

# Microstructure-Functional Behavior- Relationships in High Entropy Shape Memory Alloys

Priority Programme “Compositionally Complex Alloys – High Entropy Alloys (CCA-HEA)” (SPP 2006)

Deutsche  
Forschungsgemeinschaft

**DFG**

## Motivation

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### high entropy alloys **and** shape memory alloys

are special in terms of:

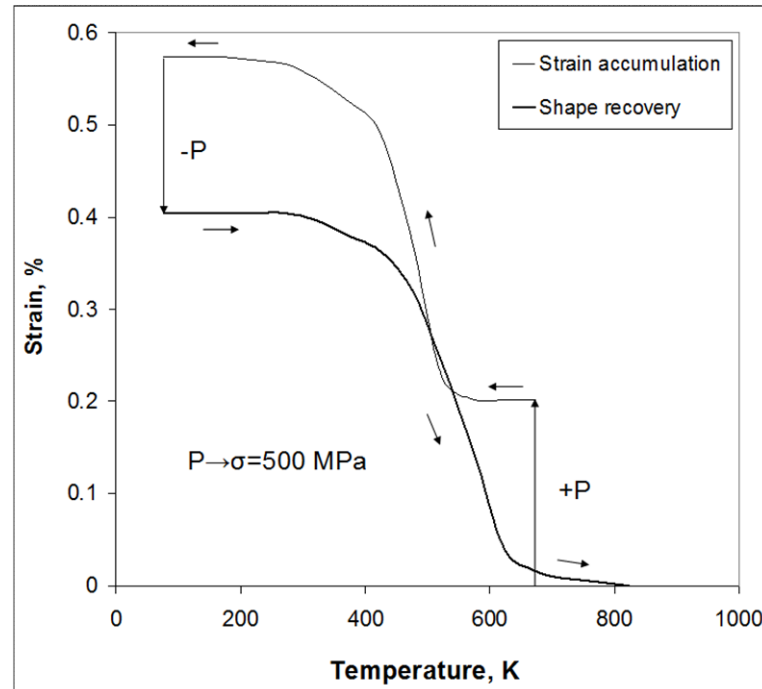
- high strength ( $> 1$  GPa)
- slow diffusion
- twinning
- structural stability/precipitates
- phase transformation

→ **ideal system to improve our understanding of the processing-microstructure-property-relationship of HEA**

## Good news

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TiZrHfCoNiCu HEA has been reported to feature a SMA effect



shape memory behavior measured in 3 point bending for  
 $\text{Ti}_{16.667}\text{Zr}_{16.667}\text{Hf}_{16.667}\text{Ni}_{25}\text{Cu}_{25}$  HEA (G.S. Firstov et al., Proc. Icomat-2014)

→ **perfect system to start with**

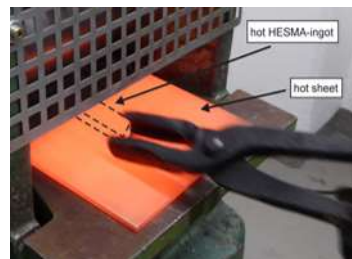
# First samples already available



←----- arc melting ✓

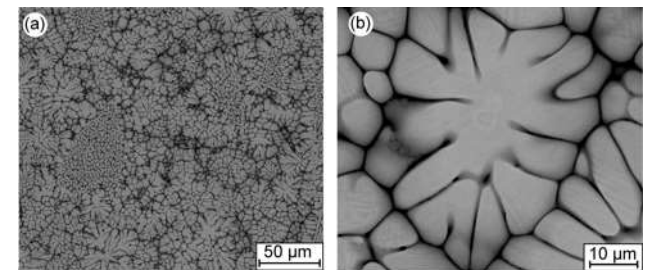
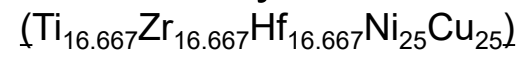


←----- heat treatment ✓

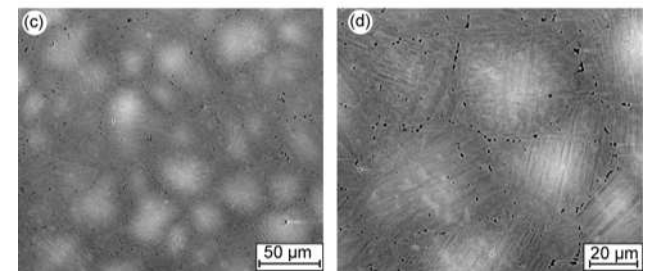


←----- future work:  
processing

## SEM-analysis



(a) and (b) as-cast

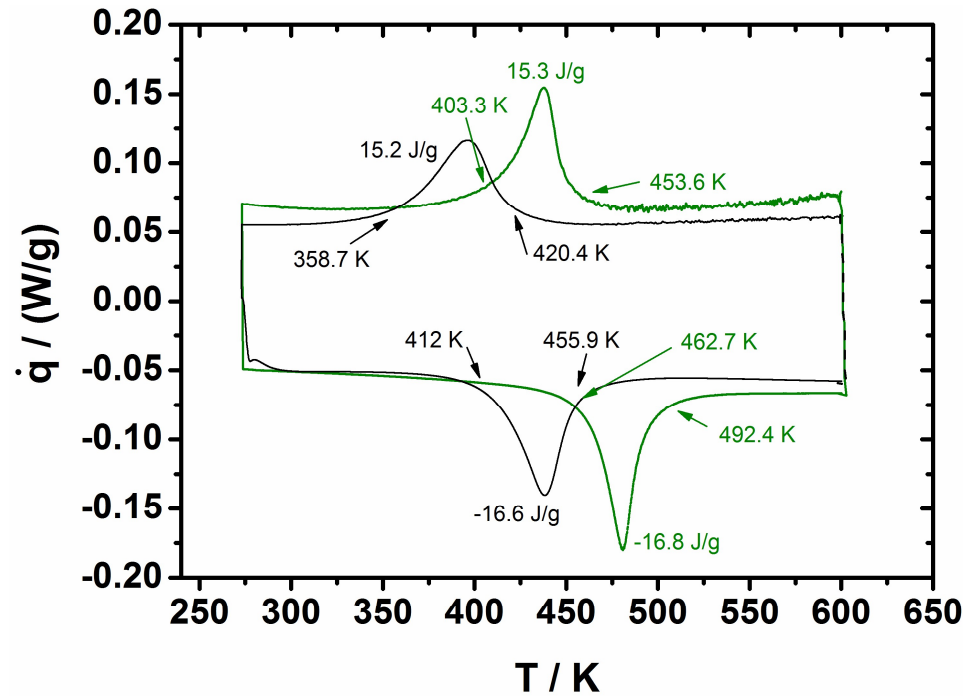


(c) and (d) after homogenization  
(72h, 900 °C)

previous joint studies on HTSMAs, e.g. Shap. Mem. Superelasticity, vol. 1, 2015, 6-17

# Characterization of bulk behavior

## DSC thermal transformation behavior

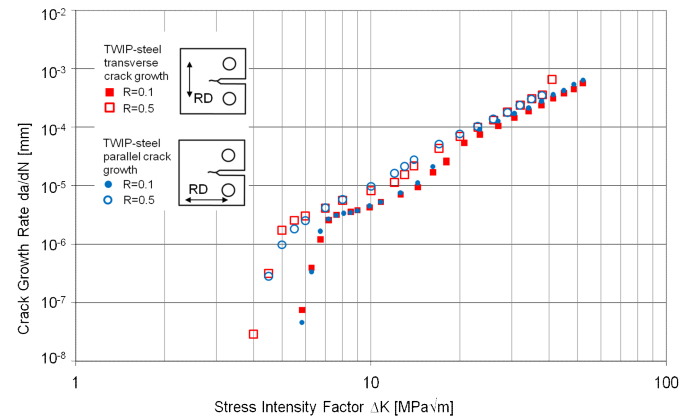
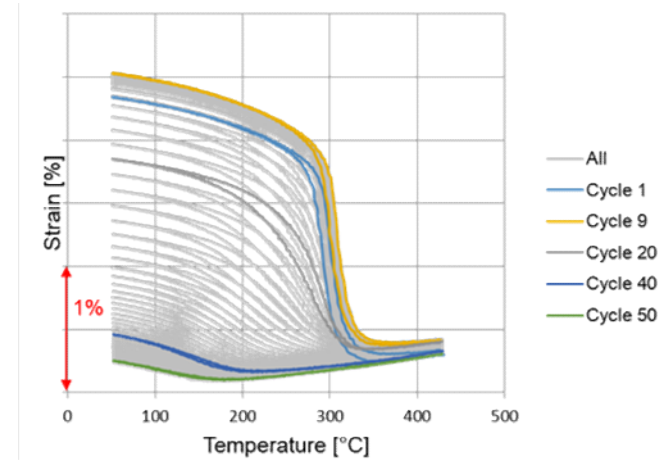
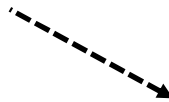
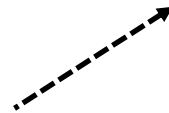
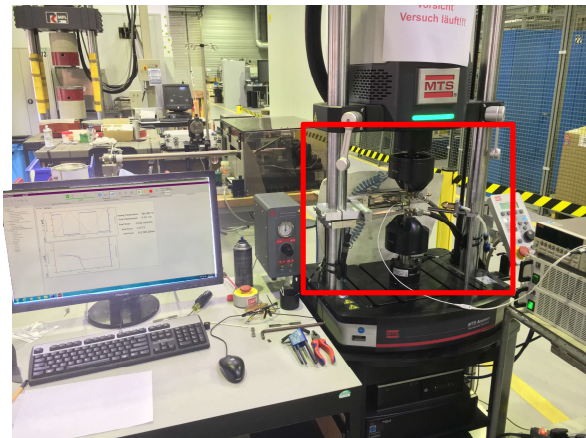


DSC charts: green line:  $\text{Ti}_{16.667}\text{Zr}_{16.667}\text{Hf}_{16.667}\text{Ni}_{25}\text{Cu}_{25}$  and  
black line:  $\text{Ti}_{16.667}\text{Zr}_{16.667}\text{Hf}_{16.667}\text{Co}_{10}\text{Ni}_{25}\text{Cu}_{15}$

**objective of WP 1 to 4: validated process for high quality samples**

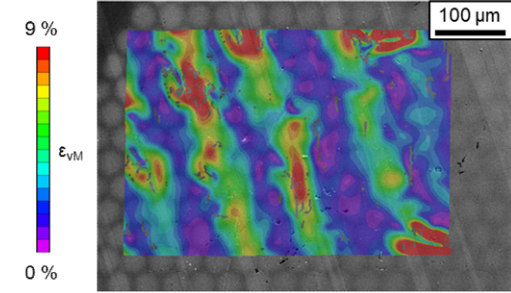
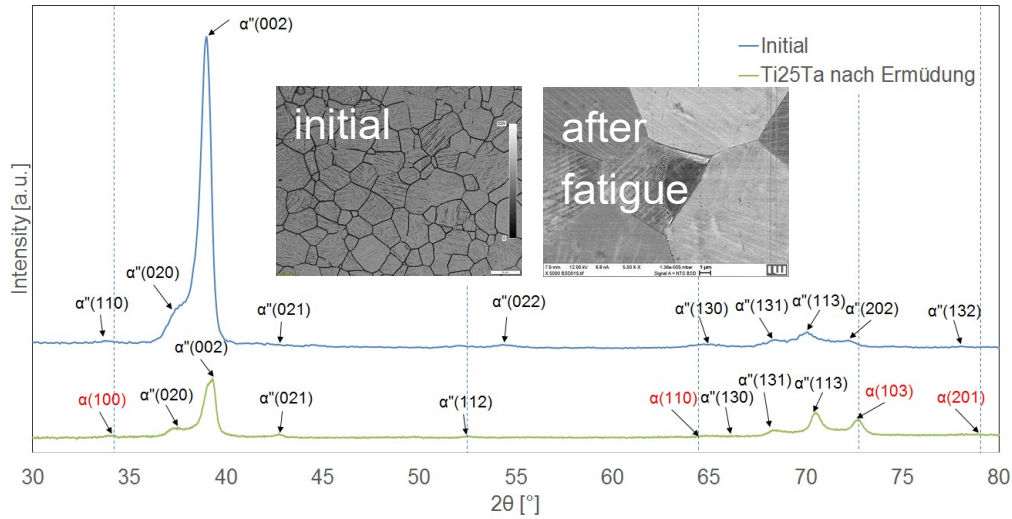
# Functional fatigue at the macroscale

WP 5 to 8: functional (PE and thermo-mech.) and structural fatigue



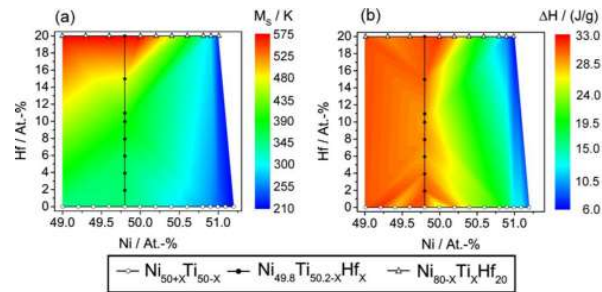
HEA are expected to demonstrate superior behavior

# Studies at the meso and microscale

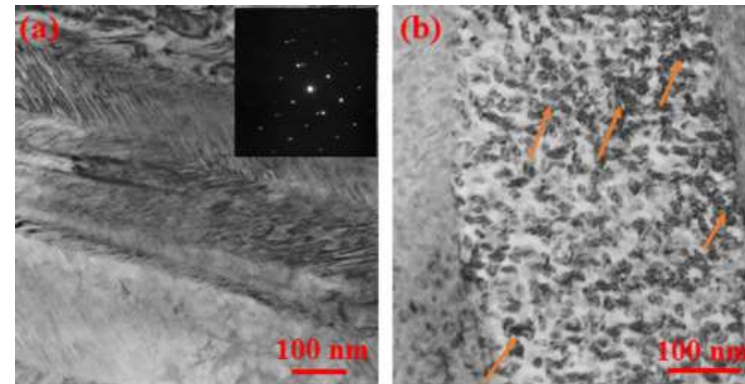


DIC – transformation strain

## X-ray and SEM analysis



analysis of sub-systems



TEM imaging and SAED

## WP9 Publications / Collaborations within SPP 2006

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