ATHENA WFI
Flight Production PXD14
Defect Search & Surgery

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24.05.2023

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GLOBAL TESTS OF LARGE DETECTORS

● **production status**

▷ priority sub-batch PXD14.6 of flight production, 12 wafers

▷ 1st metal layer AL1N deposited & patterned

▷ global contacts accessible: - ring2 = p+ implant (connecting ring1, source, drain by punch-through)

  - clear = n+ implant (via bias bus, connecting bulk)

  - cleargate = polySi1 (via bias bus)

  - gate = polySi2 (via bias bus)

● **probe station tests**

▷ device: chip d.05, large area detector, 512 x 512 pixels

▷ all available contact pairs, 2-terminal I(V) tests

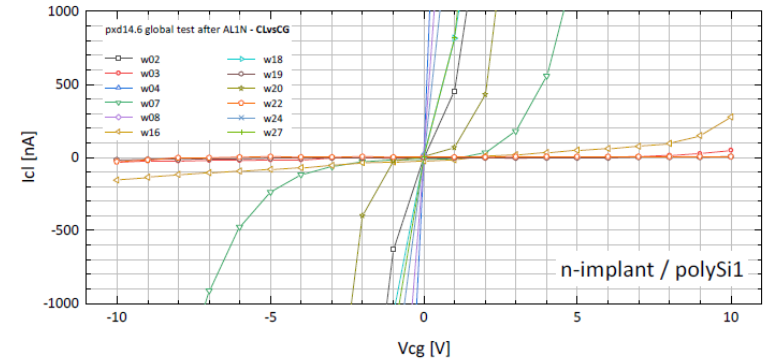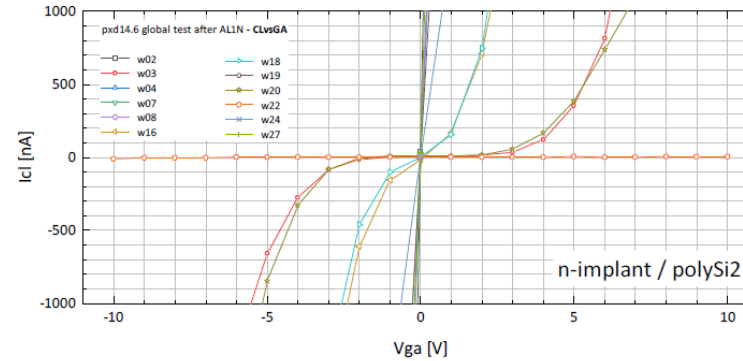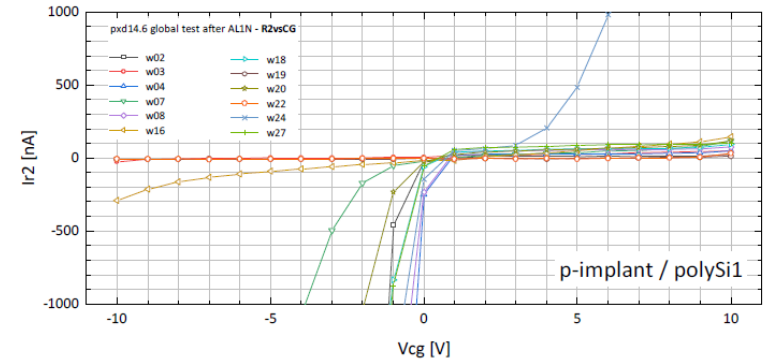▷ voltage range   -10 V … +10 V

▷ current limit   10 μA
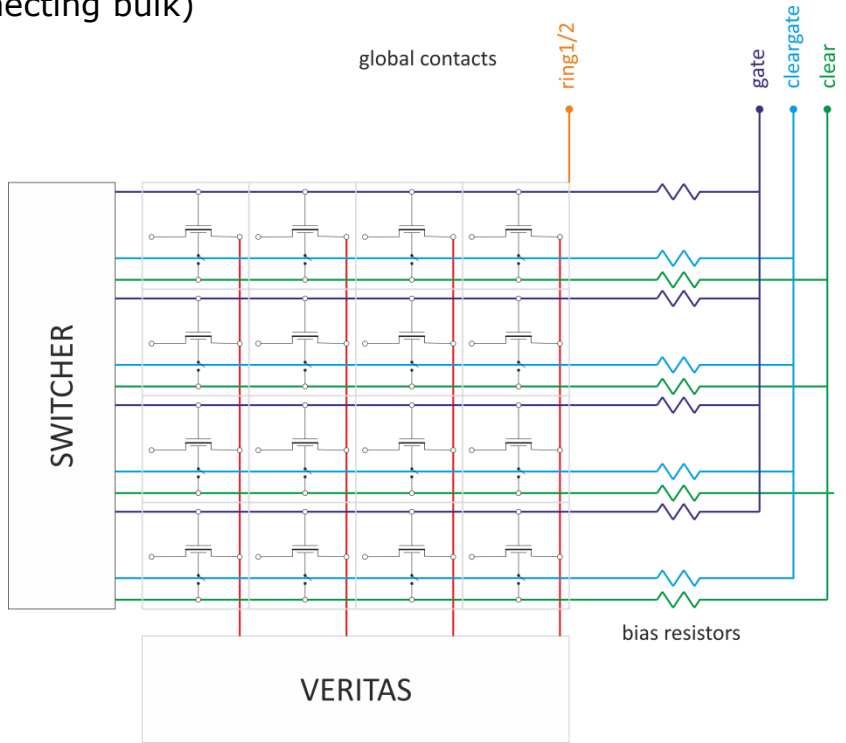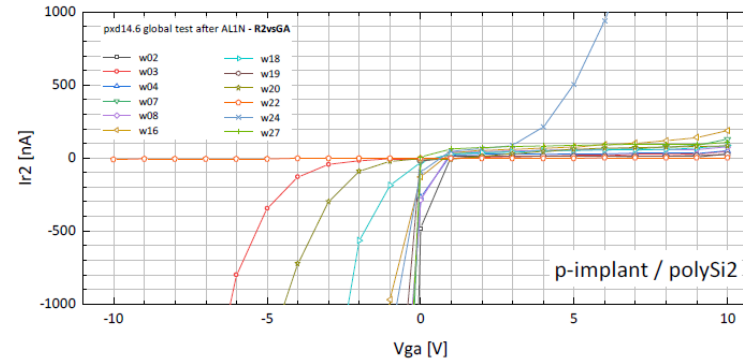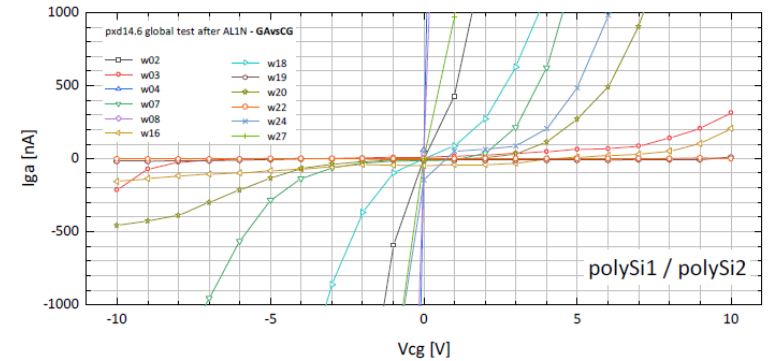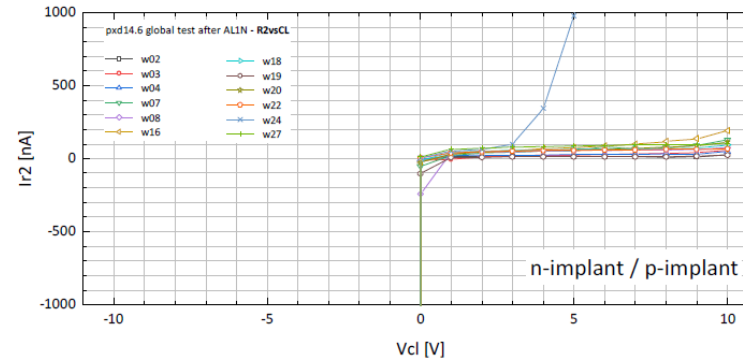
GLOBAL TESTS OF LARGE DETECTORS

- summary

  ▷ 1 device free of defects

  ▷ 3 devices with single kind of defect

  ▷ others with multiple or combined defects

  ▷ no information about number & location of defect(s)

  ▷ wafer 24: broken diode ring2/clear, probably lost
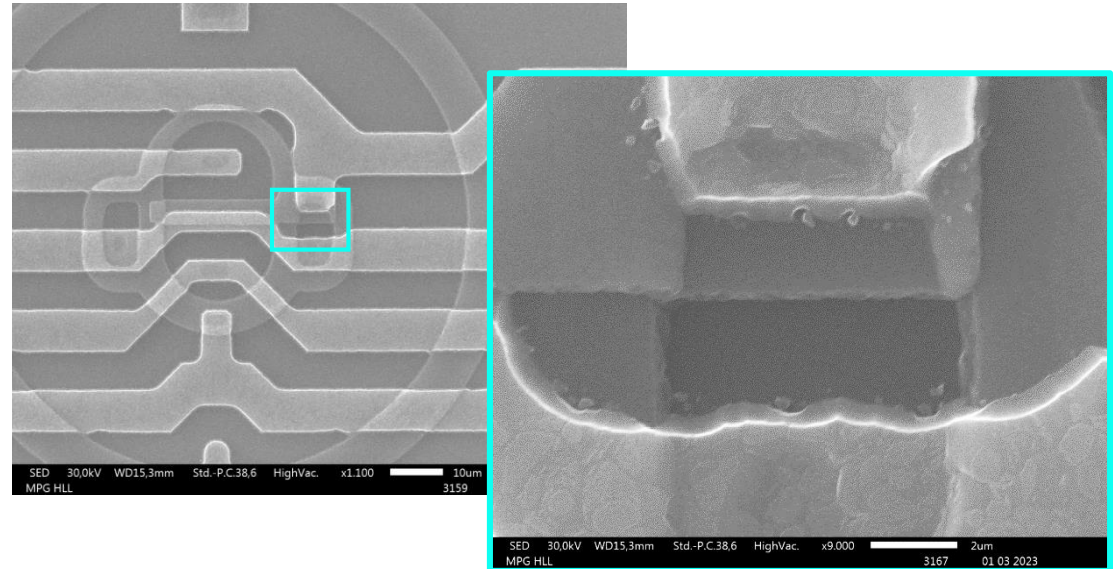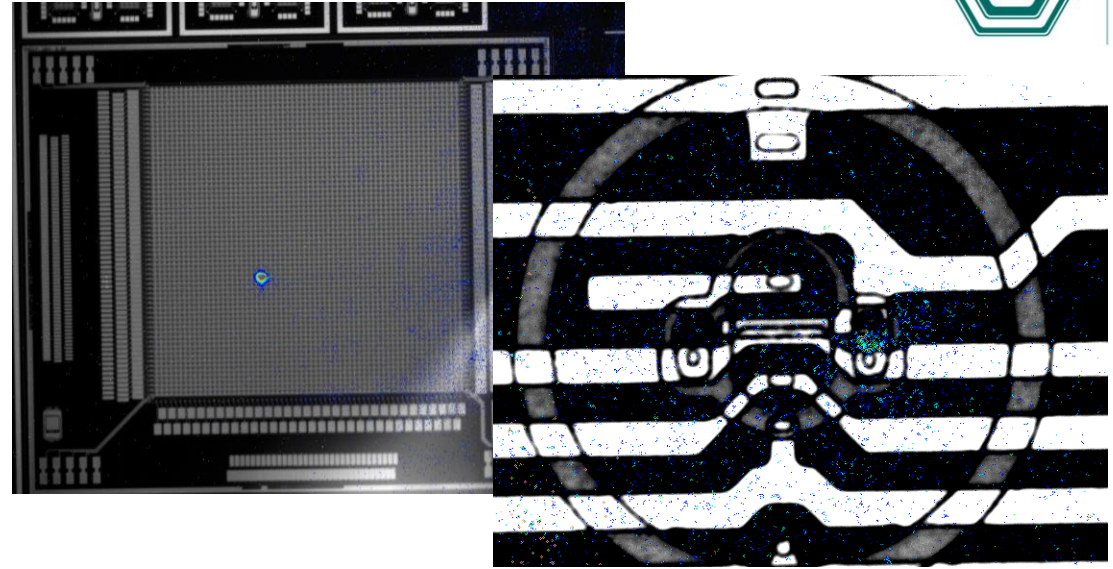
DEFECT SEARCH

- ⬡ small chips

  - ▷ use of prototype format 64 x 64 as monitor

  - ▷ total 216 chips ≈ 0.9 Mpixels ≈ 3½ LDs

  - ▷ global test on probe station

    - → 4 defect devices found

  - ▷ row-wise test on probe station

    - → identification of defect row

  - ▷ PHEMOS emission microscope

    - → identification of defect pixel

    - → identification of defect spot within pixel

  - ▷ scanning electron microscope

    - → origin of shorts unresolved

    - → no repair option

 - ▷ no further non-destructive diagnostics

LARGE DETECTOR STRATEGY

- **defect pixel search**

  ▷ row-by-row short test on probe station

    → identification of defect row

    → restriction of search area

  ▷ defect localisation by emission microscope

- **deactivation of defect pixels**

- **preparations**

  ▷ protection of entrance window side by 10 µm resist

  ▷ temporary pixel row & column in photoresist
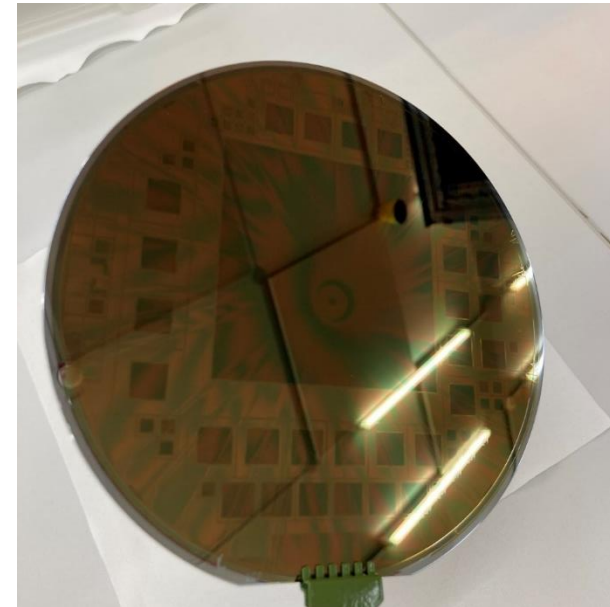

wafer back side protection
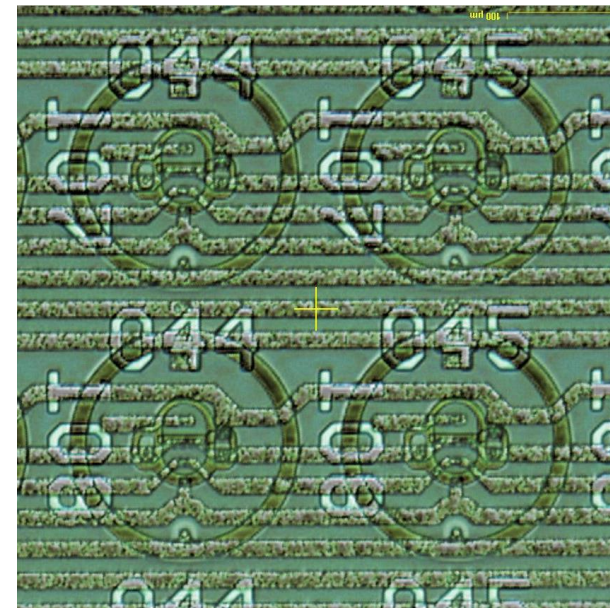
pixel address in photoresist

ROW-BY-ROW SHORT TEST

- **automatic probe station PA200**
  - ▷ 3 stationary needles, programmable moveable chuck
  - ▷ wafer on permeable tissue, fixation by vacuum

- **test procedure**
  - ▷ 3 short tests per row
    - – cleargate / clear
    - – gate / clear
    - – cleargate / gate

  - ▷ I(V) curve
    - – voltage ramp   -10 … +10   V
    - – step width   0.5   V
    - – current compliance   10   µA

  - ▷ measurement time
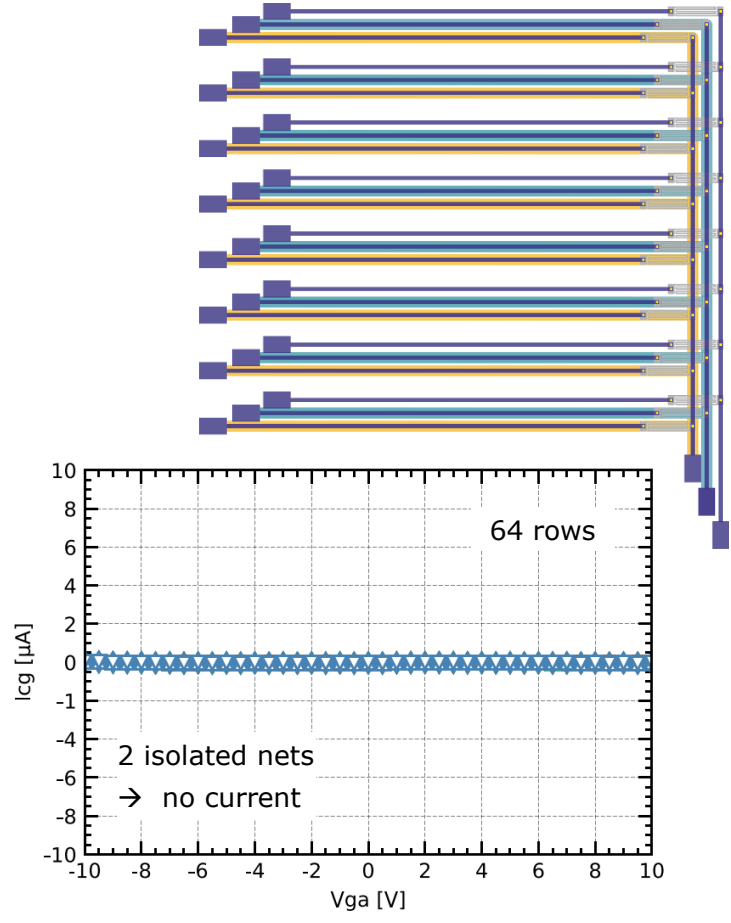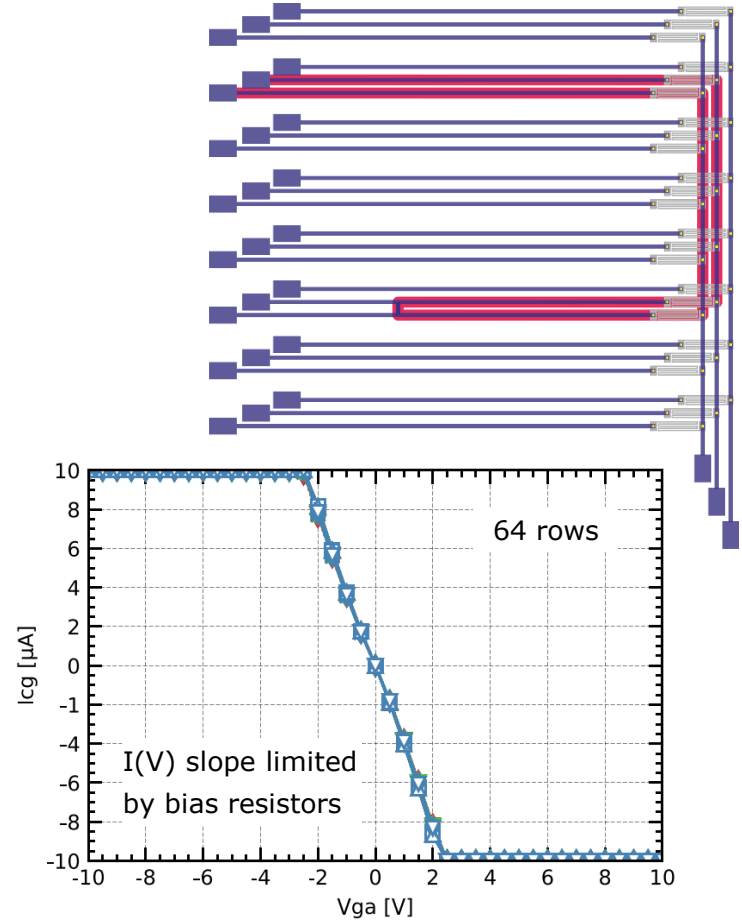   - – ~ 2.5 min / row
    - – ~ 22 h / device
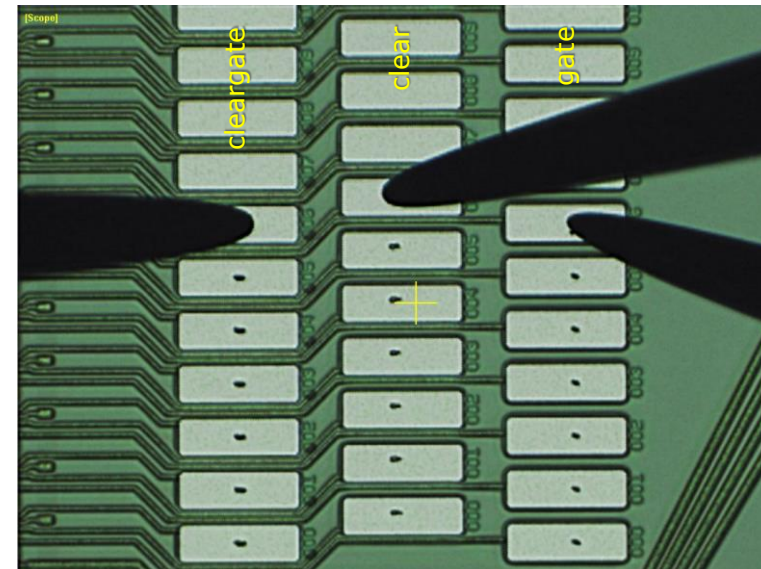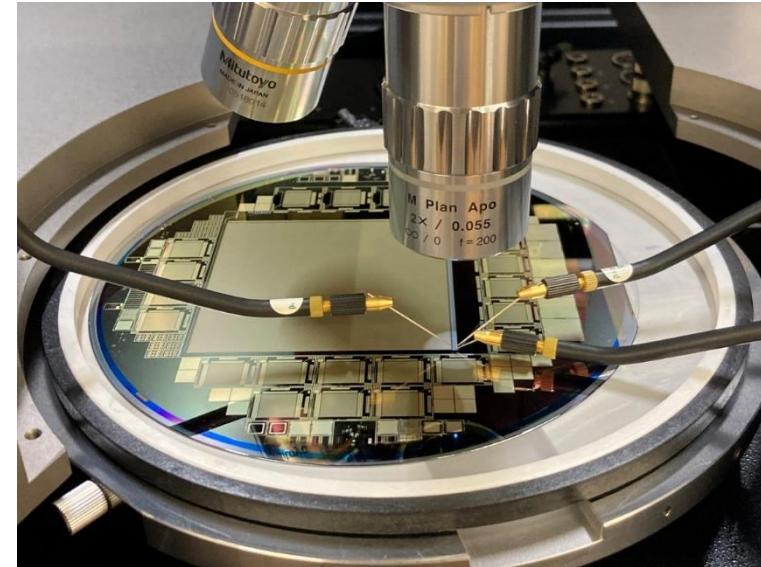
ROW-BY-ROW SHORT TEST

● short detection

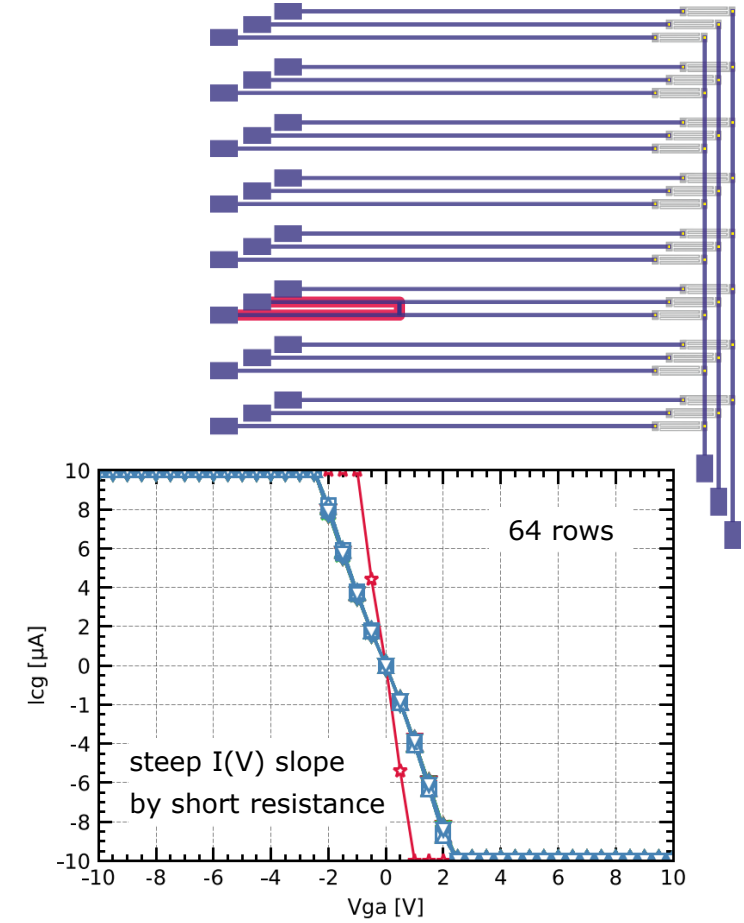▷ no short   ▷ short outside of tested row   ▷ short in tested row

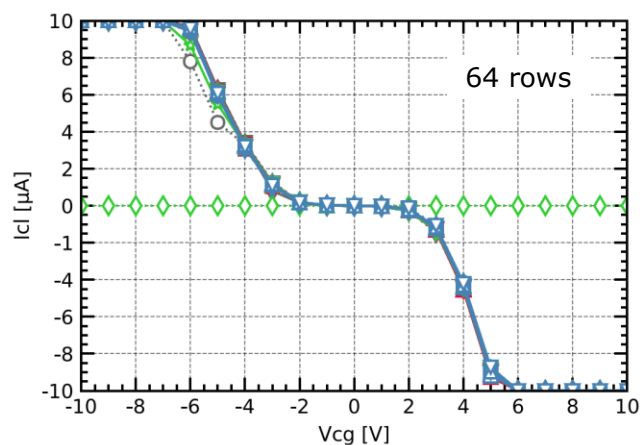# ROW-BY-ROW SHORT TEST

◆ summary

▷ 12 wafers tested for shorts polySi1 / polySi2 / n-bulk

- 1 (22)   free of shorts

- 2 (16, 19)   single short in 1 row

- 2 (03, 20)   shorts in neighbouring rows

- 5 (04, 08, 18, 24, 27) multiple or combined shorts in 1 row

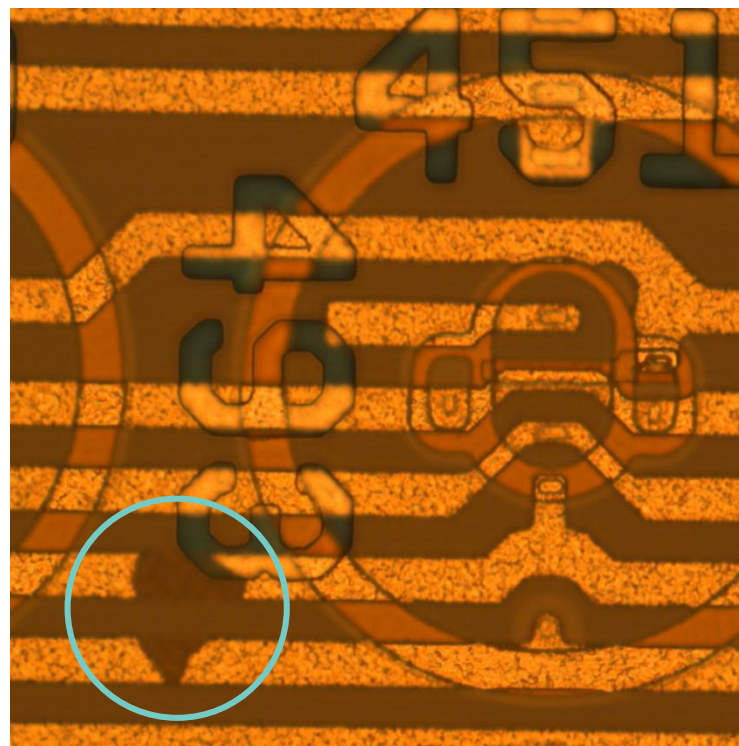- 2 (02, 07)   shorts in 2 separate rows
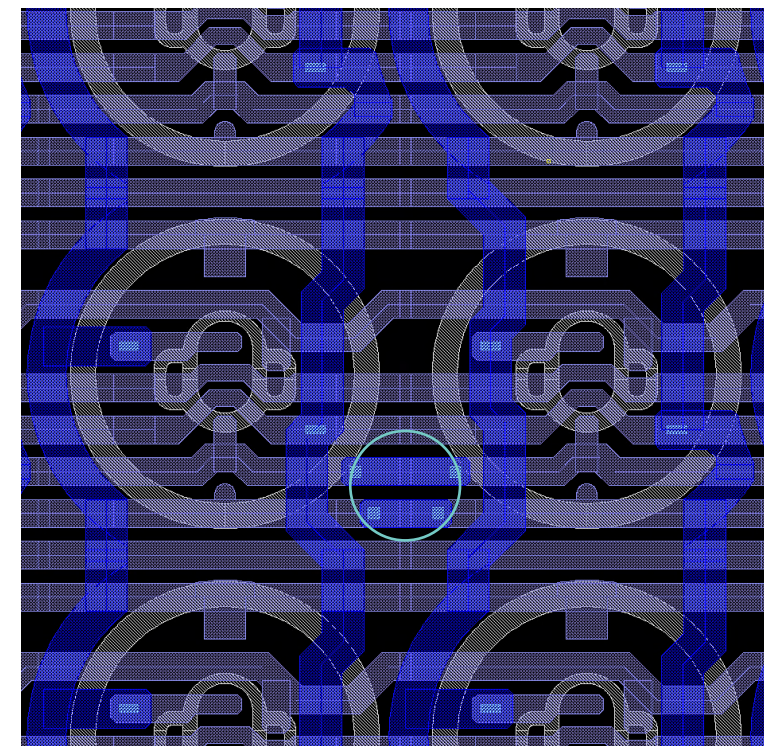
ROW INTERRUPTION

- **w20 - row interruption**
  - ▷ repair by metal2 bridges

64 rows

random discovery of interrupted cleargate connection

interrupted metal1 lines, cleargate & insub, row #493, probably caused by particle in sputtered Al layer


repair by
- – individual contact2 & metal2 lithographies
- – modified routing of drain & source lines

DEFECT PIXEL SEARCH

- PHEMOS emission microscope

  ▷ device biased by prober needles

    → power dissipation @ short

    → emission of heat & light

  ▷ detection devices

    – Si CCD → low level light

    – InGaAs IR camera → heat

  ▷ system limitation

  sensor row length (~ 7 cm)

  vs.

  microscope travel distance (~ 5 cm)

    → wafer twist angle 45°
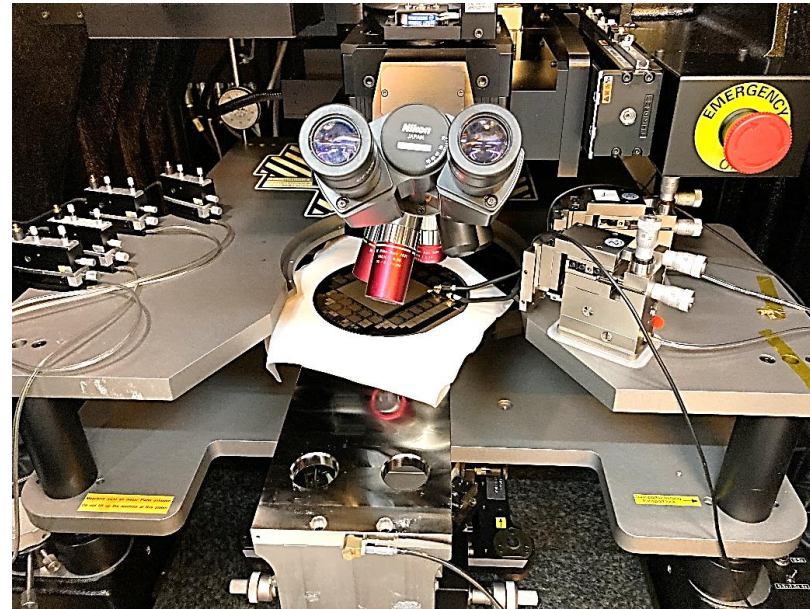
PHEMOS emission microscope

close-up of chuck & wafer
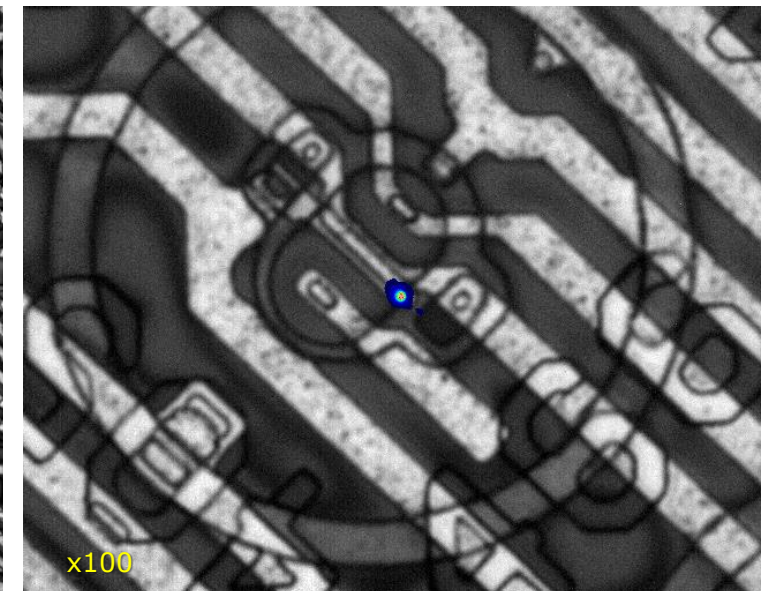
DEFECT PIXEL SEARCH

- PHEMOS emission microscope

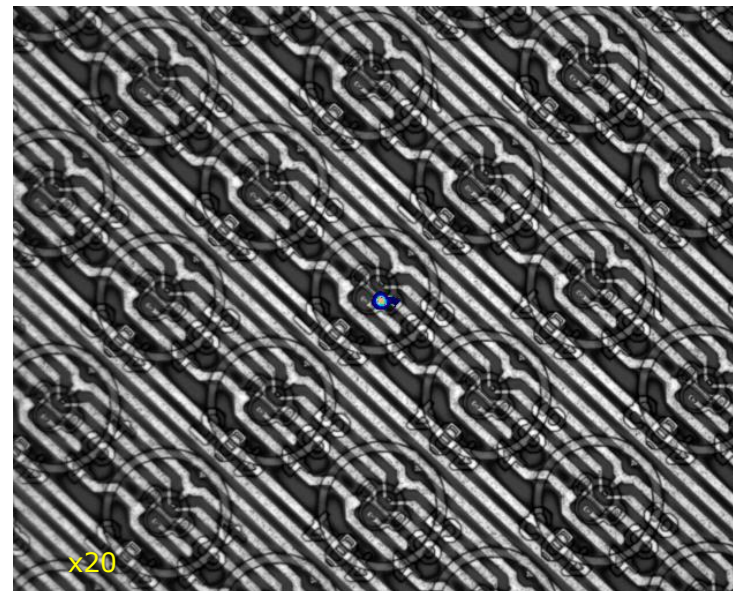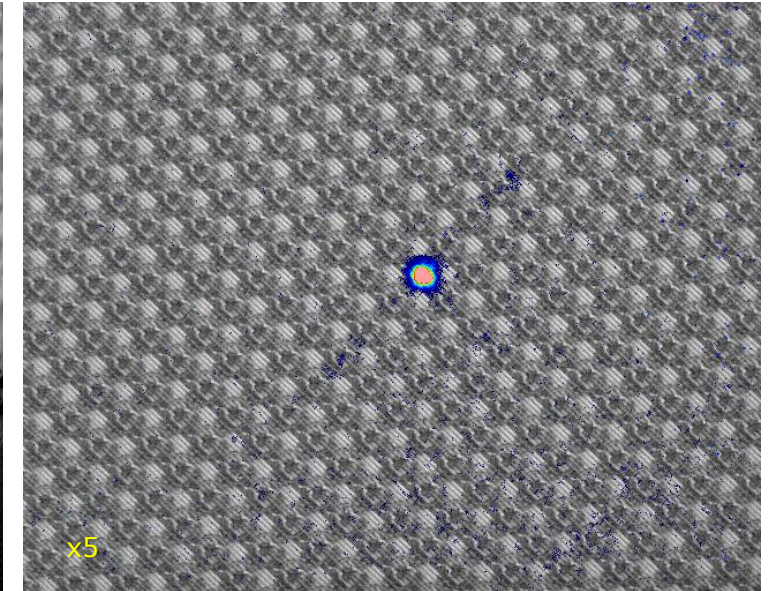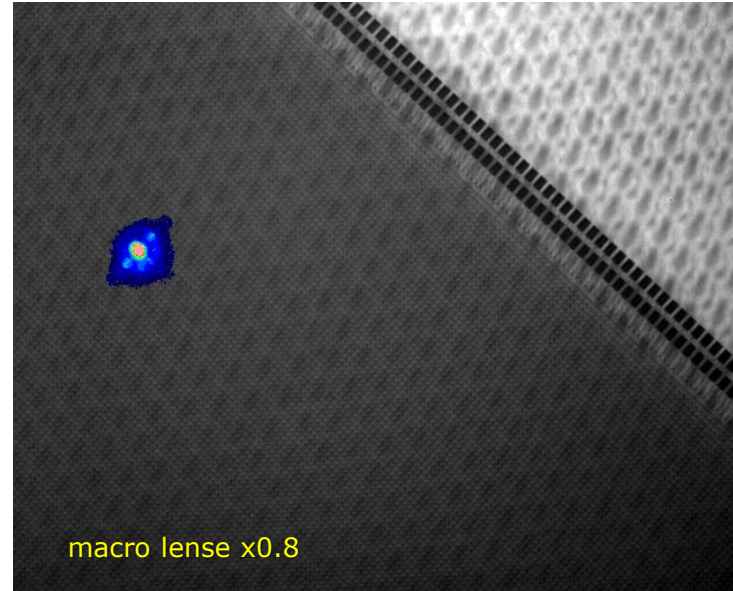 ▷ row scan with macro lense x0.8

  – field of view ~ 100 x 100 px
  – 6 images

  → defect detection

  ▷ successive increase of resolution

  – x5, x20, x100

  → pixel identification

macro lense x0.8

x5

x20

x100

DEFECT PIXEL SEARCH

- **summary**

  ▷ 12 wafers tested

  - 1 (22)   free of shorts
  - 1 (24)   multiple defects, probably lost
  - 8 (02, 03, 04, 07, 08, 16, 18, 19) single defect pixel
  - 2 (20, 27)   shorts in 2 separate rows or columns

 ▷ defect origin(s) unknown

  ▷ statistics (w/o wafer 24)

  - 13 defect pixels on 11 large detectors
  - pixel yield

 $$Y = 1 - 13/(11 \times 512^2) = 0.999995$$

PIXEL "BLINDING"

● procedure

   ▷ disconnection of gate & cleargate

      – lithography @ defect pixel

      – local etching of metal1

   ▷ test, verification of disconnection

   ▷ omission of drain connection

      – local layout modification in metal2 or contact layer

      – no extra step, part of standard flow

      – approved by ASICs experts
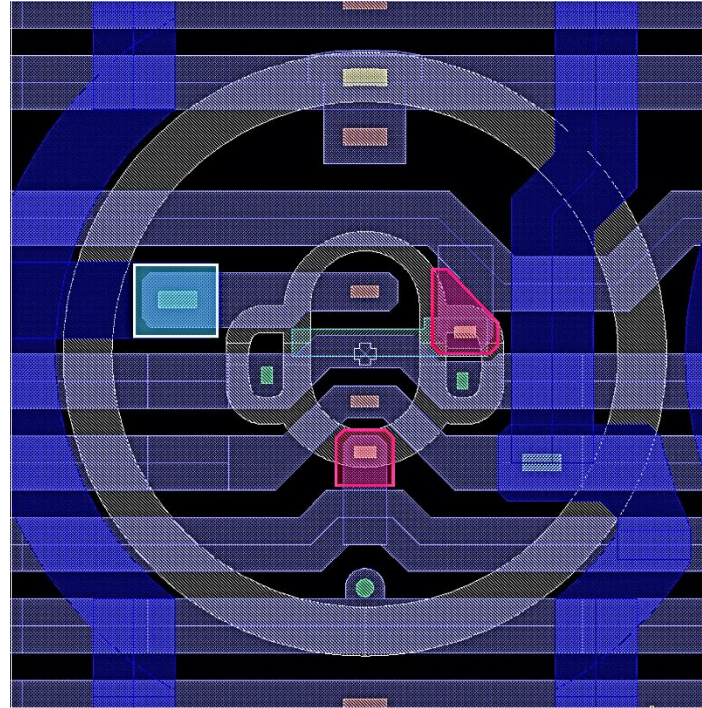
PXD14 pixel layout
- mask for disconnection of gate & cleargate
- omission of drain connection
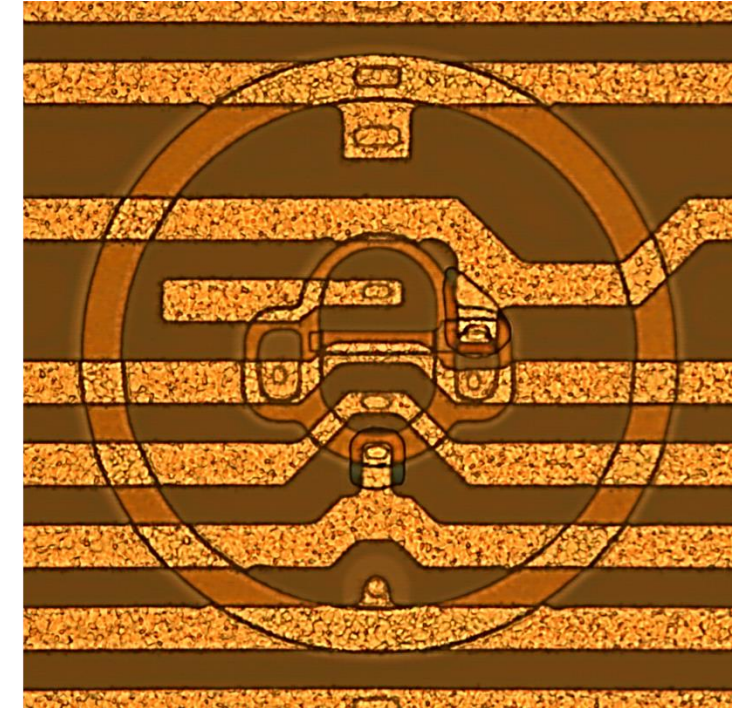
PXD14 pixel, actual status
- lithography for disconnection of gate & cleargate

SUMMARY

- procedure for fault-finding on pixel level established

- applied for 12 wafers of the ATHENA WFI flight production

- density: ~ 1 defect pixel / large detector (yield 99.9995 %)

- root cause of defects still unknown → no repair option

- deactivate or "blind" defect pixels by removing gate, cleargate and drain contacts