Development of a Novel Low-Mass Flip-Chip-Capable Module Flex PCB

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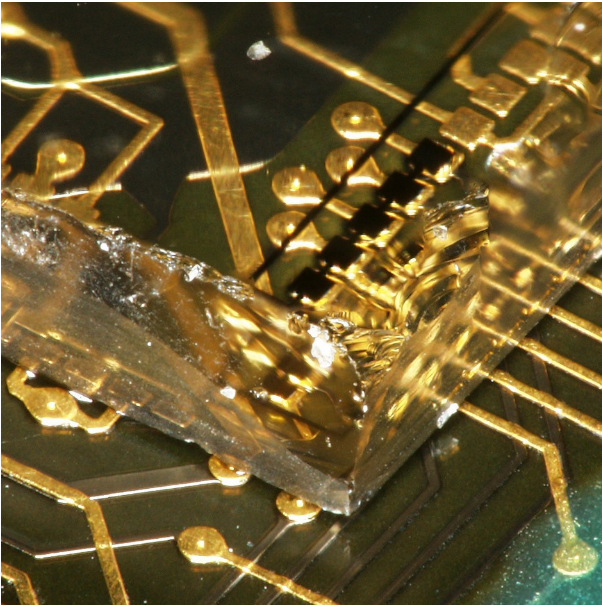
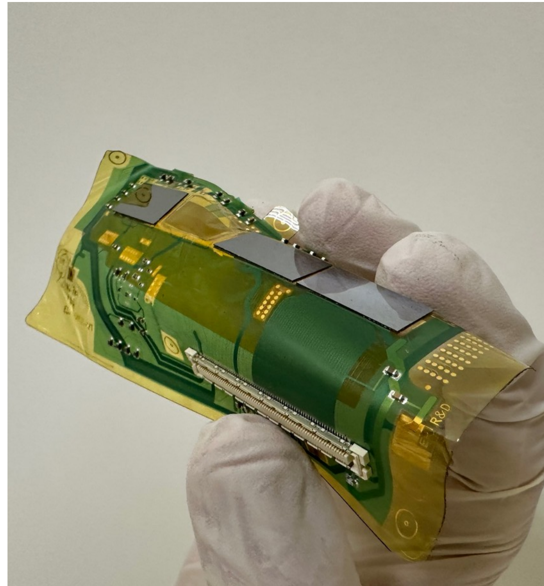
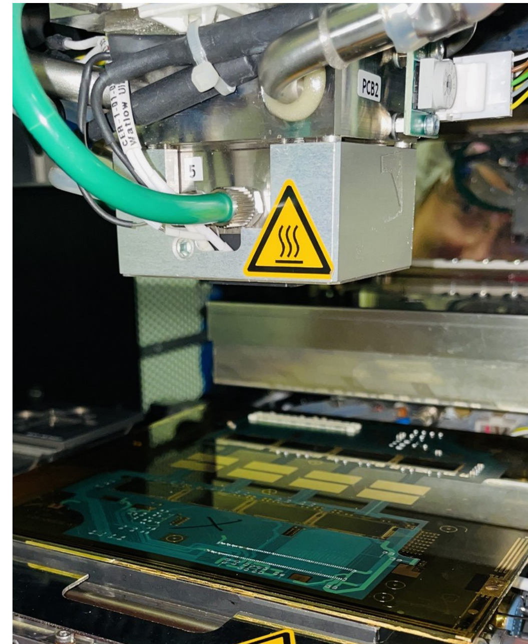
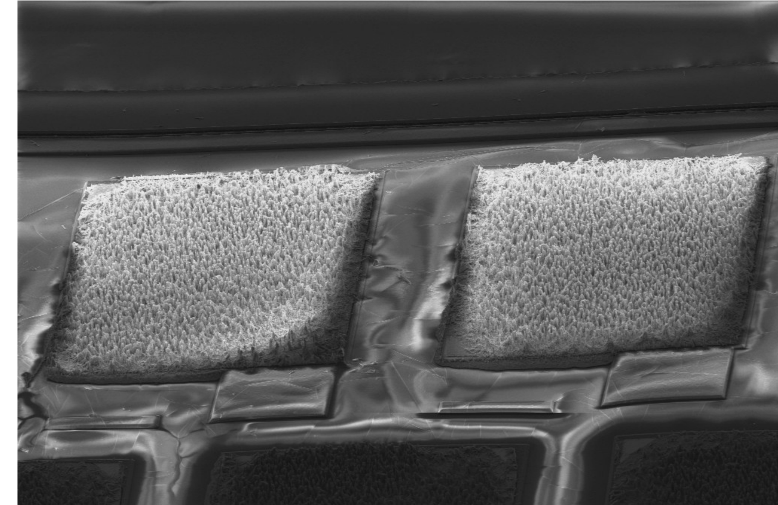








Outline

EP R&D CERN

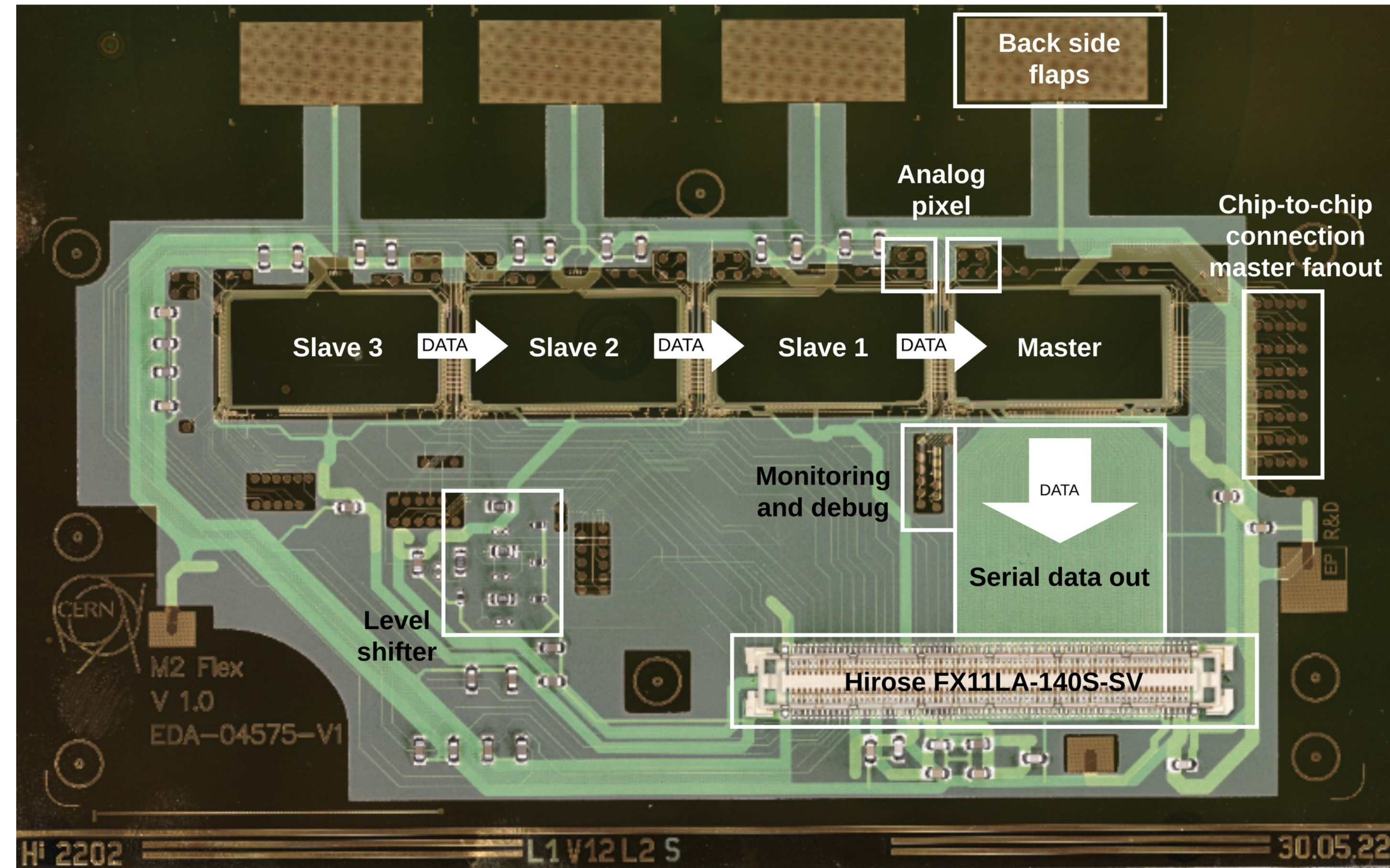
Thin-film Flexible PCB	• Concept and design • First electrical and mechanical tests
Interconnection technologies	• Overview • Pre-bonding verification
Results and Outlook	• Forceless flex detachment • Further development

Goal: Flexible, low material, dense and reliable modules

Flex Demonstrator Overview

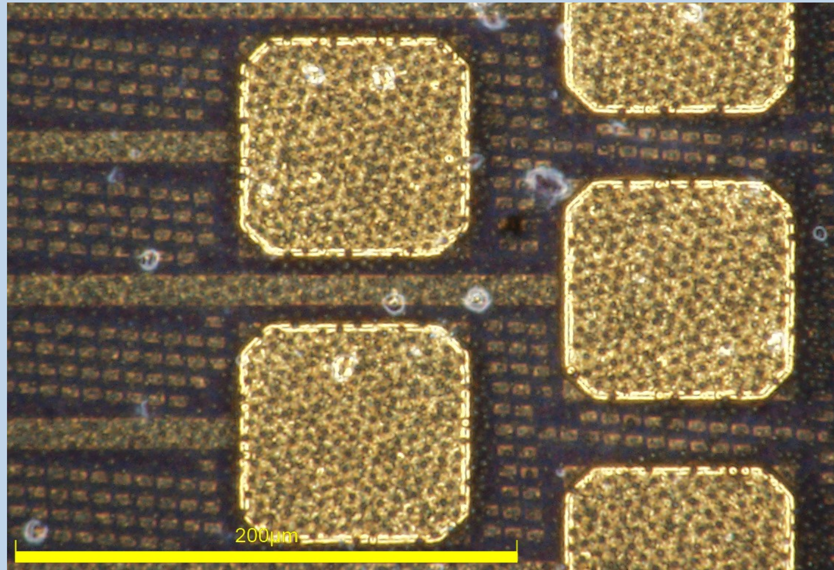
The manufactured flex provides:

- Manufacturing **low-mass**, highly flexible PCB
- **Demonstrating a dense integration of silicon pixel chips**
- **Two-layer** layout ~30µm high with 17µm trace width and spacing
- Data **transfer from chip-to-chip**
- Individual powering with **500mA per chip**
- 140 pin **connector** for lab tests
- Integrated **back side flaps** providing bias voltage
- Inclusion of **debug pads** and data fan-outs



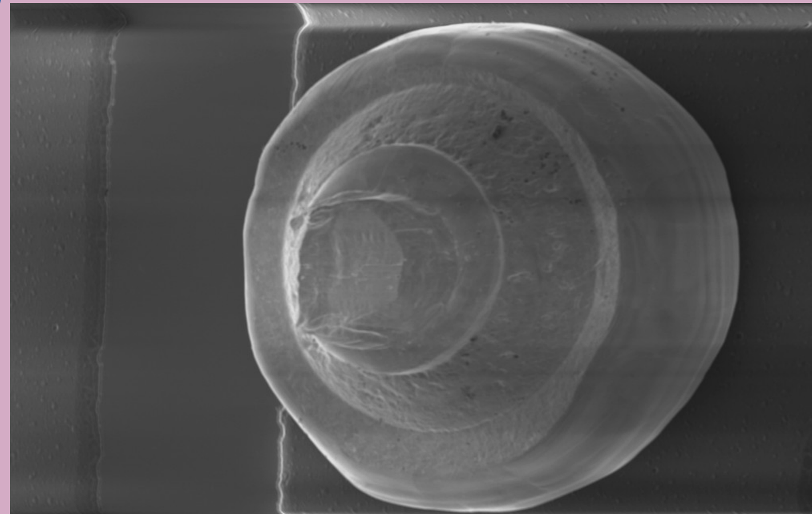
Interconnection Technologies for Flip-chip

ACF



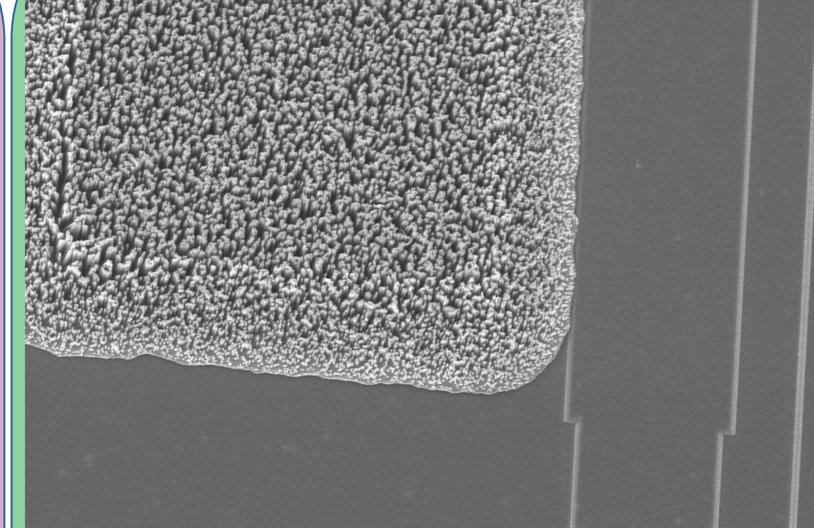
- **Cost effective**
- **In-house** processing
- **No mask** needed

Gold studs



- **Individual** pad selectable
- **Touch before** bond possible
- **No mask** needed

Nano-wires (NW)



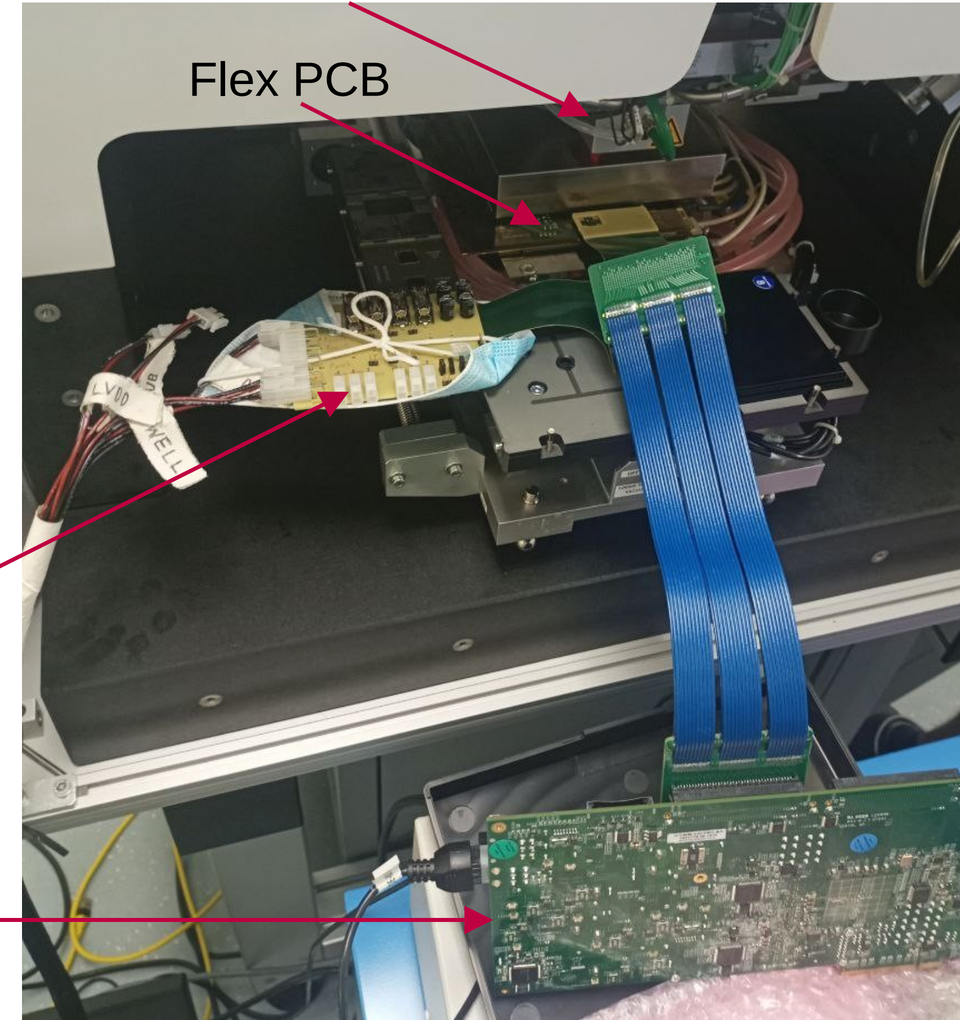
- Applicable for a **wide range of pad and spacing sizes**
- **Glue-free** process available
- **Chip** and **wafer** level

- **Scalable** on chip-chip or flex-chip
- **Glue support** for mechanical stability
- **Fast** interconnection
- Suitable for **large number of pads**

In-situ verification

- **Pre-bonding verification** is a crucial part on the track to flip chip modularization of large modules
- **Successfully tested** full pre-bond verification with powering and reading out chip before bonding
- Compatible with **gold studs** and **nano-wires**
- **Automation** for a larger scale production foreseen

Bond head with chip



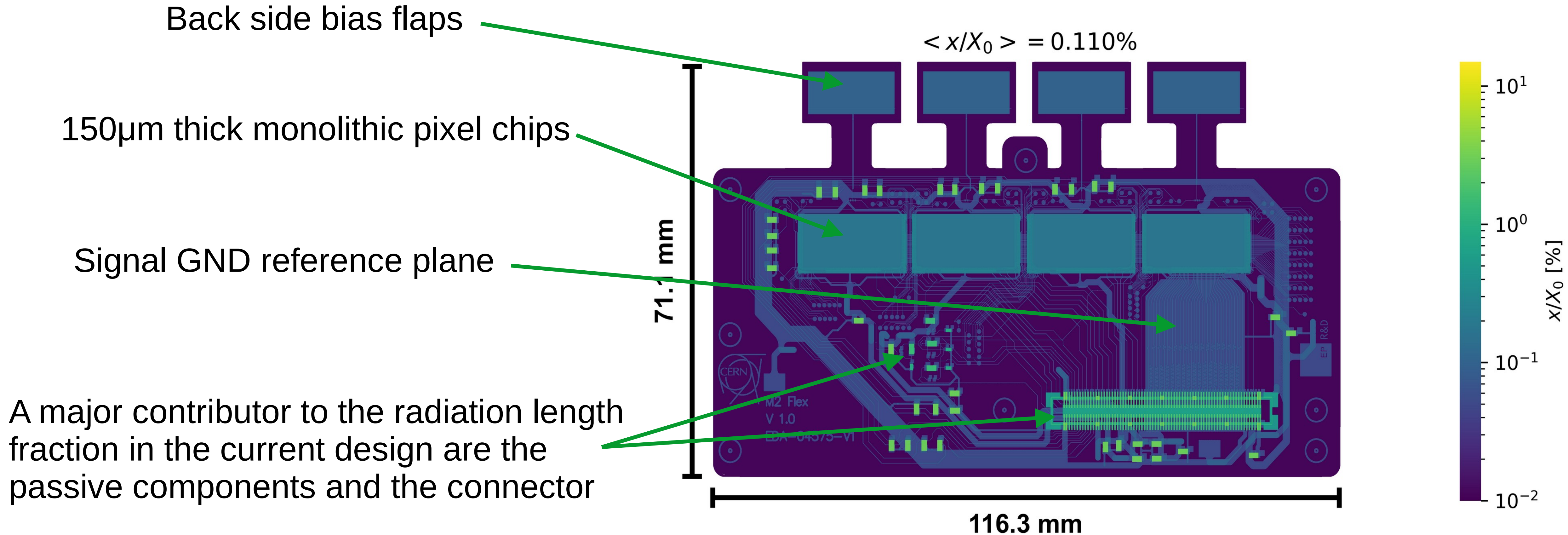
Power delivery board

Read out FPGA

Process steps:

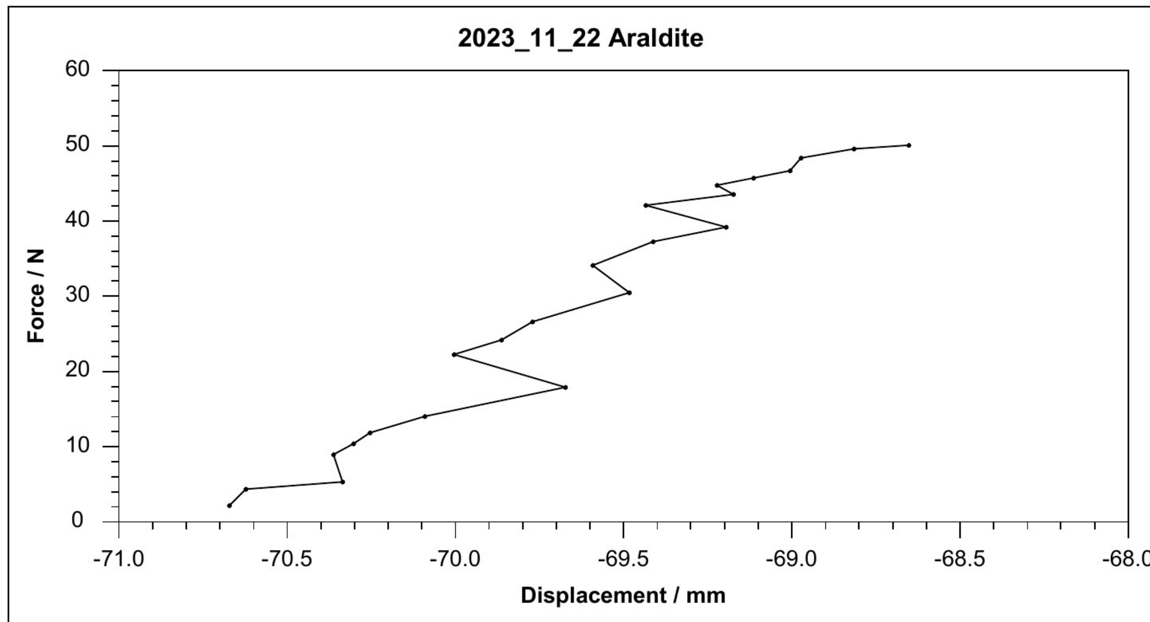
1) **Connect** Flex to power and read out
2) **Align** chip on bonehead with flex pads
3) **Hold** chip on flex with 0.5 x bond force
4) **Power** up chip and run **tests**
5) If chip OK, start **bonding** procedure, else **replace**

Calculated Material Budget



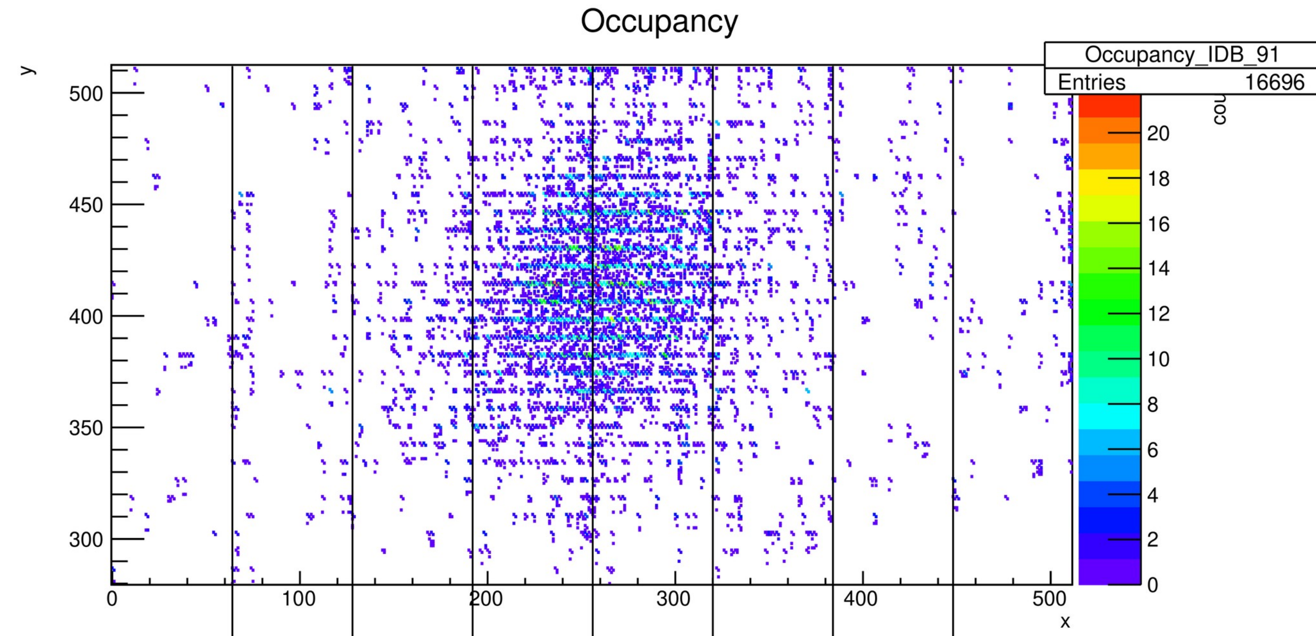
First Tests

Mechanical



- **Araldite 2011** as under fill
- **Pull force** to detach a chip from the flex **>50N**
- The used under fill is **compatible** with all shown interconnection technologies

Electrical

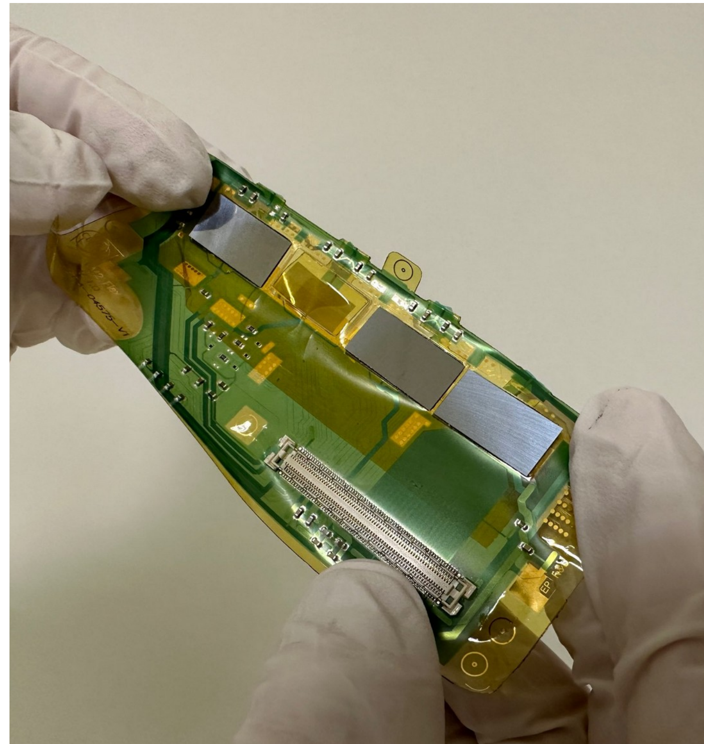


- Hit map of a Sr90 source on master chip bonded to flex
- Demonstrating a **successful communication** with the chip

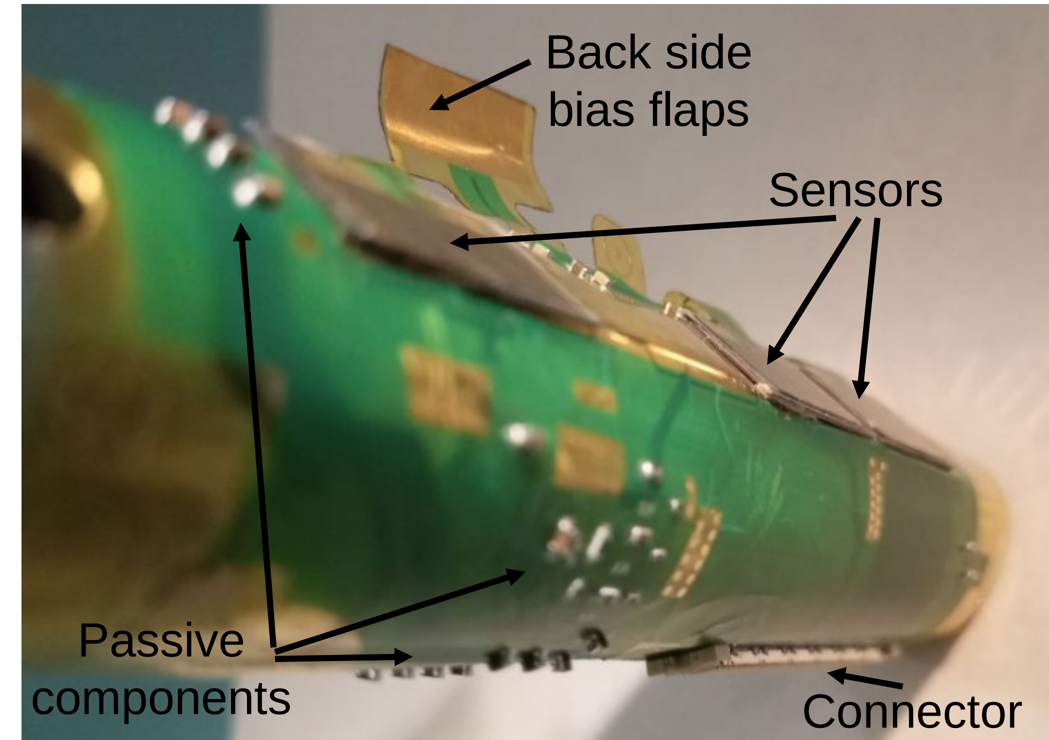
Detaching Flex

- Detachment from production carrier conducted **after flex assembly**
- **Force needed** for the detachment process, resulting in tension onto the polyamide
- Bonding on production carrier **preserves tolerances** during assembly

Testing and delamination

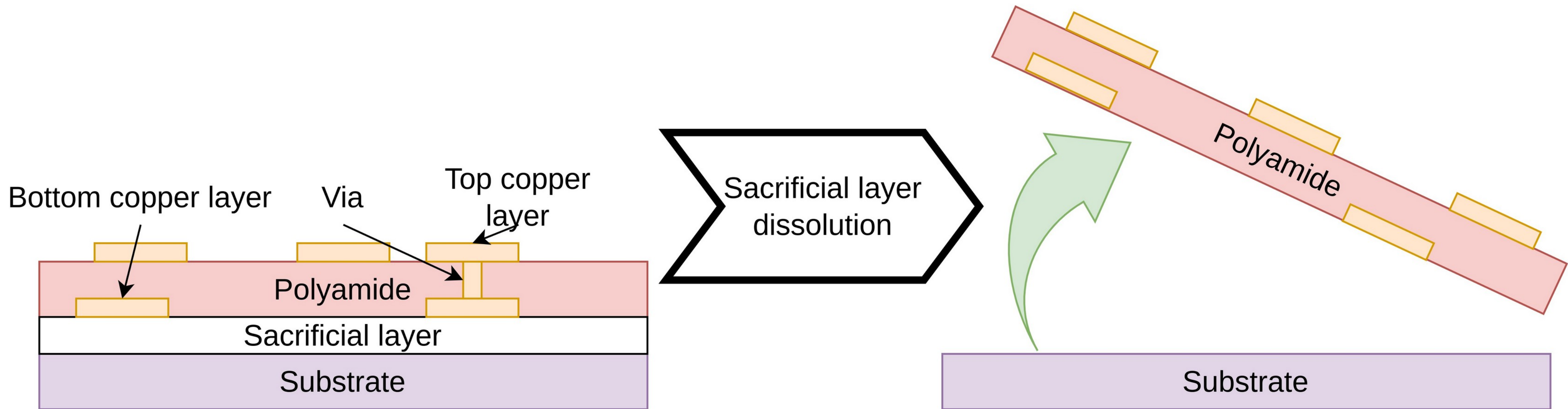


Detached flex



Detached flex around tube

Forceless flex-carrier separation



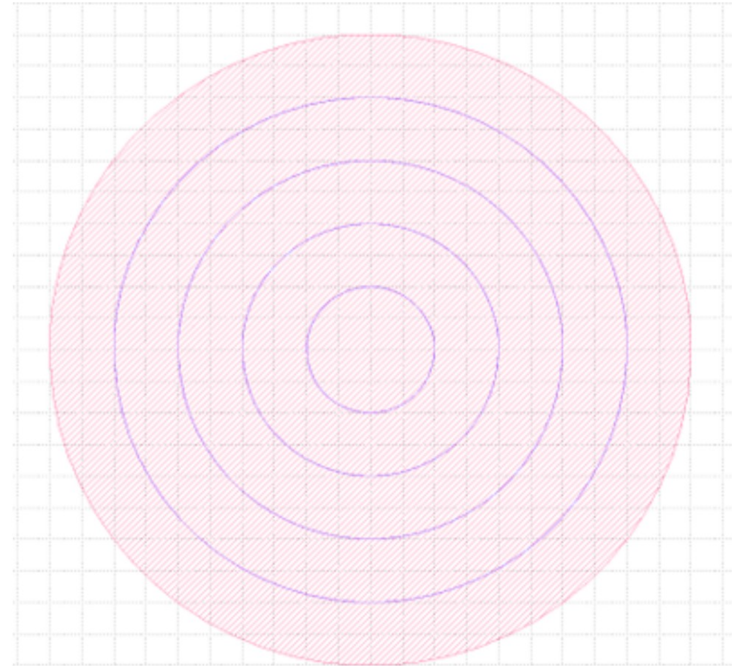
- **Forceless separation** process reducing stresses of the flex during detachment
- **Reducing mechanical deformation** of the flex during the separation process
- Potentially enabling the **manufacturing of pads on top and bottom** of the flex
- Reducing manual labor in **large scale manufacturing** processes
- In a first try, **aluminum** is used as sacrificial layer and **removed by electrolytic corrosion**

Separation prototype - design

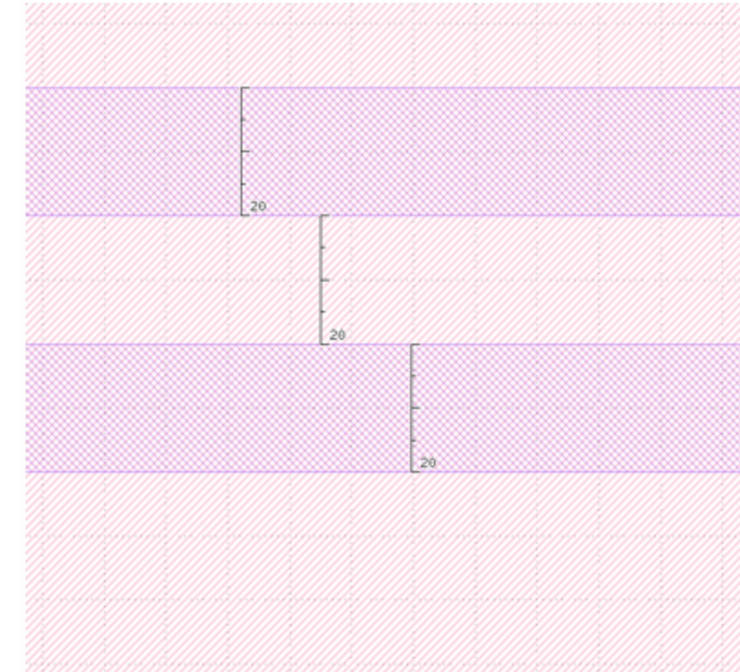
- Flex manufactured on **4 inch wafer**
- 4 **double ring** construction
- Testing the manufactur ability of **20µm track width and spacing**
- Testing **forceless detachment**
- Manufactured by the summer student Maria Sousa at **Campus Biotech**

campus biotech

Fondation Campus Biotech Geneva +

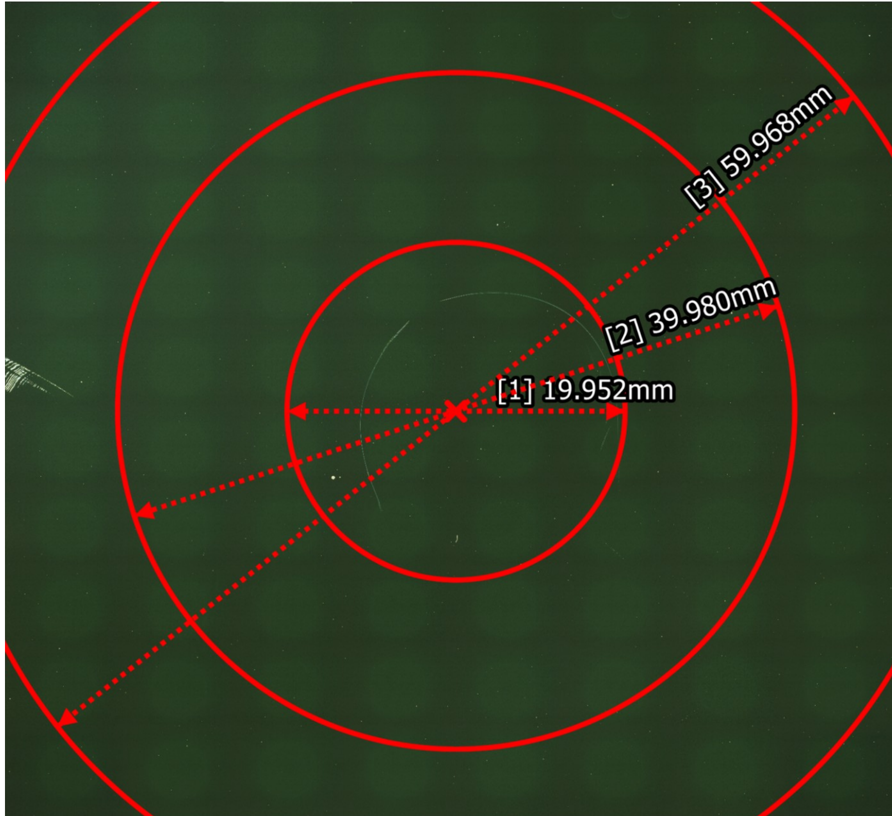


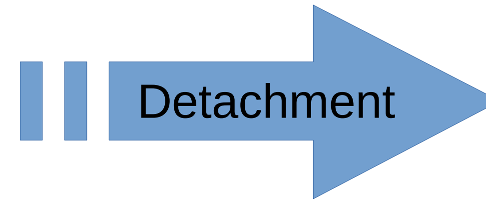
Double ring on 4” wafer

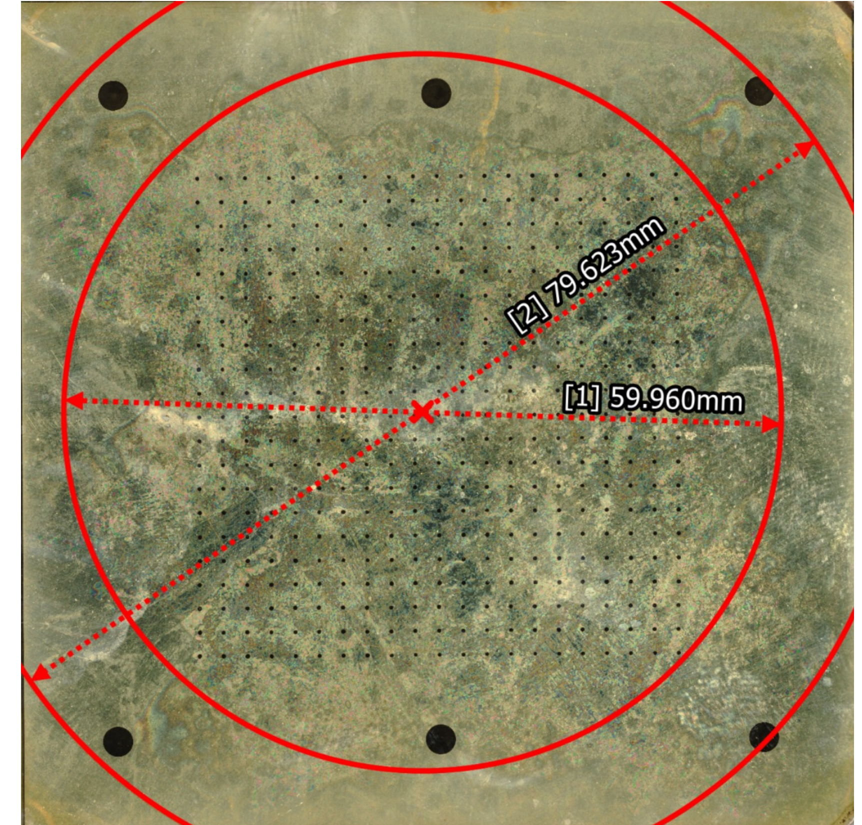


20µm track width and spacing

Separation prototype - detachment tests

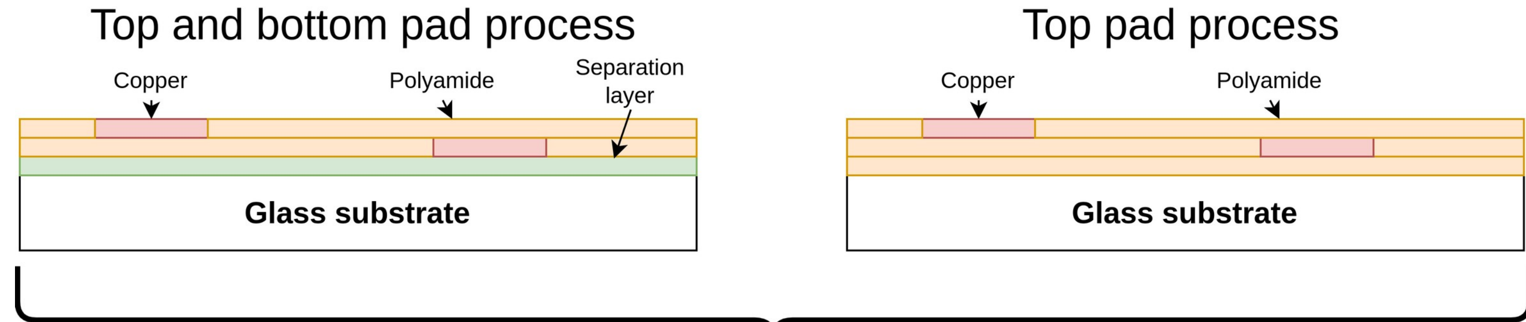


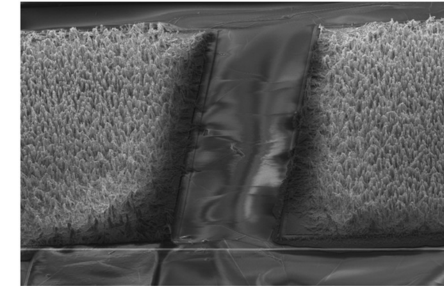




- Circular test structure on **8μm polyamide flex** before and after forceless detachment
- Forceless separation of single layer flex **successfully demonstrated**
- First tests show a **deformation of <0.5%**

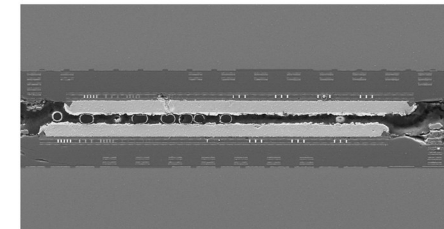
Towards custom fully integrated circuits



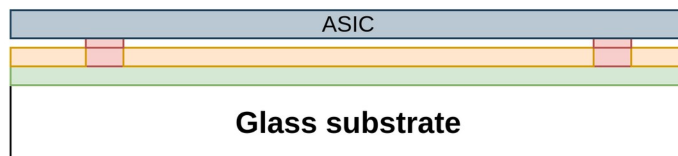


Development of in-house prototyping of flex utilizing 20/20 technology.

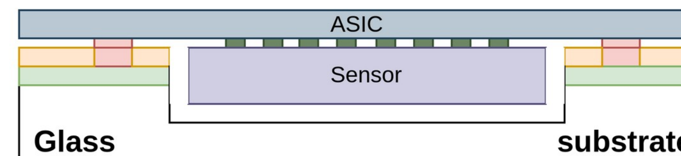
+ **Nano wires**
Gold studs
ACF/ACP



Integration of monolithic sensors



Integration of hybrid sensors



To sum it up

Thin-film Flexible PCB	• Fabricated a **thin film flex** demonstrator • Demonstrated **forceless detachment** • Integration and flex are **electrically tested**

Interconnection technologies	• Three interconnection **options** • **Pre-bond verification** with gold studs

Results and Outlook	• Forceless flex **detachment process** • Further developments on the **pre-bond verification**

-> **Flexible framework** for the modularization of pixel chips

Questions?

Thank you very much for your attention