SWTEST

PROBE TODAY, FOR TOMORROW

2025 CONFERENCE

Ultra-low leakage probe card for wafer parametric testing enabled by µ3D printing

EXADDON

SYNERGIE CAD GROUP

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Content

- Recap: µ3D probe printing
- History: from innovation to industrialization
- Goal: ultra-low leakage probe card
- Method: from simulation to test
- Result: ultra-low leakage probe card
- Discussion: pros and cons
- Summary: more than one solution
- Follow-on work: more than ultra-low leakage

Recap: µ3D probe printing

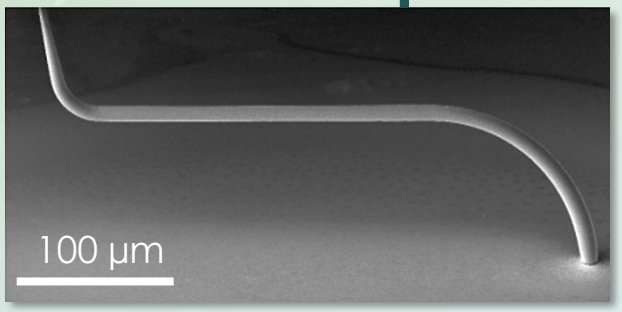
3D printing cantilever
Width: 1/3 of a human hair

3D printing nozzle
Opening 500nm

3D printable shape
“Any”. From cantilever to springs

Recap: µ3D probe printing

3D scaffold printing



Diameter

From few to tens of microns and tuneable along the probe

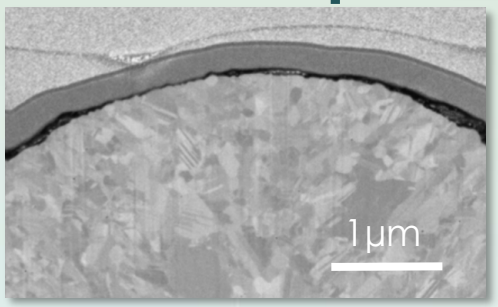
Length

From tens to hundreds of microns

Shape

“Any”. From cantilever to springs

Material quality



Material density

> 99%, homogeneous

Mechanical strength

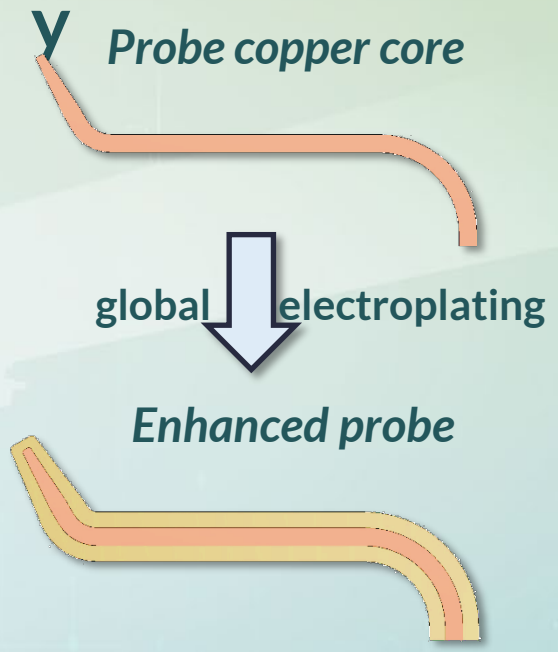
Yield stress in line with cold drawn copper

Electrical conductivity

> 87% of bulk copper

=> Pure copper metal

Tunabilit y

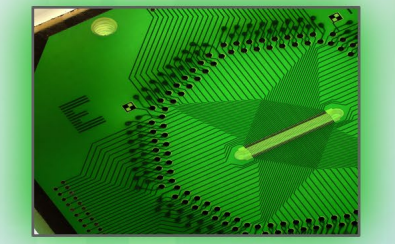


=> Adding metal shells
=> Tune stiffness & force
=> Contact resistance
=> Max. current

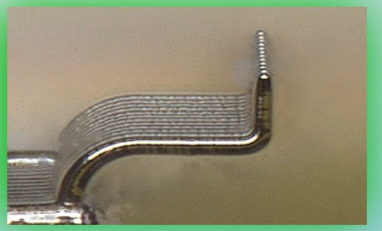
From innovation to industrialization

- 5500 B.C. Chalcolithic era (copper age)
- 2017 start of a new copper age, Exaddon micro metal object printing
  - Hardware and process development
  - Focus on scientific and R&D applications

- 2022 focus on semiconductor testing
- 2023 presenting first µ3D printed probes
- 2024 µLED wafer testing with 3D printed probes



- 2025 ultra-low leakage probe card with 3D printed probes
  - production ramp up µLED & parametric testing



Goal: Ultra-low leakage probe card via µ3D printing

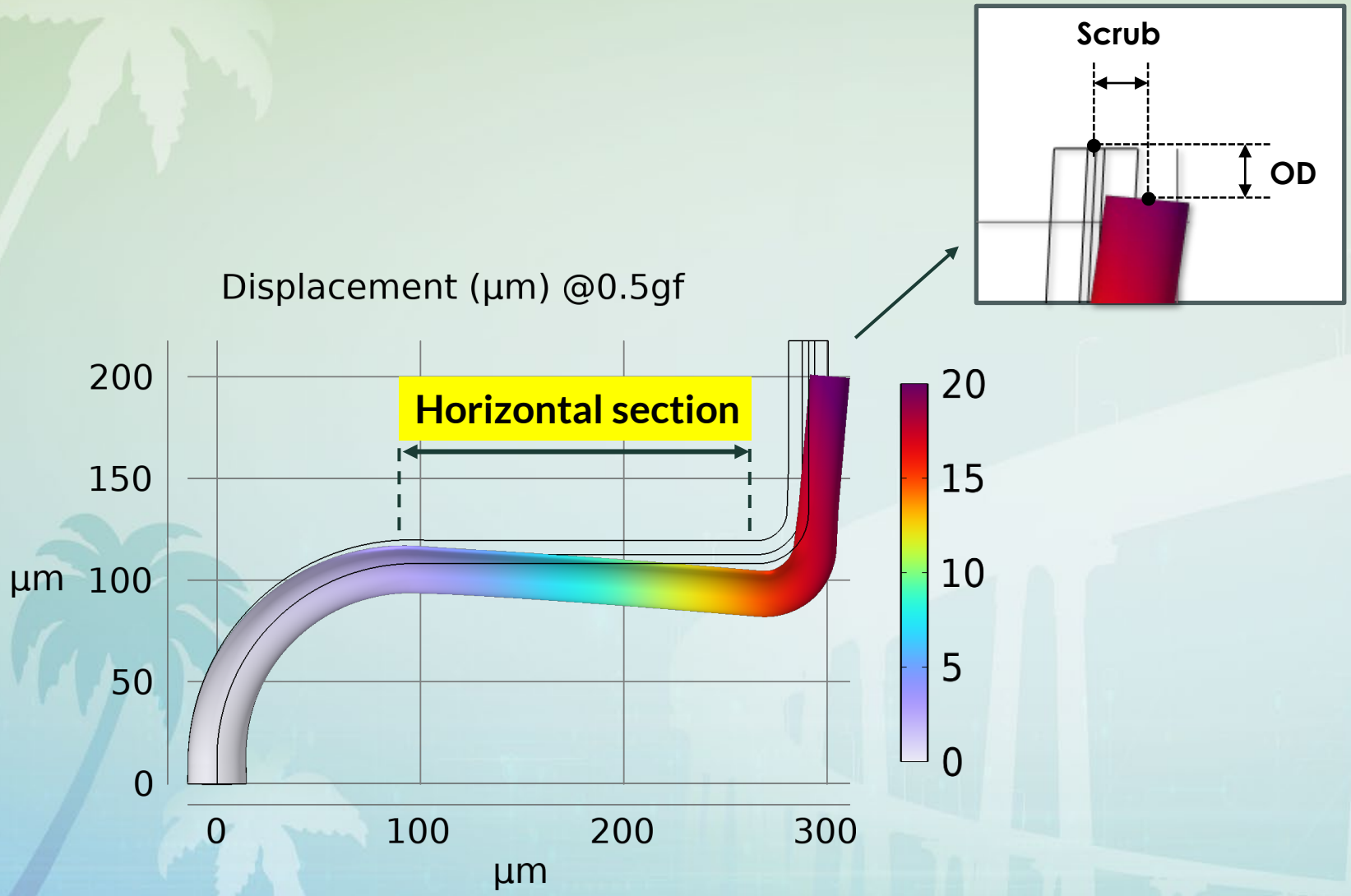
- Achieve background ultra-low leakage < 1 fA/V
  - for sensitive applications (e.g., CMOS, MEMS)
- Enable 30 × 30 µm² test pads through minimized scrub
  - Creating 50% less trench width, and reducing product cost
- Introduce modular, replaceable (in minutes) probes
  - With precise force control to prevent pad / chip damage

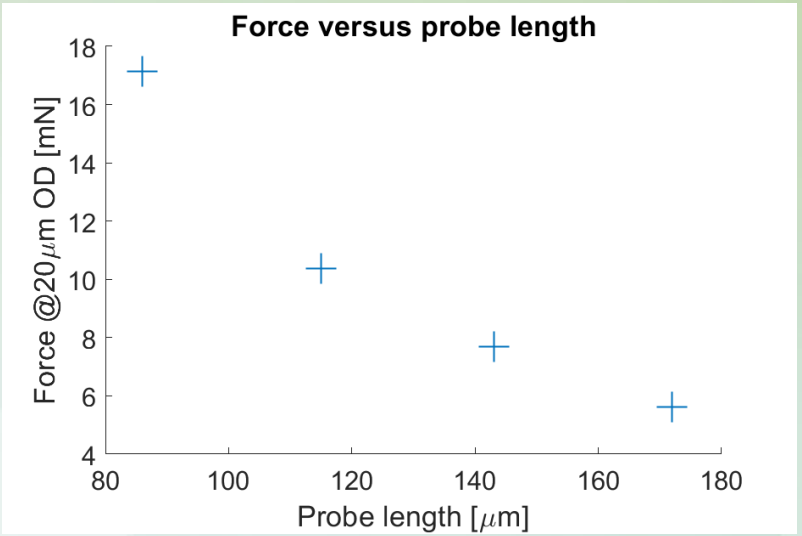
=> Establish µ3D printing as a scalable solution

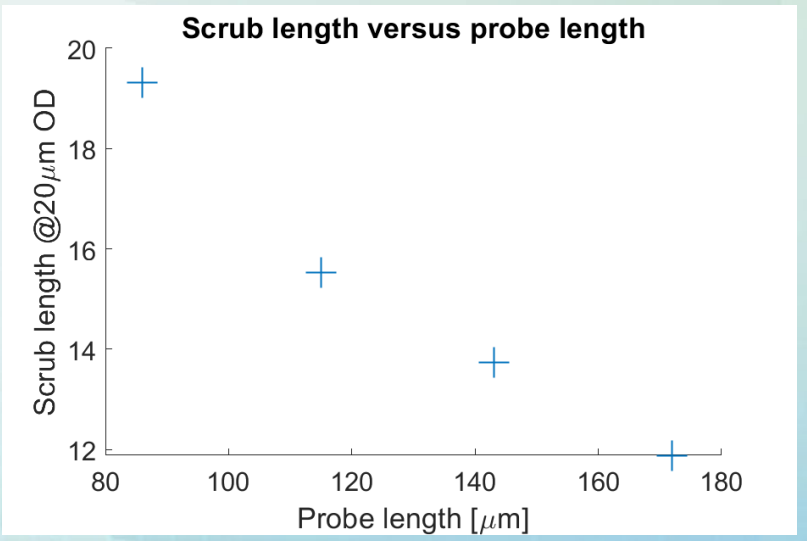
- For advanced parametric probe cards

Simulation

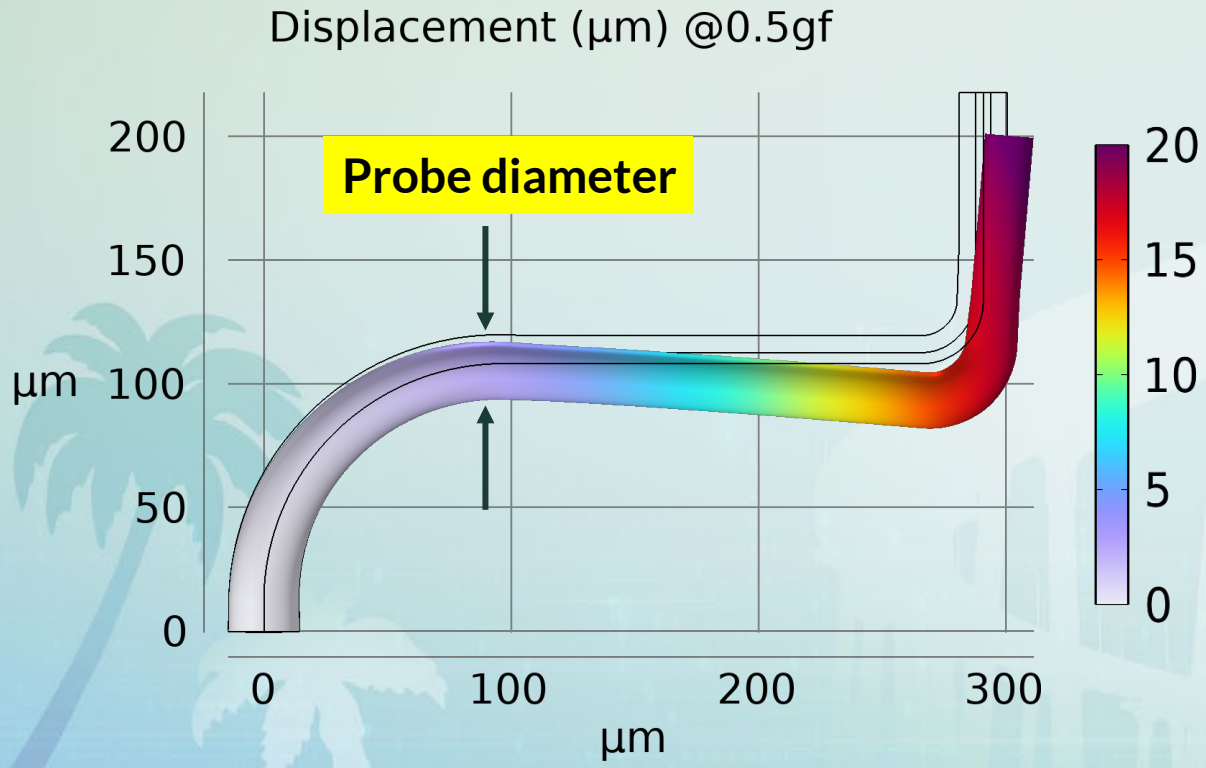
Impact of the probe geometry

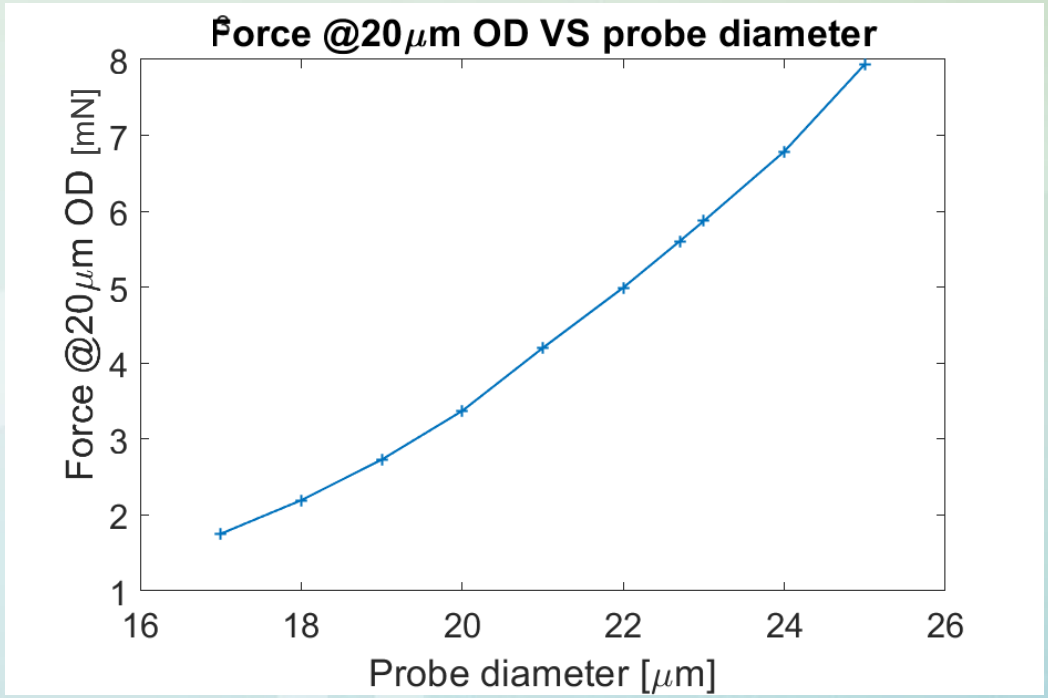






Impact of the probe diameter



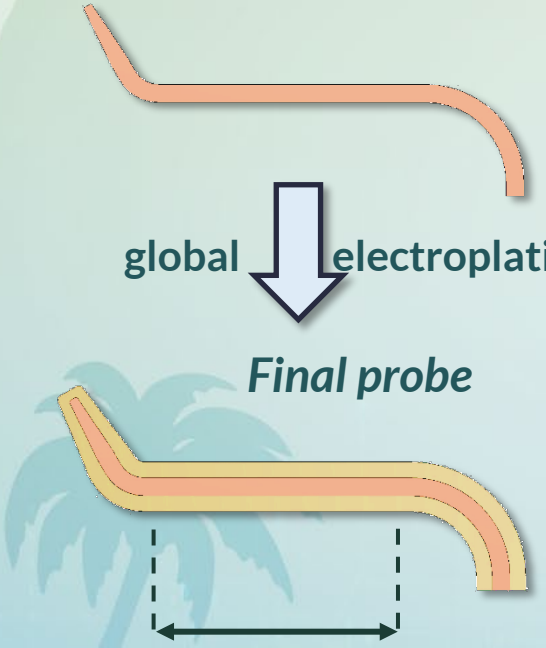


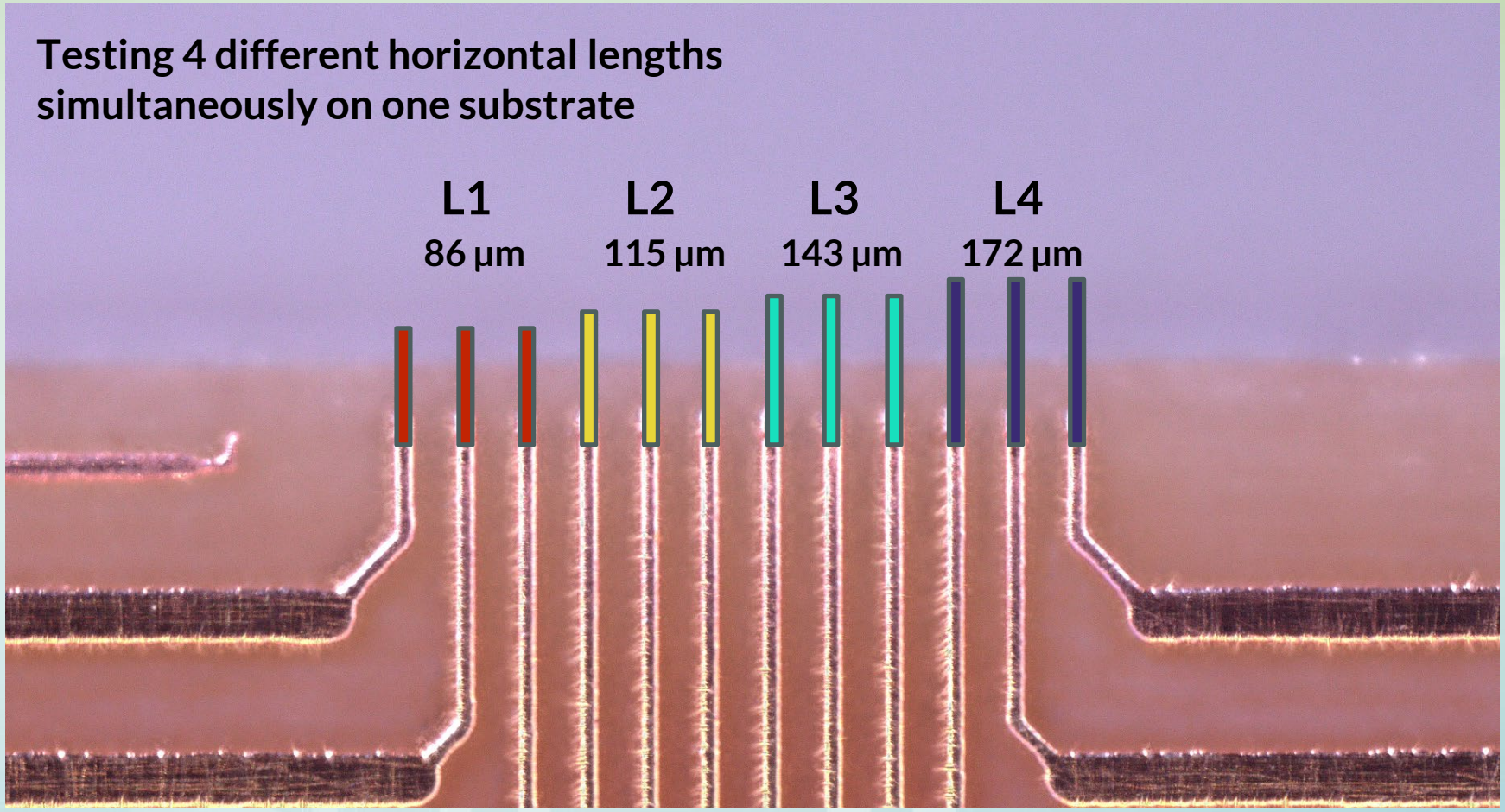
DOE and Fabrication

Experimental validation - DOE

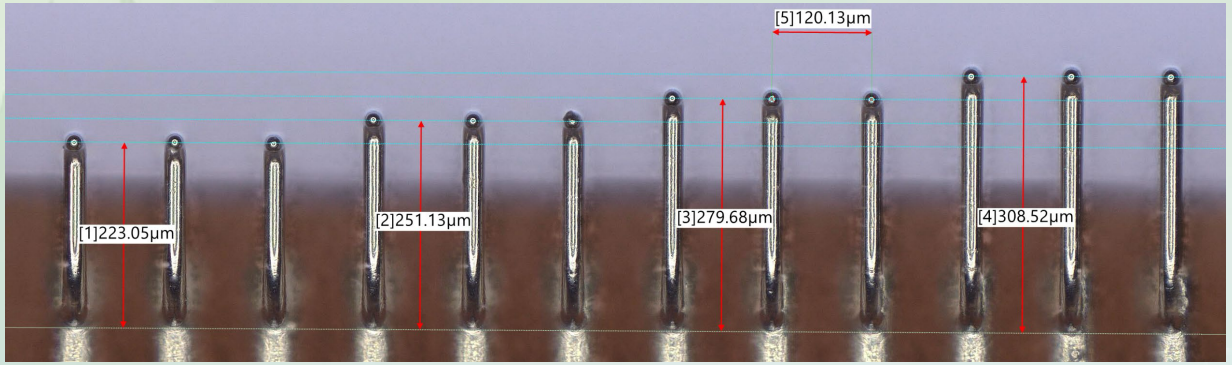
Fabrication

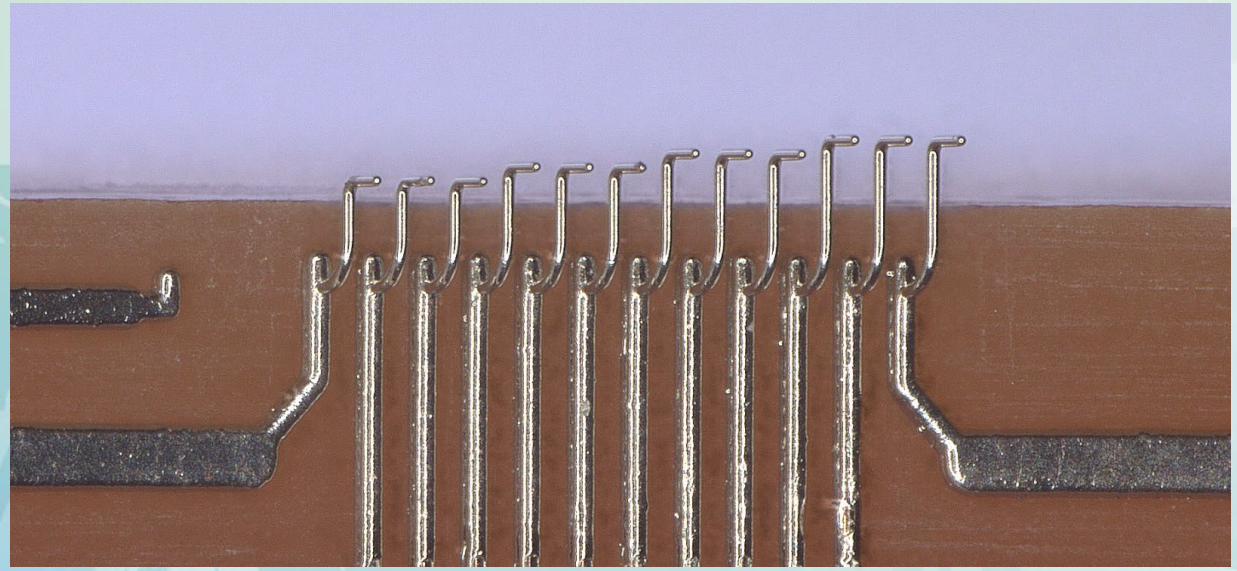
3D printed probe copper core

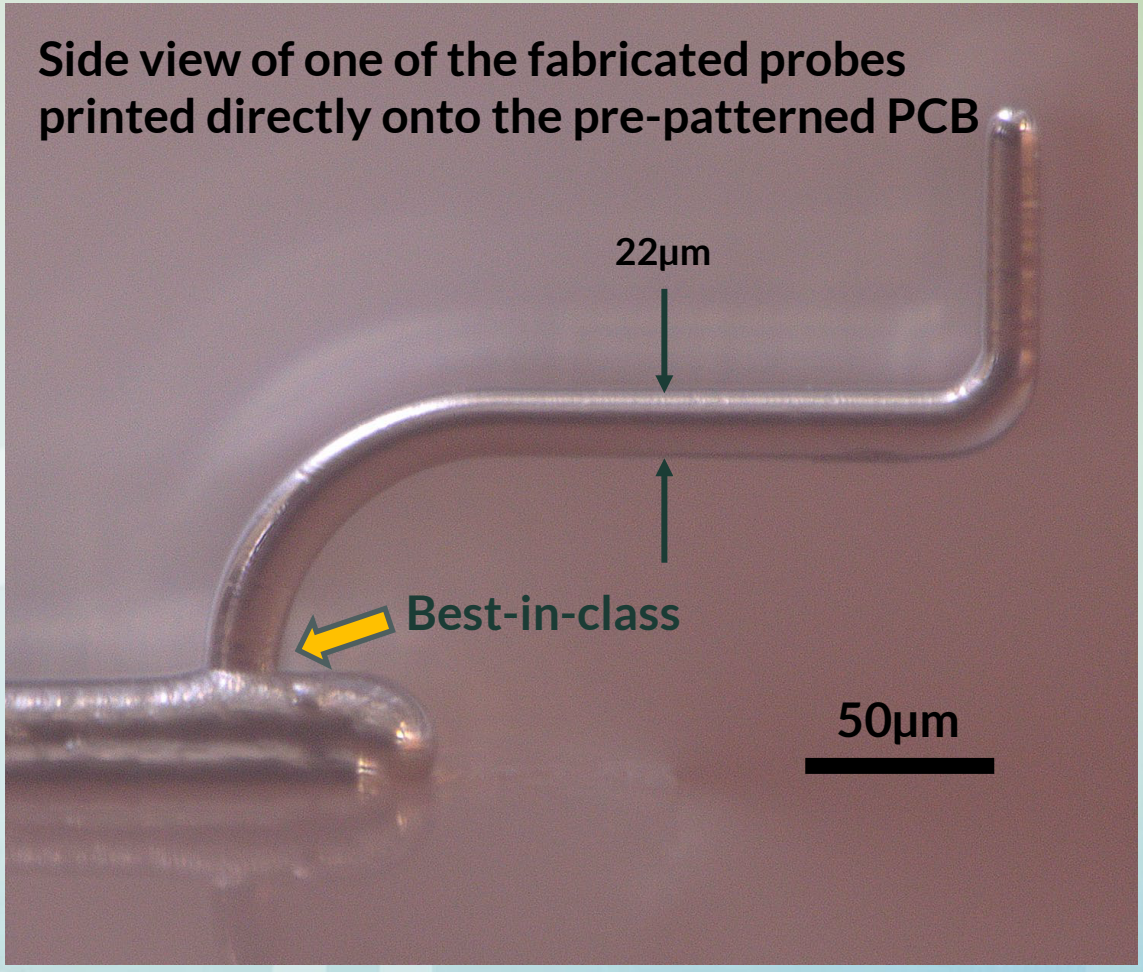




Experimental validation - FAB

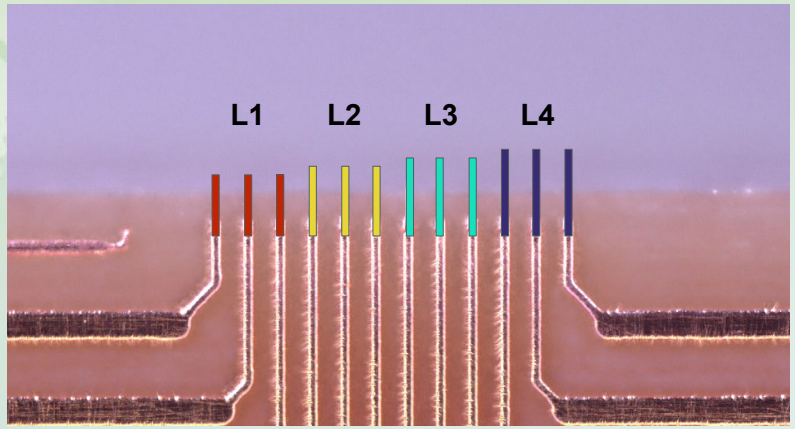


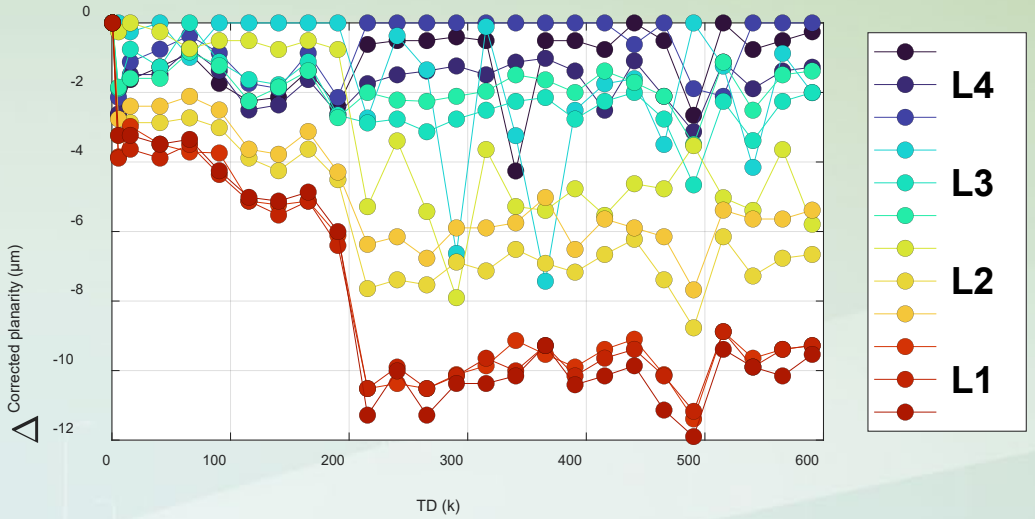




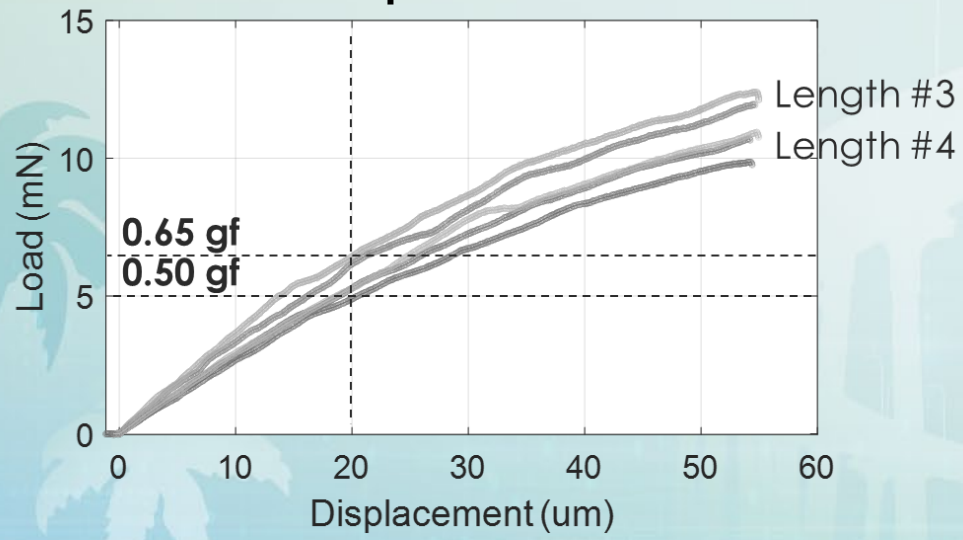
Testing

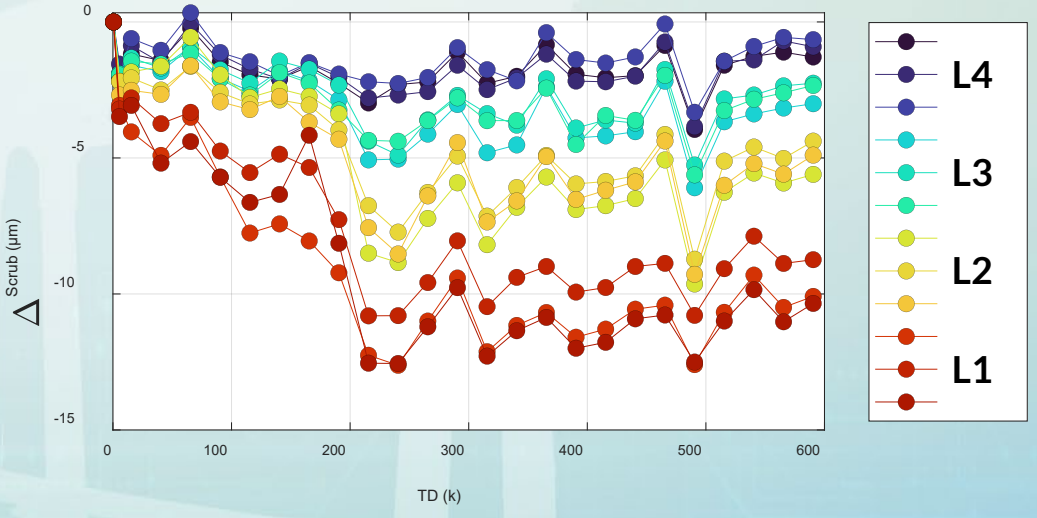
Results @20 µm OD





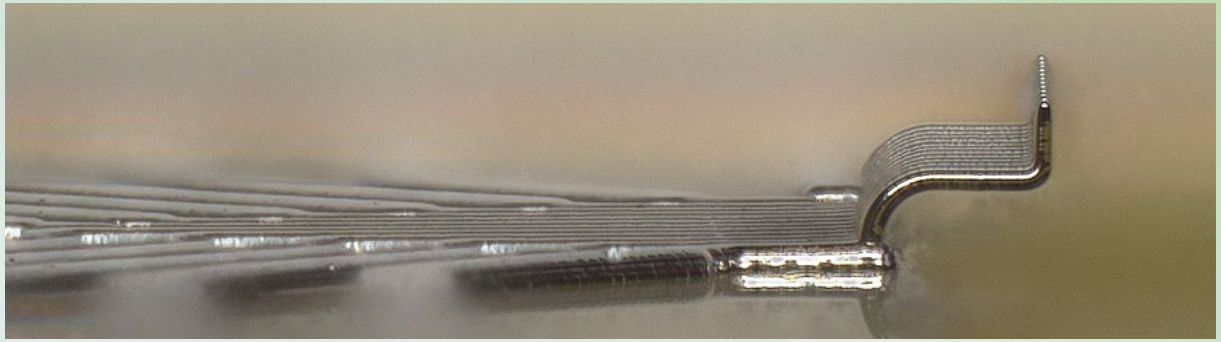
Load-displacement curve

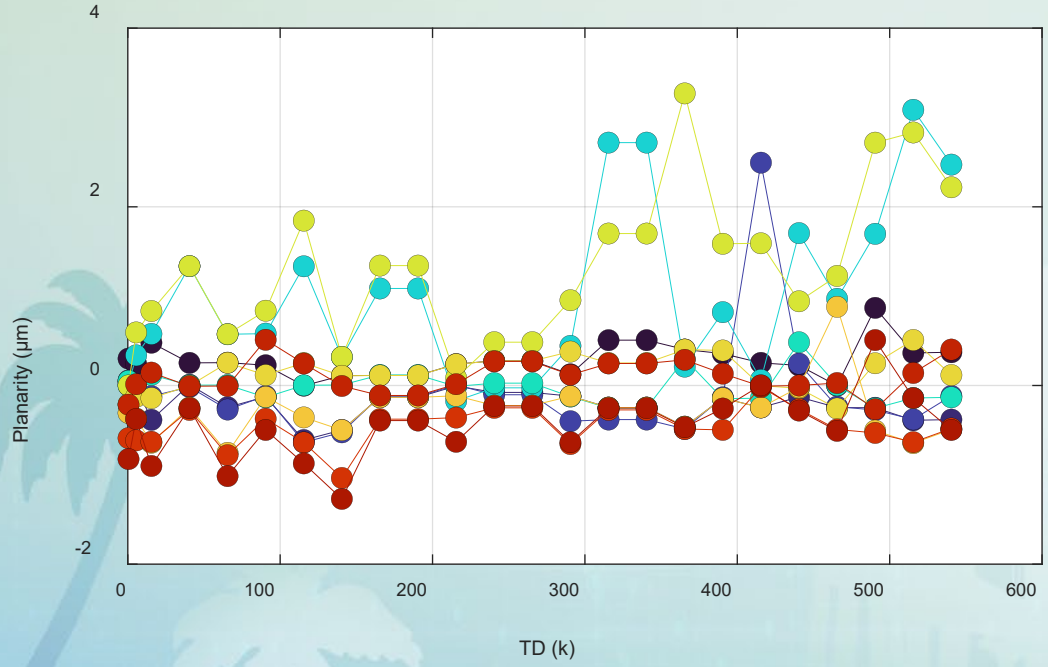


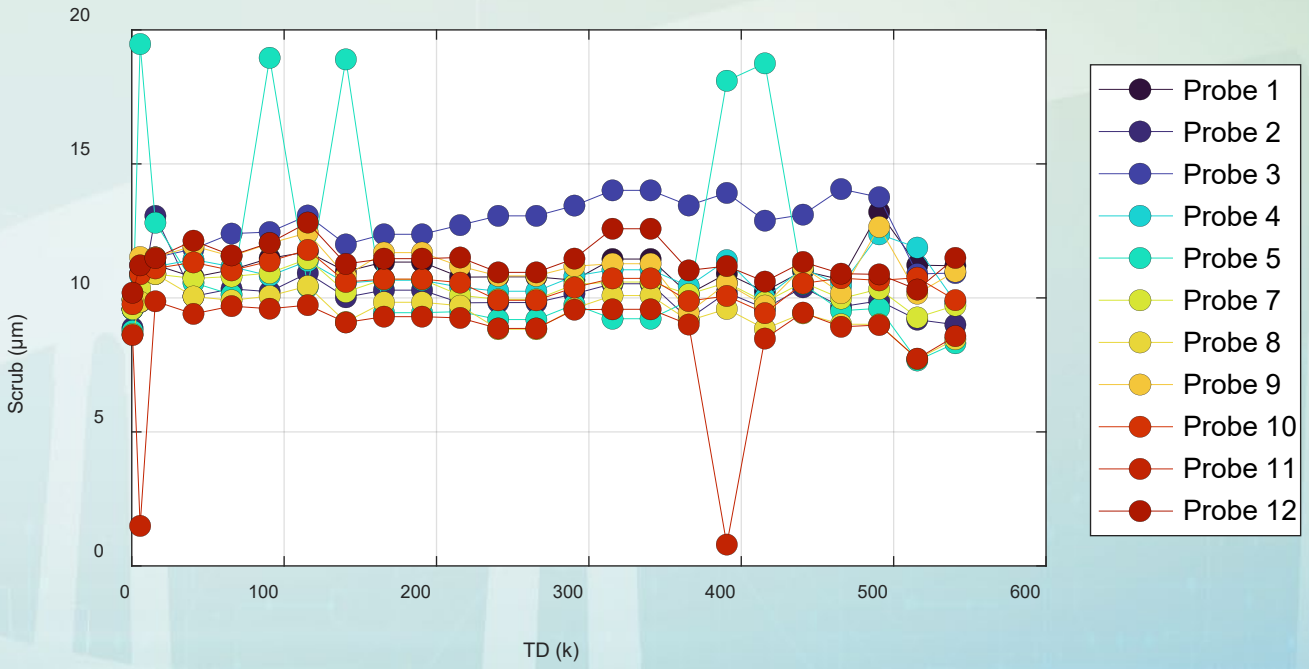


Validation and performances of L4 geometry

A new probe head with a set of L4 probes only has been manufactured and has put under test.
Results confirms that planarity, scrub length and tip shape are not significantly altered after 0.5M+ Touchdowns.

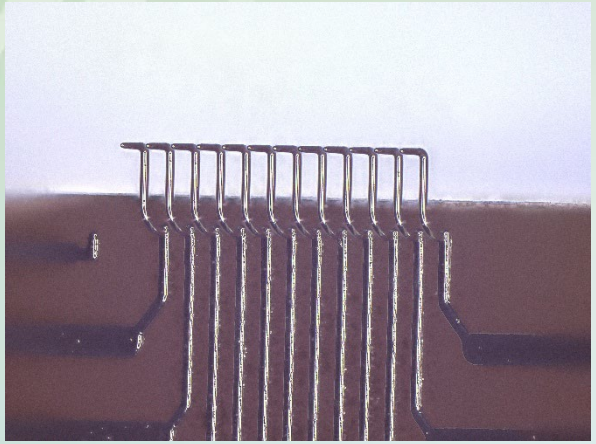






Fluctuations are due to errors in the measurements

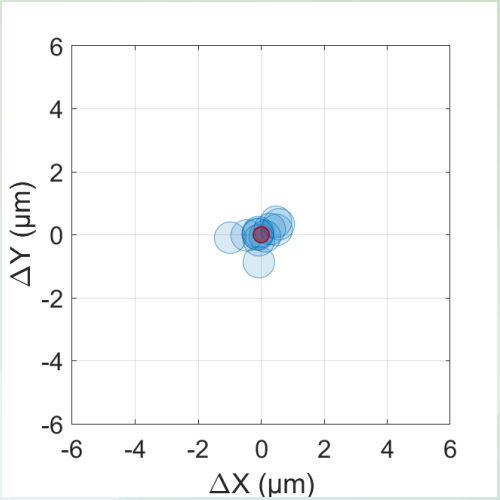
Parametric test Probe head

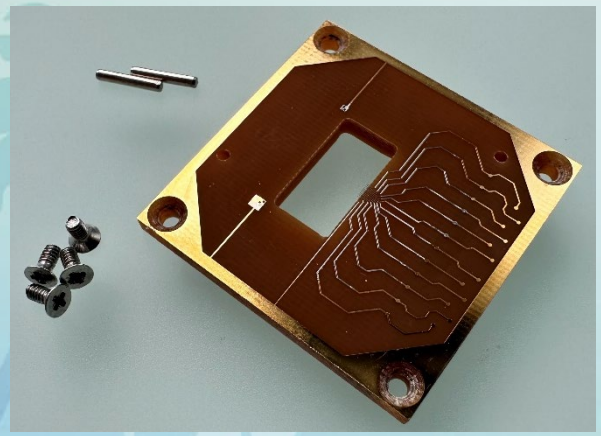


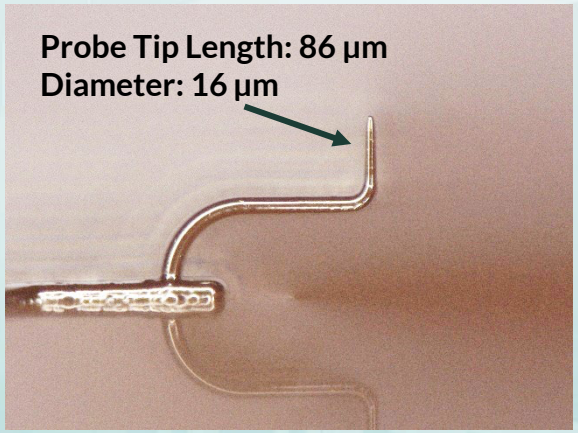
Final parametric test probe head characteristics:

- State-of-the-art tip positioning accuracy
- Force @20 µm OD: 0.5-0.8 gf range
- Scrub length @20 µm OD: ~10 µm
- Lifetime > 0.5M TD (tested)
- Opening window for easy alignment
- Long and narrow tip designed to fit small pads and access deep trenches

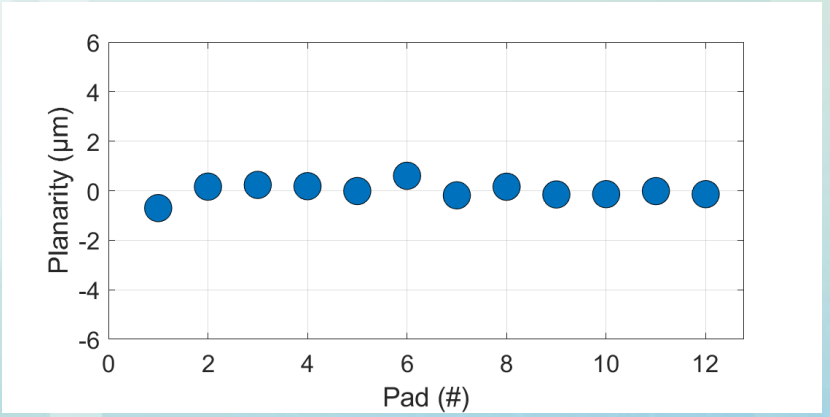
Horizontal tip positioning (XY)







Vertical tip positioning (Z planarity)

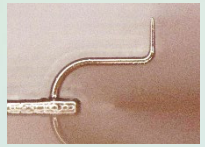


Modularity

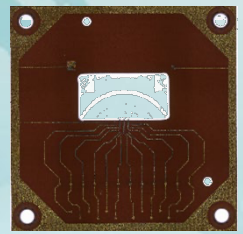
Probe card - Modularity

Manufacturing the probe head
(3D printing probes onto µPCB)

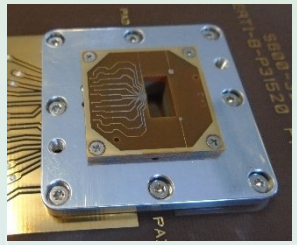
3D printed probes



µPCB



Assembling the probe head
(4 screws)

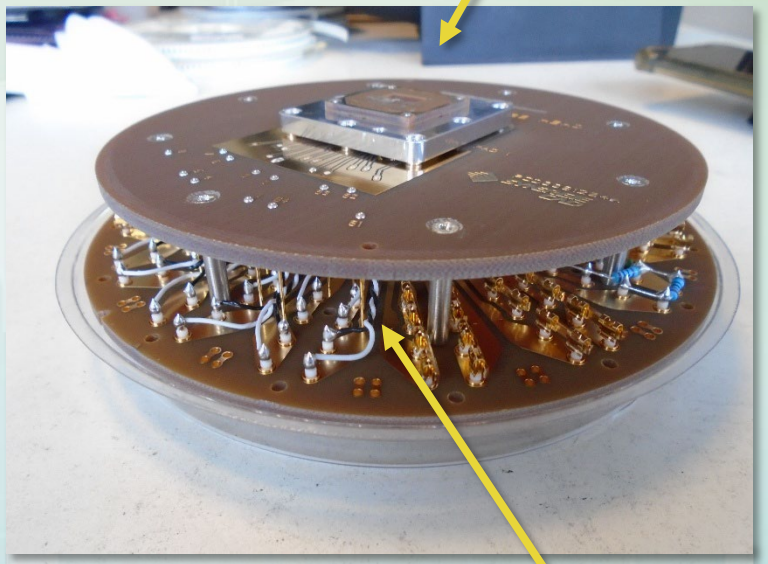


Probe head

interposer

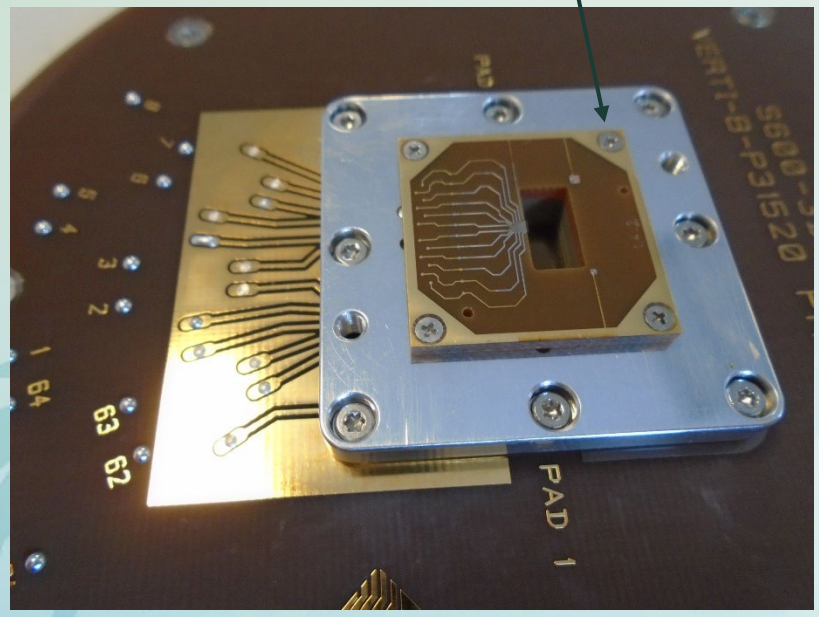
Docking board (main PCB)

Full assembly



Replaceability

Screws x4



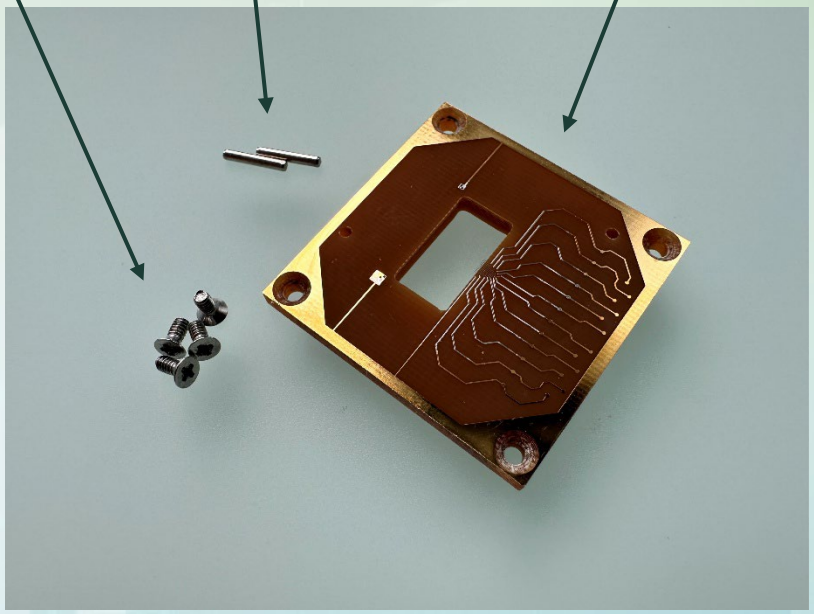
10 min

- Most efficient replacement
- Low cost, quick replacement
- No need for specifically specialized engineers

2 locating pins

4 screws

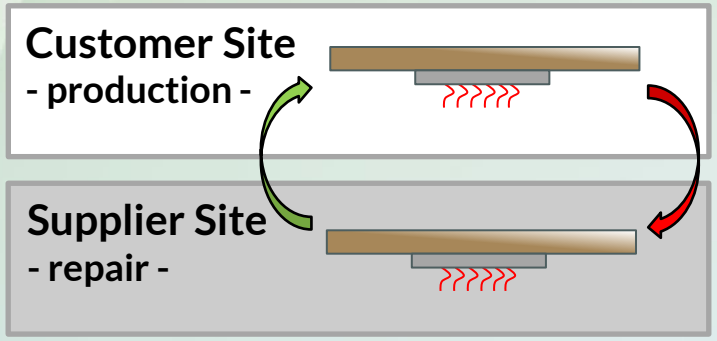
Probe head



Compatible with *in-vacuum* or *inert atmosphere* storage

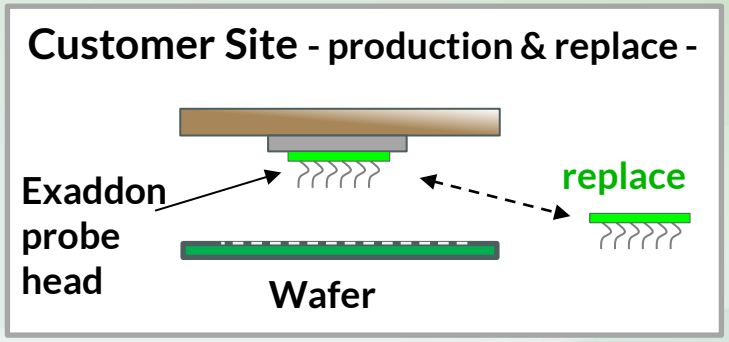
Probe card versatility

Traditional Probe Card Exchange



- ✗ Replace with twin probe card
- ✗ Redundant cards or long downtime
- ✗ Variable performance between cards
- ✗ High overhead (logistics, quality check)
- ✗ Bulky, difficult to storage: card tend to lose ultra-low leakage performances due to adsorbed water and contaminants

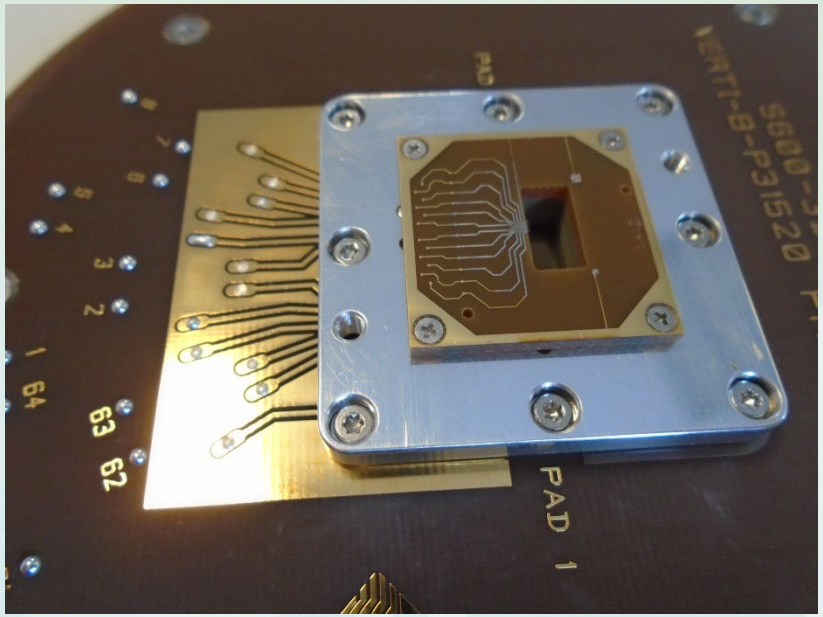
Exaddon Probe Head Exchange



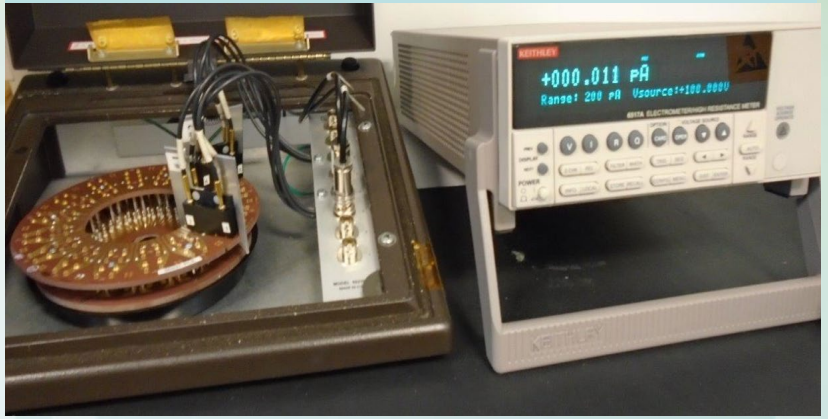
- ✓ Quick, easy replacement process
- ✓ Lower CAPEX, near-zero downtime
- ✓ Consistent performance
- ✓ No overhead (logistics, quality check)
- ✓ Very compact, compatible with *in-vacuum* or inert atmosphere storage: retaining ultra-low leakage performances

Ultra-low leakage

Tested ultra-low leakage performances



Voltage test: 100V (Keithley S600)



Docking board

Background current: < **0.3 fA/V**

Docking board + µPCB (no probes)

Background current: < **0.7 fA/V**

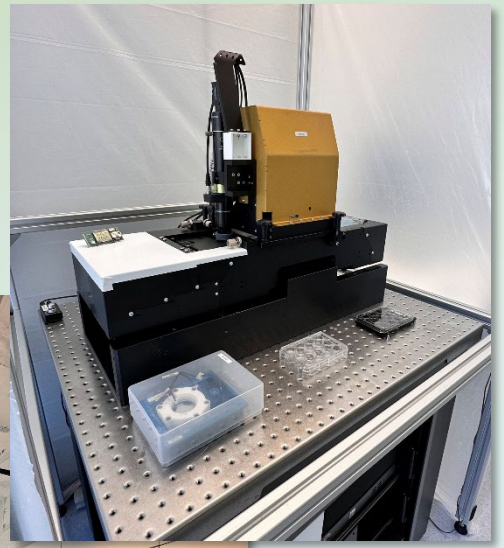
Docking board + µPCB + Probes

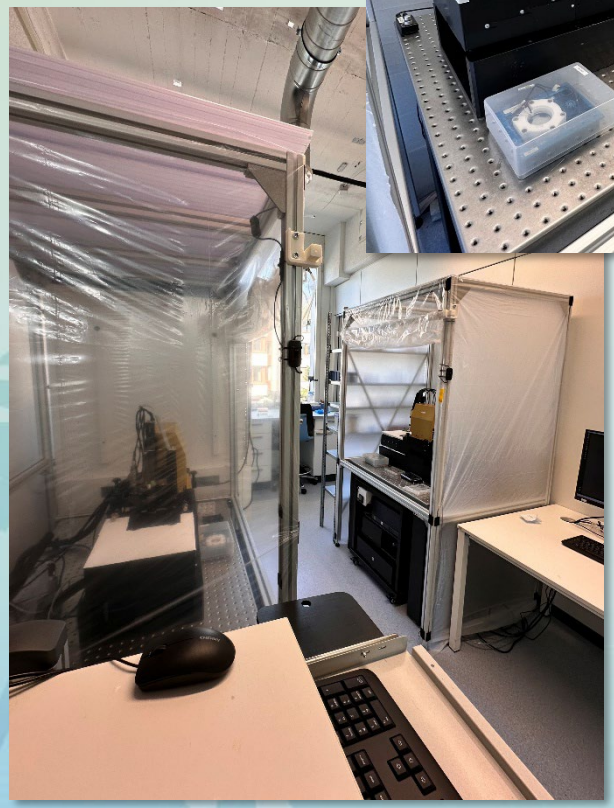
Background current: < **0.8 fA/V**

Scalability

Innovation Pilot Line

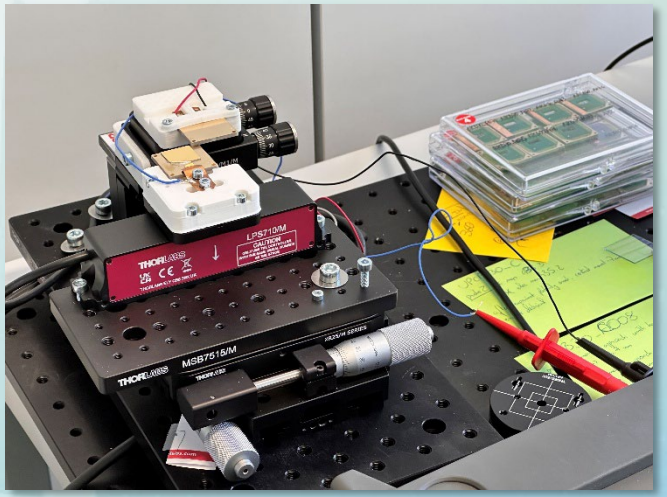
3D printers





Electroplating station

Quality control



Discussion

- State-of-the-art probe tip positioning
  - Due to 3D printer accuracy and print at place
- State-of-the-art leakage performance, easy to maintain
- Modularity introduces an industry paradigm shift:
  - From slow and costly repair to quick and convenient replacement
  - Changing test layouts within minutes
- No single probe repair possible – is it really needed?
  - Due to the manufacturing process, but also pitch and accuracy

Summary

- Parametric Probe card
- Ultra-low leakage < 1 fA/V
- Minimized scrub
- Modular concept
- Manufacturing ability

Follow-On work

- Next Gen. Parametric Probe Cards
- More probes >12 and up to 64
- New products (besides next-gen microLED)

=> Innovation …

=> to Industrialization

Thank you!

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