Thermomechanical Behaviour Of Shape Memory Rivet In Situ Study

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Abstract

A Ti-rich NiTi shape memory alloy (SMA) was used to join two components through shape memory effect (Fig. 1) adapted from the principle presented by a recent patent [1] that opens interesting perspectives in the field of aeronautics. In the concept study and viability of such type of rivet, DSC, dilatometric and in-situ XRD during thermomechanical cycles were performed [2]. In situ XRD study during thermomechanical cycle was conducted in a modified dilatometer DIL-805, Bähr (Fig. 1) at the HZG beamline (HEMS/P07-EH3, Petra III, DESY, Hamburg) to identify the structural changes following combined thermal and mechanical loading, namely the preferential variants orientation at different steps of the process.

Experimental Details

Equipments:

Material: Ti-rich NiTi alloy

Synchrotron radiation based XRD (DESY/PETRA III, Germany)

- Spot size: 200 x 200 µm; wavelength: 0.124 Å (98 keV)
- modified dilatometer DIL-805 (Bähr)

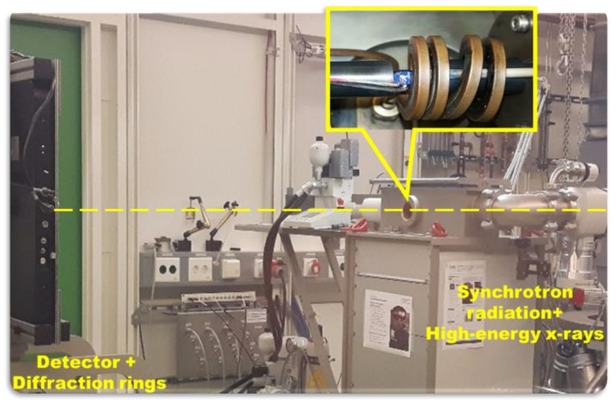
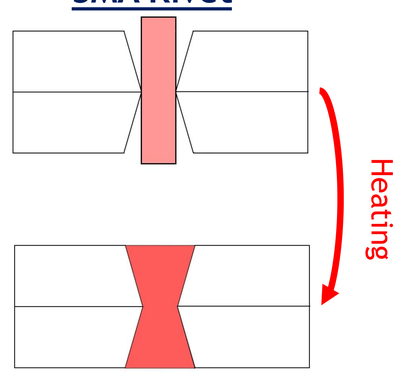


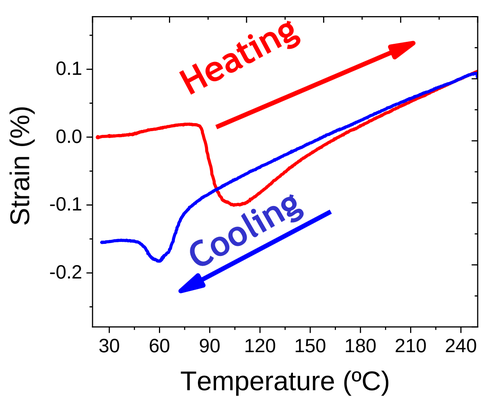
Fig. 1 - Schematics of the beam direction, dilatometer and part of inside the equipment and the position of the detector in relation of the sample.

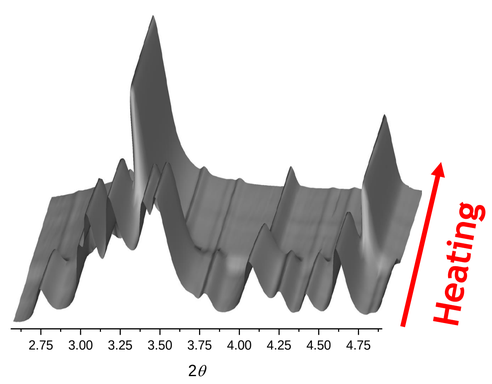
SMA Rivet

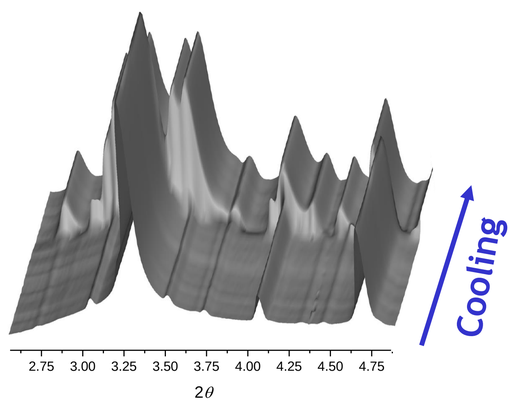


Experimental Results

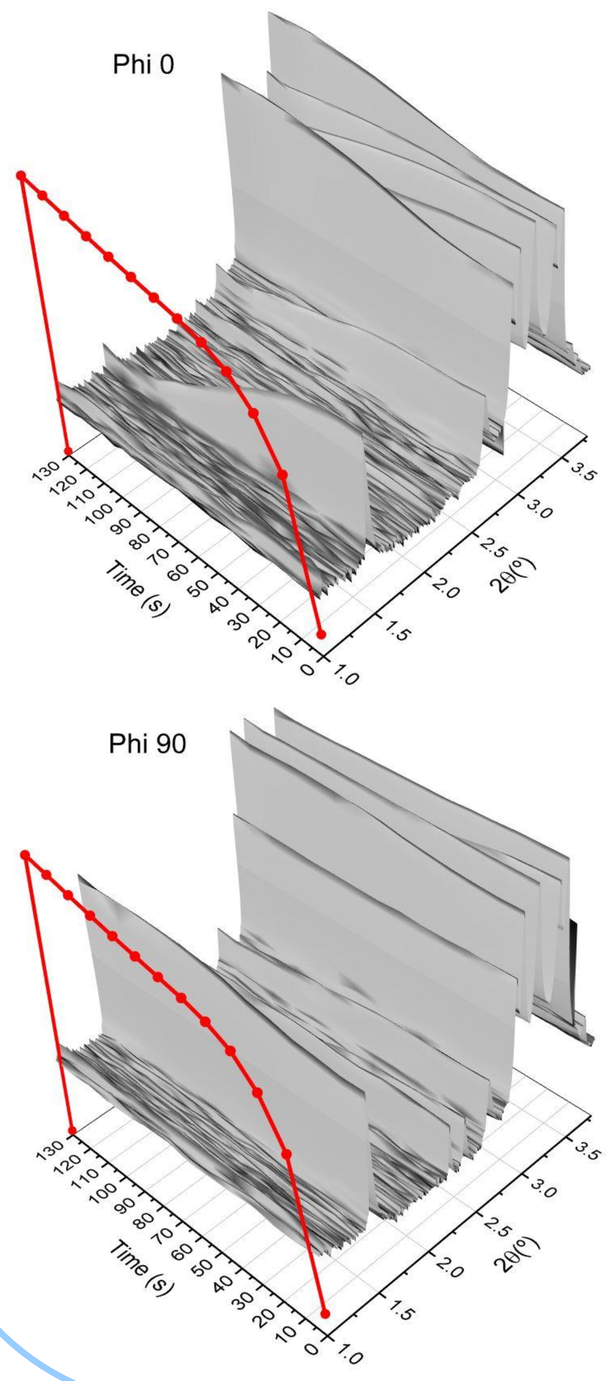
Dilatometric Test (free recovery)



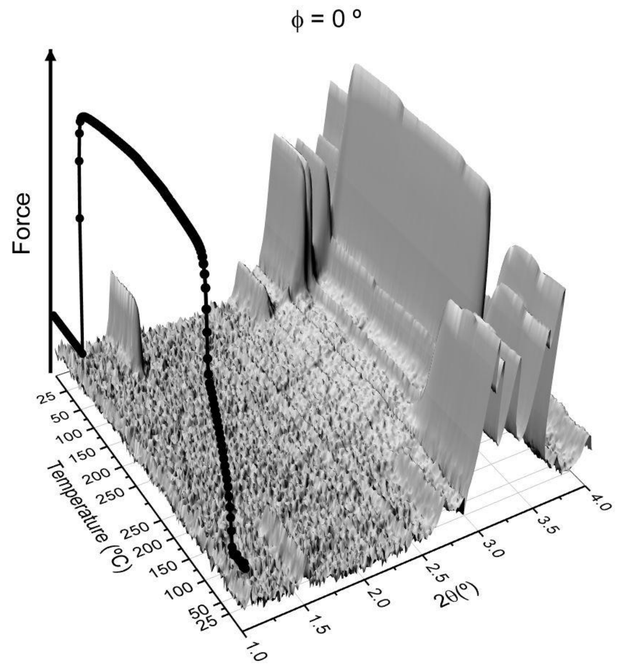


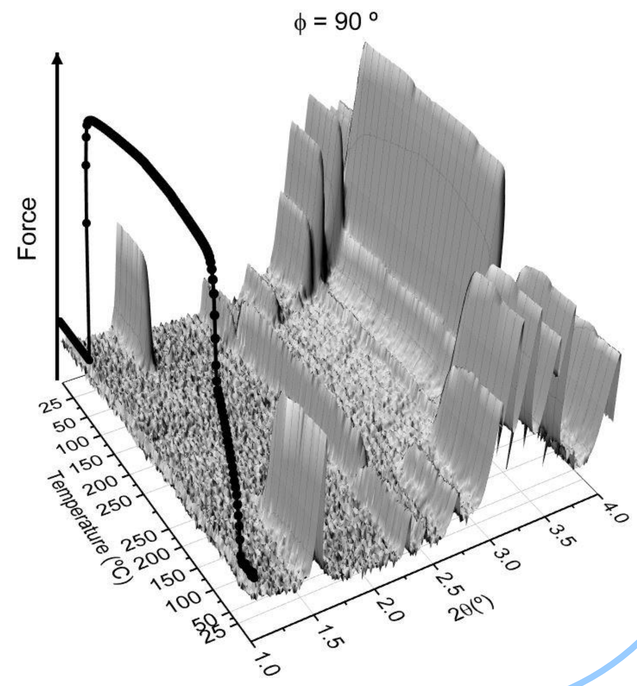


Deformation at room temperature



Actuation force under constraint





Conclusions

- ✓ During compression, (001)B19' is preferentially oriented parallel to the loading axis.
- ✓ After ex situ compression, the variants (0 1 0), (0 1 1) are suppressed, but they reappear after austenitization (heating to 250ºC) under constraint; on the other hand, (1 -1 1), (1 0 0) and (1 0 1) are not suppressed; after austenitization, (1 -1 1) reappears with higher intensity and (1 0 0), (1 0 1) with lower intensity.
- ✓ The force exerted by SME, is directly related to the reorientation of the variants of the material.
- ✓ The maximum recovery reached by SME was **4.2%** creating an actuation stress of **370 MPa**.
- ✓ Thermal hysteresis increases after the deformation of the samples.

References

1 – Kirkwood et al, 2014. US Patent 8,918,978 B2 - Self Expanding Fastener.

2 – E. Camacho, 2016. MSc thesis - Aplicação de ligas com memória de forma para rebites", FCT/UNL.

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