Intelligent Materials in Modern Production – Current Trends for Thermal Shape Memory Alloys

Dr. Joachim Strittmatter
M. Eng. Marc Hiefer
Prof. Dr. Paul Gümpel

WITg I Konstanzerstrasse 19 I CH-8274 Tägerwilen I Phone +41 (0) 71 666 4208 I www.witg.ch I info@witg.ch
WIK | Alfred-Wachtel-Strasse 8 | D-78462 Konstanz | Phone +49 (0) 7531 206 313 | www.wik.htwg-konstanz.de

Intelligent materials in modern production – Current trends for thermal SMAs

Outline

Short introduction to thermal shape memory alloys (SMAs)

- Effects
- Properties

Overview of possible applications

- Medical area
- Civil engineering
- Automotive area
- Aerospace and aviation
- Power engineering
- Automation and robotic area

New possibilities by using additive manufacturing

Summary

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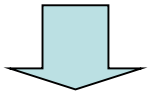
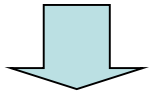
Shape memory effect is based on a martensitic phase change

Material will change the shape by temperature changing



Actuator

Material change the proprieties during temperature and deformation changings



Sensor

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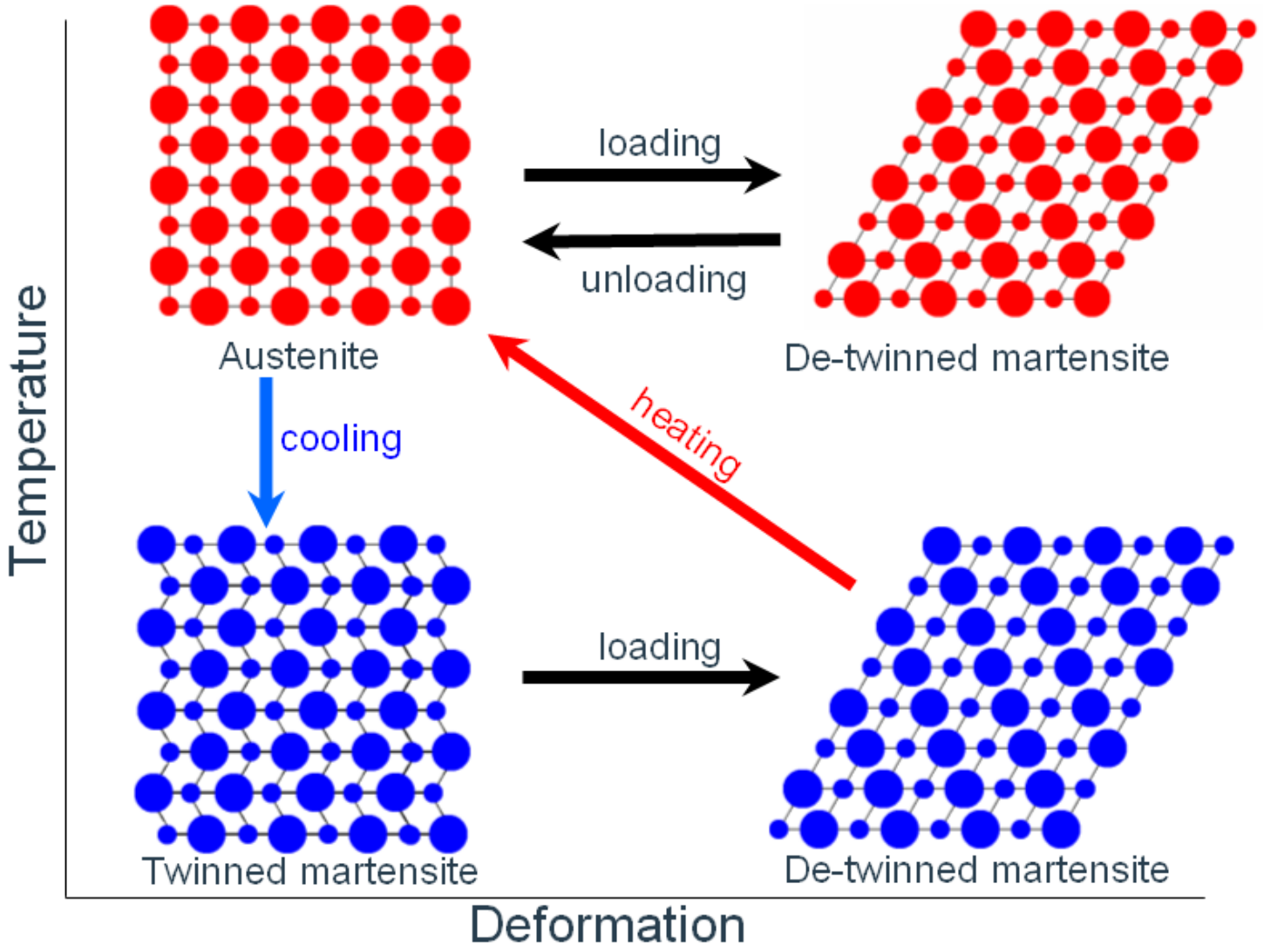

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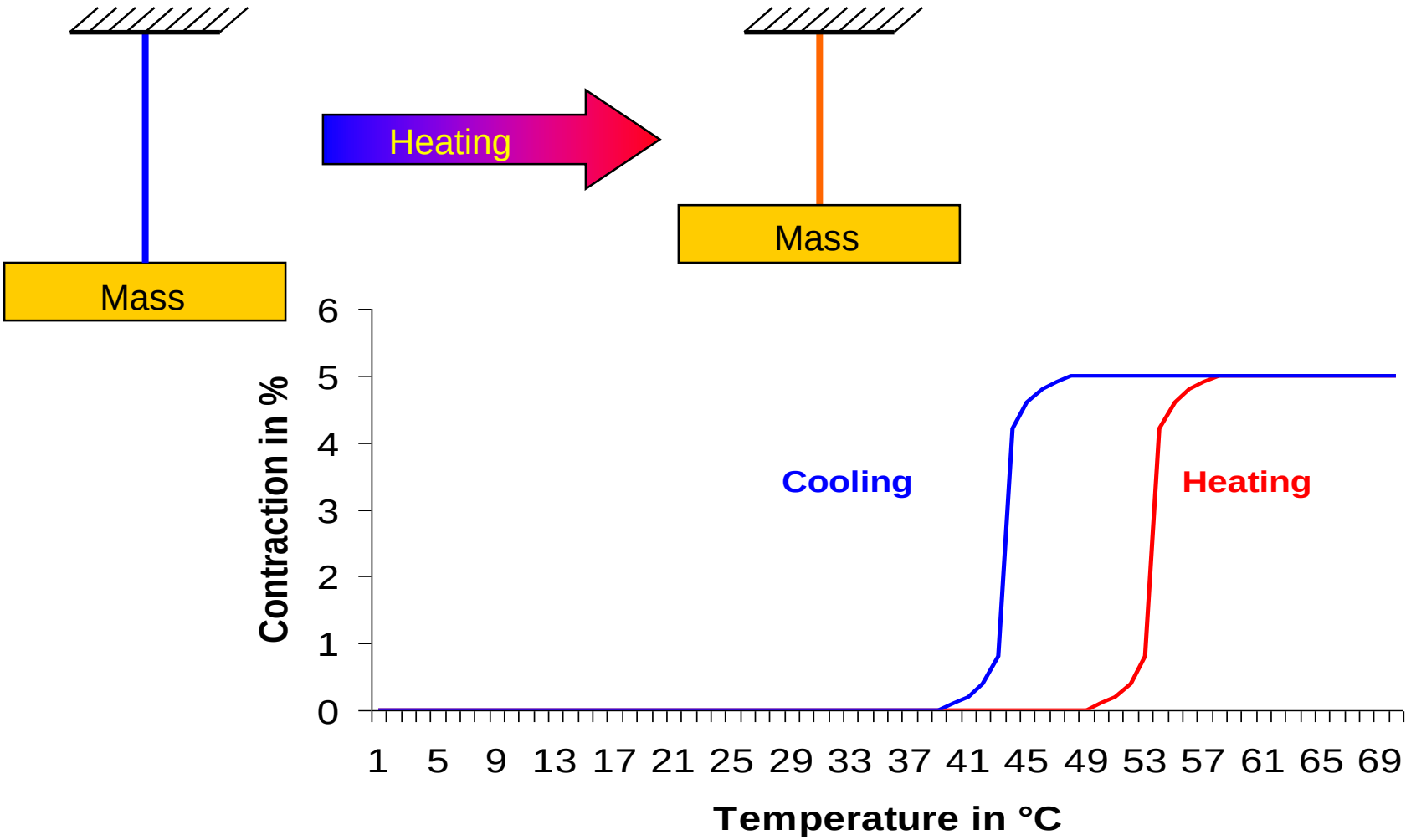
Principle of a thermal shape memory actuator



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Characteristic values of NiTi SMA

	NiTi	unit
One way shape memory effect (OWSME),max	8	%
Two way shape memory effect (TWSME),max	3,2	%
Phase change temperatures	-200 … +110	°C
Temperature hysteresis	30 … 80	K
Overheatable up to	400	°C
Thermal conductivity, martensite	9 … 10	W/mK
Thermal conductivity, austenite	18	W/mK
Linear thermal expansion coefficient,martensite	6,6	10^{-6} 1/K
Linear thermal expansion coefficient, austenite	11	10^{-6} 1/K
Specific electrical resistance	0,5 … 1,1	10^{-6} Ωm
Density	6,45	103 kg/m^3
Ultimate tensile strength, martensite	700 … 1100	N/mm^2
Ultimate tensile strength, austenite	800 … 1500	N/mm^2
Number of achievable thermal cycles	≥100 000	
Corrosion resistance	excellent	
Biocompatibility	excellent	

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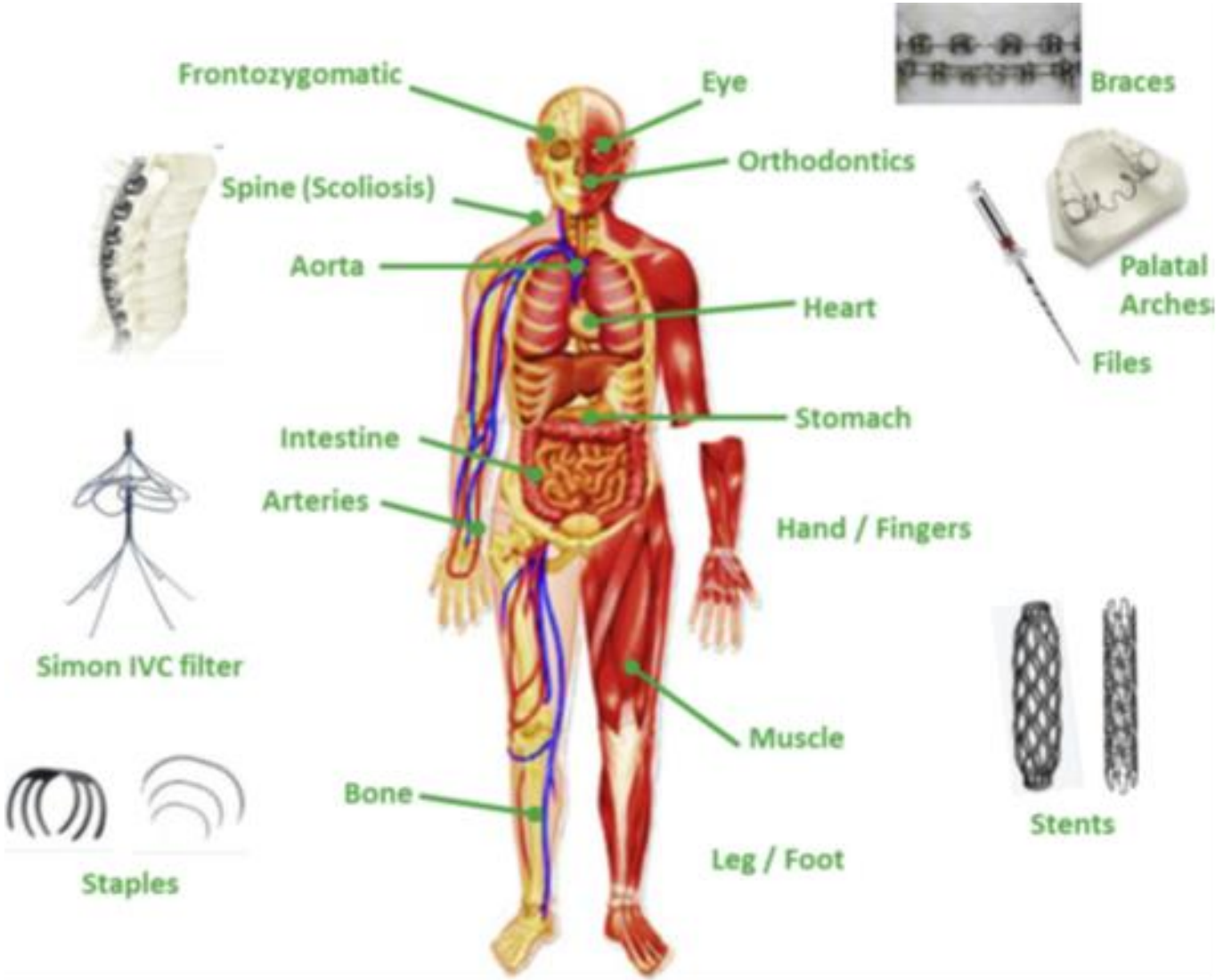
Overview of possible applications

Existing and potential applications in the medical area



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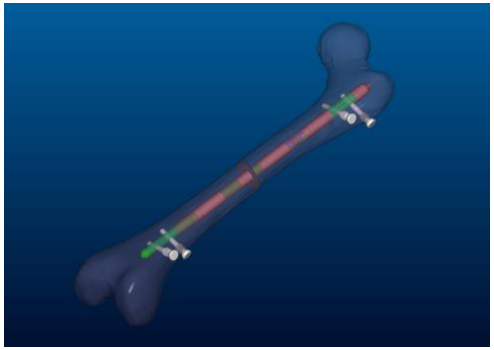
Overview of possible applications

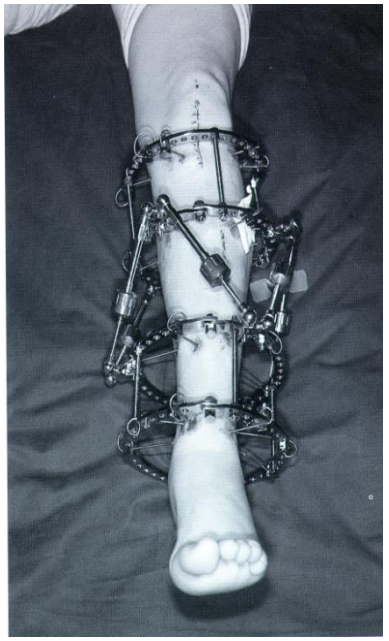
SMALL – Shape Memory Alloy Limb Lengthening Nail

Advantages

- Linear Movement
- Simple mechanical principle
- Small number of moving parts
- No rotating parts
- Maintaining of the intramedullary tube
- Reduced risk of infections
- Cosmetically good result
- Short hospital stages
- Creation of “own” new bone material
- Possible miniaturization thanks to high power density of SM elements



Internal SMALL



External fixator (Ilisarov)

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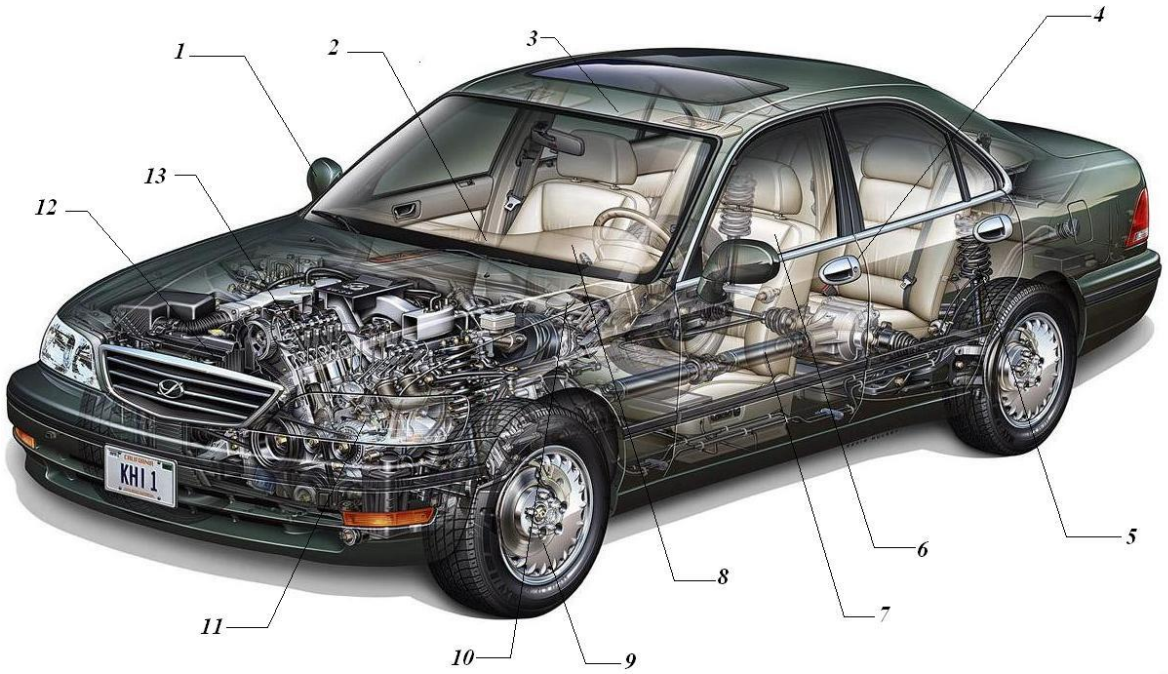
Overview of possible applications

Existing and potential applications in the automotive area



1 Mirorr settings
2 Dashboard actuators
3 Settings
4 Door lock
5 Suspension system
6 Cushion and headrest adjustment
7 Automatic gear
8 Switch on the dashboard
9 Cooling the brakes
10 Wiper contact pressure
11 Light ajusting
12 Switchable radiator cover
13 Engine valves
… Fog lamp protection
… Glove box releasing device
… Hatchback releasing device
… Load limiter

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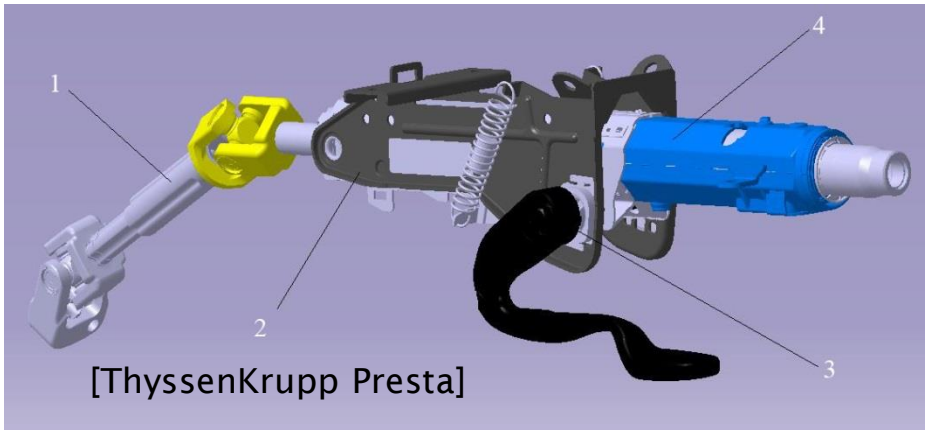
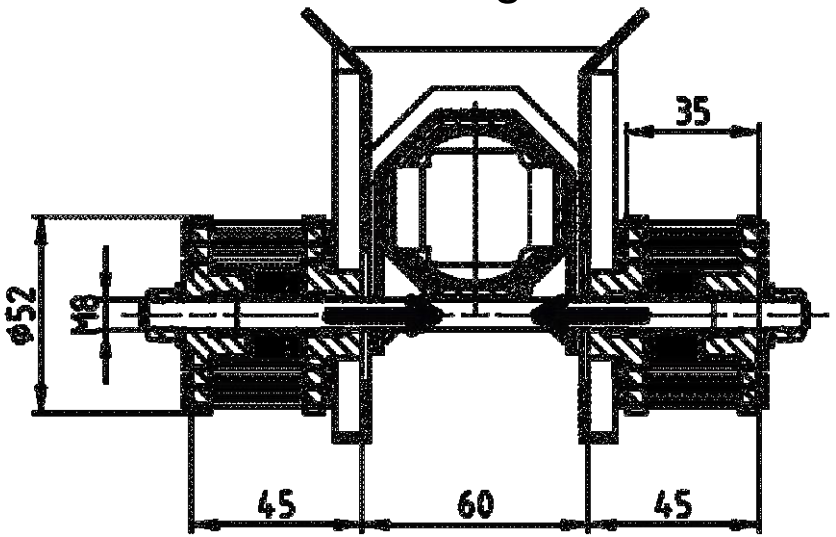
Overview of possible applications

Some own developments in the automotive area



Intelligent clamping system for automotive steering columns



Quick changing shape memory actuators for adaptive automotive safety systems

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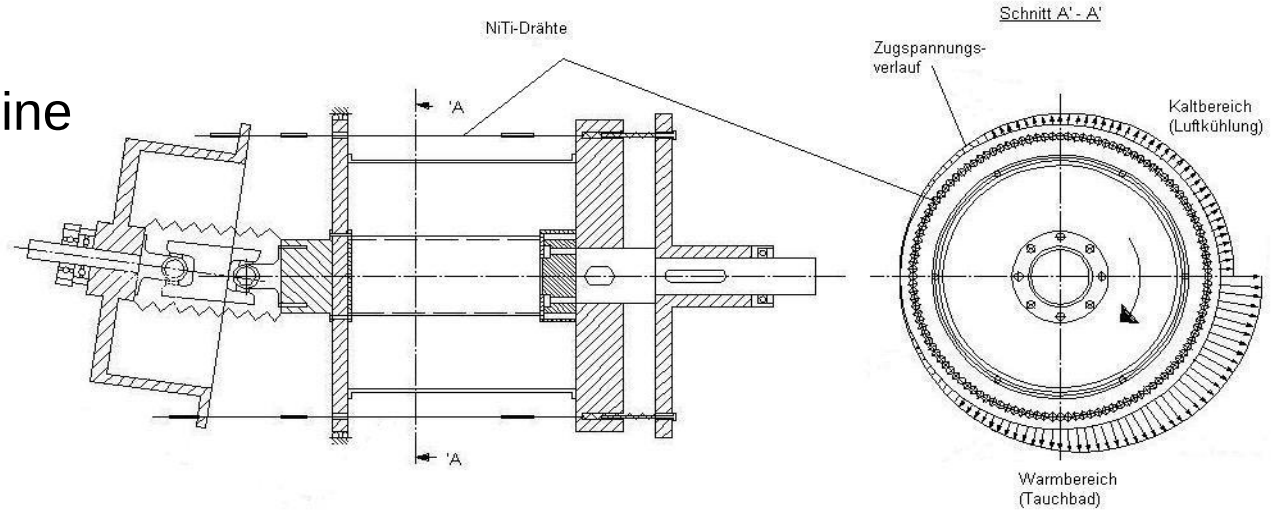
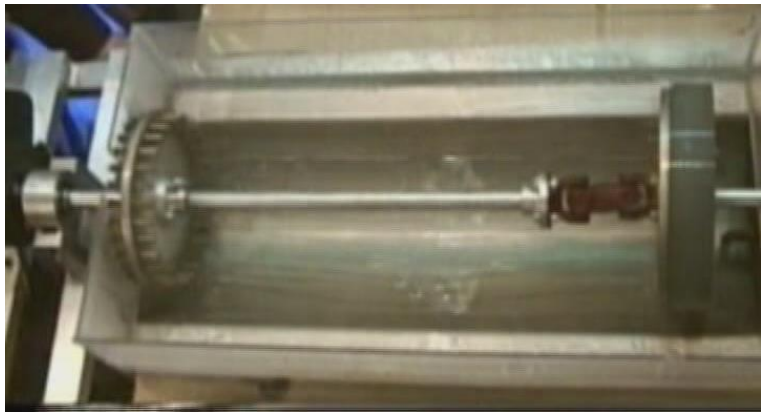
Overview of possible applications

Some own developments in the power engineering area

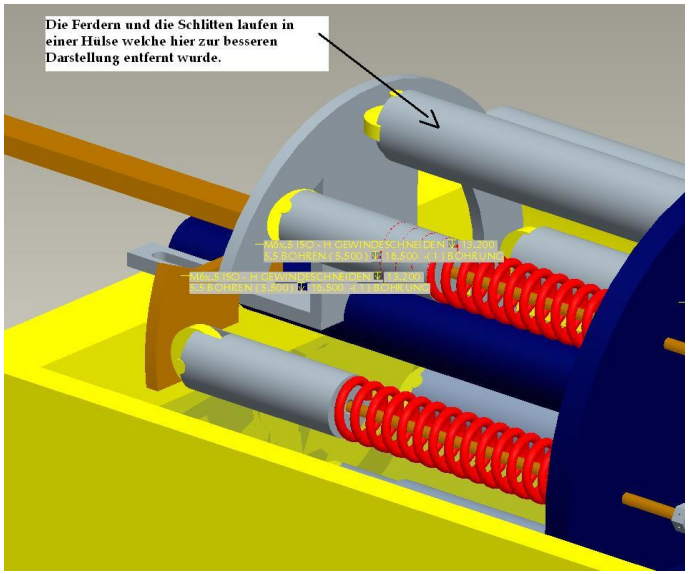
Tilt plate heat engine for energy conversion in the low temperature range





Demonstrator model

Efficiency increase by using revolving energy storage



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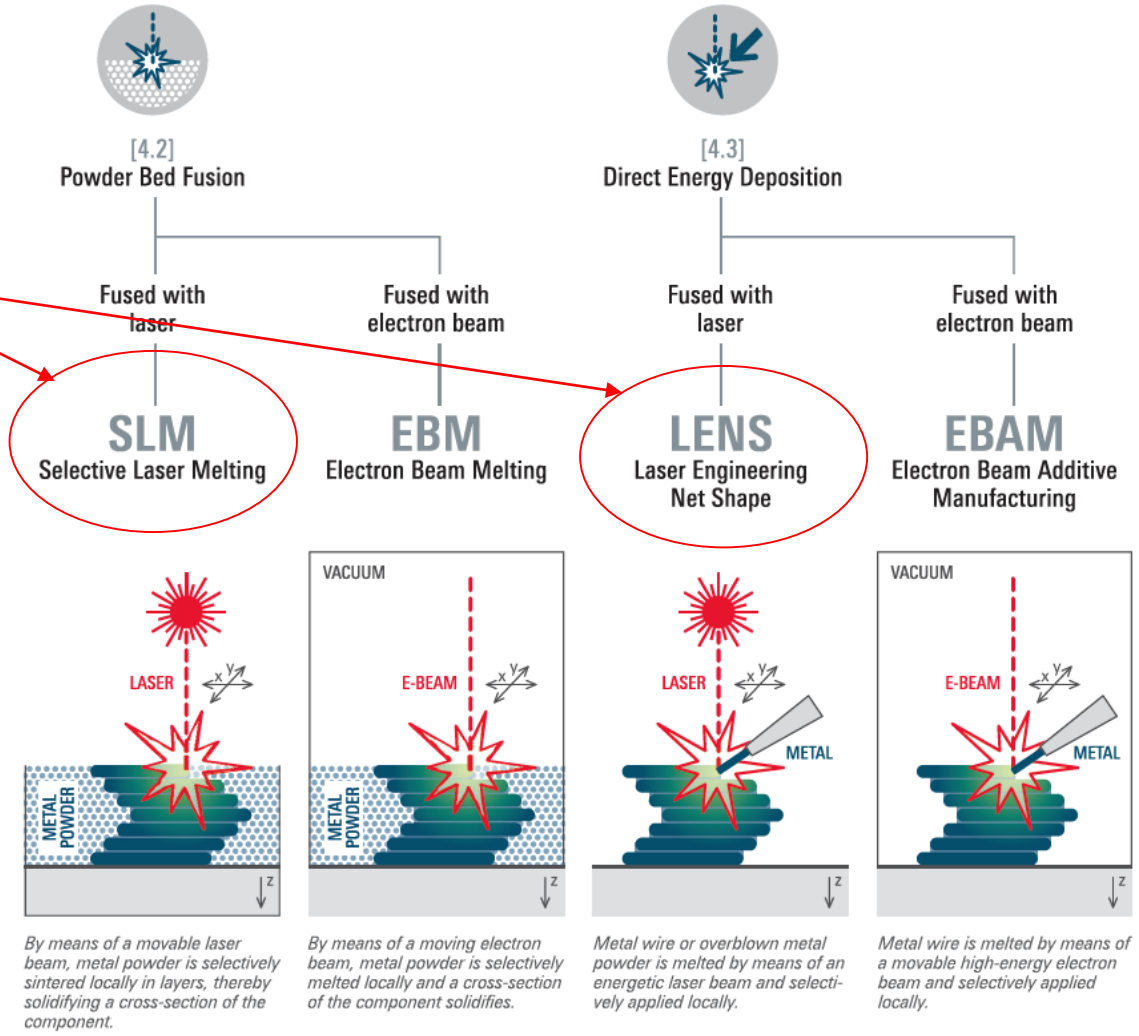
New possibilities by using AM

Overview of production possibilities by Additive Manufacturing

Most used production technologies for NiTi:



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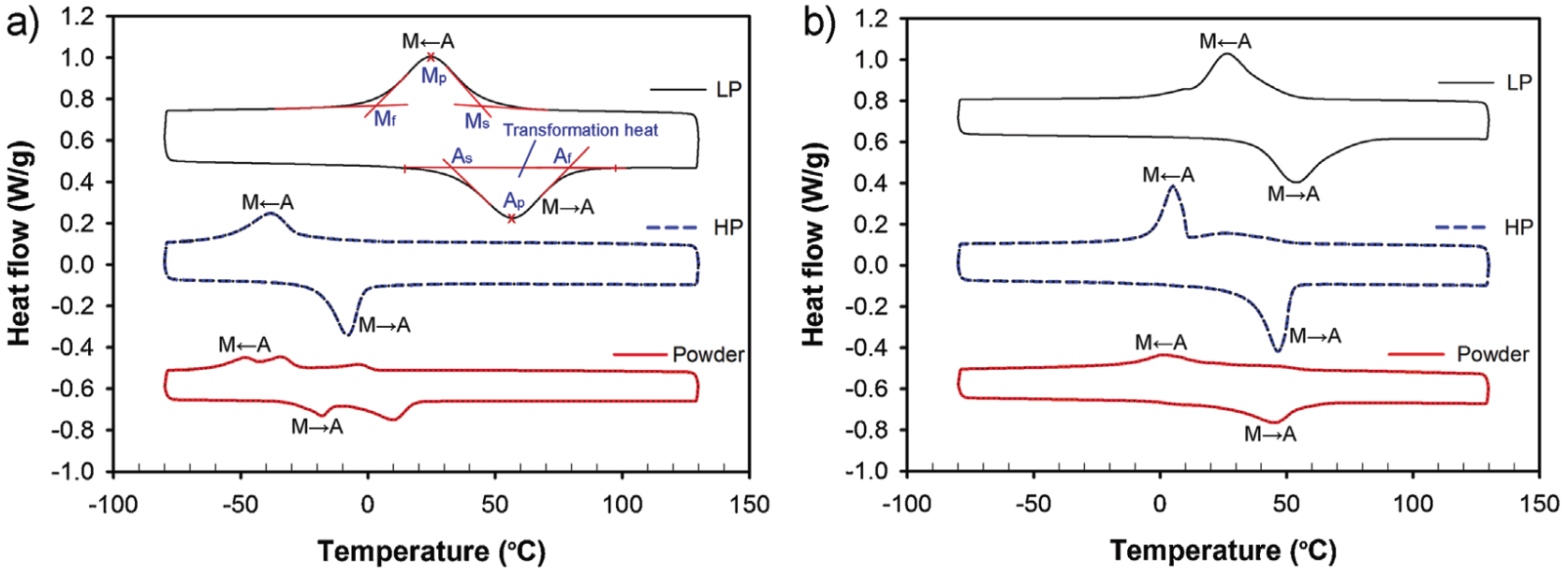
New possibilities by using AM

Influence of manufacturing parameters on shape memory properties

	Laser power [W]	Scanning velocity [mm/s]	Hatch spacing [µm]	Energy density [J/mm³]
LP	40	160	75	111
HP	250	1100	60	126

- 2 sets of laser parameters
- before (a) and after (b) annealing (830 °C for 25 min)



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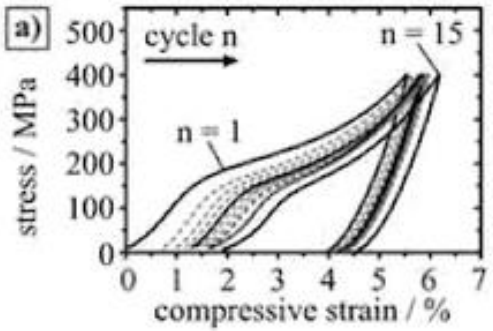
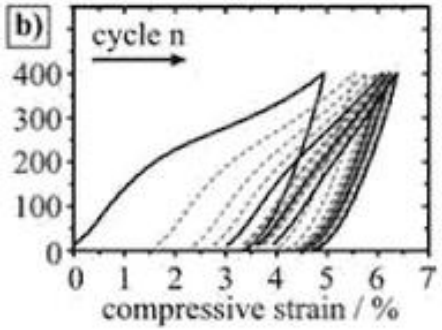
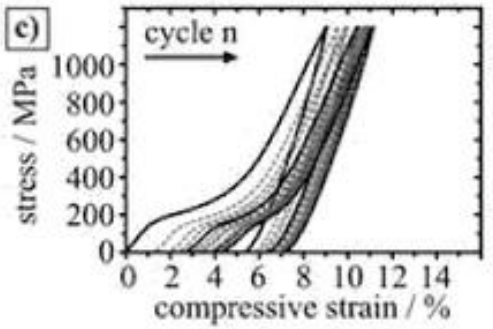
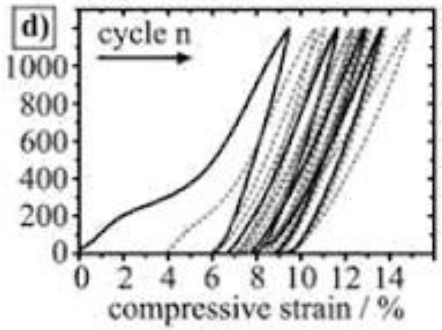
New possibilities by using AM

Comparison between SLM NiTi and conventional NiTi

	SLM NiTi	Conventional NiTi
400 MPa		
1200 MPa		

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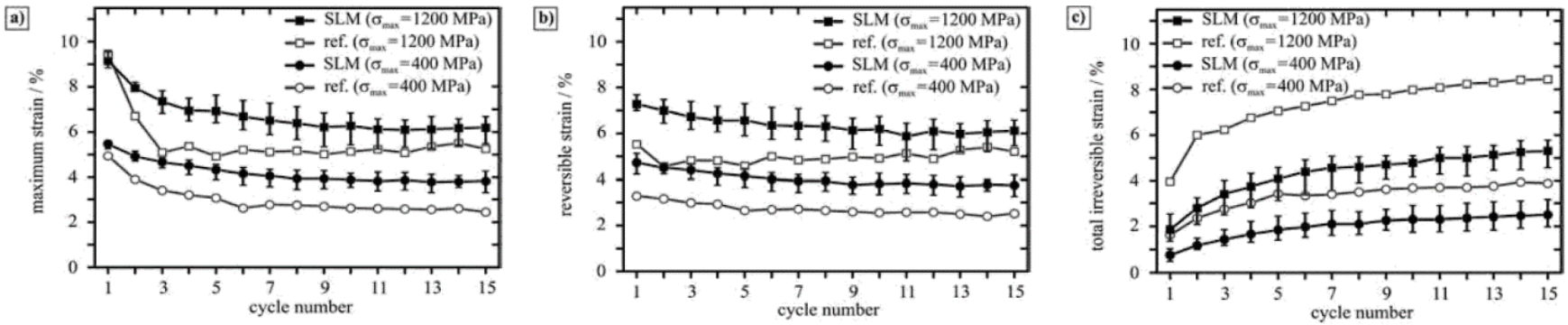
New possibilities by using AM

Comparison of functional properties of SLM produced NiTi sampels versus conventionally produced NiTi sampels



Result:

SLM NiTi samples show

- better cyclic stability
- higher level for max. strain
- higher level for reversible strain
- lower level for total irreversible strain

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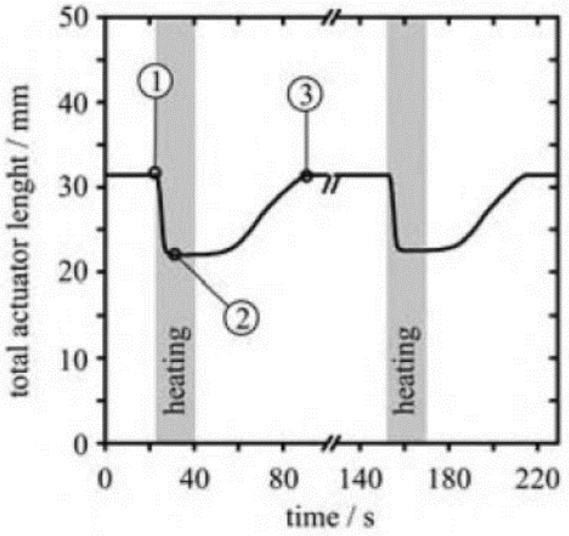
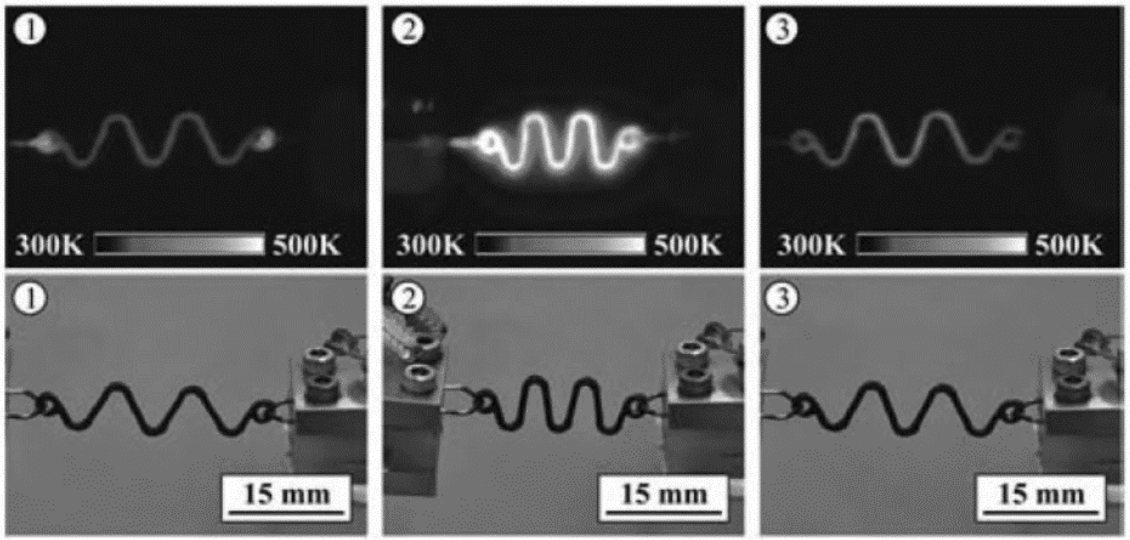
New possibilities by using AM

Potential for additive manufactured parts

The meandering actuator manufactured with SLM method demonstrates in an impressing way the possibility to create complex functional parts





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Summary

- Thermal Shape Memory Alloys can be used as actuators, dampers and sensors
- In almost every field
- Higest number of important products in the market can be found in the medical, aeronautic and robotic area
- Additive Manufacturing like SLM and LENS will push the further commercialization
  - Small series production
  - Manufacturing of components with equal and even better functional properties are possible
- New standardization directives will also push the further commercialization

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Thank You for your attention!

Questions?

Dr.-Ing. Joachim Strittmatter

Institute for Material Systems Technology
Konstanz at the Hochschule Konstanz (WIK)
Faculty of Mechanical Engineering
Brauneggerstraße 55
D-78462 Konstanz
Tel. 07531 206-317
Fax 07531 206-448
joachim.strittmatter@htwg-konstanz.de
https://www.wik.htwg-konstanz.de

Institute for Material Systems Technology
Thurgau at the Hochschule Konstanz (WITg)
Smart Materials / Shape Memory Alloys
Konstanzer Strasse 19
CH-8274 Tägerwilen
Tel. 071 666 4208
Fax 071 666 4201
j.strittmatter@witg.ch
http://www.witg.ch