Microfluidic thermal management of components

for High Energy Physics and Space Applications

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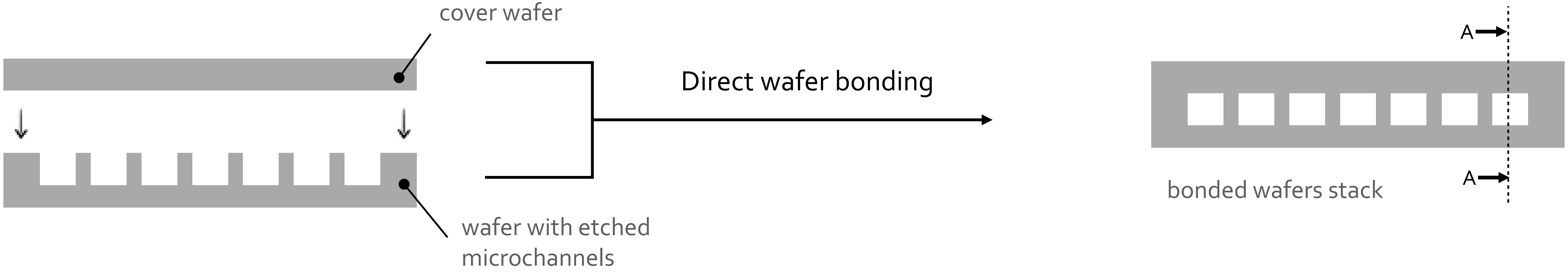
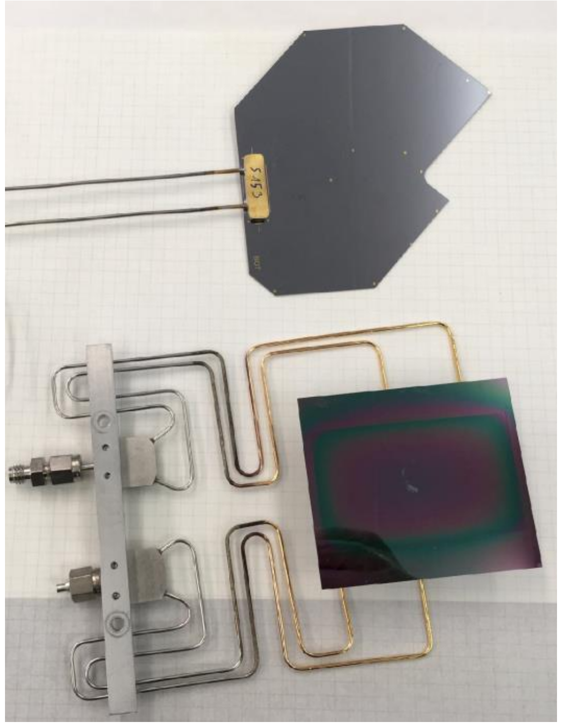
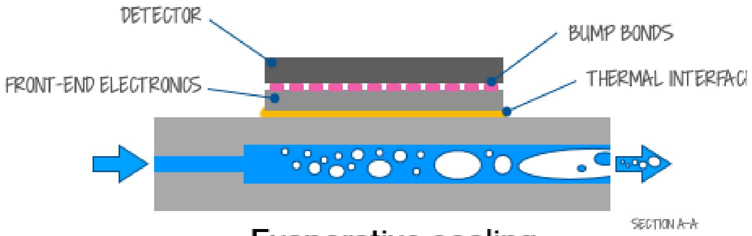
Silicon microfluidic cold plates



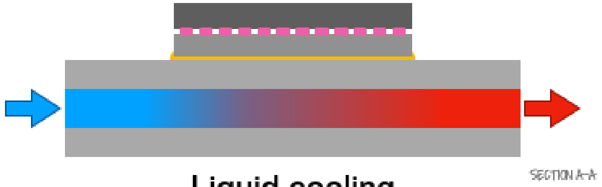


LHCb VeLo

NA62



Evaporative cooling



Liquid cooling

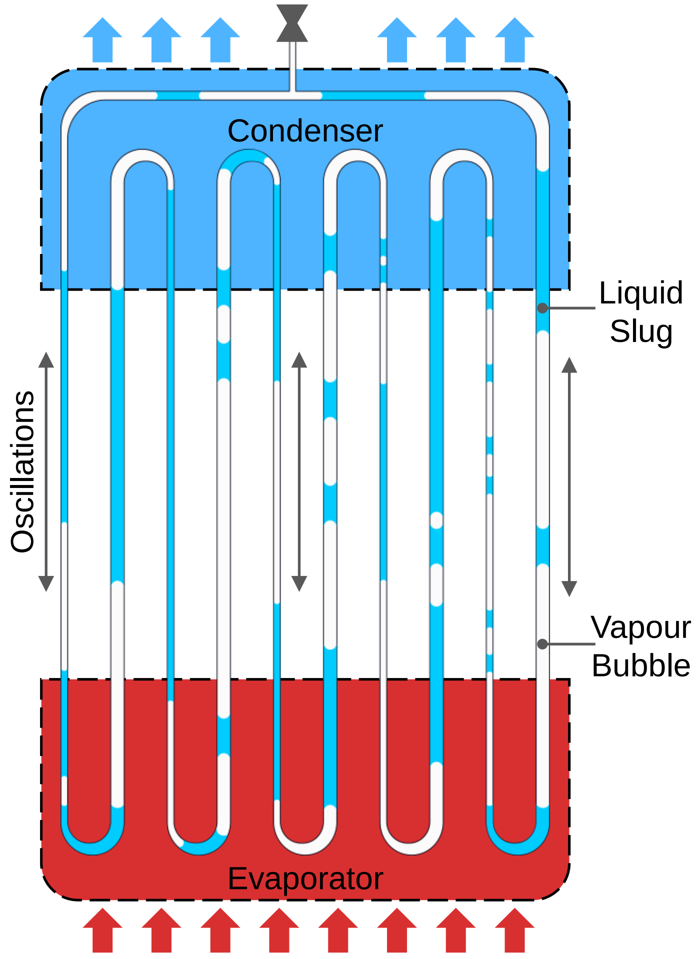
Silicon-based micro oscillating heat pipe (µOHP)

Principle of operation

- Multiple turns channel
- No wick structure
- Partially filled
- Change of fluid's state drives the fluid motion
- Highly chaotic and unstable two phase flow.

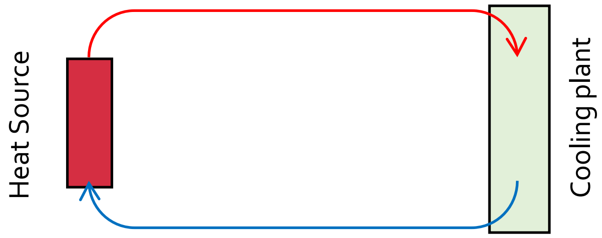
Advantages

- High thermal conductivity
- Self-actuating / passive
- Micro-fabricated (reduced thickness)

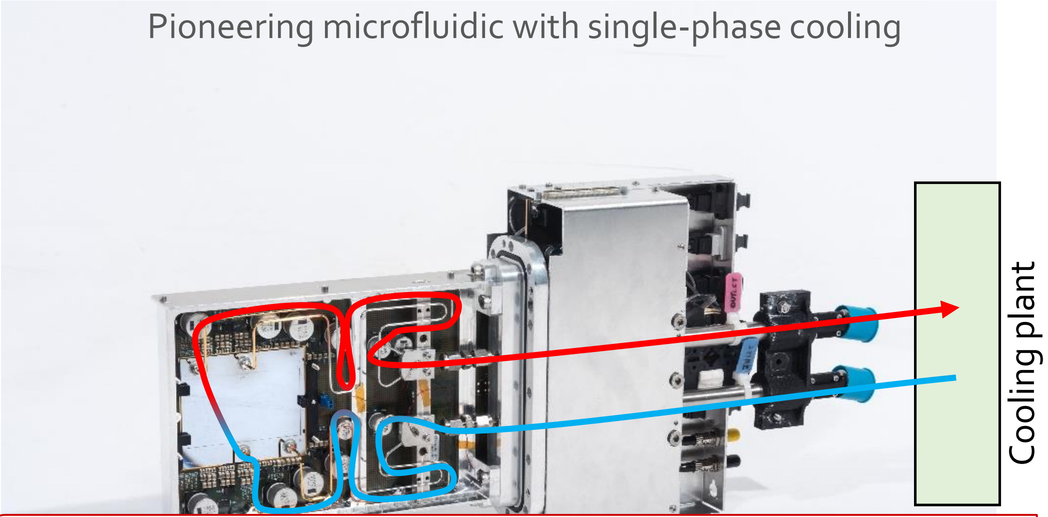


From a single cooling circuit to two cooling circuits

Common approach : single cooling circuit



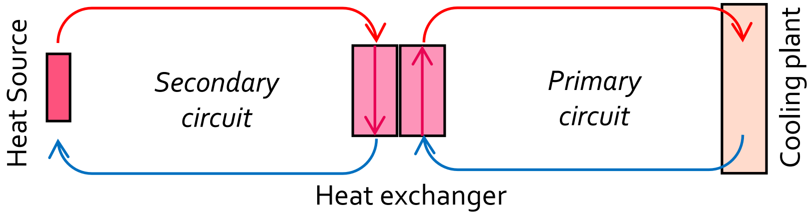
NA62 module

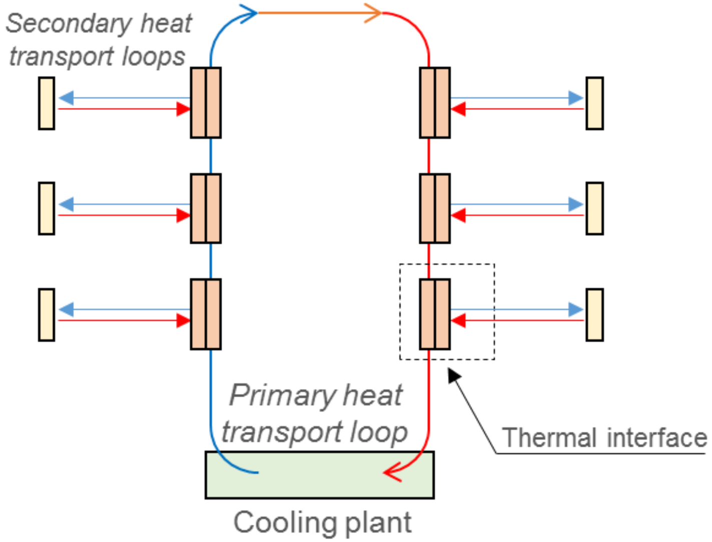


Challenging fluidic interconnection
(material budget, joining technique, reliability)

Decoupling the fluidic interface by creating two cooling loops:

- Two fluidically independent cooling loops
- Mechanical and thermal interfaces only (re-workable)

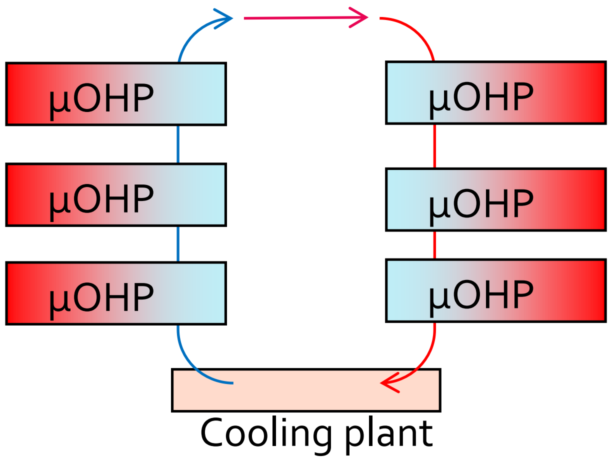


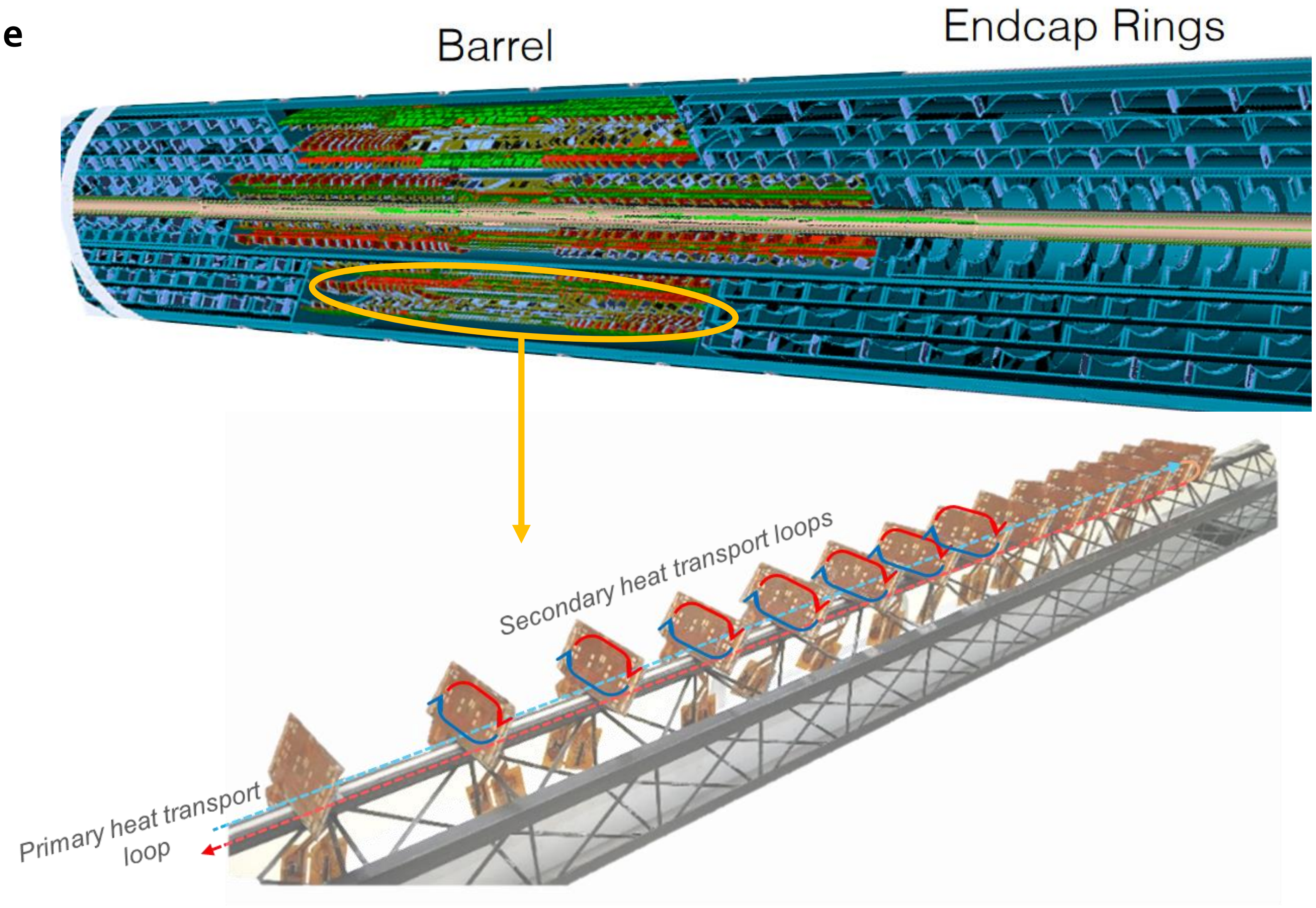


Case study in HEP: ATLAS ITk Outer Barrel stave

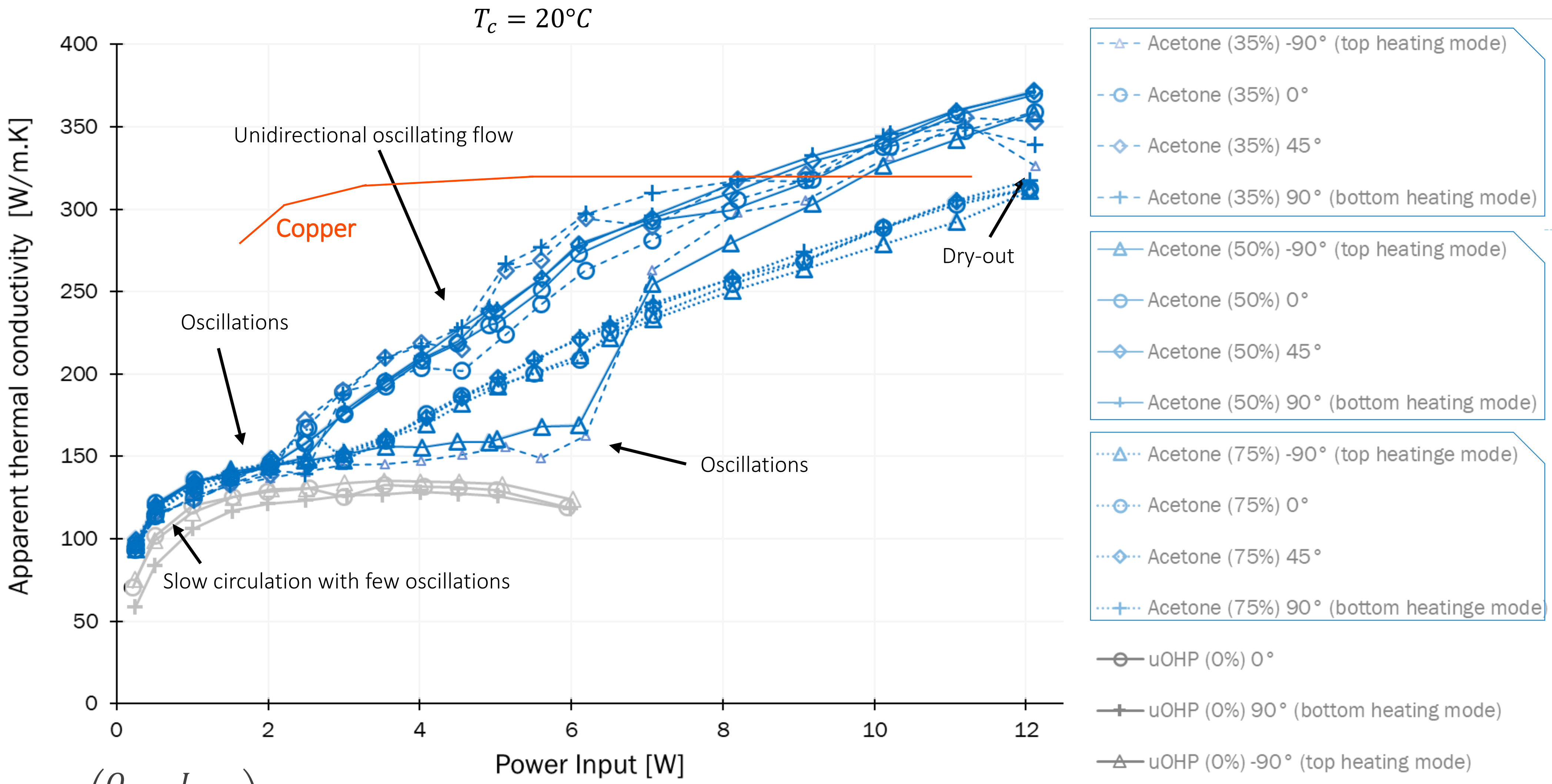
Integration on the backside of the silicon sensors

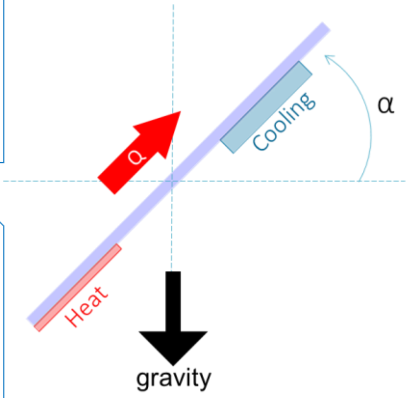
- Reduced thermal path
- Easier integration





Thermal Performance of the device





Dimensions

LOA: 60mm
L: 35mm
W: 20mm
t: 1.1mm
w_1 : 400um
w_2 : 225um
d: 400um

$$k_{app} = \left(\frac{Q}{A}\frac{L}{(T_h - T_c)}\right)$$

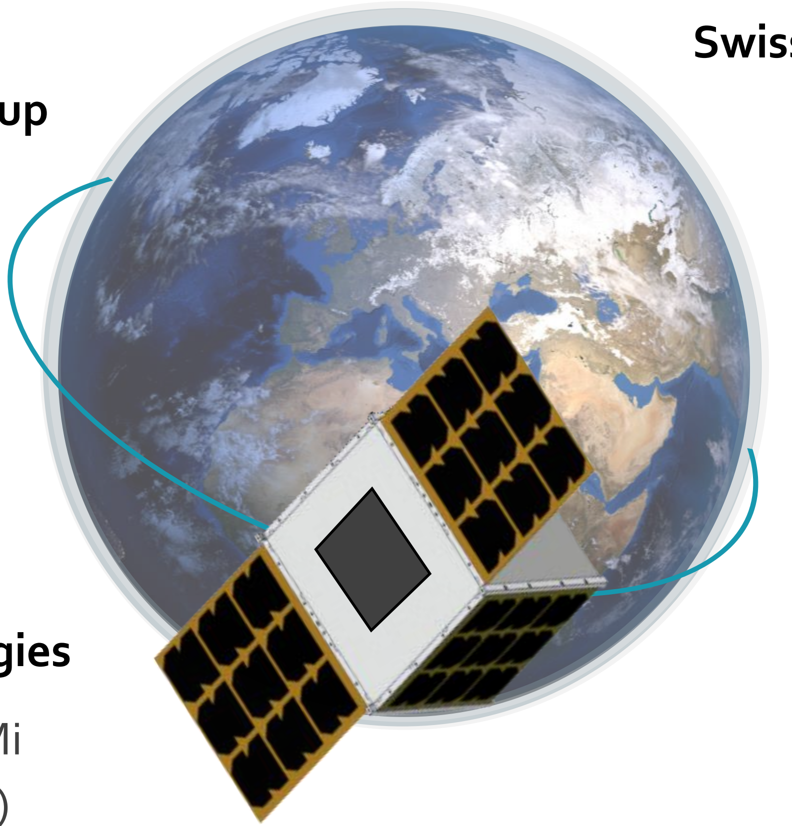
- Up to 535 W/m.K (9W , $T_c = 42°C$)
- Low impact of gravity depending on liquid quantity and power input

Project partners

Knowledge Transfer group

Swiss Centre of Electronics and Microtechnology

- Microfabrication expertise
- Silicon processing facilities access (6” silicon wafers processing)



Swiss Federal Institute of Technologies

- Strengthen link with CMi (4”silicon wafers processing)

- Promoting CERN’s visibility
- Identifying space applications

Space: similar environment & similar requirements for silicon sensors and electronics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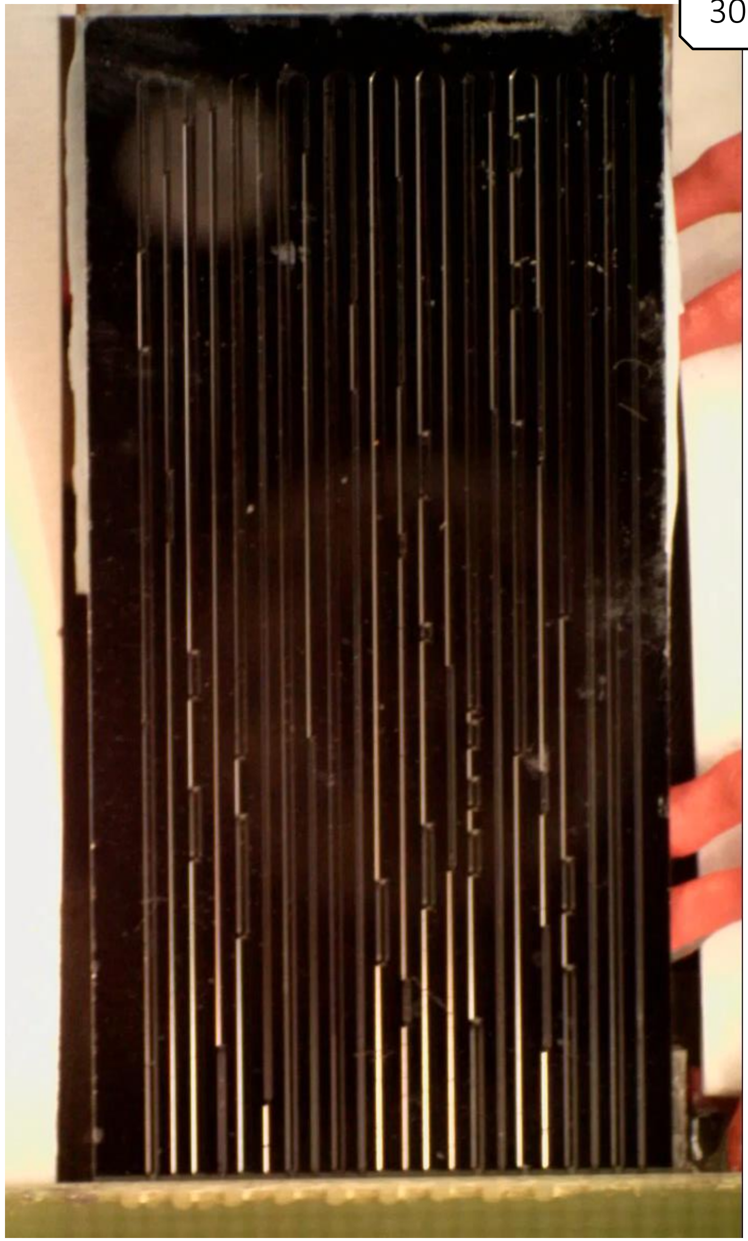
Additional Material

First oscillations

30 FPS



Heat (evaporator)

Cooling (condenser)

1000 FPS