STANDARD CONNECTORS FOR MICRO-CHANNELS

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Introduction

Need of a device that can connect microchannels with cooling plant (commercial pipes, pump, chiller, …)

- Has to withstand the same pressure inside the whole circuit;
- Prevents leakages;
- Radiation hardness;
- Low material budget.

Other features that may be required:

- Structural support of the pipes;
- Manufactured in large scale;
- Self alignment.

The wide variety of solutions developed for microfluidic connections in other fields are usually application-oriented.

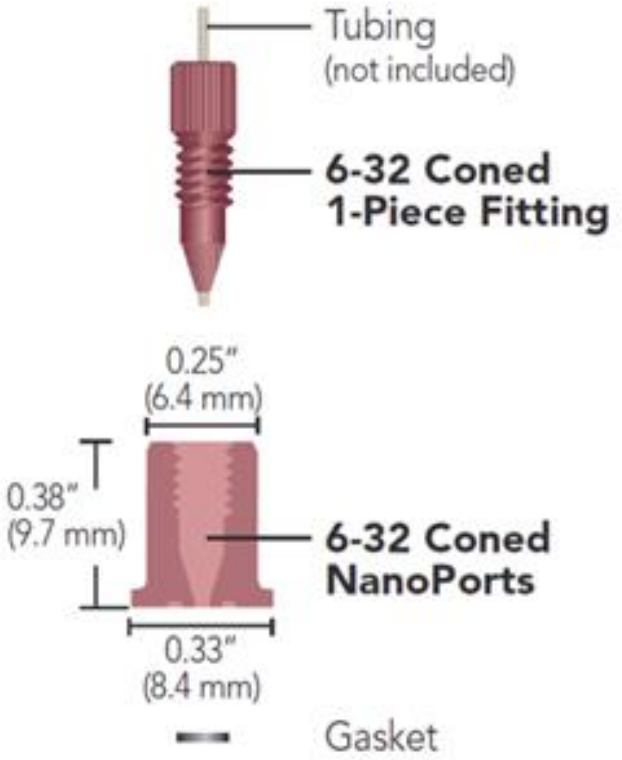
↓

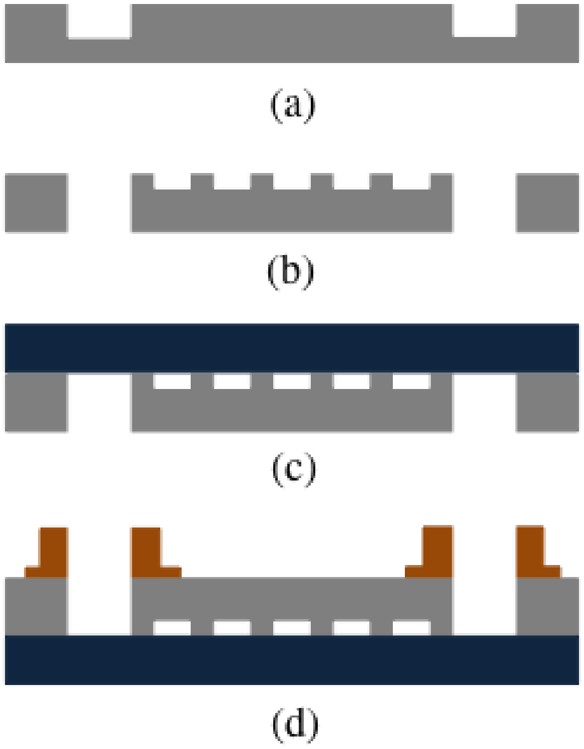
No standards available

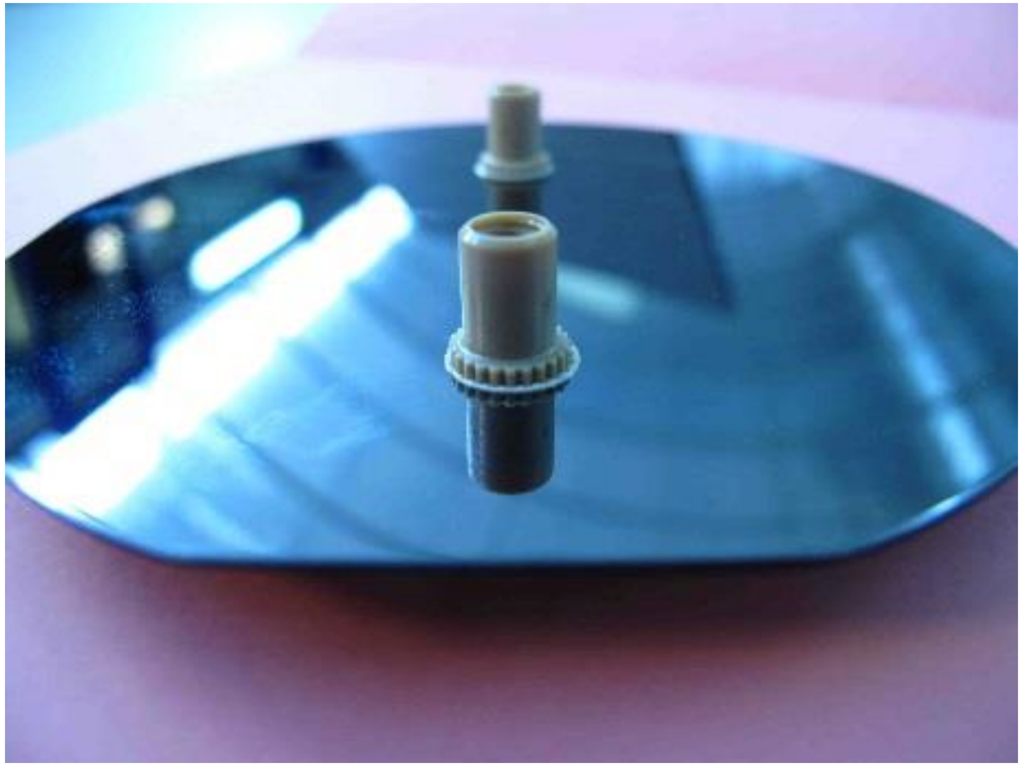
Commercially available connectors

NanoPort Assemblies:

- Material: PEEK
- Up to 69 bars. Possibility to increase with glue reinforcements
- Used to test silicon/glass cooling plates prototypes for NA62 experiment
- Bonding method: adhesive







Soldered-based solutions

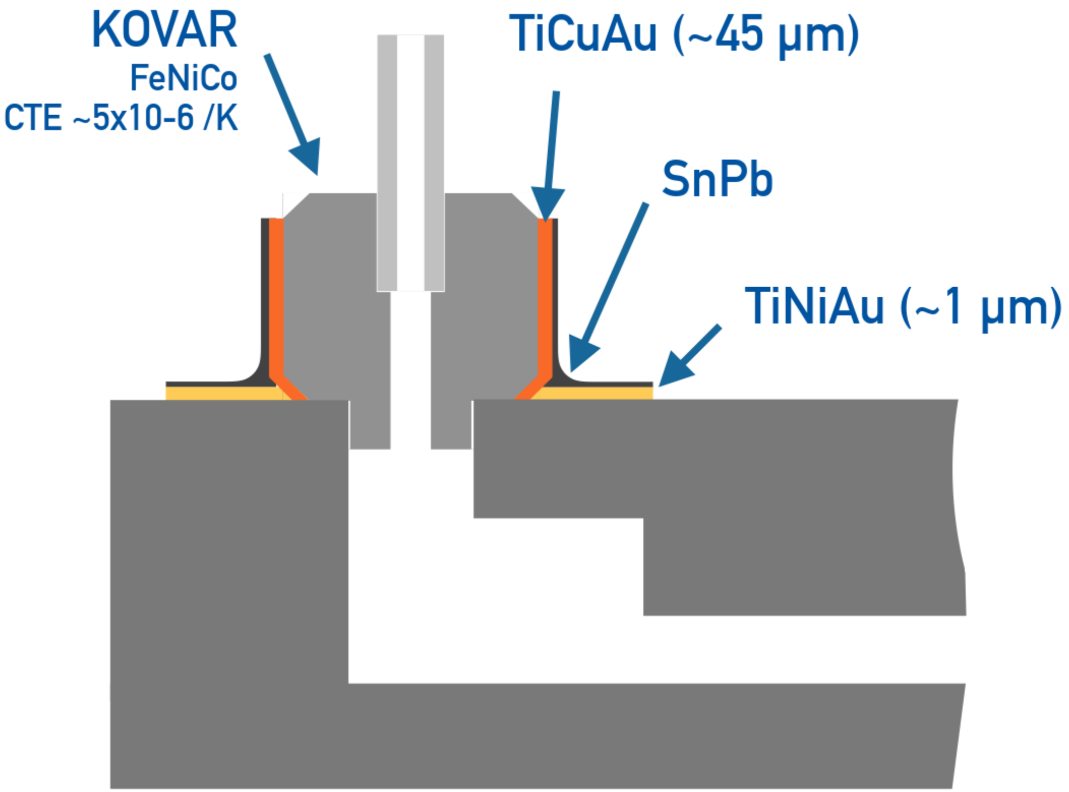
Adapted from Murphy, et al. (2007) Solder-based chip-to-tube and chip-to-chip packaging for microfluidic devices, Lab Chip, 7 pp. 1309-1314

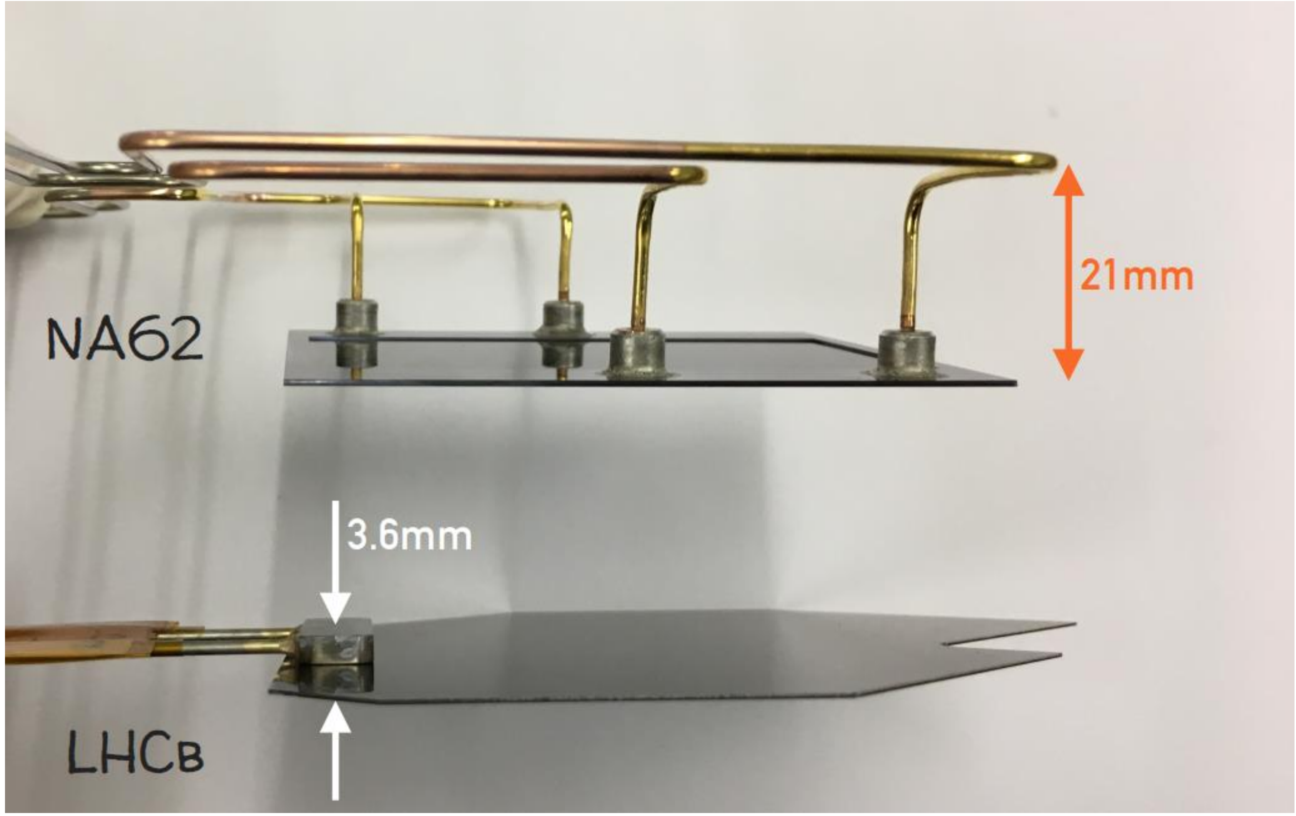
1. Ferrules crimped around the stainless steel capillaries → prototypes

    - Tool to hold the capillaries and the micro-channels in position
    - Filler material required
    - Soldering point tip or oven

Soldered-based solutions

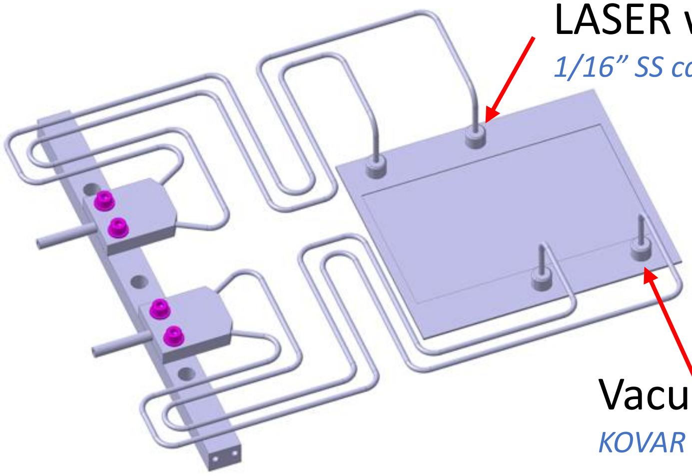
2. Machined connectors in alloys with CTEs close to the silicon one (ex. Kovar, Invar)
   - Used in LHCb and NA62 experiments
   - Laser welding between connector and pipe
   - Vacuum brazing between connector and cooling plate





Two different approaches:

- One connector for each pipe (NA62) → hyperstaticity

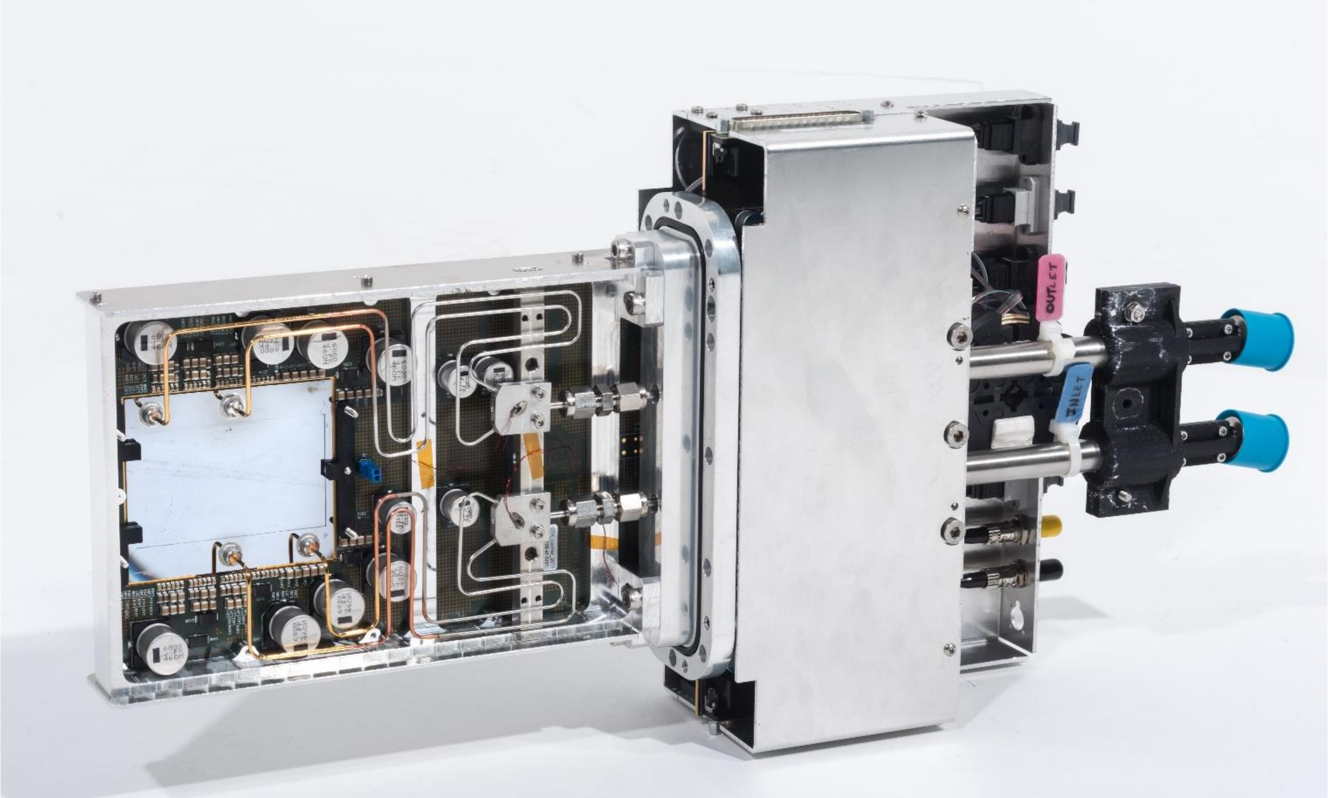


LASER welding

1/16” SS capillaries to KOVAR connectors

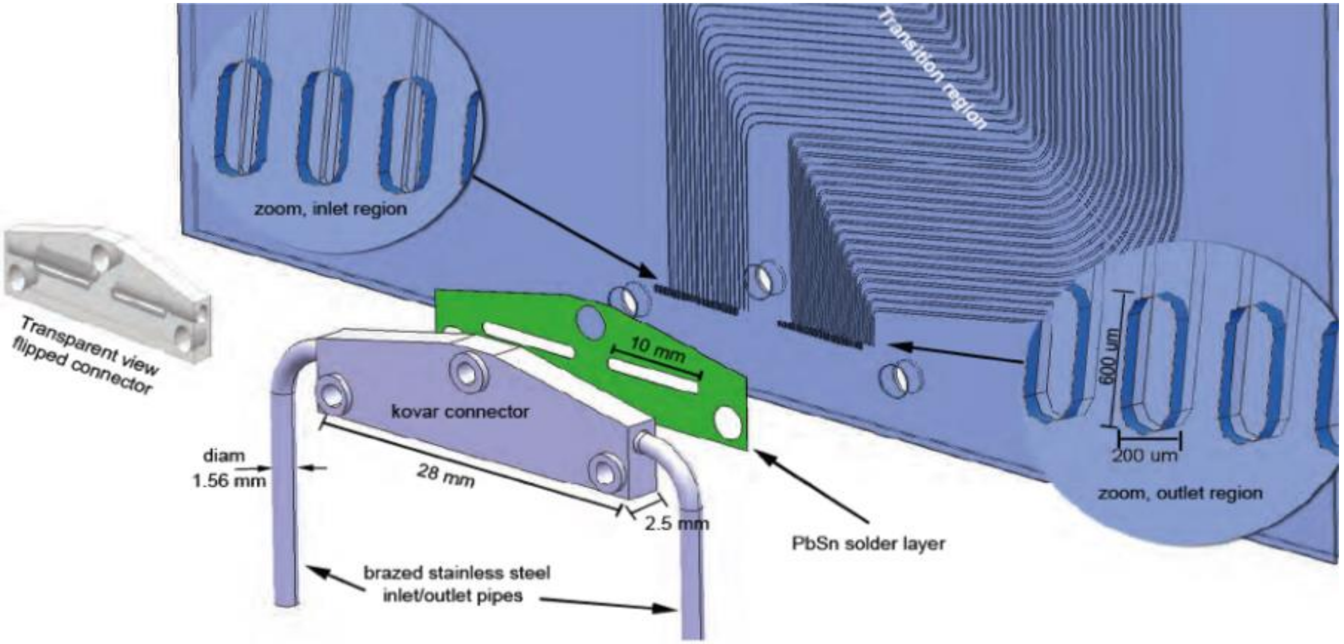
Vacuum brazing

KOVAR connectors to Au-plated Si



Soldered-based solutions

- One connector for many pipes (LHCb)



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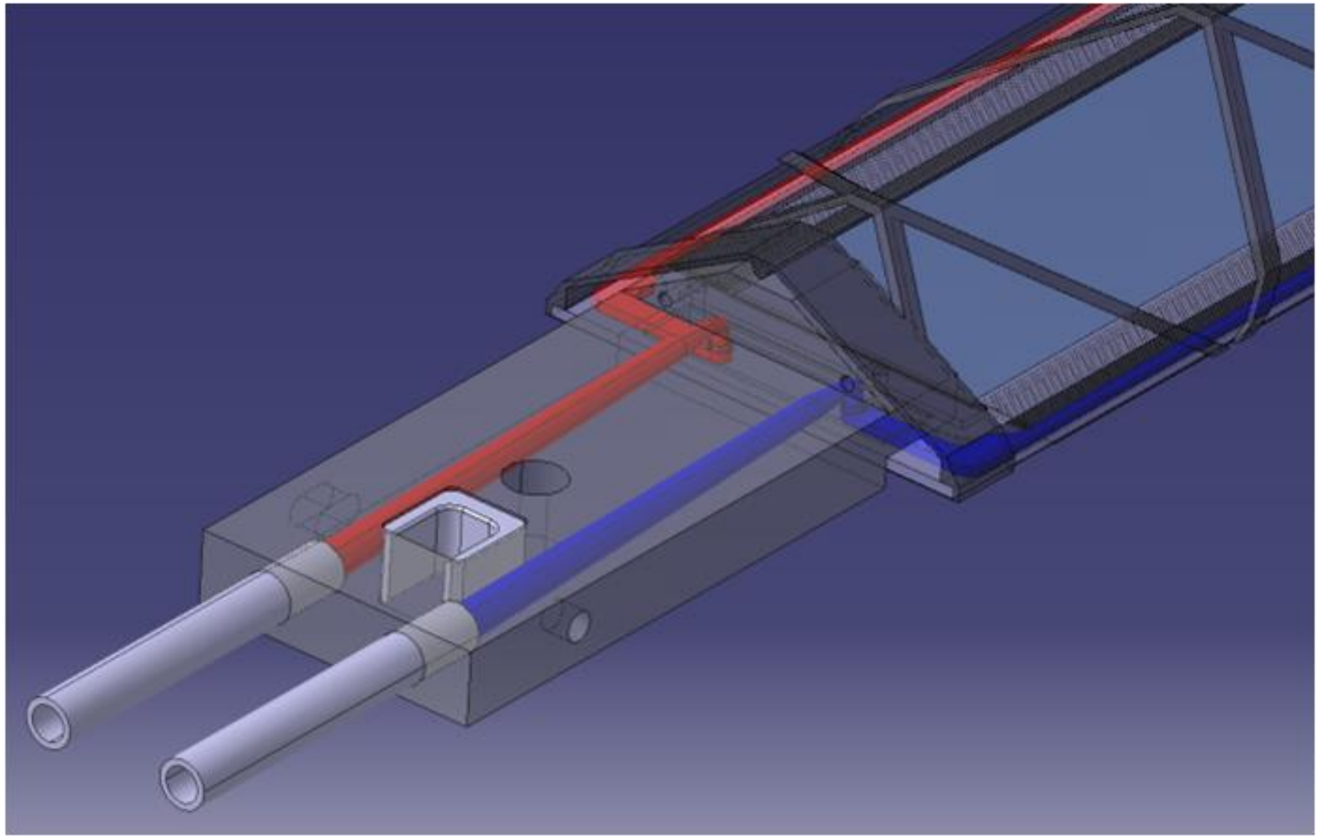
- Shapes not achievable with conventional machining
- Possibility to obtain in few time a large number of connectors with different design → attempts, calibrations, tests



Investigated within the framework of the ALICE ITS LS2 upgrade by Adrien Toros: https://edms.cern.ch/ui/file/1538000/5/2015_MSc_TOROS_Adrien.pdf

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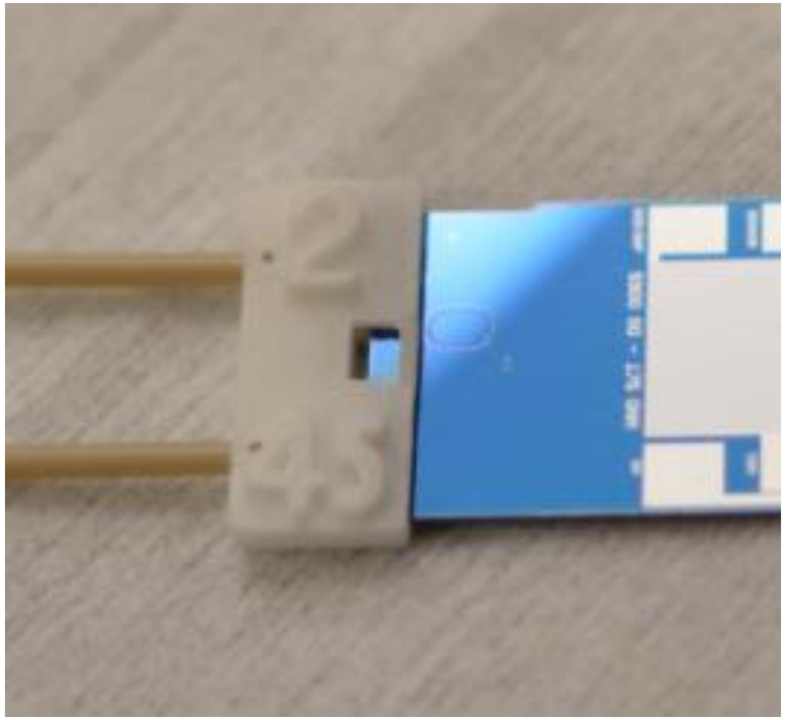
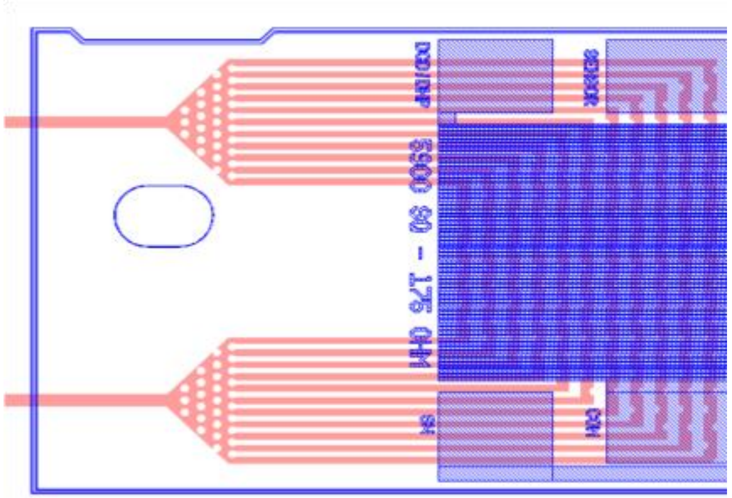
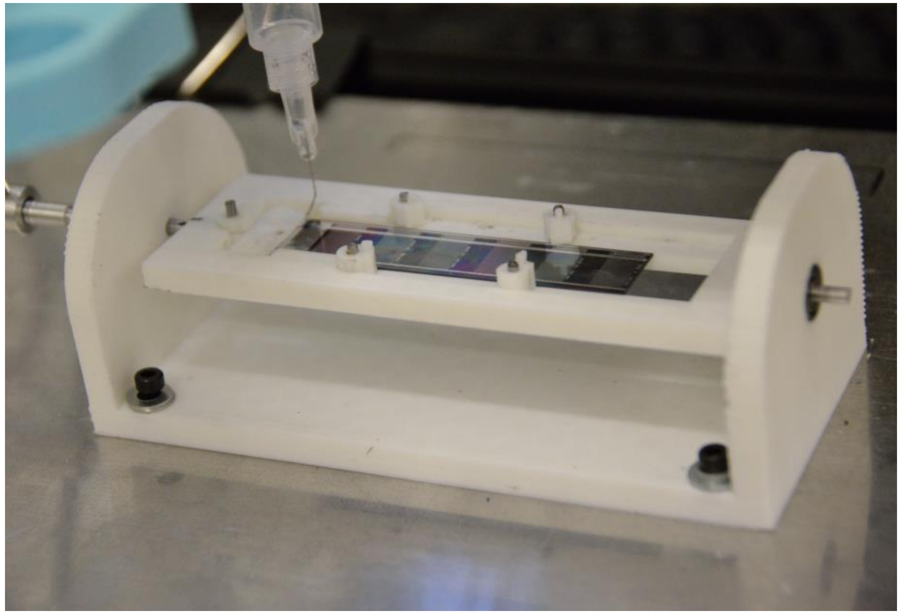
In-plane connector developed by IFIC (UVEG/CSIC), Valencia, in collaboration with the University of Bonn and the semiconductor laboratory HLL of the Max Planck Society.

Designed to interface with commercially available hydraulic standards







3D printed

Main advantages of in-plane connectors:

- Low material budget;
- Good solution staves in barrel configurations;
- Possibility to connect several structures to form a long string.

Destructive tests under pressure load performed at CERN showed a P_{fail} > 80 bar

Conclusions

Three standardized solutions are now available to connect microchannels to:

- Laboratory test setups;
- Primary cooling circuits of experiments .

Solution 1 is based on **commercial PEEK connectors**. It is rated up to 70 bars and has been mainly used for prototypes.

Solution 2 consists in **soldering capillaries to cooling plates**. Pressure of 100s of bars can be reached.

- It is used for the GTK detectors in the NA62 experiment since 2014;
- It will be used for the Velo LS2 Upgrade in the LHCb experiment.

Solution 3 makes use of additive manufacturing to **3D-print custom-designed designed connectors glued** to the microchannels. Out-of-plane and in-plane connectors have been demonstrated. In-plane design allow inter-connectivity of micro-channels in daisy-chain configurations.

Although the R&D activity on connectors is continuously progressing, these three families of connectors cover all the present community needs, in particular in terms of high and low pressure testing of any new cooling device.

More details are available on the Milestone Report AIDA-2020-MS77: http://cds.cern.ch/record/2314041