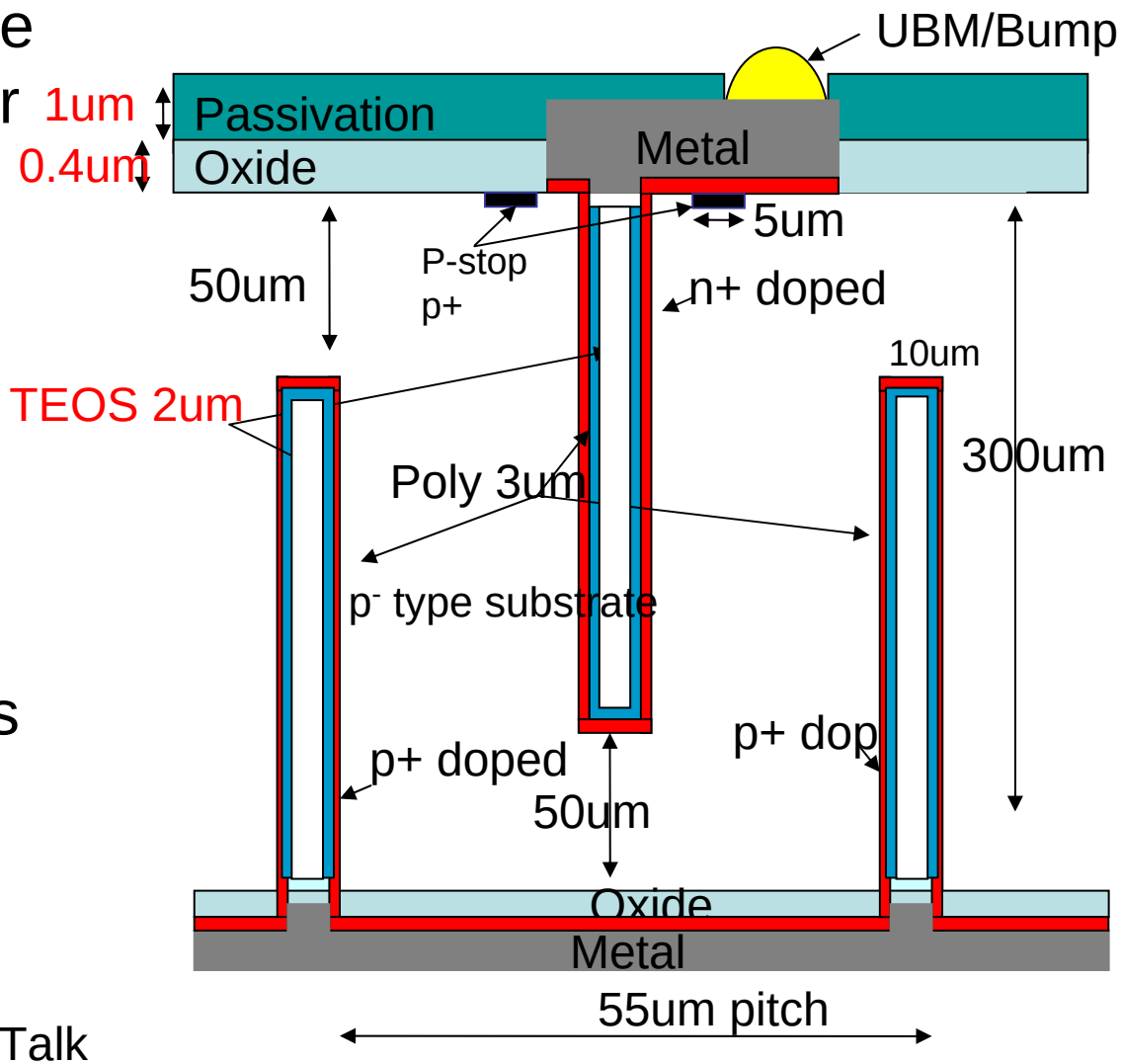
New Mask and vendor for 3D detectors

R. Bates, G. Pellegrini et al. at Glasgow and CNM

- Introduction
  - 3D geometry
- Mask design
  - Details of items on the mask
- Fabrication at CNM
- ICEMOS Tech
- Bump bonding

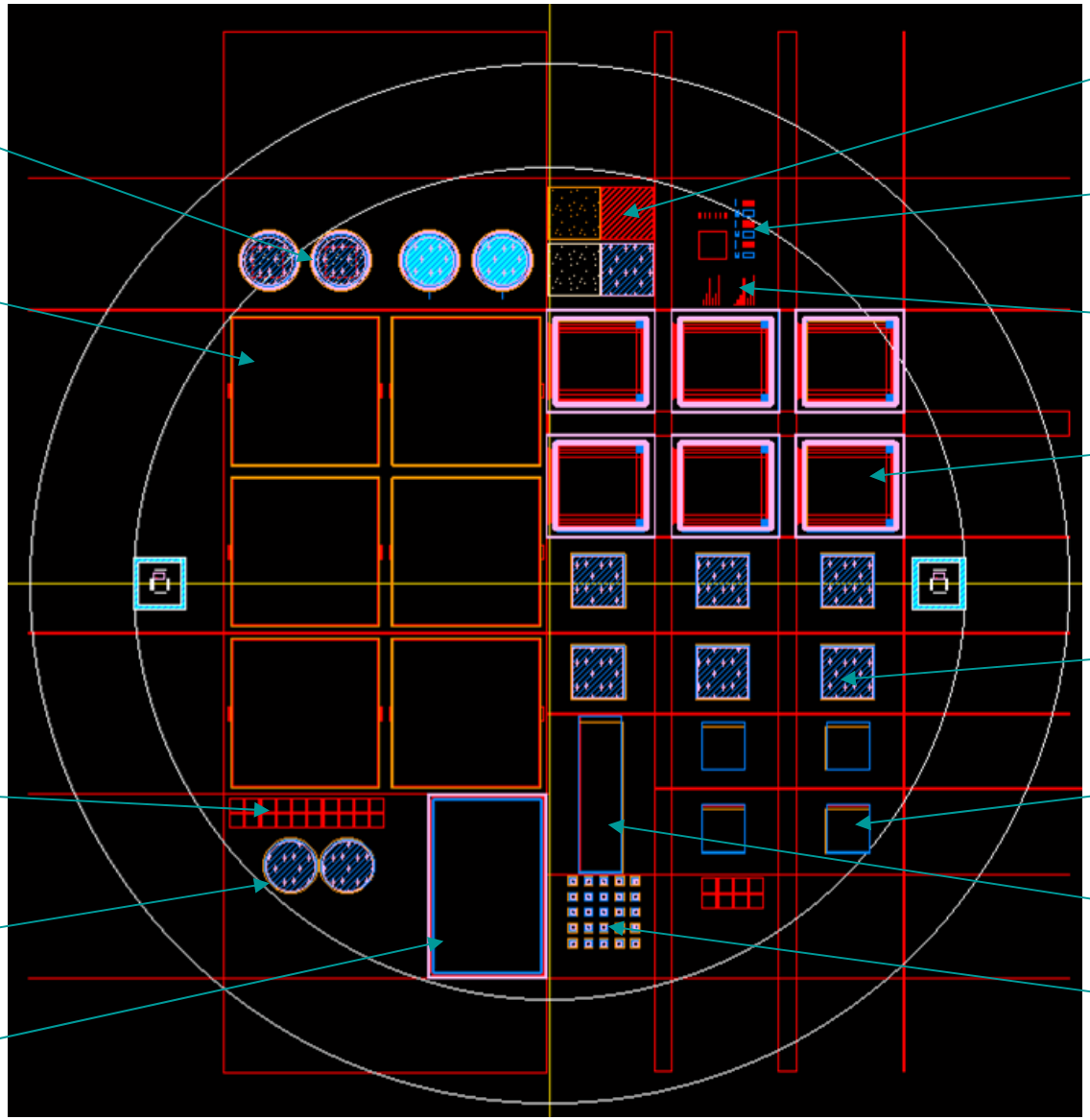
Introduction

- CNM and Glasgow have designed a mask set for 3D detector fabrication
  - Mask ordered in past weeks
- Funded by RD50 Common fund
  - Request will arrive for 2kCHF from signatures
- Aim to fabricate devices at CNM with n- and p-type wafers



E-field and CCE simulated at Glasgow – Next Talk

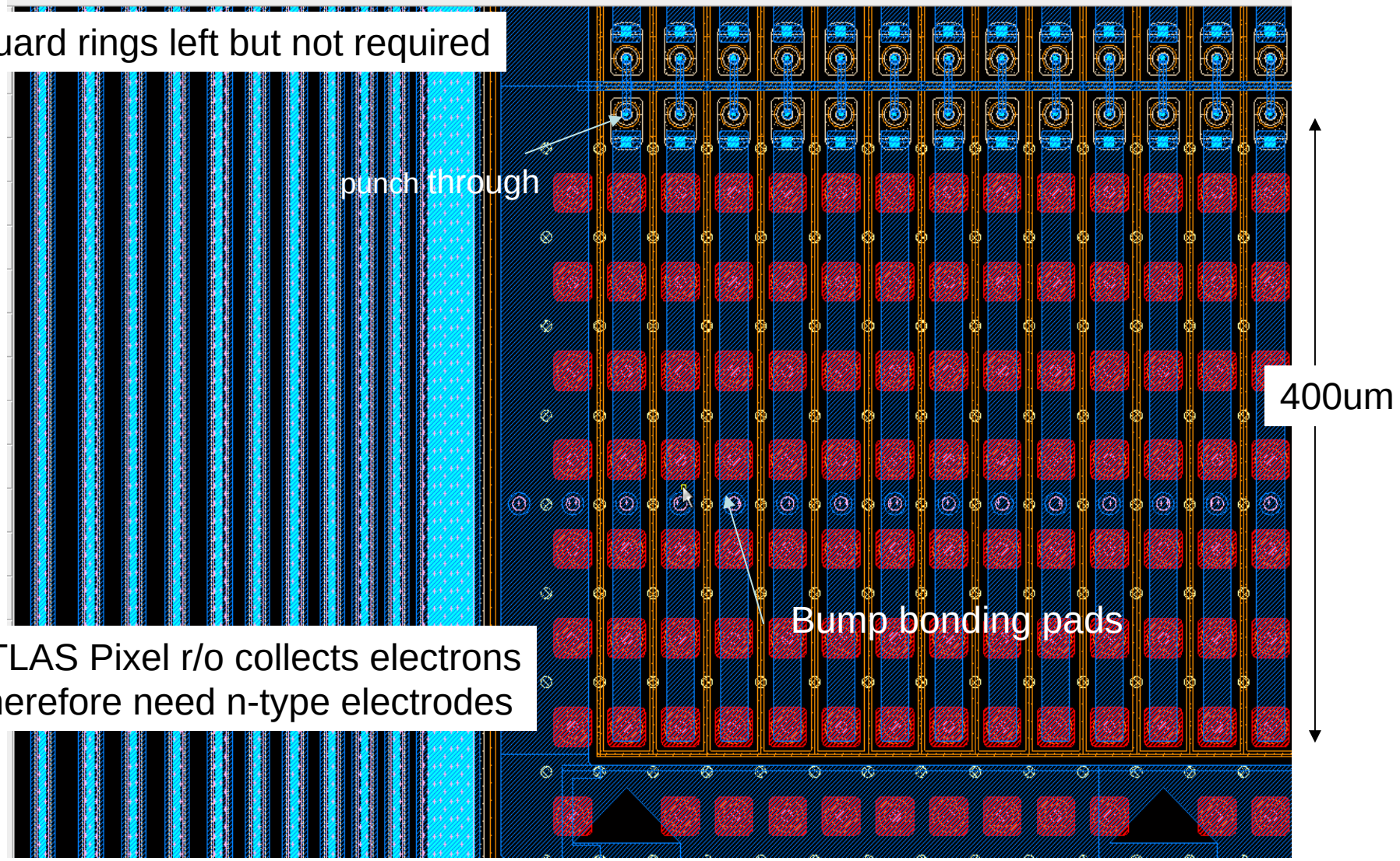
Mask design


Diodes 2D
Medipix2
Pixels
MOS
Pilatus
Pixels
Test for SEM
spreading
3x3 matrix
Test structures
Atlas pixel
3d pads
strips
Long strip
10x10 matrix

Device summary

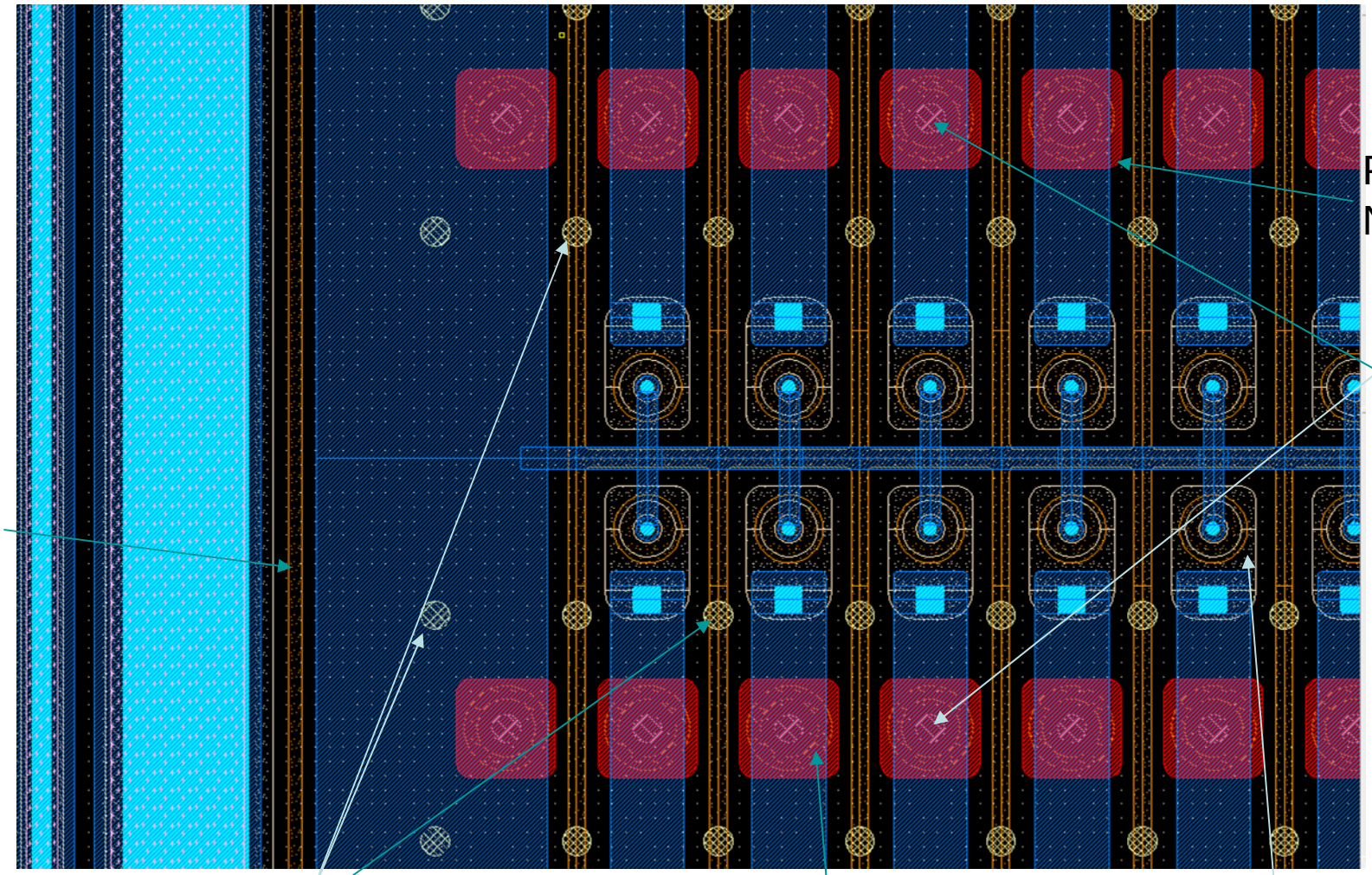
• 6 Medipix2 pixels	Pitch 55um, 256x256
• 6 ATLAS pixels	Pitch 50x400um, 164x18
• 1 Pilatus pixel	Pitch 172um, 97x60
• 4 short strip	Pitch 80um, 50x50
• 1 long strip	Pitch 80um, 180x50
• 6 pads	Pitch 55um, 90x90
• 25 10x10 pads	Pitch 55um, 10x10
• 25 3x3 pads	Pitch 55um, 3x3
• 2 standard pads, diffusion	Diameter: 5000um
• 2 standard pads, poly	Diameter: 5000um
• 2 MOS structure	Diameter: 5000um
• Different test structure	
• Structure for holes alignment	

Atlas pixels

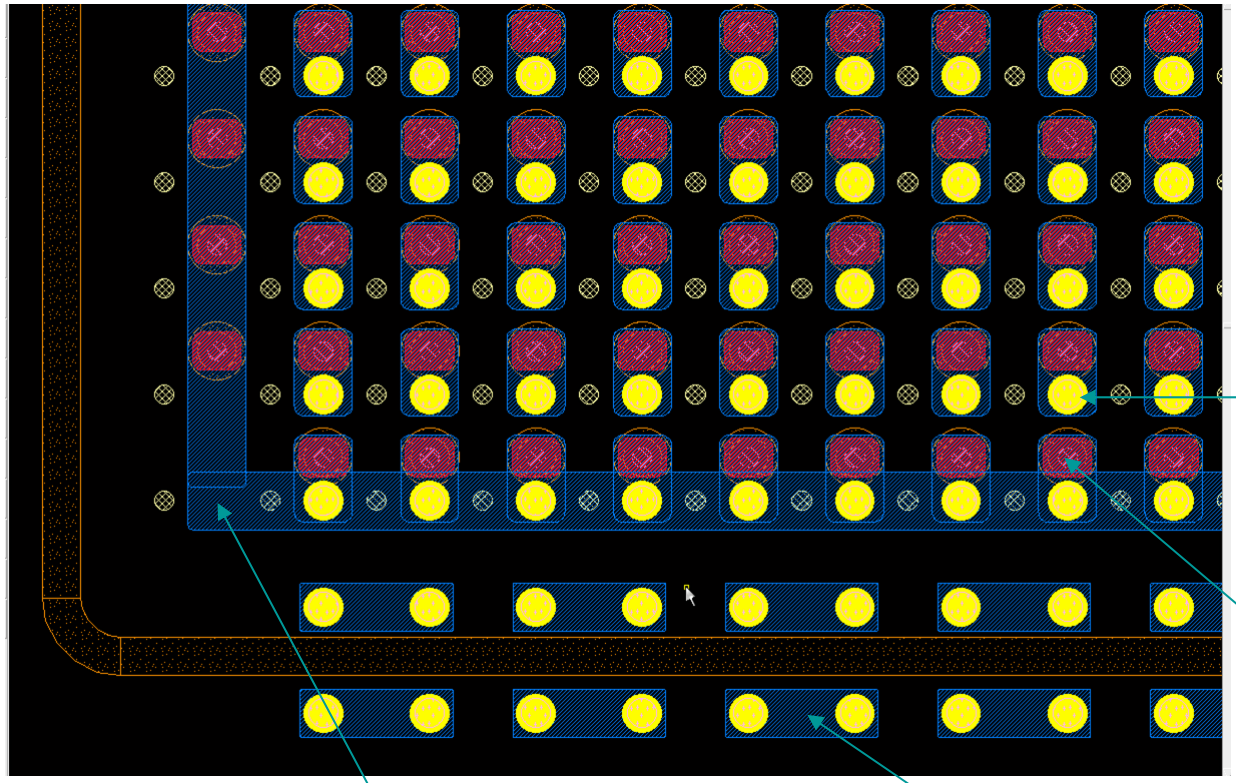


Atlas pixels

Design based on real ATLAS device



Medipix2 detector



Pitch = 55 x 55 um
Square array of holes

Bump bonding pads

N+ r/o holes

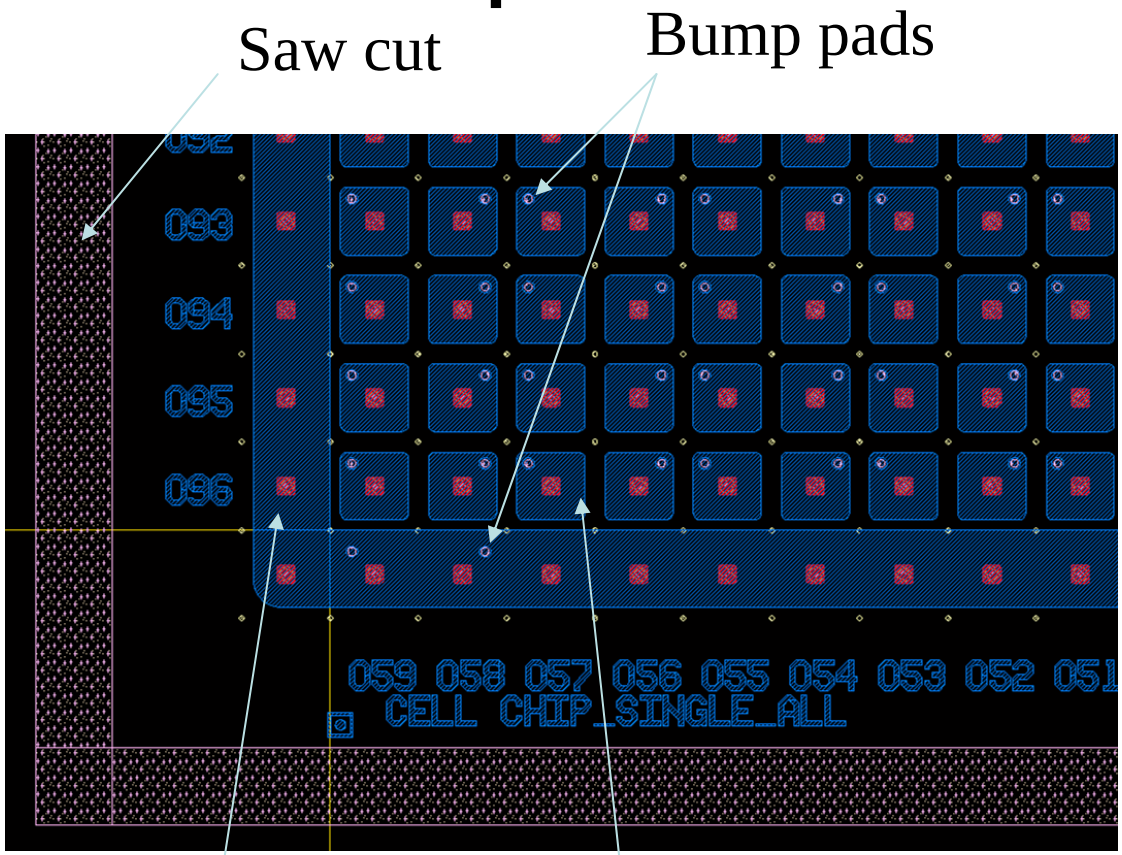
Medipix2 collects electrons and holes

3D Guard ring

Snake - tests bumping

Pilatus chip

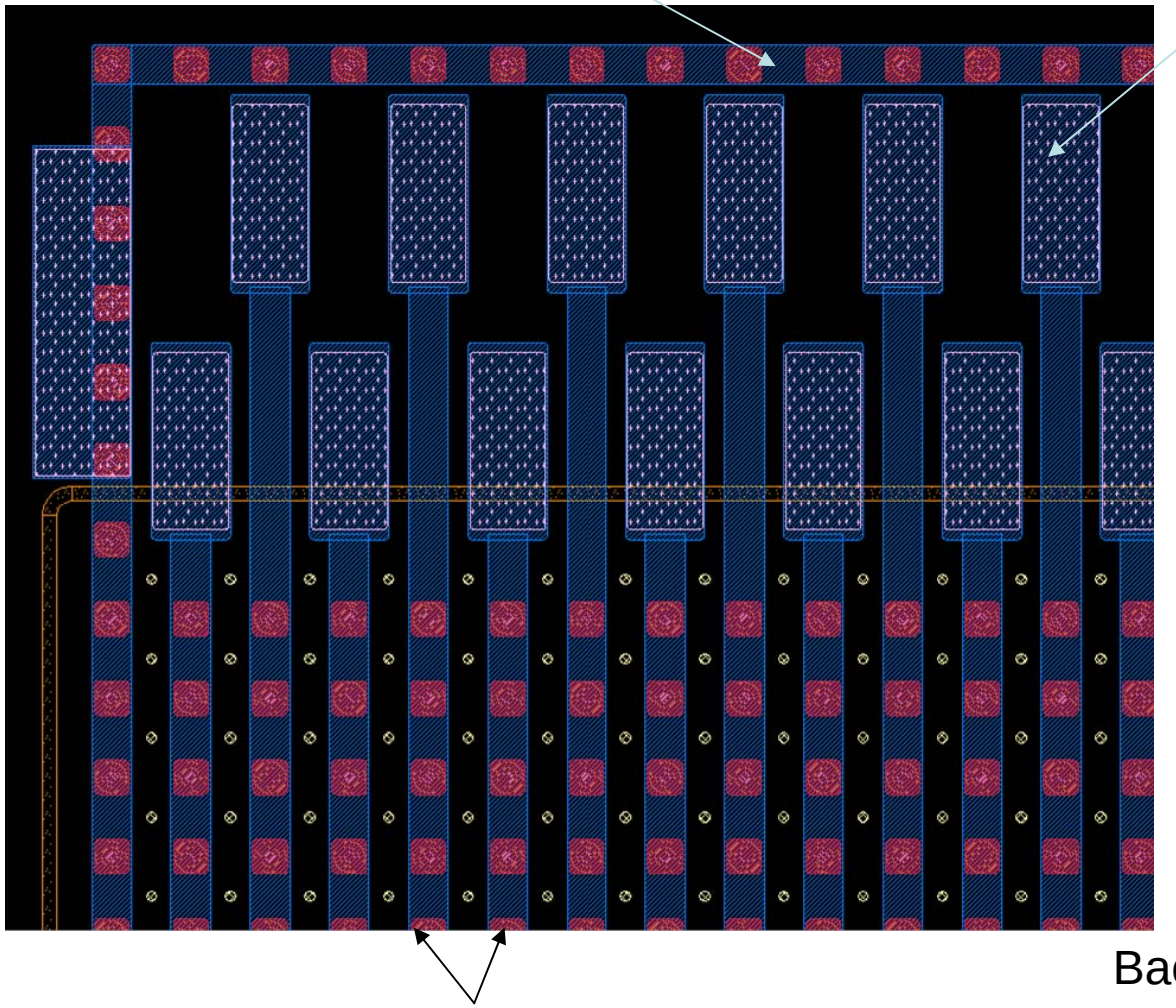
Pitch = 172 x 172 um
Square array of holes

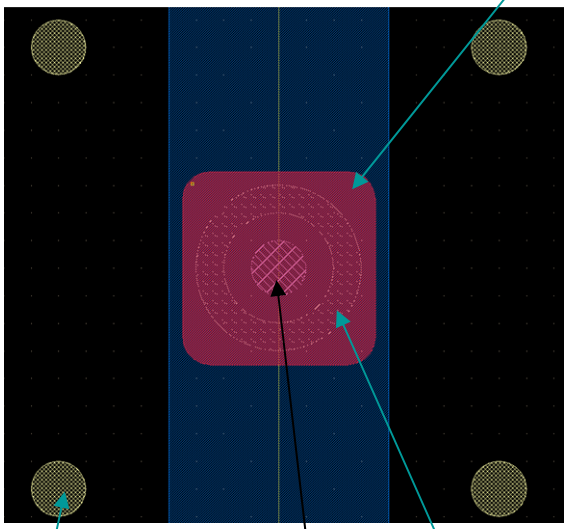


Pilatus r/o collects holes
p-on-n type device required

PSI R/O for Synchrotron sources

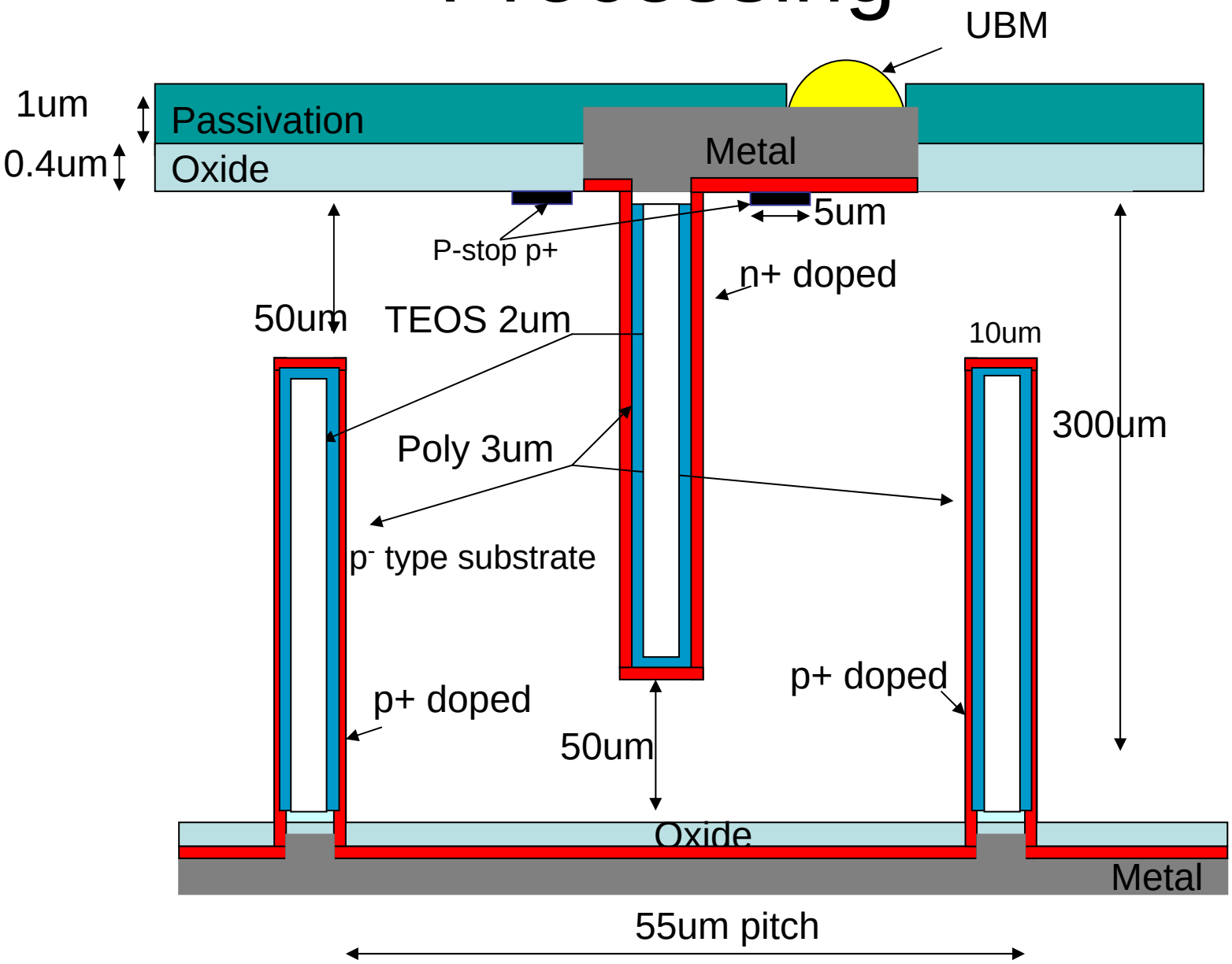
Strip detectors





All DC coupled

Processing

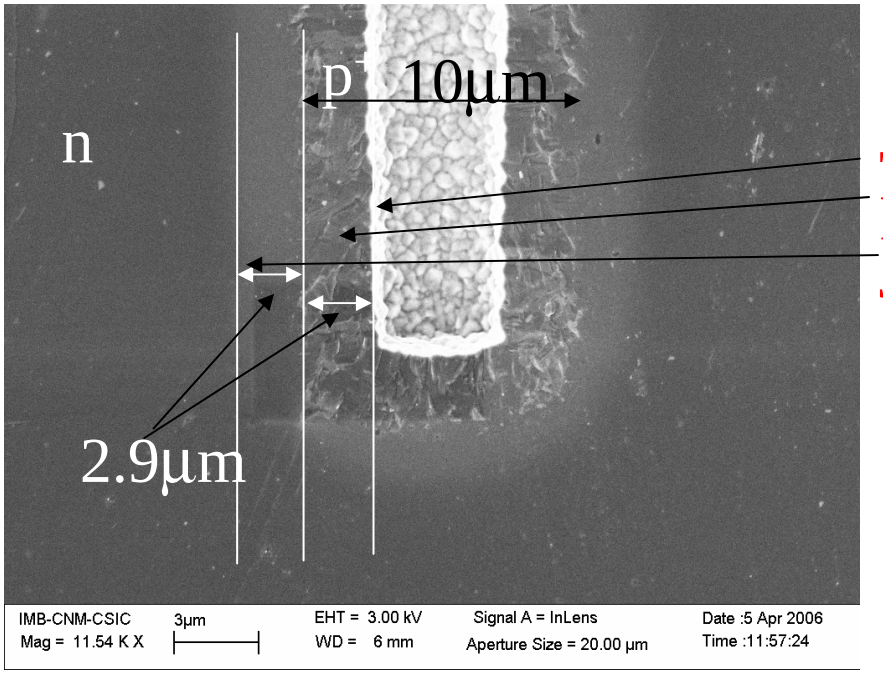

UBM
1um
Passivation
0.4um
Oxide
Metal
5um
P-stop p+
n+ doped
50um
TEOS 2um
10um
300um
Poly 3um
p- type substrate
p+ doped
p+ doped
50um
Oxide
Metal
55um pitch

Process developed and checked

Process flow:

Etch ⇒ Fill with Poly ⇒ P doping ⇒ TEOS ⇒ Etch ⇒ Poly ⇒ B doping ⇒ TEOS

- Hole etching working well
  - Aspect ratio 24:1
  - Better with Al mask



- Doping down the hole works
  - Smooth profile at corners, not square
  - [B] same at top and bottom
- Study of P & B doping performed to obtain junction in crystal Si down hole
- Poly uniform down the hole
- TEOS enters the hole

Processing plan

- 1st : p readout columns in an n-type bulk
- 2nd : n readout columns in a p-type bulk
- 9 wafers:
  - 1 wafer single sided for planar devices
  - 4 wafers with no bumps
  - 2 wafers for Medipix2 Sn/Ag bumps with Ni UBM left on strip pads
  - 2 with UBM for Indium – Pilatus and ATLAS
    - Ratios may change due to bumping developments

IceMOS Technology Ltd

- Small N.I. Based silicon MEMS company
- Have all required equipment and skills for 3D
- 3 stage development plan negotiated
  - Dense high aspect ratio hole array development
  - Hole doping optimisation
  - Device fabrication
- We will supply new sets of masks
- Time scale to full devices order 6 months!

Bump bonding

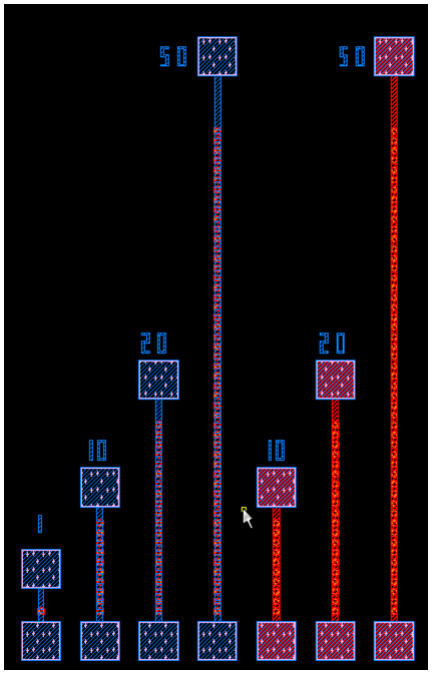
- Critical aspect for pixel devices
  - More effort required in this area with in RD50
- ATLAS r/o pixels in Glasgow with Indium bumps
- Pilatus Indium bumped at PSI
  - Diamond/RAL are building up a resource to work with PSI on bonding
- Medipix2 Solder bumps at CNM
- Freiburg to work on bumping 3D devices
- CNM produced Bump test device to check yield

Summary

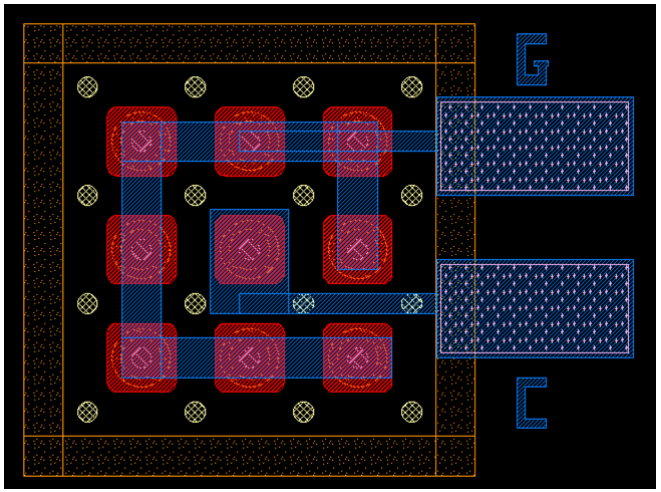
- Multi-project pixel 3D Mask designed
- Fabrication process understood
- 1st: p-in-n 3D detectors + single sided
- 2nd: n-in-p detectors
- End of 1st process foreseen for the end of October
  - if we get the mask before summer.
  - CNM clean room closed in August.
- Bump bonding unsolved issue
- Commercial 3D vendor being pursued

Extra Slides

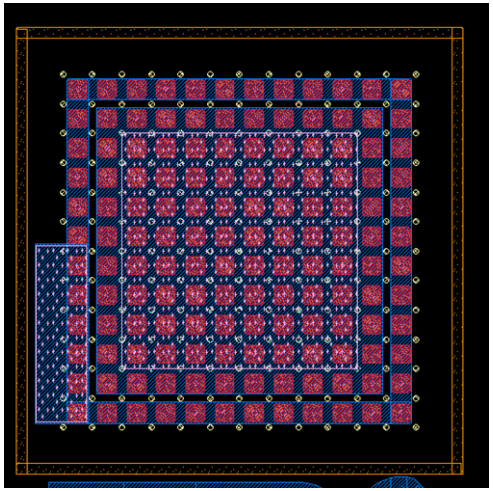
Test structures



Test structure to measure the connection between the holes.

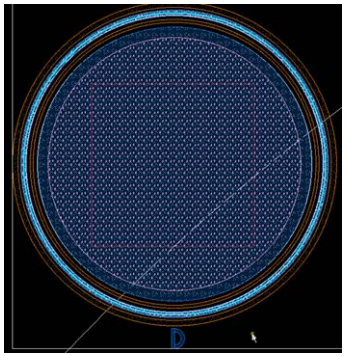


3x3 matrix

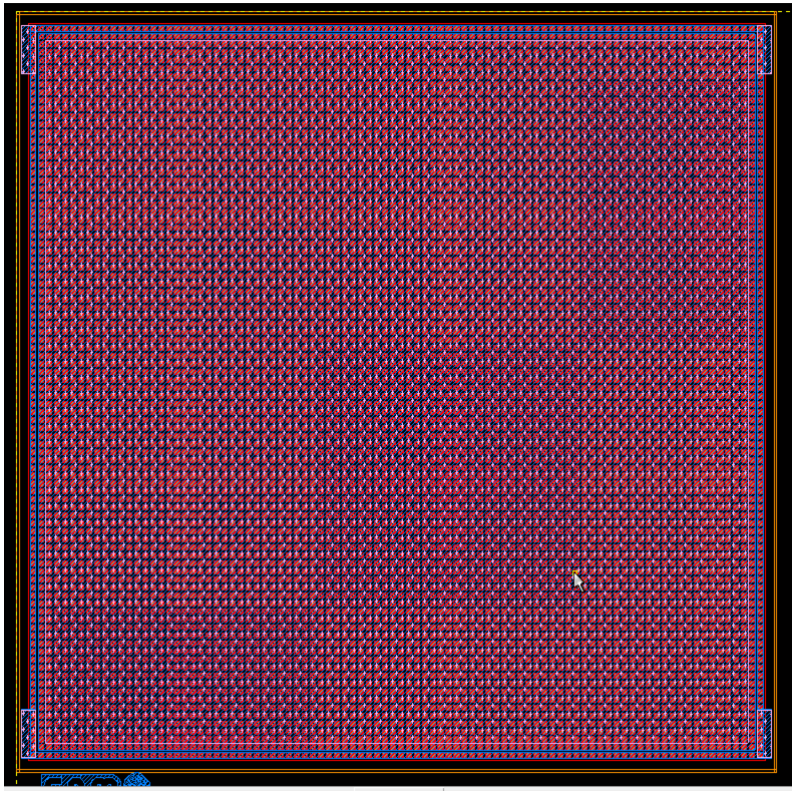


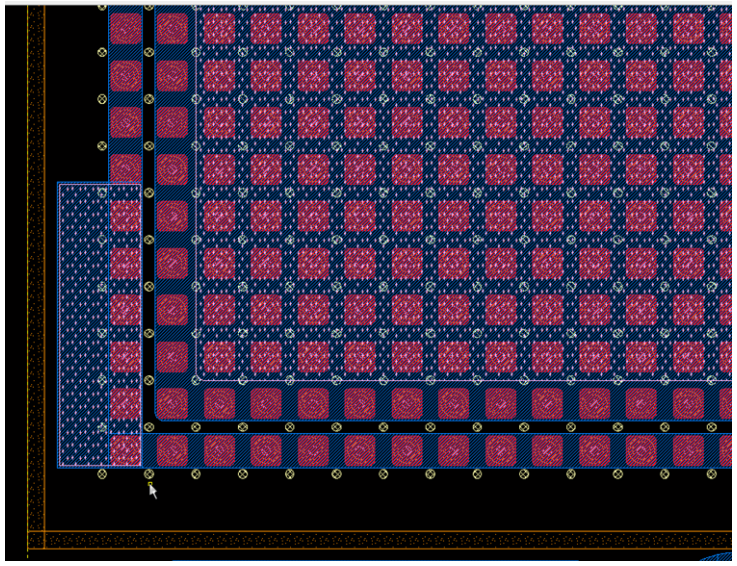
10x10 matrix

Standard Diode



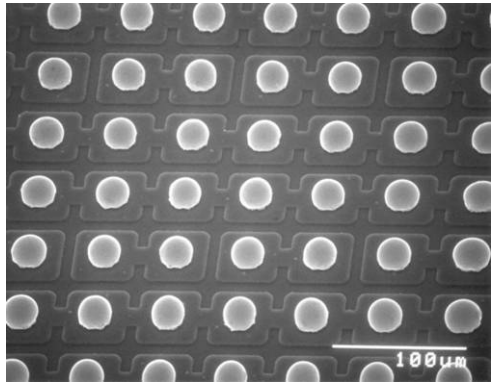
3D pad detectors

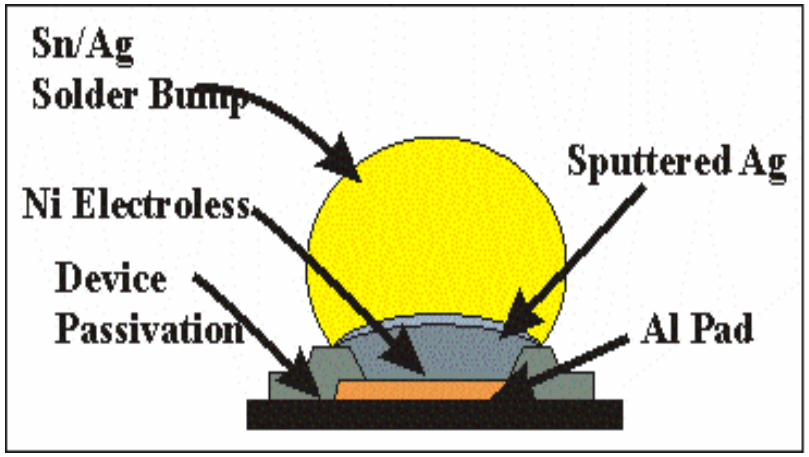




All holes connected by the metal layer

Bump bonding





- Minimum pitch: 40um
- Lead free technique
- Low cost process
- Fabrication steps:
- 1. Under Bump Metalisation (UBM)
- 2. Bump formation by electroplating
- 3. Reflow