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Single-phase Modeling in Microchannel with Piranha Pin Fin

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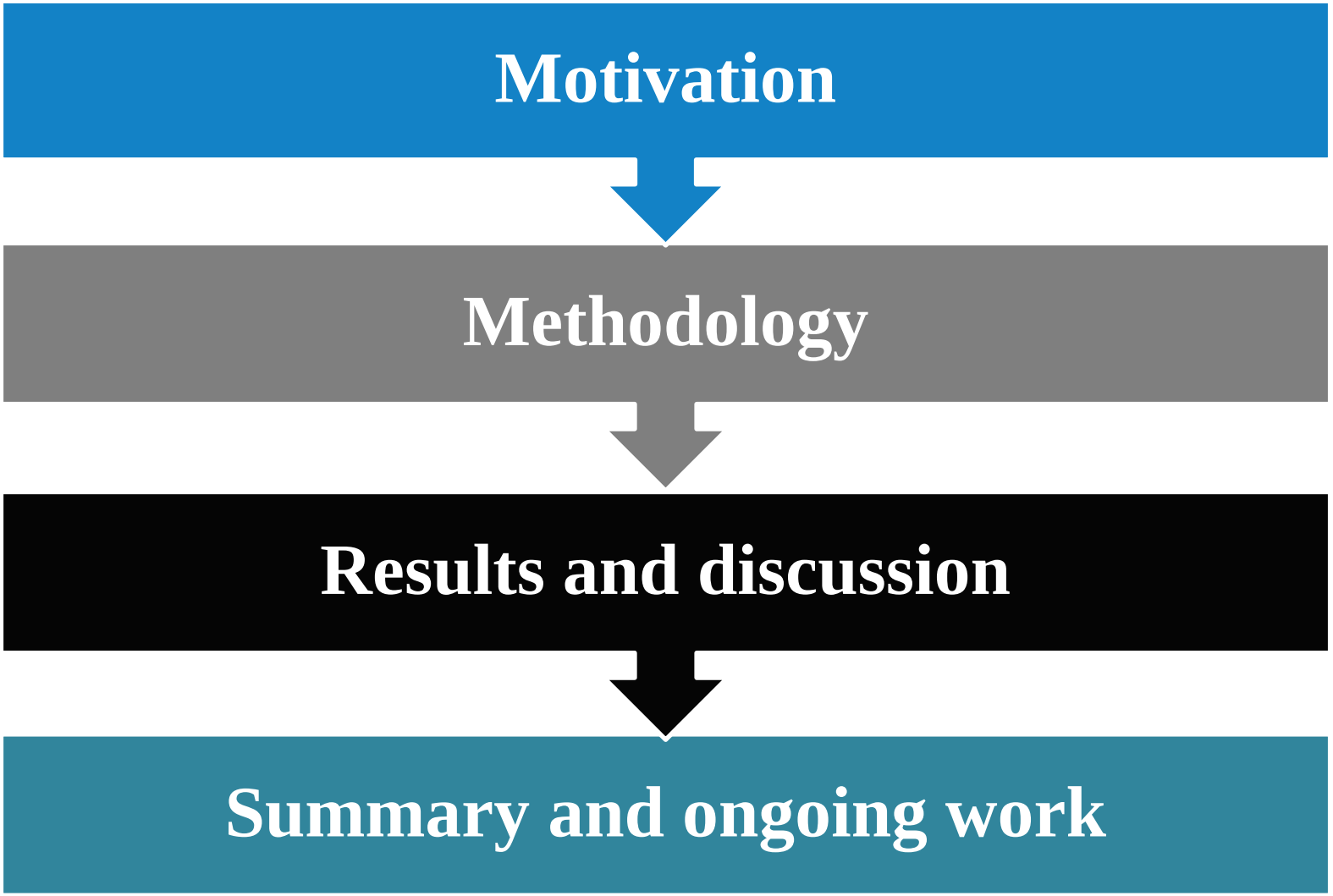
DARPA Rensselaer UCF

Overview

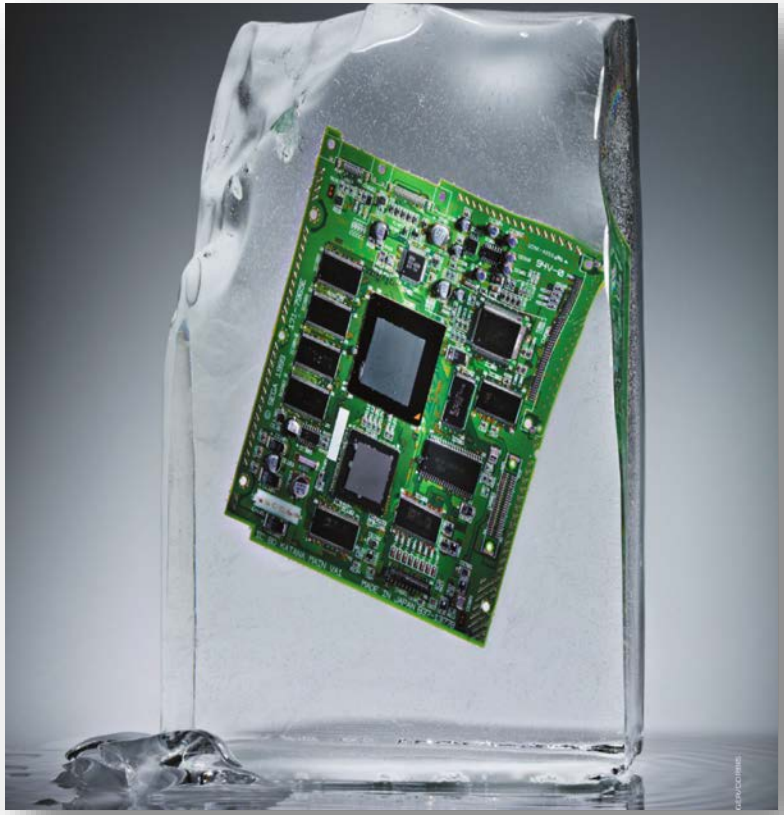

Motivation
Methodology
Results and discussion
Summary and ongoing work

Motivation

Feeling the heat

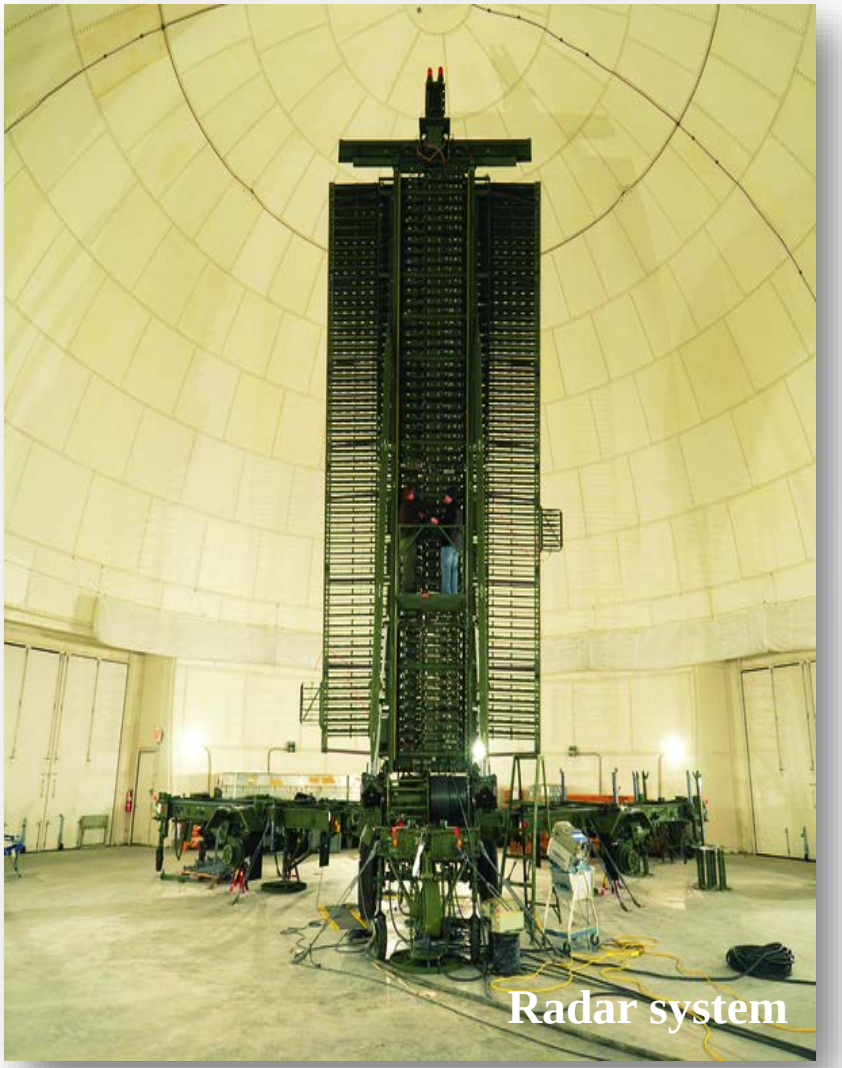
Steam carries heat away from Google's data centre in Dalles, Oregon.

“The more that microcircuits are shrunk, the hotter they get. Engineers are on the hunt for ways to cool off computing.”



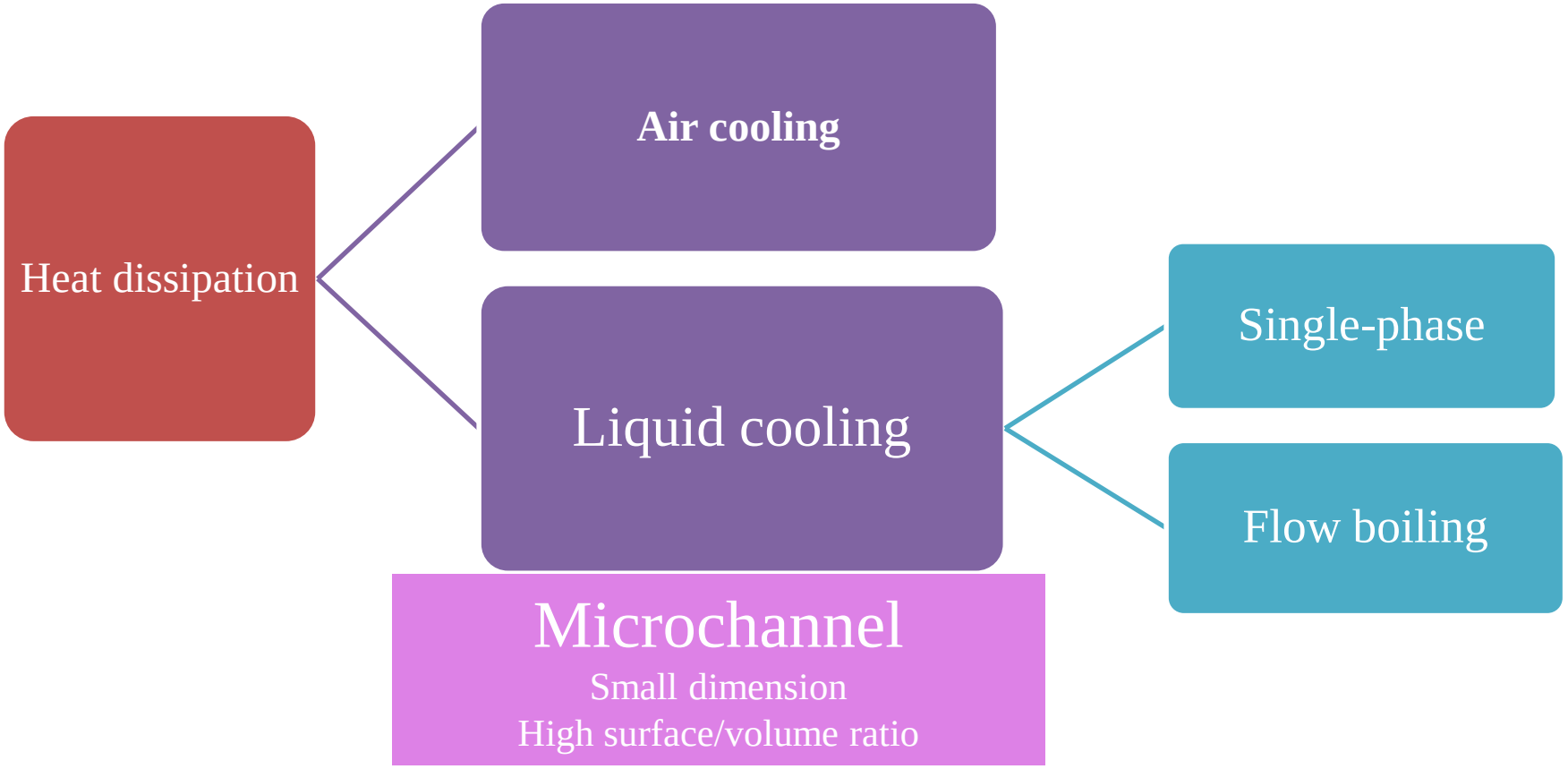
Philip Ball, Computer engineering: Feeling the heat . 174, Nature News, Vol 492, Dec. 2012

Challenges of cooling



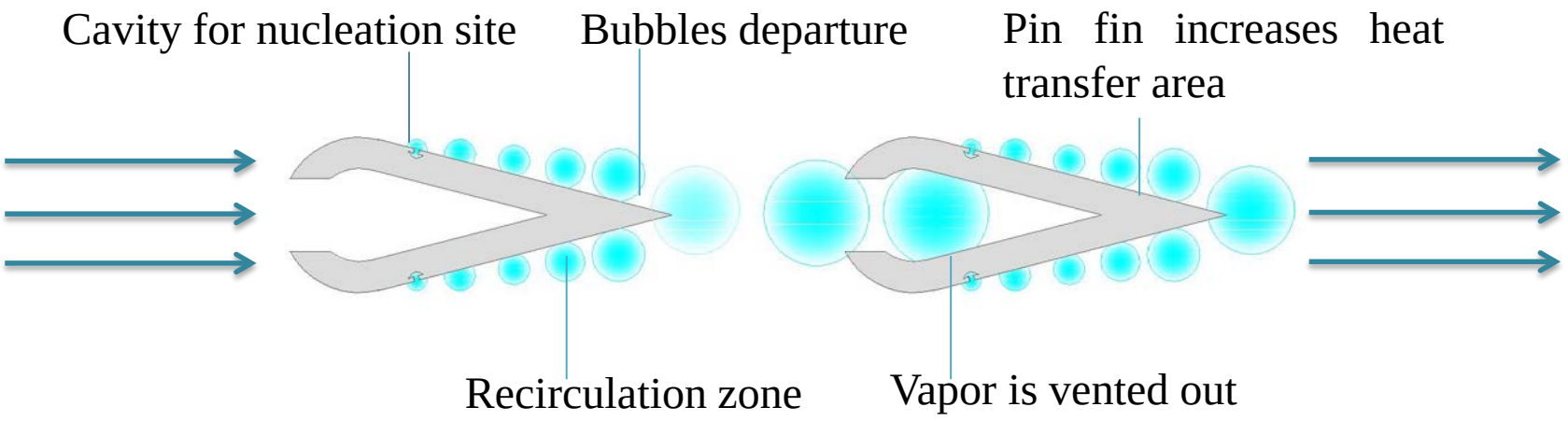
Methodology

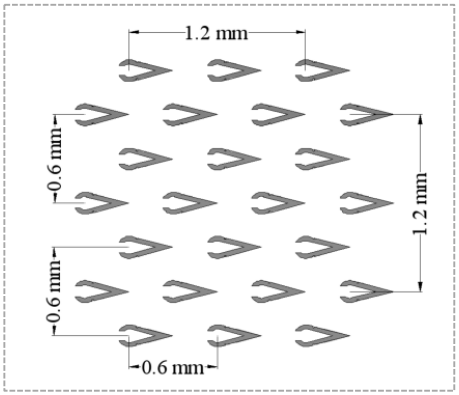
How to meet cooling challenges

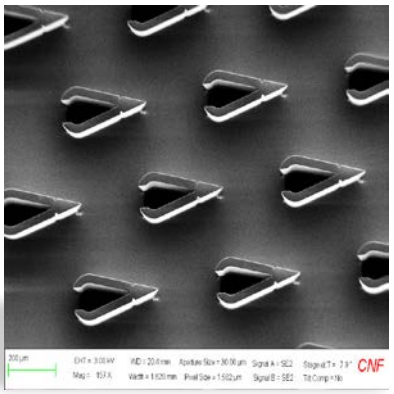


Tuckerman and Pease, 1981, microchannel, 800 W/cm^2

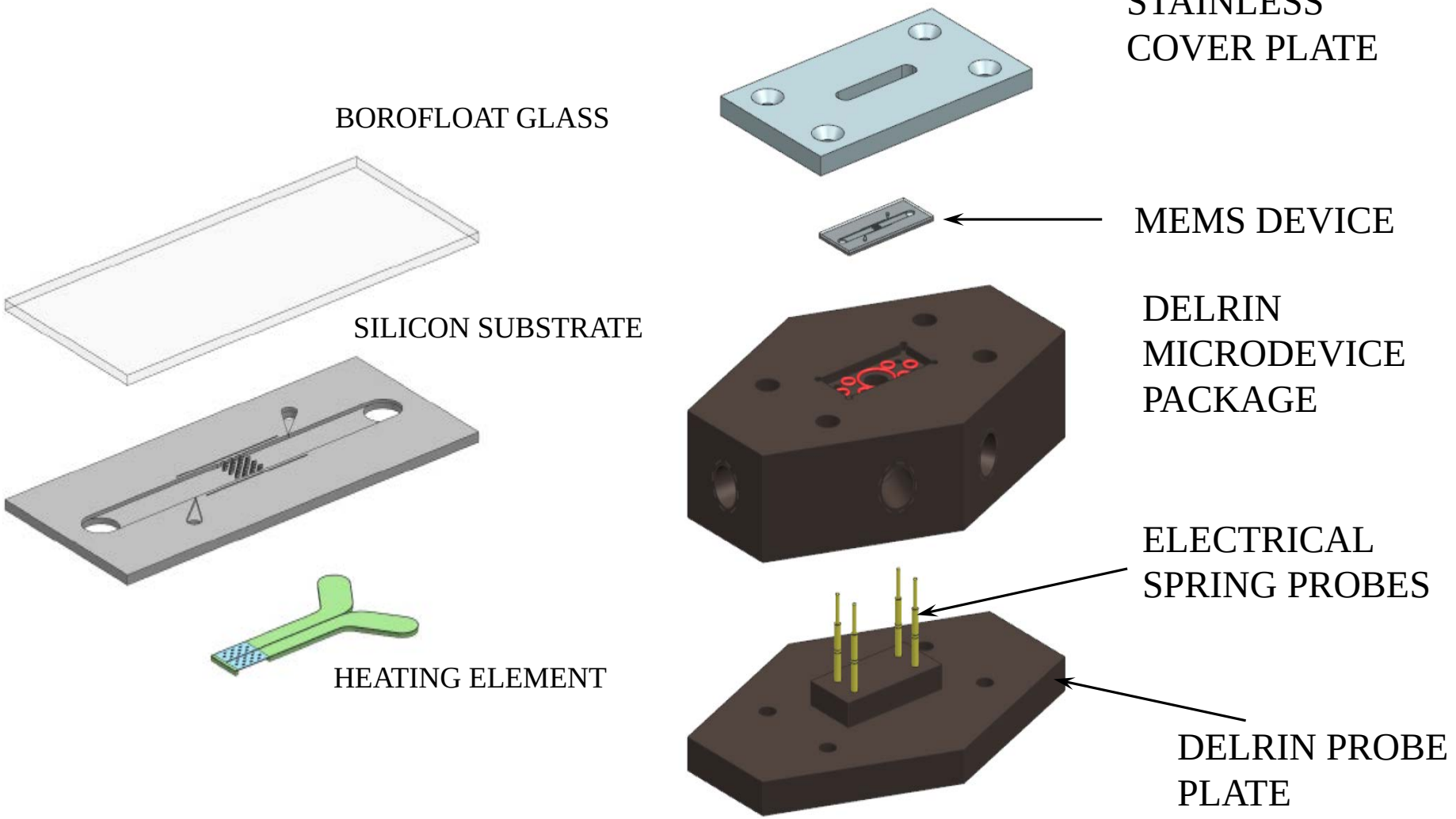
Piranha pin fin



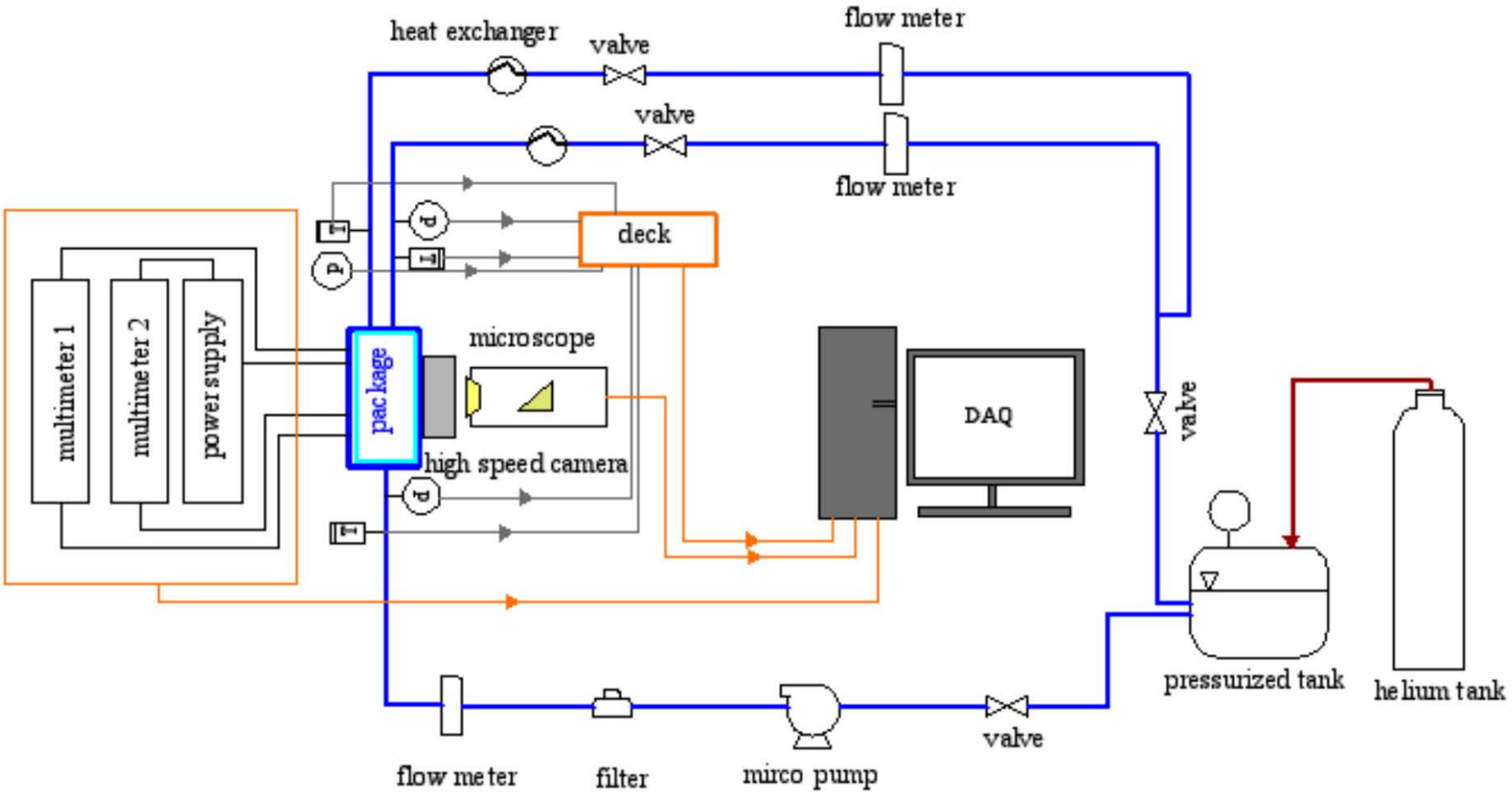




Apparatus


STAINLESS
COVER PLATE
BOROFLOAT GLASS
MEMS DEVICE
SILICON SUBSTRATE
DELRIN
MICRODEVICE
PACKAGE
ELECTRICAL
SPRING PROBES
HEATING ELEMENT
DELRIN PROBE
PLATE

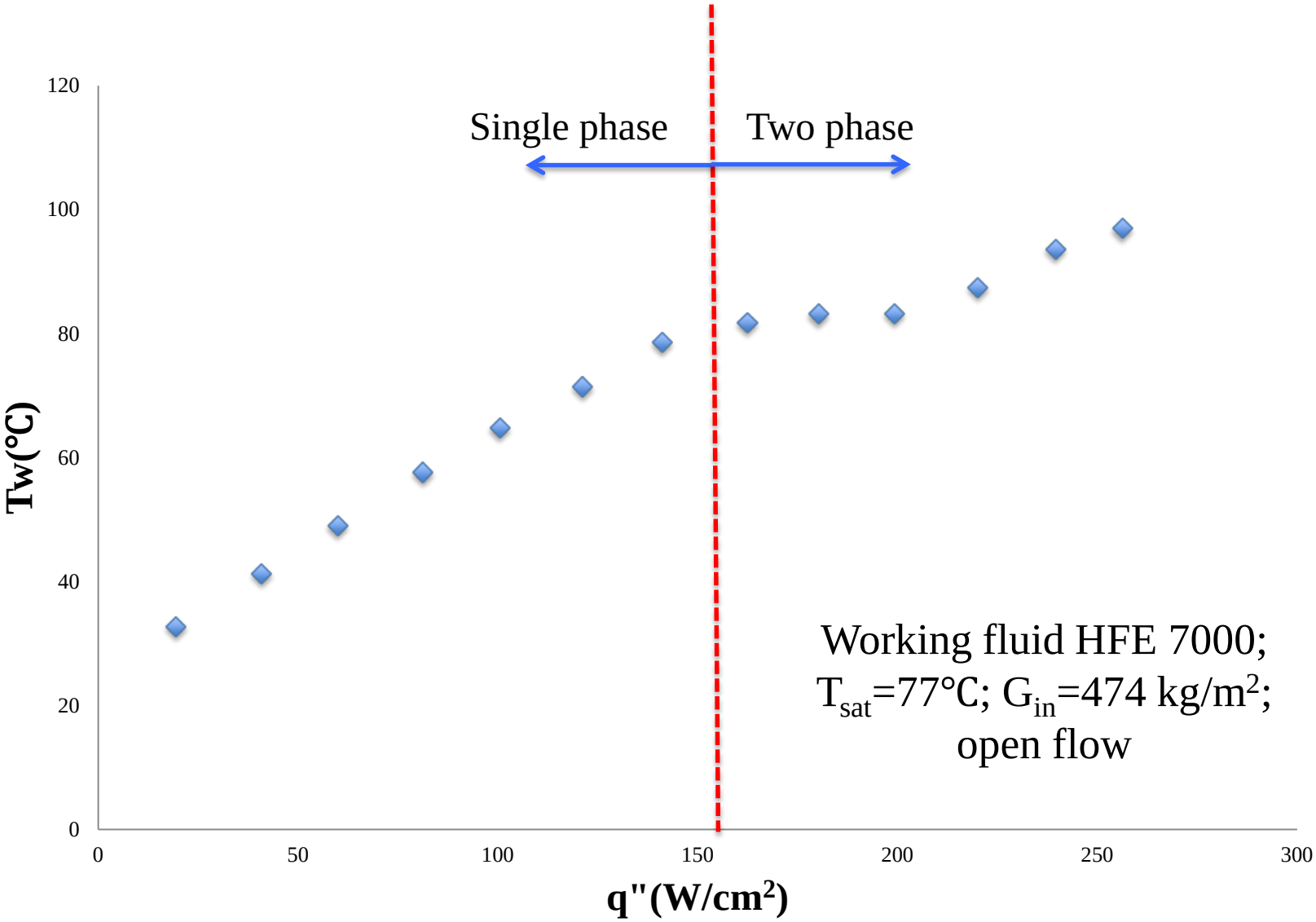
Apparatus



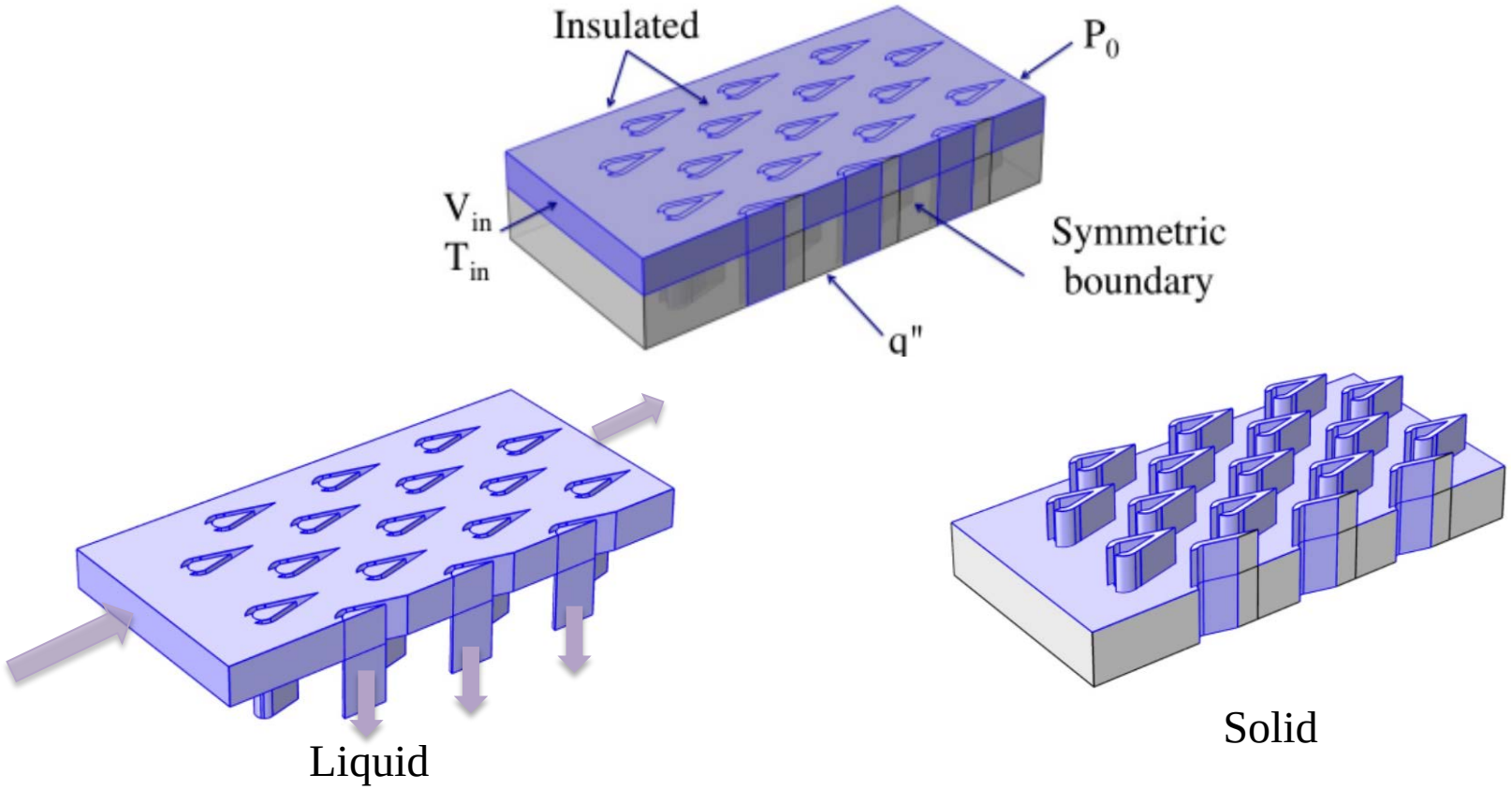
Working fluid: HFE7000

Results and discussion

Experimental measurement

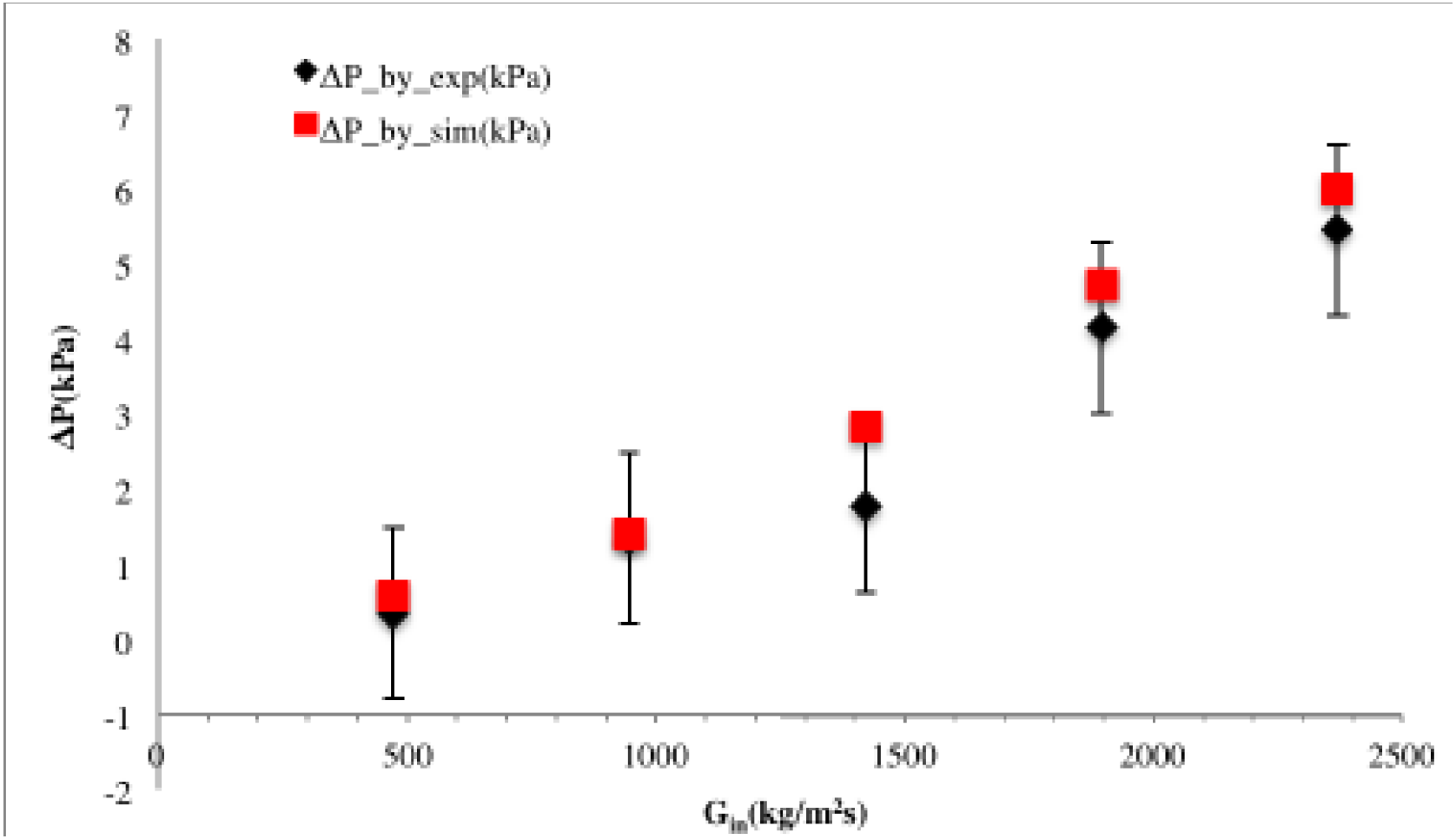


Single-phase set up

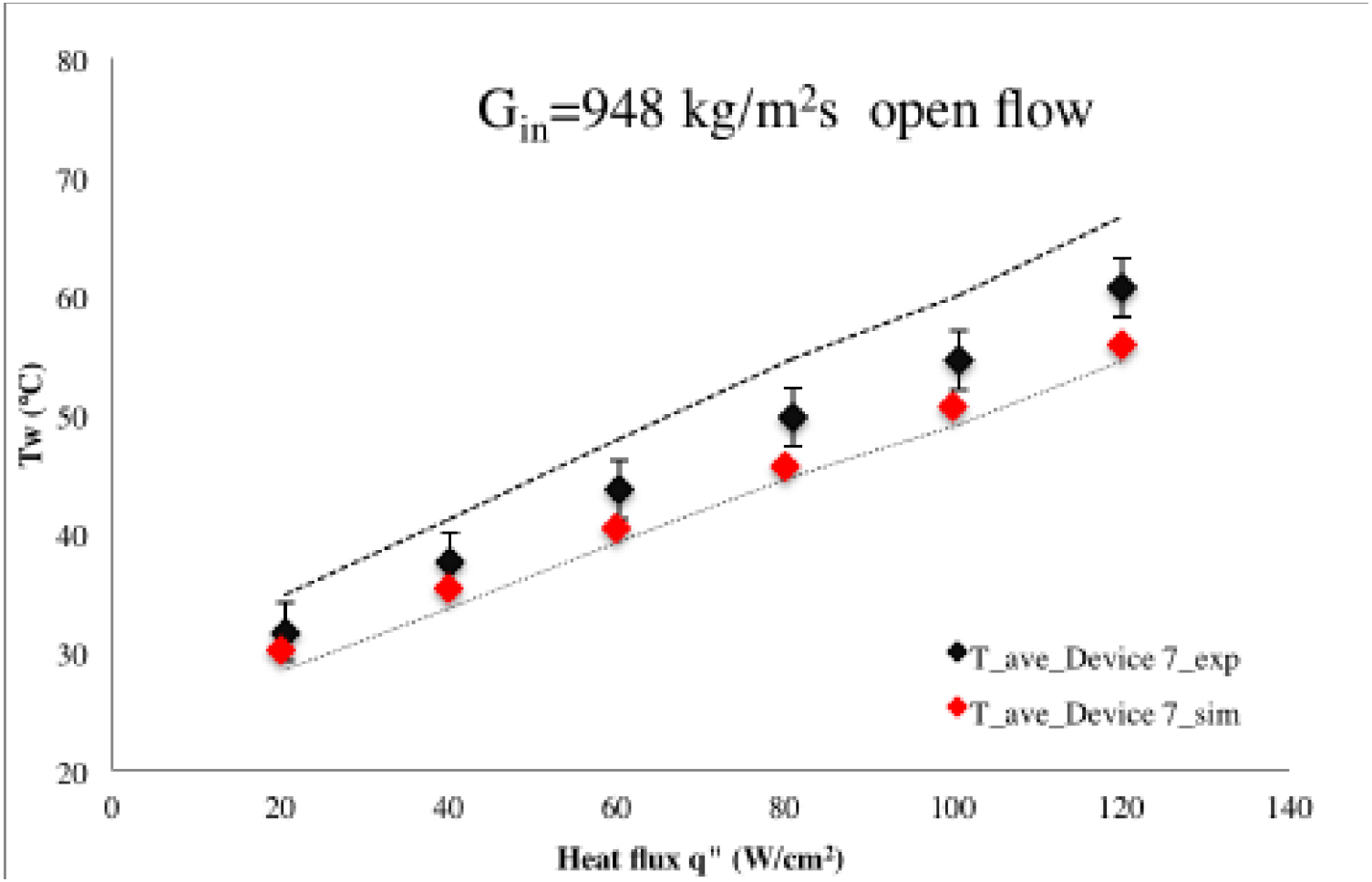


- ✧ **Conjugate heat transfer**
- ➢ **Laminar flow**
- ➢ **Heat transfer in solid & fluid**

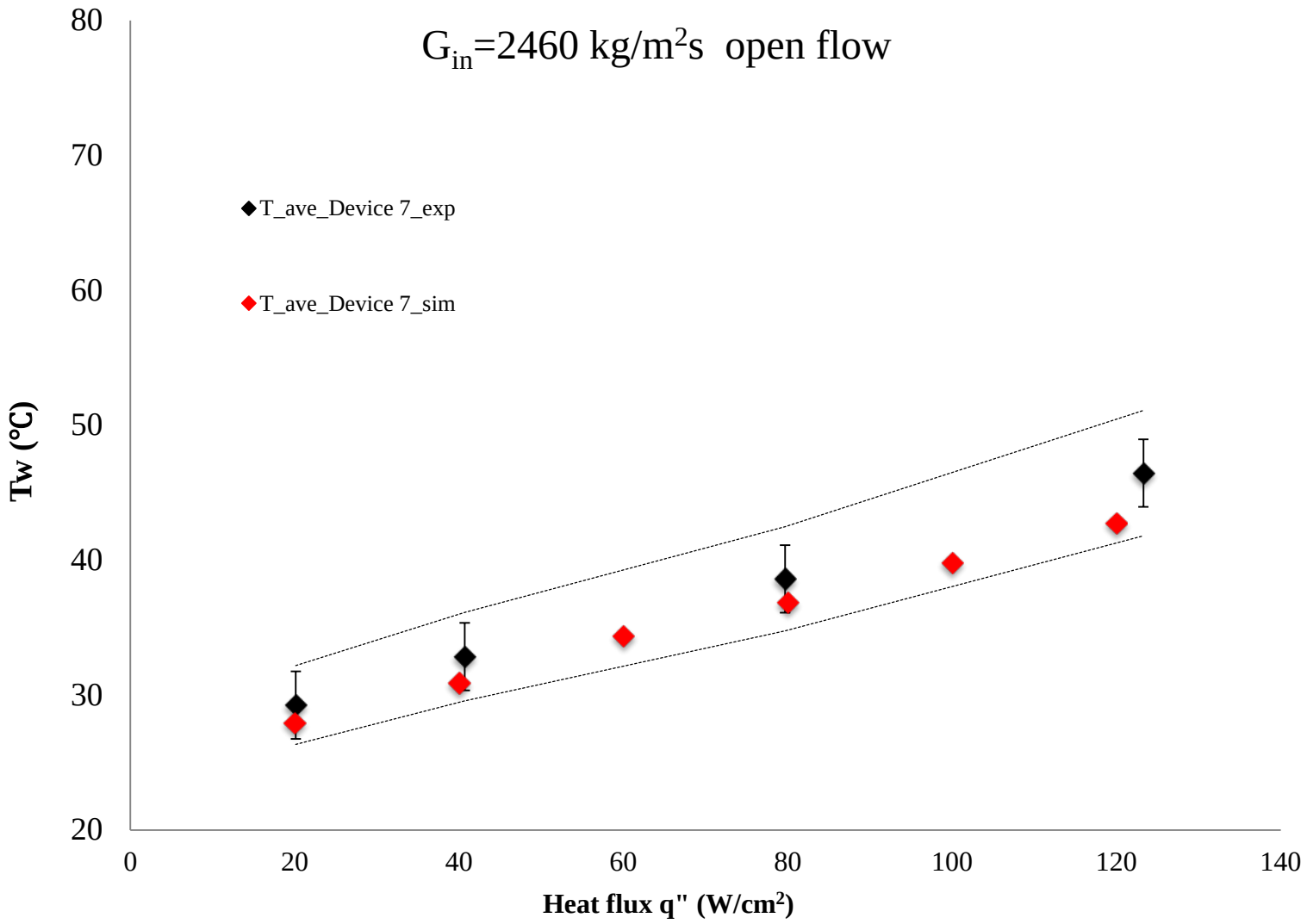
Pressure drop



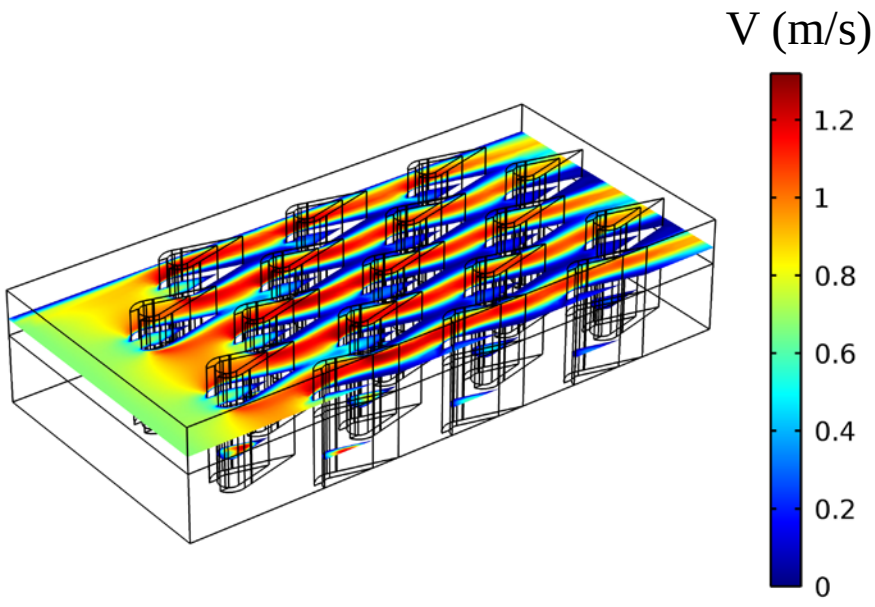
Temperature

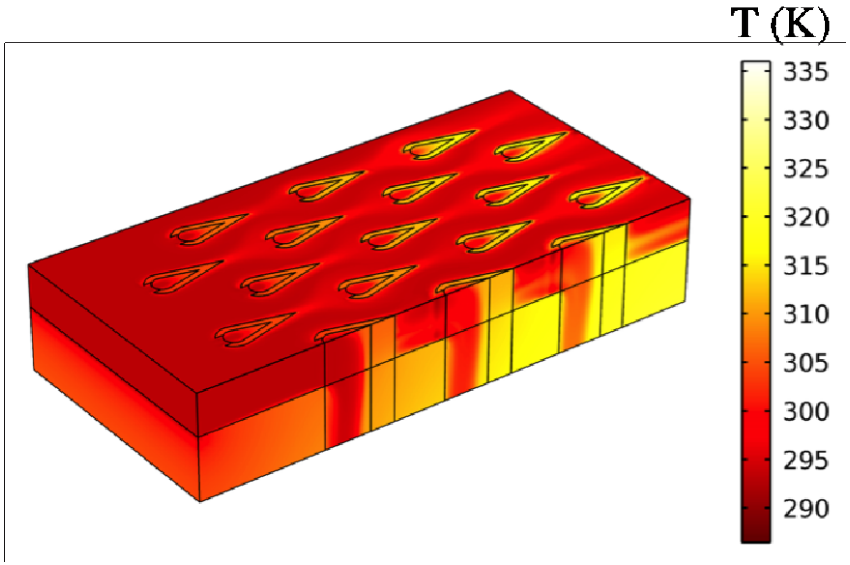


Temperature

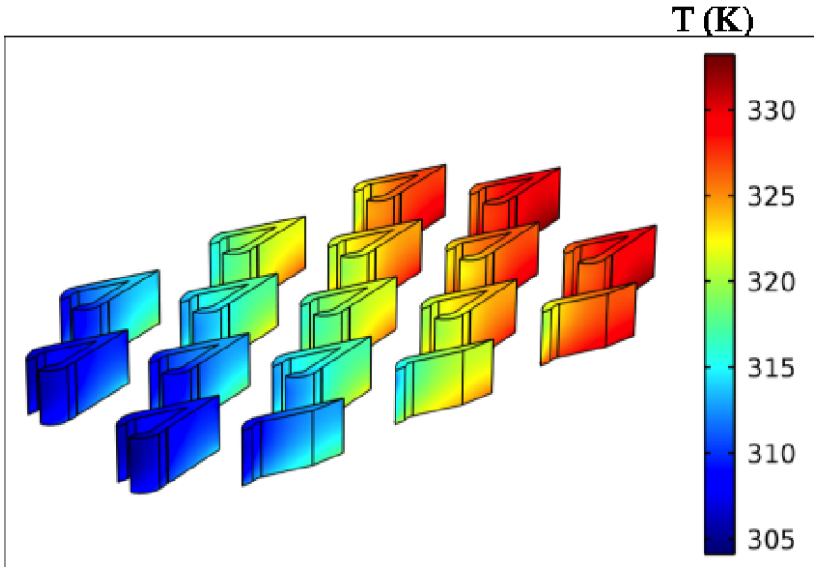


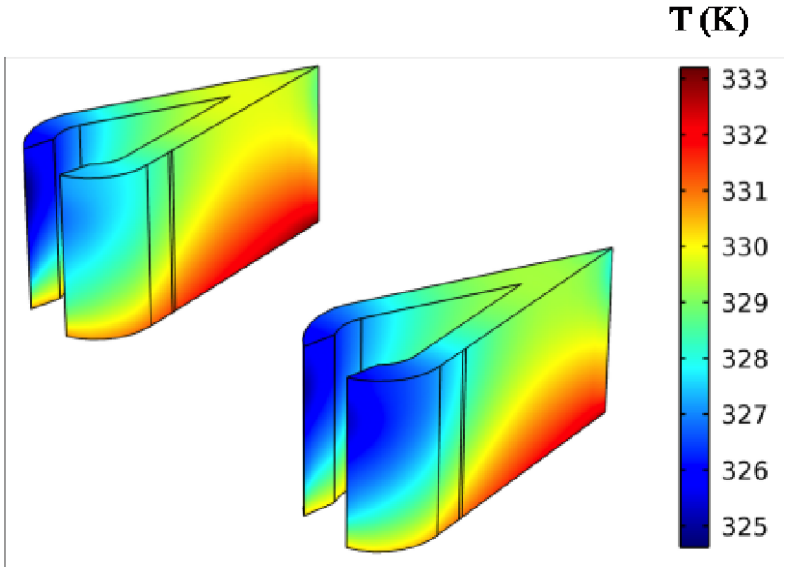
Analysis

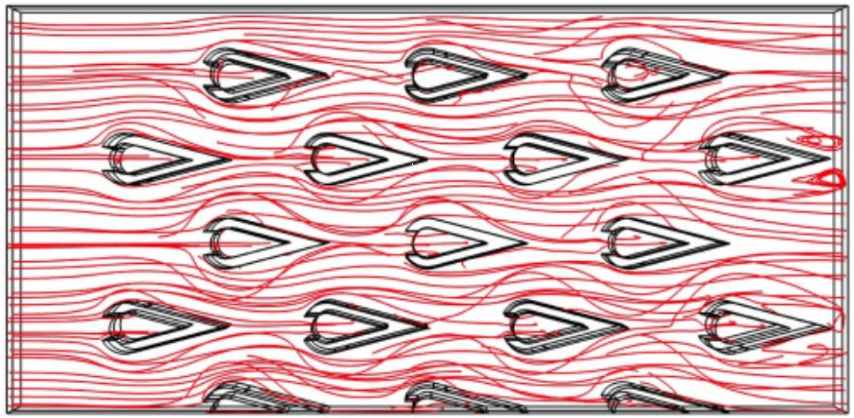




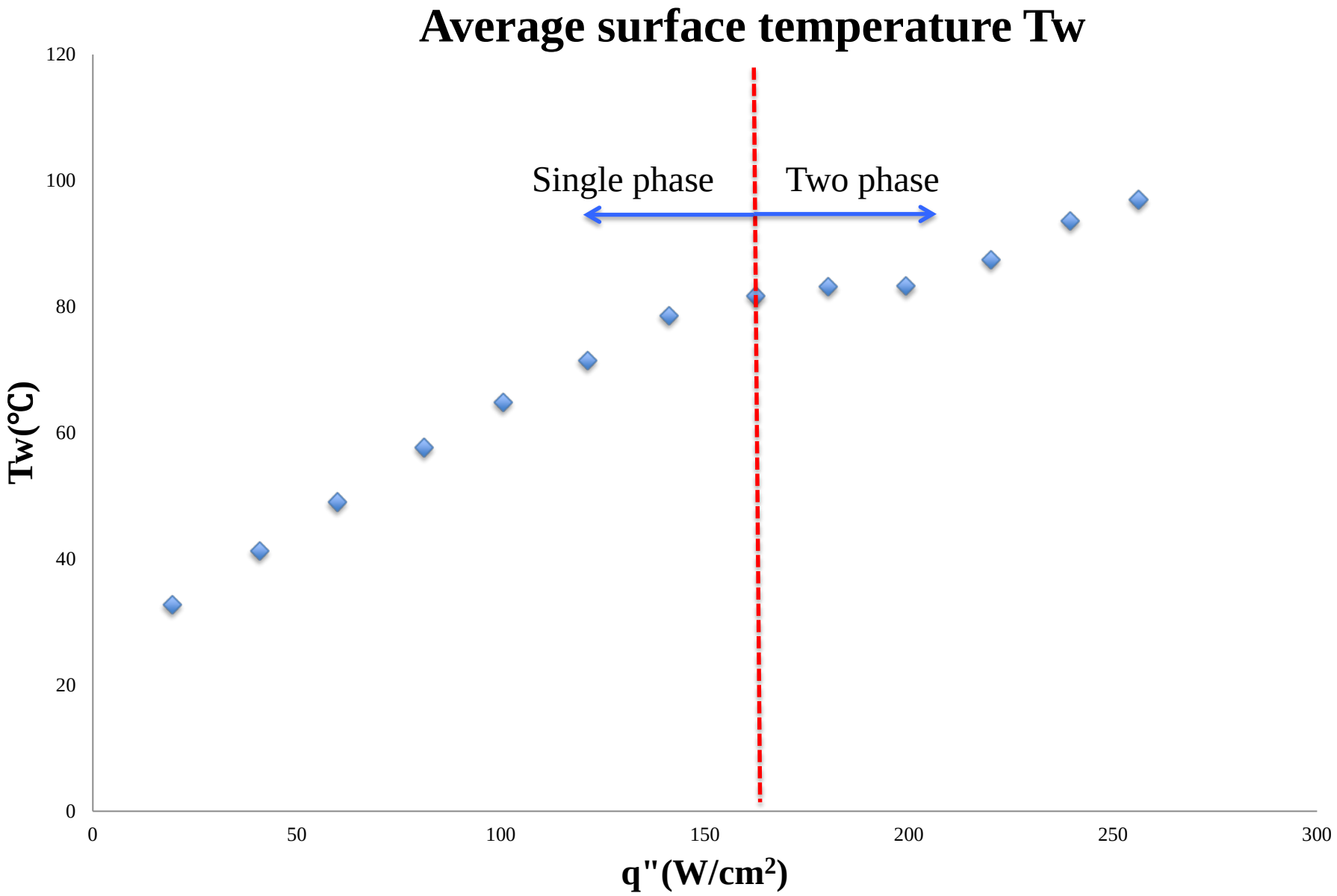
Analysis



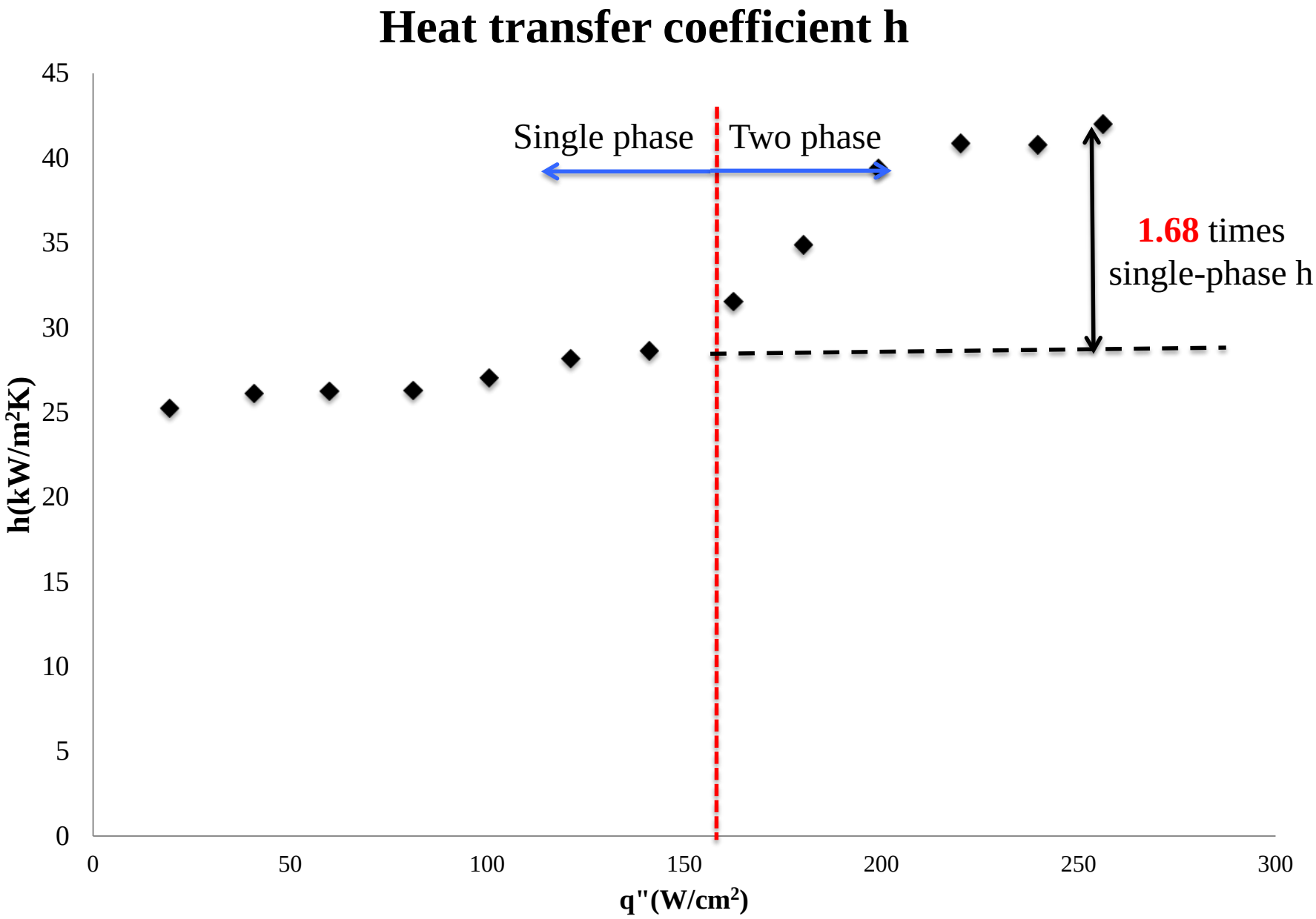


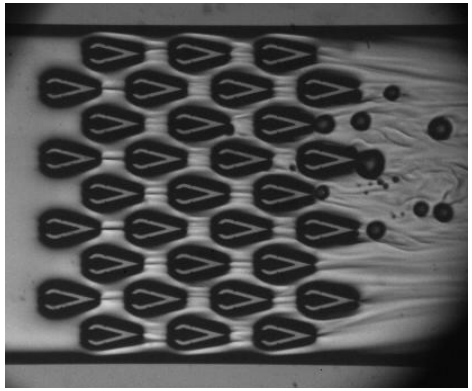


Streamlines

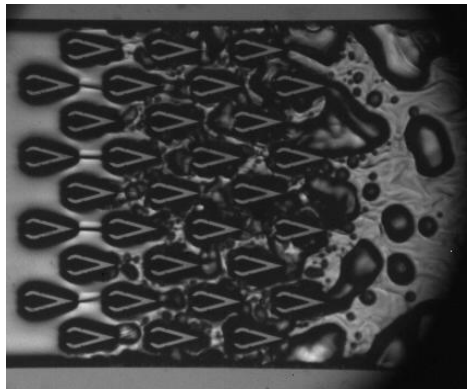


Working fluid HFE 7000; T_{sat}=77°C; G_{in}=474 kg/m^2; open flow

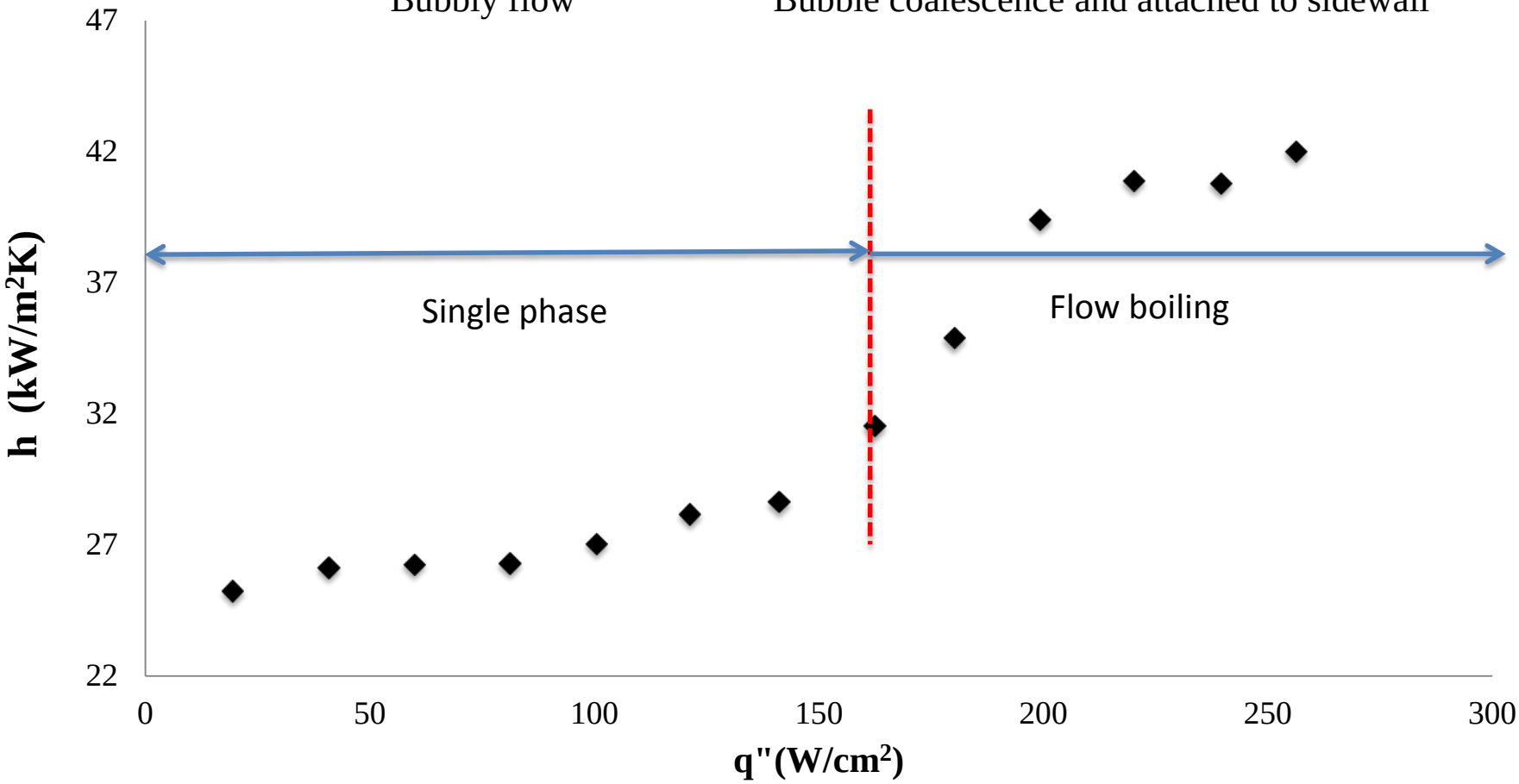

Heat transfer coefficient h
Single phase
Two phase
1.68 times
single-phase h
h(kW/m²K)
q"(W/cm²)
0
5
10
15
20
25
30
35
40
45
0
50
100
150
200
250
300



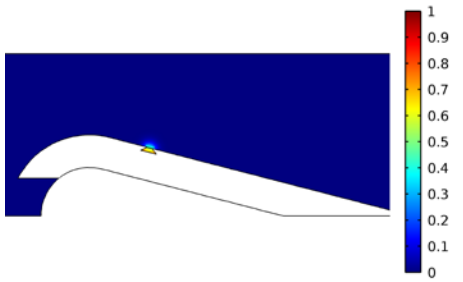
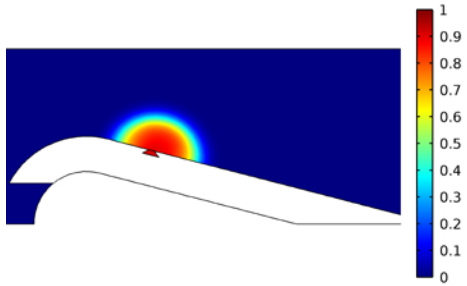
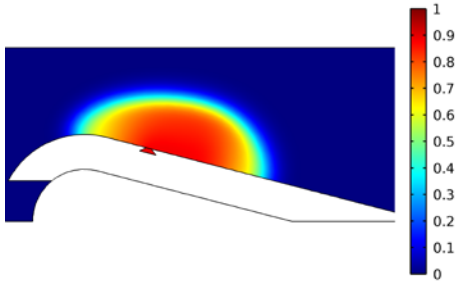
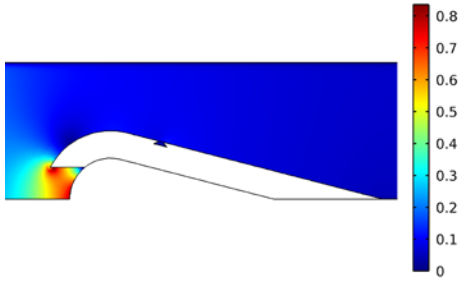
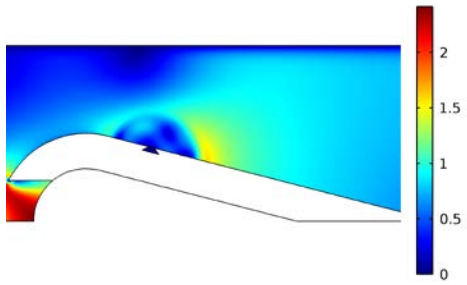
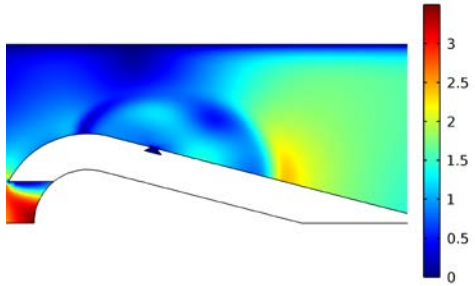
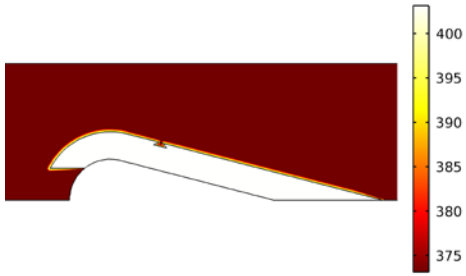
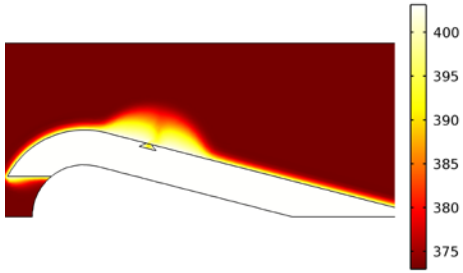
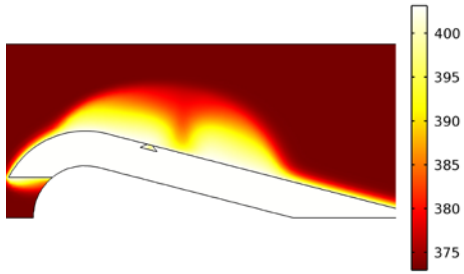
q=160 W/cm^2
Bubbly flow



q=255 W/cm^2
Bubble coalescence and attached to sidewall



2D Two-phase modeling

	T=0 s	T=3E-5 s	T=6E-5 s
Void fraction			
Velocity			
T			

Summary and on going work

- Single-phase heat transfer has been studied with experiments and simulation
- Pin fins can realize heat dissipation effectively.
- Optimization of *PPFs* is ongoing.
- Two-phase modeling is ongoing.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Thank you