Simulations of heat and mass transfer in the capillary evaporator of a two-phase loop
Towards an optimized evaporator design

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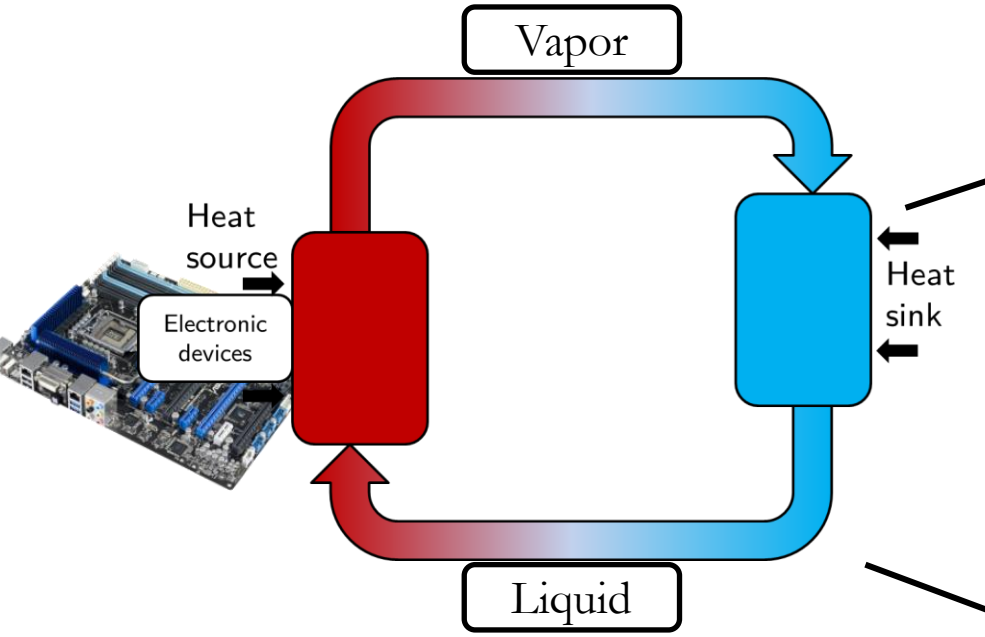
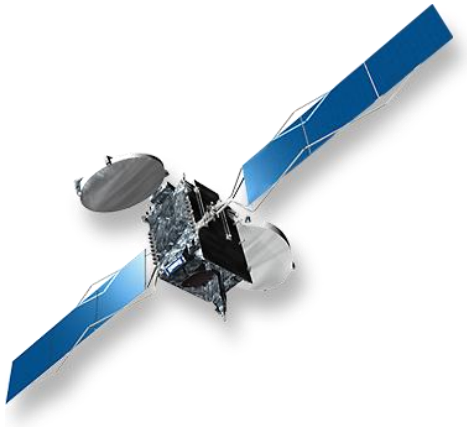
Thermal control



Space application

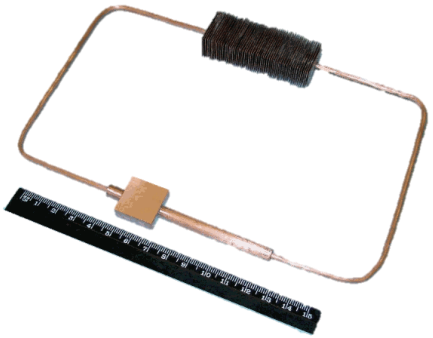


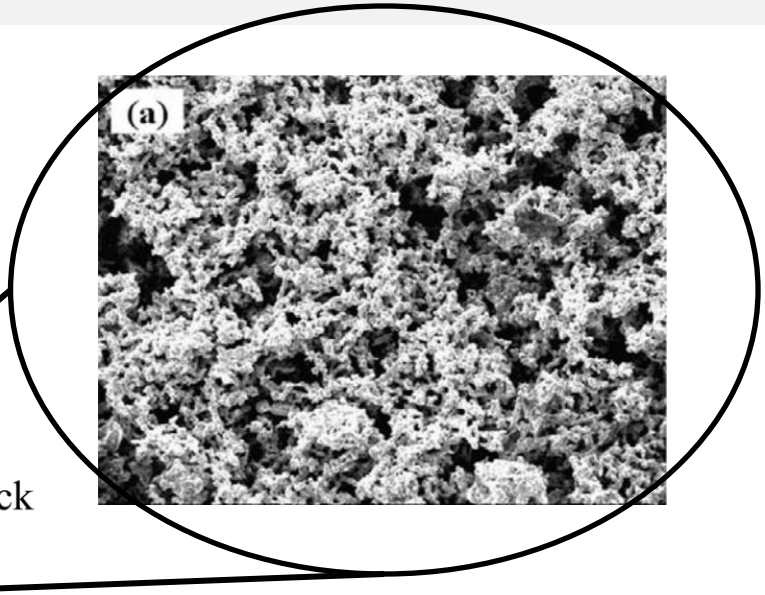
Terrestrial application

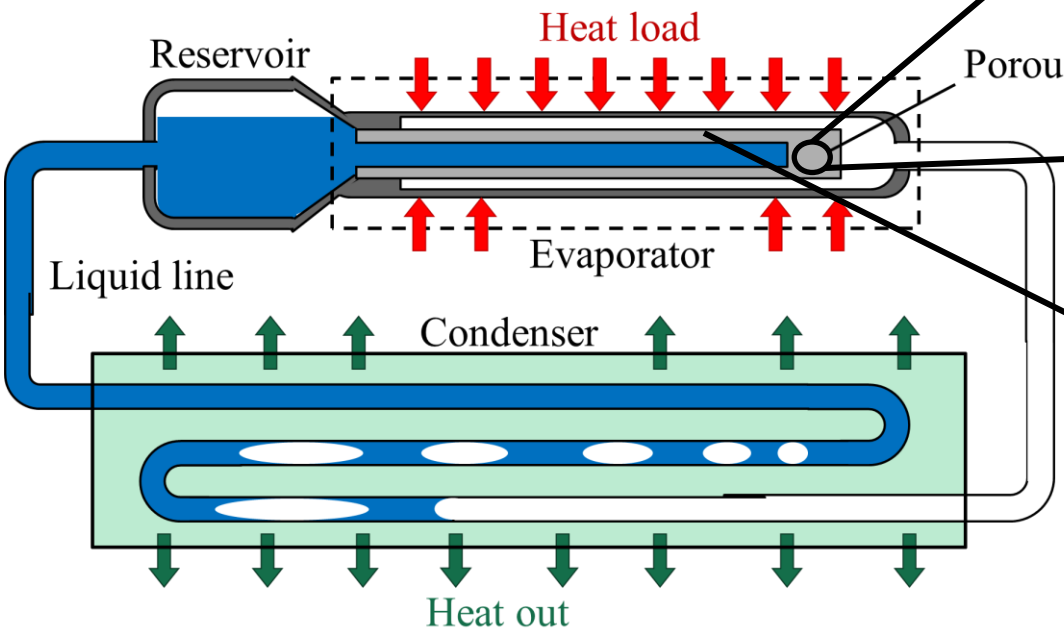
Two-phase loop

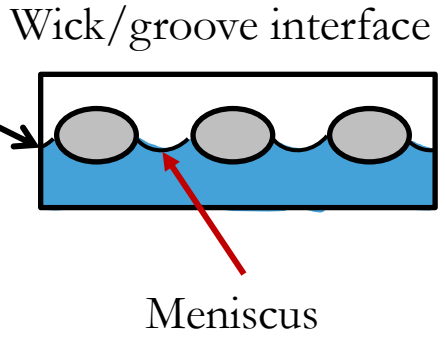
⇨ Loop heat pipe (LHP)

Loop heat pipe components and fluid motion

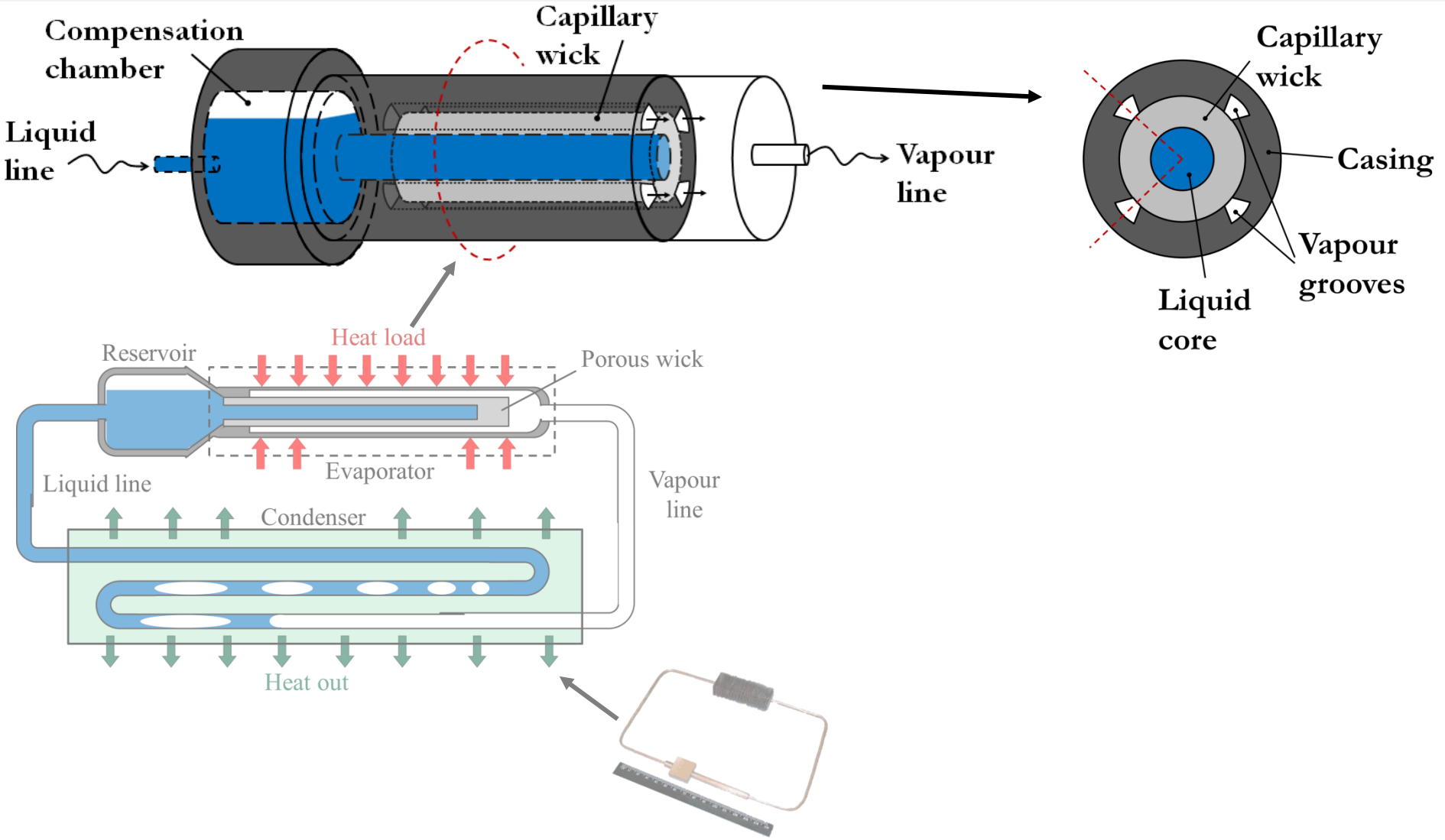




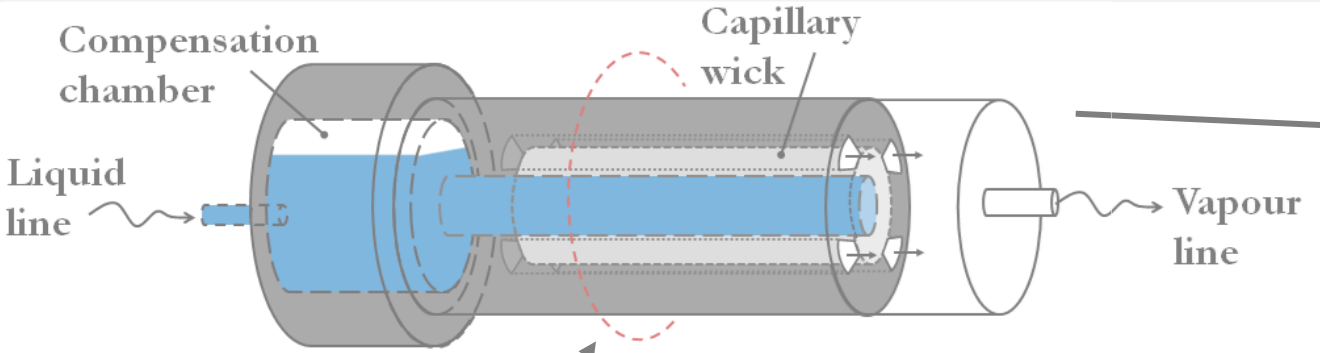


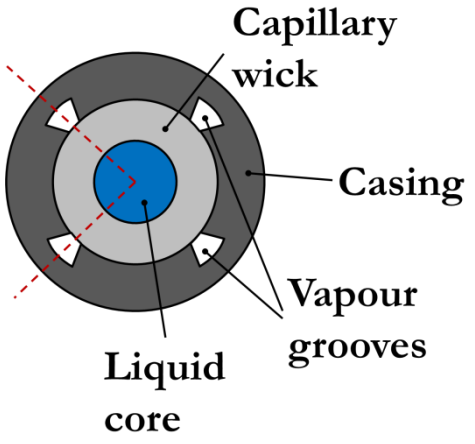


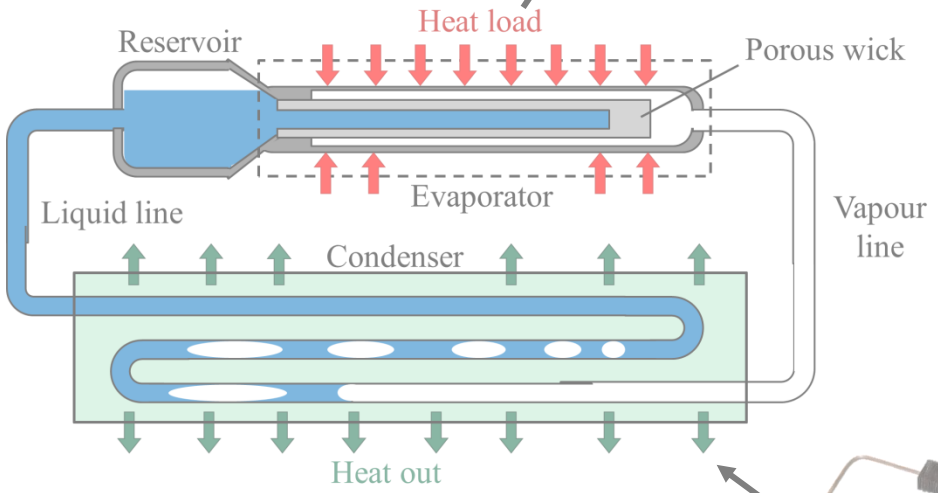
Cylindrical evaporator

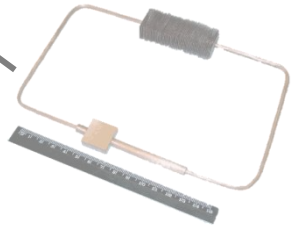


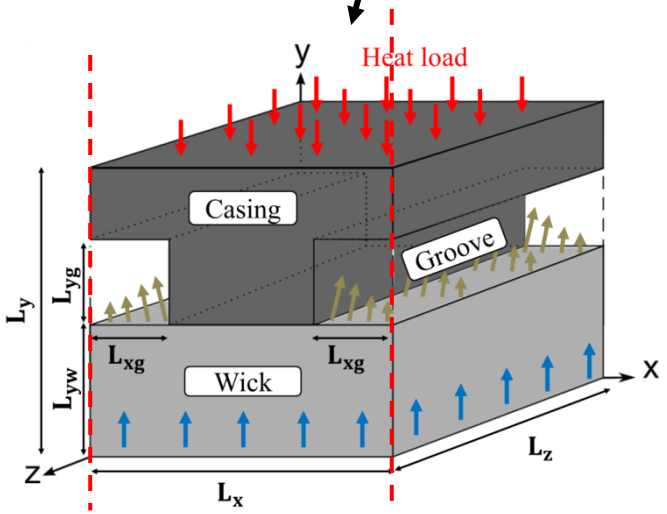
Evaporator unit cell











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Distribution of liquid and vapour phases

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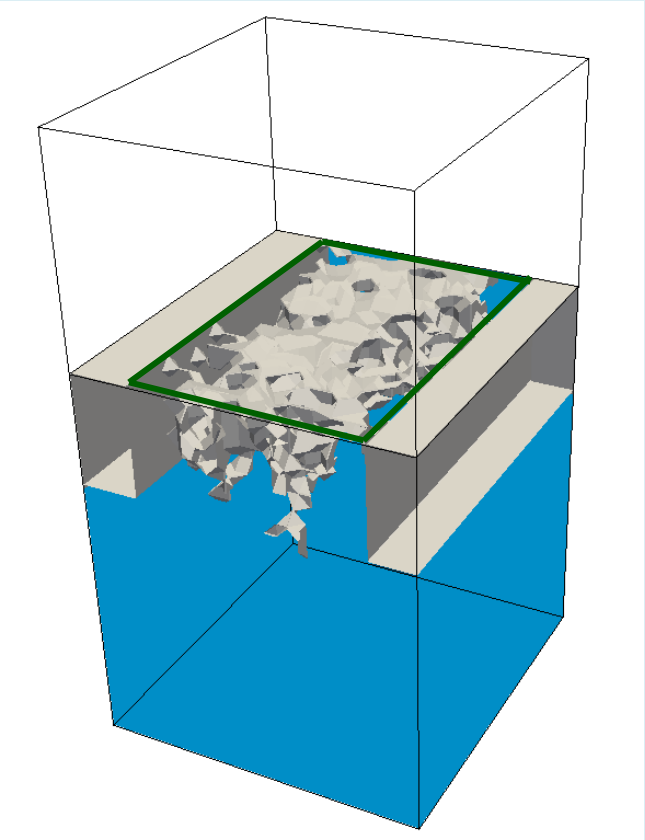


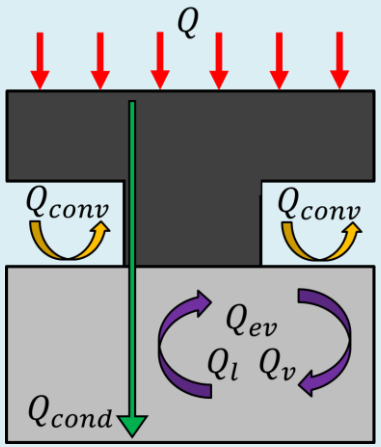
- S_{vc} and S_{lc}: fractions of pores occupied by vapour and liquid respectively right under the casing

Performances of evaporator

Heat flux balance

$$Q = Q_{ev} + Q_{cond} + Q_{conv} + Q_v + Q_l$$

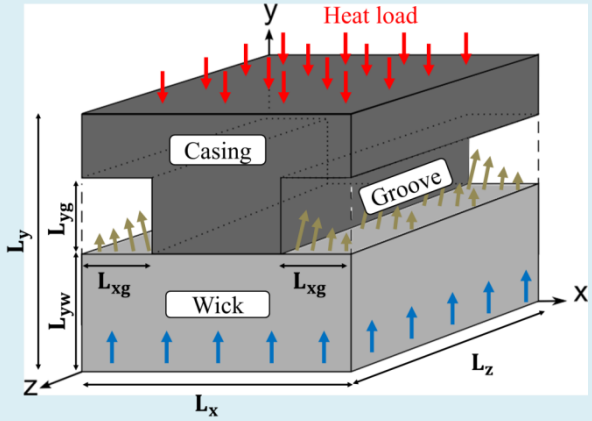
- Q : heat load applied at the external surface of the casing
- Q_{ev} : heat flux actually used for vaporisation
- Q_{cond}: parasitic heat flux, i.e. flux lost by conduction towards the wick inlet



Thermal performances

- Conductance

$$h_{ev} = \frac{Q}{T_{max} - T_g}$$



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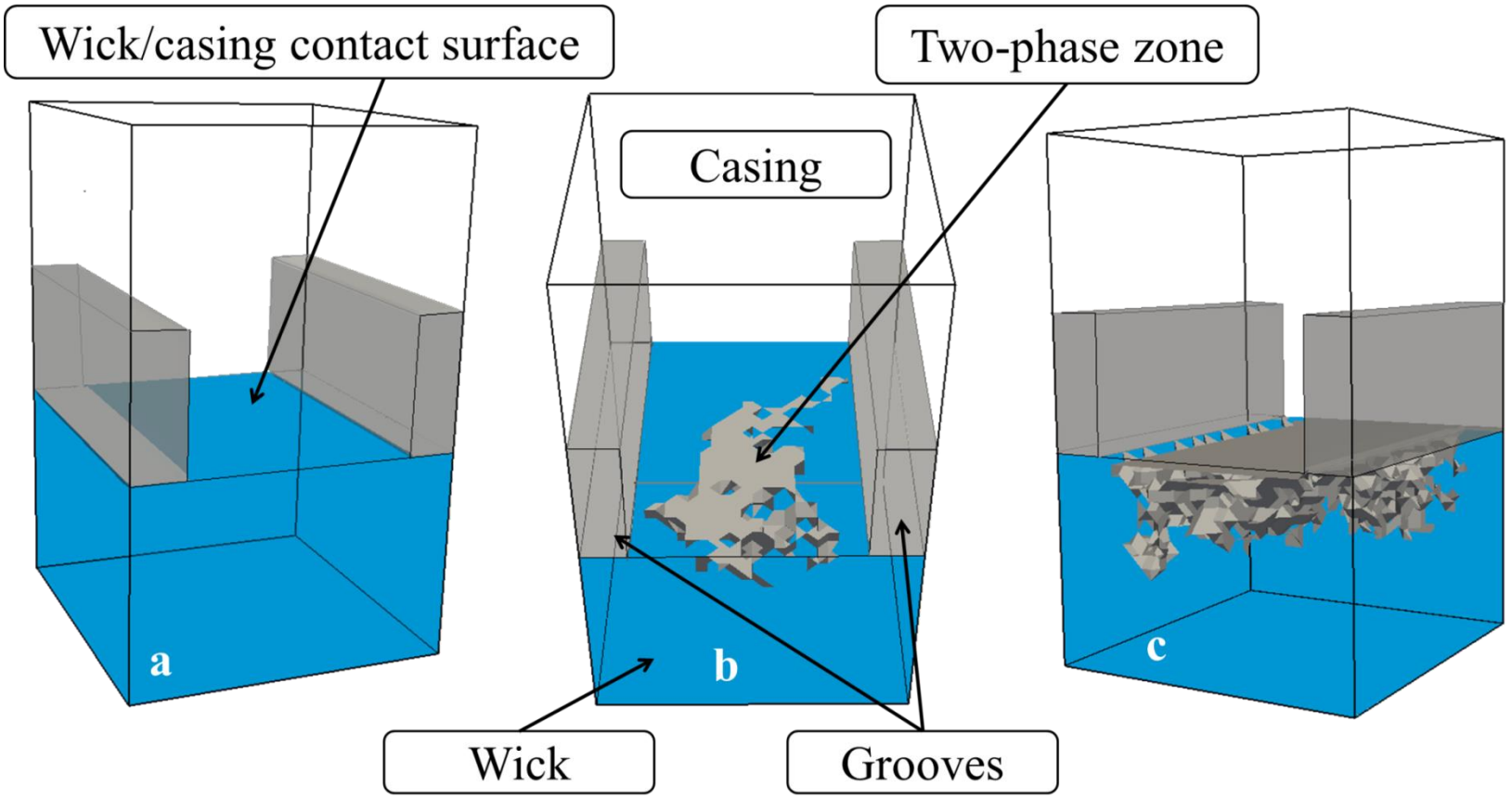
Main operating regimes

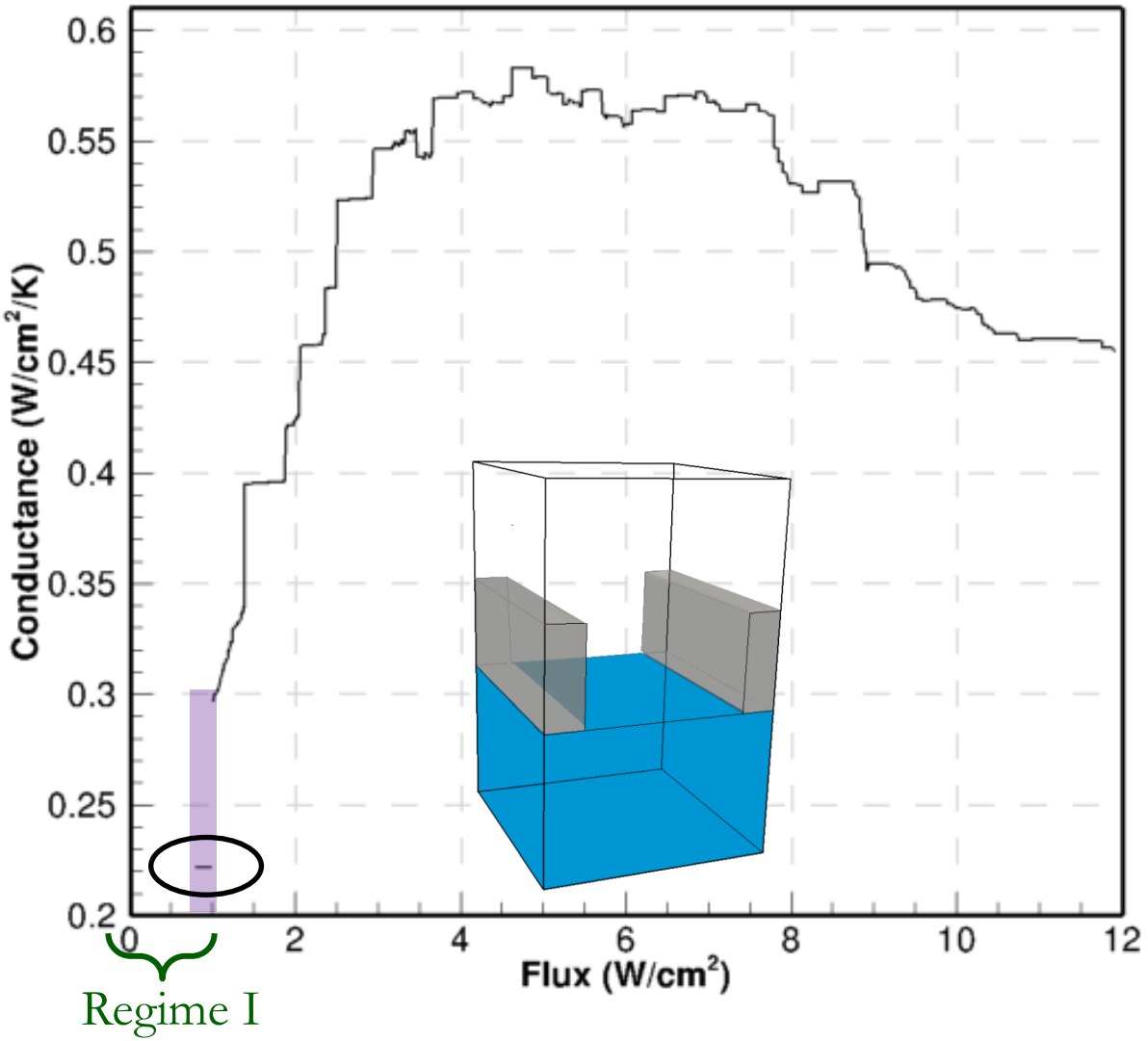


a) 0.8W/cm²
Regime I
Low heat flux

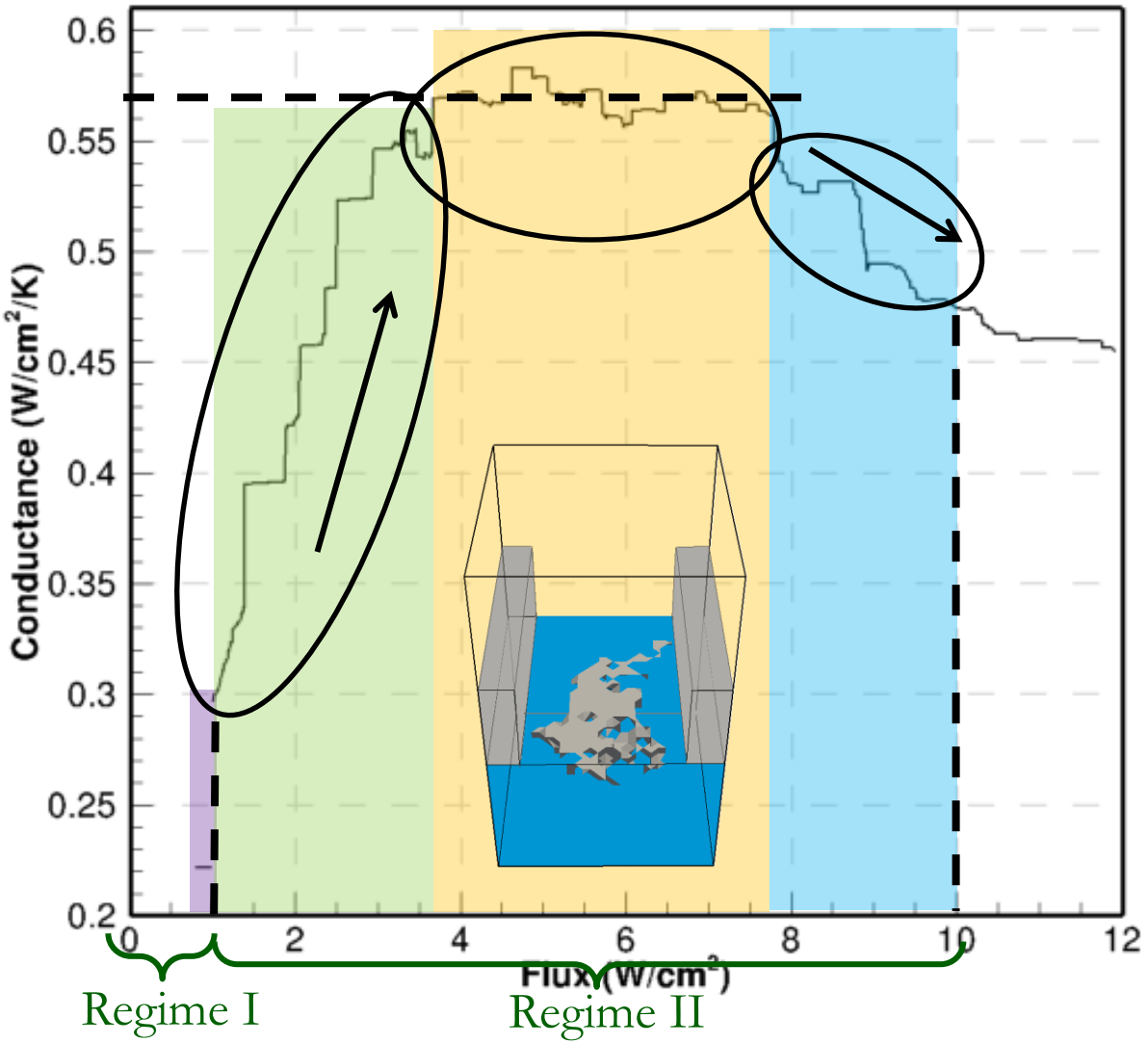
b) 1W/cm²
Regime II
Moderate heat flux

c) 10W/cm²
Regime III
High heat flux

Conductance



Conductance



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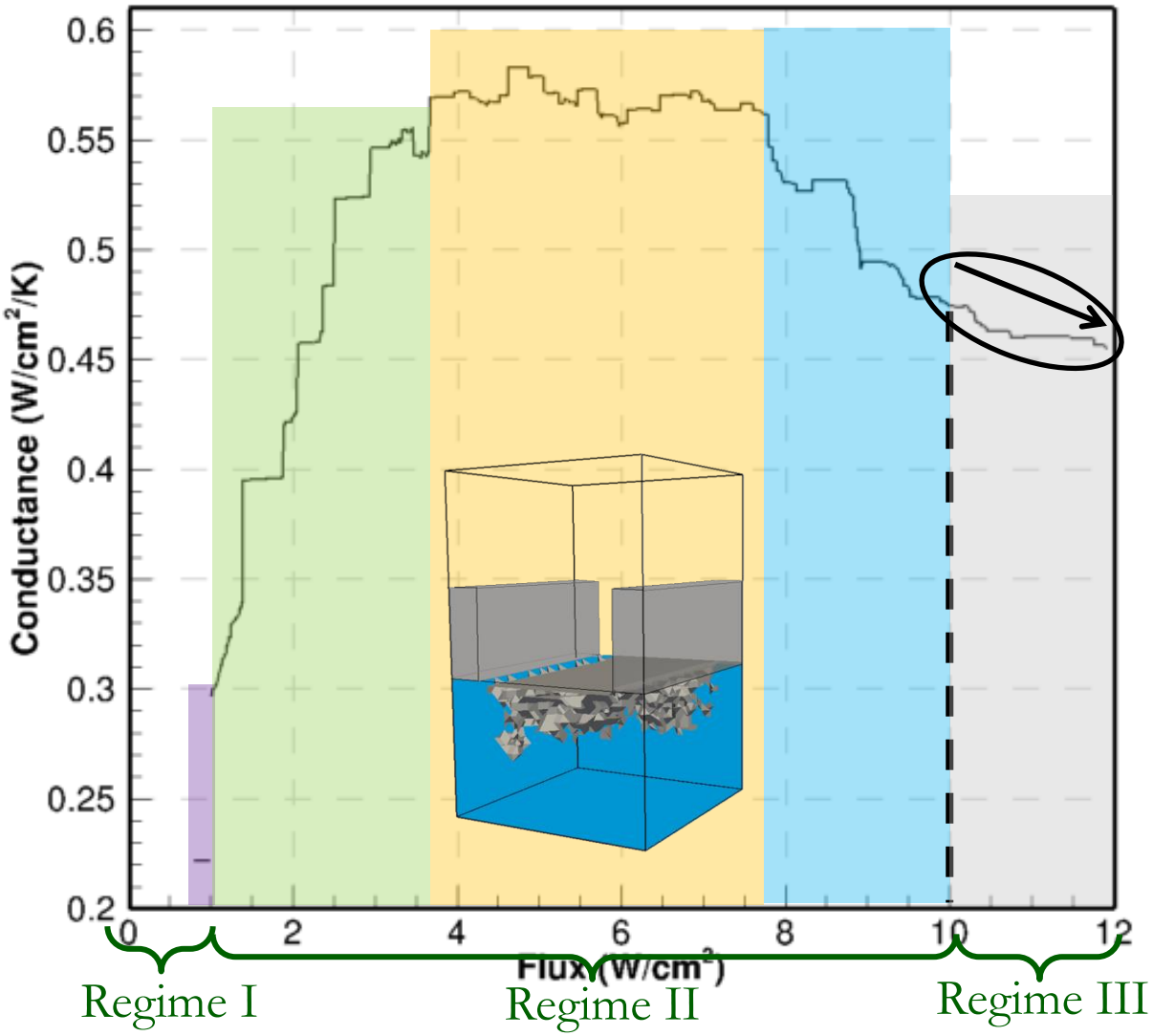

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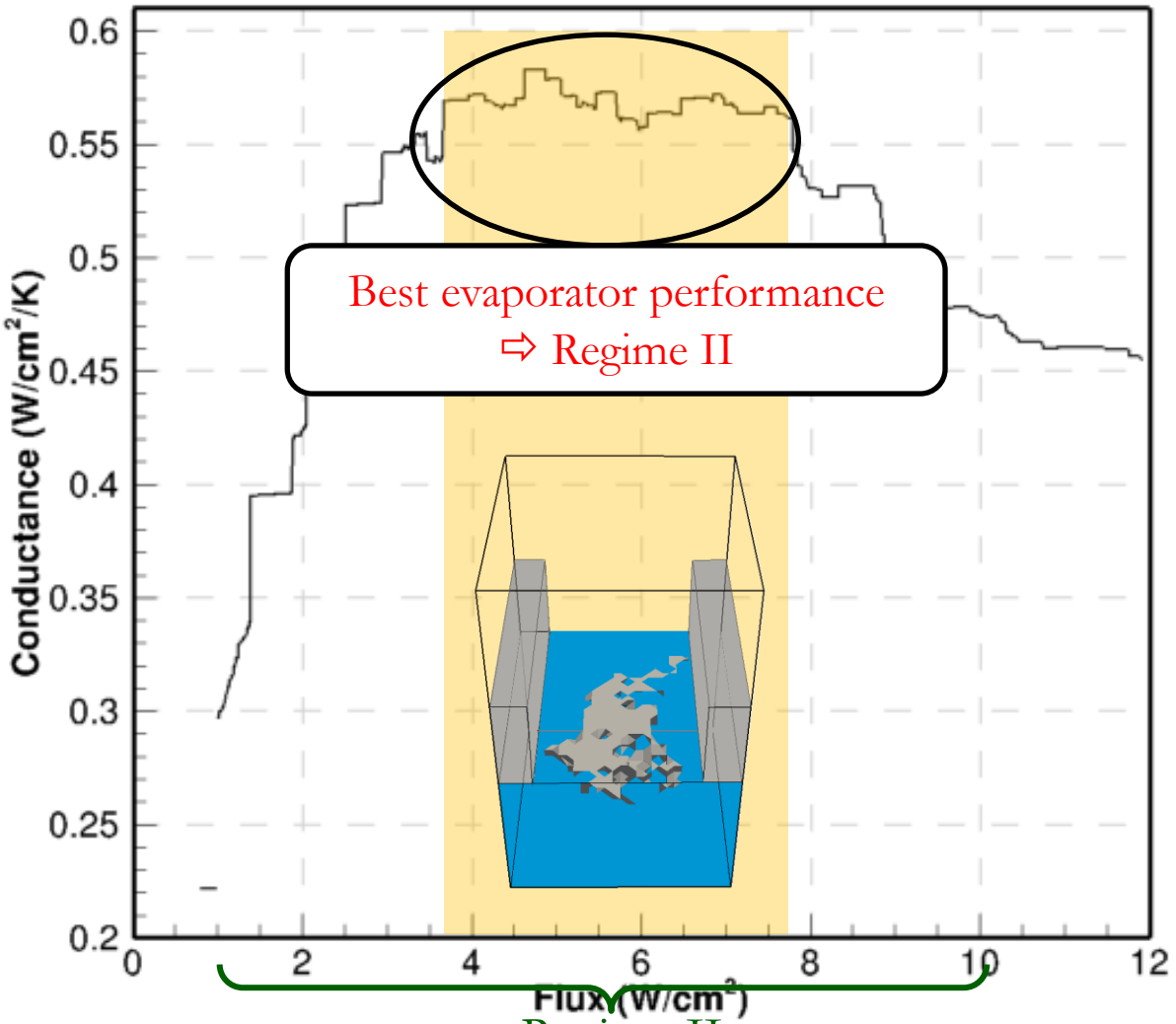

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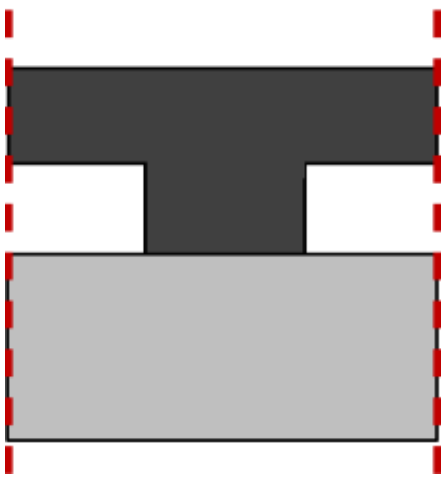
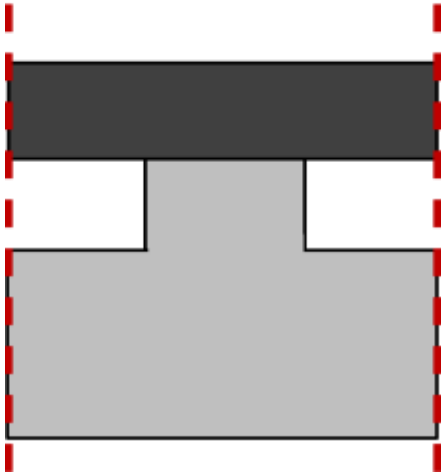
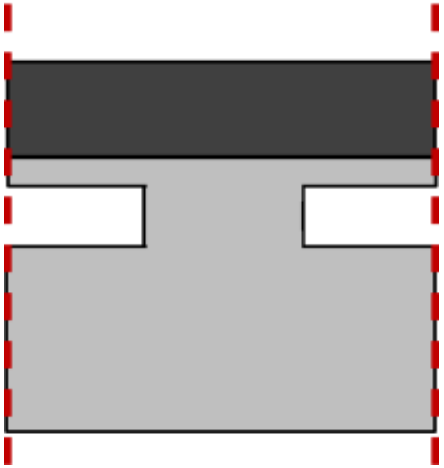
Objective



Geometry A



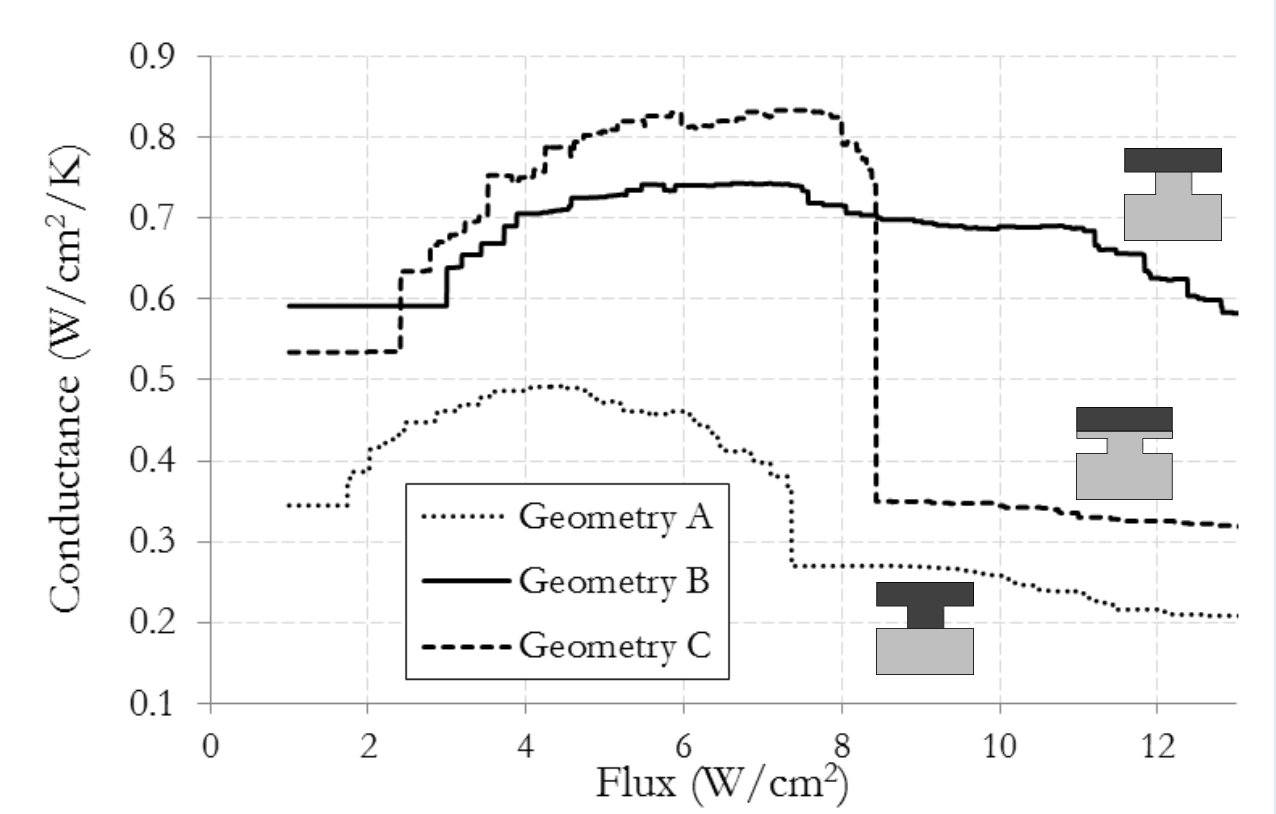
Geometry B



Geometry C

Conductance

Conductance



Conductance

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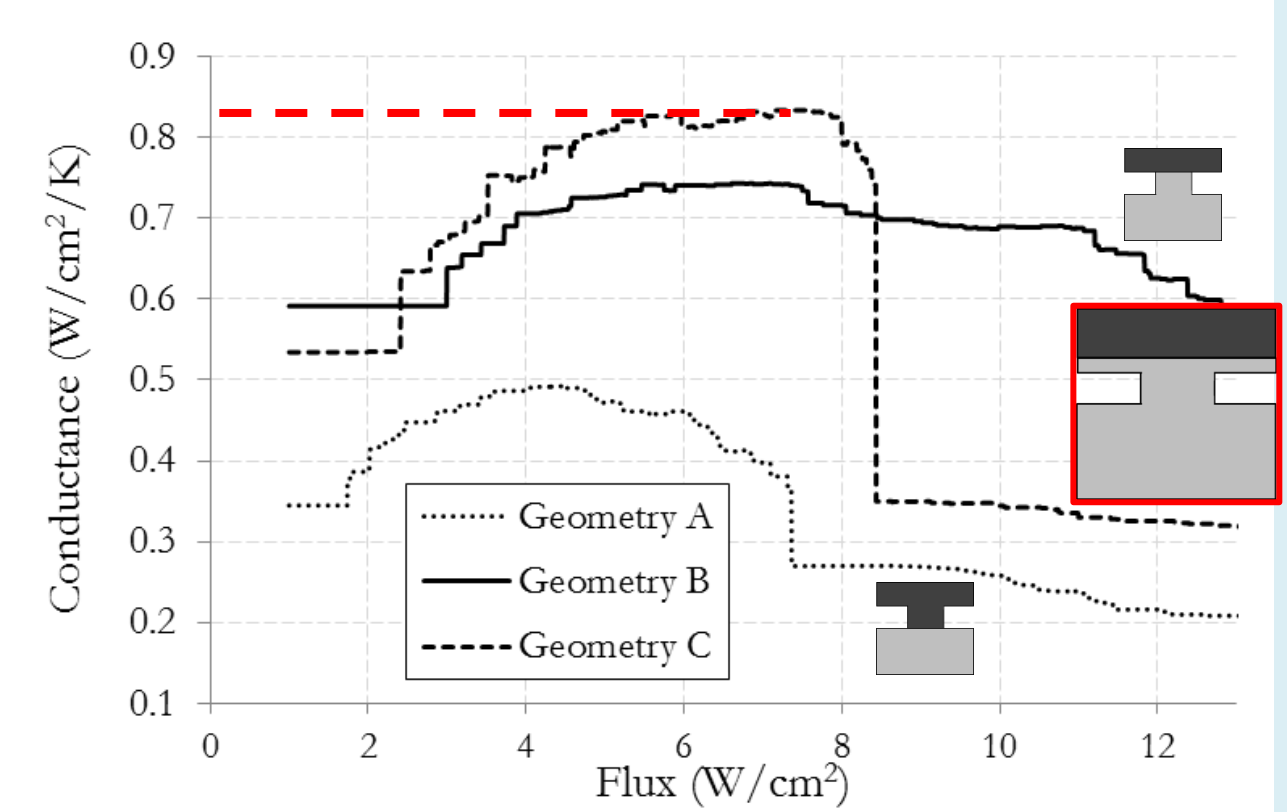

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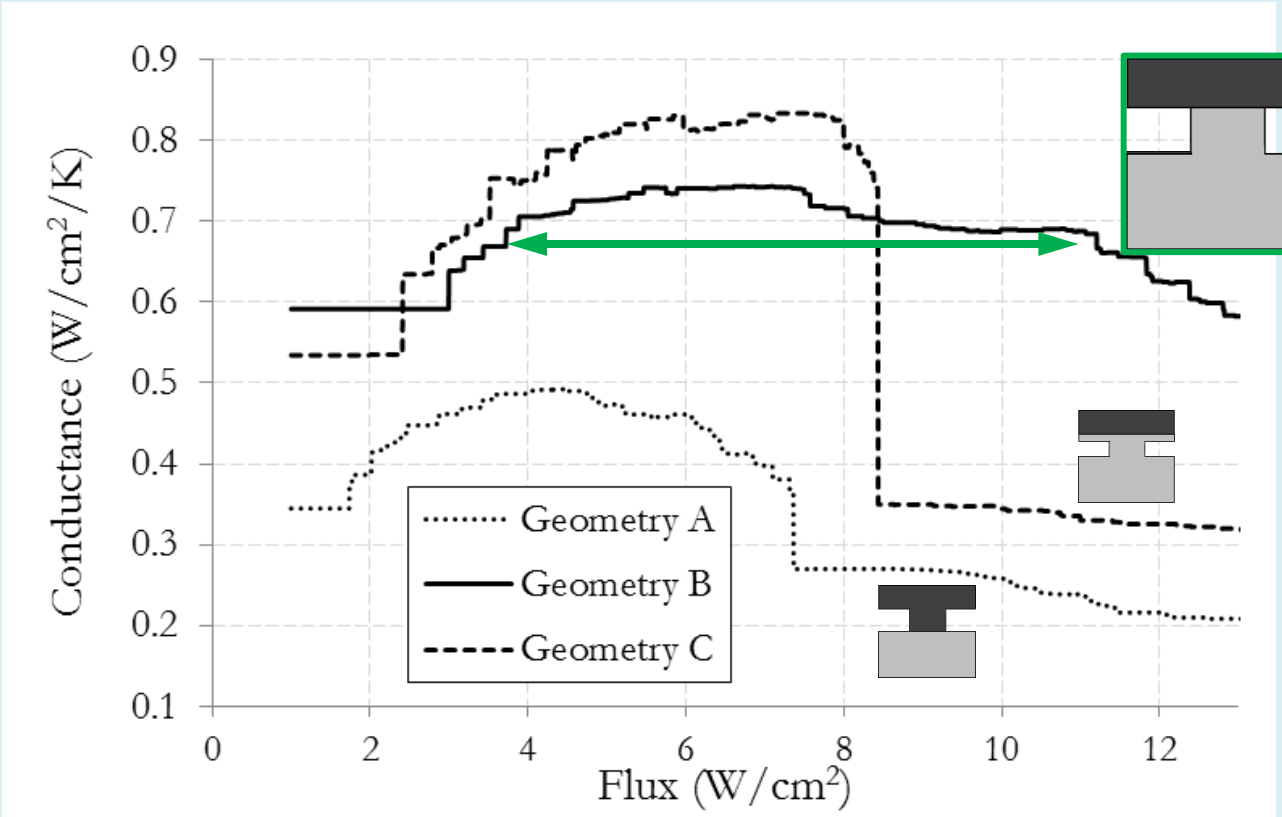
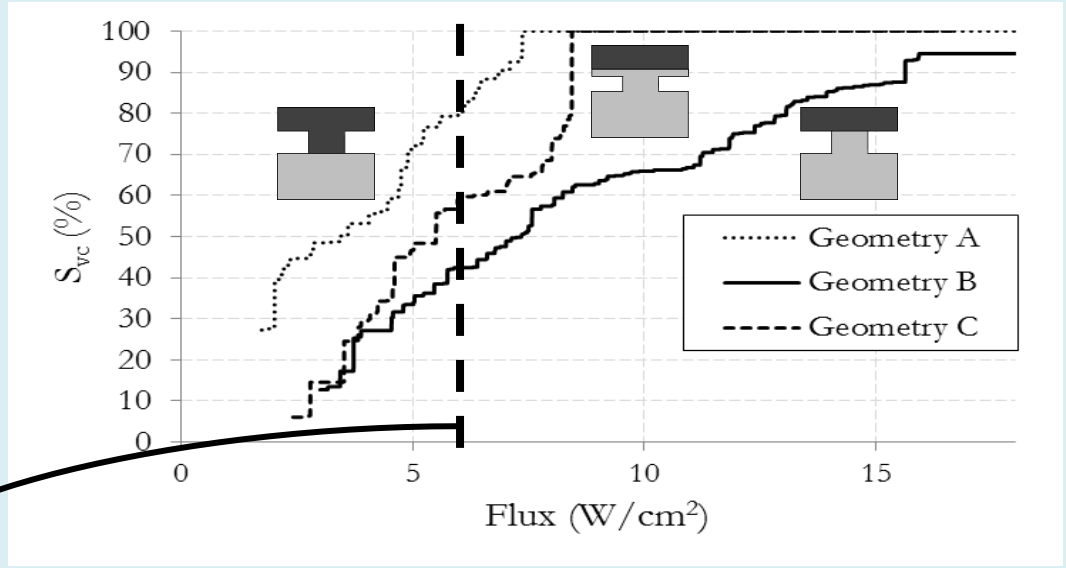
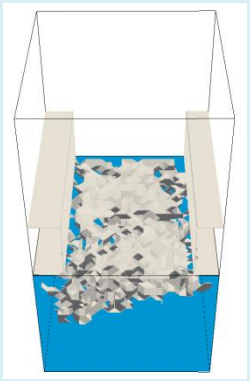


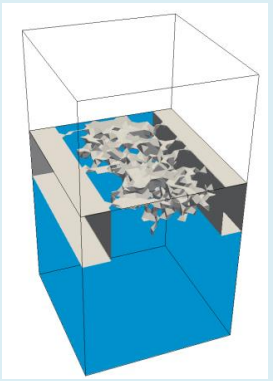
Fraction of vapour pores under the casing

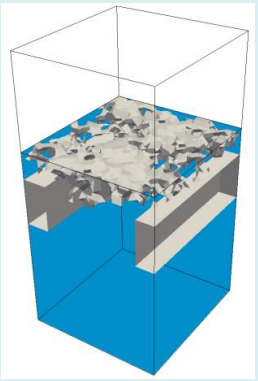
Fraction of vapour pores under the casing



6 W/cm²







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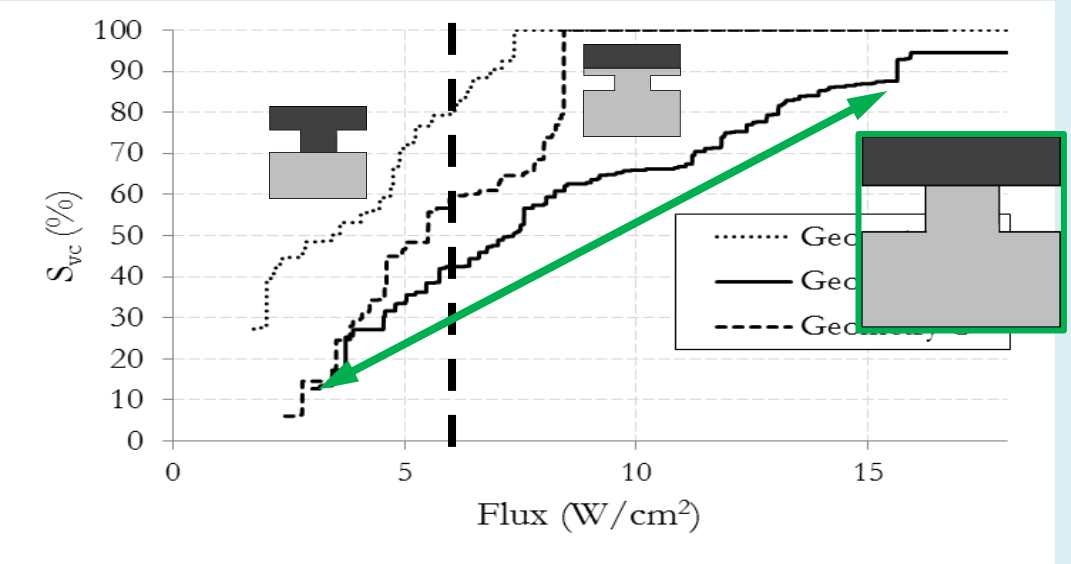

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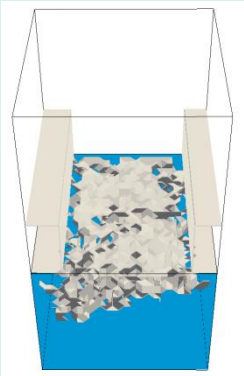
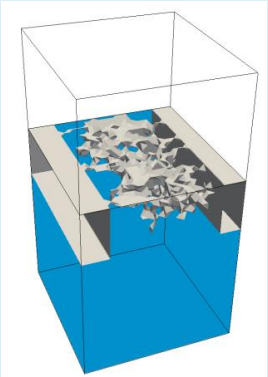
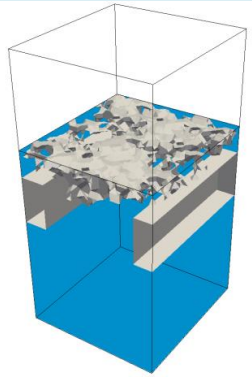
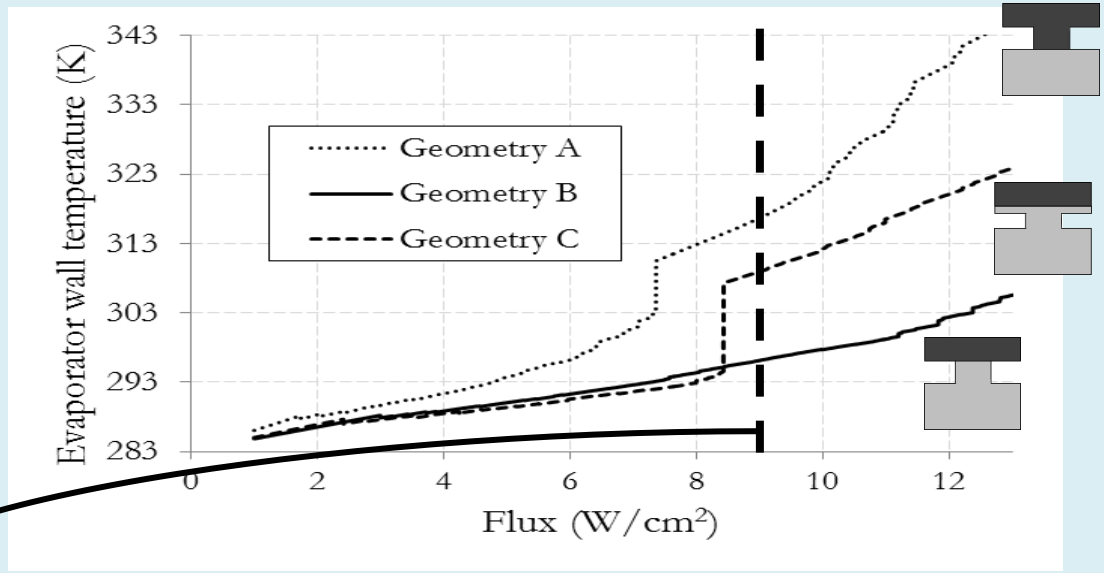




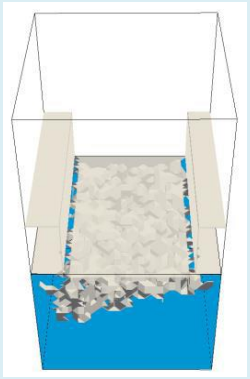


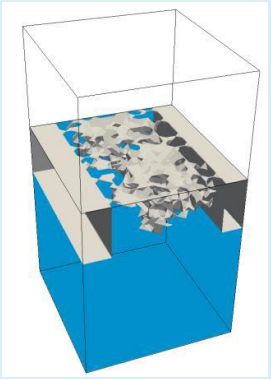
Evaporator wall temperature

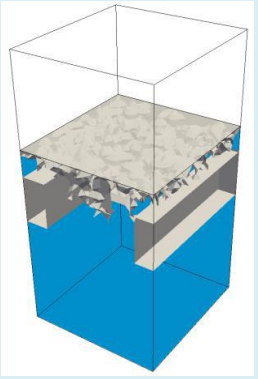
Evaporator wall temperature



9 W/cm²







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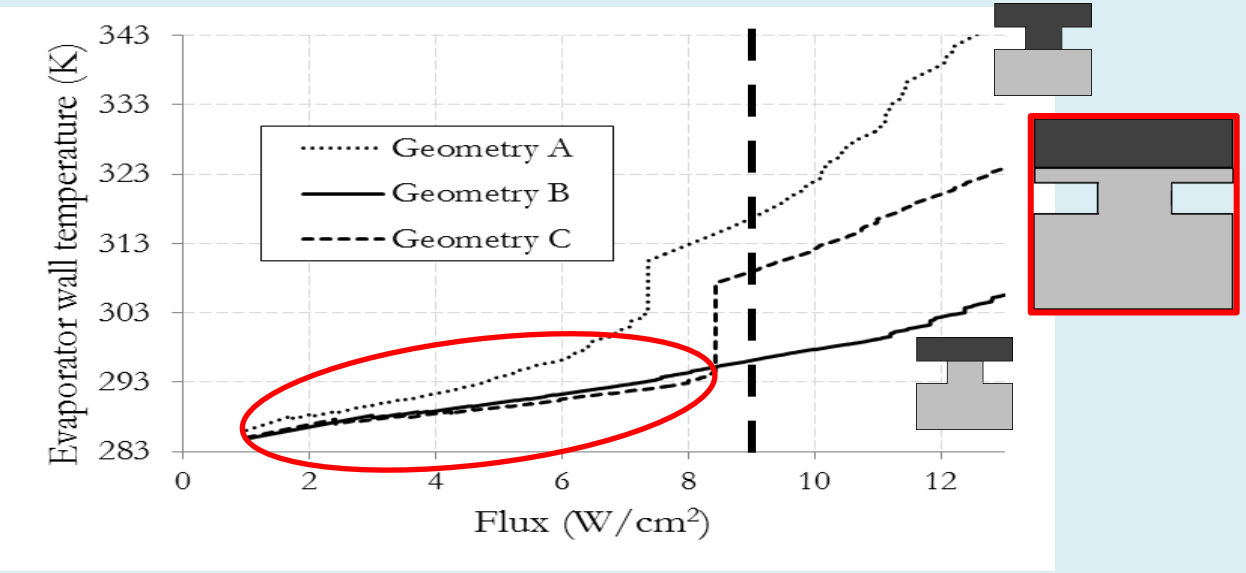

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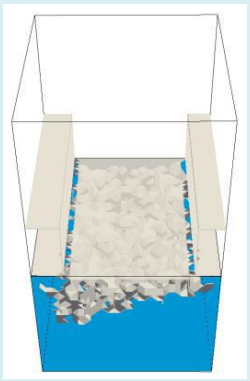
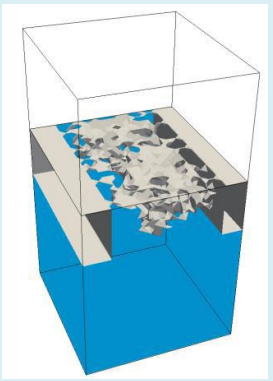
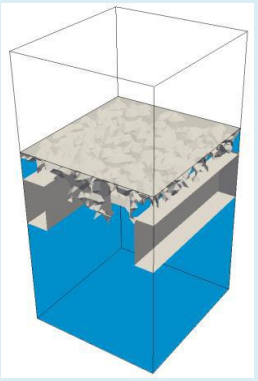
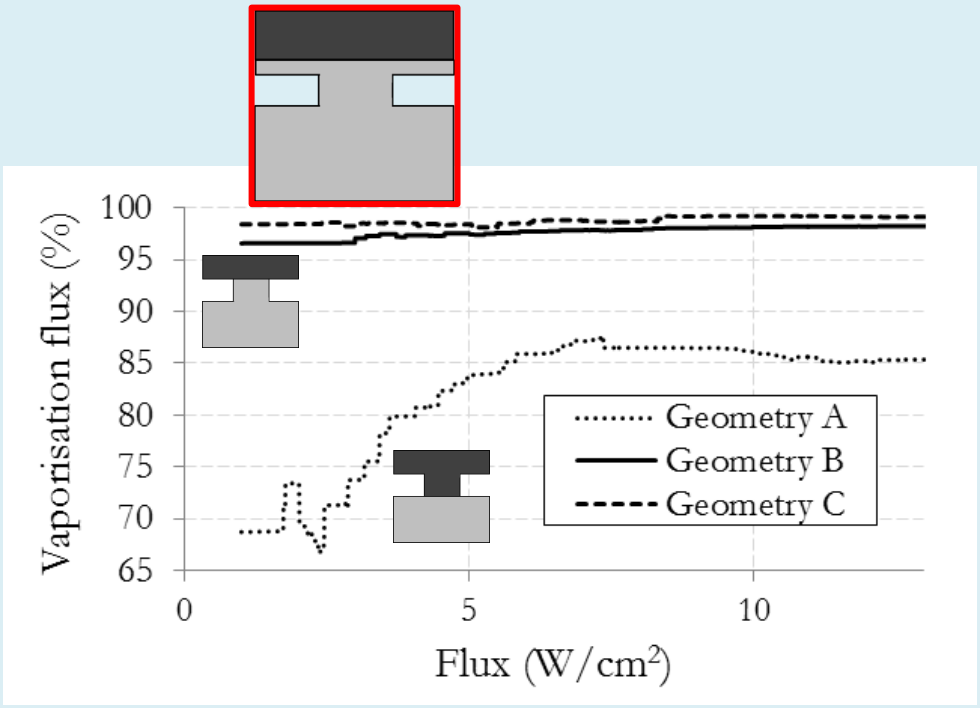


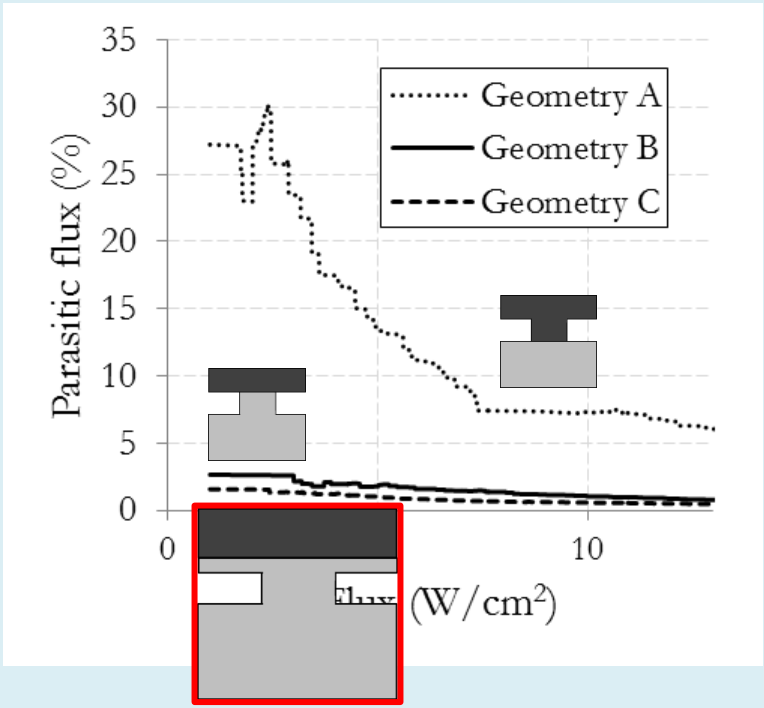




Vaporisation flux and parasitic heat flux

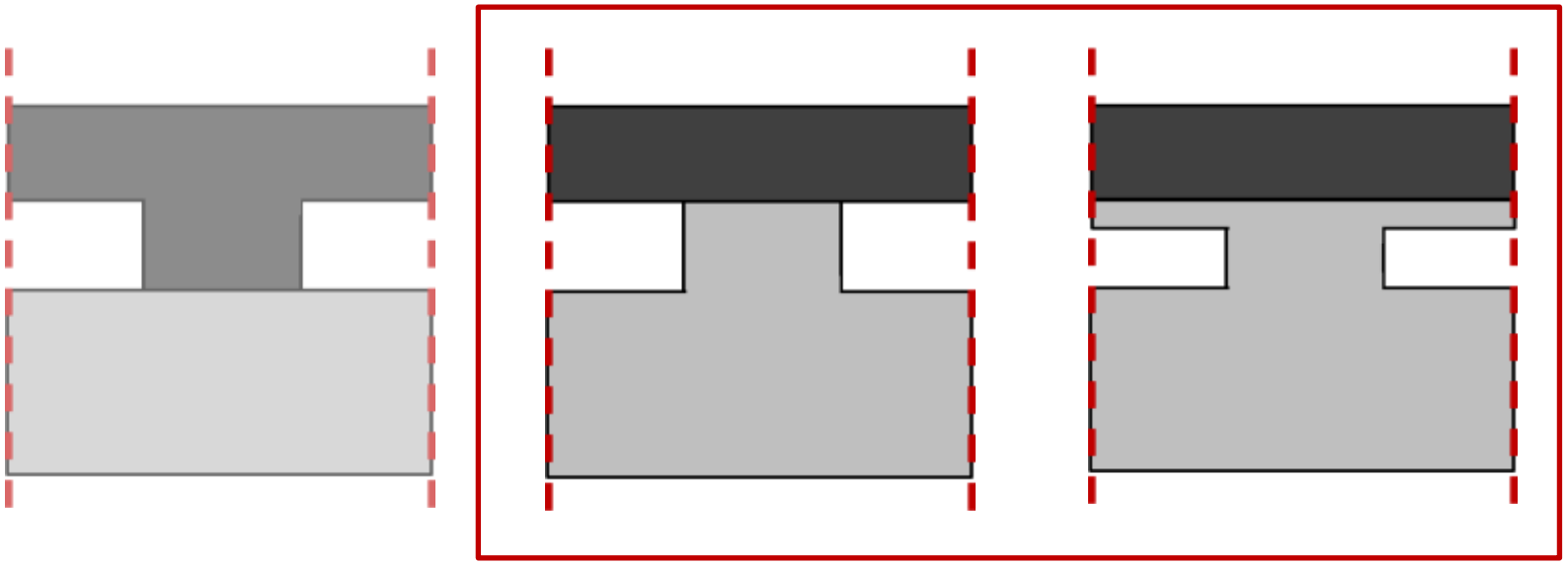
Vaporisation flux and parasitic heat flux





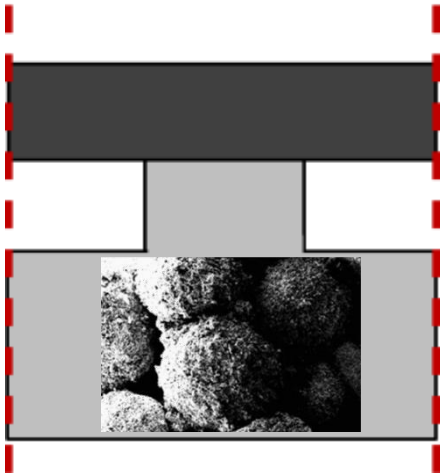
Summary

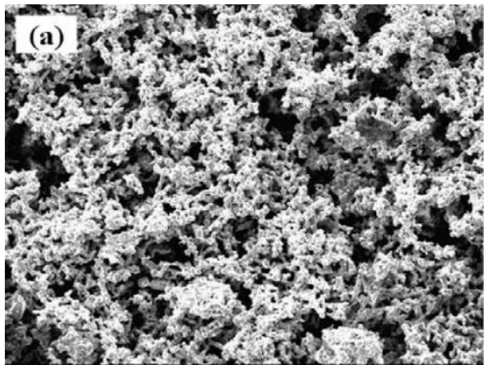
Geometry	- Groove locations

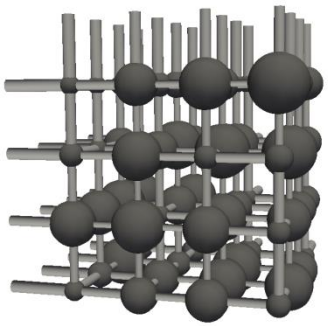


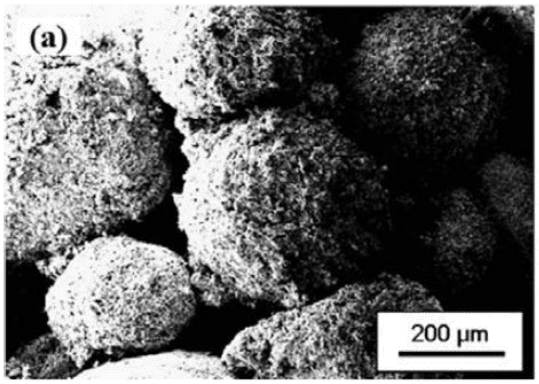
Summary

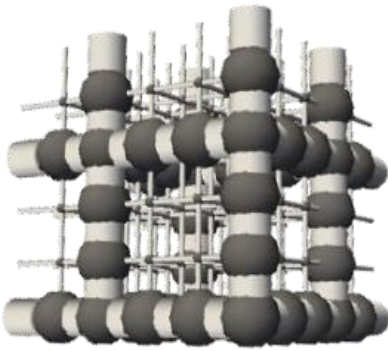
Geometry	- Groove locations
Wick properties	- Monomodal vs. Bimodal
	- Porosity
	- Throat size distribution
Materials	- Casing
	- Wick











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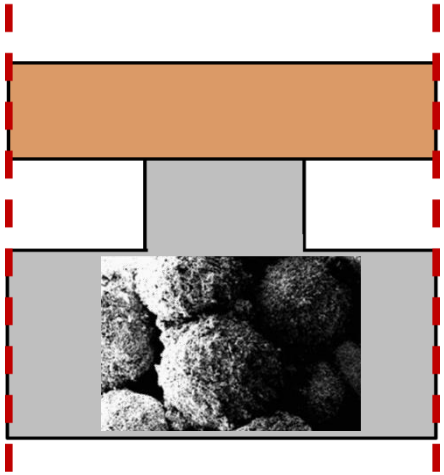
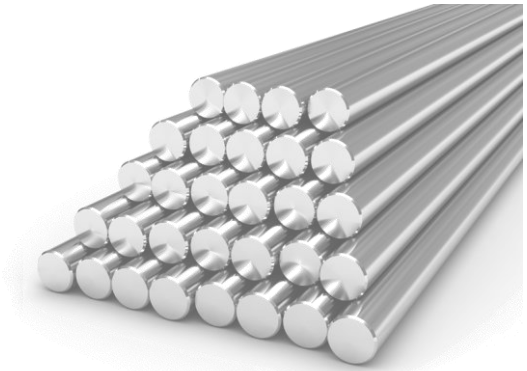
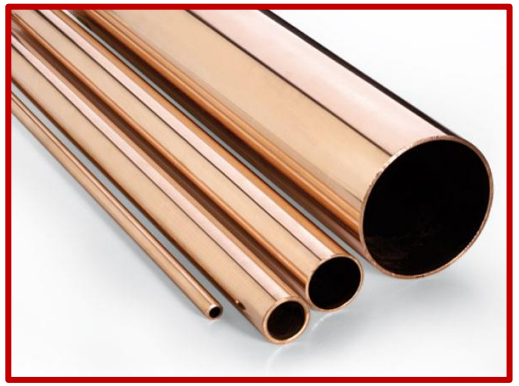


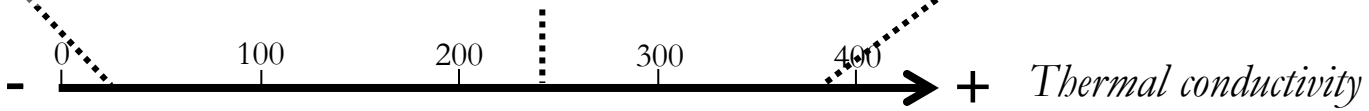


Stainless steel

Aluminium



Copper



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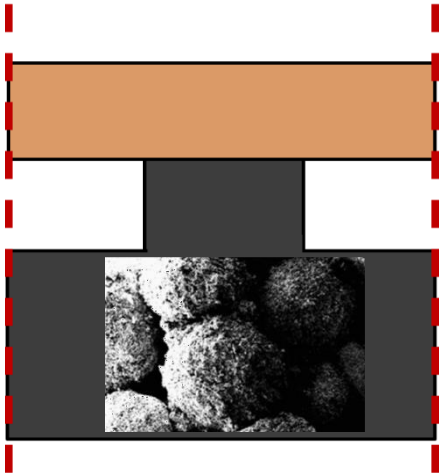
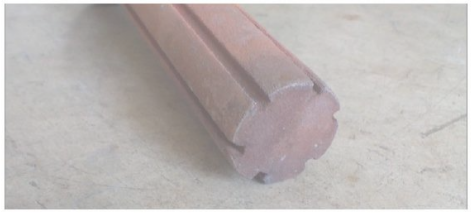
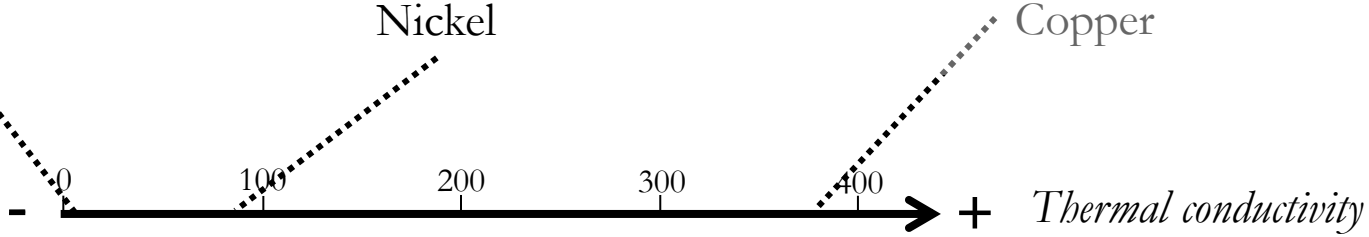




PTFE Nickel Copper



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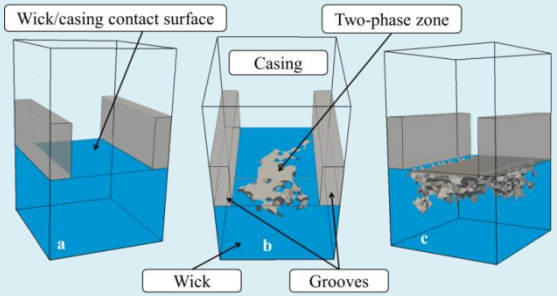
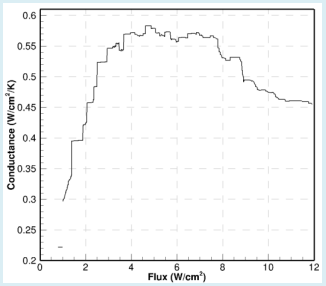
Conclusions

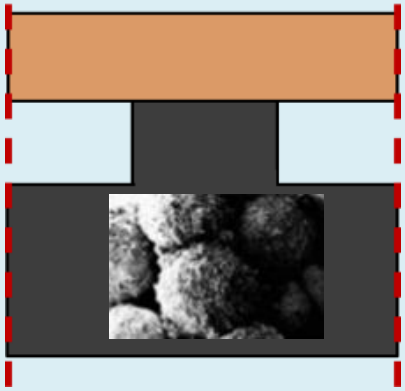
Main questions

- Regime(s)?
  - Saturated with liquid
  - ~~Vapour pocket mode~~
  - Two-phase zone
- Towards design optimisation?

Answers

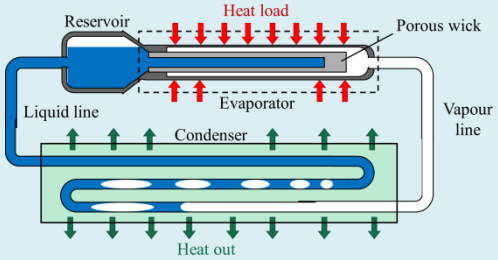




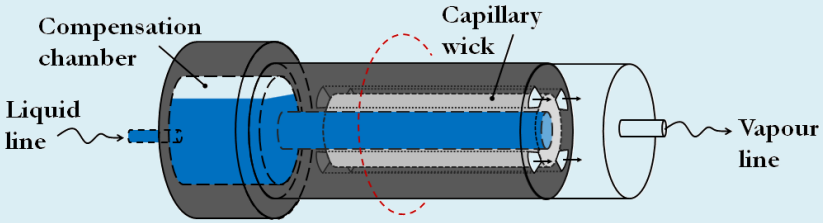


Further work

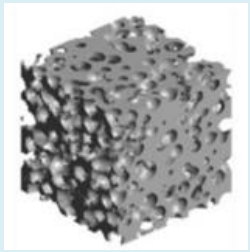
- **Pore network model**
  - Loop model needs to be more accurate



- **Continuum model**
  - Extension to the evaporator scale



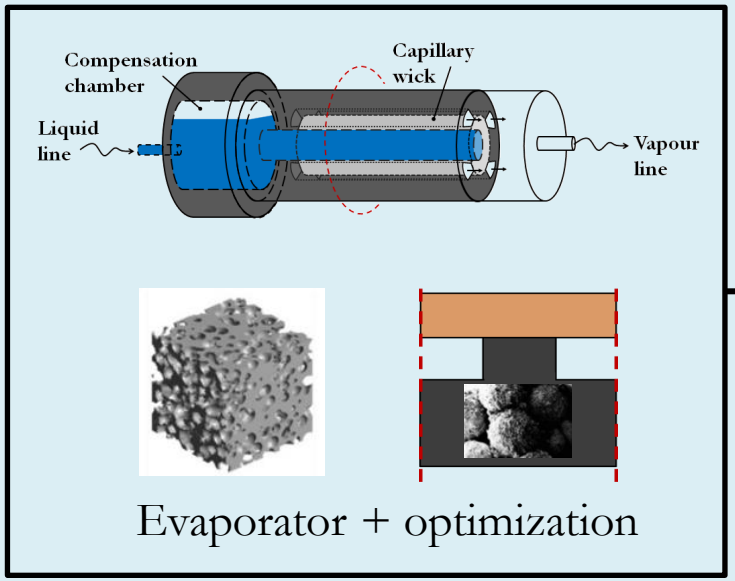
- **Towards realistic microstructures**
  - Pore network simulations of continuum model parameters on 3D digital images of "real" microstructure



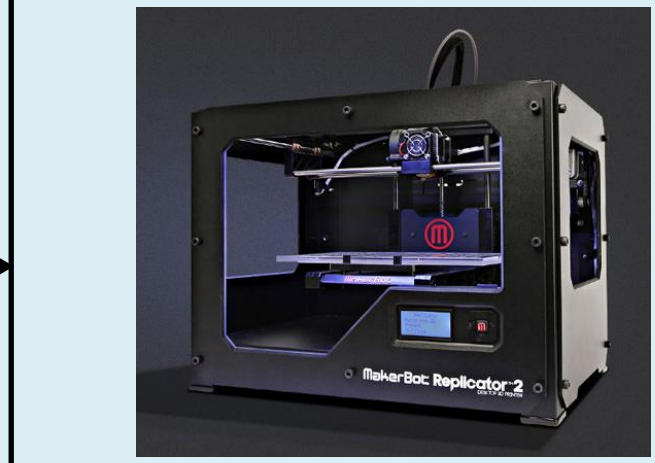
For example: sintered nickel microstructure.

In the longer run

- **3D printing of the evaporator**



Evaporator + optimization



3D printing

Thank you for your attention.

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