OAK RIDGE National Laboratory

FTOF Module assembly procedure and requirements

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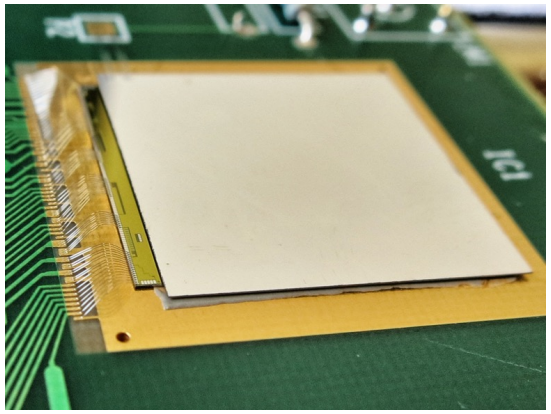
ORNL is managed by UT-Battelle, LLC for the US Department of Energy

U.S. DEPARTMENT OF ENERGY

Outline

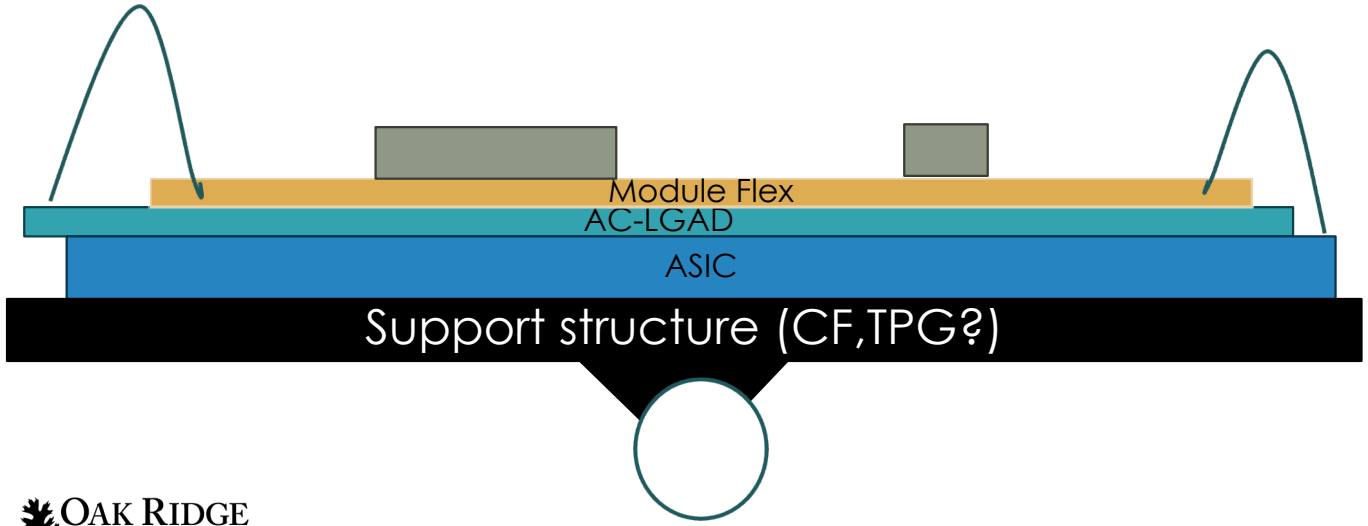
- Module design and consideration
- Module assembly procedure
  - Gantry-based assembly scheme
  - Jig-based assembly scheme
- Module QA/QC

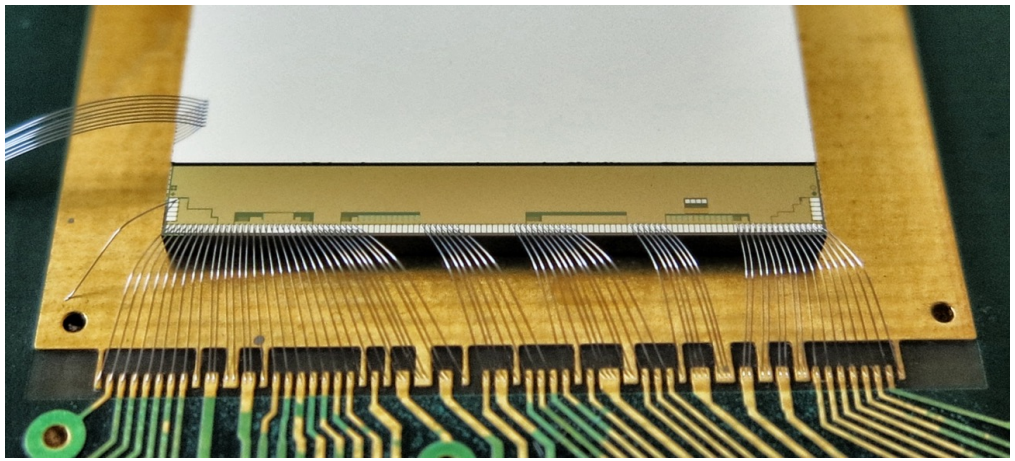
Module design and consideration



Module consist of :

- Thin AC-LGAD (20-50 µm) bonded to thick ASIC (200-300 µm preferable)
  - Thick ASIC, if allowed by material budget, allow for more rigidity
- Module flex hybrid populated with HV decoupling, connectors and other needed components
  - HV-Capacitor should be potted to avoid sparks
  - Flexible circuit is preferred for material budget but also for the flexibility limiting possible stress on the thin sensor
  - ASIC and sensor backside are wire-bonded to flex circuit (encapsulated)
  - **Sensor DC Node (pixel side) should be connected to ASIC (?)**





Module assembly procedure

- Module assembly consist of:
  - Alignment of Assembly to glue dispenser coordinates
  - Dispensing of glue pattern (stamping, motorized dispenser)
  - Alignment of Flex circuit to Assembly
  - Mating of Flex to Assembly
  - Curing (UV/heat/time)
  - Wire-bonding of signals
  - QA/QC testing of module
  - Mounting to mechanical/thermal support
- Produced modules in **design and pre-production phase should be tested for failure modes under stress**
  - Delamination, fracture of thin sensor, chipping, wire-bond integrity
  - Thermal cycling (accelerated aging) and thermal shock should be carried to ensure reliability of the assembly method

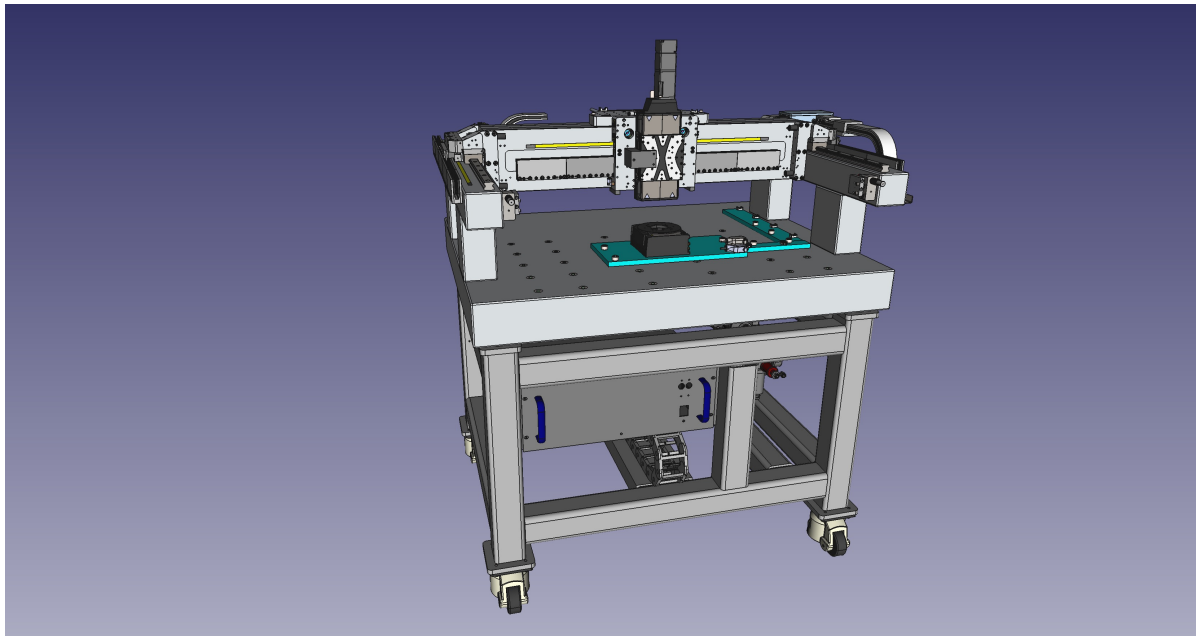
Gantry/Flip Chip assembly

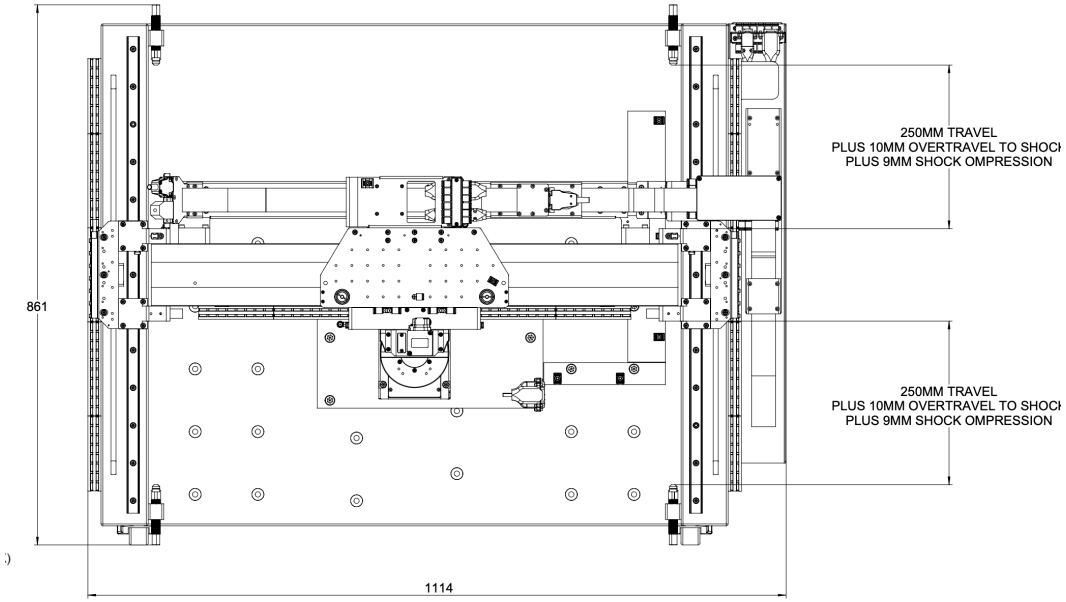
Automated gantry is often used for serial assembly in microelectronics factories

- High precision movement over large volume
- Tool handling and switch capabilities
  - Vision for alignment
  - Suction handling tools
  - Dispenser head
  - Weight handling and curing tool

- Delivery to ORNL cancelled to due delay in production, seeking alternate solution

- Possible alternate solution is using the FC150 dispenser and bonding head to add Flex circuitry to assembly after bonding , in one go
  - Sensor+ASIC already aligned after bonding
  - Need to develop precise pickup tool adapted to Flex circuit





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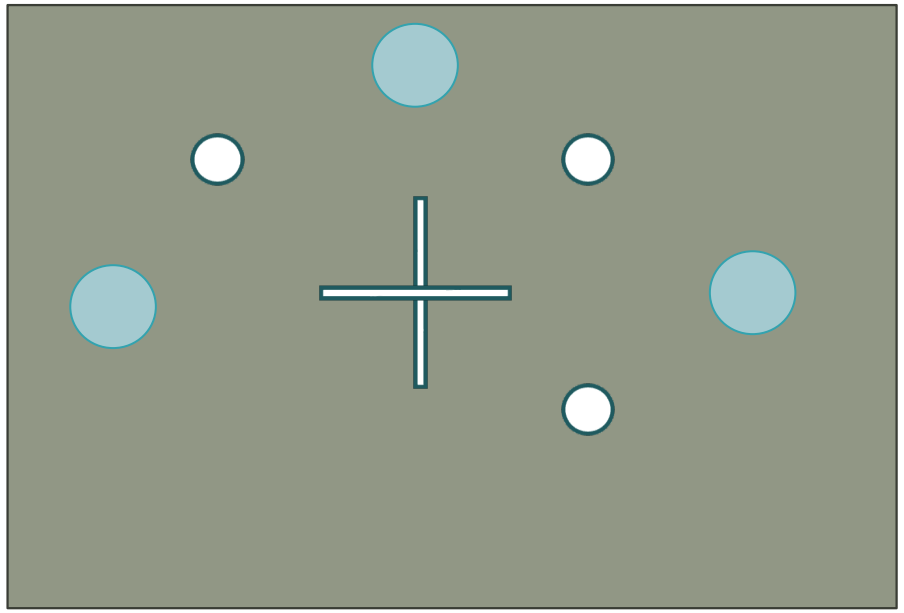
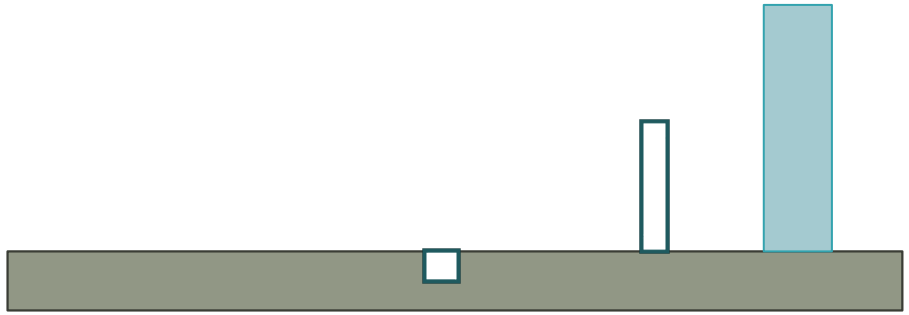
Jig-based assembly procedure

A precisely machined jig can be used to manually perform module assembly.

- vacuum site
- alignment pins
- Insertion pins





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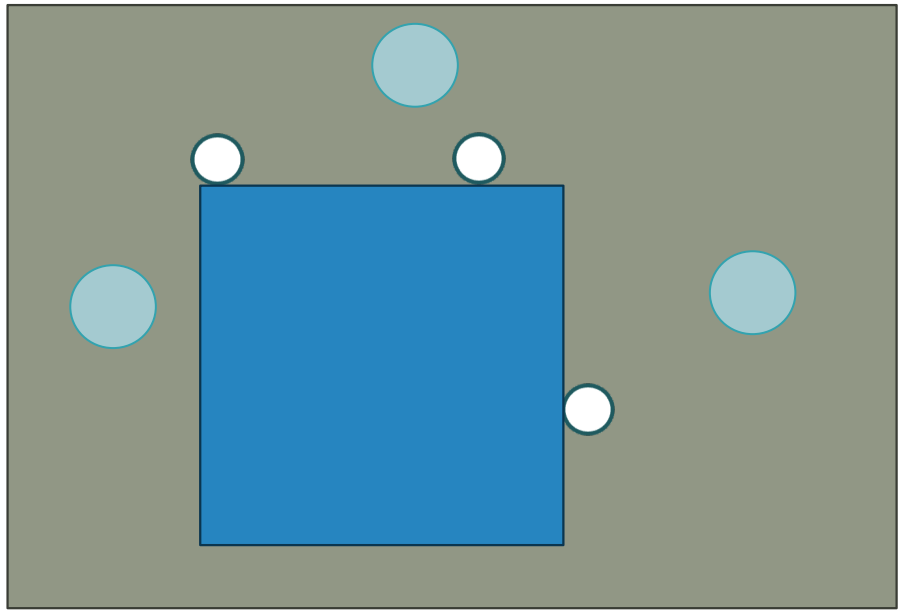
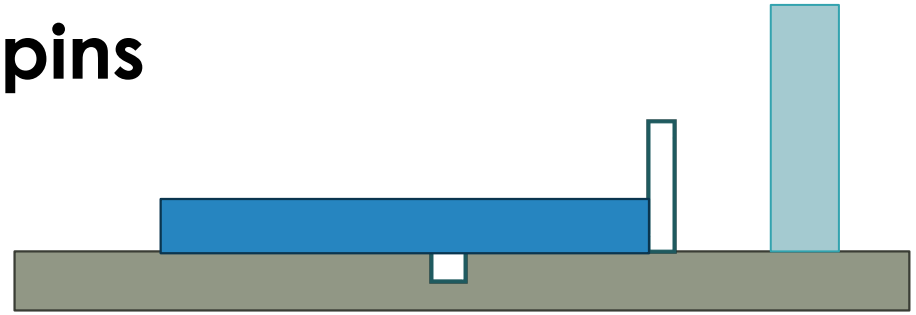


Sensor is aligned to jig using aligment pins



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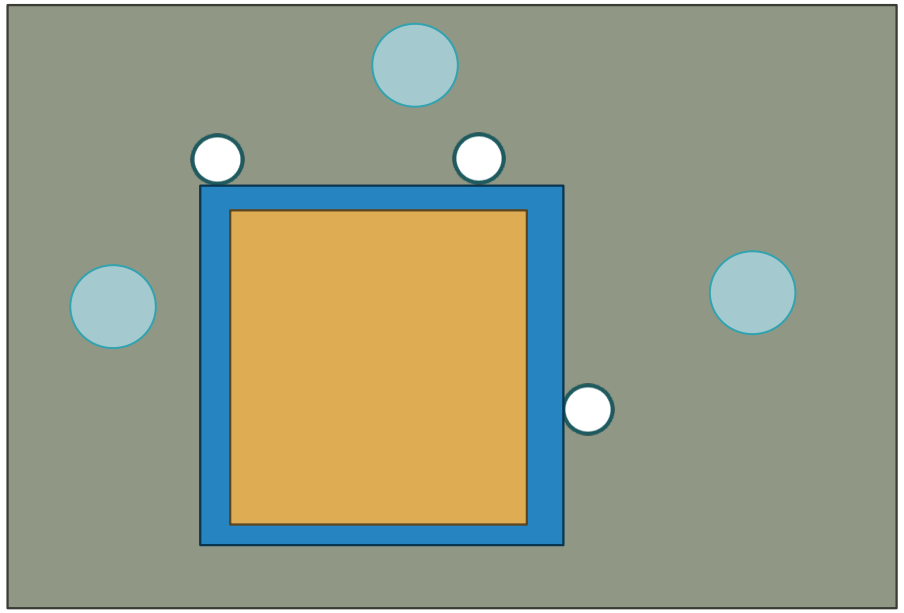
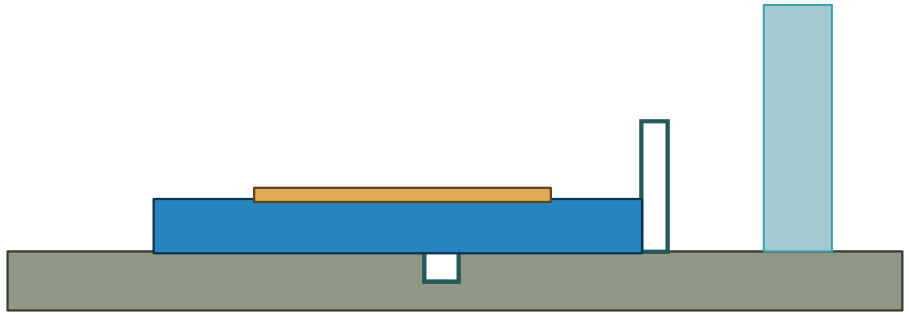


Glue is dispensed



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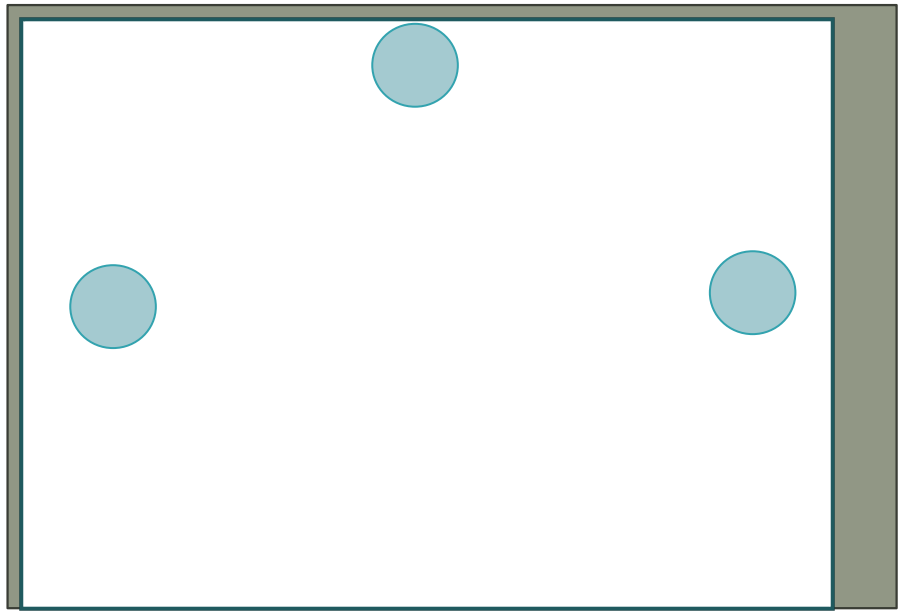
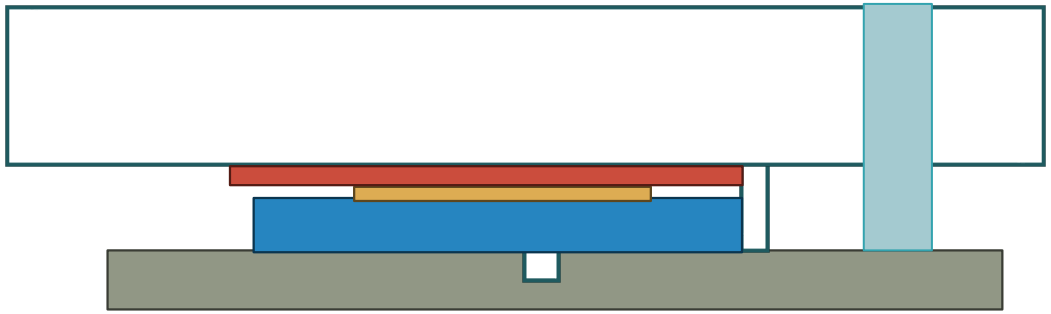


Flex is aligned in a similar way to a top jig and applied to assembly



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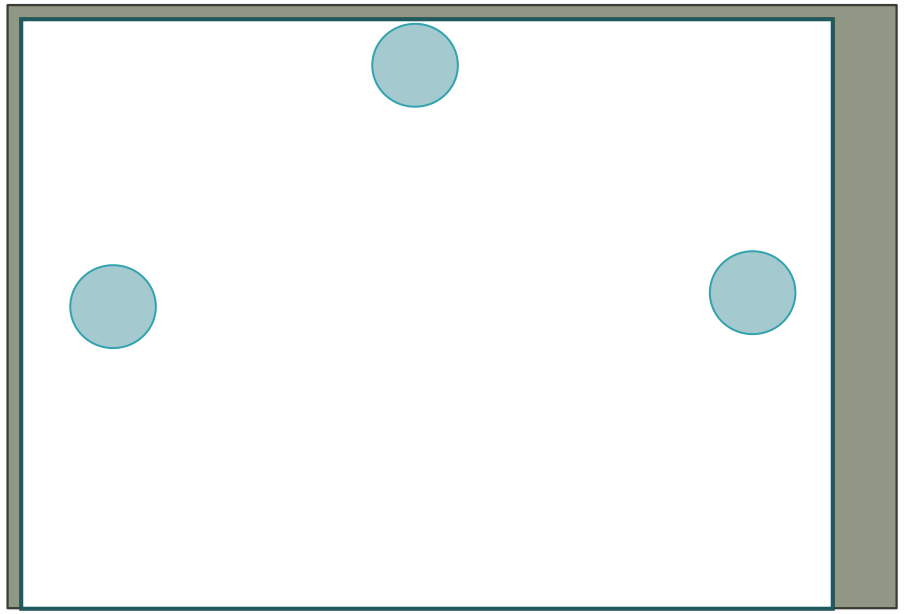
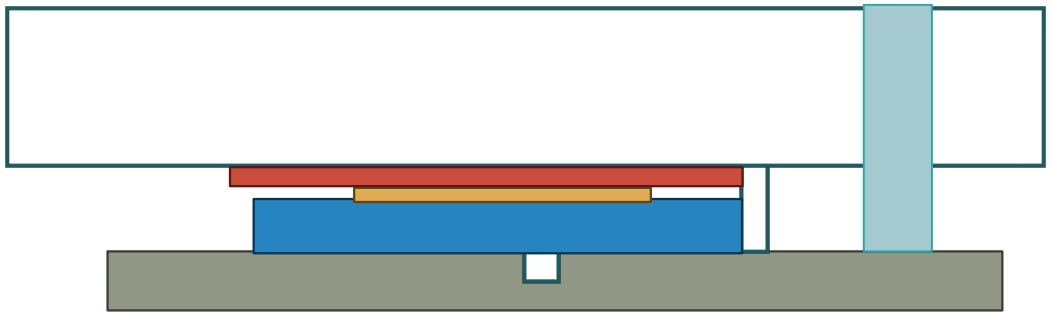


Glue is cured in place , then alignment pins are removed and module ready for wire-bonding



QA/QC procedure for module testing

- The main deliverable for the module part of the scope is **known good modules** , tested to meet a set of requirements at the assembly site

- The testing of production modules done covers
  - **Visual inspection** of the module after assembly
  - **Functional testing :** Power-up, tuning, stress test, thermal cycling
  - **Source testing** : Functional testing with source, test beam with subset of modules for QA
  - Repeat test after **irradiation** to verify compliance with requirements

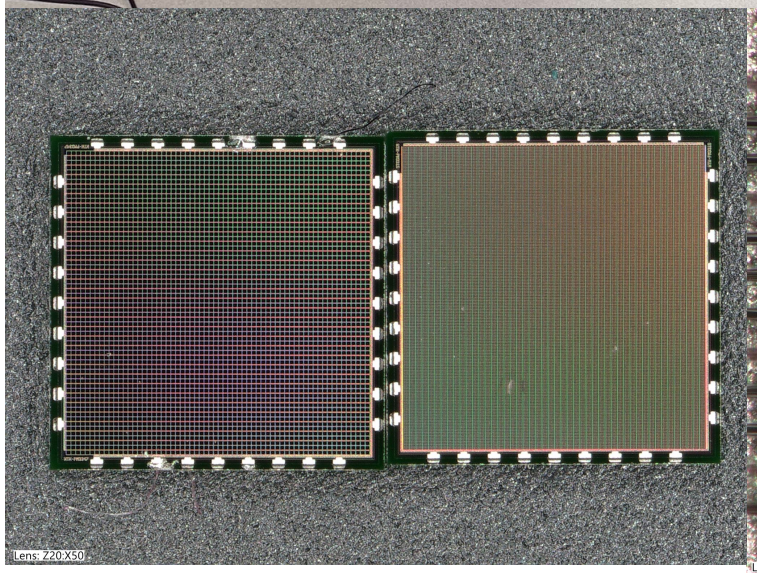
Visual inspection QA Test setup

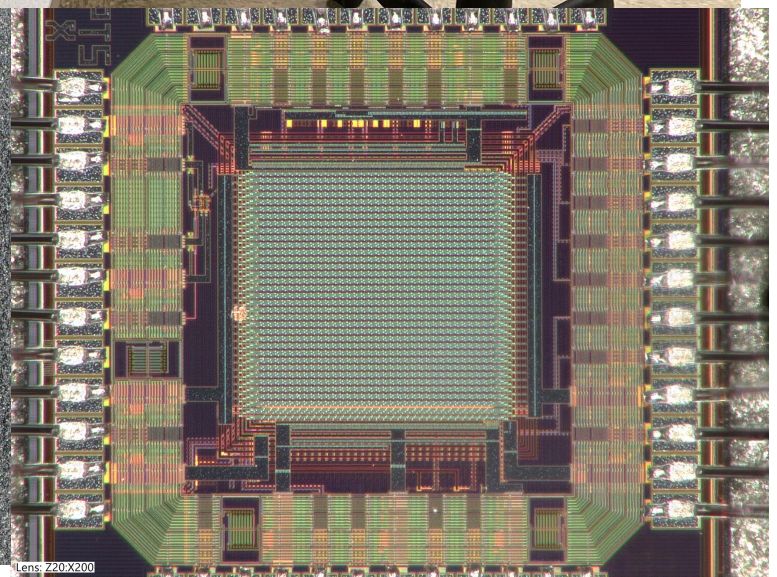
We have a Keyence VHX-650 digital microscope with :

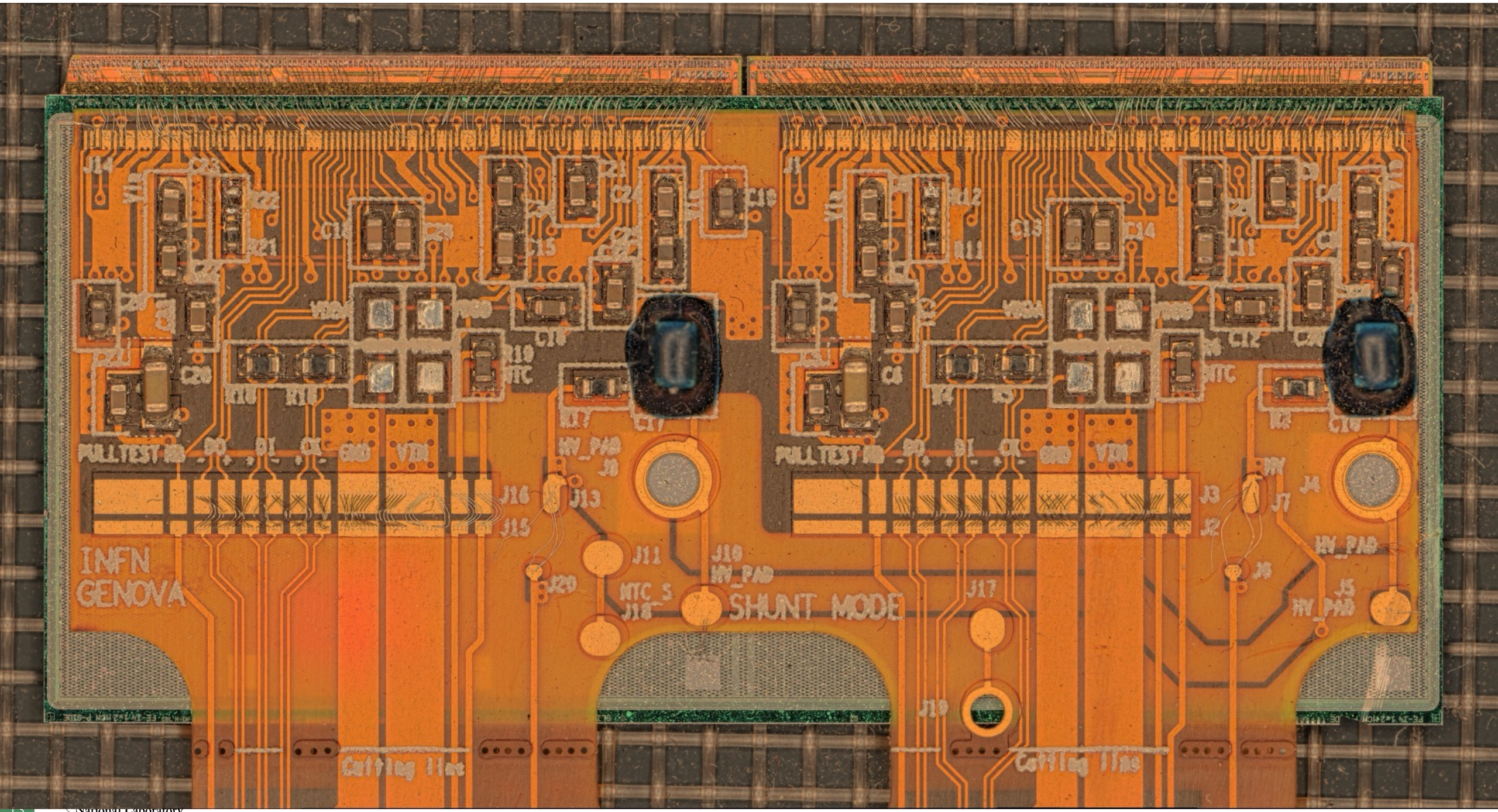
- 100X zoom , 100x100mm platen
- +- 75deg observation angle
- Motorized XY staged
- Stiching, 3D scanning capabilities
- Automated metrology

Visual inspection and logging into the database is an important step of QA, to spot damage during transport and keep track of possible defects that could have consequences down the line after bonding.

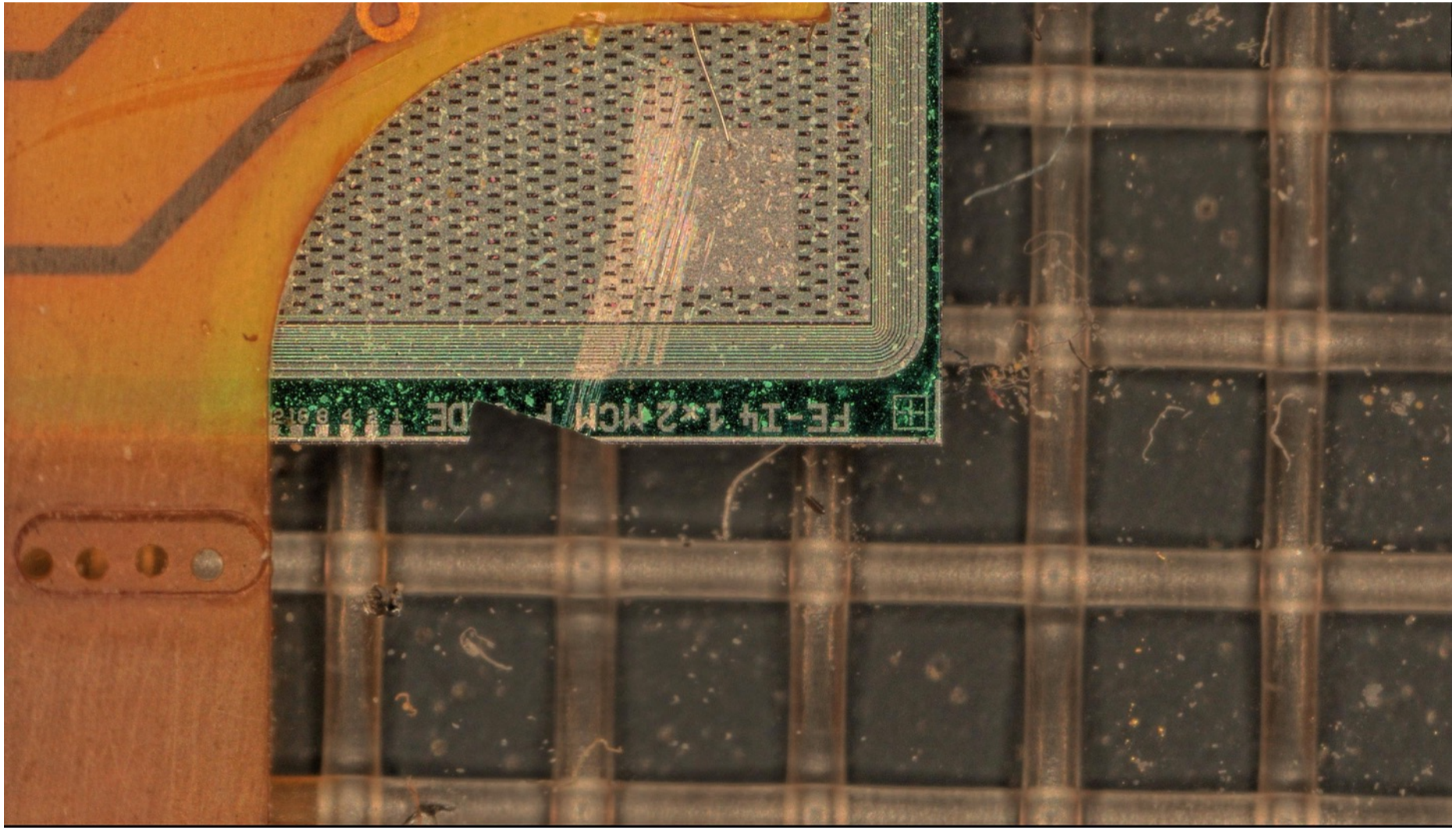
We are exploring the possibility to use machine learning in the production phase to accelerate inspection






INFN
GENOVA
SHUNT MODE
HV_PAD
NTC_S
PULLTEST
GND
VIN

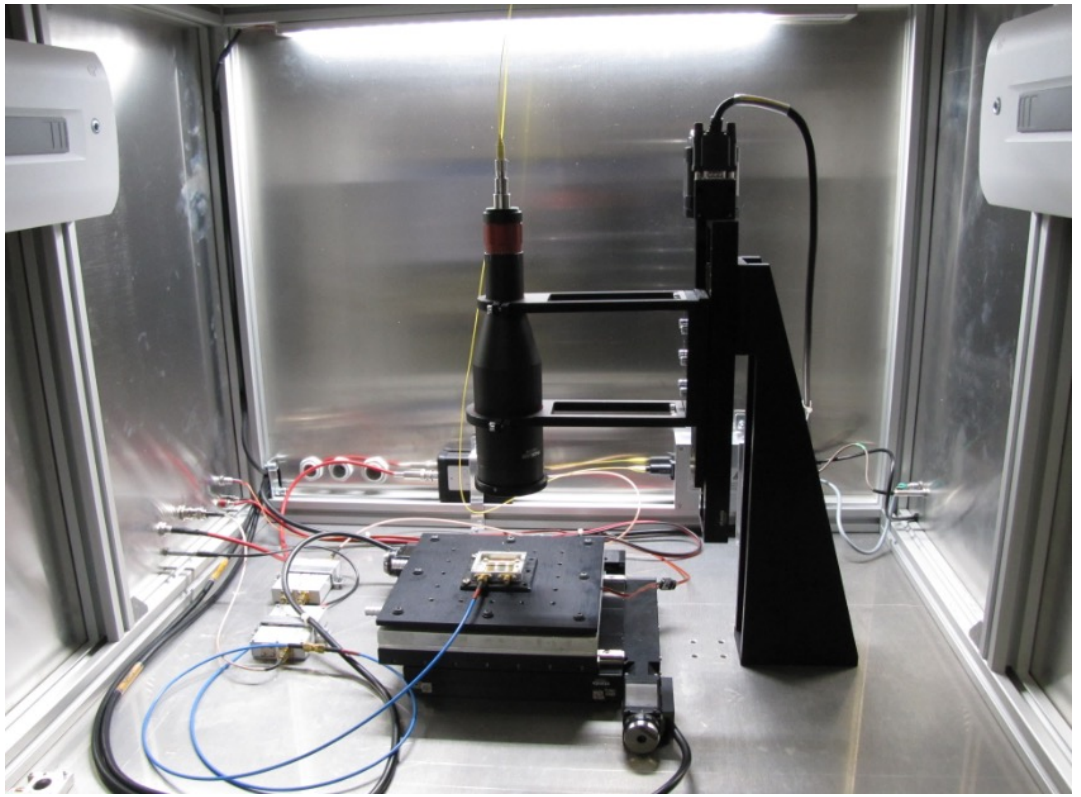
Visual inspection
QA Test setup



Source/Laser characterization QA Test setup

Samples selected to be taken out of production for testing will be assembled on PCB for testing with a scanning laser setup

- 100X100mm scanning area
- 1064nm anf 550 nm pulsed laser, 350-4000 ps pulse
- Focus to ~10 µm spot
- Scanning axis to map response over sensor surface
- The setup will be equipped with Peltier and chiller for operation at -20C after irradiation
- Laser system from Particulars
- Chiller, amplifiers, power supplies and table for the test setup after irradiation



Next steps

- Thermo-mechanical dummies need to be produced to advance the interconnect for fTOF
  - Key building block for thermo-mechanical prototype (FY24-25)
  - Allow testing of assembly procedure, cooling, stress testing etc.
- EICROC1 will be the first available ASIC for functional module assembly
  - Targeting first functional module in FY25
  - Subsequent iteration with EICROC2-3 in FY25-26
- Module assembly production Q2-FY25 -> Q1 2029