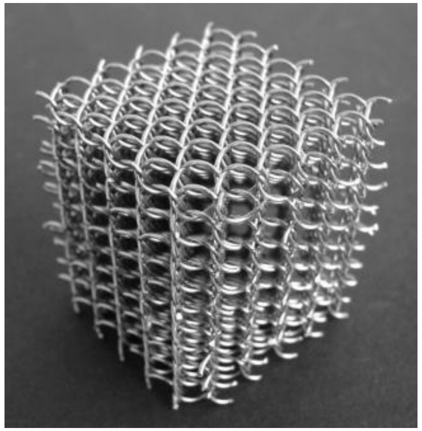
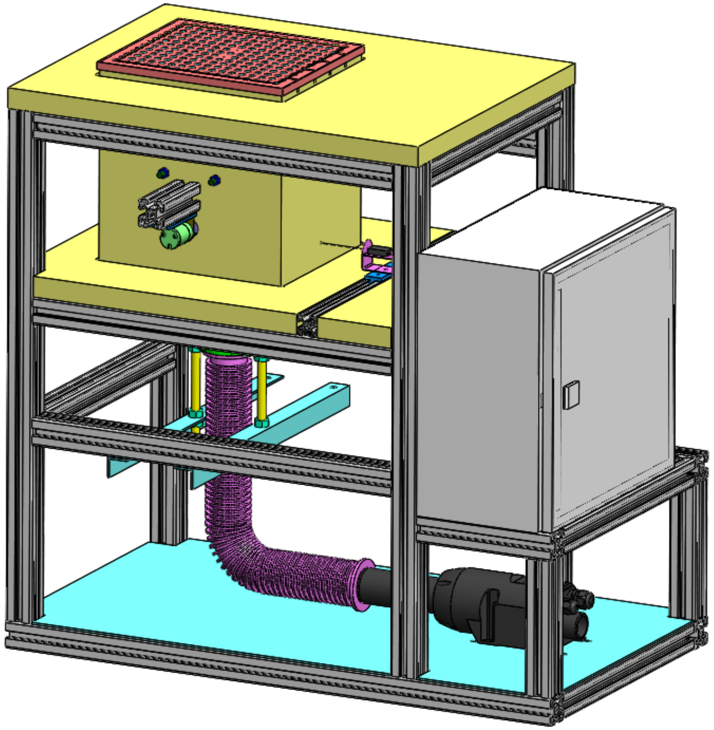
# How to characterize bulk PCMs without building a whole storage

Florian Hengstberger

DSC Workshop, Wien, 5. 4. 2016

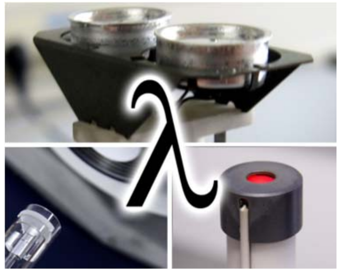
# Introduction

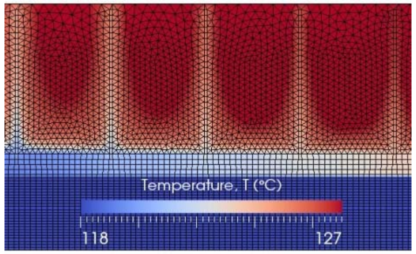




- Concept study for a calorimeter (master‘s thesis)
- Long term goal:
  - Characterize large macroscopic structures for heat transfer enhancement
  - Information on the nucleation/subcooling behaviour
  - Realistic sample dimensions and charge/discharge conditions
  - High temperature range (400 °C) for non-residential applications

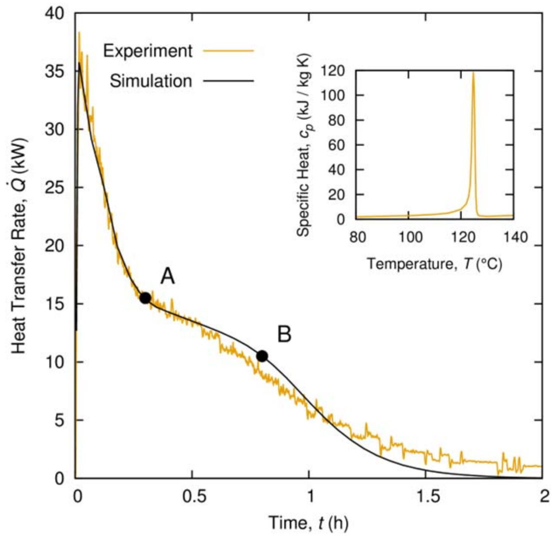
# Motivation: Ideal Situation

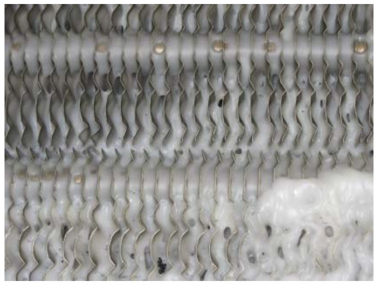





Thermophysics Simulation

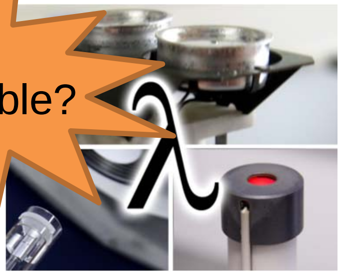
Prototype Measurement

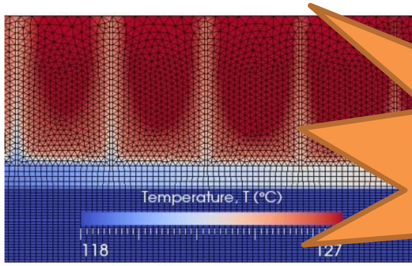


# Motivation: Reality

Appicable?

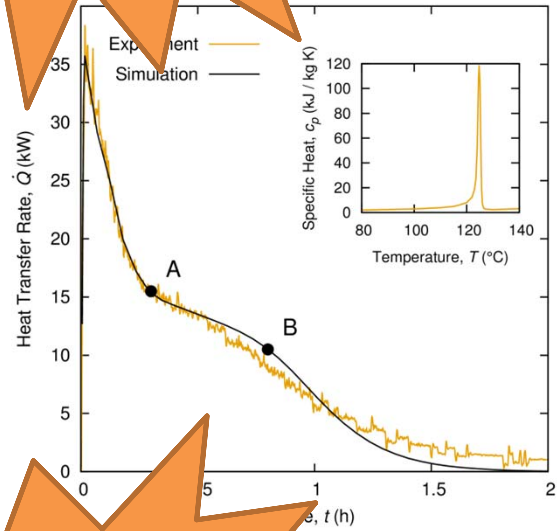





Time consuming

Thermophysics Simulation

Prototype Measurement

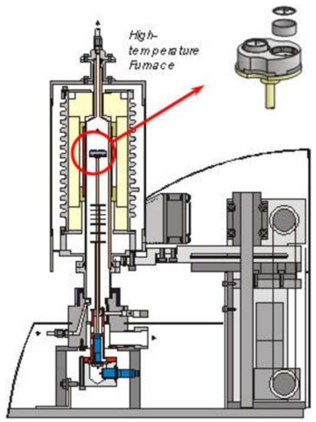



Time consuming

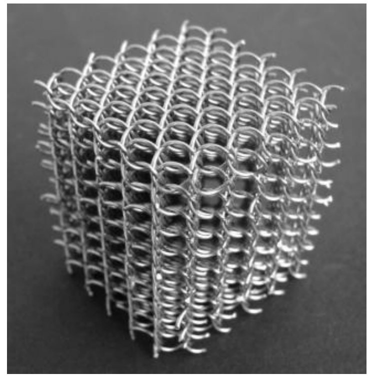
Expensive

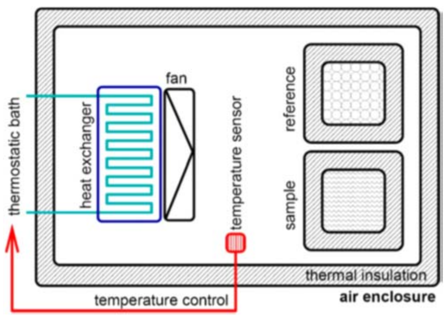
Time consuming

# Pros and Cons of DSC and T-History




DSC:
– Small sample size
+ High temperature range (Tmax)
+ High heating and cooling rates
– Expensive



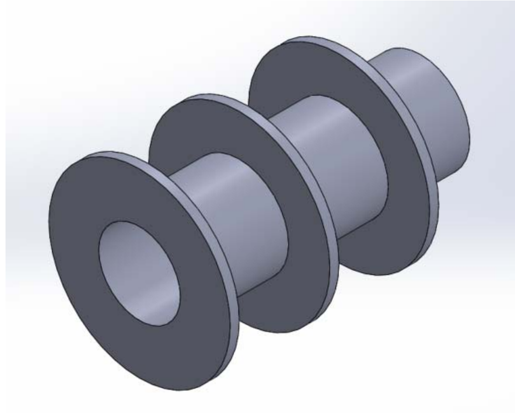



T-History:
+ Large sample size
– Limited temperature range
– Low cooling rates (Bi < 0.1 to reproduce DSC)
+ Calorimetric concept: forced convection, determine *h* from reference

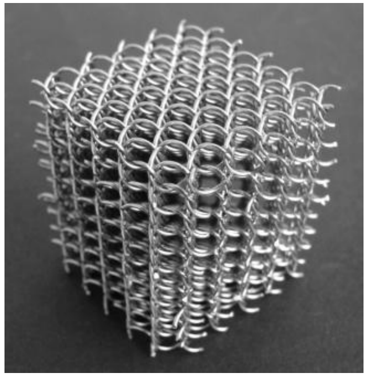
$$C_{p,\mathrm{ref}}\dot{T}_{\mathrm{ref}} = hA(T_{\mathrm{ref}} - T_{\mathrm{air}})$$
$$\dot{Q}_{\mathrm{sam}} = hA(T_{\mathrm{sam}} - T_{\mathrm{air}})$$

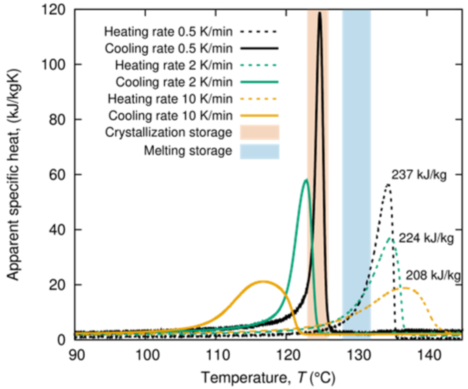
Sole et al, Renewable and Sustainable Energy Reviews 26 (2013) 425–436

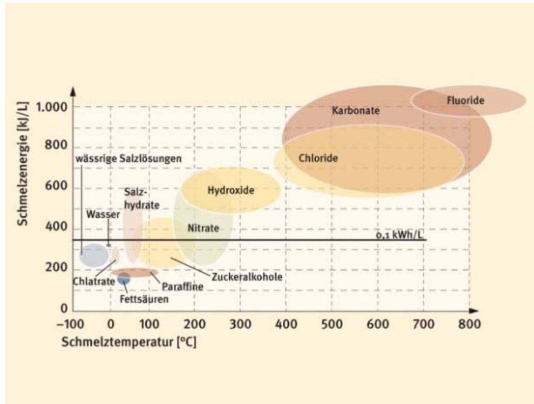
# Basic Idea



1. Use the largest functional unit of the HEX
2. Realistic heat transfer conditions (Bi > 0.1)



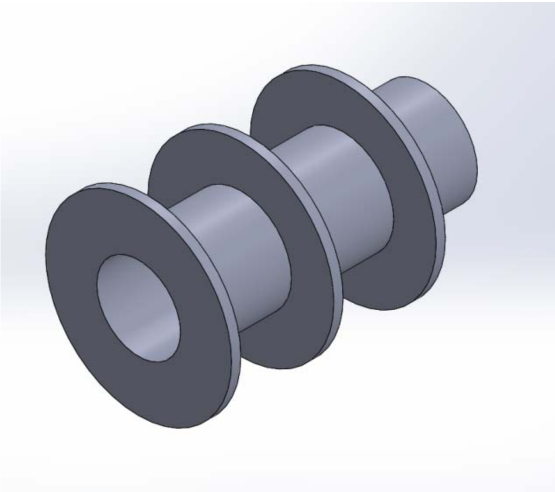


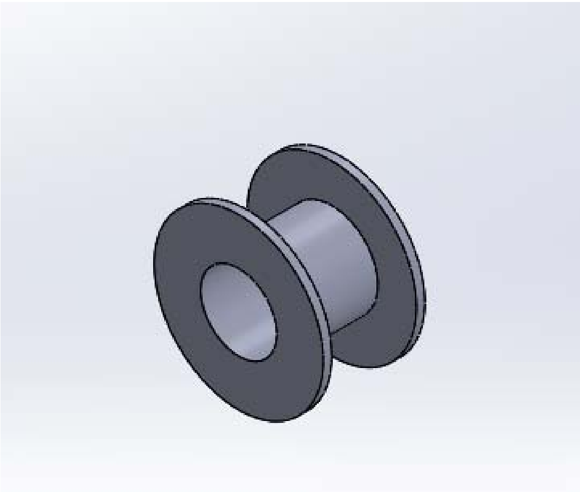



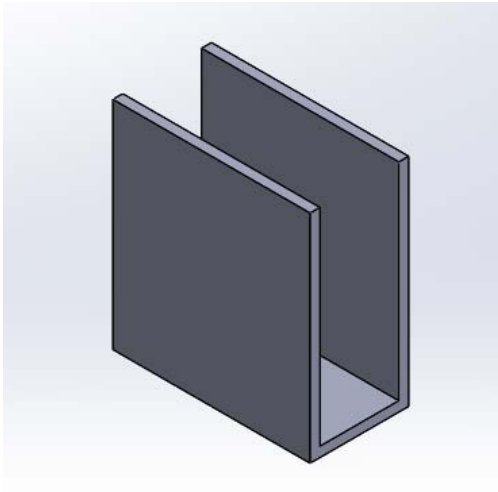

## Requirements

1. Sample size several centimeters (spacing between fins)
2. Flexible and realistic discharge conditions: Inhomogeneous melting (Bi > 0.1)
3. Calorimetry: Good measure of the stored heat (±10 %)
4. Large temperature range: Up to 400 °C
5. Easy handling

# Sample Geometry: Cut and Unroll the Finned Tube



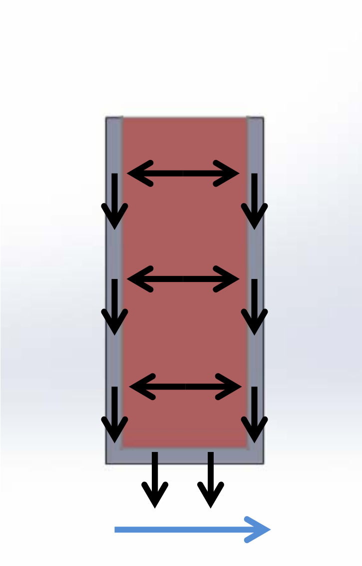
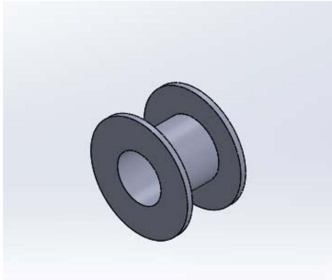
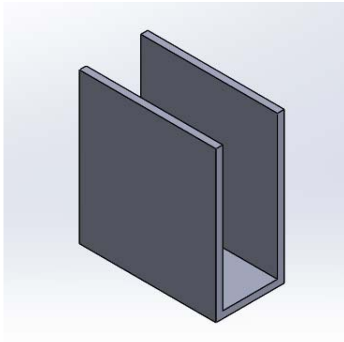
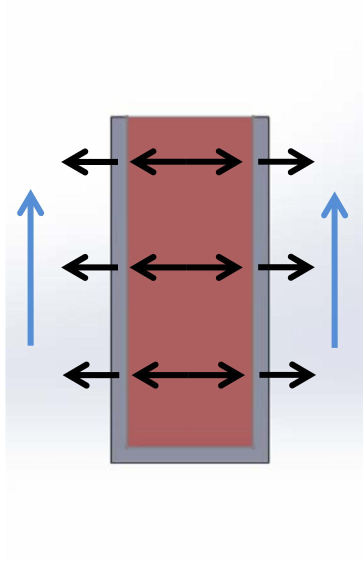




- Crucible dimensions about 10 x 10 x 2 $cm^3$ (large samples)

# Heat transfer: Forced convection

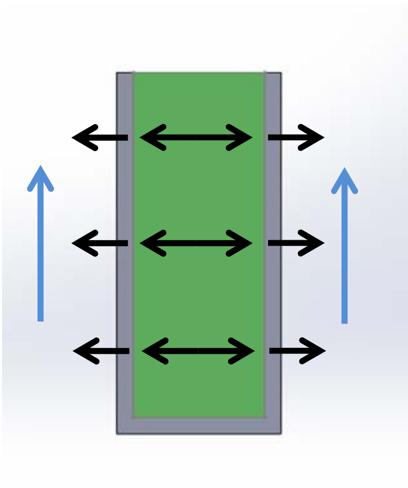
AIT AUSTRIAN INSTITUTE OF TECHNOLOGY
TOMORROW TODAY

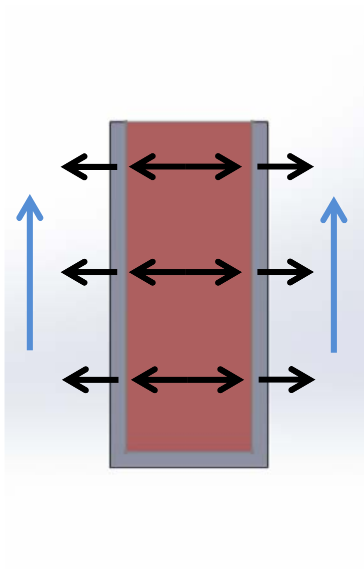





- Air as heat transfer medium:
  - Save, versatile, no phase change
  - Cooling is for free (HVAC)
- Compensate low heat transfer rate by large heat exchange surface (full fin surface)
- Heat transfer rate can be controlled:

$$\dot{Q} = hA(T_{\mathrm{air}} - T_{\mathrm{fin}})$$

# Calorimetry: Reference Sample





- Borrow idea from T-history and use a reference sample

$$\dot{Q} = hA(T_{\text{air}} - T_{\text{fin}})$$

- Low turbulence or laminar flow conditions
- Measured quantity $\dot{Q}(\bar{T}_{\text{fin}})$

# Development Phase

AUSTRIAN INSTITUTE OF TECHNOLOGY
TOMORROW TODAY

Temperature measurement:
Non-contact infrared

Thermal expansion

High temperature materials

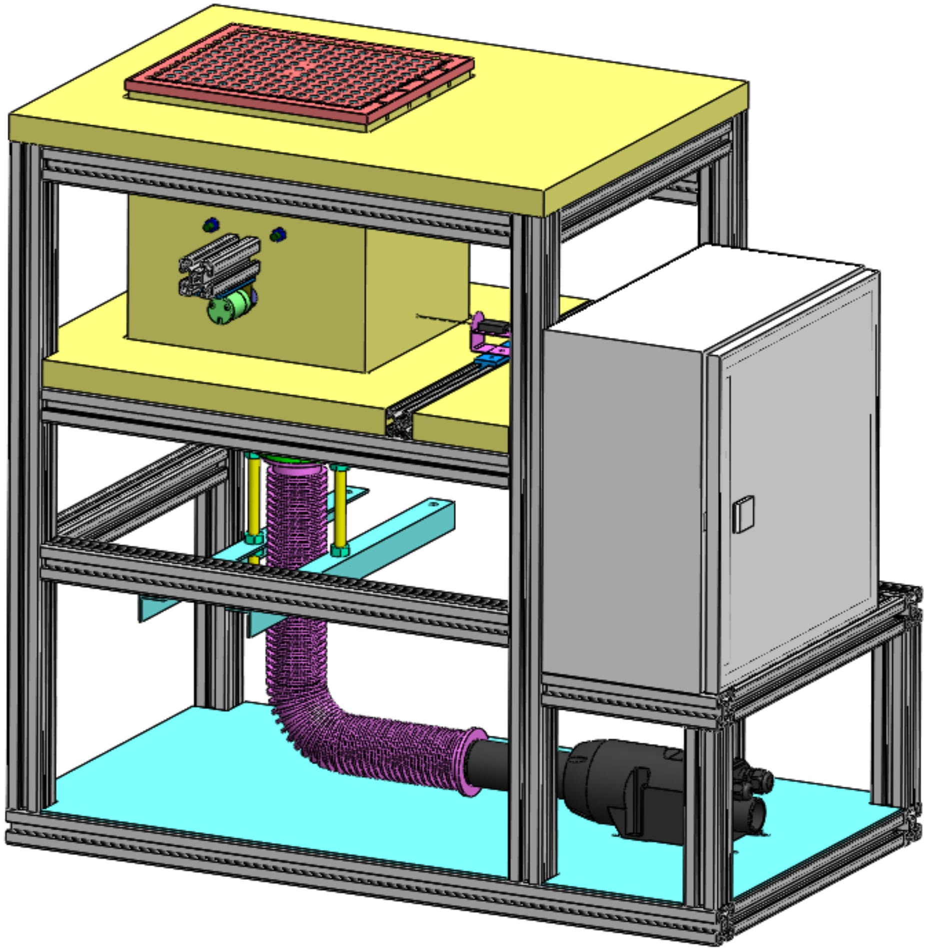
Low turbulence

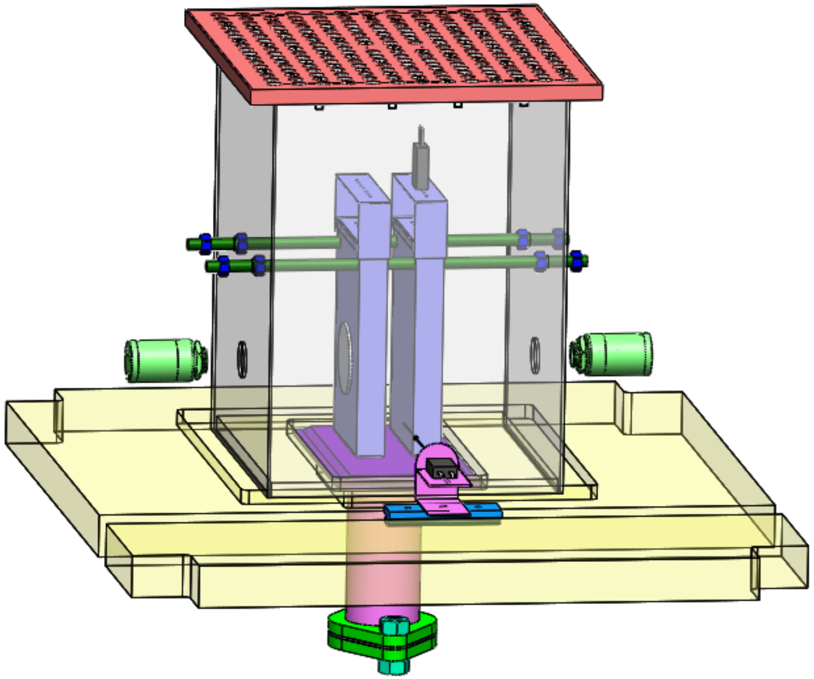
Simulations

Sizing of components

# Design

AIT AUSTRIAN INSTITUTE OF TECHNOLOGY
TOMORROW TODAY





# Future Work

Control concept for $T_{air}$?

Laminar flow Conditions?

Reference sample?

Maximum temperature?

Useful results?

Redesign and rebuild