INTELLIGENT MATERIAL SYSTEMS LAB

ZeMA

UNIVERSITÄT DES SAARLANDES

Integration von smarten Materialien in Textilien

Perspektiven für intelligente Datenauswertung und Ansteuerung

Sebastian Gratz-Kelly

Intelligent Material Systems Lab (iMSL)
Saarland University, Saarbrücken, Germany

06.12.2023

Zentrum für Mechatronik und Automatisierungstechnik – ZeMA gGmbH

- founded 2009
- ca. 120 employees
- ca. 100 cooperation partners

Gesellschafter

Forschungsbereiche

Smarte Materialsysteme

Data Engineering & Smarte Sensorik

Montagesysteme

Fertigungssysteme

Industrial Security

Biomechatronische Systeme

iMSL – intelligent material systems lab

Prof. Dr.-Ing. Stefan Seelecke

PhD, Engineering Science, TU Berlin, 1995

- Habilitation, TU Berlin, Thermodynamics, 1999
- Associate Professor, Dept. Mech. & Aero. Eng., North Carolina State University, 2001-2010
- Professor, Mechatronics, Saarland University, since 2011
- Material Science & Engineering, since 2015

Research Team

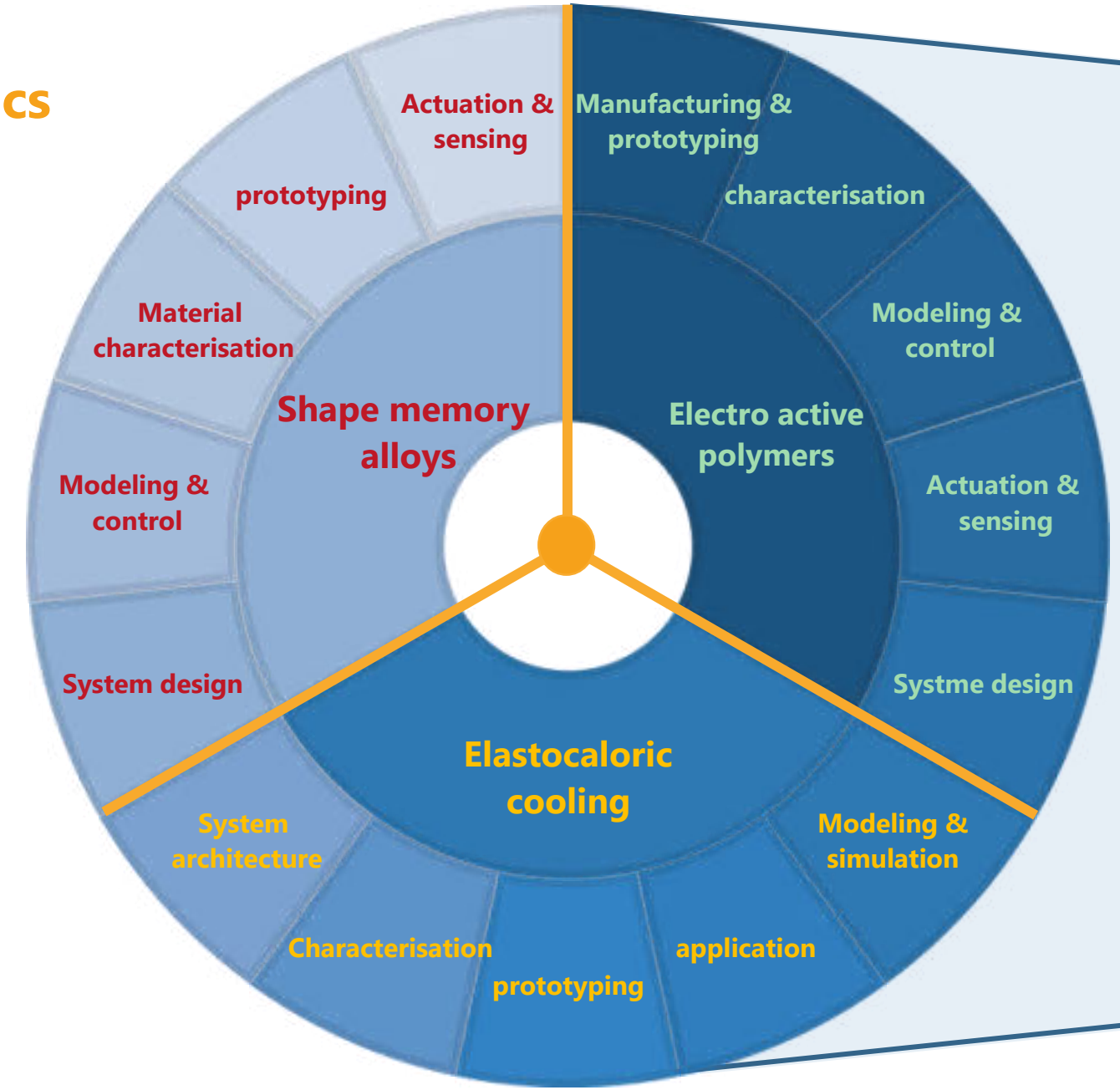
- 2 cooperative Chairs (Prof. Motzki, Jun. Prof. Rizzello)
- 1 Postdoc
- 27 PhD students
- 3 research employees
- 16 research assistants
- 6 Master/Bachelor students
- 5 Technicians
- 2 Administrative assistant

Main research topics:

Electro active Polymers and **Shape Memory Alloys**:

- Materials characterization
- Production of Dielectric Elastomers (DE)
- Improvement material and characteristic
- Model development for system design & control
- System and application development

Research topics



Electronic development

Smart fluidics

Software development

Smart textiles

AI methods

Hybrid systems

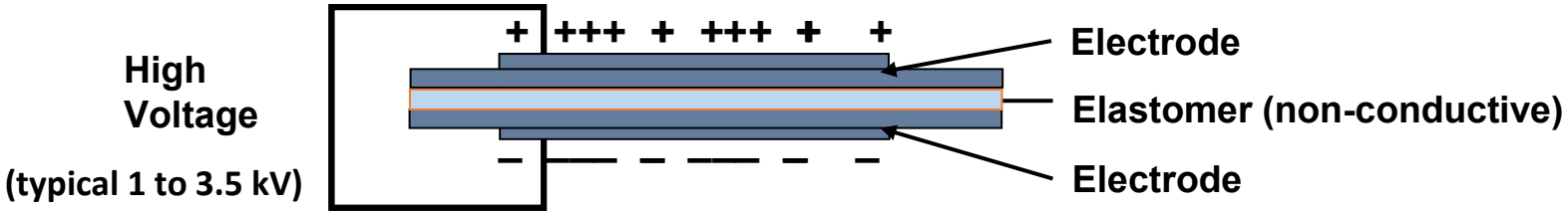
Multi-functional systems

Bionics

medicine

Working principles

DE working principle

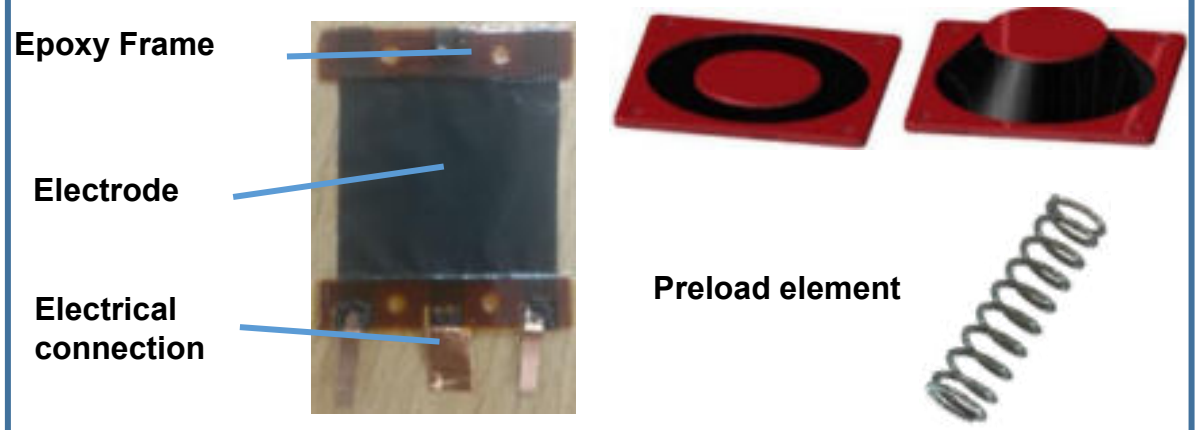


$$p = \varepsilon_0 \varepsilon_r E^2$$

Thickness compression

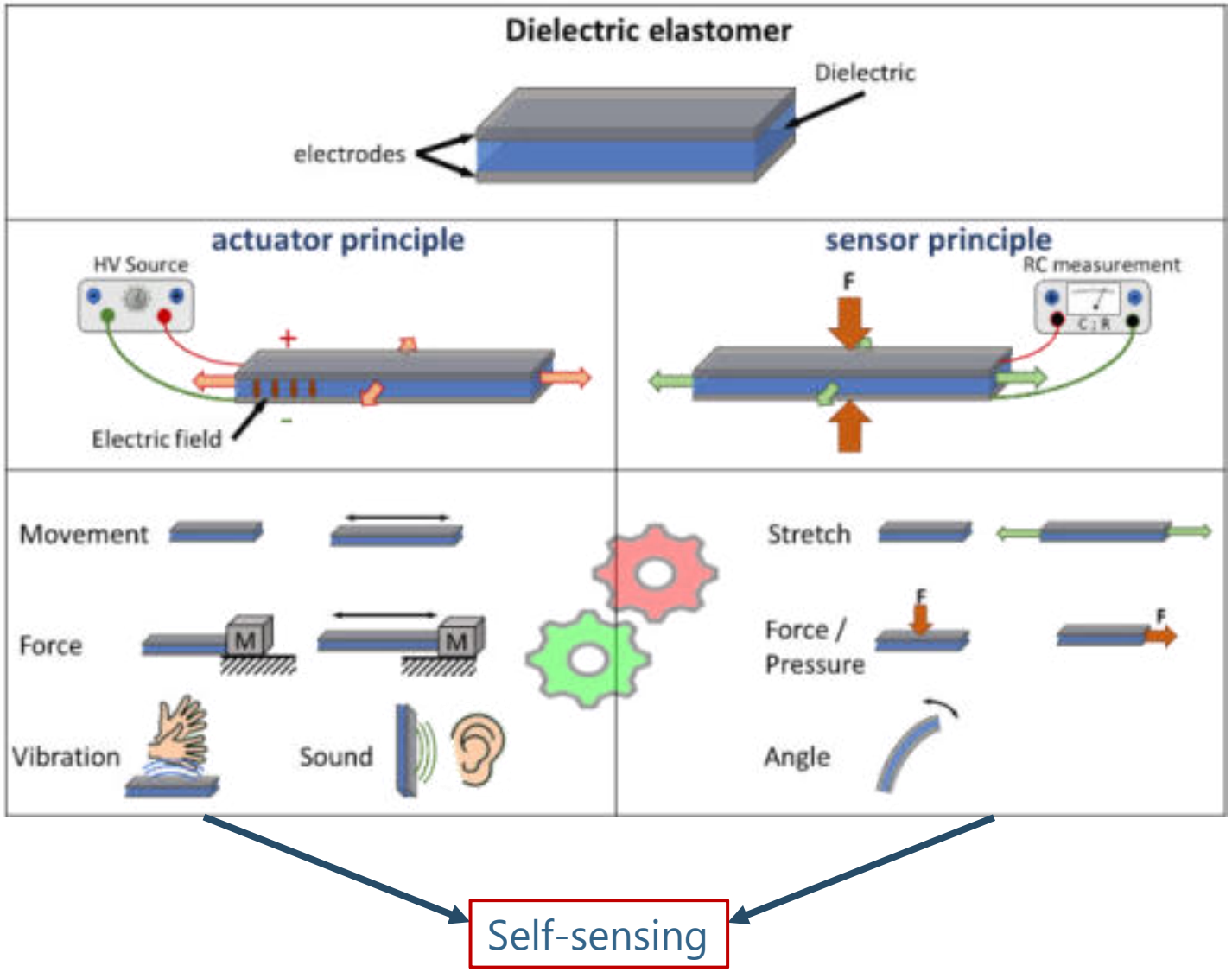
Source: www.ct-systems.ch/index.php/products

Area expansion

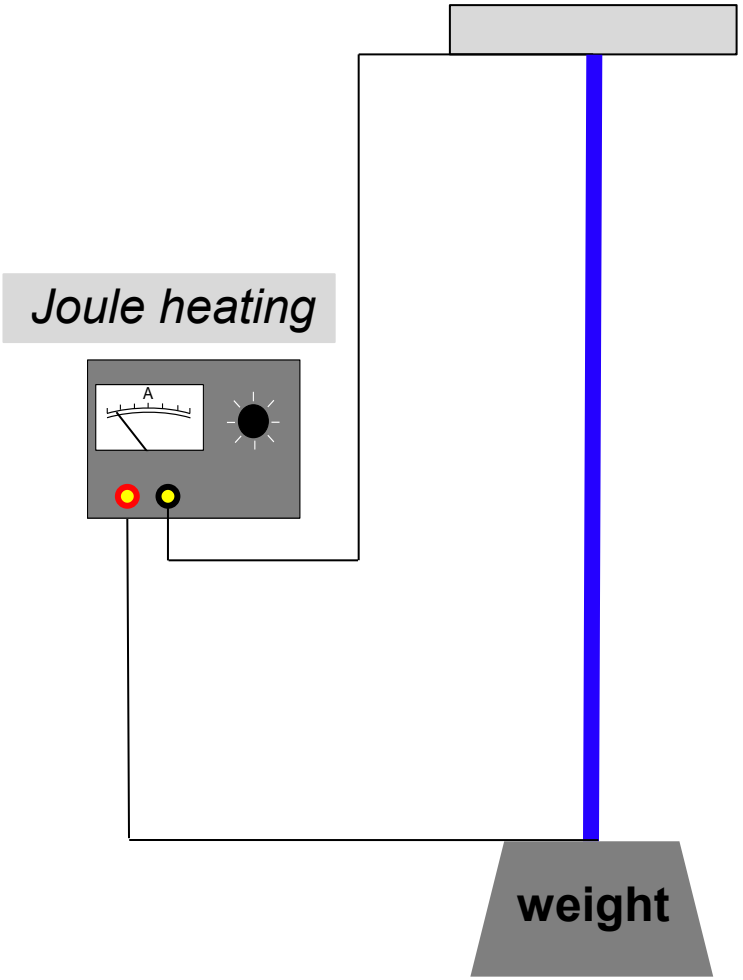


DE working principle

- Thin silicone membrane
- Two compliant electrodes
- Actuator characteristics
- Sensor characteristics
- Combination with self-sensing
- Low power consumption



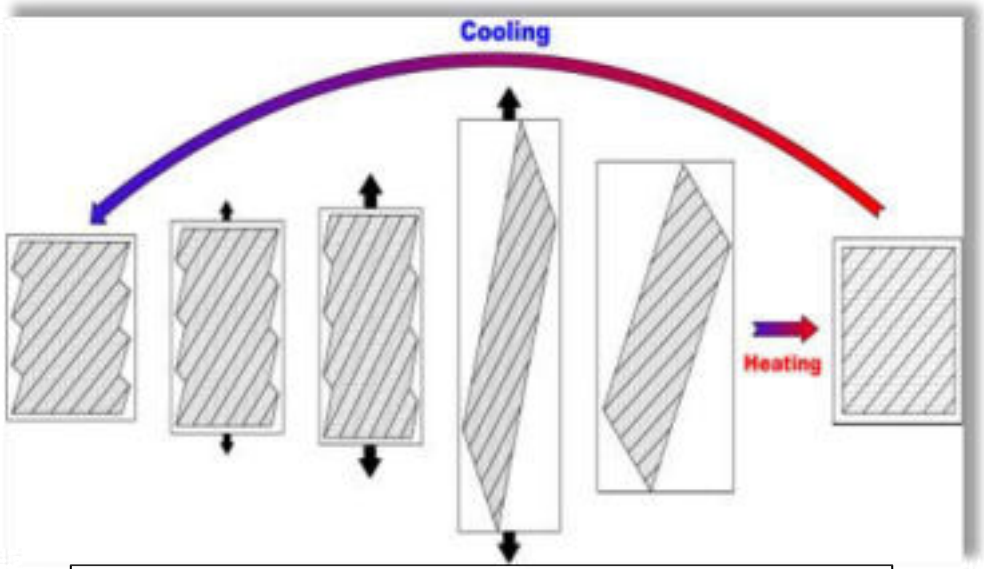
Shape memory alloy working principle



Shape Memory Alloys (SMA)

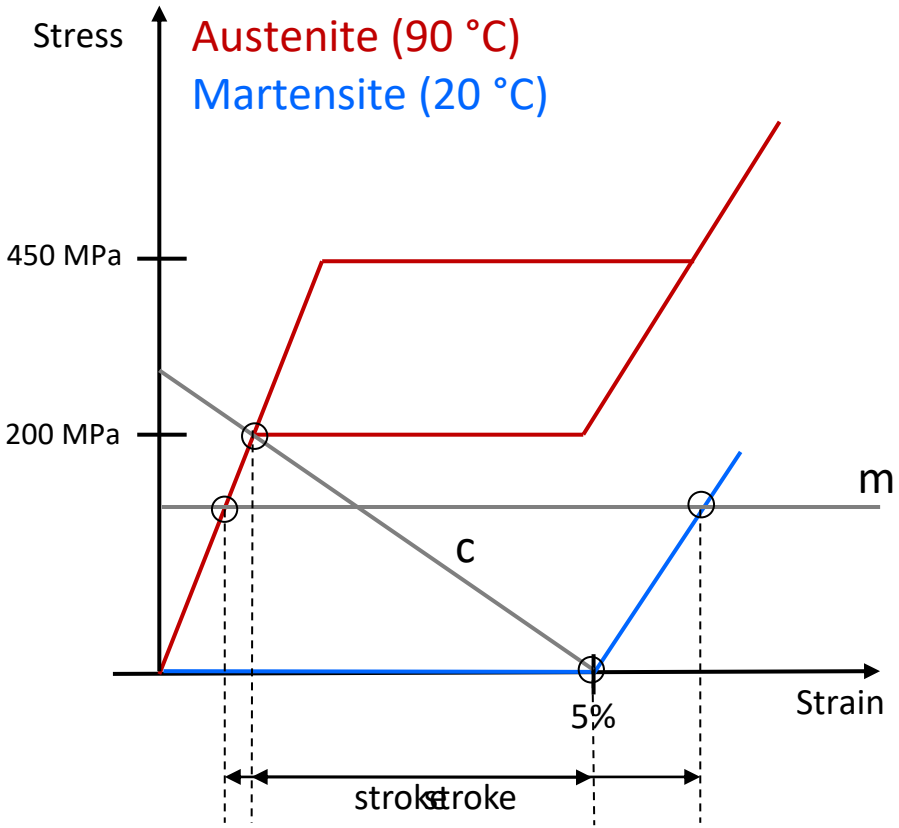
- *Nickel- Titanium (NiTi)*

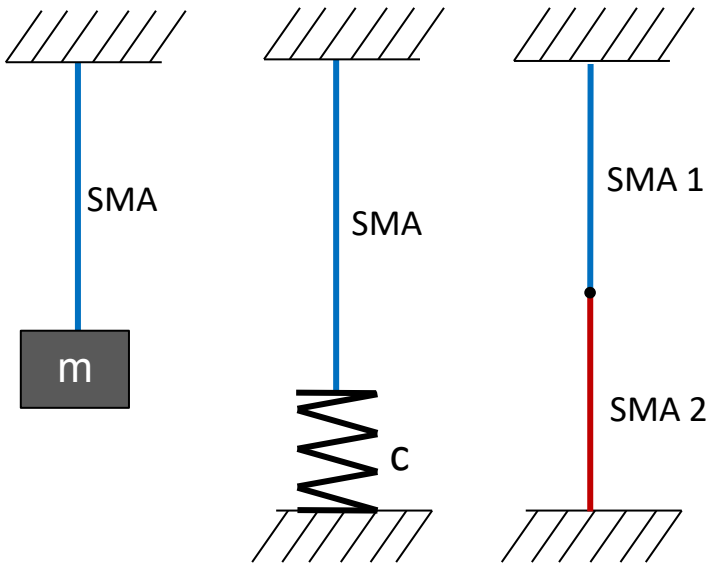
- *SMA* wires – *metal muscles activated by electric power*

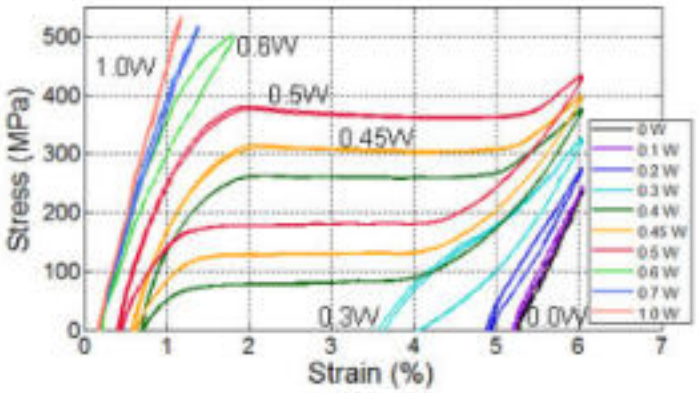


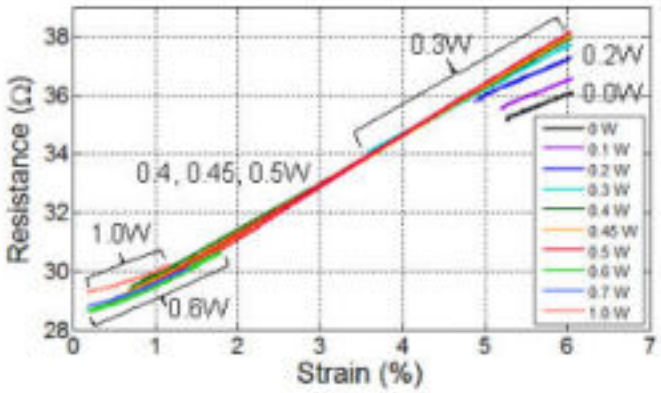
<u>Reversible Phase Transformation</u>
from Martensite (low temperature)
to Austenite (high temperature)
during a heating and cooling period

Shape memory alloy actuator



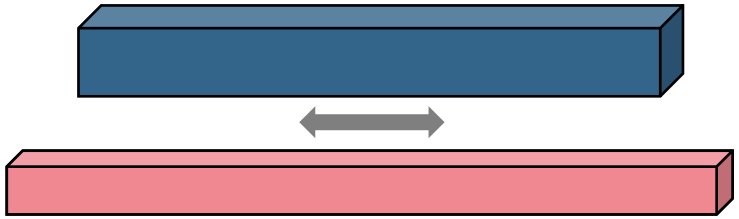


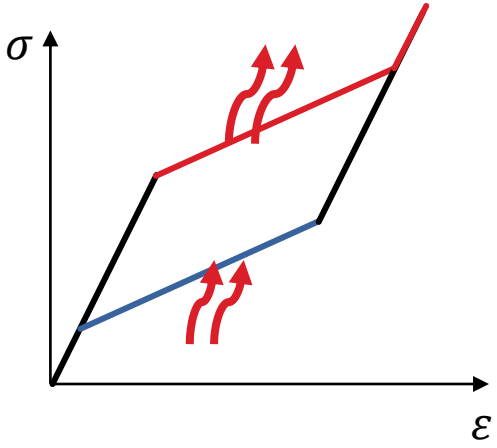


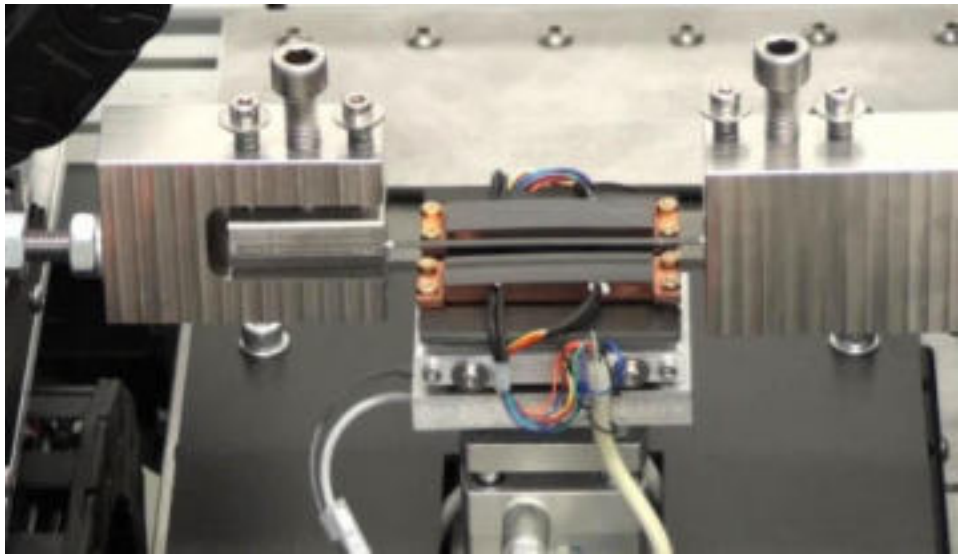


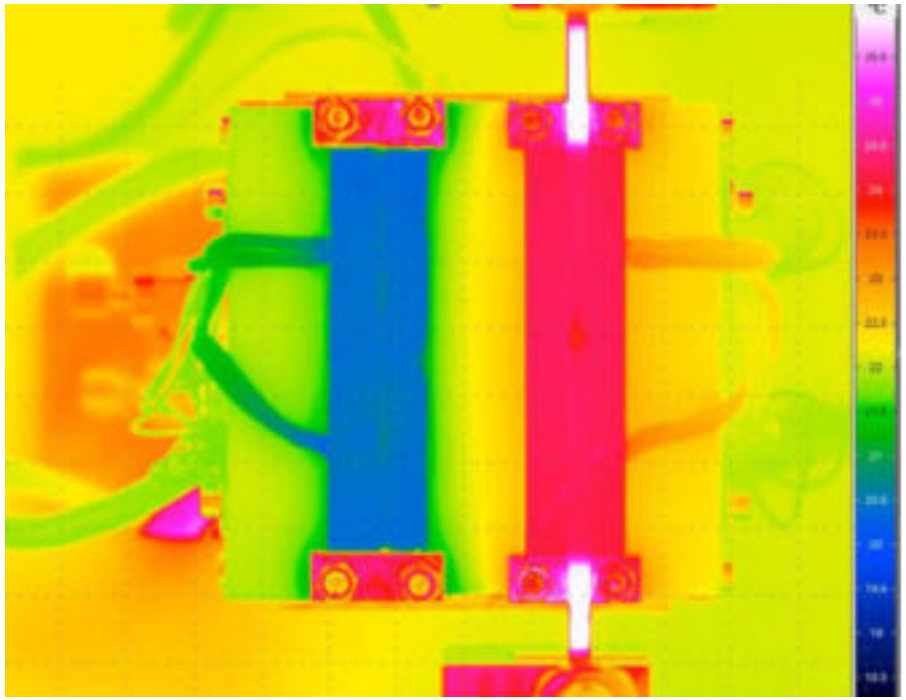
Shape memory alloy elasocaloric cooling

- Latent heats of the phase transformation lead to a temperature change of the NiTi element
- Heat transfer at different temperature levels





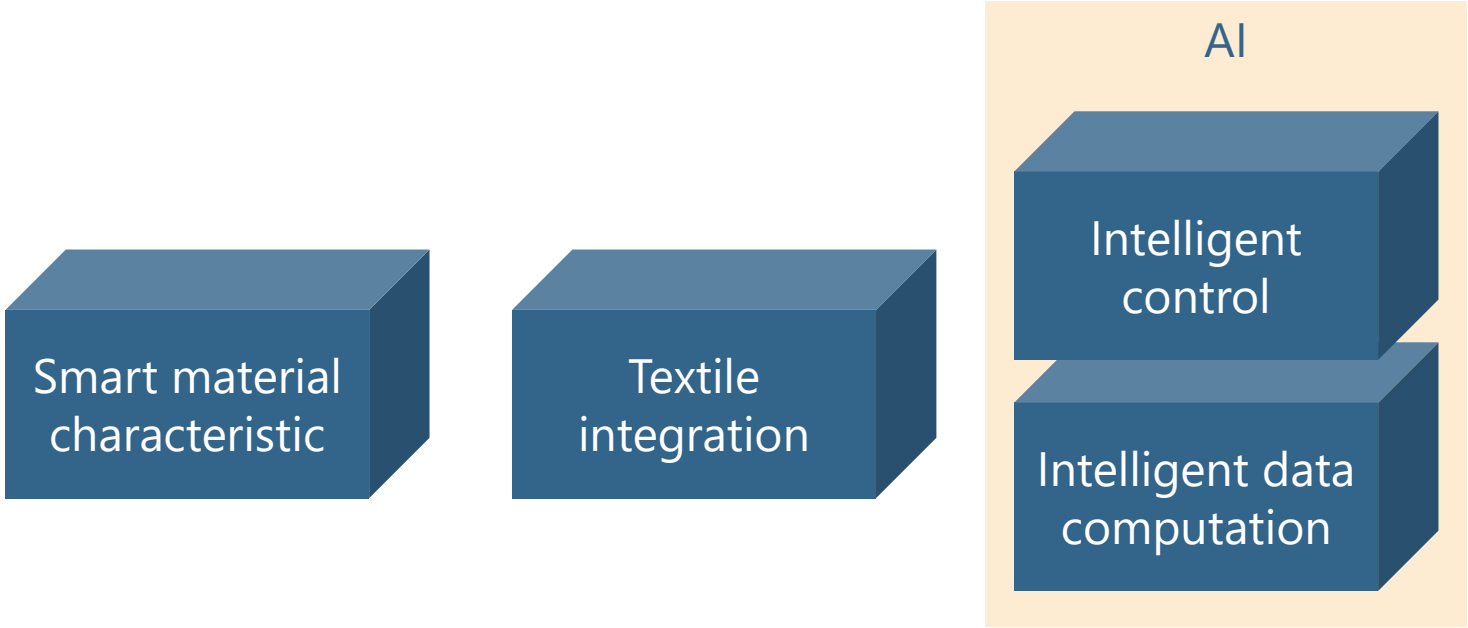




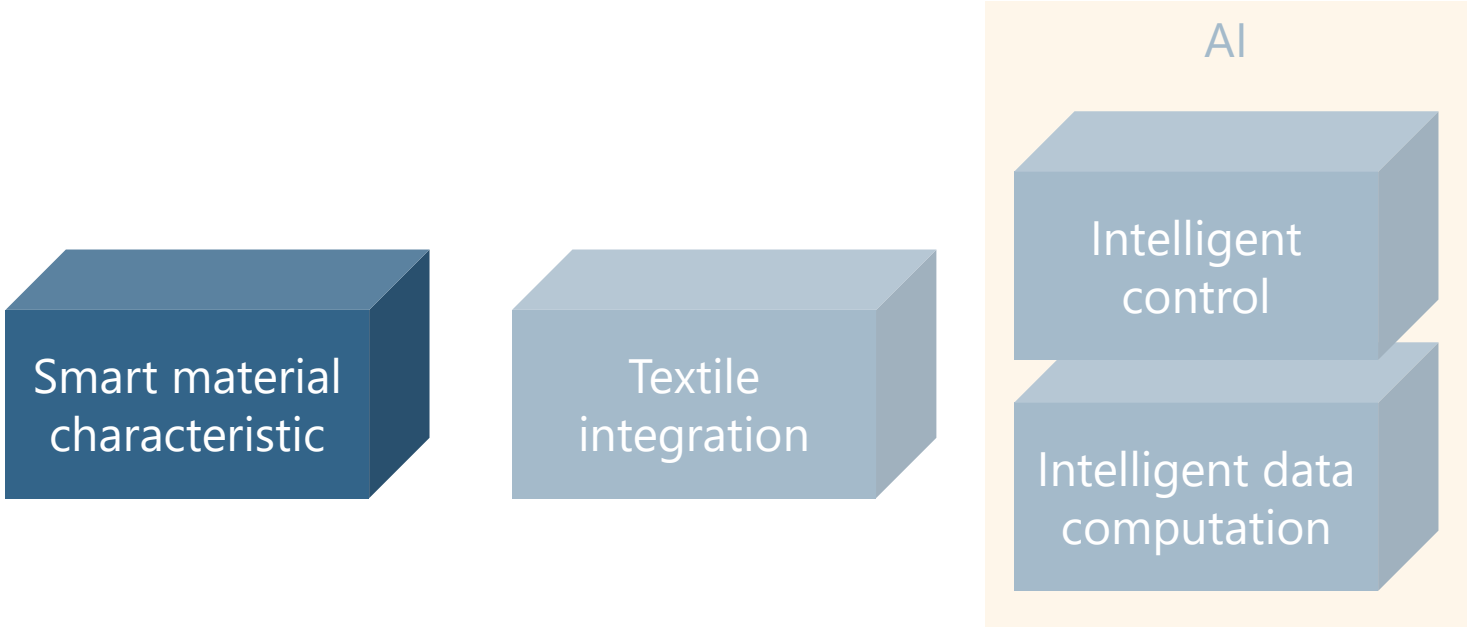
Working principles

Textile integration

Smart materials integrated in smart textiles



Smart materials integrated in smart textiles



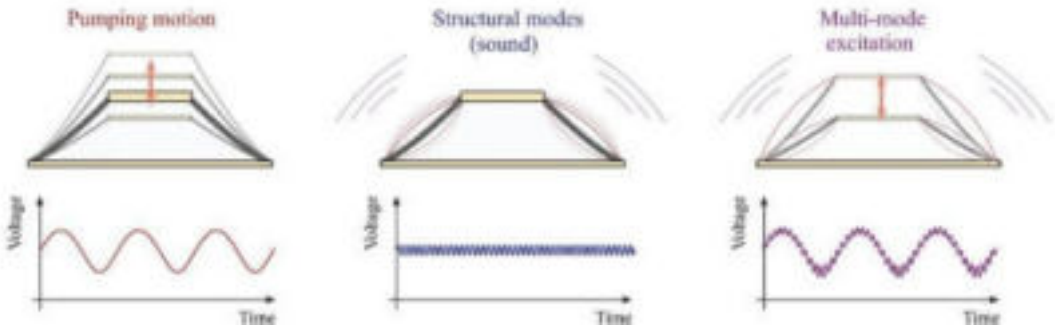
SMA

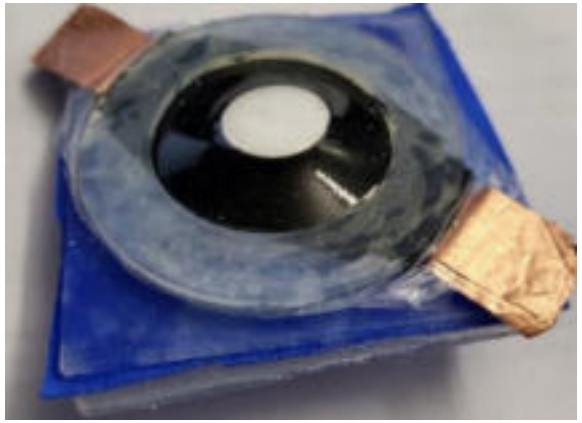
- Position and movement sensing
- Force feedback
- Heating
- cooling

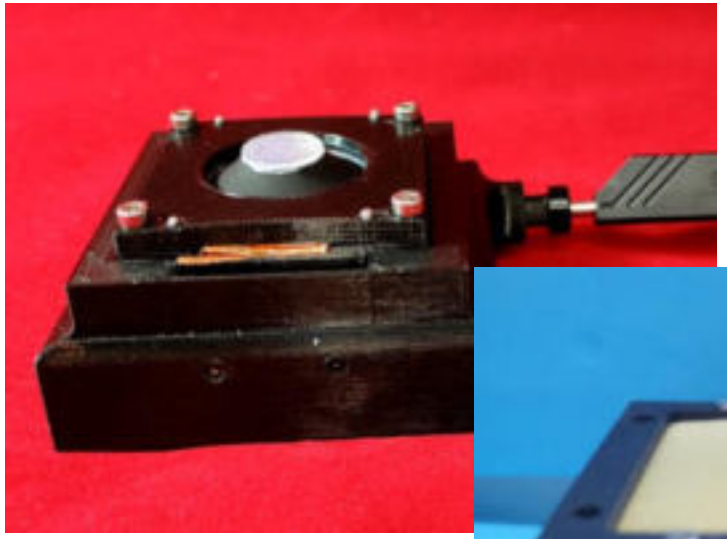
DE

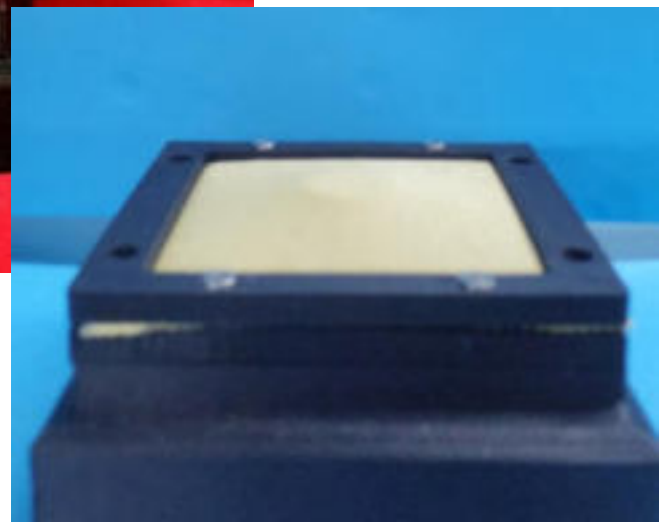
- Position and movement sensing
- Tactile feedback
- Acoustic feedback
- Multifunctional interaction
- Energy harvesting

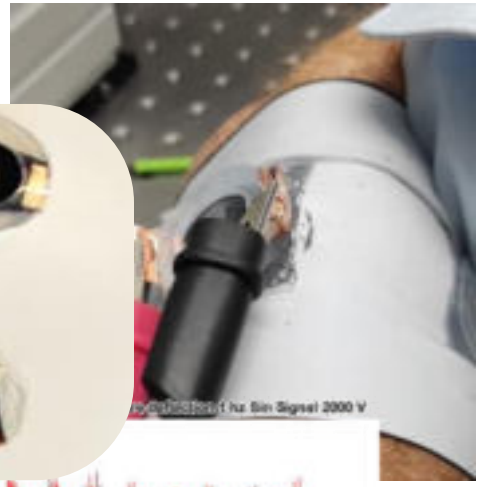
Example – multi mode DEA

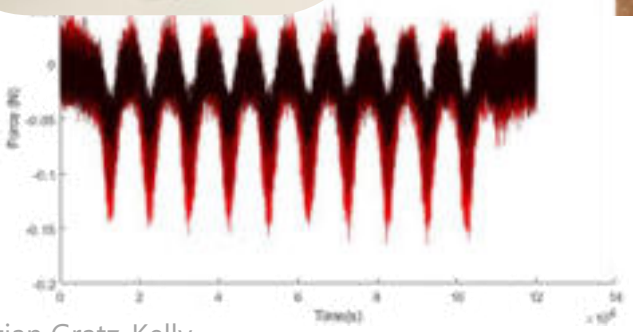










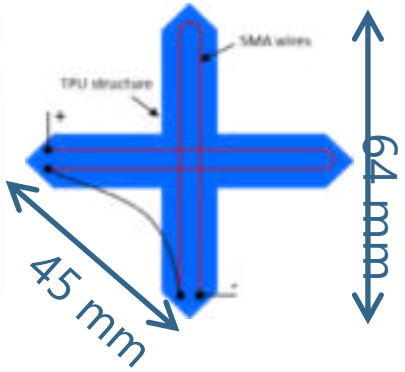


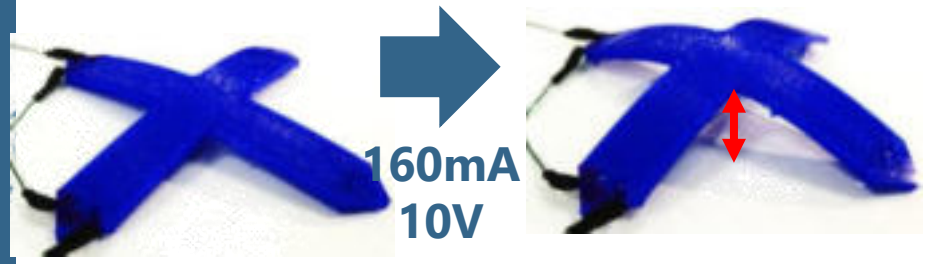
AI

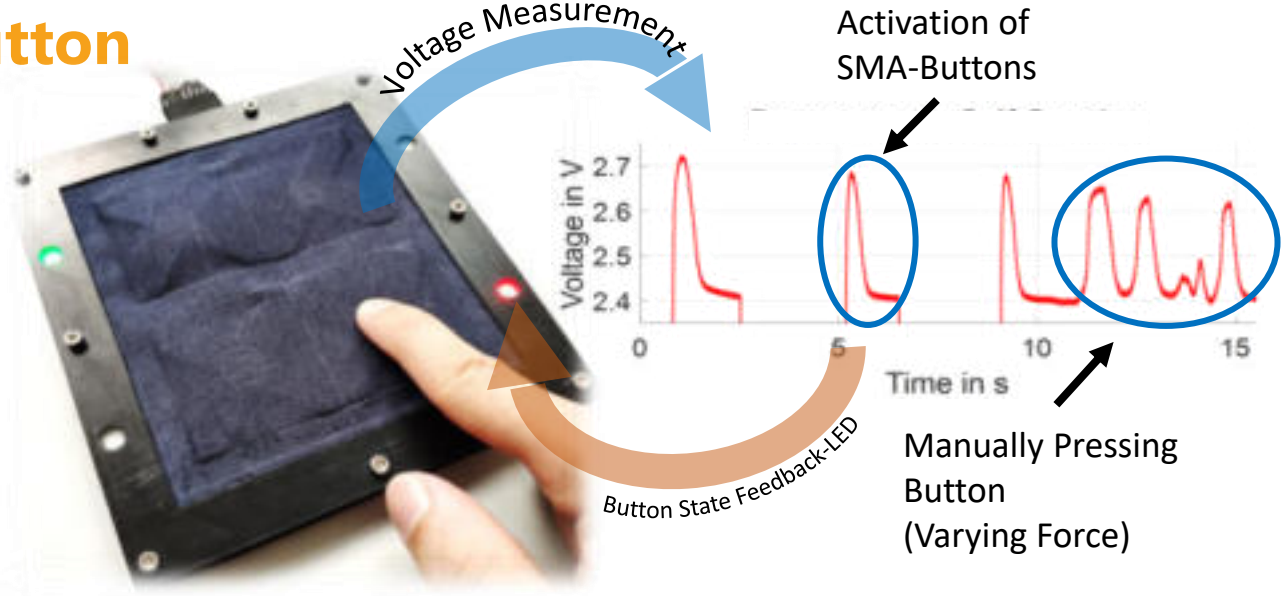
- Intelligent control
- Increasing sound quality
- Human adapted feedback
- Increasing multi-functionality

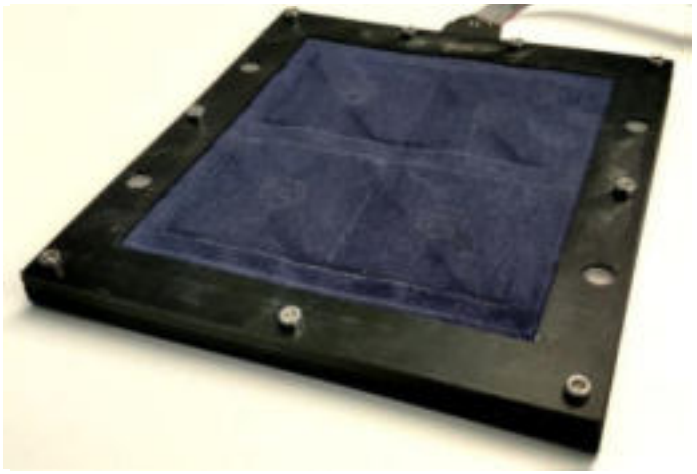
Example - SMA morphing Button

Smart material characteristic







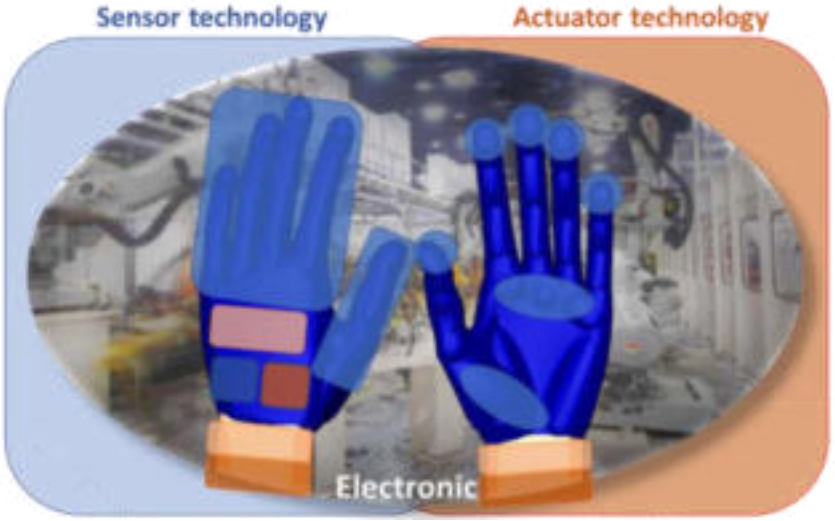


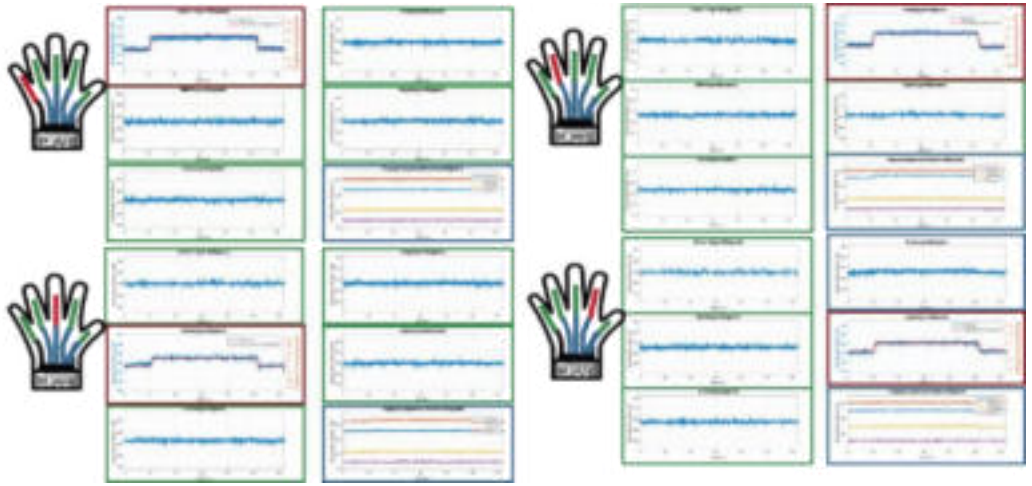
AI

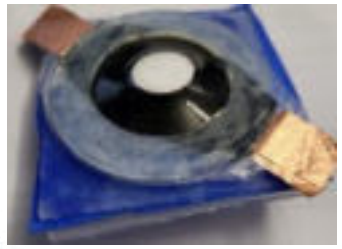
- Intelligent accurate sensing
- Increasing feedback stimuli and adapted feedback
- Increasing multi-functionality

Example – DE sensing Glove

Smart material characteristic







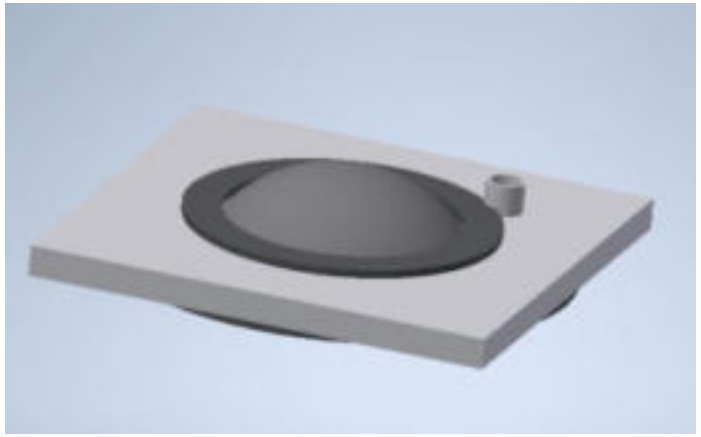
AI

- Gesture recognition and prediction
- Movement recognition and prediction
- Behavior prediction

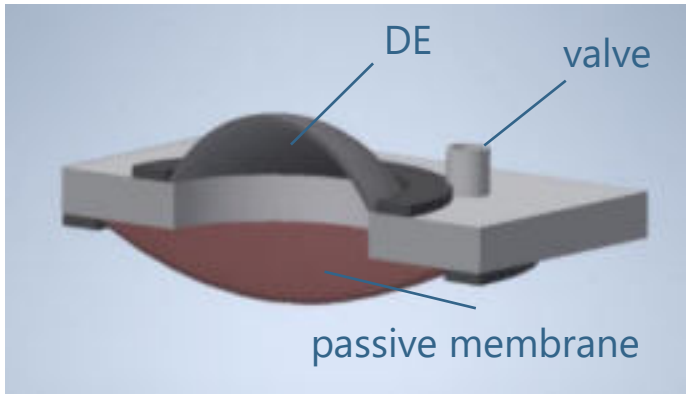
Example – haptic wrist band

Smart material characteristic

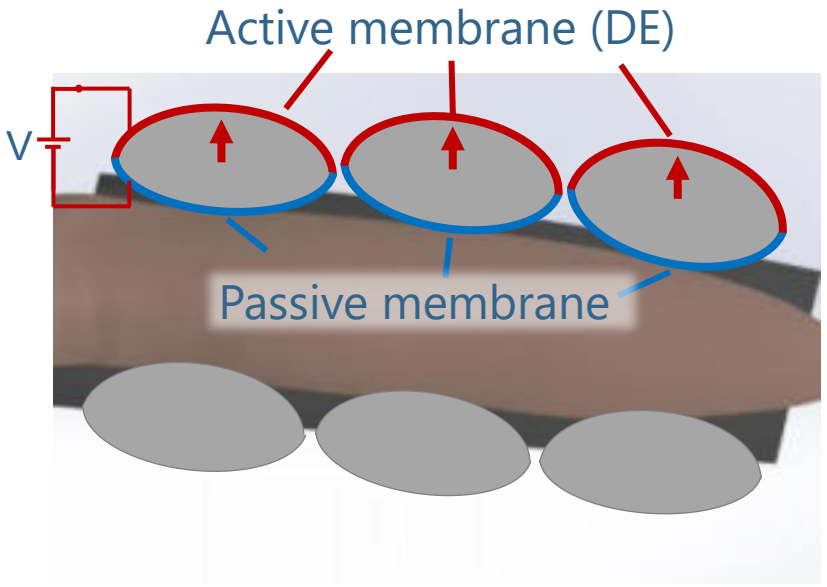
Single actuator



Top-view



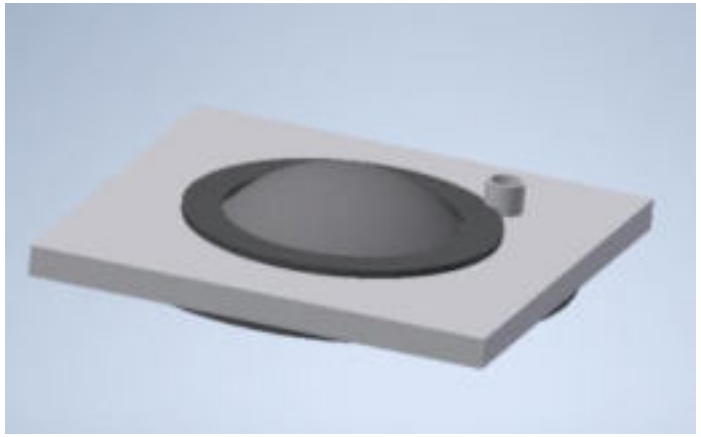
Cross-sectional view



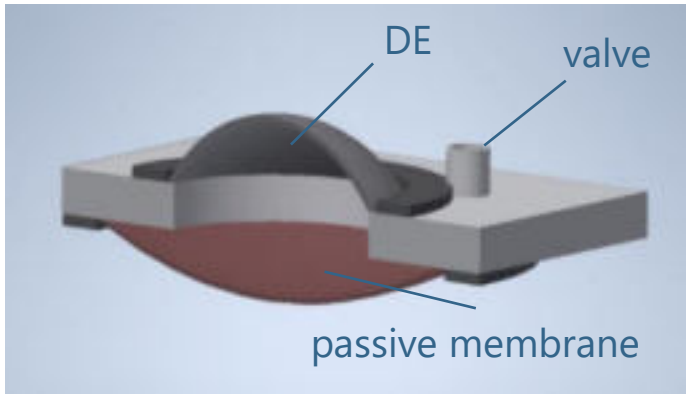
Example – haptic wrist band

Smart material characteristic

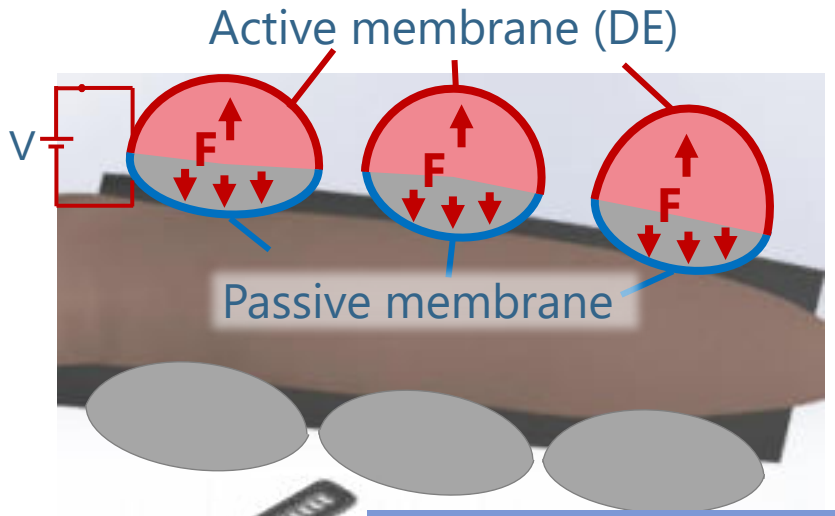
Single actuator



Top-view



Cross-sectional view



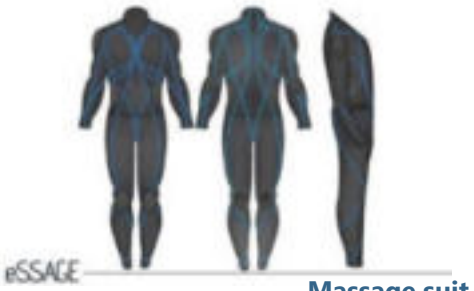
AI

- Intelligent control
- Human adapted feedback
- Increasing multi-functionality
- Combination with glove sensing

Application scenarios

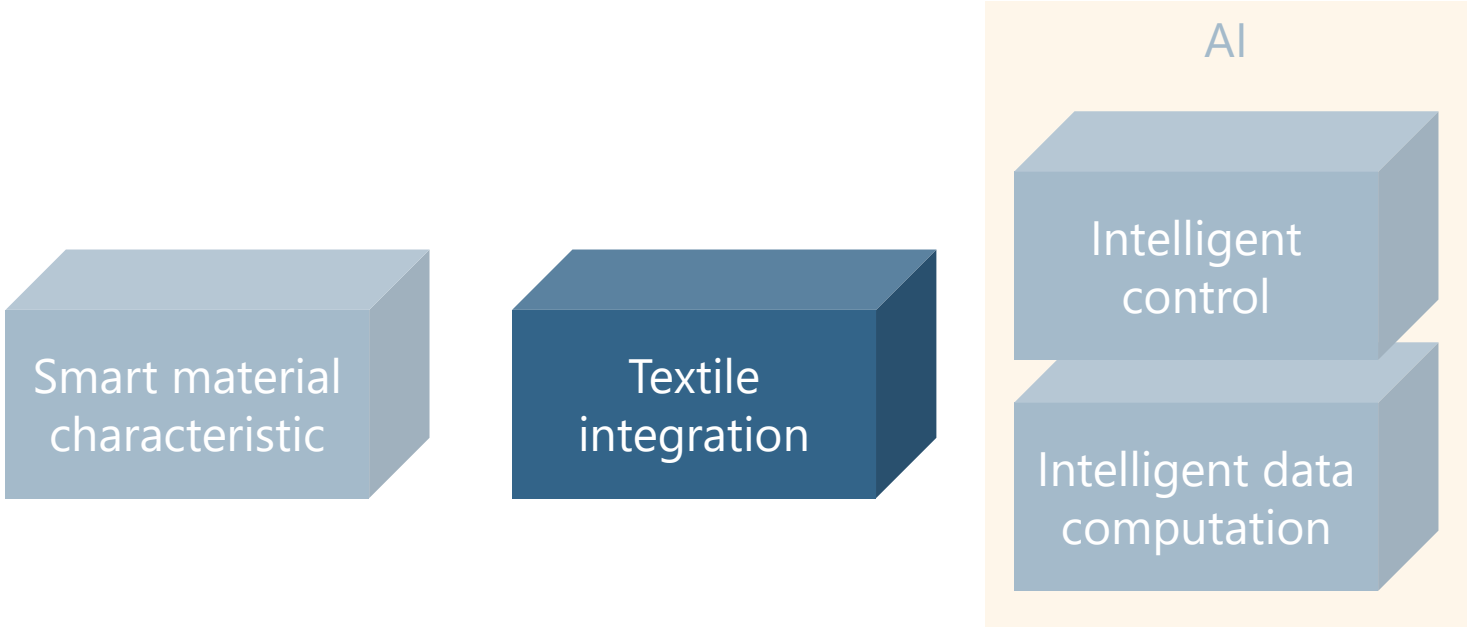
- Smart Clothes
- Assistance for older people
- Entertainment
- Virtual reality
- Sport , sports medicine
- comfort

Superflex Aura Powered Suit



Massage suit

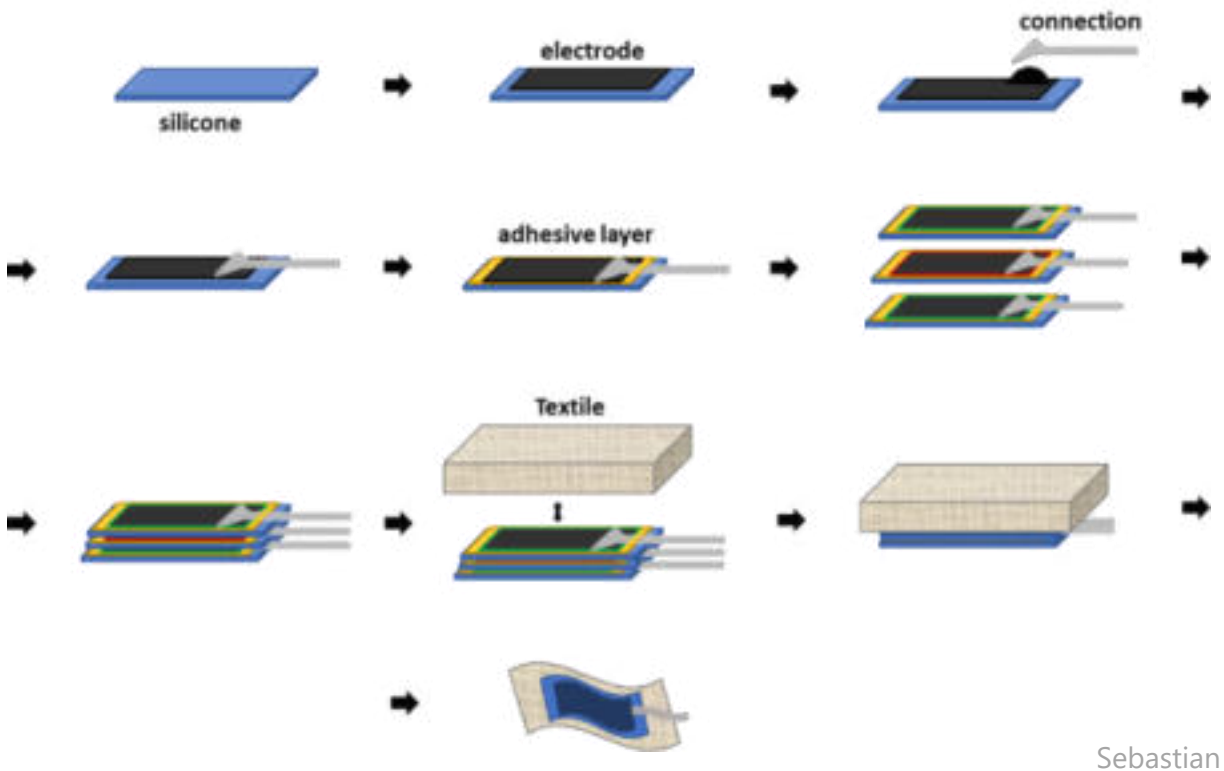
Smart materials integrated in smart textiles



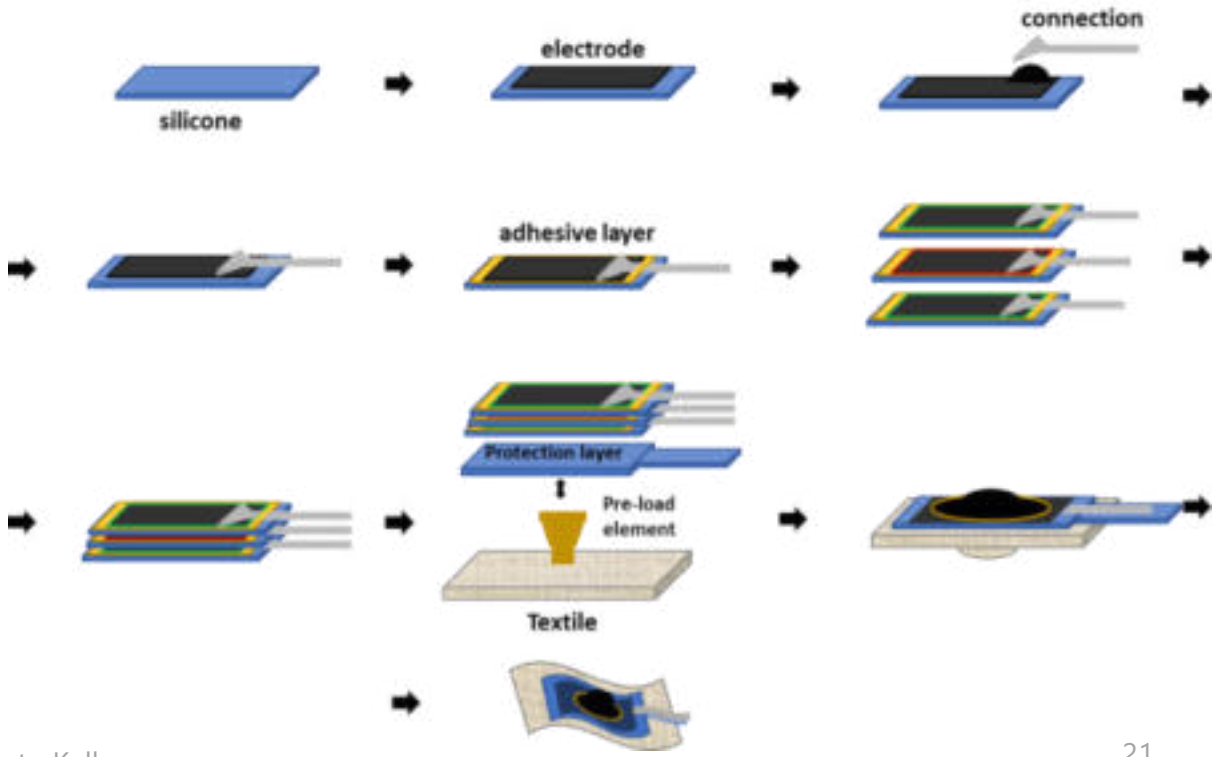
DE textile integration

Textile integration

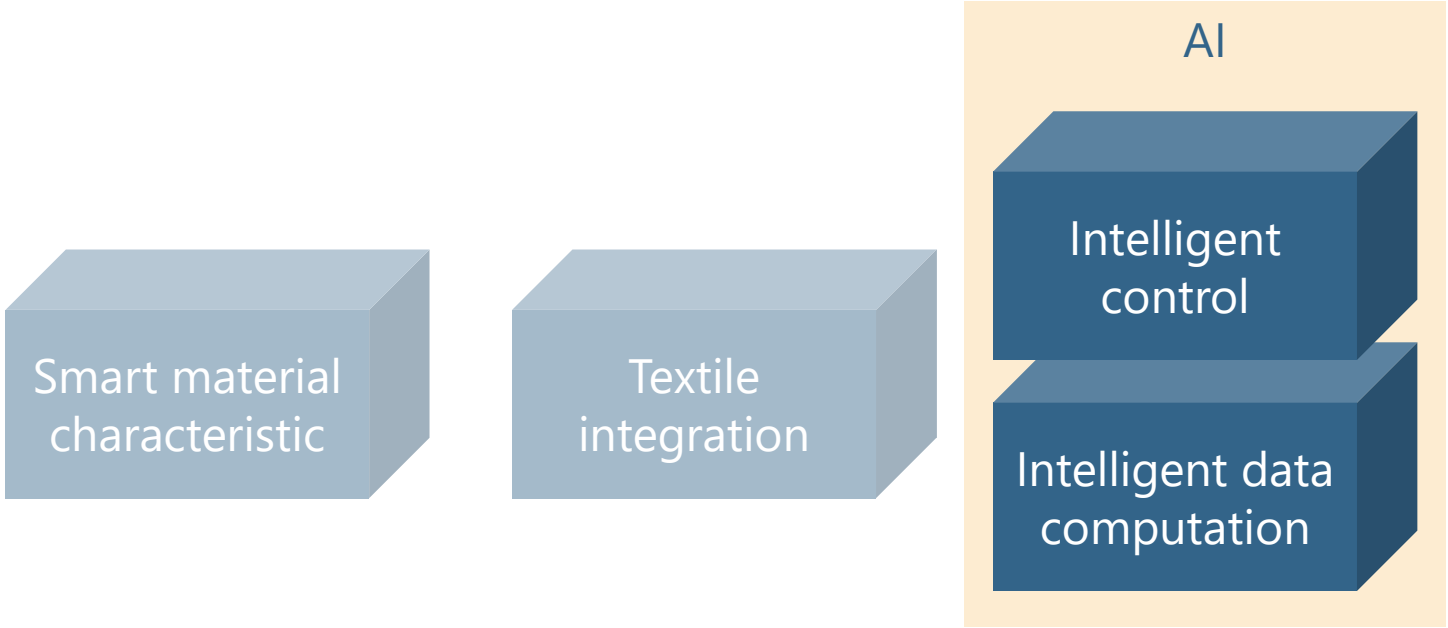
Sensor integration



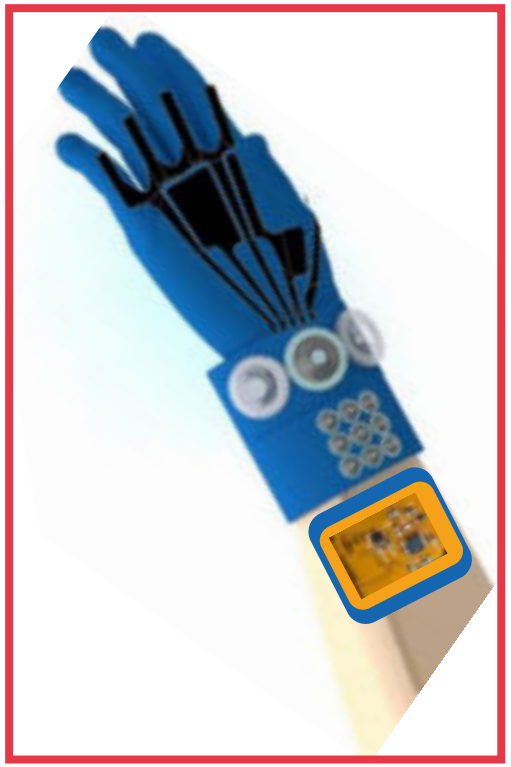
Actuator integration



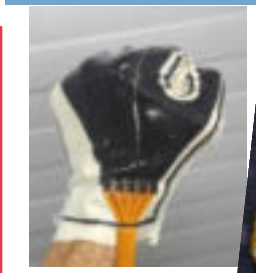
Smart materials integrated in smart textiles



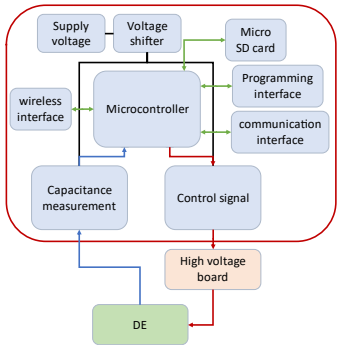
AI in smart textiles

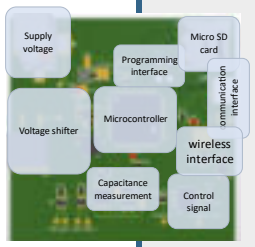


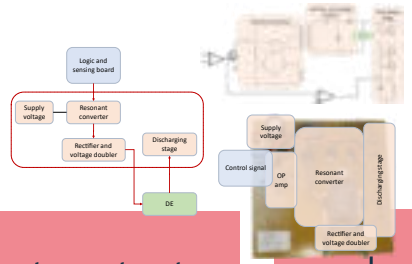
data acquisition

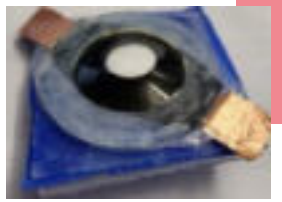


data validation









generate output signal

calculate output signal

data structuring

data interpretation

decision making process

determine scenario

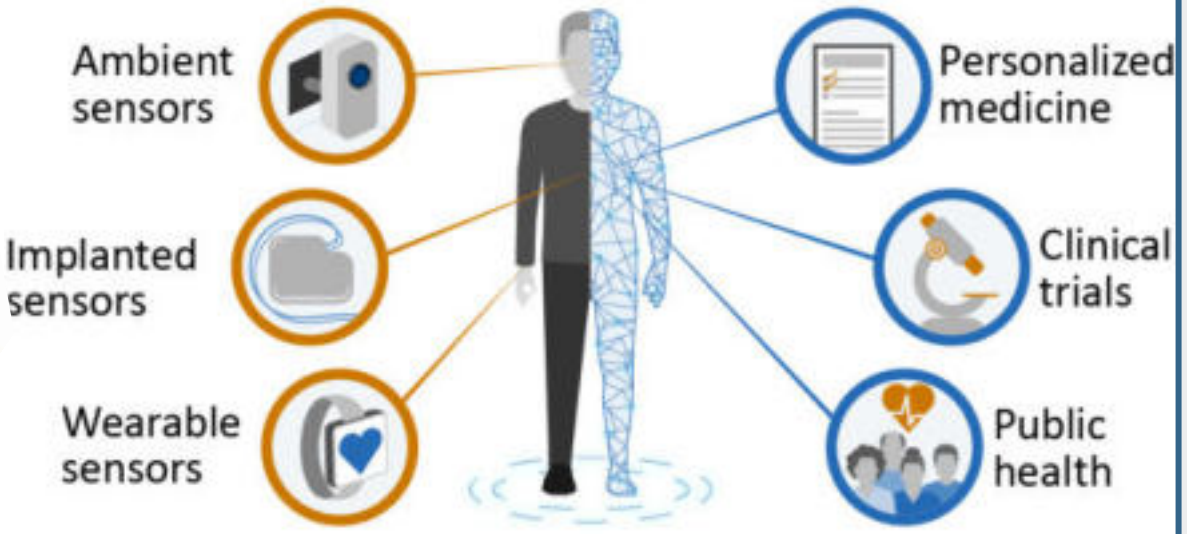
AI

Intelligent control

Intelligent data computation

determine output stimuli

AI in smart textiles



data acquisition

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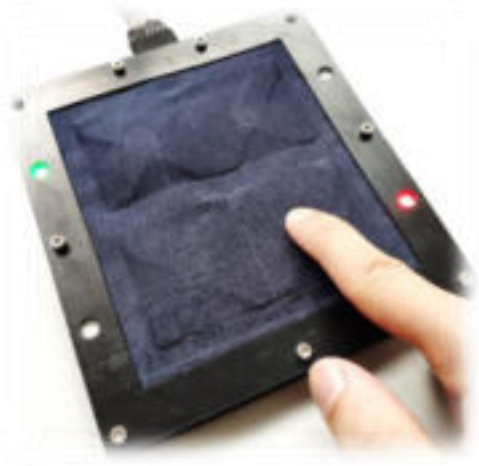
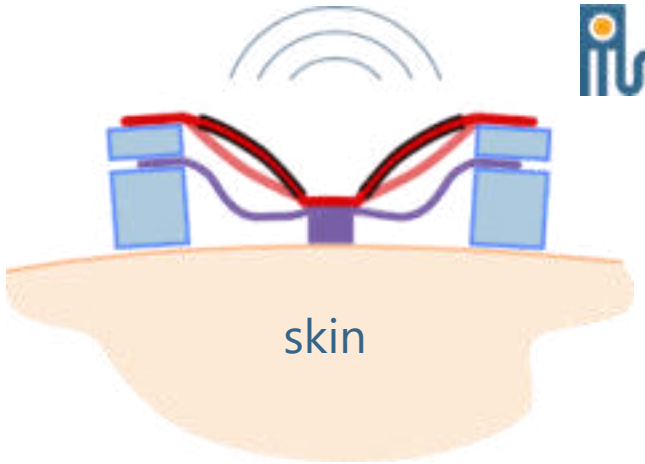
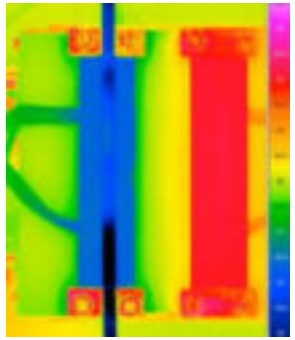
conclusion

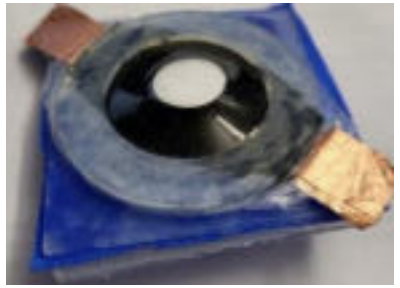
- Material characteristics
  - Shape memory alloys
  - Elastocaloric cooling
  - Dielectric elastomers
- Development of multifunctional elements
- Textile integration
- Outlook for AI possibilities
- Further talk :
  - **Tajbeed Chowdhury:** Textile integrated sensor analysis for biometric data collection and processing - human digital twin in reality







Smart Vest



INTELLIGENT MATERIAL SYSTEMS LAB

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Thank You!
Questions?

Sebastian Gratz-Kelly

Intelligent Material Systems Lab (iMSL)
Saarland University, Saarbrücken, Germany

Europäische Union
EUROPÄISCHER FONDS FÜR REGIONALE ENTWICKLUNG

VProSaar
iSMAT