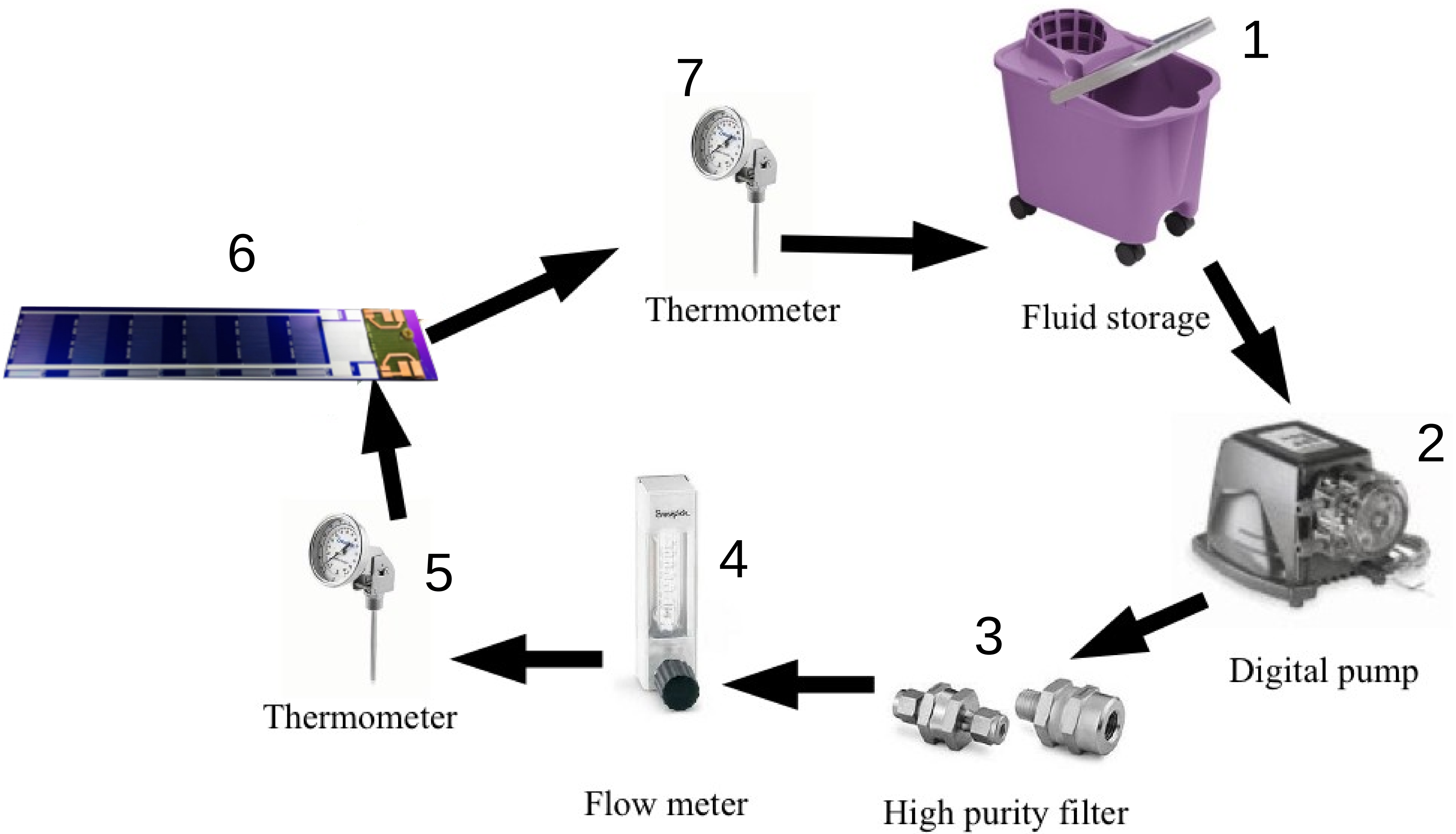
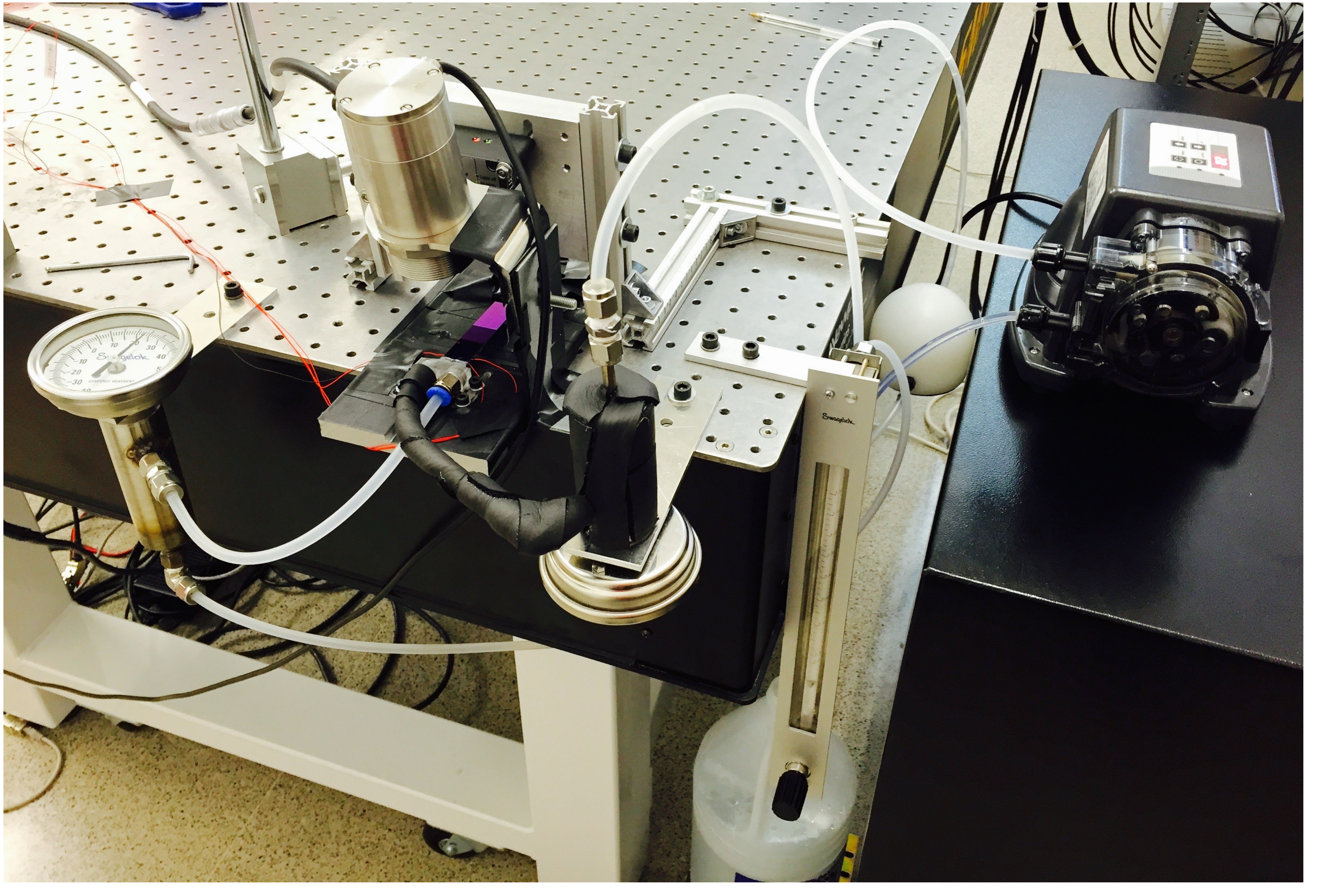
MC Cooling Update from IFIC

Experimental setup



Experimental setup



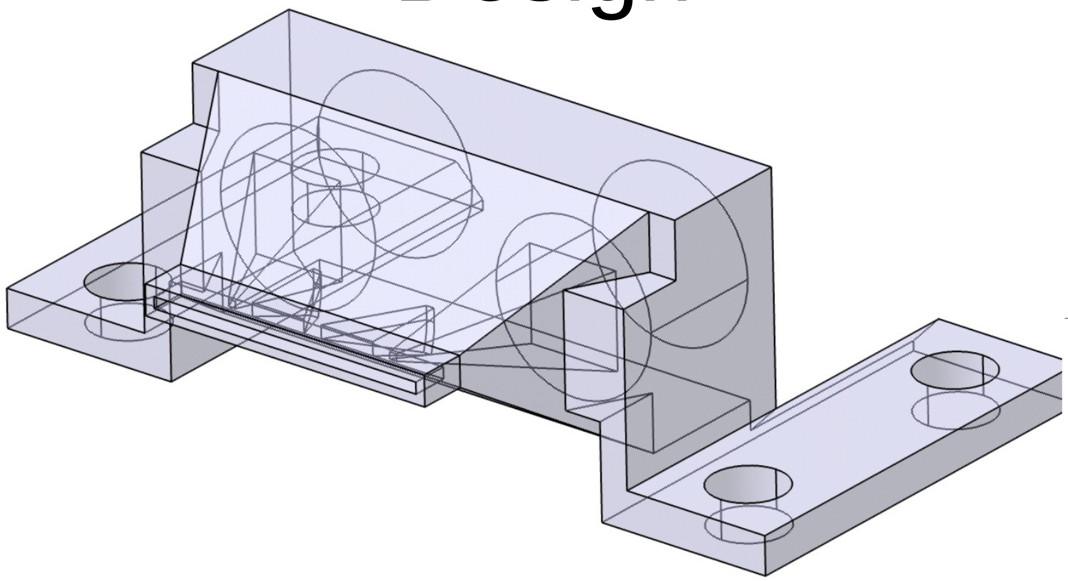
3D-printer technology

Built by 3D-printer (stereolithography technology):

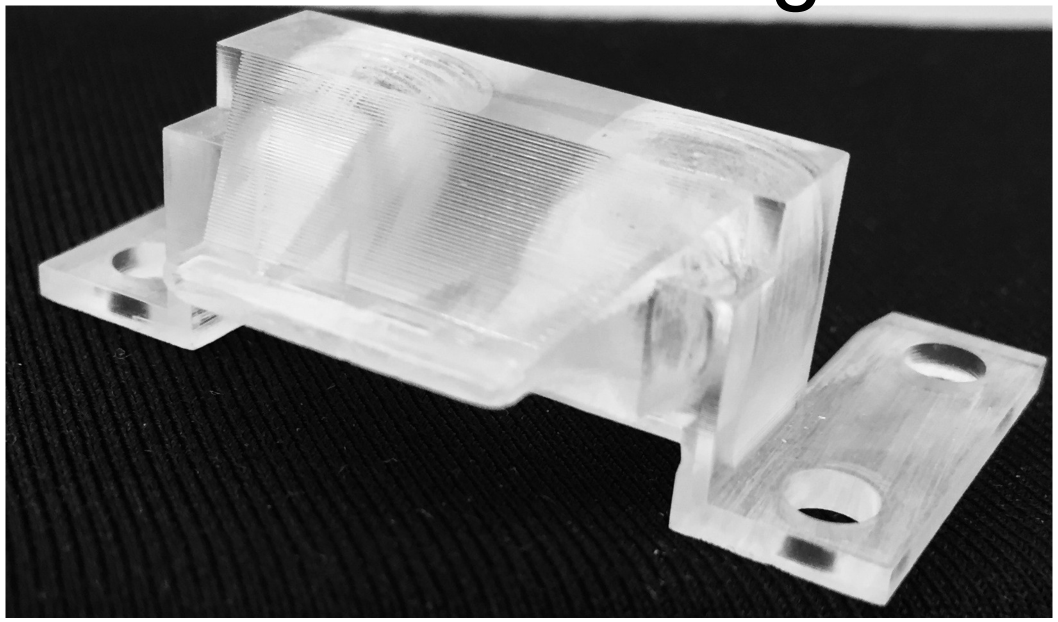
- 15 µm precision
- 300 µm per layer
- Very complex geometries
- Material: X0=350mm
- Joint: 3D Part glued to MC silicon module
- Cheap and fast manufacture (not the 3D printer)
- Good performance below 70ºC

3D-printed adaptor PREVIOUS design

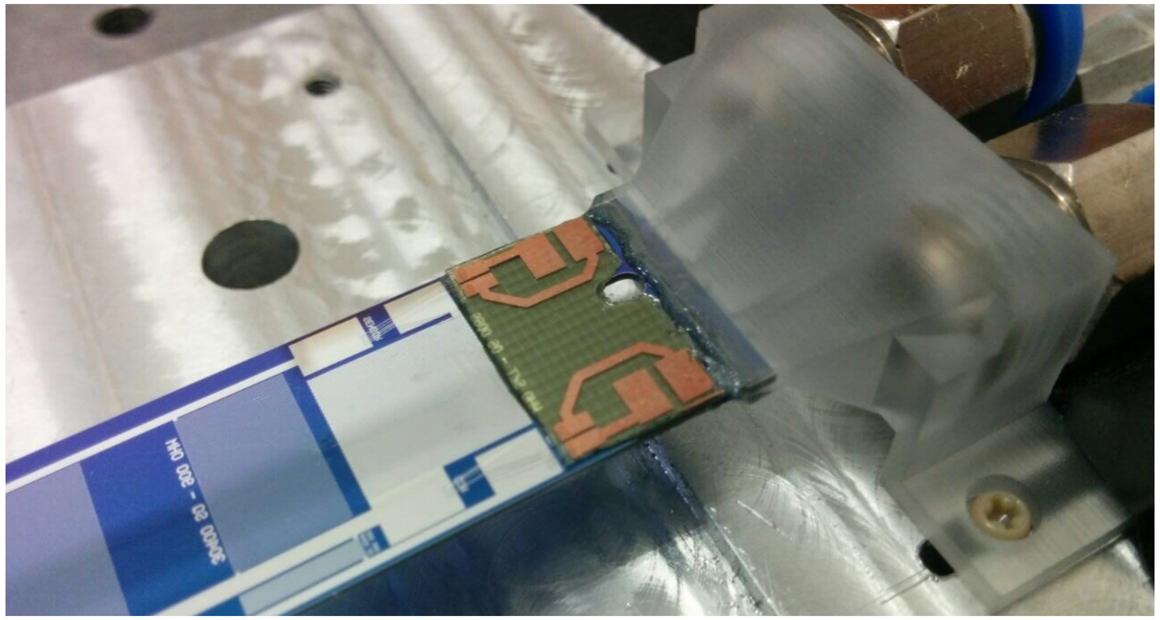
Design



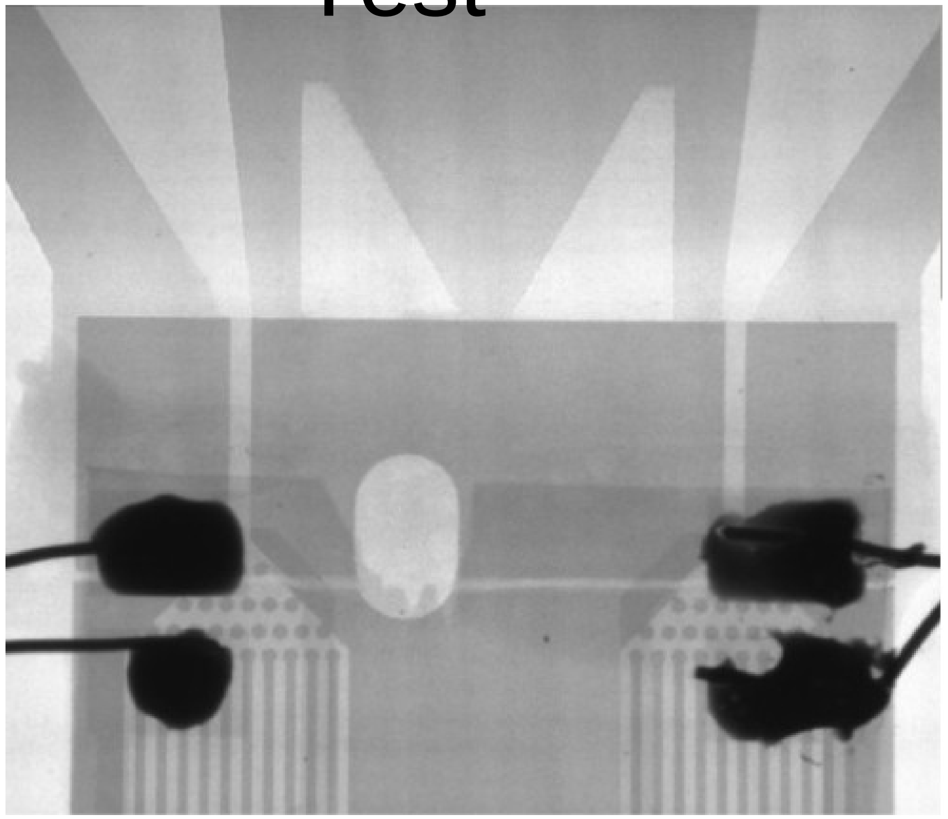
3D-Printing



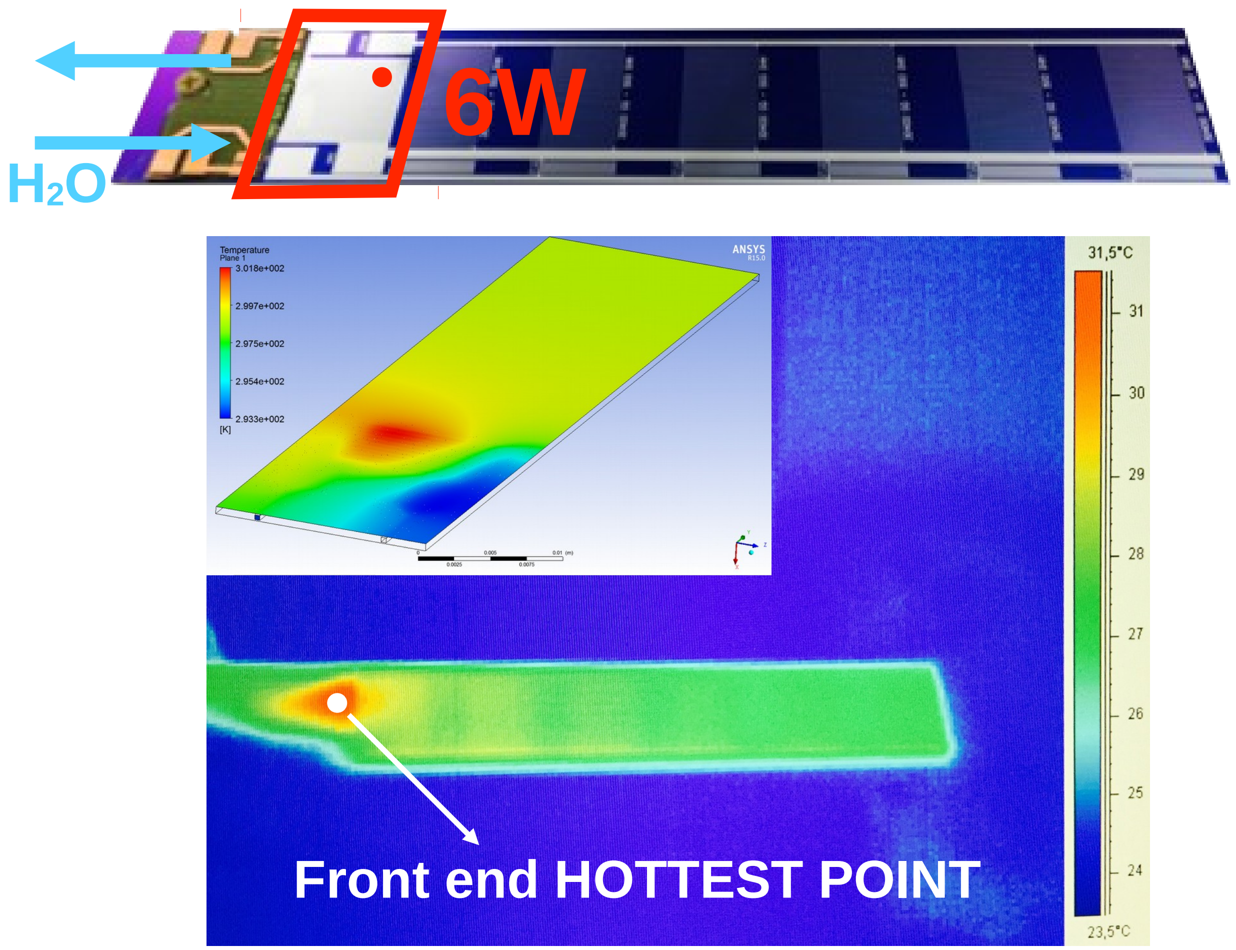
Gluing

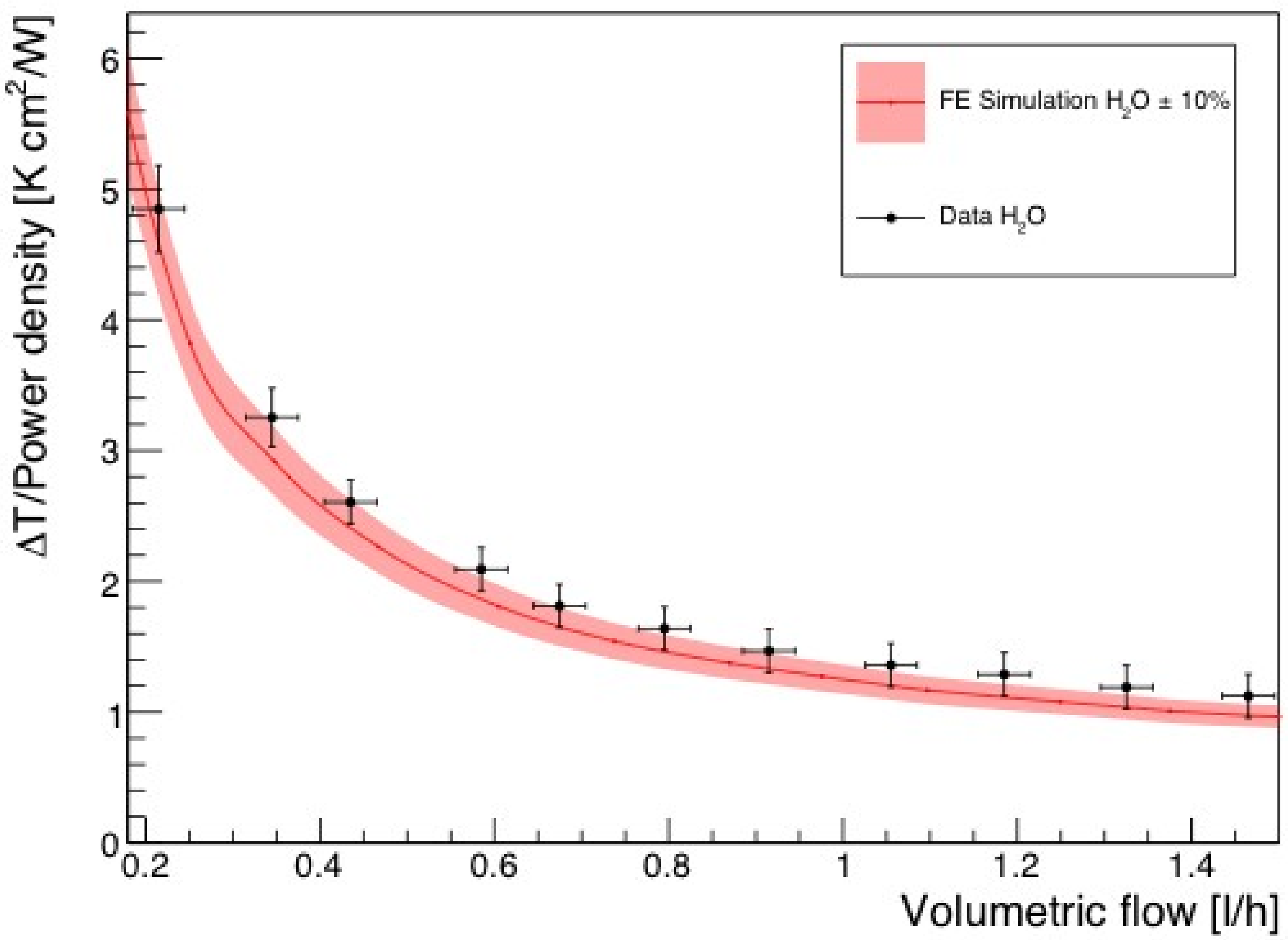


Test



Thermal measurements: MCC



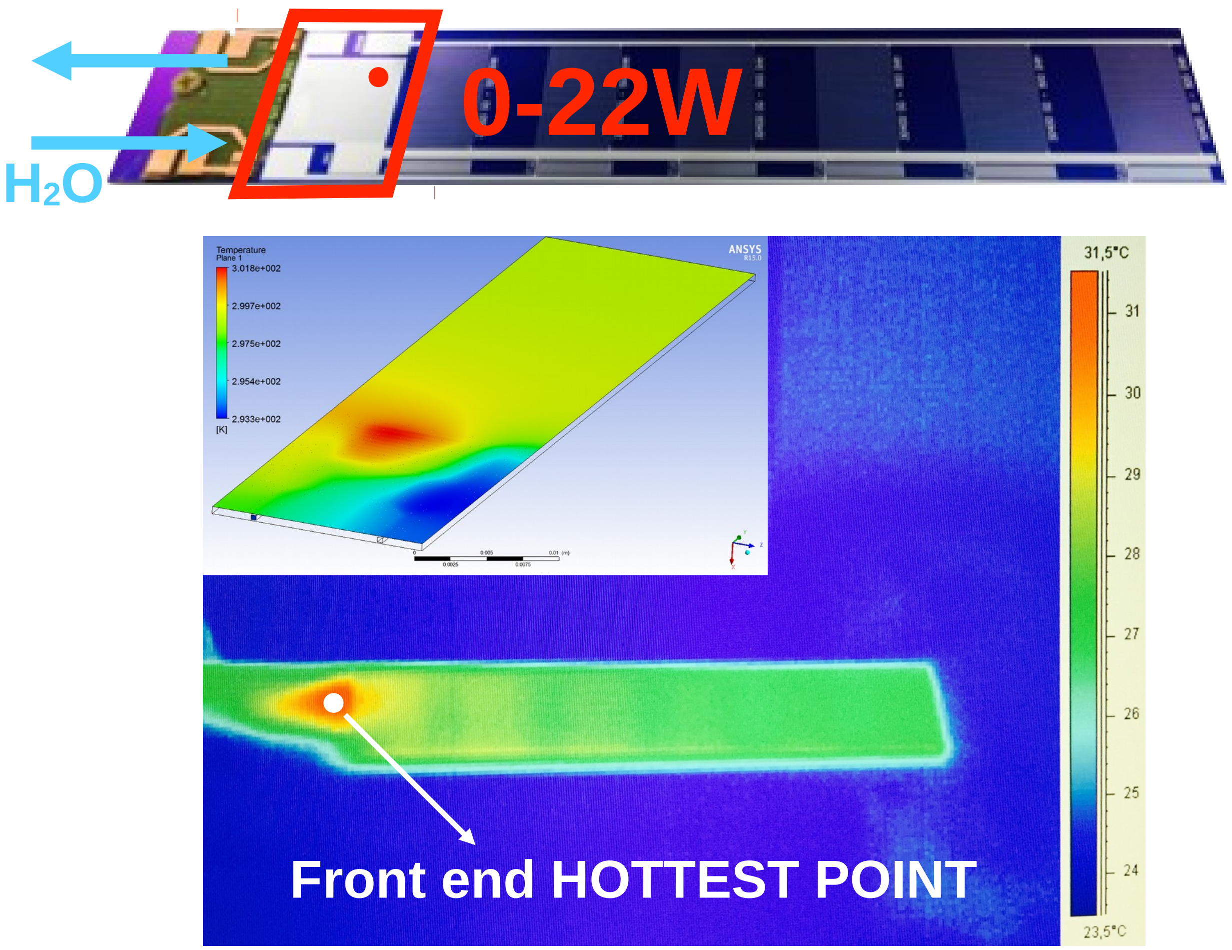


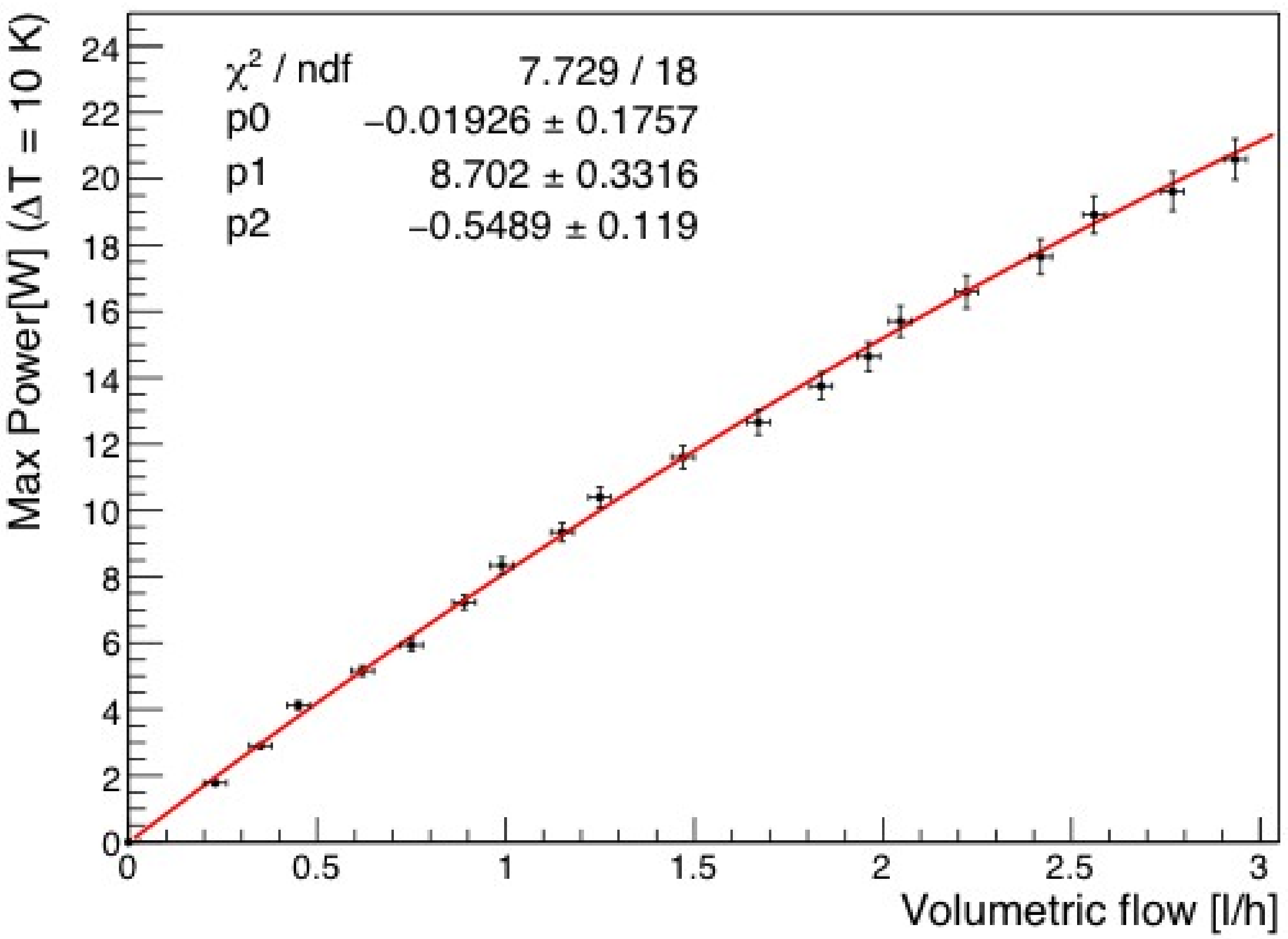
- Fluid: H_2O
- **With flows (~1l/h) and low pressure drop (<1bar) are good enough**
- **Good agreement** with the **FE simulation** inside an error area of **10%**

Measurement data errors

- P ±1% W
- T ± 1 ºC
- ΔT/Power density ± 0,14 ºC/W
- flow ± 0,03 l/h

Thermal measurements: Maximum Power vs Volumetric flow

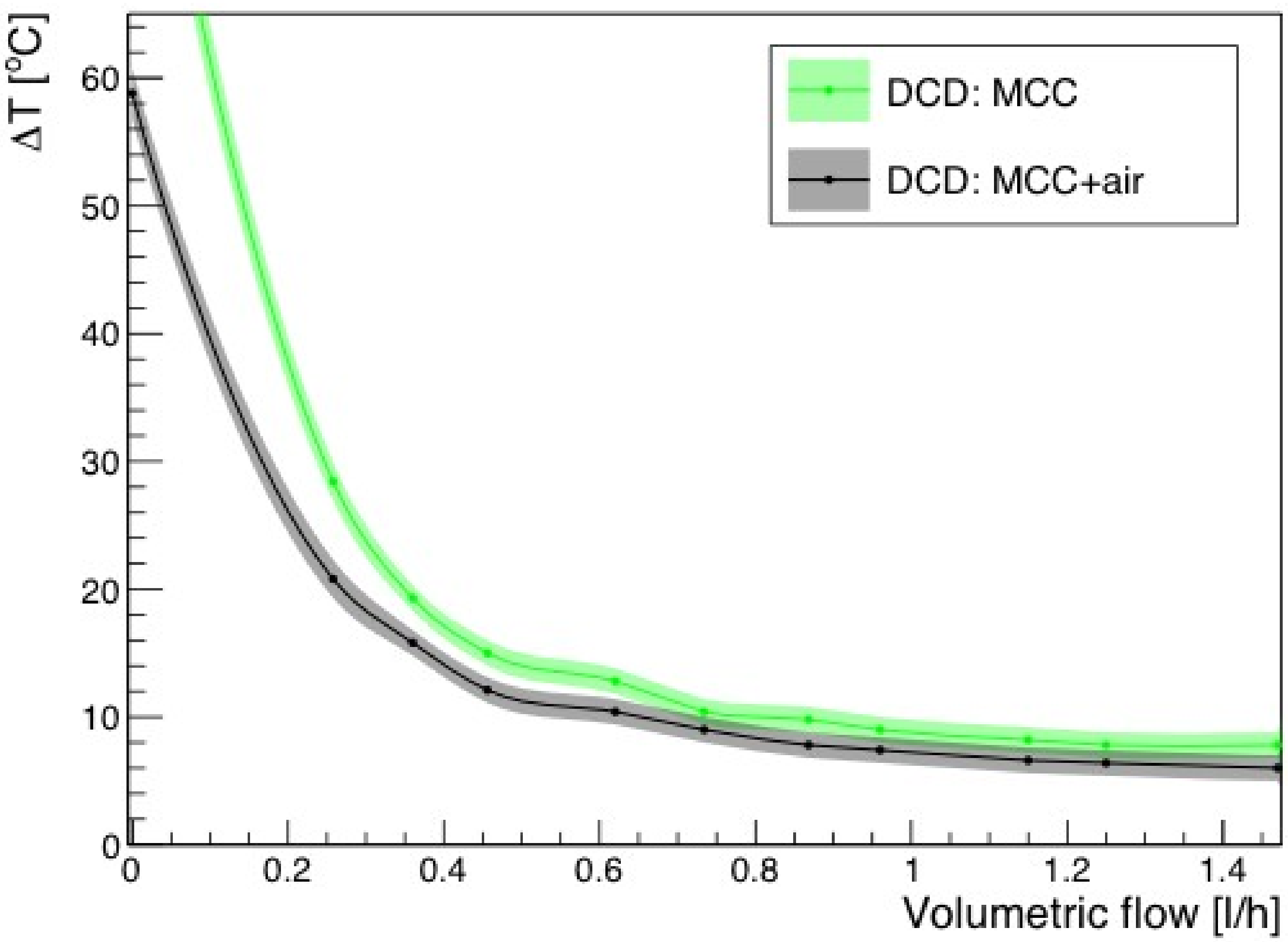


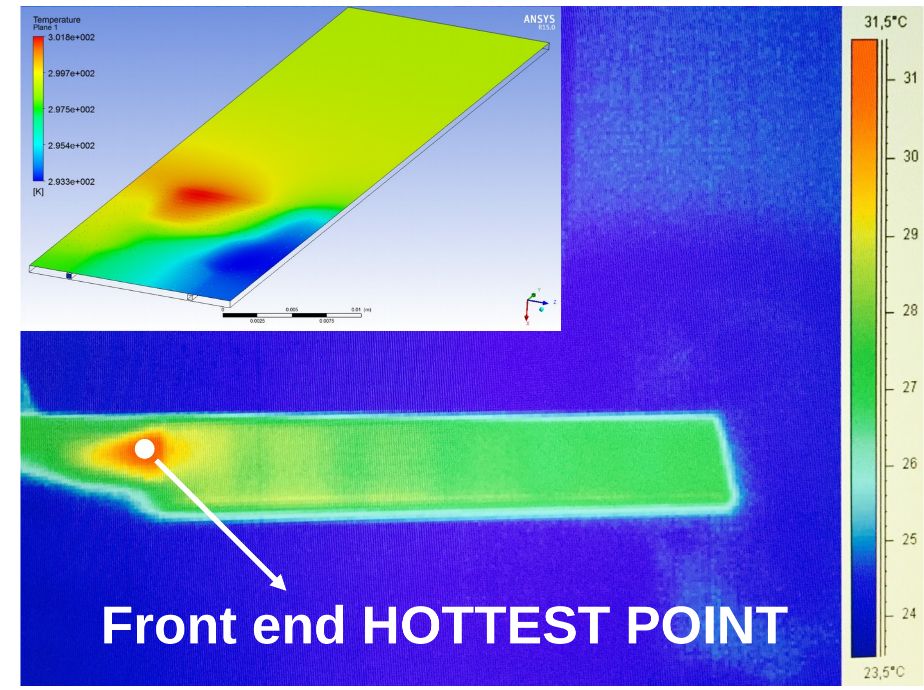


Maximum power supported for a ΔT of 10 ºC as a function of the volumetric flow

- **Temperature stable** even with power density of **25 W/cm²**
- **Power vs vol. flow** at max. pump power (~ 3 l/h)
- **Low pressure** needed: 0.2 - 1.5 bar

Thermal measurements: MCC+air

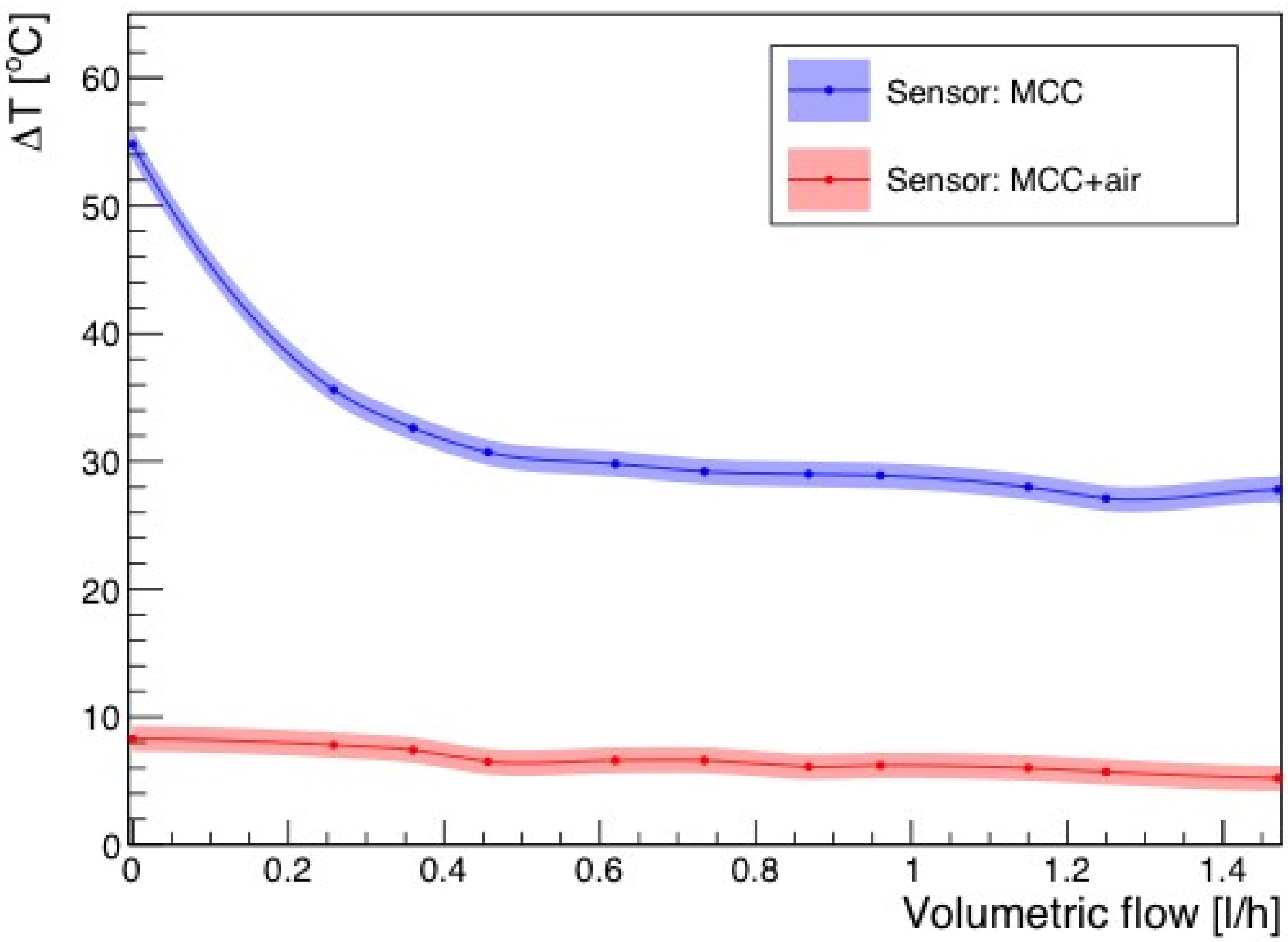




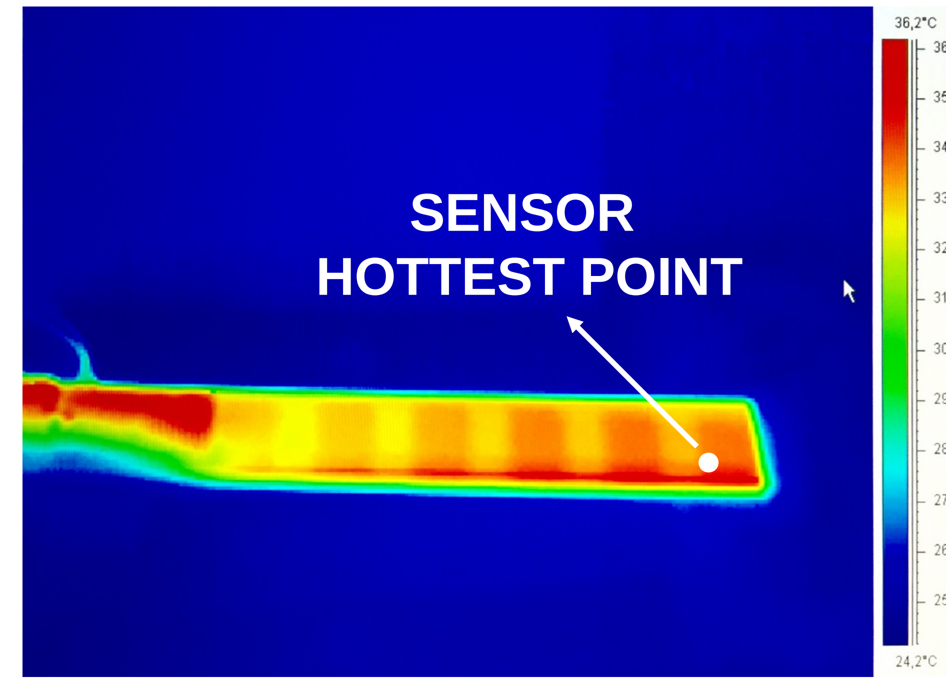
- **There is not big difference between MCC and MCC+air at the DCD hottest point**
- **Farthest regions to the air inlet are less affected**
- **Even with low volumetric water flow, high cooling**
- **93% of total heat removed by MCC**

Cooling strategy: micro-channels running under the front end and gentle air flow on the sensor part

Thermal measurements: MCC + air

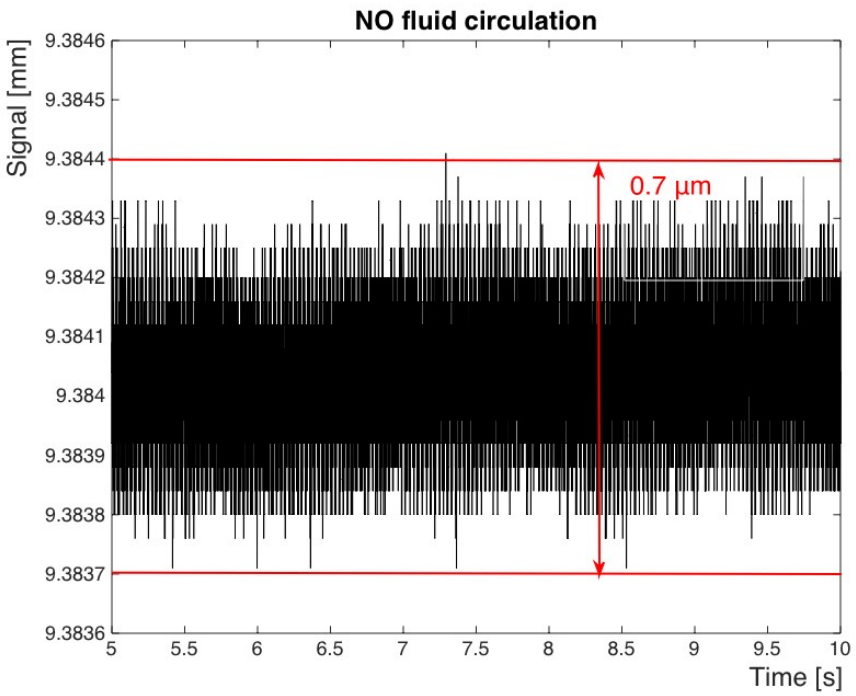


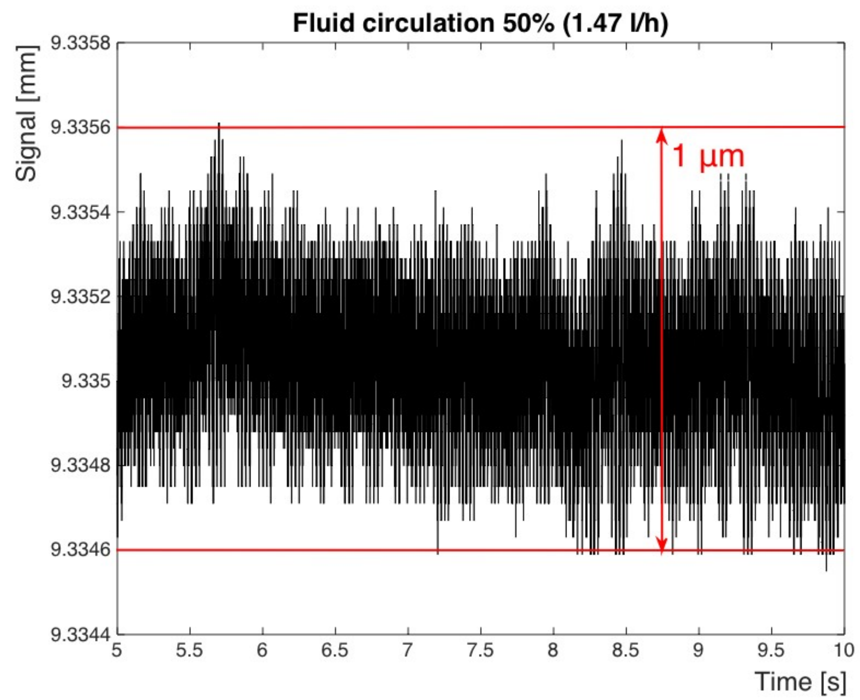
Cooling strategy: micro-channels running under the front end and gentle air flow on the sensor part

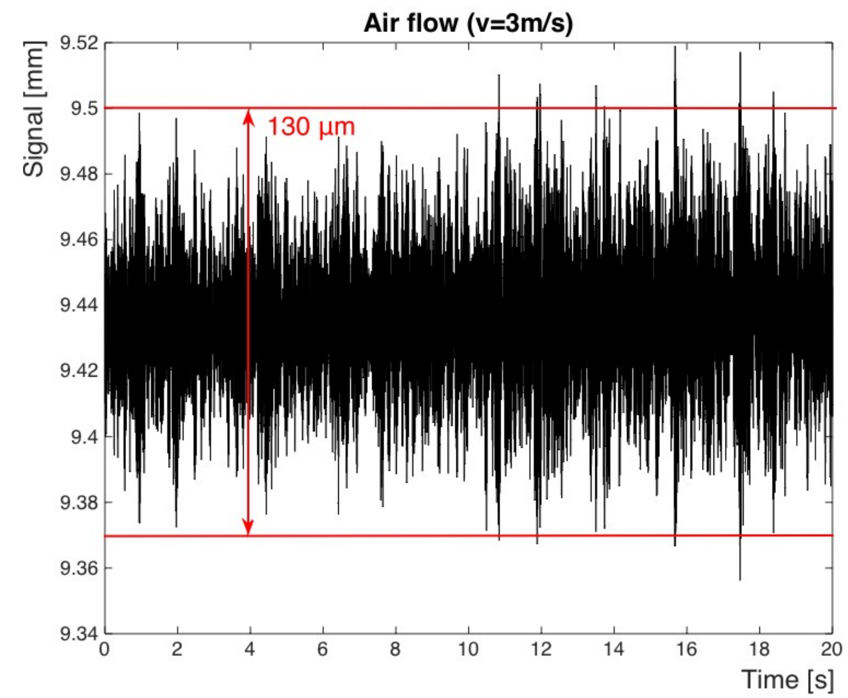


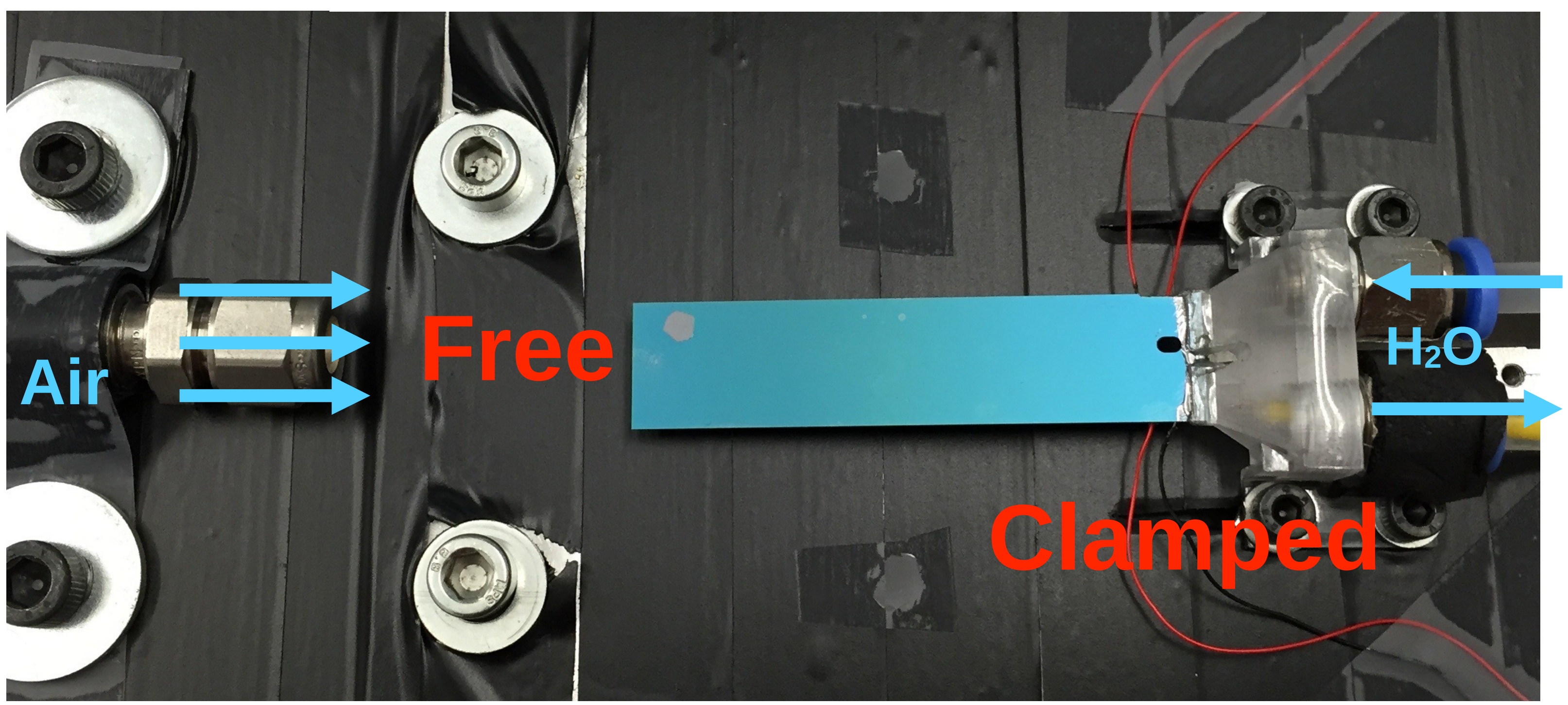
- **Big difference between MCC and MCC+air at the sensor area hottest point**
- **Nearest regions to air input are efficiently cooled even with low air flow**
- **MCC has less impact in away points as expected and great cooling locally**

Vibrations and deformations



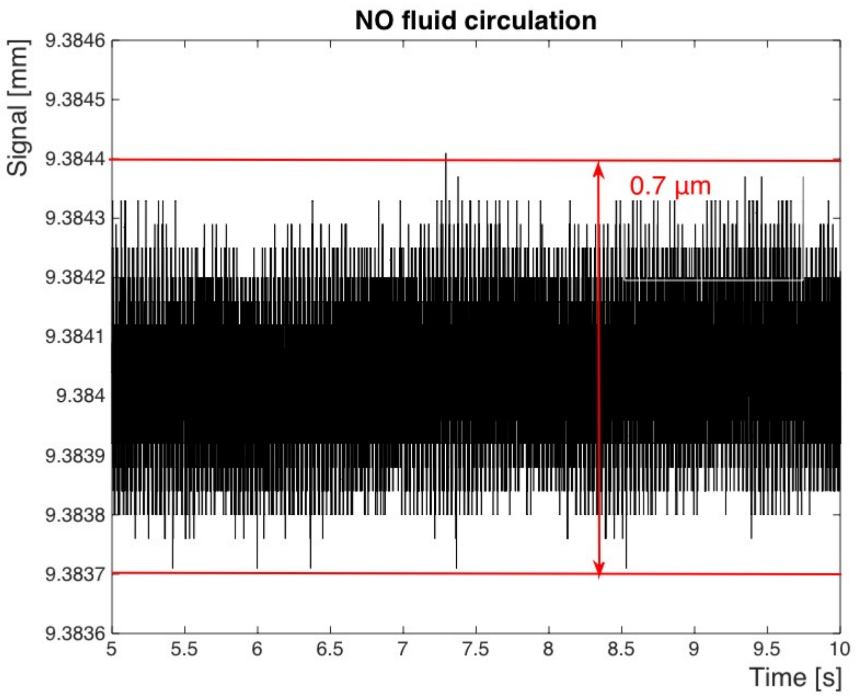


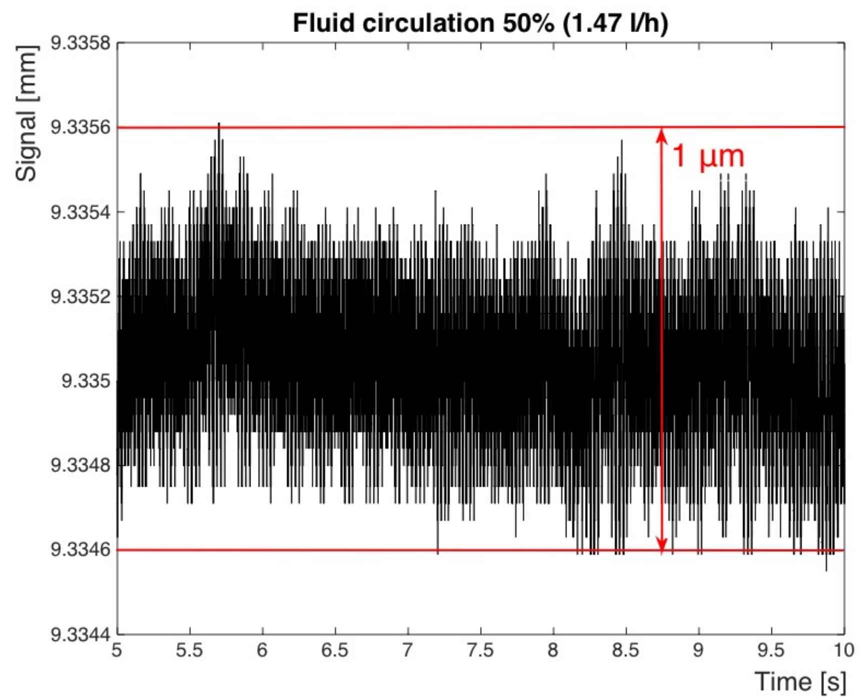


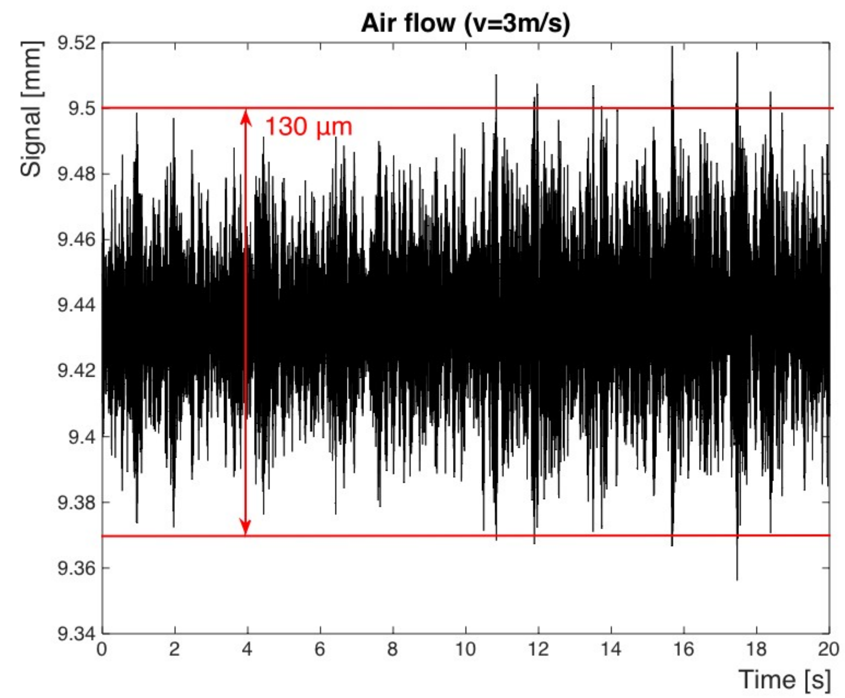


Clamped-free (CF) configuration: One extreme of the dummy is clamped to the 3D adaptor while the other is free of movement

Vibrations and deformations







No fluid circulation and no air flowing	Fluid circulation 1,47 l/h	Air flowing 3 m/s
Peak to peak of the signal ~0,7 µm	Peak to peak of the signal ~0,1 µm	Peak to peak of the signal ~130 µm
RMS ~0,3 µm	**RMS ~0,4 µm**	**RMS ~57 µm**

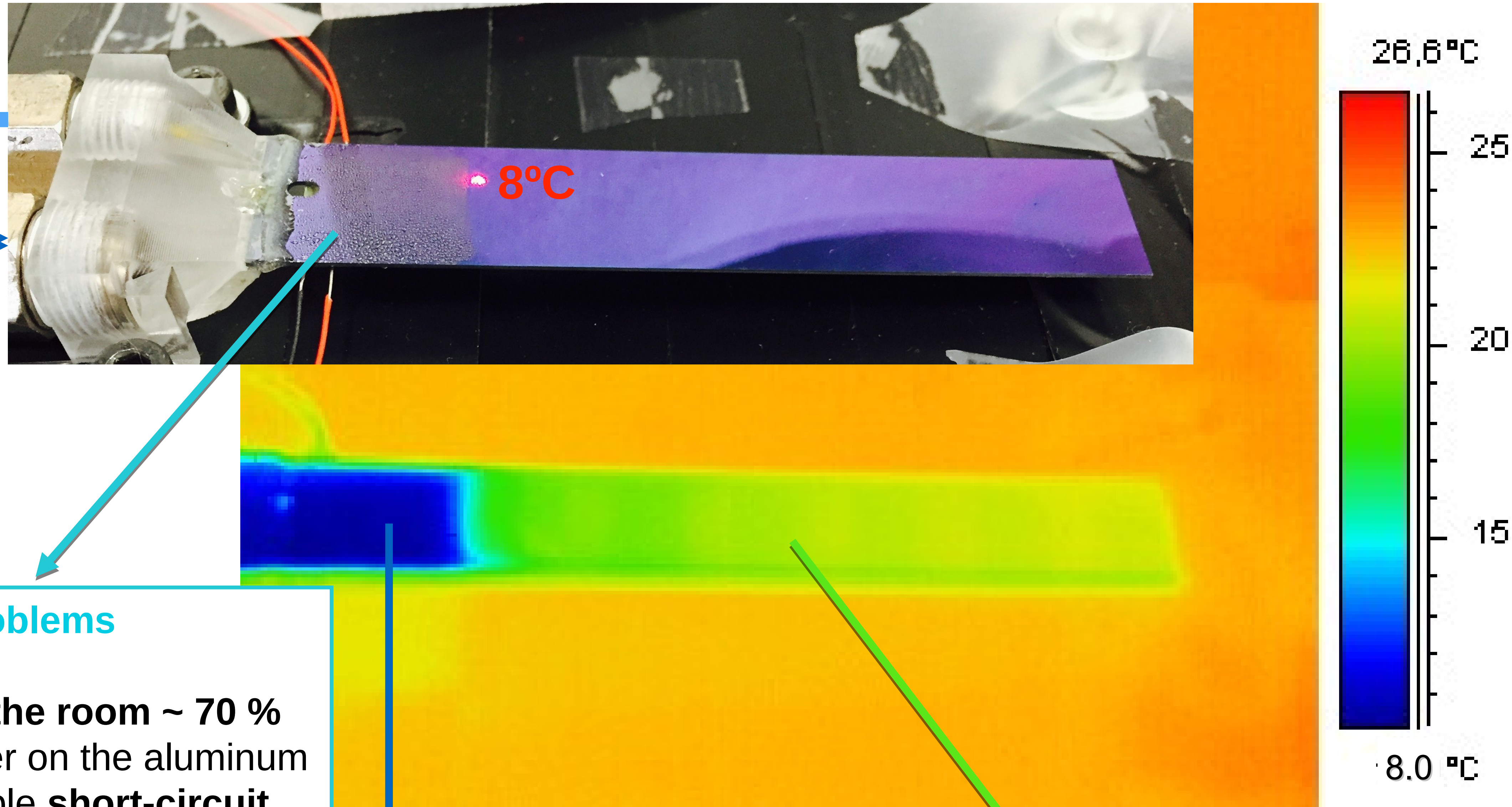
MCC has no significant impact on mechanical stability in the clamped-free configuration but air deformations are more than 100 µm if v=3m/s (could be reduced a factor 10 for velocities under ≤0.5m/s)

Pressure test

Thermal measurements: cold water

T_{out} ~ 10ºC

T_{in} ≈ 5ºC



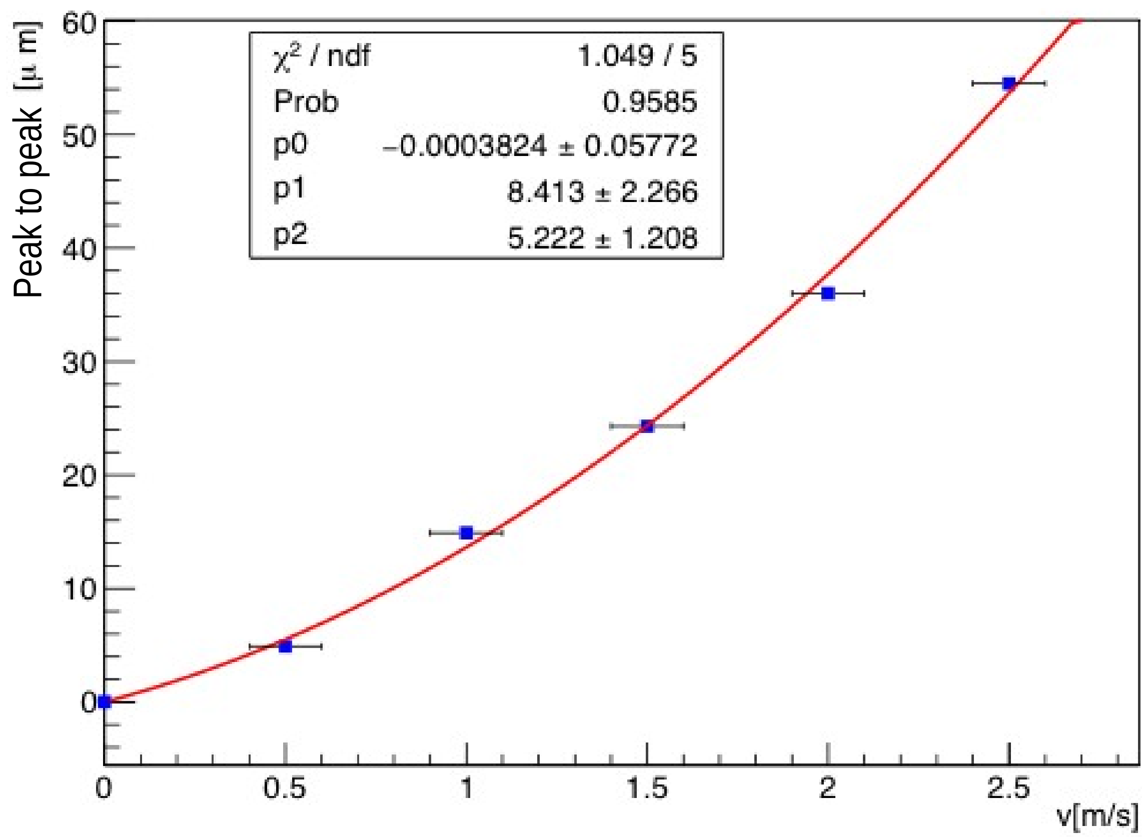
Condensation problems

High humidity in the room ~ 70 % impossible to power on the aluminum resistances (possible **short-circuit** due to the water on the soldering)

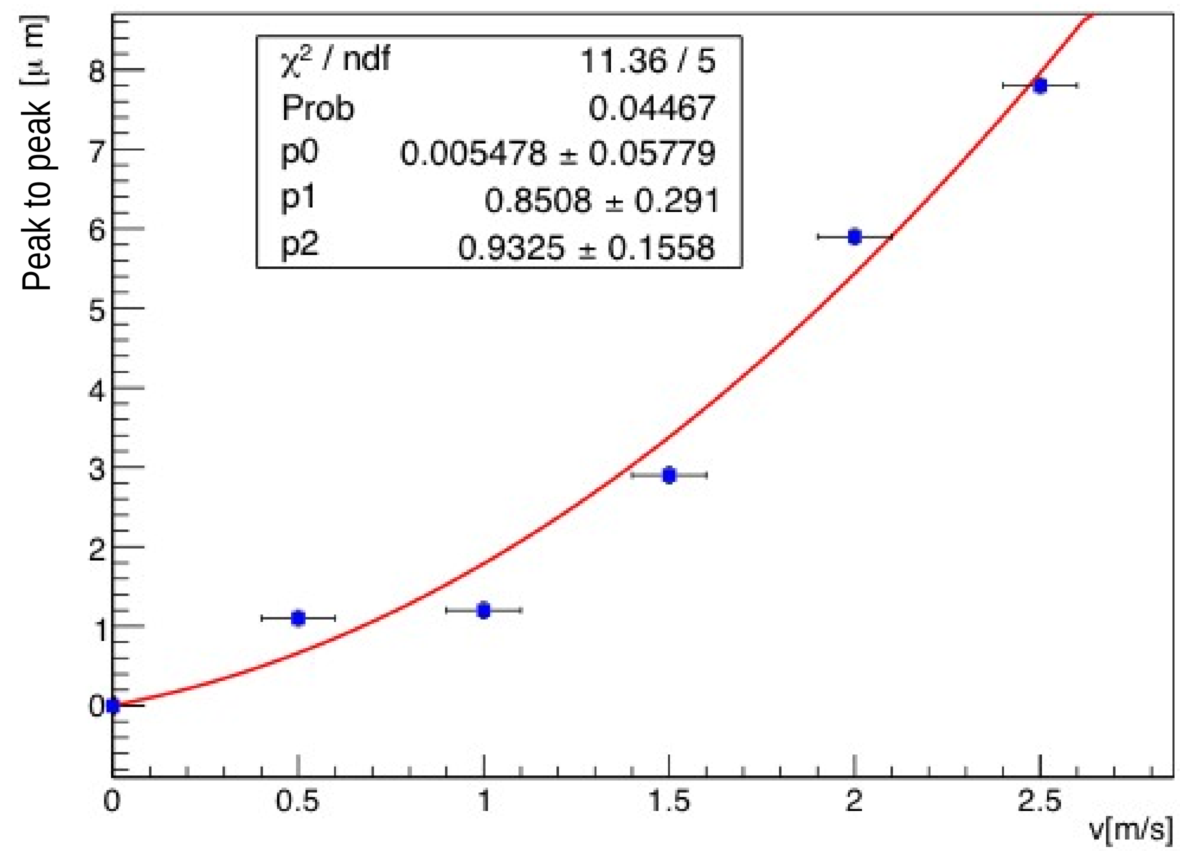
In this region the effect of the MCC is quite less pronounced 5-10 ºC below

MCC region is cooled 18ºC below T_{Room}

Amplitude vs v_{air}



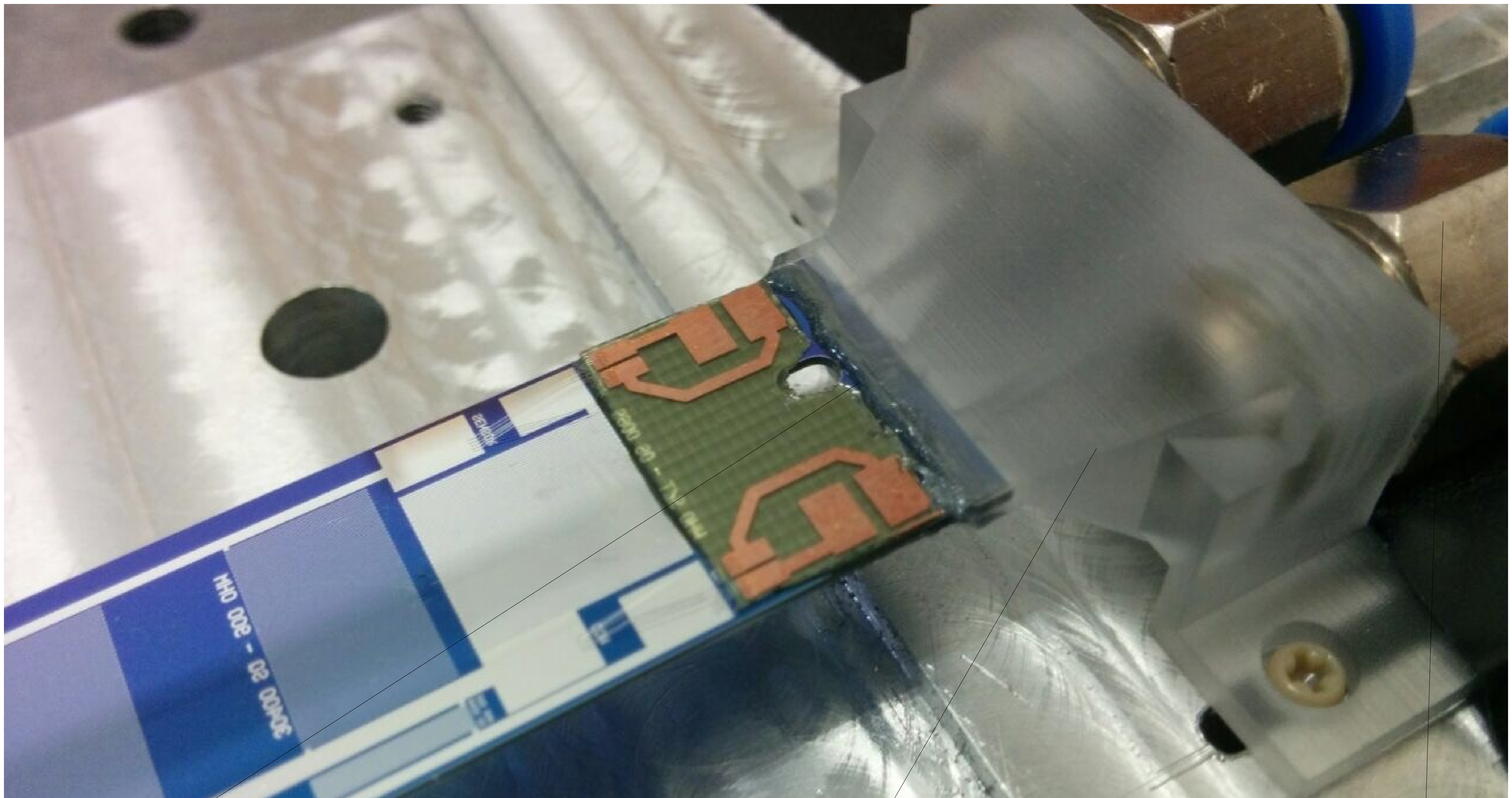
Clamped-Free



Clamped-Clamped

- *Peak-to-peak amplitude is the change between peak (highest amplitude value) and trough (lowest amplitude value)*
- RMS ≃ (PeaktoPeak/2) * 0.707 (approximation)
- For **v= 2.5 m/s** the amplitude of vibration is:
  - **~19 μm for clamped-free configuration**
  - **~2.8 μm for clamped-clamped configuration**

3D-printed adaptor PREVIOUS design: problems



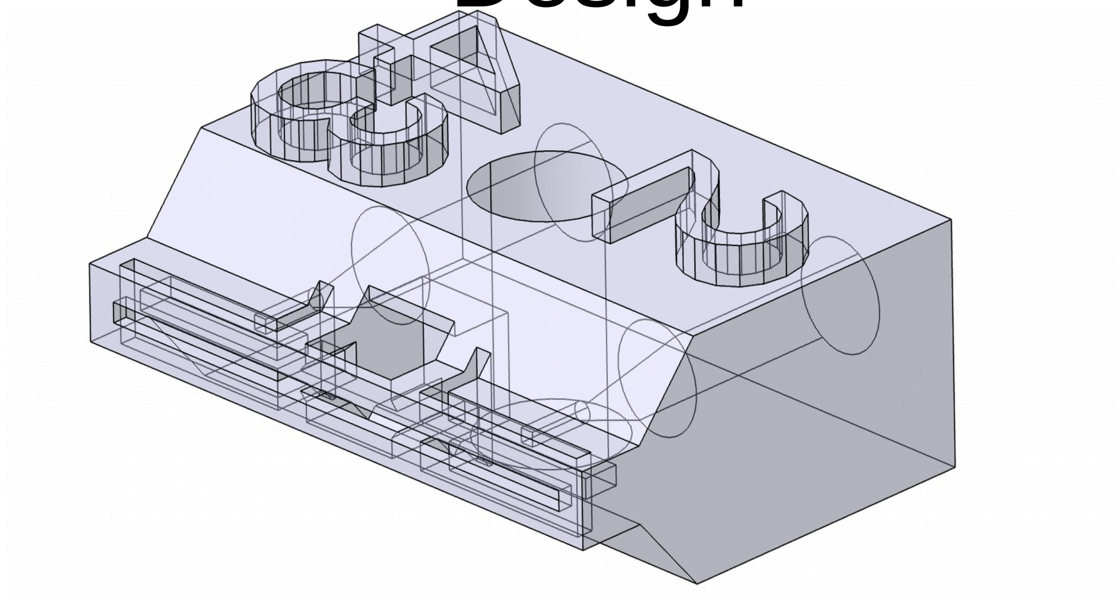
Glue: leaks

3D printed part: massive → X/X0=0,81%

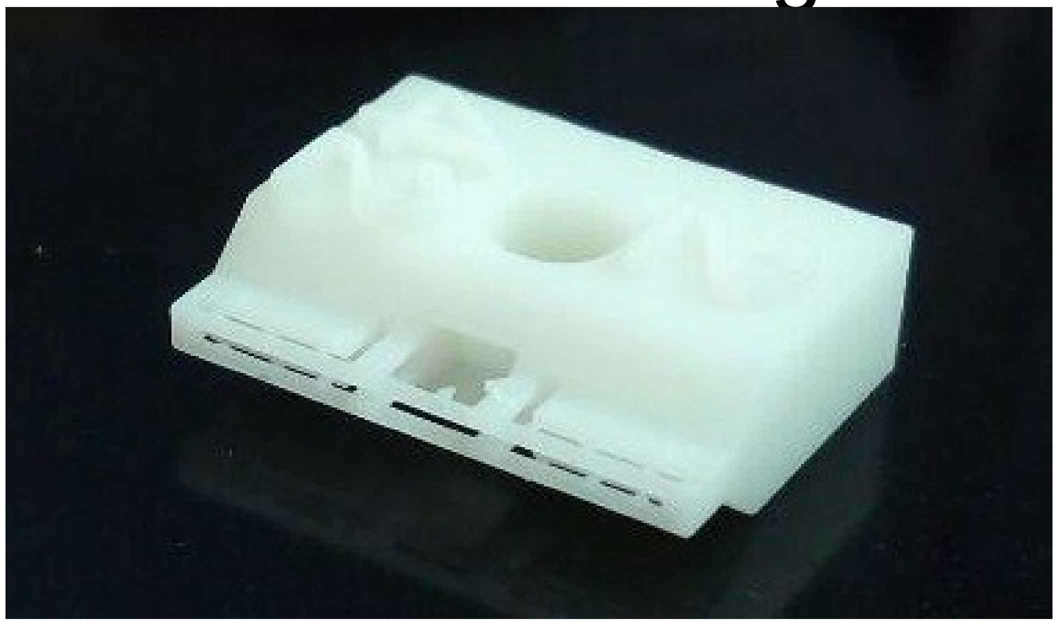
Connectors: space and massive

3D-printed adaptor CURRENT design

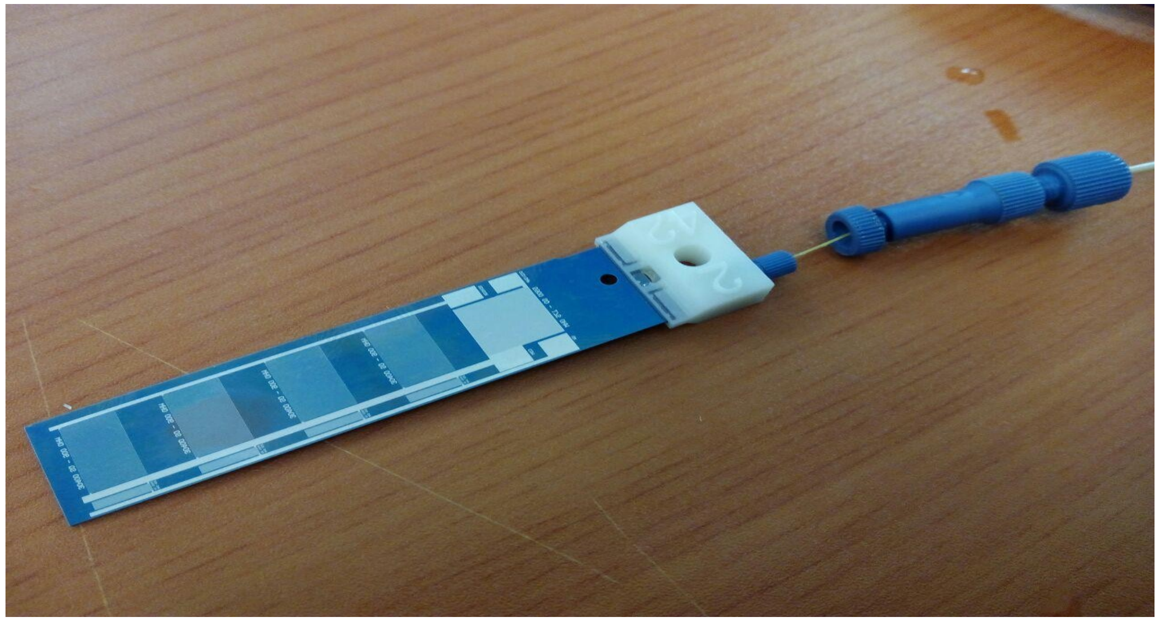
Design



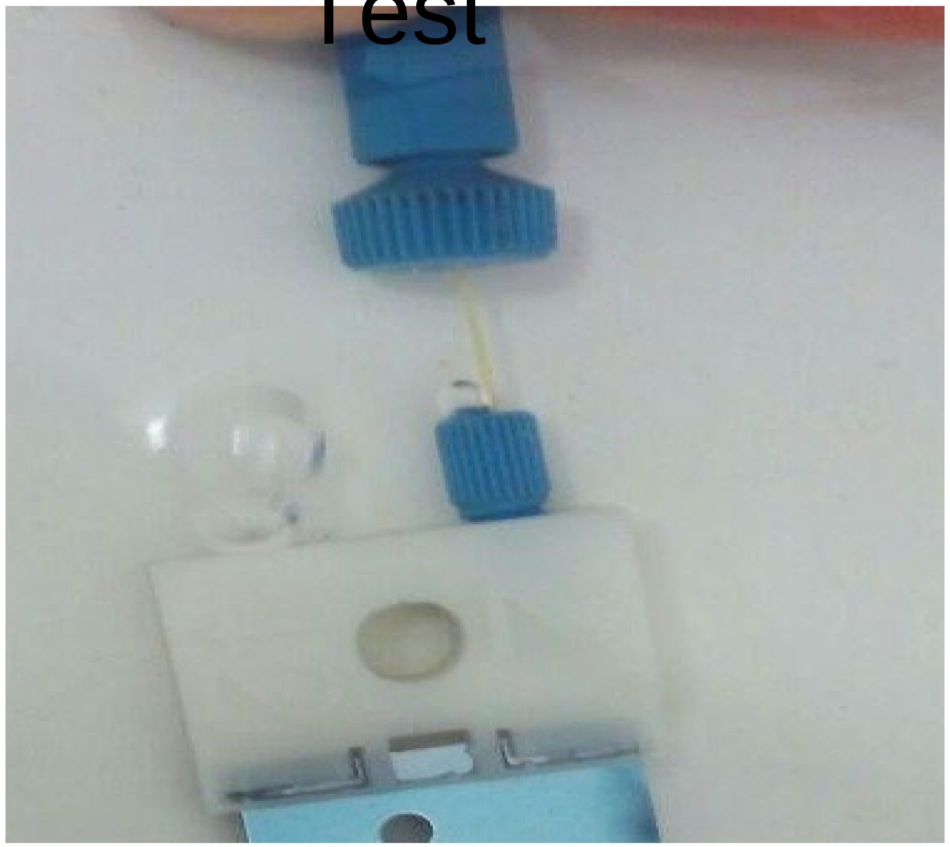
3D-Printing



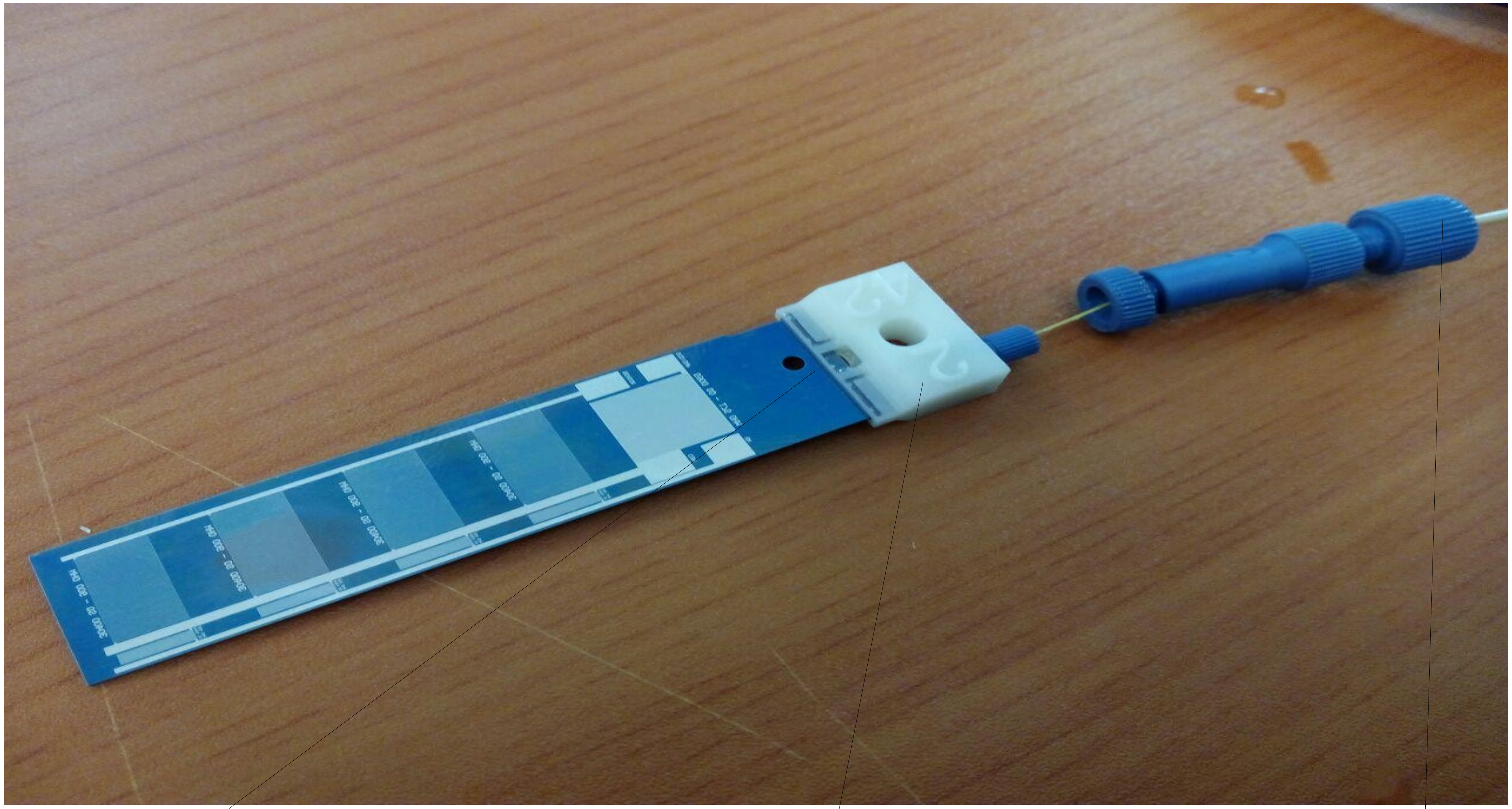
Gluing



Test



3D-printed adaptor CURRENT design: Characteristics

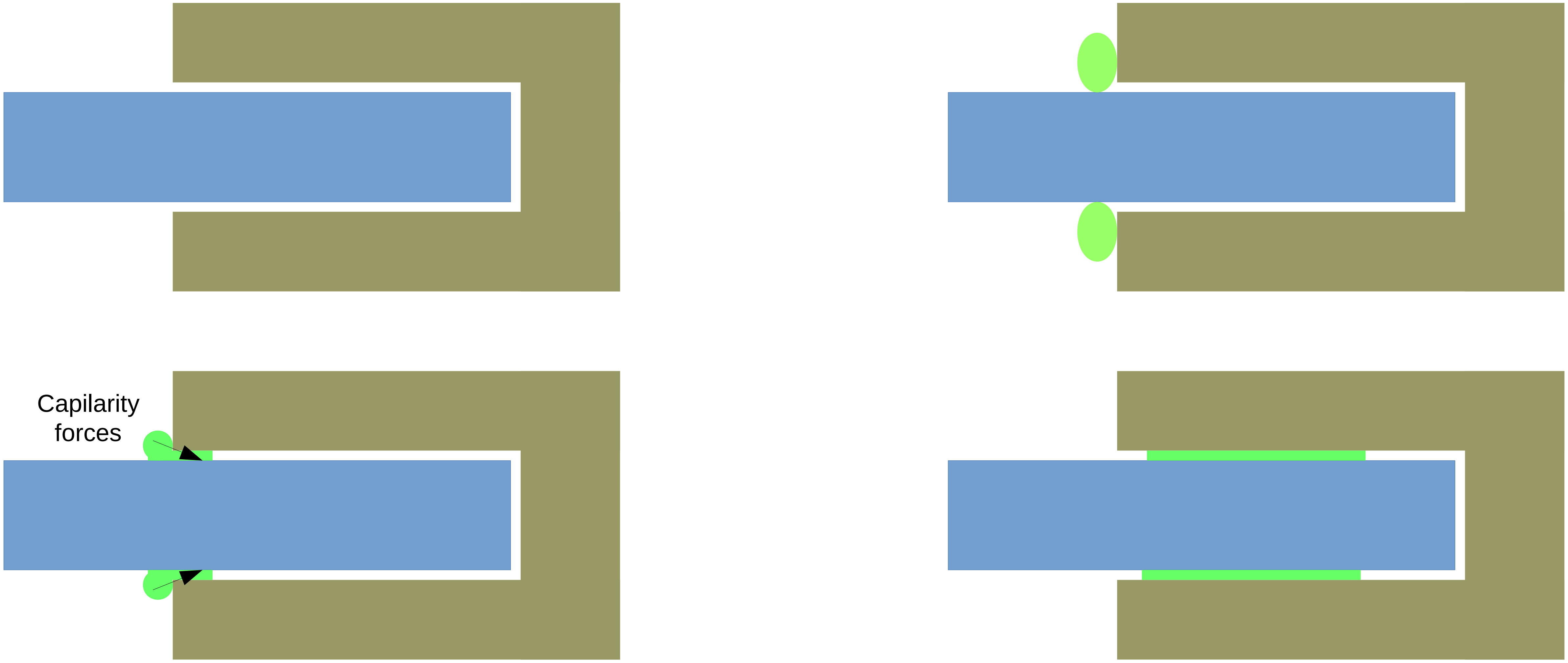


Glue: Araldite2020

3D printed part: less massive → X/X0=0,21%

Connectors: far from VX region

3D-printed adaptor CURRENT design: Glue issue



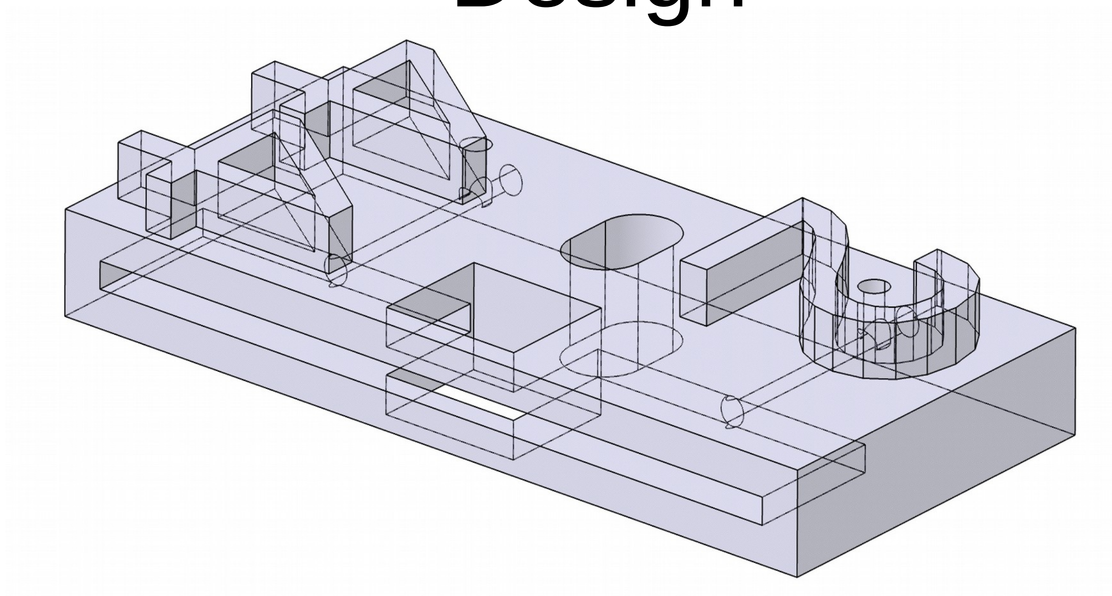
Glue: Araldite2020

Expected max. pressure: 150bar

Possible problem: Clog of MC

3D-printed adaptor FUTURE design

Design



3D-Printing

X/X0=0,05%

Gluing

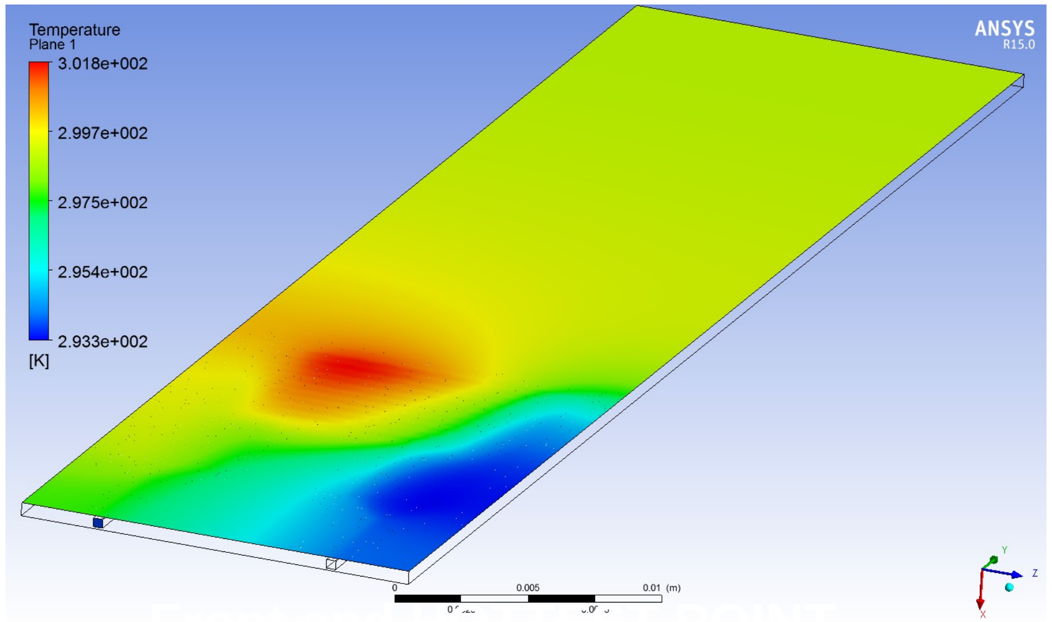
Test

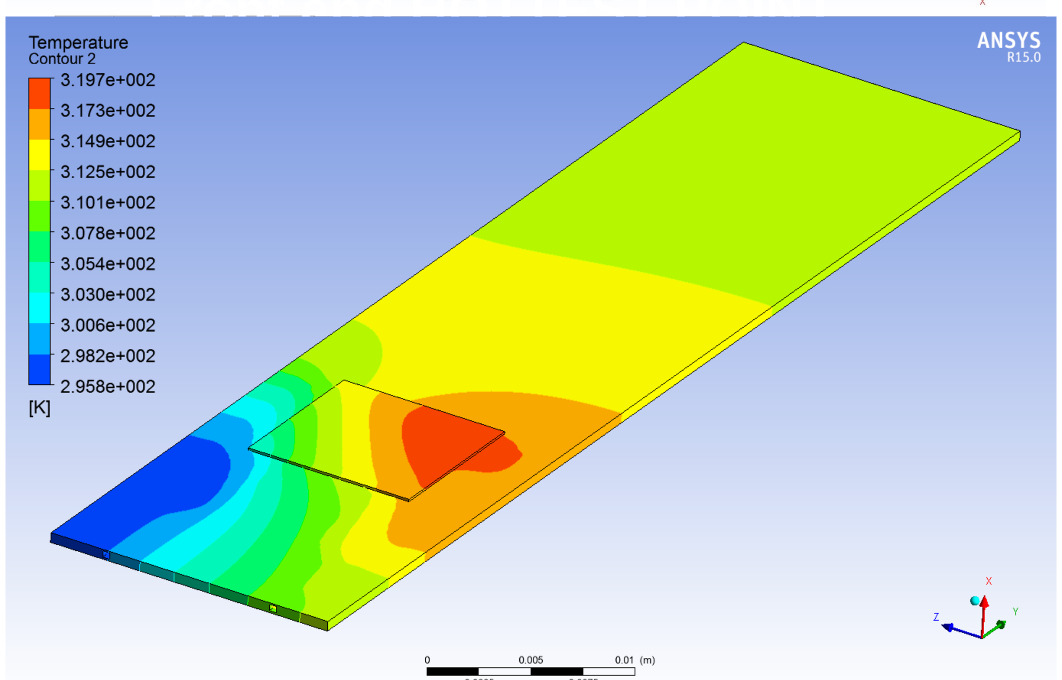
To try different
types of glue:
2020
2011
Epolite

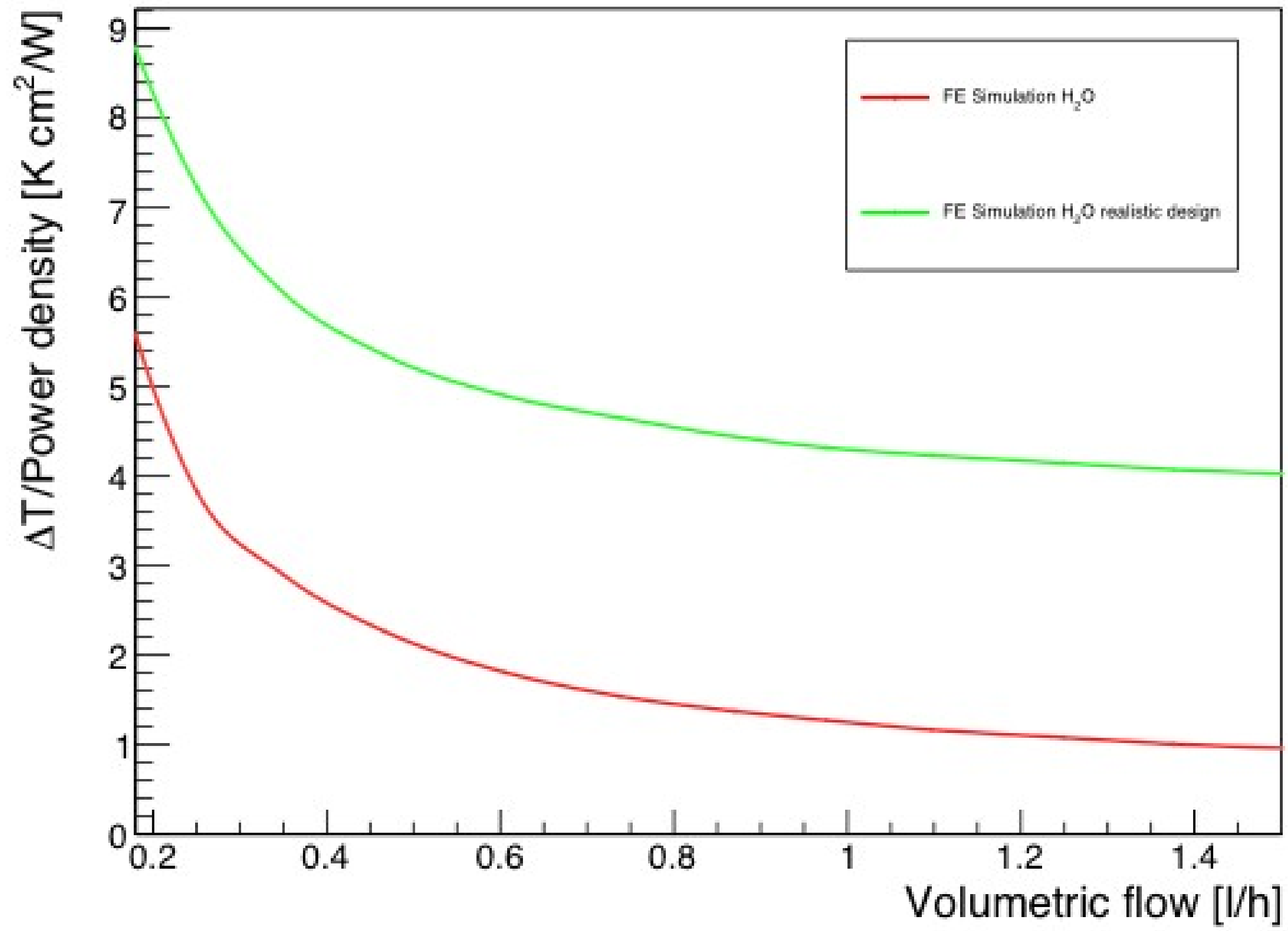
Possibility to include:

1) Bumpboundings (next slides)
2) Thermorresistors (next slides)
3) New MC layout (next slides)
4) Automatize gluing process

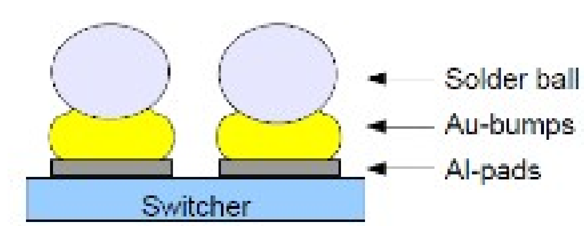
Thermal simulations: bumpboundigs







Realistic design

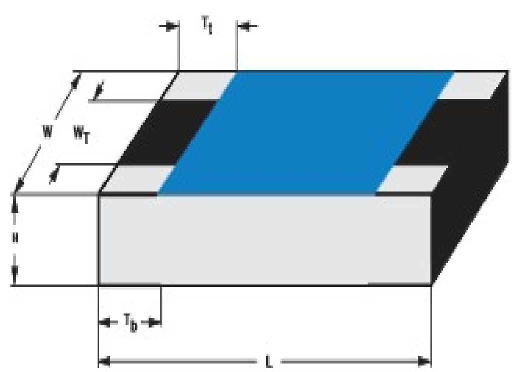


300 µm Si ASICS +
100 µm Bump-boundings
thermal resistivity of 6 W/m·K

C.Mariñas PhD thesis
http://digital.csic.es/bitstream/10261/41942/1/Carlos%20Mari%C3%B1as-Tesis.pdf

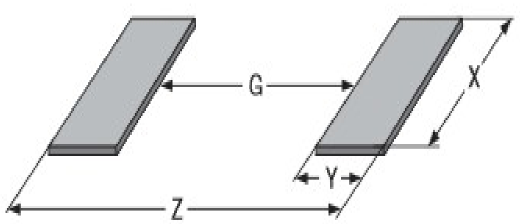
In the realistic design the power dissipation is degraded

Thermal simulations: bumpboundigs

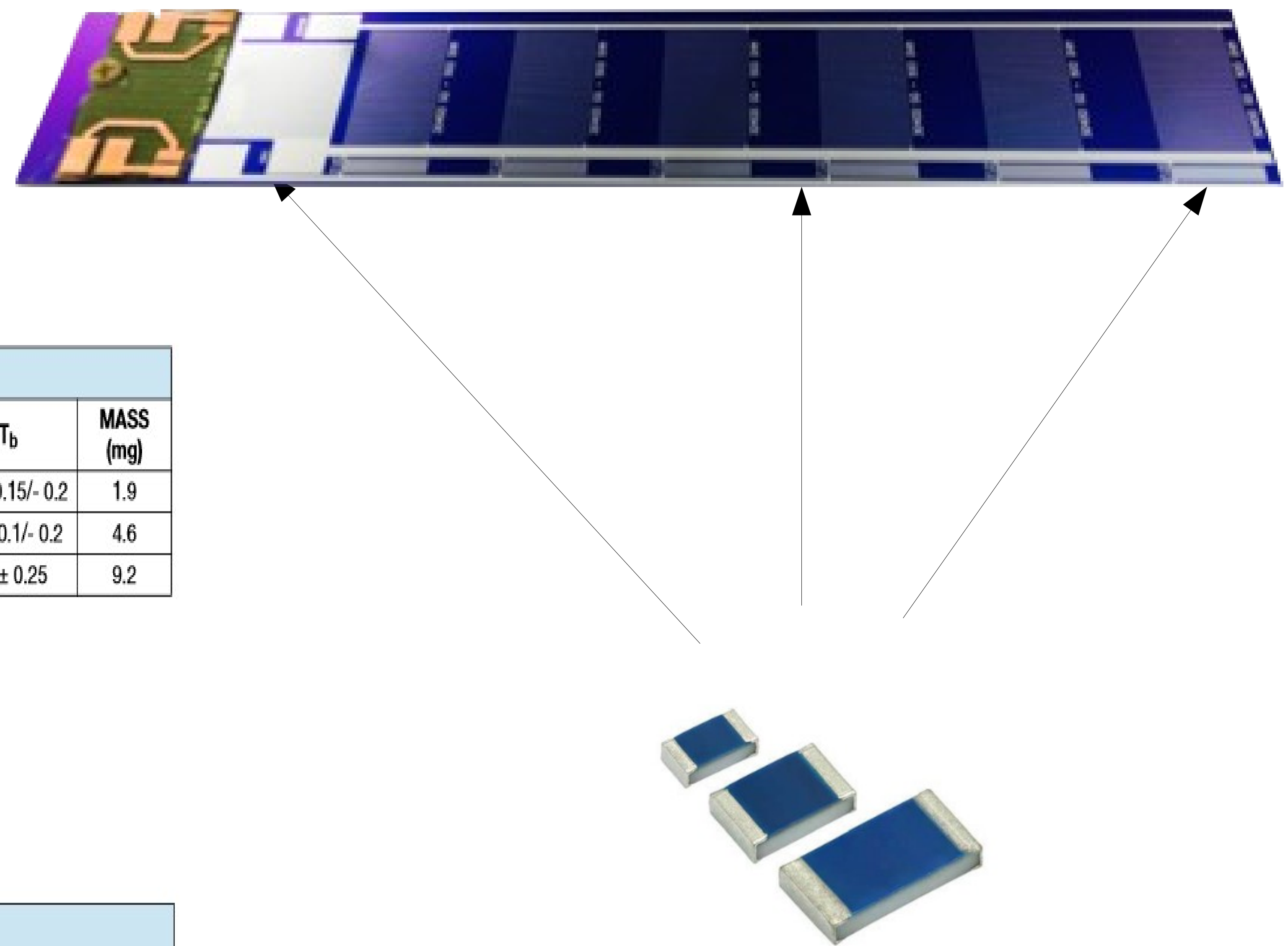


DIMENSIONS - PTS sensor types, mass and relevant physical dimensions							
TYPE	H	L	W	W_T	T_t	T_b	MASS (mg)
PTS 0603	0.45 + 0.1/- 0.05	1.55 ± 0.05	0.85 ± 0.1	> 75 % of W	0.3 + 0.15/- 0.2	0.3 + 0.15/- 0.2	1.9
PTS 0805	0.45 + 0.1/- 0.05	2.0 ± 0.1	1.25 ± 0.15	> 75 % of W	0.4 + 0.1/- 0.2	0.4 + 0.1/- 0.2	4.6
PTS 1206	0.55 ± 0.1	3.1 + 0.1/- 0.2	1.6 ± 0.15	> 75 % of W	0.5 ± 0.25	0.5 ± 0.25	9.2

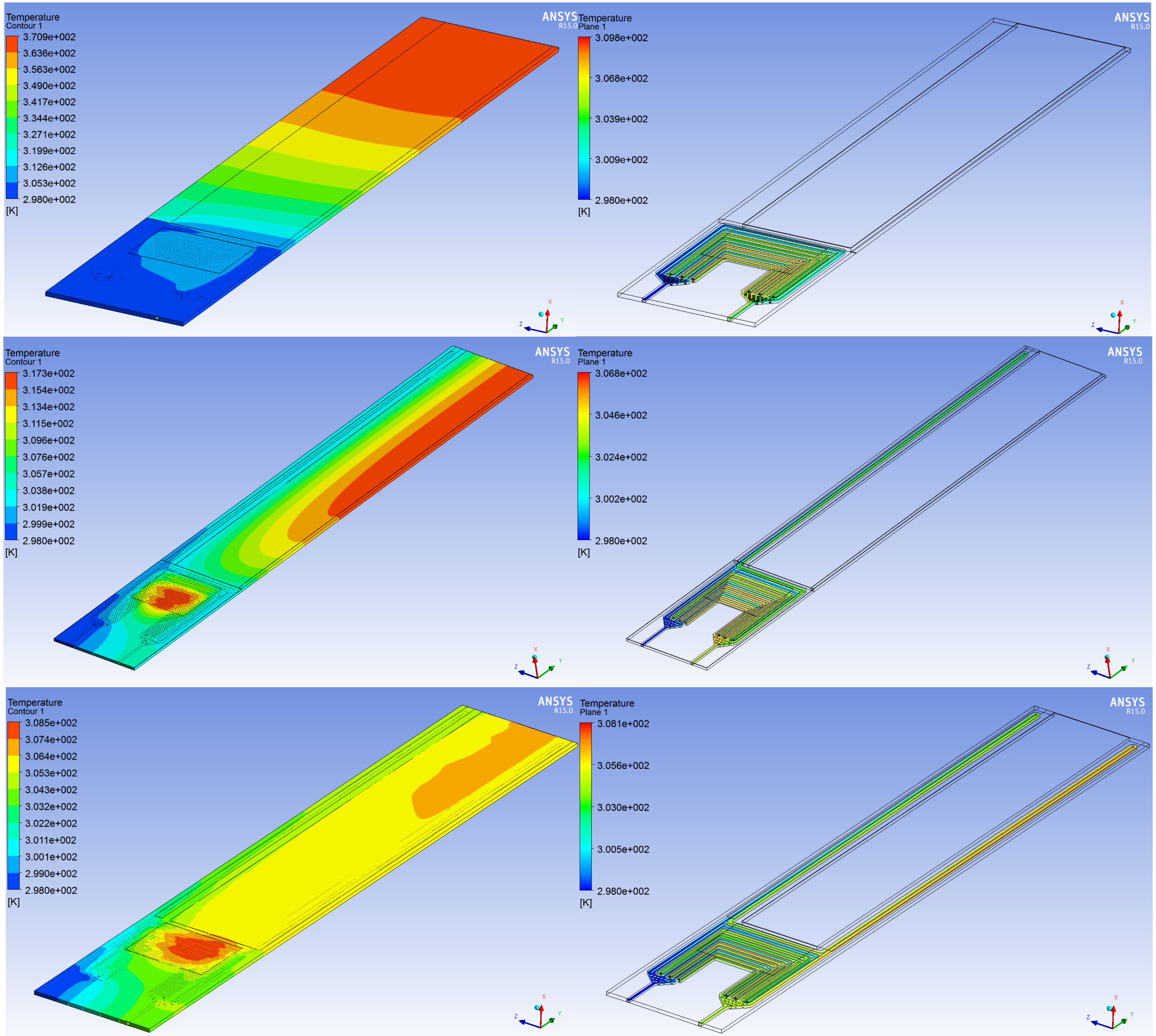
SOLDER PAD DIMENSIONS in millimeters



RECOMMENDED SOLDERPAD DIMENSIONS								
TYPE	WAVE SOLDERING				REFLOW SOLDERING			
	G	Y	X	Z	G	Y	X	Z
PTS 0603	0.55	1.1	1.1	2.75	0.65	0.7	0.95	2.05
PTS 0805	0.8	1.25	1.50	3.2	0.9	0.9	1.4	2.7
PTS 1206	1.4	1.5	1.9	4.4	1.5	1.15	1.75	3.8



Thermal simulations: Layouts



Standard MCC layout
ΔT = 73 K

Standard MCC layout + channel below switchers
ΔT = 15 K

Standard MCC layout + channel below switchers + channel in the balcony
ΔT = 5 K