# THERS – THERMAL ENERGY RECOVERY SYSTEM

New ideas to offer more power

Fraunhofer

IWU

Europäische Union

Europa fördert Sachsen.

EFRE

Europäischer Fonds für regionale Entwicklung

# AGENDA

- Who we are - short introduction of Fraunhofer IWU
- a spark to THERS
- idea behind the project
- problems faced
- approaches of realization
- current state of research (first results)
- future prospects

# Who we are - short introduction of Fraunhofer IWU

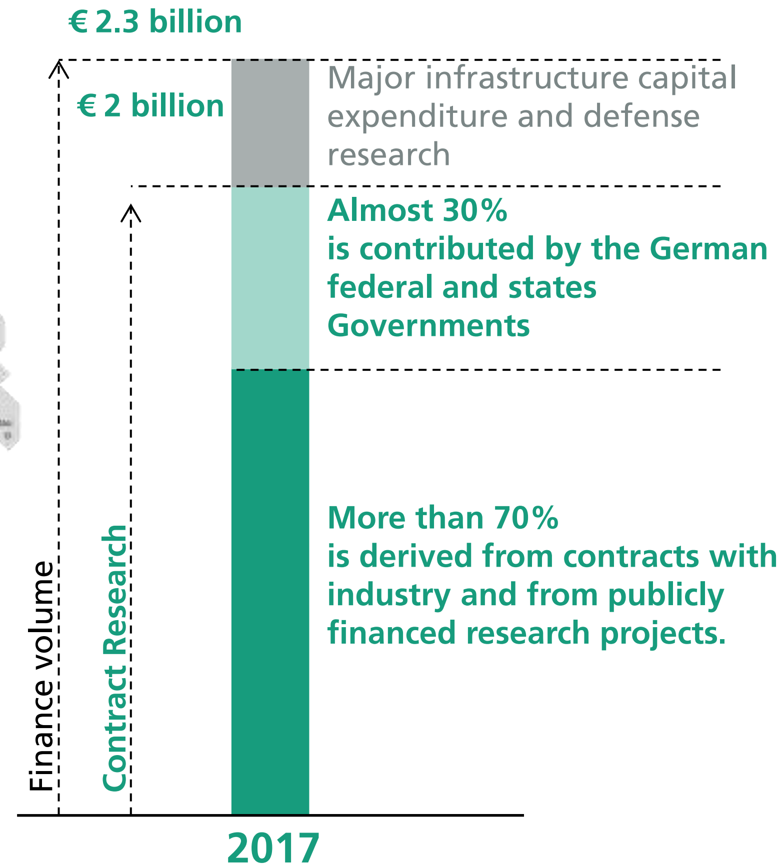
- Fraunhofer-Gesellschaft, the largest organization for applied research in Europe
  - Application-oriented research for immediate benefit to the economy and to the benefit of society
  - 72 institutes and research units
  - 25,327 staff

# Who we are - short introduction of Fraunhofer and IWU

## The Fraunhofer-Gesellschaft undertakes applied research of direct utility to private and public enterprise and of wide benefit to society.

**25,327 staff**


**72 institutes and research units**







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# Who we are - short introduction of Fraunhofer and IWU


**Fields of Expertise**

- Virtual Reality
- Mechatronics
- System Technology
- Production Systems
- Machine Tool Design
- Joining Technology
- Forming Technology
- Process Control Engineering
- Generative Technologies…


Mechatronics and Lightweight Structures


Forming Technology


Machine Tools, Production Systems and Machining


IWU Locations





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# The spark to THERS

## KERS – Kinetic Energy Recovery System...


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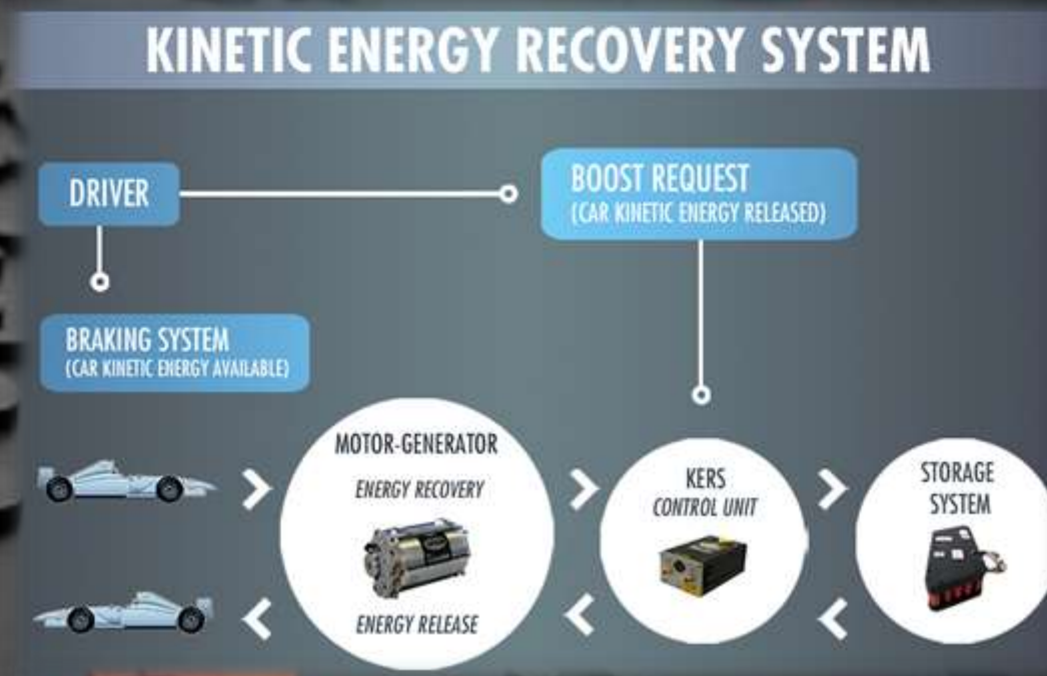
# The spark to THERS




**KERS – Kinetic Energy Recovery System…**



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# The spark to THERS

Heat recovery for fast warm-up

Passenger room heating of e-cars



Thermal management of batteries and high power electronics


Passenger room cooling at start/stop

**THERS – Thermal Energy Recovery System!**





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# The idea behind THERS…an experience!

- project meeting at the Fraunhofer IWU in Dresden
- travelling by e-Golf (not fully charged)
- just made the distance <u>twice</u>
  → logical conclusion: Turn all actors off!
  (heating, stereo, lights…)




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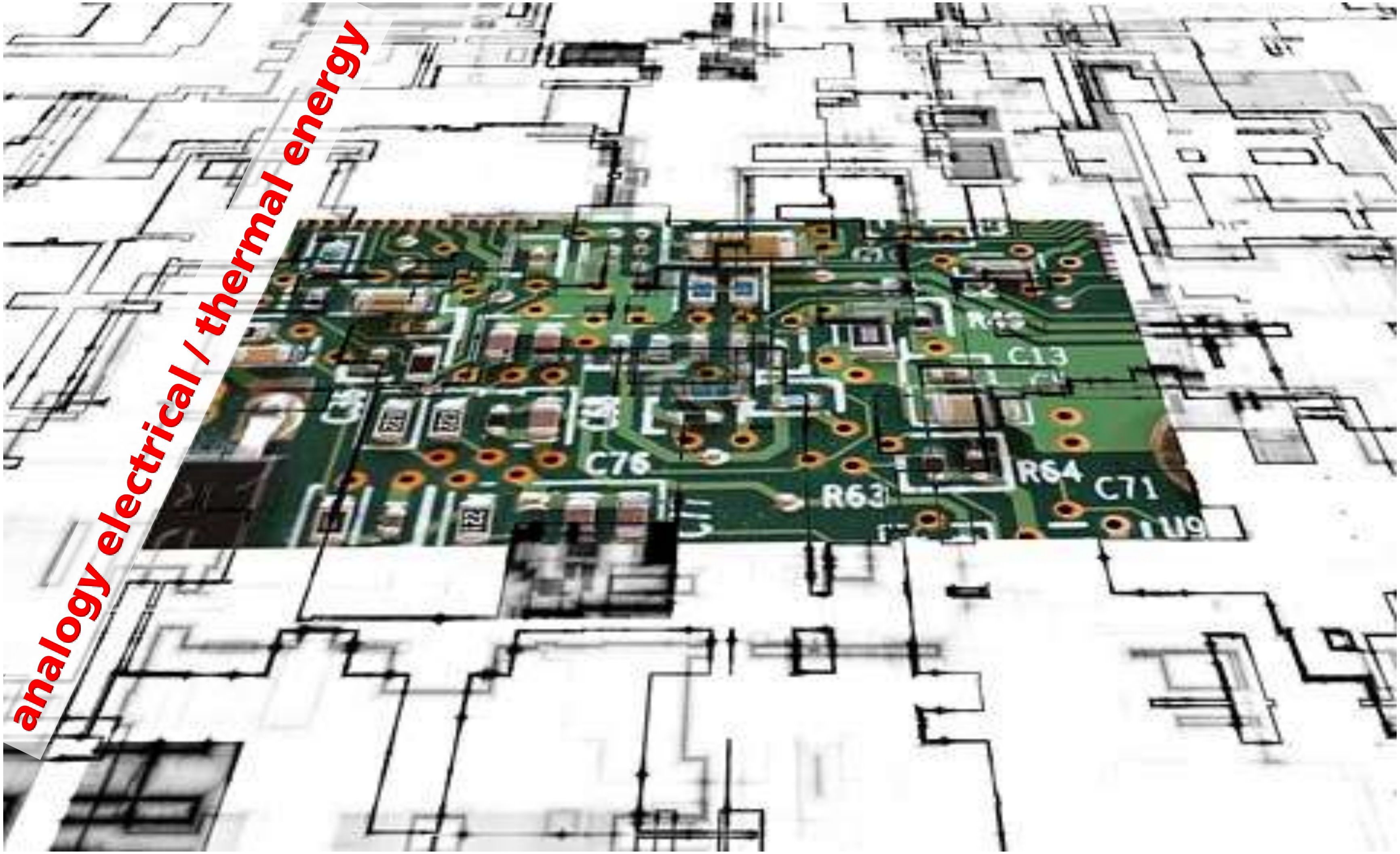
# The idea behind THERS



# The idea behind THERS

| component | electrical energy | thermal energy |
|---|---|---|
| storage | battery | THERS |
| generator | alternator | brakes, engine |
| load | motor, heater | air conditioning |
| wiring | copper wires | heat pipes |

Vision of THERS

# Problems that had to be faced

- potential systems are to slow!
- limited heat storage capacity
- no serial systems available
- checklist:
  - heat pipes
  - heat sources
  - loads
  - storage systems
- integral version would be the favorite one (functional integration into existing/needed components)

# Problems that had to be faced

- Job of storage system? We asked a customer (example=battery housing)



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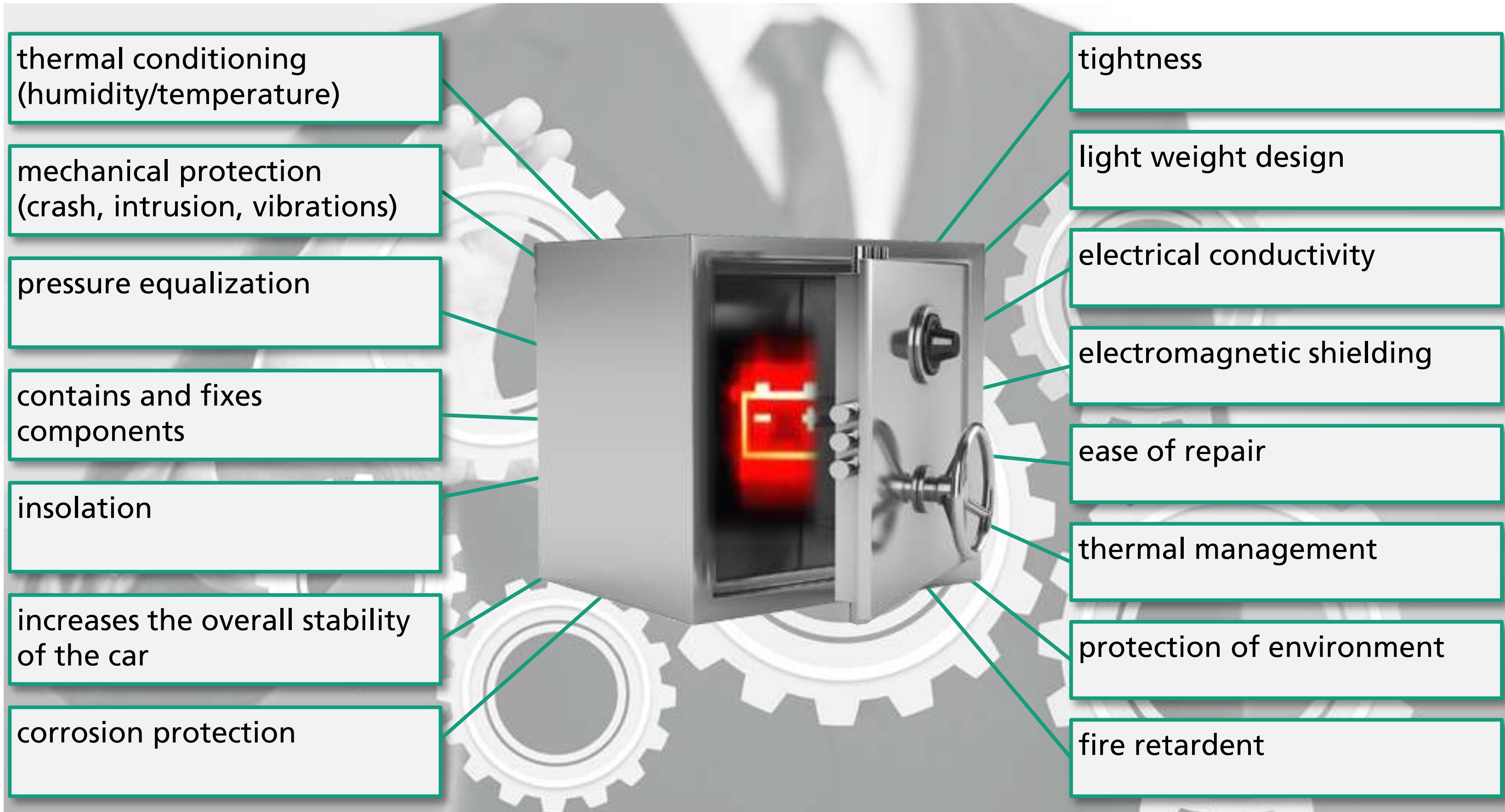
- Job of storage system? We asked a customer (example=battery housing)




Currently no norms available – testing specifications are defined by the manufacturer.





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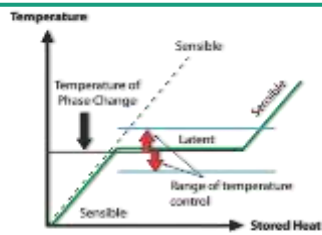
# Approaches for realization

- Current activities:




## Phase Change Material (PCM)

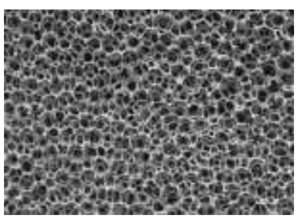
→ using the melting enthalpy during phase change
→ high heat storage capacity

**advantages**

- high latent heat storage capacity
- change of aggregate state reversible process
- adjustable melting range
- physiologically harmless
- fire protection properties

**drawbacks**

- poor thermal conductivity
- embedding / sealing required



## Metal foam

→ high mechanical energy absorption
→ permeable
→ high heat conductivity

**advantages**

- very good thermal conductivity
- good mechanical properties
- adjustable density
- good damping properties
- good electrical conductivity
- high thermal resistance

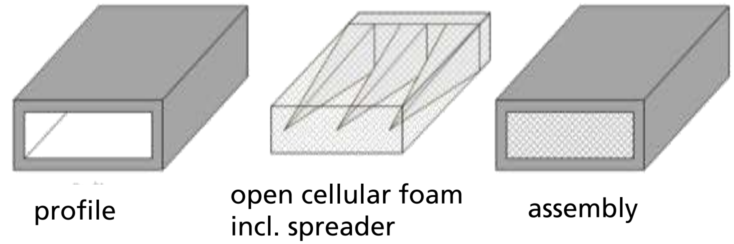
**drawbacks**

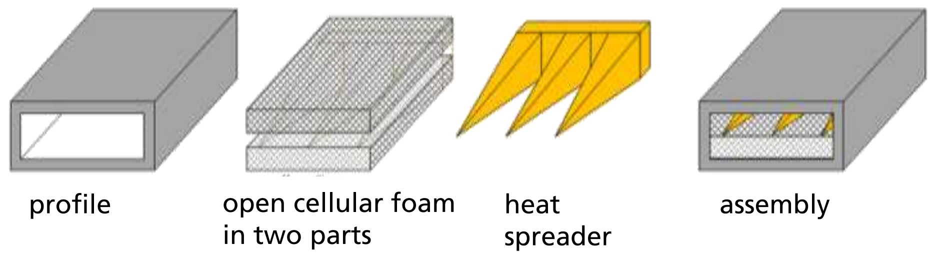
- low heat storage capacity

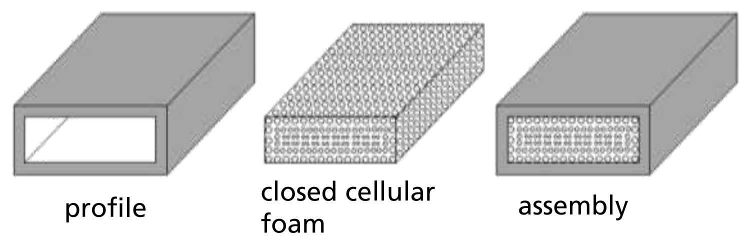
**material combination**
combining the advantages / elimination of drawbacks

# Approaches for realization

- Increasing heat transfer ***speed***:
  - defined guideways (solid heat spreader)
  - structural distribution
    - open cellular foam
    - closed cellular foam

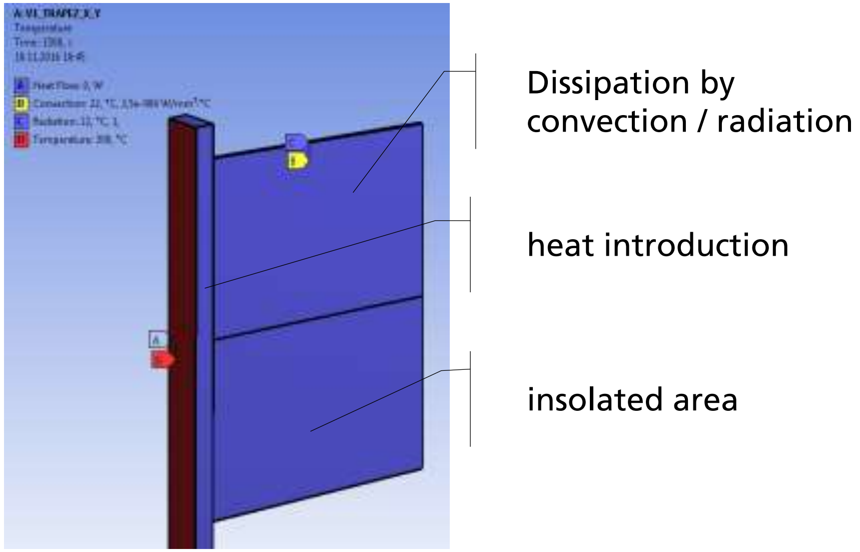


# State of research – heat spreader

- optimization of a heat spreader geometry using ANSYS Workbench (parameter optimization)
- boundary conditions:
  - one-sided introduction of heat (plate dimension 200 x 20 x 10 mm³ )
  - insulation on all other sides
  - heat dissipation compared to initiation into heat spreader with variable geometry
  - dissipation at heat spreader free convection and radiation
  - material: aluminum



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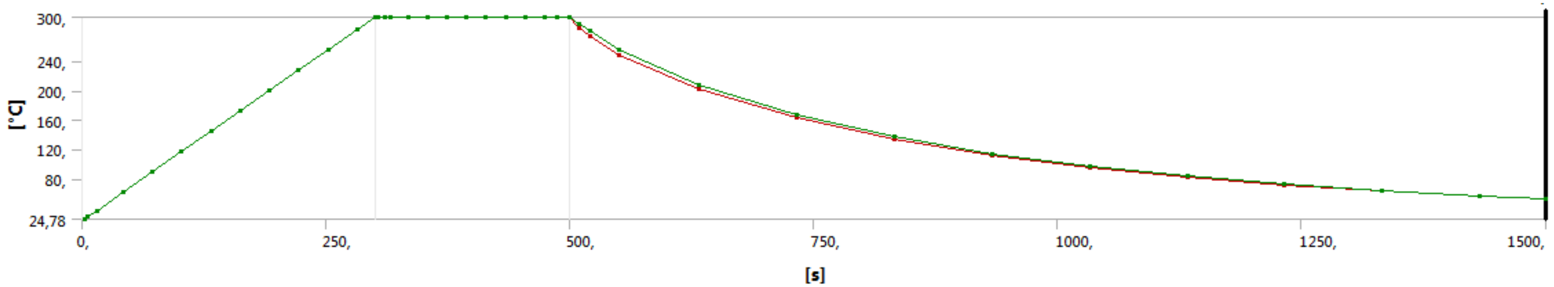
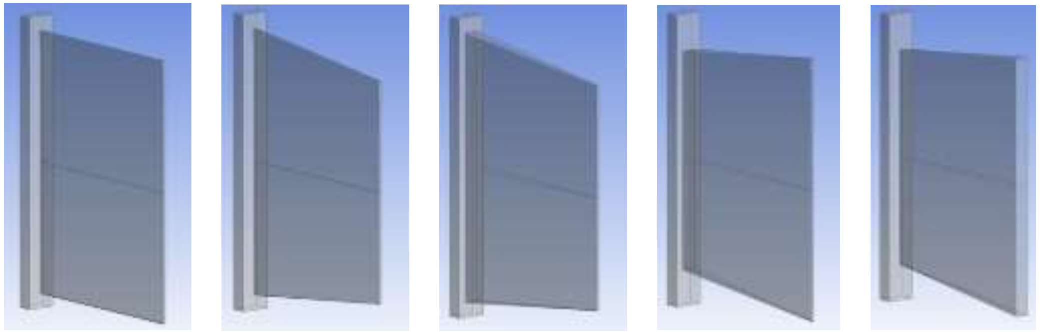
# State of research – heat spreader

- simulation of heat dissipating efficiency
  - step 1: heat introduction up to 300 °C in 300 s
  - step 2: constant temperature at 300 °C for 200 s
  - step 3: no further heat intro. and cooling via spreading structure (minimum temperature of the introduction surface defines efficiency)




- geometries investigated:



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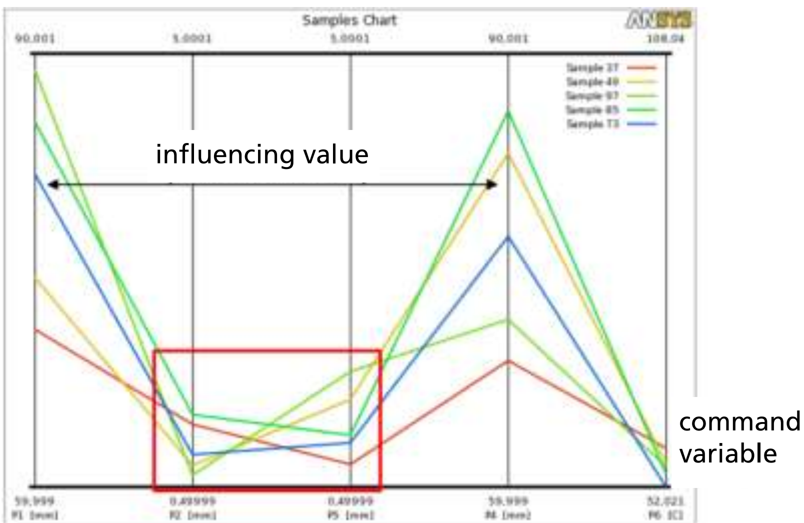
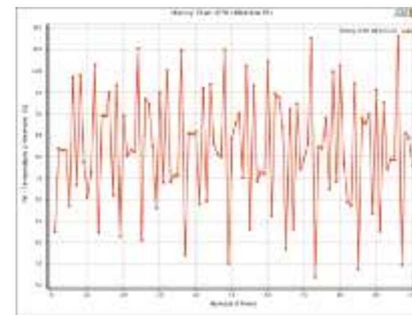
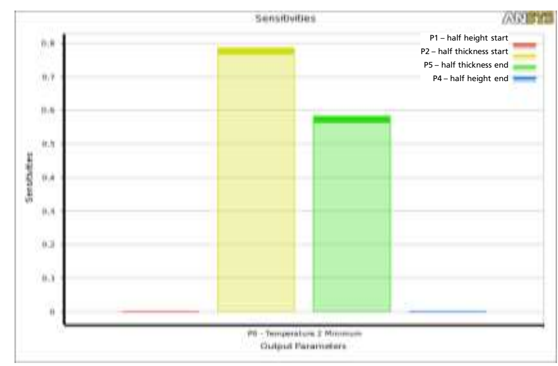
# State of research – heat spreader

- material thickness shows highest influence for heat dissipation
- thin walled spreader is working best
- relation of surface to volume as big as possible
- best results for varying thickness from 1,2 – 1,4 mm at heat introduction to 0,5 mm at opposite side
- best result of equal thickness: at 1 mm









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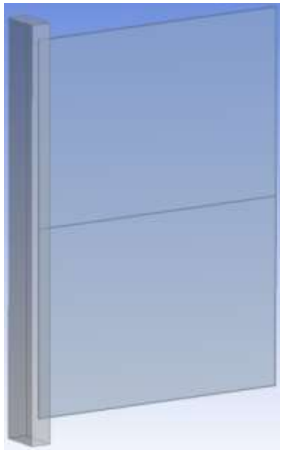
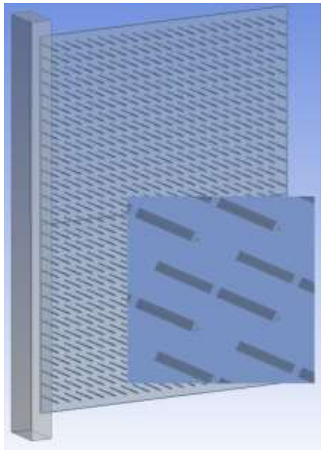
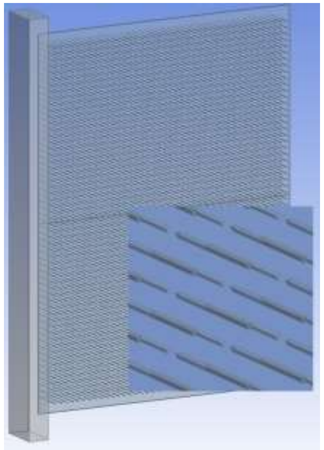
# State of research – heat spreader

- influence of pore density (simplified geometry)







| version | sheet metal 1 mm | sheet metal 1 mm + rough pins | sheet metal 1 mm + finepins |
|---|---|---|---|
| pins [number] | - | 704 | 4674 |
| Length of pins [mm] | - | 7,5 | 7,5 |
| Edge length of pins [mm] | - | 0,65 (triangle equilateral) | 0,3 (triangle equilateral) |
| raster [mm x mm] | - | 6 x 6 | 3 x 3 |
| A spreader [mm²] | 47.240 | 58.369 | 79.105 |
| V spreader [mm³] | 23.400 | 24.366 | 24.794 |
| volume PCM [g] | 392 | 374,6 | 374,4 |





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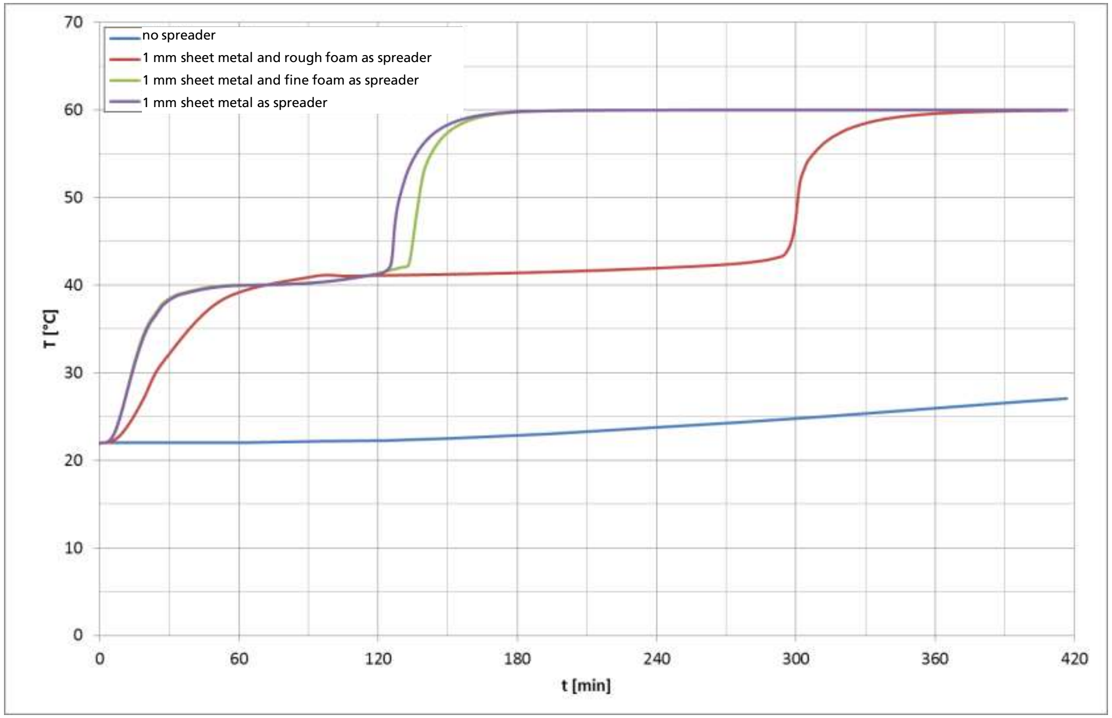
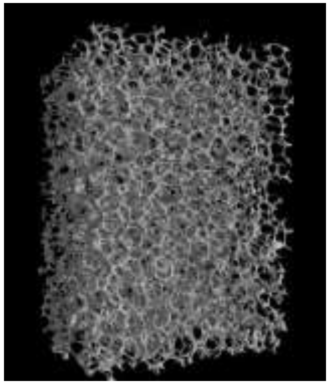
# State of research – heat spreader

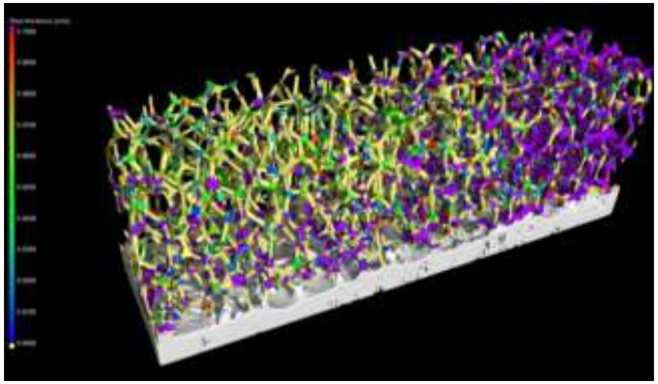
- significant improvement of the heat dissipation capacity by combination with open-porous structures is to be expected
- improvement by a factor >2
- a fine foam structure shows slightly better results

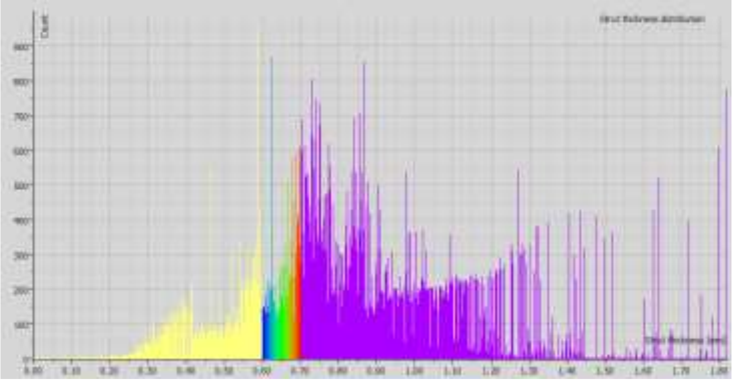


# State of research – structural reality

- ct-scan of open-cell Aluminum foam
- surface analysis and re-engineering
- structural analysis
  (cell size and strut thickness)
- pictures show first trials for graded foam









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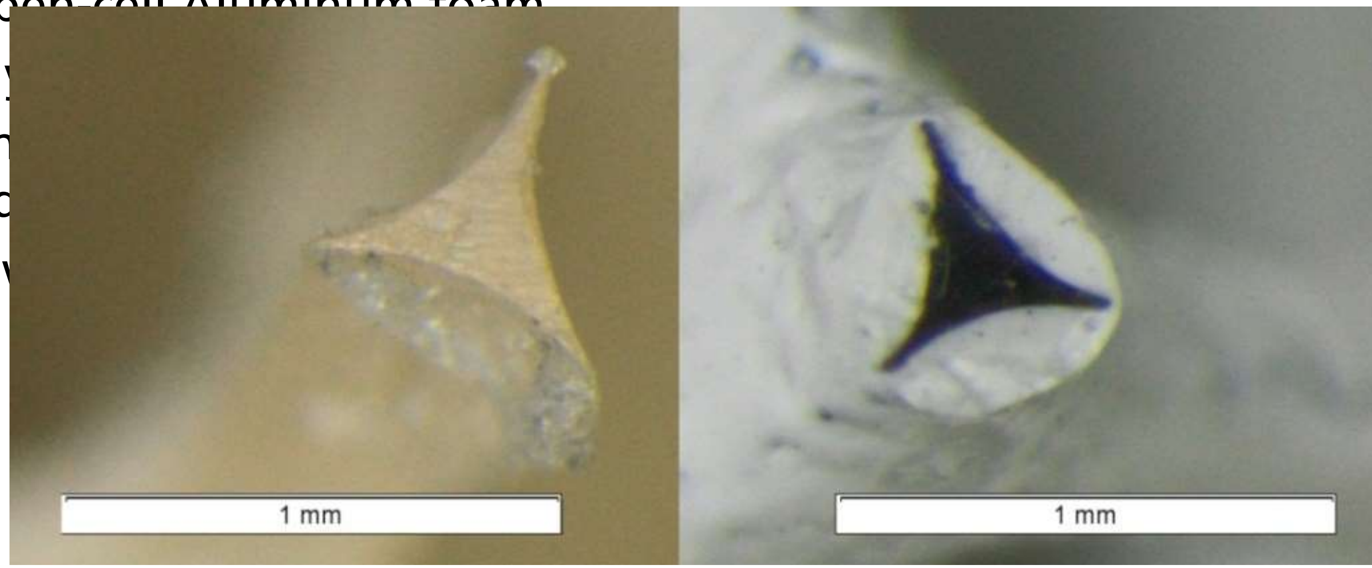


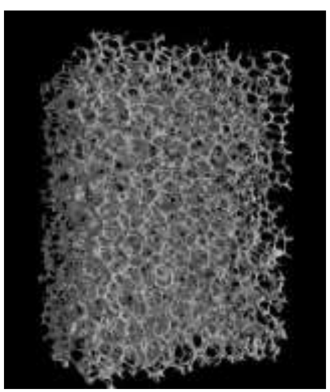

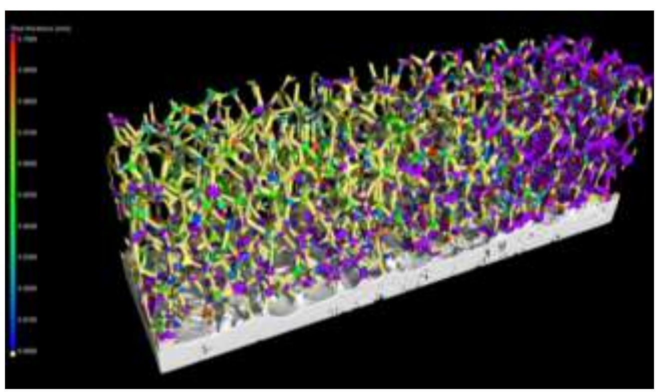

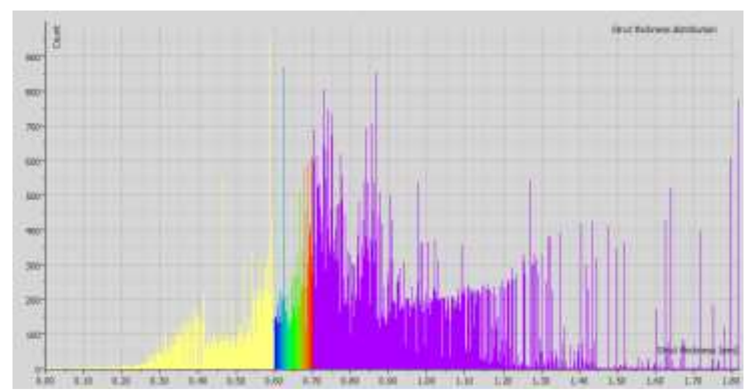





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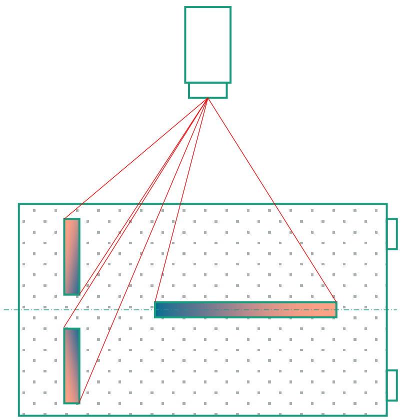
# State of research – demonstrator

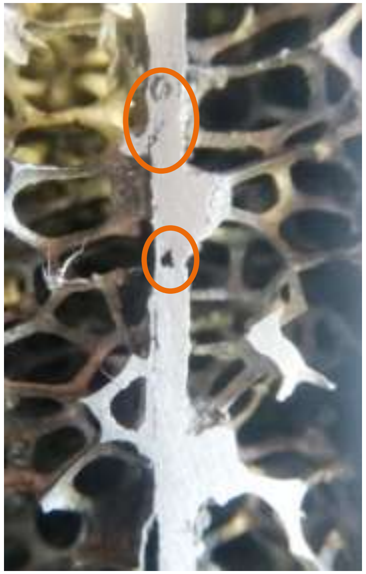
- Prototypical build up of different versions
- housing of foam structure
- infiltration with Rubitherm RT33 – PCM
- thermal analysis



- heat introduction plate with spreader and foam
- insolation assembly
- testbench

# State of research – demonstrator

- connection of foam and heat spreader
  - casted against sheet metal spreader (alloying connection)
  - casted together with spreader (one piece → large potential)
  - force closure heat transfer reduced to app. 15 %!







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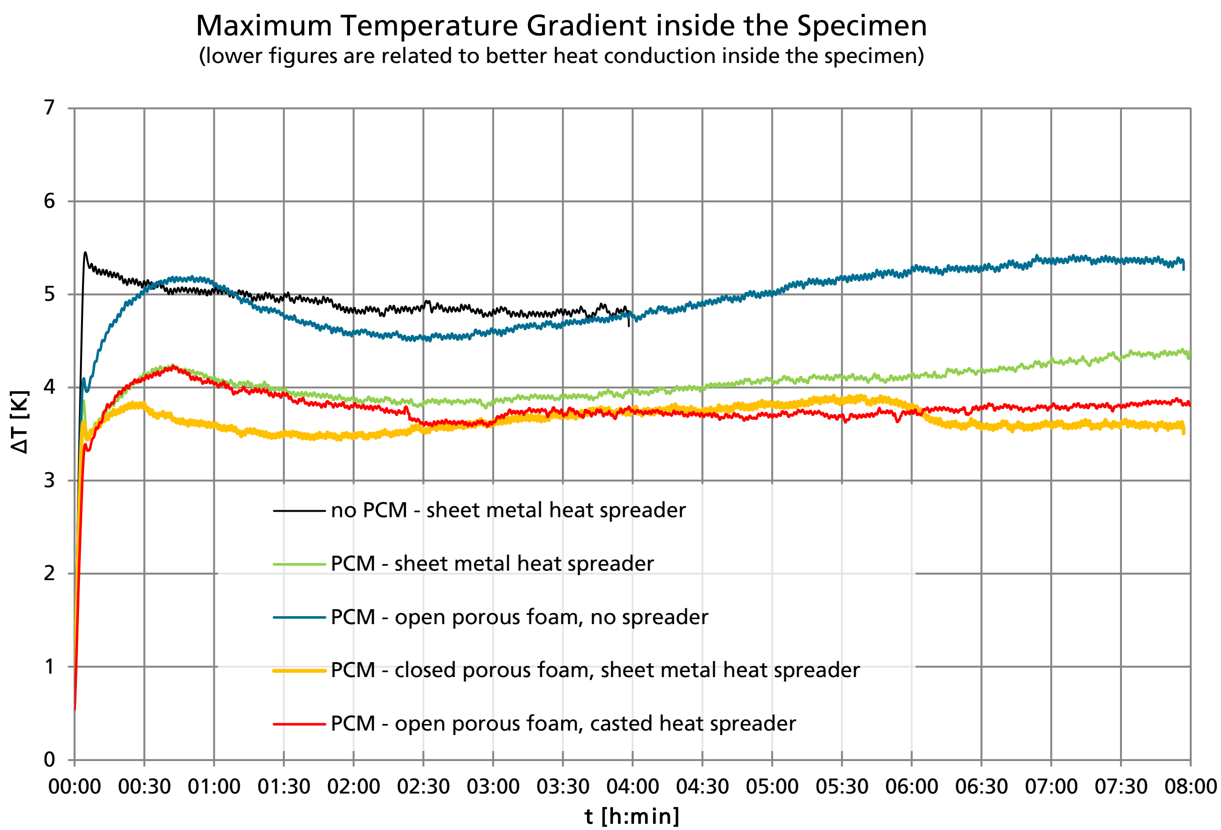
# State of research – demonstrator

- better distribution of heat





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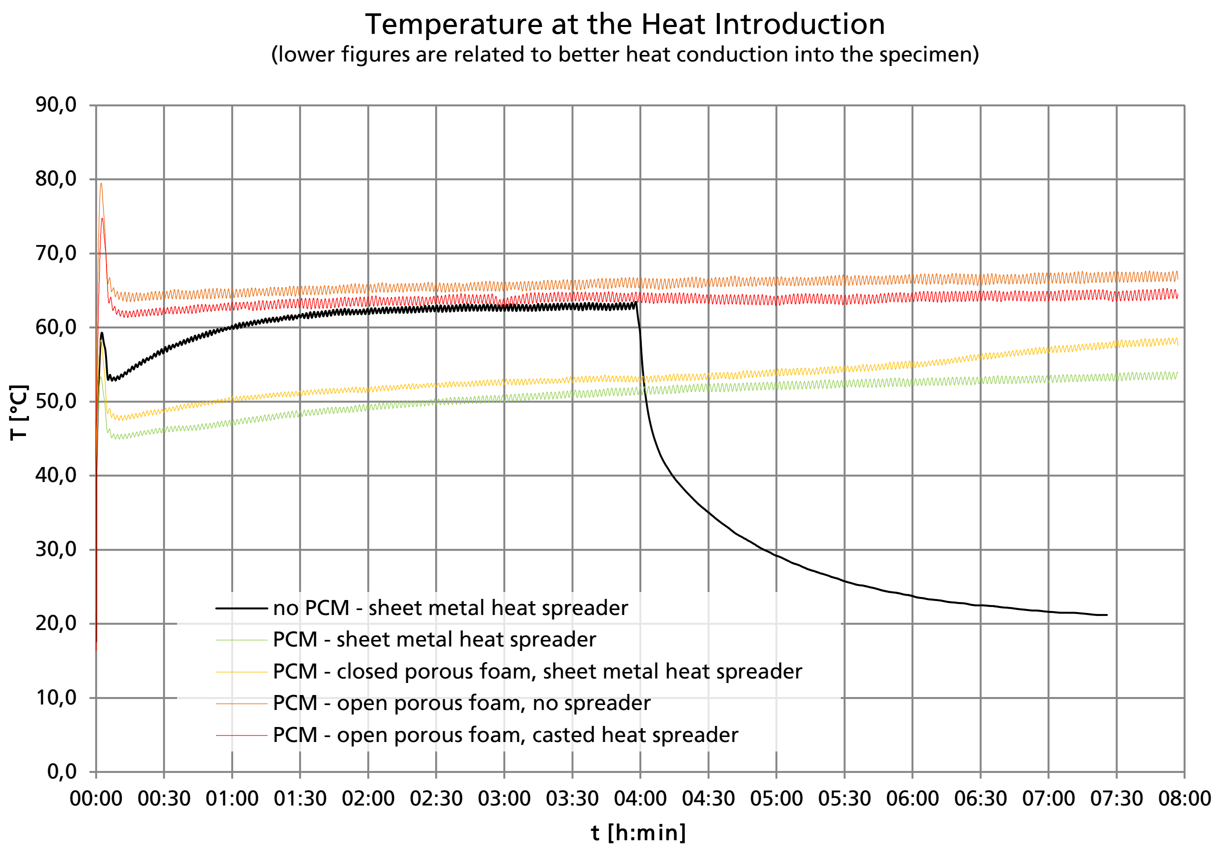
# State of research – demonstrator

- open questions in heat introduction
- material closure is key feature




# Conclusion and future projects

- Conclusion
  - heat distribution by spreader verified
  - functionality proved
  - still a long way to go…

- Future projects and investigations
  - heat spreader and open porous foam casted in one single piece
  - verification of reaction speed till PCM-saturation
  - reproduction of samples for reproducibility
  - shape adaption to battery housing or other structural geometry

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# Conclusion and future projects

- Function-integrated battery housing

OPEN HYBRID LABFACTORY
Der LeichtbauCampus.

consuming of crash energy

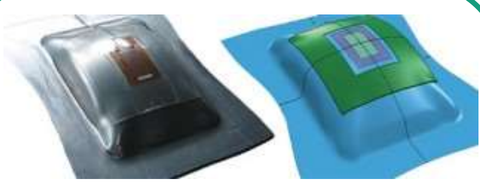
Intrusion protection

**PCM – Metal – Compound**

- high heat storage capacity
- very good heat conduction into the storage material

Homogenisation of thermal load peaks for battery protection

Buffering of thermal E and release if needed



**Sensor and actuator**

- Application of SME
- Integration of sensors in FRP and metal components
- structure monitoring


**FRP-Metal-Hybrid FKV-Metall-Hybrid underbody structure**

- Use of pultruded profiles
- Press hardening of metal components
  - Crash safety

1) Quelle: elektronik-zeit.de





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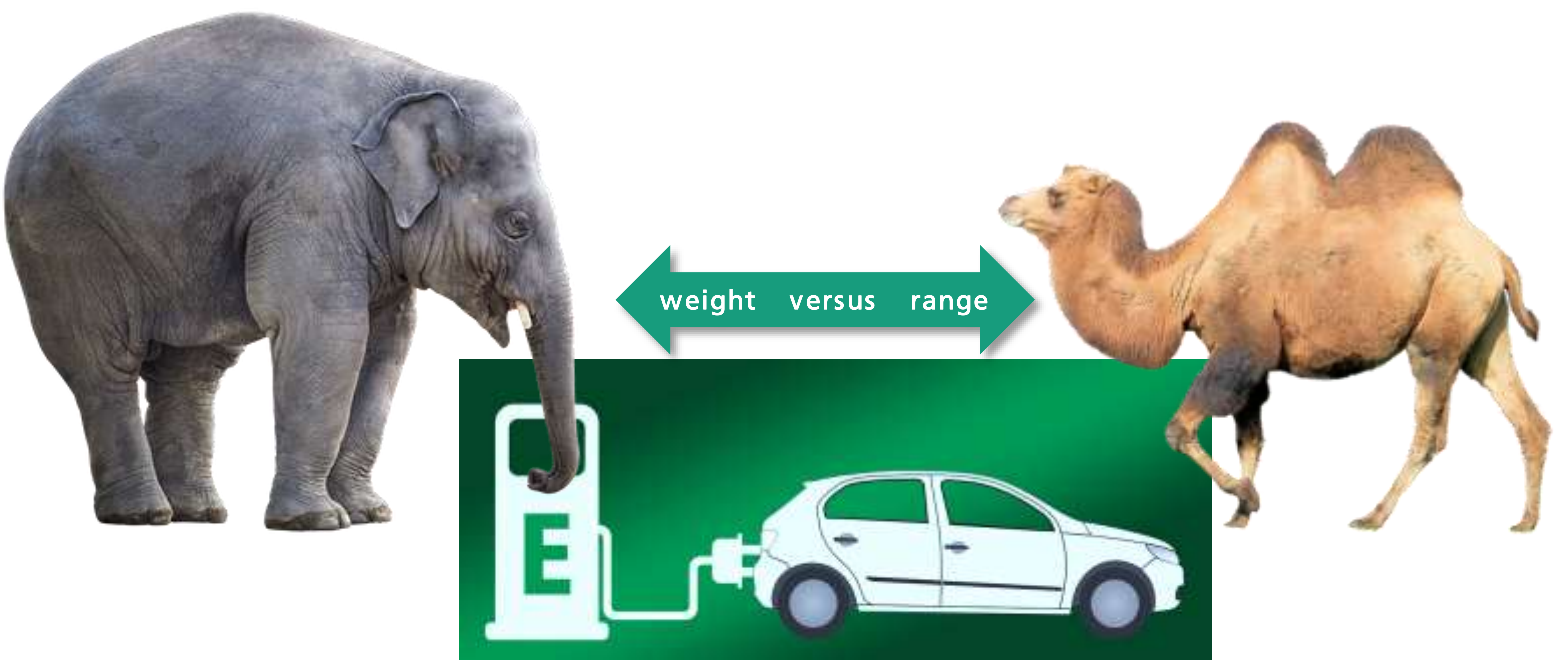
# Conclusion and future projects

- Combination of metal foam and PCM in automotive application
  - research on more efficient PCM needed
  - efficiency of all components must be increased
  - partners for further development needed





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