Sensor Design and Test Structures

onto the Medipix3 wafer

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Outline

Sensors:

- 64 x 64 single chip sensors
- 16 x 16 test sensors

Test structures

- Expected technology parameters
- List of test structures and information obtained to determine technological parameters and basic sensors' properties

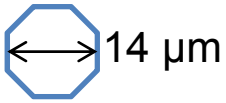
Positioning of sensors and test structures

Open questions for final AGIPD sensor

Sensors: 64 x 64 single chip sensors

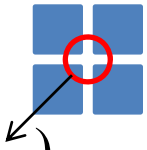
General geometry parameters of single chip sensors:

- Pitch: 200 µm
- Metal overhang: 8 µm
- Vias: 5 µm x 5 µm, with 25 µm spacing
- Bump bonding pad: octagon with 14 µm distance across flats



- 4 sensors were designed with different parameters:

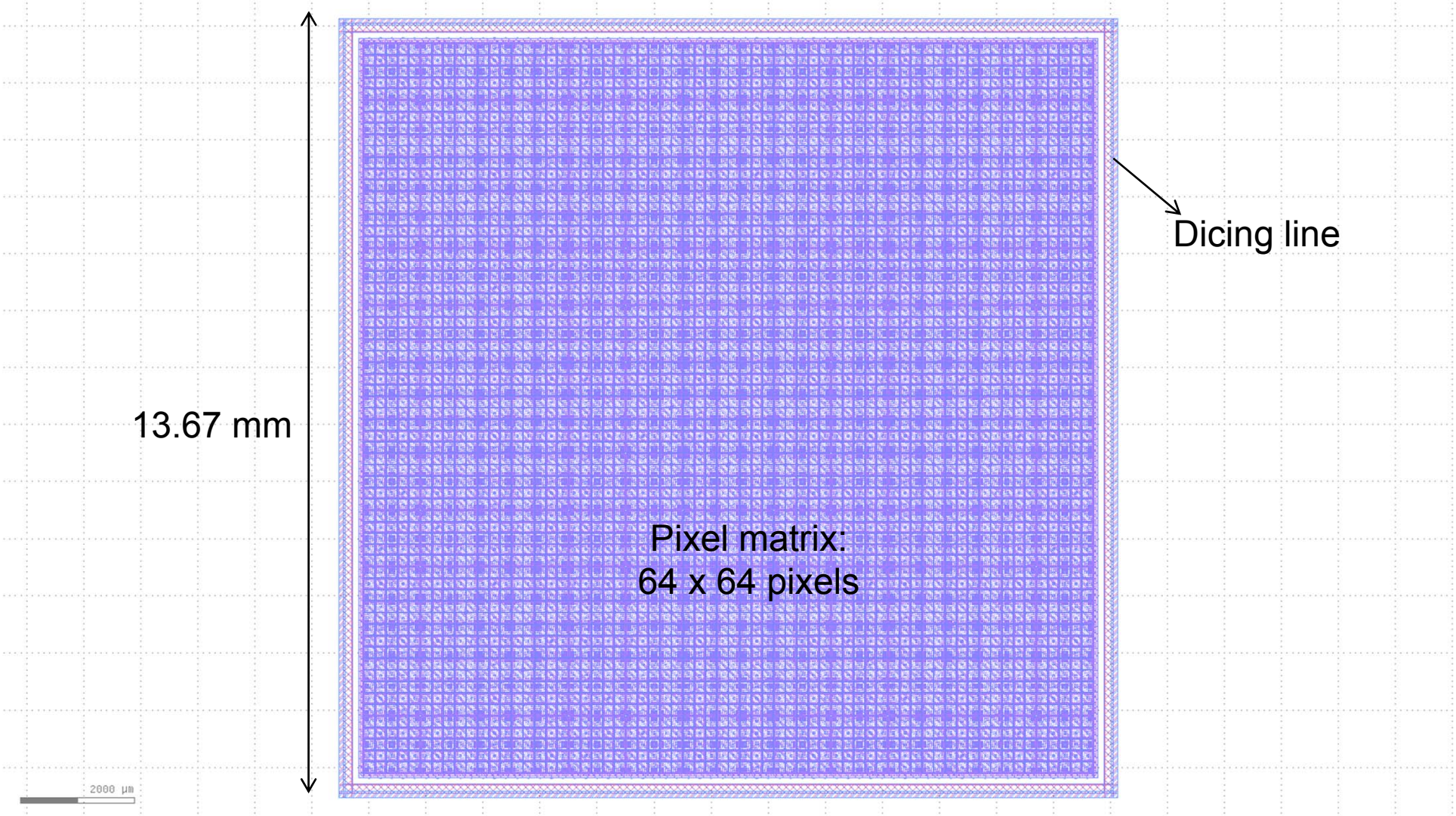
Sensor label	Gap	Radius of pixel's corner
1	30 µm	5 µm
2	30 µm	45 µm
3	50 µm	5 µm
4	50 µm	45 µm



- Aims for: effects on inter-pixel region (electric field, accumulation…)

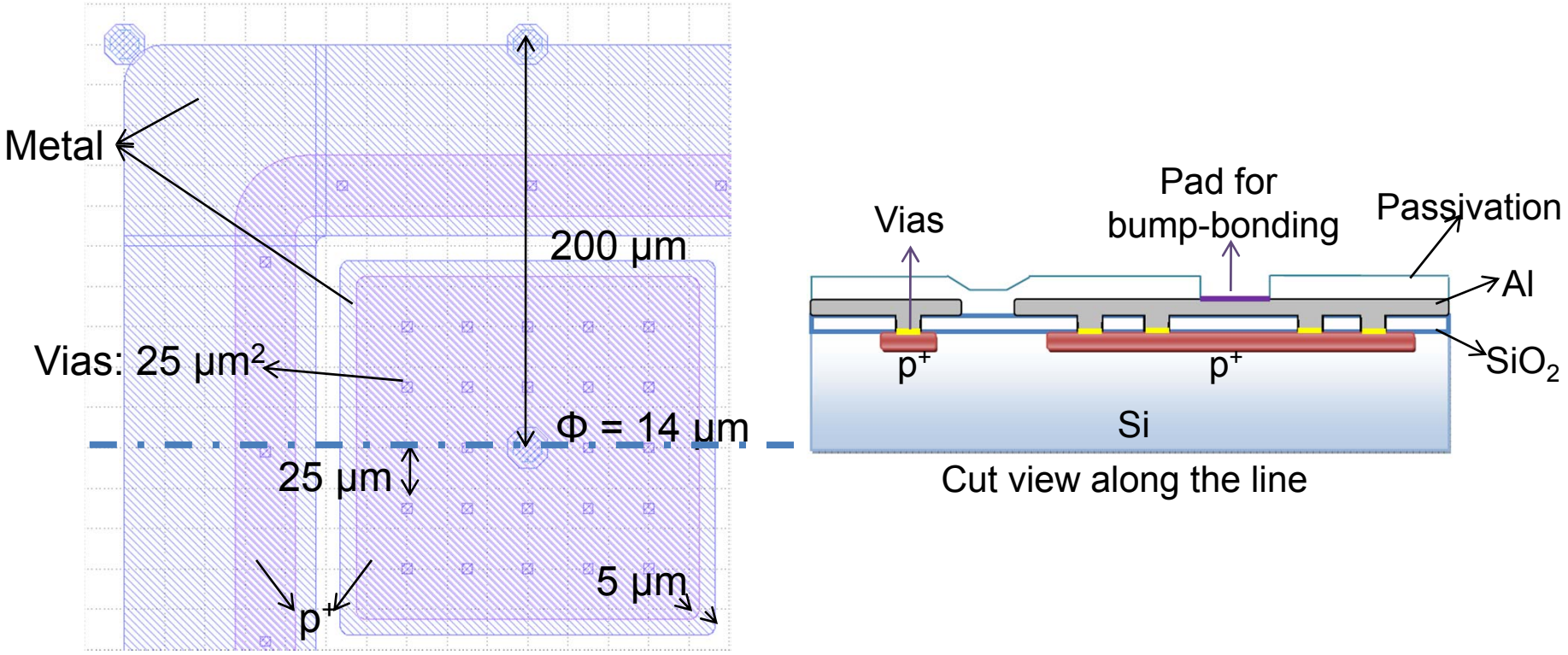
Sensors: 64 x 64 single chip sensors

Complete layout (x 4):



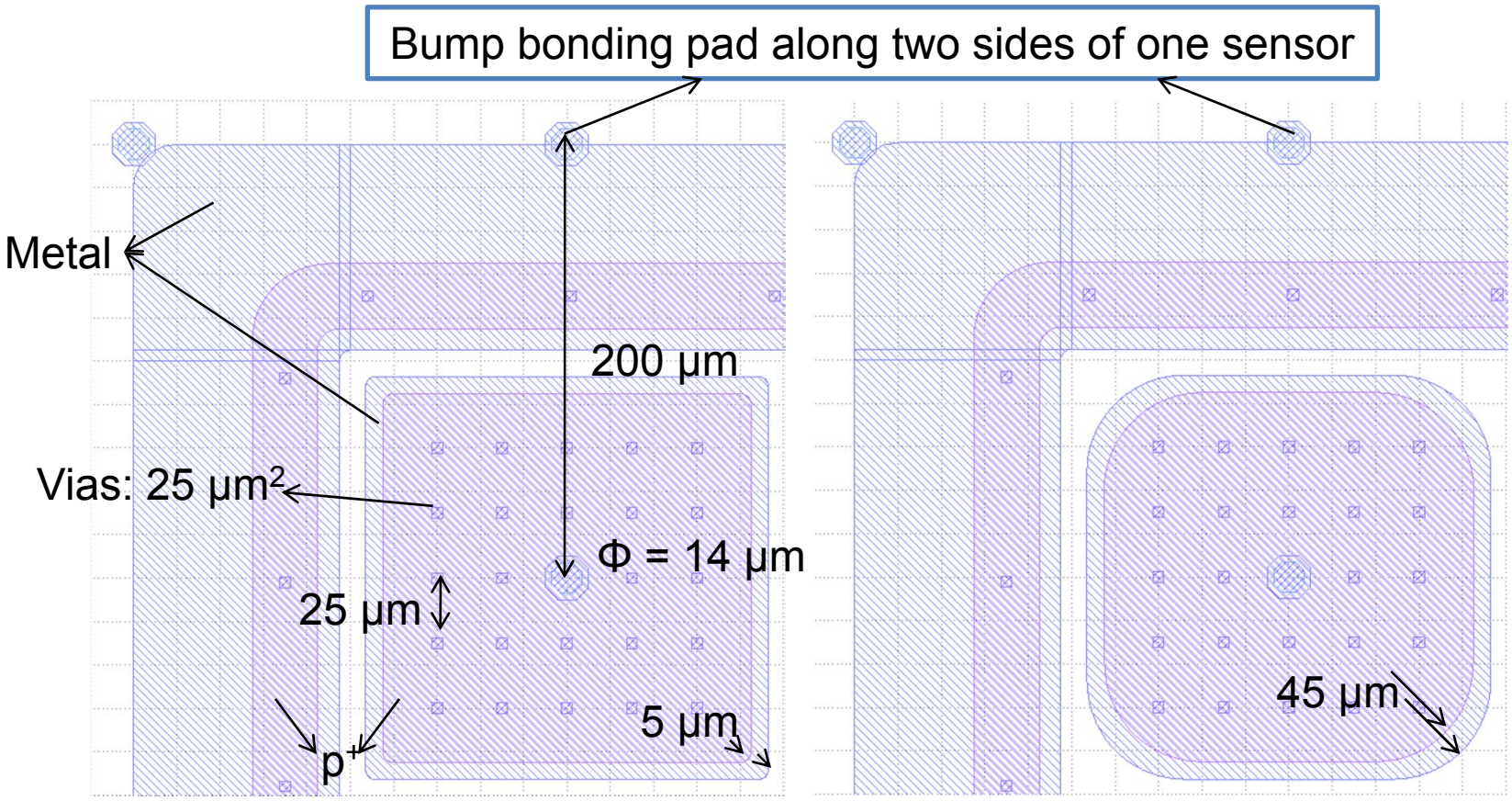
Sensors: 64 x 64 single chip sensors

Masks of individual pixels of the four different sensors:



Sensors: 64 x 64 single chip sensors

Masks of individual pixels of the four different sensors:

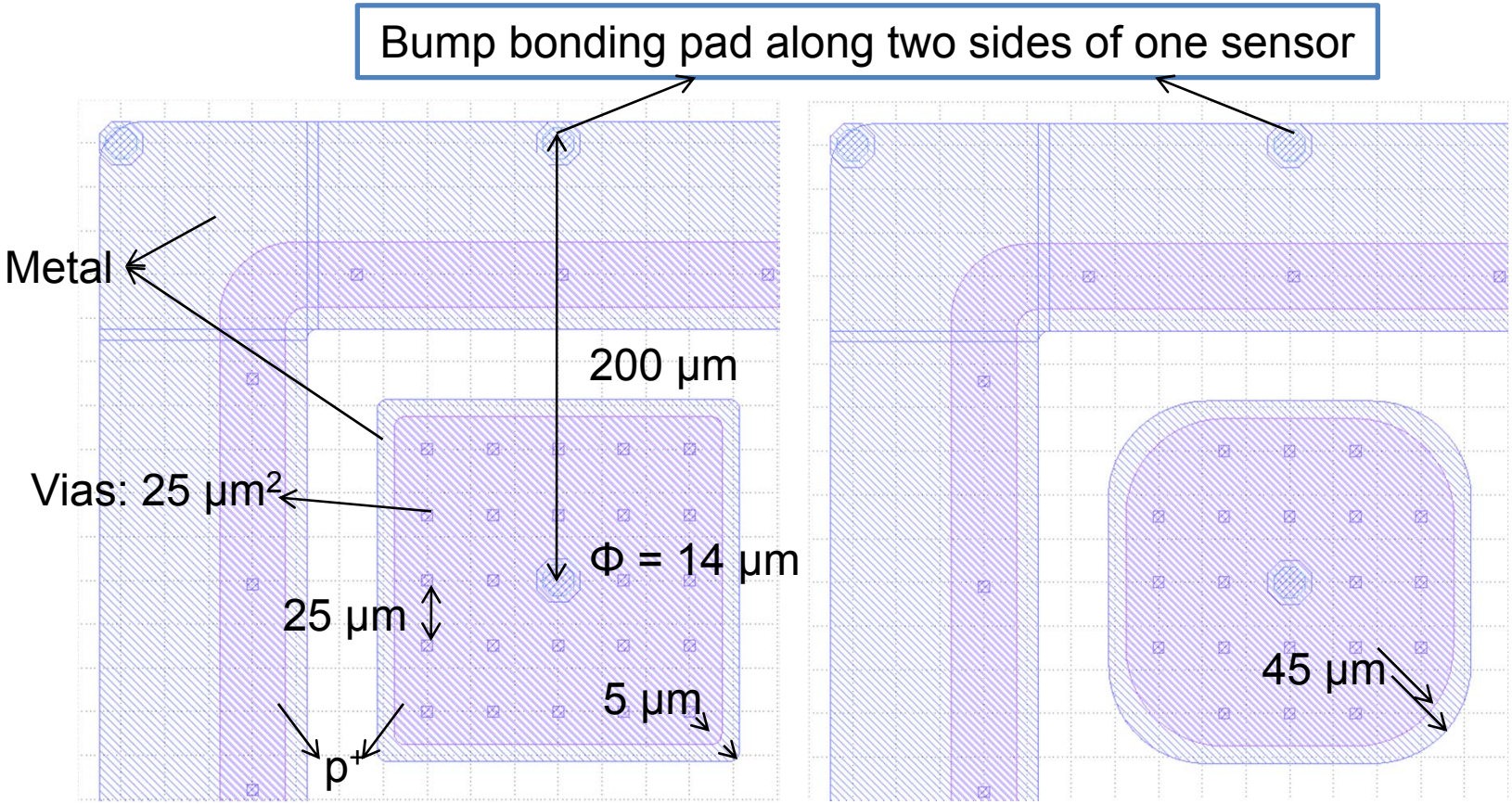


Gap: 30 µm
Radius: 5 µm

Gap: 30 µm
Radius: 45 µm

Sensors: 64 x 64 single chip sensors

Masks of individual pixels of the four different sensors:



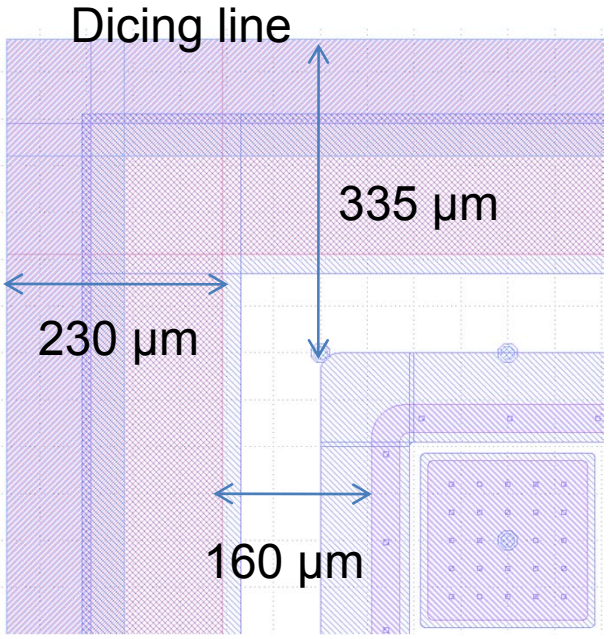
Gap: 50 μm
Radius: 5 μm

Gap: 50 μm
Radius: 45 μm

Sensors: 64 x 64 single chip sensors

As a short summary:

- Matrix of bump-bonding pads:
  64 x 64 + 2 x 66 (200 µm spacing)
- Last bump-bonding pad to dicing line: 335 µm
- Whole area of sensors: 13.67 mm x 13.67 mm



- Available single chips to fit the sensors?
- Any potential fitting problem? (size OK?)
- If using standard Canberra guard ring design and dicing line, what is the maximum size of the sensor we can have in order to fit the sensor with chip without any problems?

Sensors: 16 x 16 test sensors

General geometry parameters of test sensors:

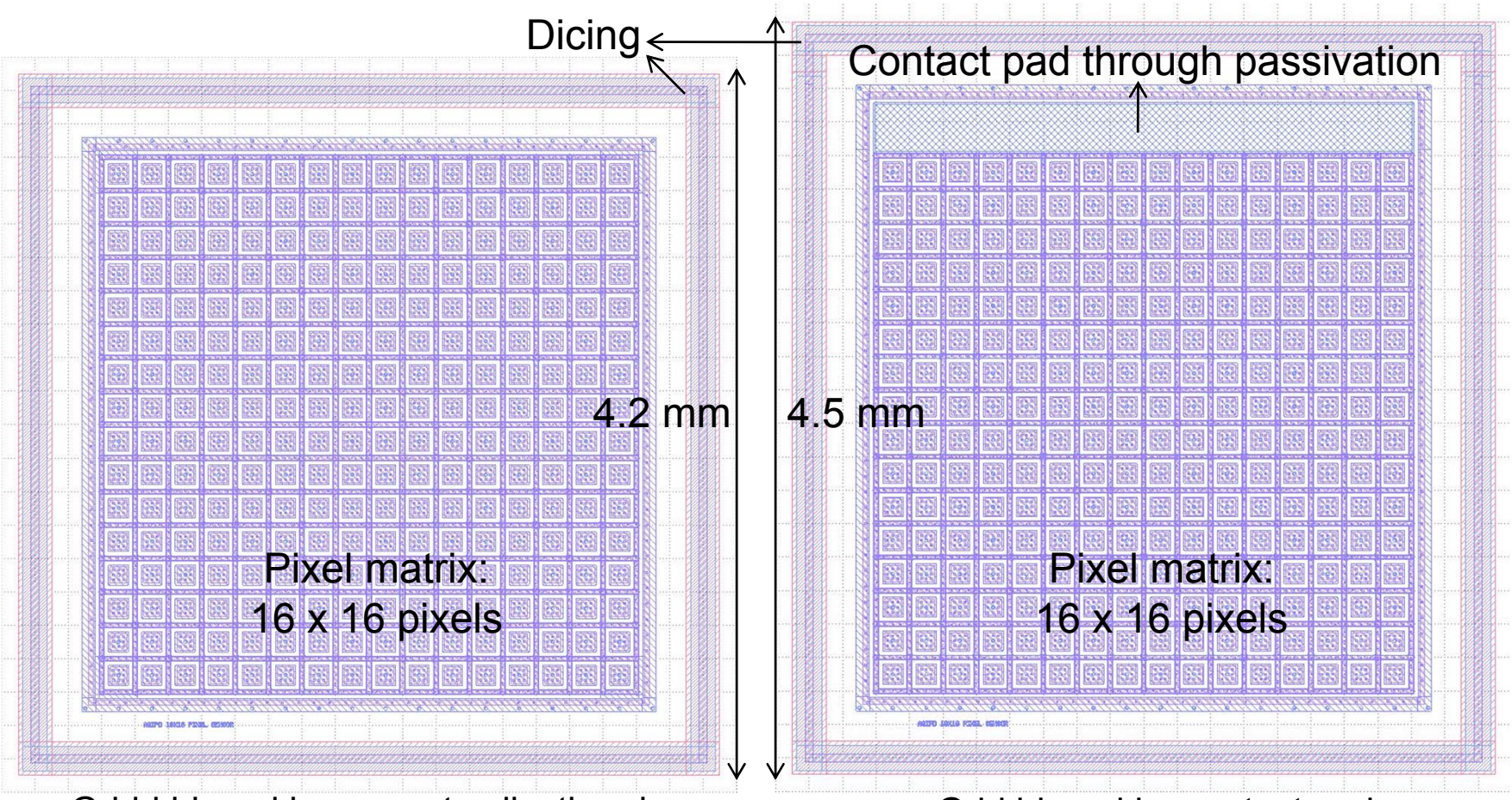
- Pitch: 200 μm
- Bump bonding pad: octagon with 14 μm distance across flats
- 2 sensors were designed with different grids:

Sensor label	Grid biasing
1	by current collection ring
2	by contact pad through passivation

- Vias: 10 μm x 10 μm with 20 μm spacing for pixel;
  5 μm x 5 μm with 45 μm spacing for biased grid
- Width of p^+ implantation: 100 μm for pixel; 20 μm for grid
- Metal overhang: 10 μm for pixel; 5 μm for grid

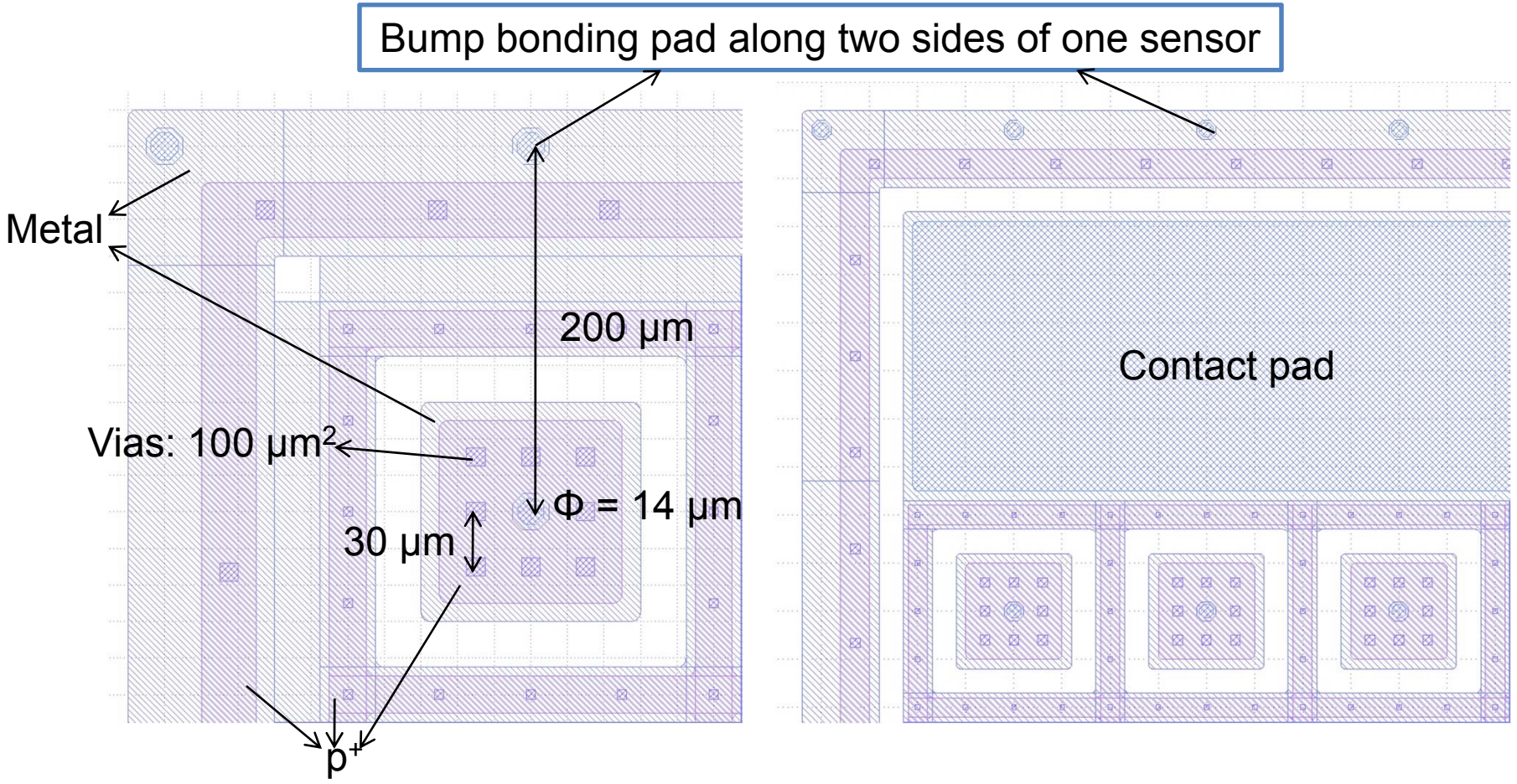
Sensors: 16 x 16 test sensors

Complete layouts of the 16 x 16 test sensors:



Sensors: 16 x 16 test sensors

Masks of individual pixels of the two different sensors:



Test structures: parameters to be determined

Parameters from Canberra technology to be determined:

- Resistivity of metallization
- Resistivity of p^+ implantation
- Depth and vertical profile of p^+ implantation*
- Horizontal profile of p^+ implantation*
- Thickness and dielectric constant of SiO_2 + Si_3N_4 layer (N_{ox}, N_{it} vs. dose)
- Resistivity of isolation/passivation surface
- Breakdown voltage
- Depth and vertical profile of n^+ implantation*
- Surface recombination velocity
- Resistivity of silicon bulk
- Crystal orientation of silicon bulk*
- Concentration and vertical profile of doping in silicon bulk
- Si-SiO_2 surface mobility
- Life time of carriers in Si bulk
- Traps in Si bulk
- Property of surface passivation

Test structures: list of test structures

List of test structures and information obtained:

Name of test structures	Variables	Information obtained
(AC-coupled) strip sensor	Width of p^+ and Al: 5 µm, 10 µm, 20 µm, 50 µm, 100 µm, 200 µm	Resistivity of p^+ and Al
Al strip	Gap of strips: 50 µm, 100 µm, 200 µm	Resistivity of SiO_2/Si_3N_4 and passivation surface
MOS capacitor	-	Thickness and dielectric constant of isolation layer, surface charge density, etc.
Pad diode	Circular/square	Doping concentration, vertical profile, guard ring breakdown voltage, etc.
GCD	Circular/square	Surface recombination velocity, surface current
PMOSFET	-	Surface mobility of minority free carriers

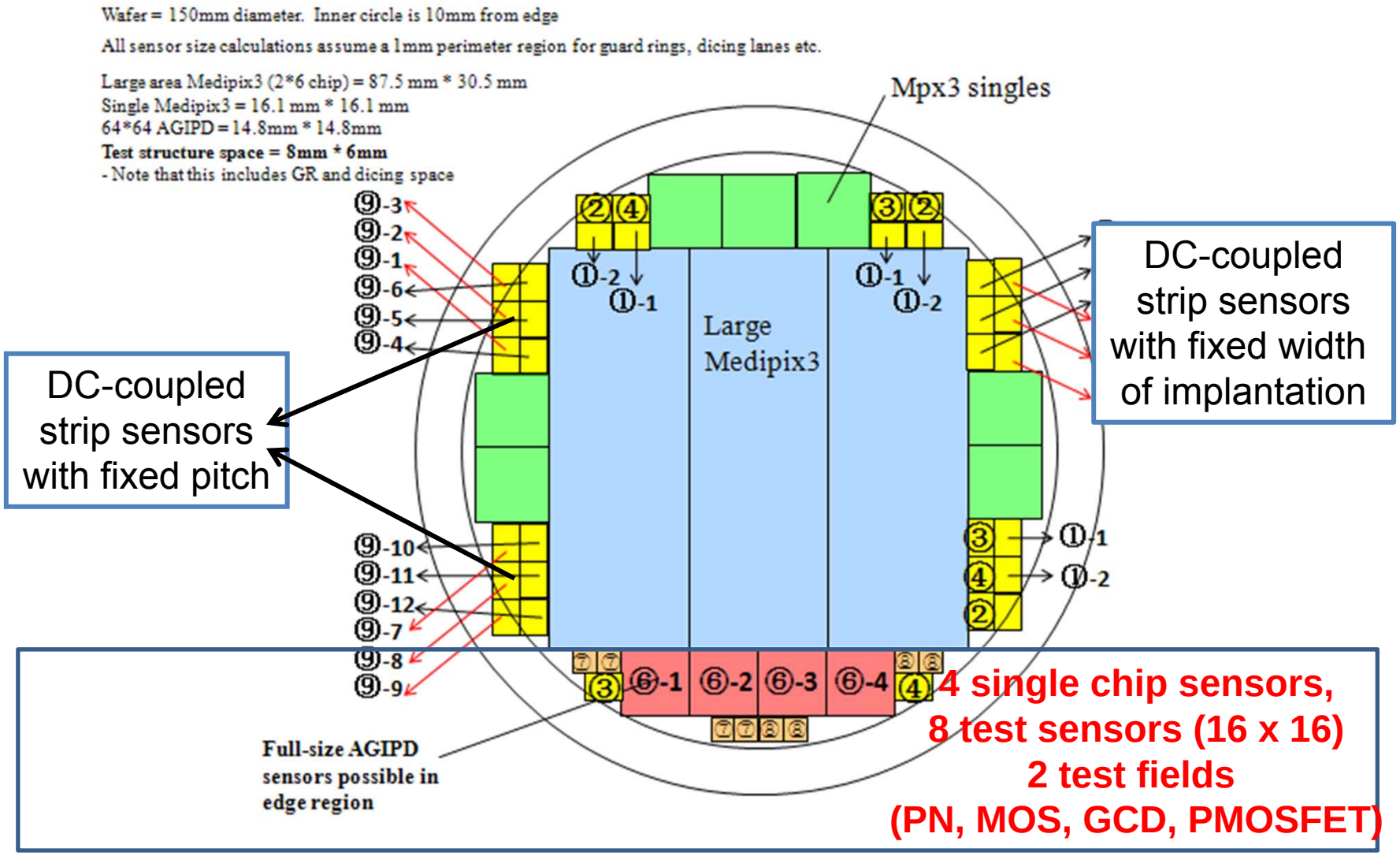
Test structures: list of test structures

List of test structures and information obtained:

Name of test structures	Variables	Information obtained
(DC-coupled) strip sensor with 48 µm fixed width of implantation*	Gaps: 20 µm, 40 µm, 60 µm, 120 µm; Overhang: 0 µm, 2.5 µm, 5 µm, 10 µm; Al cutoff/not;	Sensors' performance with X-ray irradiations
(DC-coupled) strip sensor with 200 µm fixed pitch*	Gaps: 20 µm, 40 µm, 60 µm, 120 µm; Overhang: 0 µm, 2.5 µm, 5 µm, 10 µm; Al cutoff/not;	Optimization of sensor design with different parameters from experiments

* In total 71 gds files were generated for the test structures; 60 were designed for the DC-coupled strip sensors, which we plan to use in experiments and compared with simulations for the optimization of sensor design.

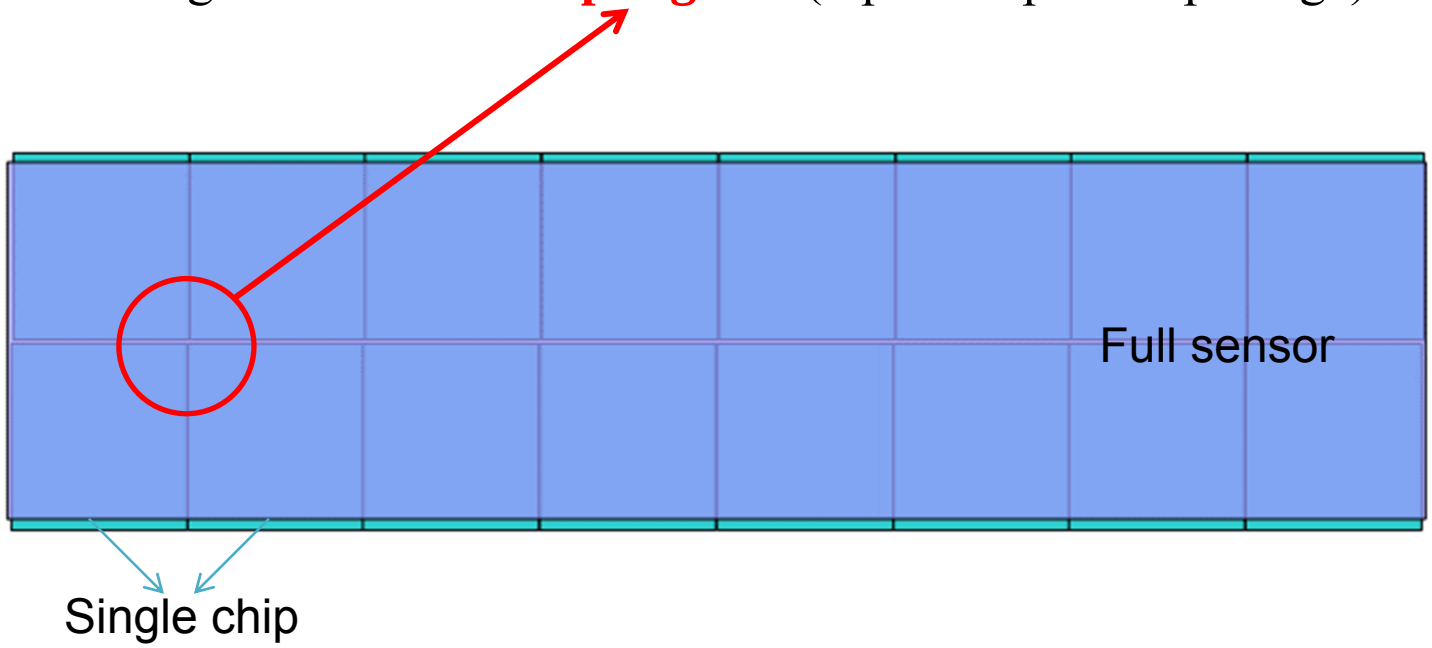
Positioning of sensors and test structures



Open questions

Questions for final AGIPD sensor:

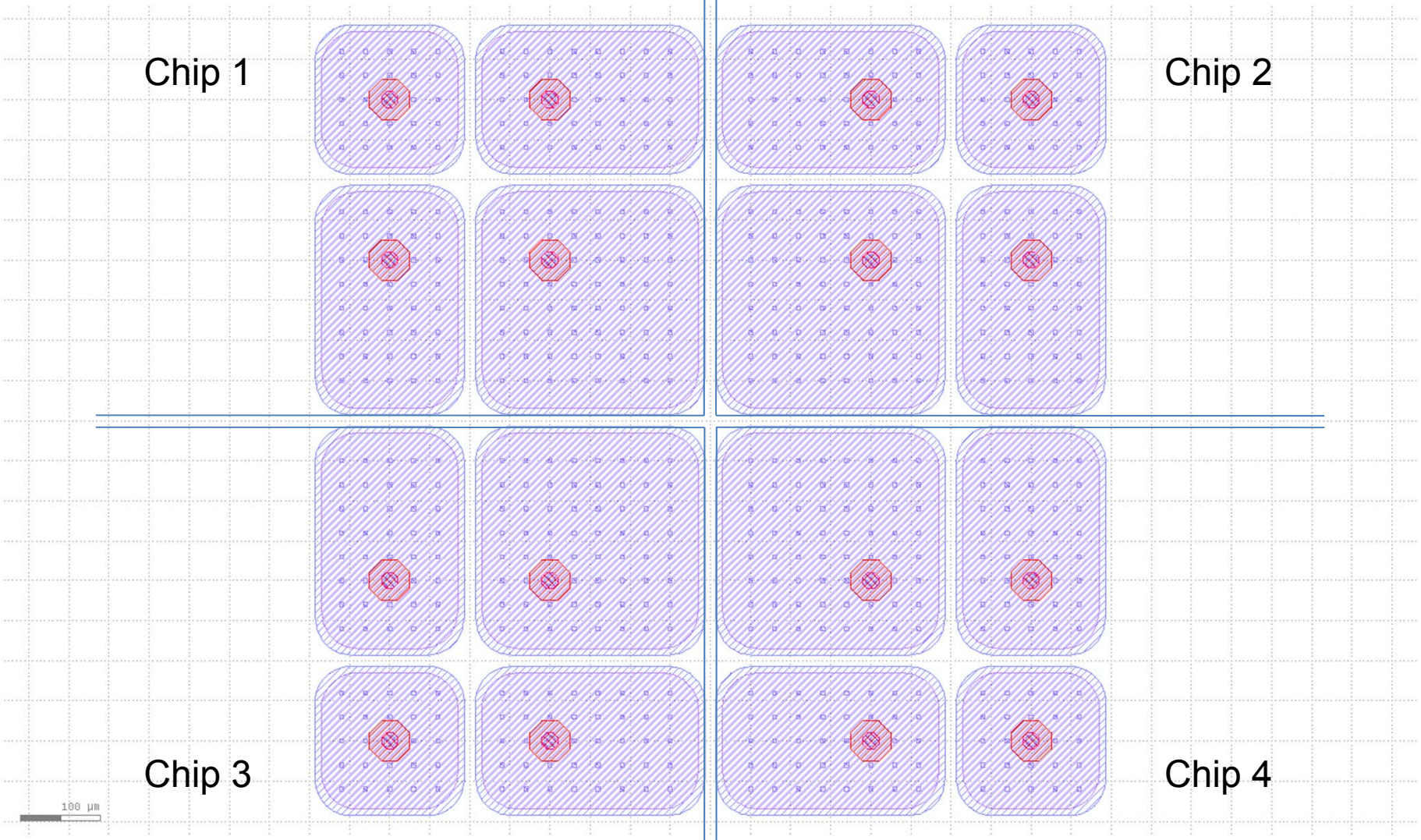
- Pixel design in the **inter-chip region**? (1 pixel/2 pixels spacing?)



- Biasing scheme of current collection ring: bump-bonding?
- How to arrange the bumps on the ring? (one bump or array of bumps?)
- Open contact pad through passivation layer on the current collection ring needed? (like Pilatus sensor)

Open questions

Pixel design for inter-chip region (1 pixel spacing assumed):



Summary

Thank you!

and a lot of contribution from my colleagues!