CHILLVENTA eSPECIAL

Refrigeration | AC & Ventilation | Heat Pumps

13.–15.10.2020

CONNECTING EXPERTS.

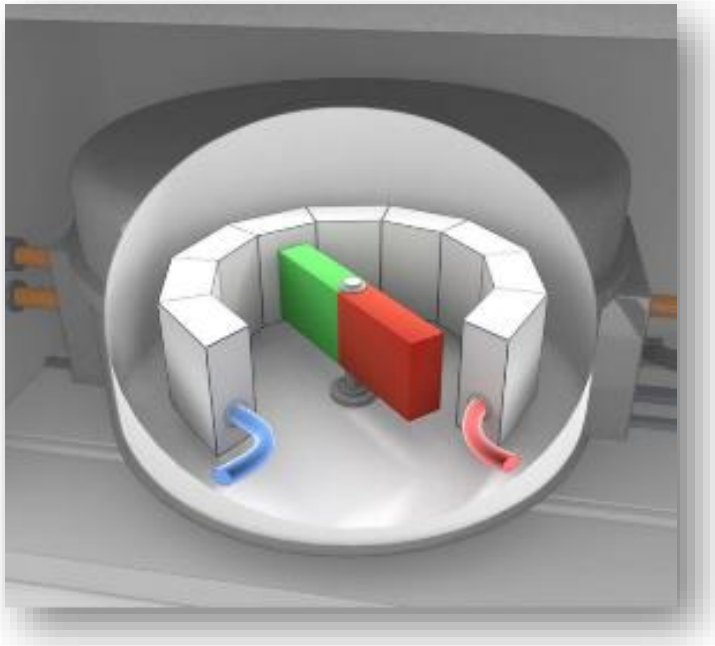
NÜRNBERG MESSE

Caloric Materials for Thermal Compression

15.10.2020 Chillventa eSpecial

K. Bartholomé, D. Bach, L.M. Maier, N. Bachmann, A. Fitger, O. Schäfer-Welsen

- Motivation
- »Active Magnetocaloric Heat Pipe« as Thermal Compressor
- Other caloric effects
- Summary



Motivation

Why to deal with calorics?

1. **Environmentally friendly:**
   No harmful refrigerants

2. **Large efficiency!**

3. **Silent and easy-maintenance technology**

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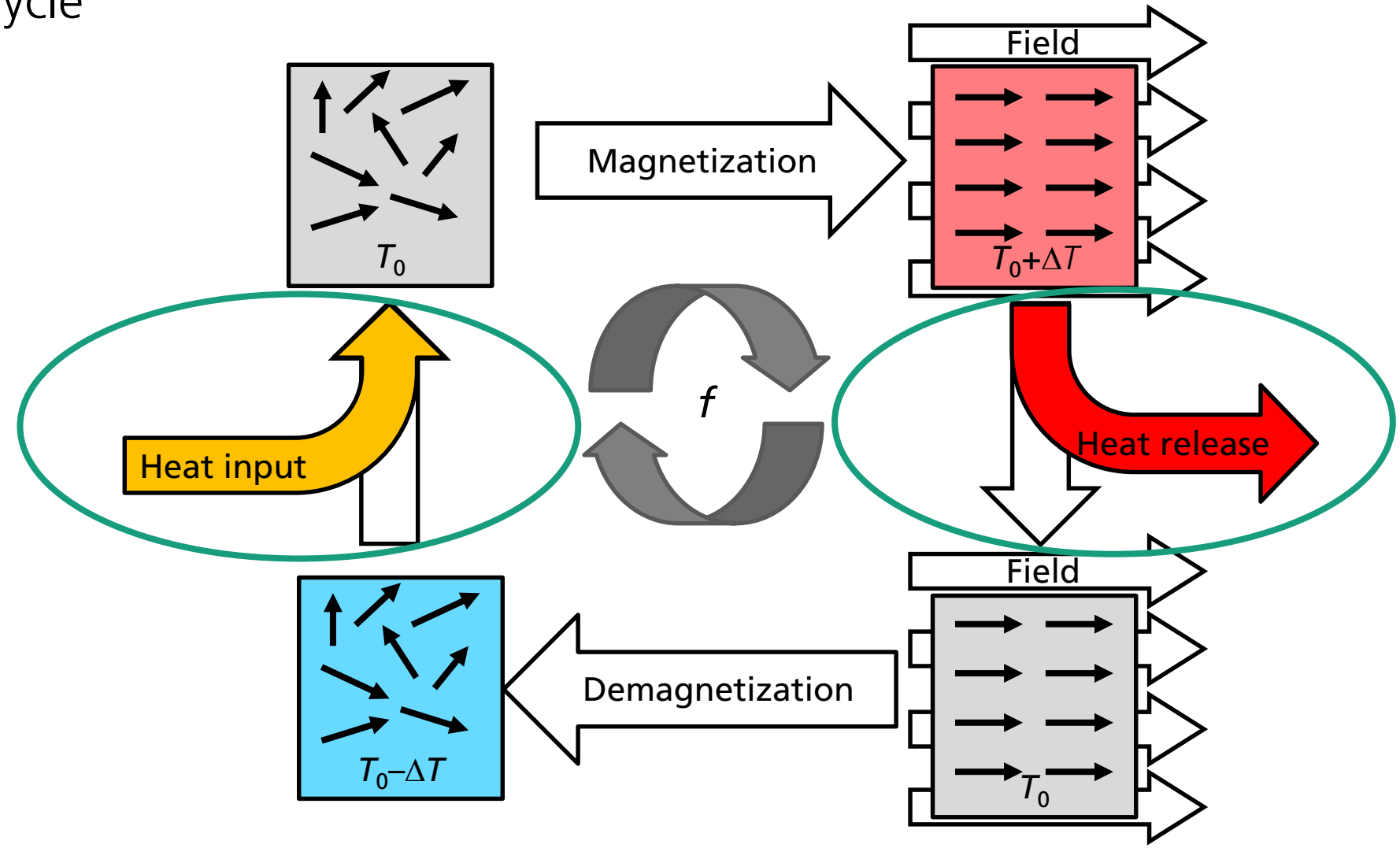
Motivation

Caloric Cycle



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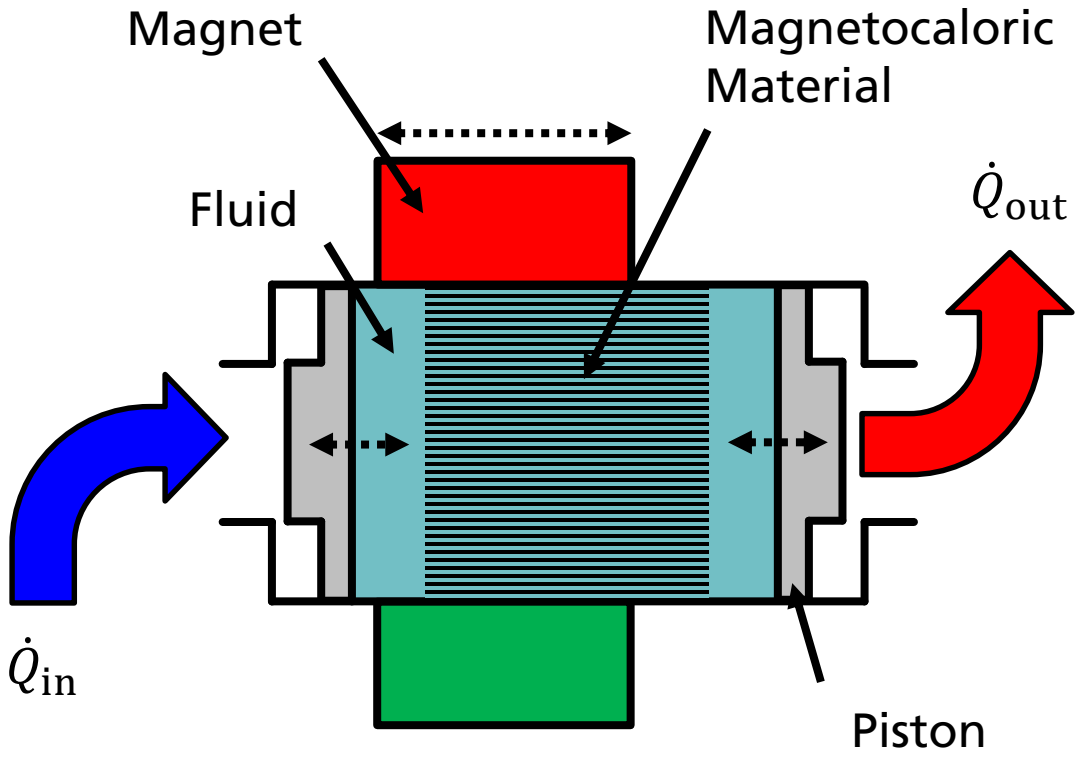
Motivation

Active magnetocaloric regeneration (AMR)

- Several Demonstrators built based on AMR concept
- Showing good performance regarding temperature span and cooling power
- Challenge:
  Realization of large cycle frequency and cooling power density!



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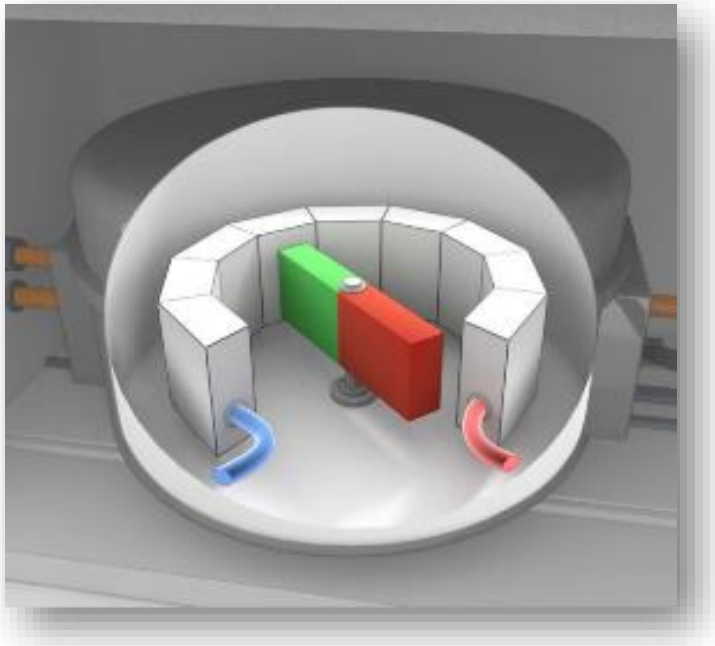
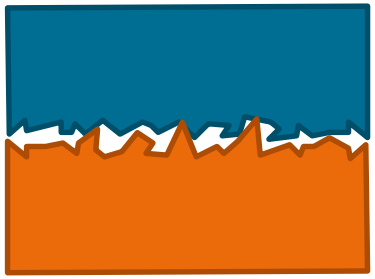


Active Magnetocaloric Heat Pipe as Thermal Compressor

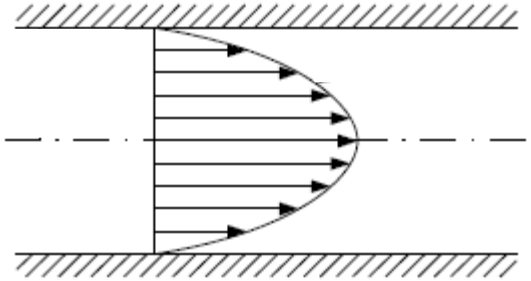
Fast heat transfer for larger cooling capacity

Solid-State Heat Transfer



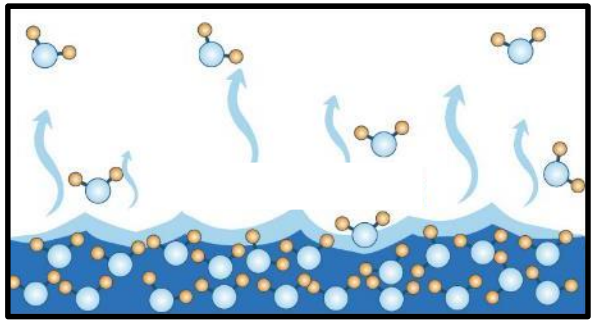
$$h = 10 \ \ldots 10.000 \frac{W}{m^2 K}$$

Convection



$$h = 100 \ \ldots 10.000 \frac{W}{m^2 K}$$

Evaporation / Kondensation



$$h = 10.000 \ \ldots 100.000 \frac{W}{m^2 K}$$

Active Magnetocaloric Heat Pipe as Thermal Compressor

New concept for heat transfer in caloric systems

Alternative system approach

Fast and efficient heat transfer by combining

- Latent heat transfer:
  Evaporation and condensation
- Thermal diode:
  Passive, uni-directional heat transfer

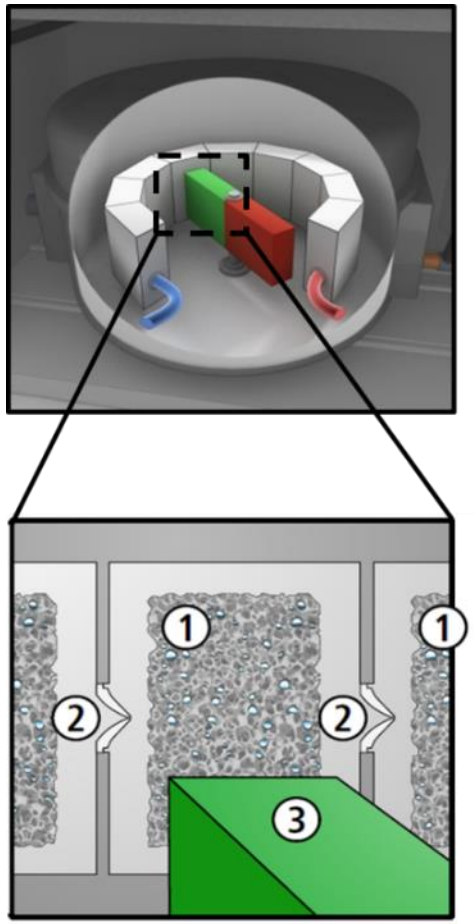
Magneto-/ Electrocalorics: Patent DE10 2014 010 476
Elastocalorics: Patent pending

Active Magnetocaloric Heat Pipe as Thermal Compressor

New concept for heat transfer in caloric systems

Advantages

- Better heat transfer using latent heat:
  - → Higher frequencies
  - → Higher cooling power density
  - → Less permanent magnet required
- Passive heat transfer:
  - → No pumps required
  - → Higher system efficiency
  - → Reduced system complexity



Patent DE10 2014 010 476

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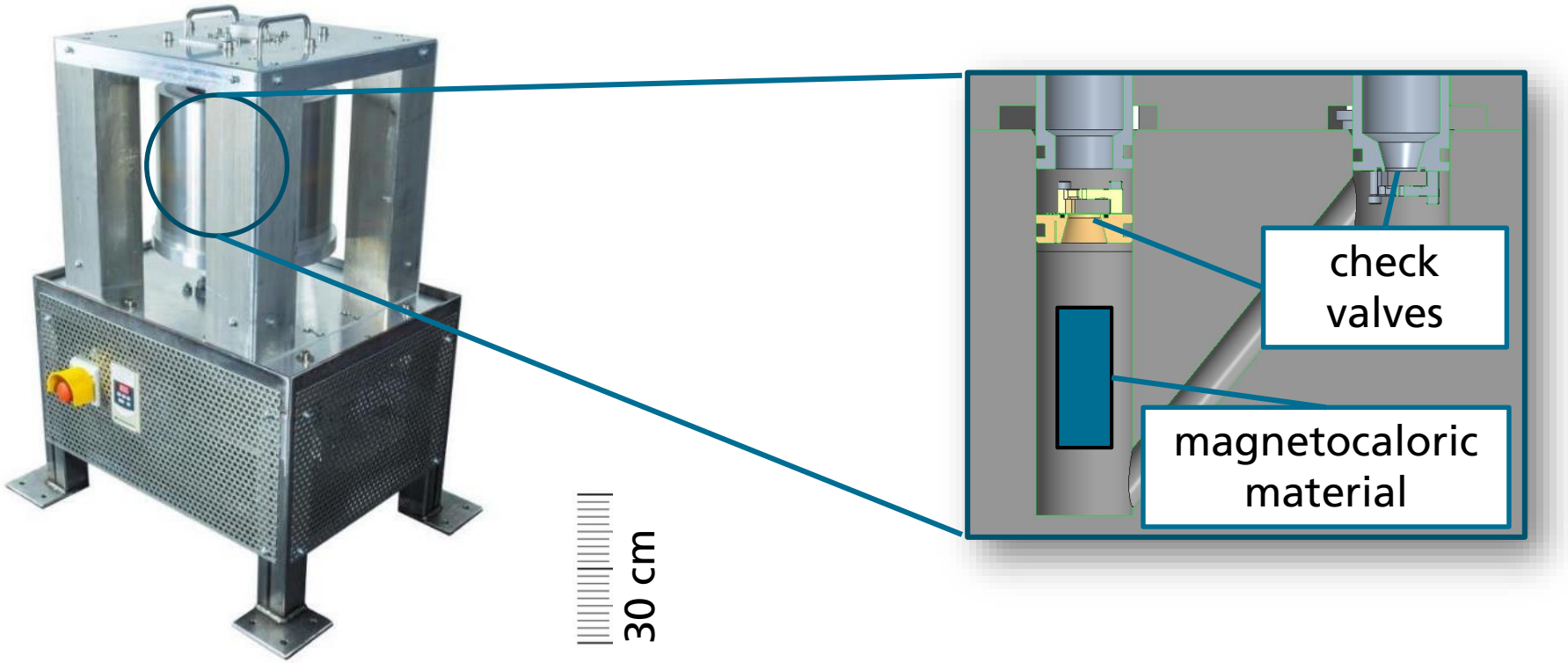
Active Magnetocaloric Heat Pipe as Thermal Compressor

Experimental Setup



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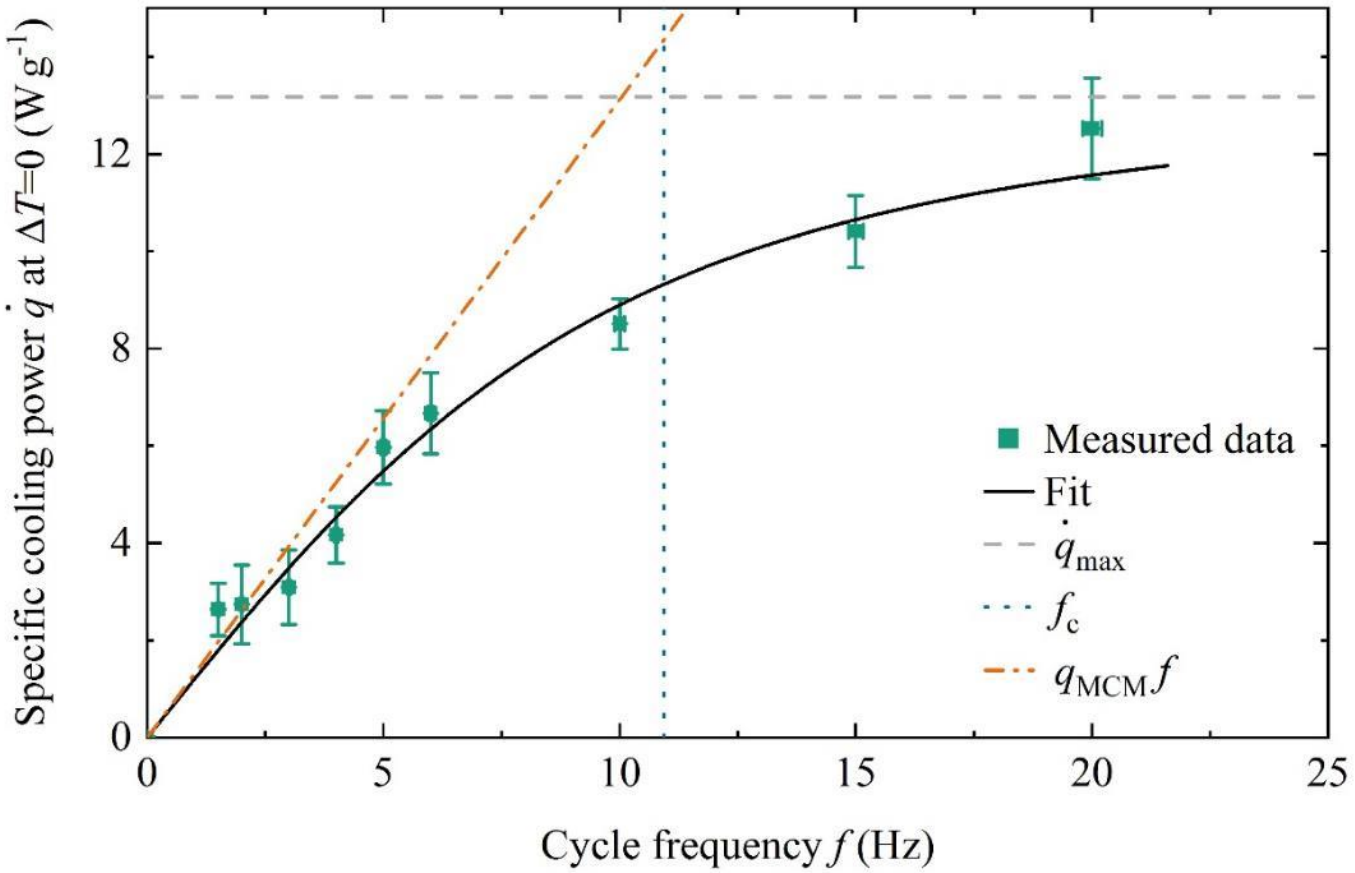
Active Magnetocaloric Heat Pipe as Thermal Compressor

Experimental Data



L. M. Maier et al. „Active magnetocaloric heat pipes provide enhanced specific power of caloric refrigeration", Nature Communication Physics, accepted

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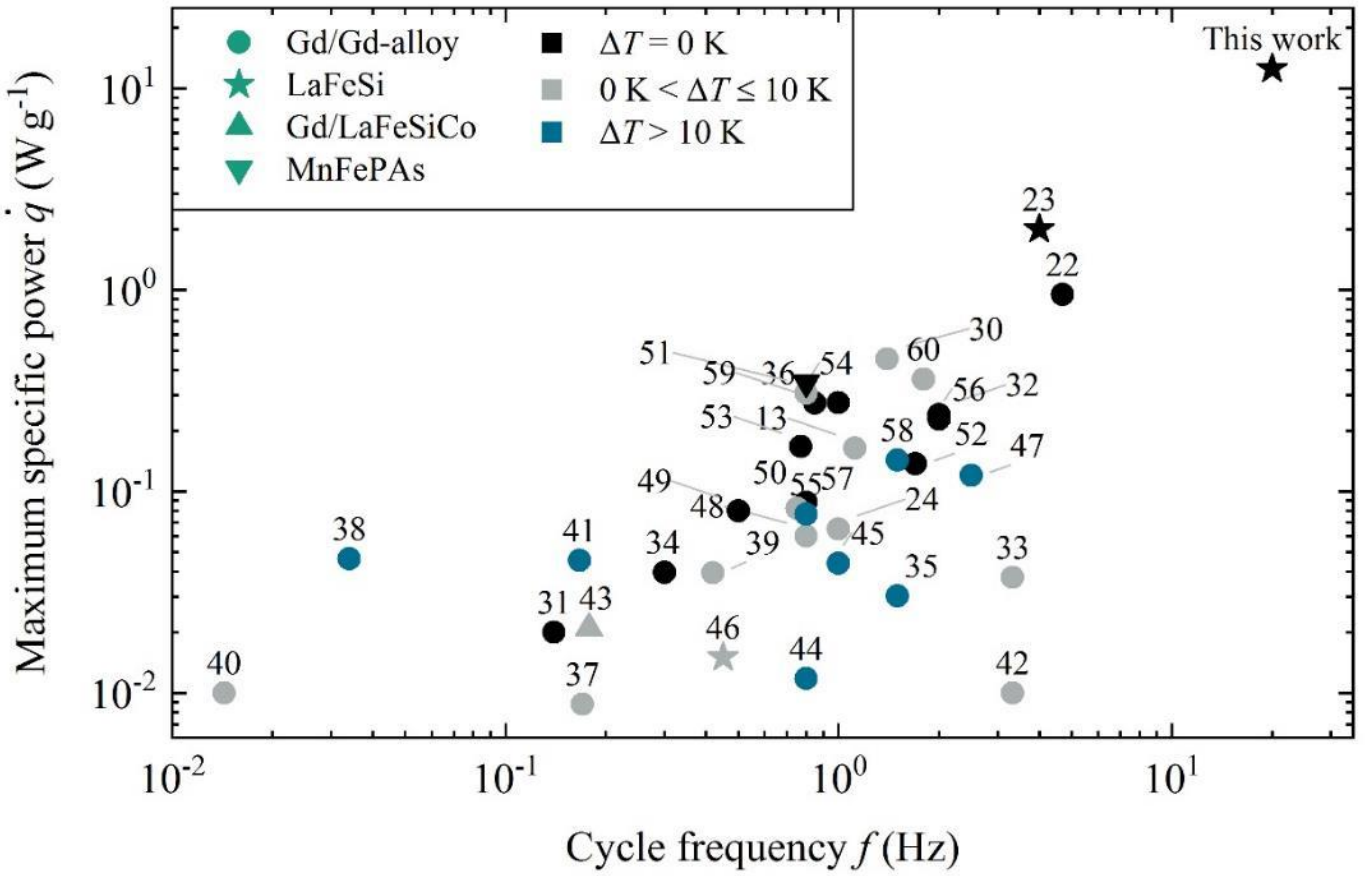

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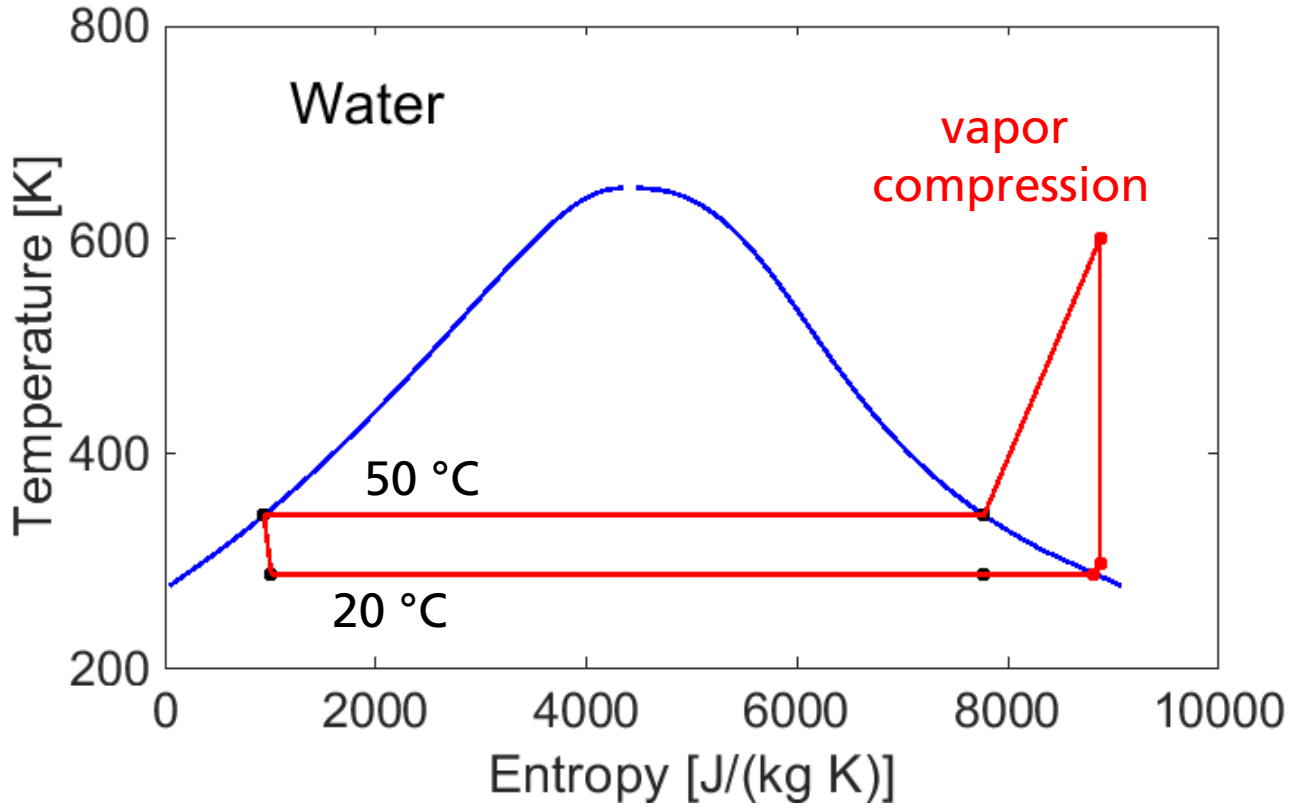
Active Magnetocaloric Heat Pipe as Thermal Compressor

Efficiency Potential: Comparison to Vapor-Compression



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Active Magnetocaloric Heat Pipe as Thermal Compressor

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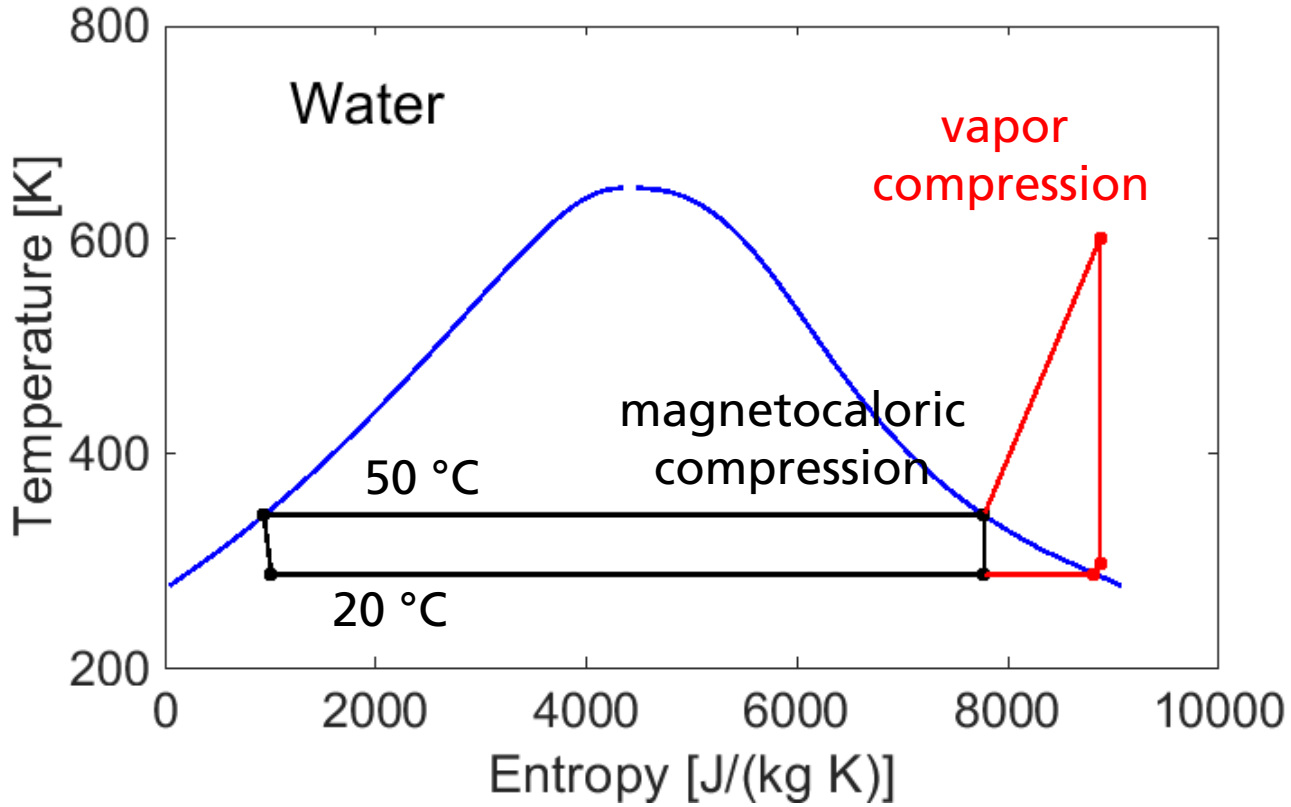

High efficiency possible – also for „wet“ fluids!

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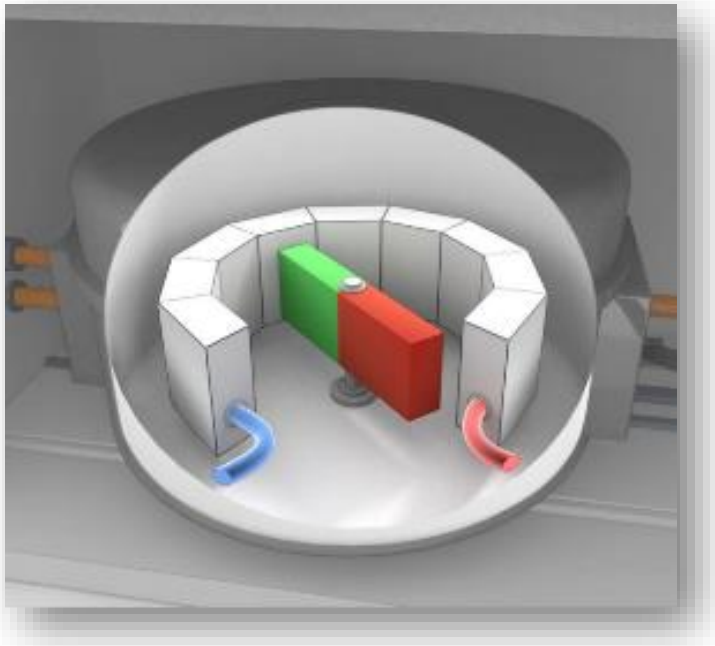

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Other caloric effects
Elastocalorics

Background

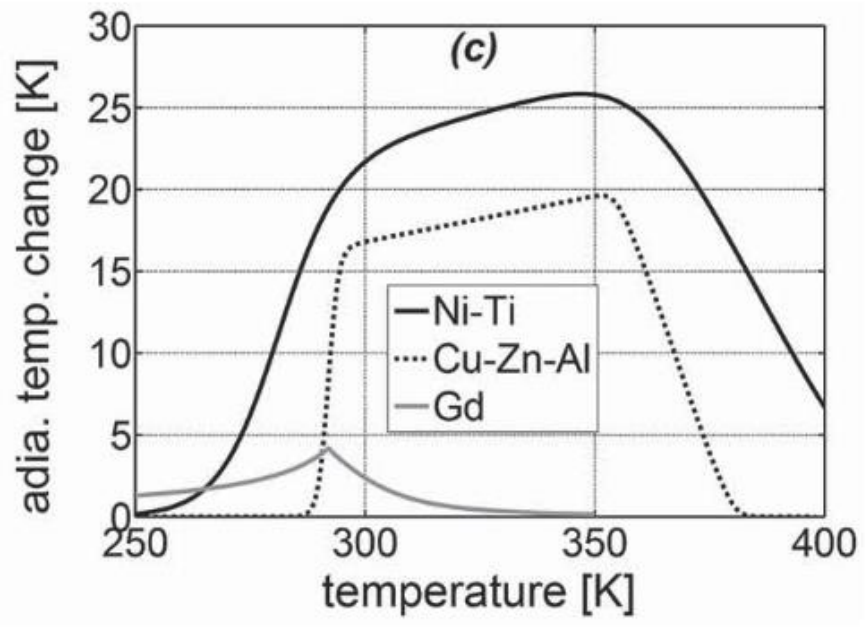
- Materials: Shape memory alloys (e. g. Nitinol)
- Phase change induction by mechanical force

Advantages

- Large adiabatic temperature and entropy changes

Challenges

- Long-term stability
- Material efficiency



Tusek, J. *et al.* The Elastocaloric Effect. A Way to Cool Efficiently. *Advanced Energy Materials* **5,** 1500361 (2015)

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Other caloric effects
Electrocalorics

www.elkawe.org

Project Information

Start: 01.10.2019
Duration: 4 Jahre

- Fraunhofer IPM (Coordinator)
- Fraunhofer FEP
- Fraunhofer IAF
- Fraunhofer IAP
- Fraunhofer IKTS
- Fraunhofer LBF

Background

- Adiabatic temperature change in capacitor-like components
- Induction of phase change by electrical field

Advantages

- No magnetic field or large forces required for effect
  → system possible (almost) completely without moving parts!

Challenges

- Breakthrough voltage, stability
- Transfer material properties → system

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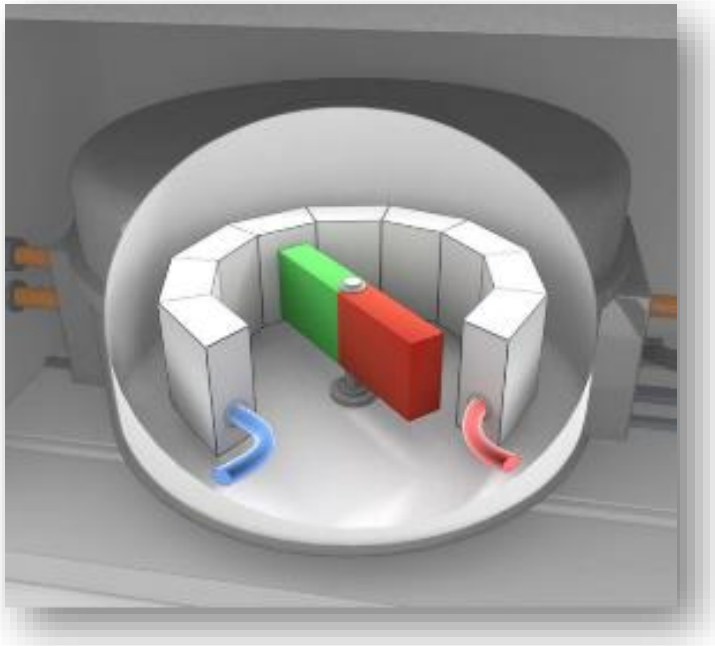
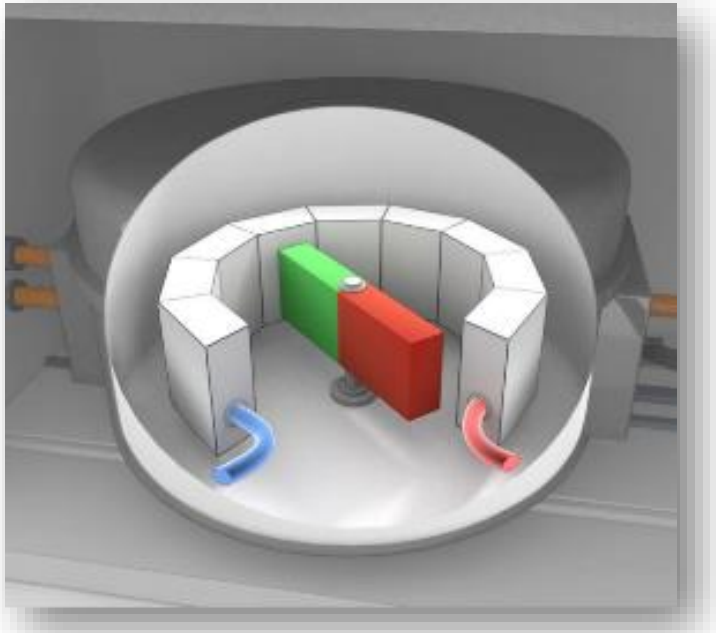


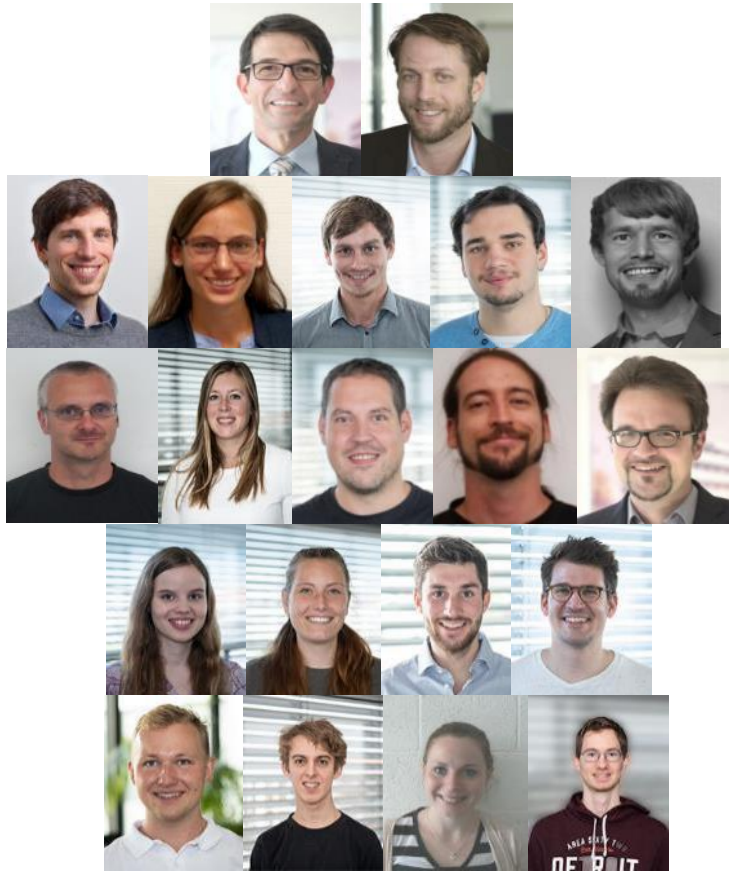
Summary

- Integration of caloric materials into heat pipes enables thermal compression!
- Hereby large system efficiencies and high cooling capacities are possible – even with water as coolant!
- Proof-of-Concept experimentally shown
- Next steps:
  - Increase temperature difference
  - Experimental quantification of efficiency



Danksagung

Project Team



Project Partners

VACUUMSCHMELZE

GSI

Kirsch
Made in Germany. Since 1865.

Project Funding

VDI | VDE | IT

ptJ
Projektträger Jülich
Forschungszentrum Jülich

Bundesministerium
für Wirtschaft
und Energie

Bundesministerium
für Bildung
und Forschung

Baden-Württemberg

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https://www.ipm.fraunhofer.de/de/gf/energiewandler-thermische/innocool-konsortialstudie-kalorik.html

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Thank you for your attention.