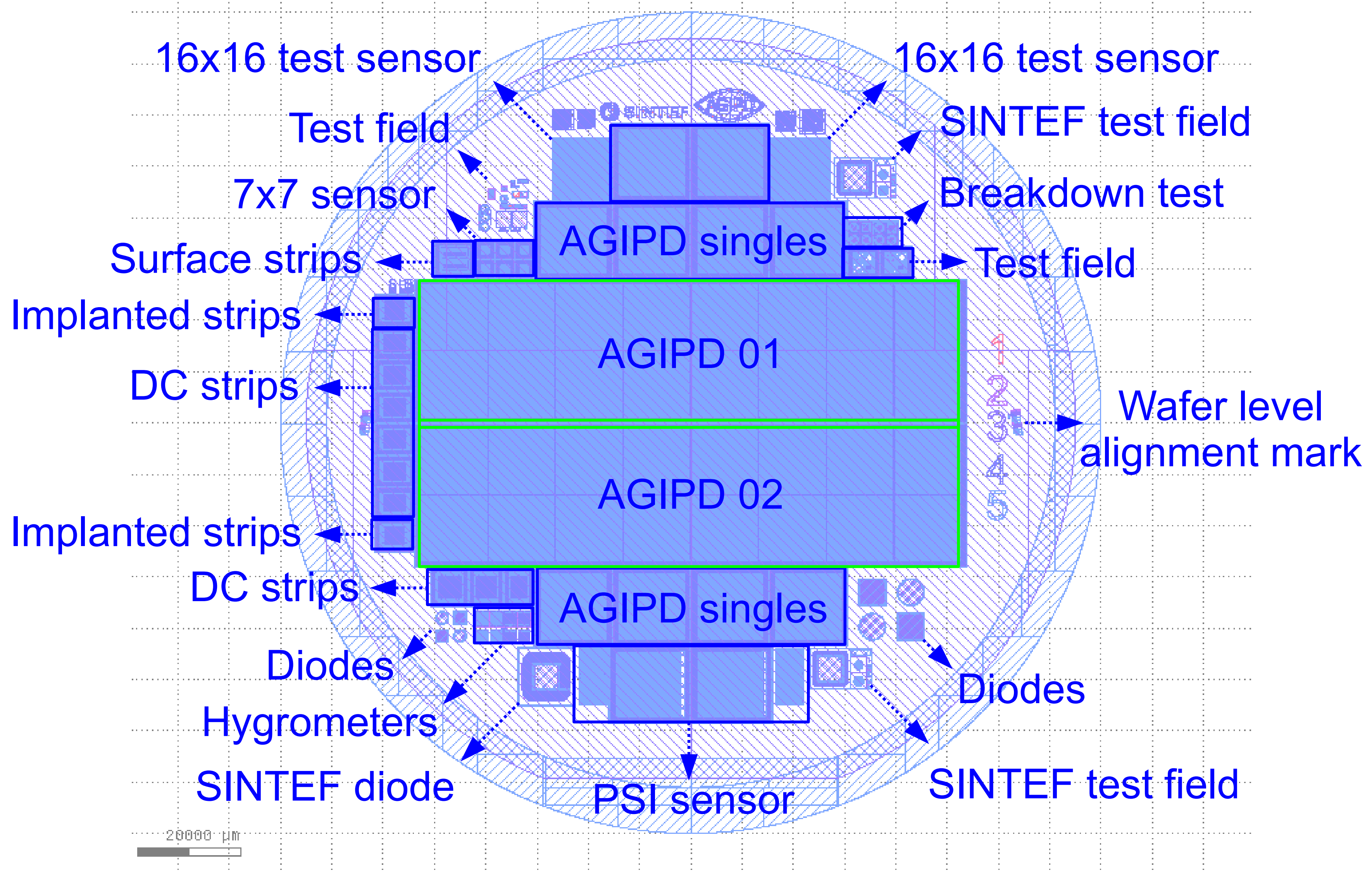
- Center of the circus of guard rings: (0, 0) → (20, 20)





Layout of the AGIPD wafer

AGIPD wafer layout:



Delivery and technology agreed

Delivery of AGIPD sensors by SINTEF:

- Wafers to be delivered: 18 (36 sensors in total)
- Expected date of delivery: end of January, 2013

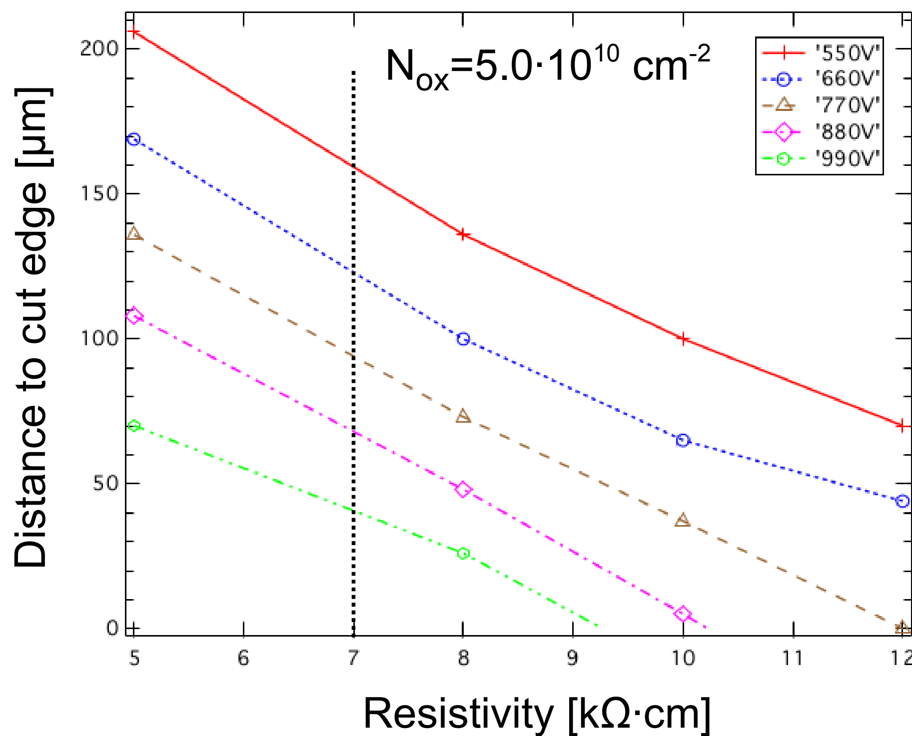
Technology agreed:

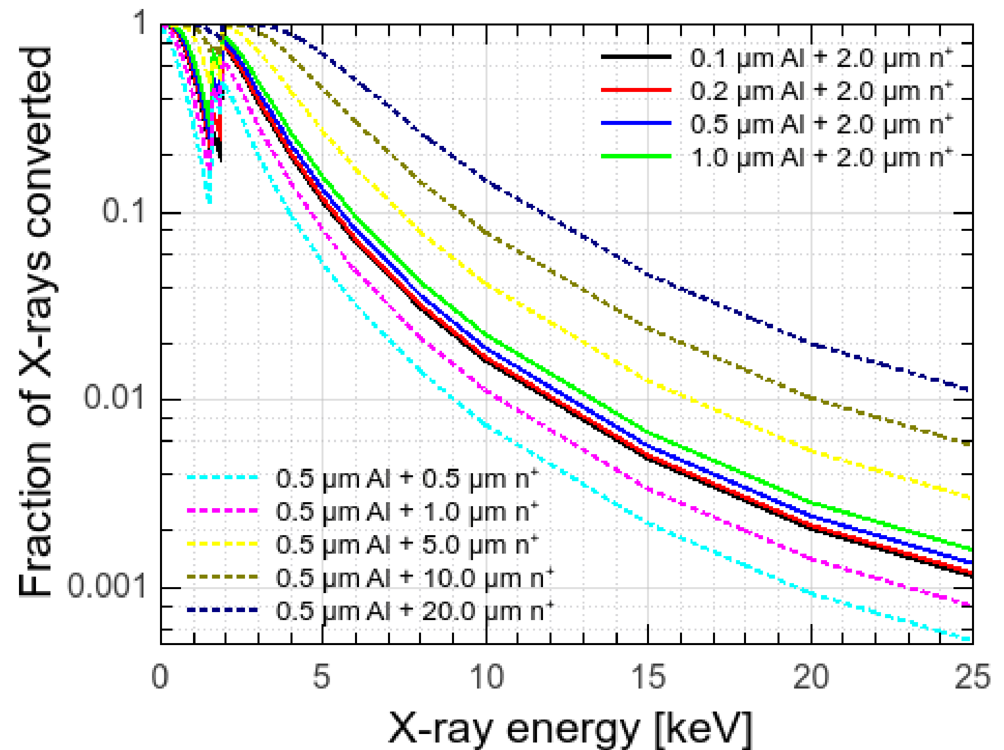
- Wafer thickness: 500 μm
- Depth of p^+ implant: 2.4 μm
- Thickness of SiO_2: 250 nm
- Thickness of passivation layer: 500 nm SiO_2 + 250 nm SiN PECVD
- Thickness of aluminium (p^+-side): 1.2 μm
- Bulk resistivity: 7 kΩ·cm ($6.3 \cdot 10^{11}$ cm^{-3})
- Depth of n^+ implant: 2.0 μm
- Thickness of aluminum (n^+-side): 0.5 μm

Effects of resistivity and entrance window

The effects of resistivity and entrance window of sensors produced by SINTEF:

- Bulk resistivity: depletion region not touching cut-edge for 7 kΩ·cm up to 990 V (J. Schwandt)
- Entrance windows: ~ 1.2 % of 12 keV X-rays converted in (0.5 μm Al + 2.0 μm n^+ implant)





Acceptance tasks

First delivery of sensors from SINTEF: 36 AGIPD sensors in total → 18 wafers

- **Wafer 1** → cut and fully measure in Hamburg
  - Before cutting: (1) Visual inspection of the full wafer
    (2) Mechanical thickness measurement (~ 20 min)
    (3) Flatness measurement (~ 30 min)

Structure	Dose	Measurement	Time needed [min]		
			Setup	Meas	Analy
7x7 interconnected sensor	0 Gy	I-V, [0 V, 500 V]	20	90	40
		C-V, [0 V, 500 V]	20	60	30
	100 MGy (half sensor)	I-V, [0 V, 500 V]	20	90	40
		C-V, [0 V, 500 V]	20	60	30
AGIPD 1	0 Gy (before cutting)	I-V, [0 V, 500 V]	20	60	20
	0 Gy (after cutting)		20	60	20
AGIPD 2	0 Gy (before cutting)	I-V, [0 V, 500 V]	20	60	20
	0 Gy (after cutting)		20	60	20
			= 160	= 540	= 220

16 hours

Acceptance tasks

First delivery of sensors from SINTEF: 36 AGIPD sensors in total → 18 wafers

- **Wafer 2-18** → measure in Hamburg without cutting → deliver to PSI for cutting and bonding
  - Flatness measurement on each wafer (~ 30 min/wafer)

Measurements of electrical properties for each wafer

Structure	Measurement	Time needed [min]		
		Setup	Meas	Analy
7x7 interconnected sensor	I-V, [0 V, 500 V]	20	90	40
AGIPD 1	I-V, [0 V, 500 V]	20	60	20
AGIPD 2	I-V, [0 V, 500 V]	20	60	20
		= 60	= 210	= 80

Total consumed time for all wafers = (30+60+210+80) min/wafer x 17 wafers = **108 hours**

Detailed measurements

First delivery of sensors from SINTEF: 36 AGIPD sensors in total → 18 wafers

- Wafer 1 → quality-control run

Structure	Measurement	Extracted parameters	Time needed [min]		
			Setup	Meas	Analy
Diode	C-V, [0 V, 250 V]	N_{eff}, ρ, V_{dep}, T_{dep}	20	30	30
	I-V, [0 V, 250 V]	I_{bulk}	20	30	20
7x7 inter-connected sensor	I-V, [0 V, 1000 V]	I_{pixel}, I_{CCR}, V_{bd}	20	120	40
	C-V, [0 V, 250 V]	V_{dep}	20	30	30
7x7 sensor (pixels connected in rings)	C_{int}-V, [0 V, 500 V]	C_{int}	30	60	30
	I_{int}-V, [0 V, 50 V]	V_{int}^{bt}	30	10	30
MOS capacitor	C/G-V, [-10 V, 5 V]	T_{ox}, N_{ox}	20	15	60
	TDRC	N_{it}	30	720	60
GCD	I-V [-30 V, 5 V]	J_{surf}	20	15	40
8 “Hygrometers”	I-t transient	$\rho_{surface}$	8x20	8x60	8x30
p^+ implanted strips	I-V, [-5 V, 5 V]	$\rho_{p\text{-}implant}$	3x20	3x10	3x10

Detailed measurements

First delivery of sensors from SINTEF: 36 AGIPD sensors in total → 18 wafers

- **Wafer 1** → quality-control run

Structure	Measurement	Extracted parameters	Time needed [min]		
			Setup	Meas	Analy
n^+ implanted strips	I-V, [-5 V, 5 V]	$\rho_{n\text{-implant}}$	3x20	3x10	3x10
Al strips	I-V, [-5 V, 5 V]	ρ_{Al}	3x20	3x10	3x10
			= 550	=1600	= 670

47 hours

* The time consuming measurements are for DC-coupled strip sensors, which are not indicated.

- Planned irradiation doses: **0 Gy, 100 kGy, 10 MGy, 1 GGy**

"Minimum" time needed for characterization of electrical properties:

47 hours x 4 doses = 188 hours

Summary

AGIPD sensor:

- Layout of AGIPD sensors and test structures designed
- Layout of AGIPD wafer completed
- Ready for mask production by SINTEF

Sensor acceptance:

- Plans made for 1st delivery of AGIPD sensors:
  - 1 wafer to be cut and fully measured in Hamburg
  - 17 wafer to be test in Hamburg → deliver to PSI for cutting and bonding
- Quality-control run for the wafer kept in Hamburg

Topics to be discussed/decided:

- Who makes measurements and analysis?
- Where to irradiate sensors?
- How to store results of measurements? → AGIPD database?

  Present sensor indico page:

  https://indico.desy.de/conferenceDisplay.py?confId=6464

Backup

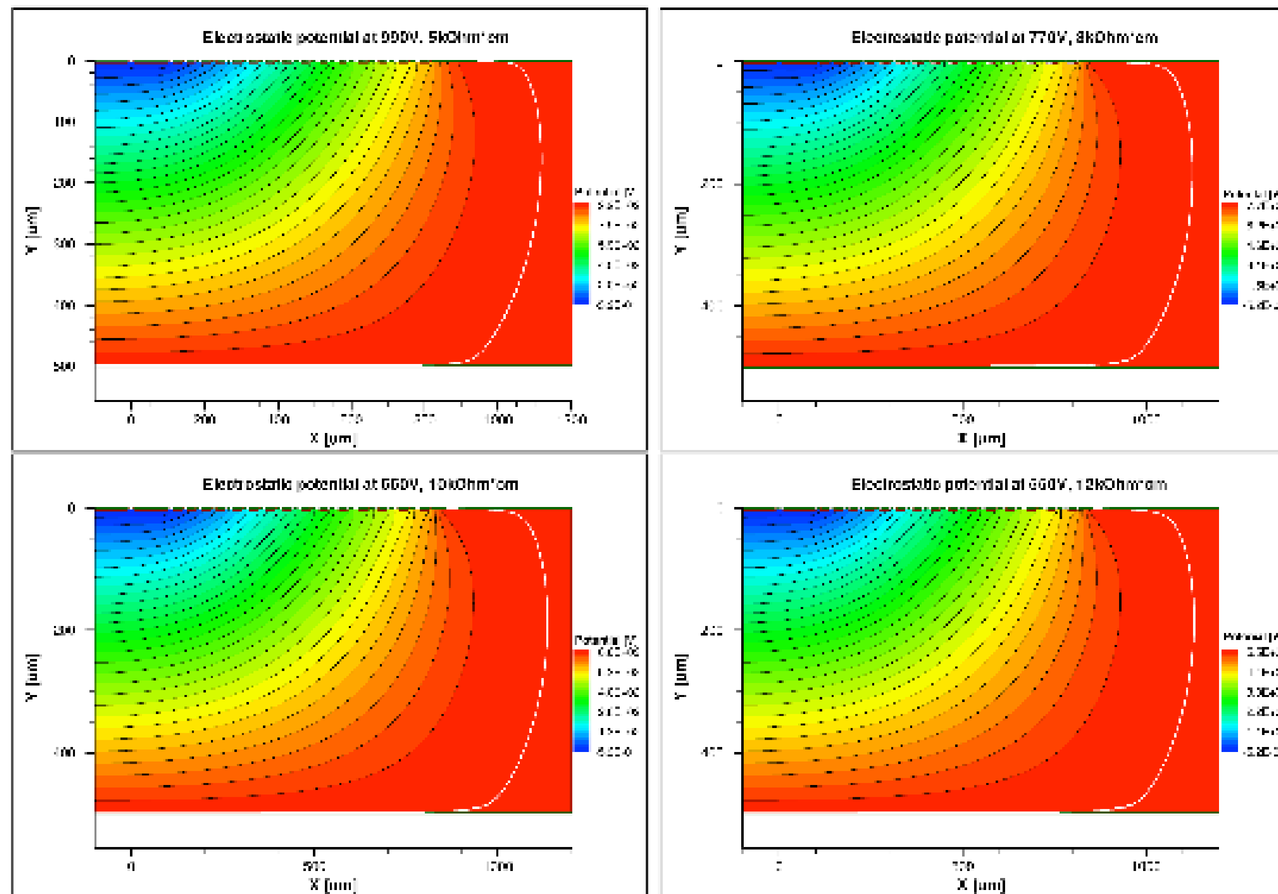


Figure 1: Electrostatic potential for an oxide charge of $N_{ox} = 5 \times 10^{10}$ cm^{-2} and resistivity of 5, 8, 10 and 12 kΩ·cm and voltages 990, 770, 660 and 550 V. The white lines indicate the depletion boundaries.

Backup

	3 kΩ·cm		5 kΩ·cm		8 kΩ·cm		12 kΩ·cm	
N_{ox} [cm^{-2}]	2D (x,y)	2D (r,z)	2D (x,y)	2D (r,z)	2D (x,y)	2D (r,z)	2D (x,y)	2D (r,z)
1×10^{12}	> 1100 V	1060 V	> 1100 V	> 1100 V	> 1100 V	> 1100 V	980 V	> 1100 V
2×10^{12}	1000 V	830 V	1080 V	910 V	950 V	950 V	870 V	980 V
3×10^{12}	1010 V	840 V	> 1100 V	910 V	1000 V	960 V	915 V	985 V

Table 1: Breakdown voltage as function of the oxide charge and bulk resistivity for irradiated sensors