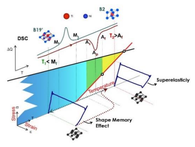

Workshop on Shape Memory Alloys
Processing, Properties and Applications
CENIMAT, FCT/UNL, 19/02/2020

In Situ Structural Characterization of Functionally Graded Ni-Ti Shape Memory Alloy During Tensile Loading

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ABSTRACT

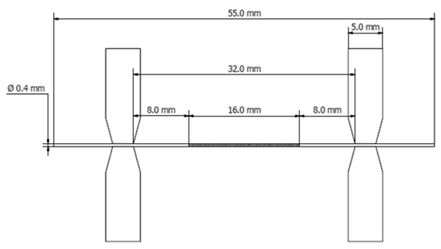
A functionally graded NiTi shape memory alloy wire was investigated by in situ synchrotron-radiation based X-ray diffraction (SR-XRD) during cyclic tensile deformation. The transformation temperatures were determined by DSC and the thermomechanical behaviour was analysed by three-point bending test. The present study focussed on the localized heat treatment (Joule heat effect, reaching 300 ºC, 350 and 400 C pulses for 10 min) of NiTi wires, using an equipment that allows a large variety of graded conditions. Structural, mechanical and thermomechanical characterization is presented to get a perspective of the different types of graded functionality. A combination of two strategies has been used for the in situ analysis by SR-XRD of the tensile tests: (i) continuously following the structural evolution at one single point (at the center of the heat-treated segment) all long the load/unload cycle and (ii) scanning the full heat-treated segment at previously defined discrete steps of the stress-strain curve. The combined information from both types of tests provided detailed information about the phase transformations taking place in different regions of the functionally graded segment, at different steps of the tensile load/unload cycle, giving a better understanding of the overall mechanical, namely the evidence of the sequence B2 ↔ R ↔ B19' for the direct and reverse transformations.

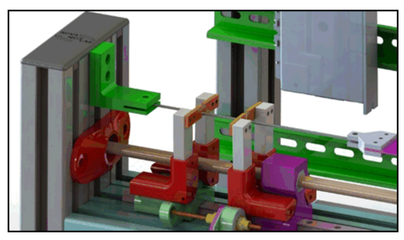
MATERIALS AND METHODS

Equipments: **Material:** Ni-rich NiTi alloy

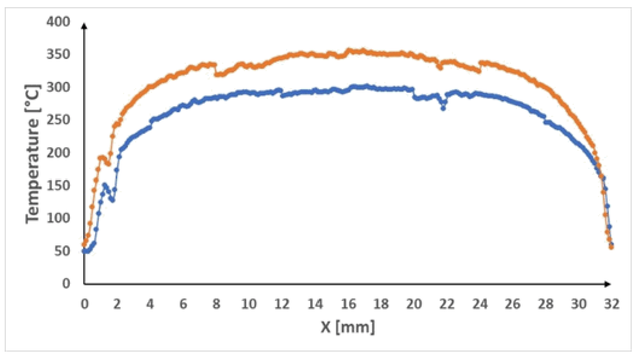
Synchrotron radiation based XRD (DESY/PETRA III, Germany)

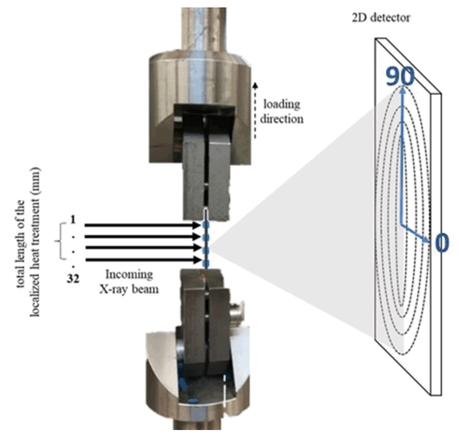
- Spot size: 200 x 200 µm; wavelength: 0.124 Å (98 keV)
- INSTRON test rig - 20 kN load cell



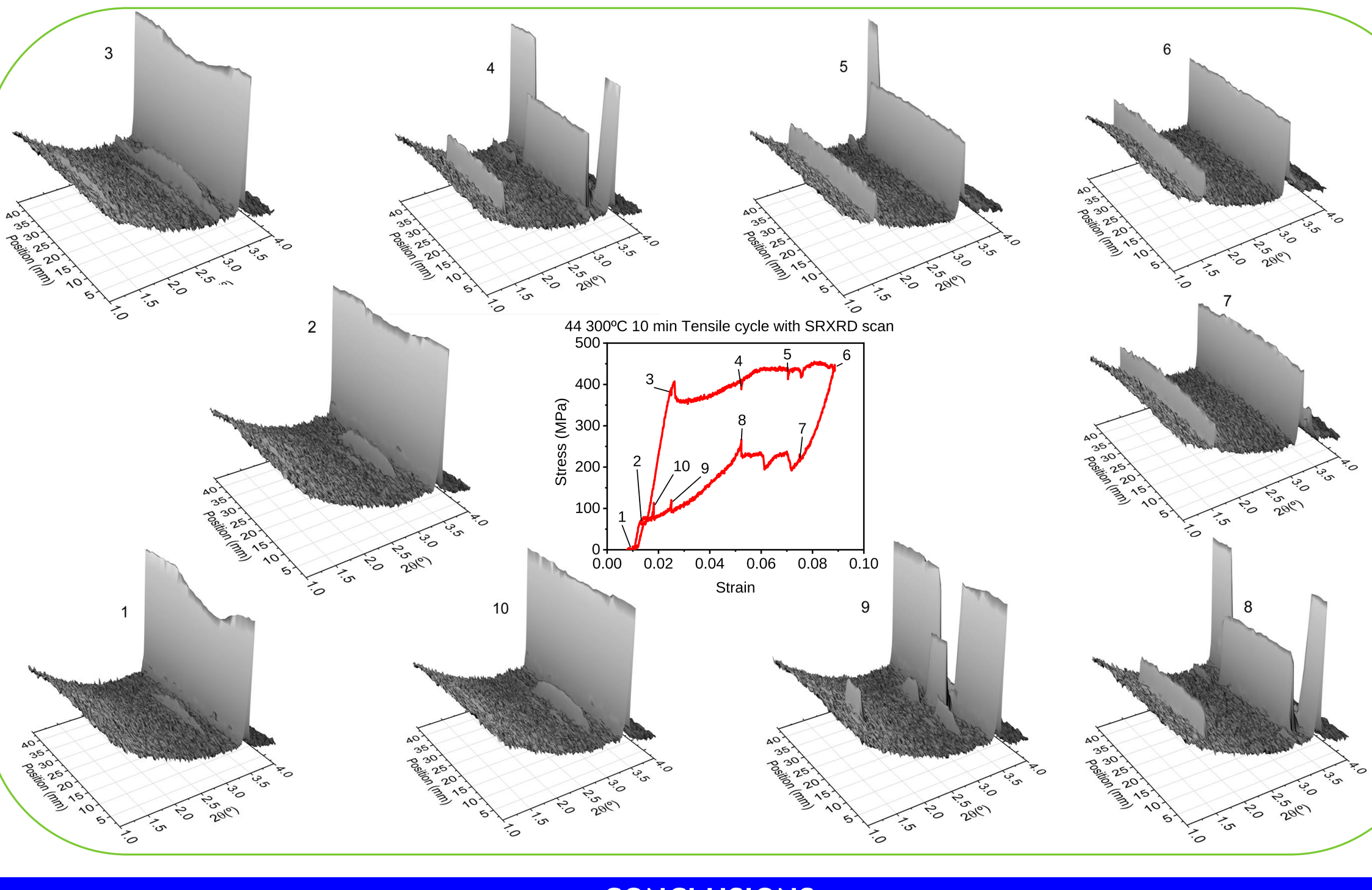


Schematic view of the home-made electrical local heating system





RESULTS AND DISCUSSION



CONCLUSIONS

- The functional gradient along the wire caused by the heat sink effect from the copper contacts used for the Joule heating has been put in evidence; such functional gradient may be used to get a "two-step" plateau for the SIM transformation;
- An overall increase of the transformation temperatures was obtained for heat treatments at 300 and 350 C for 10 and 30 min;
- The SIM transformation has been characterized by in situ SR-XRD analyses under load-unload tensile test, using two different experimental strategies: (i) in one case, a continuous follow-up of the central point of the wire (ii) another type of test has been performing the full gauge length scan at previously chosen points where the stress–strain cycle was interrupted; the first option allows a more continuous follow-up of the structural evolution, but only for the central point; the second option gives a more detailed information about the structural evolution of different regions of the wire at discrete steps of the load/unload cycle;
- The intermediate R-phase is first stress-induced, followed by the B19' martensitic phase; for the cases studied here, both phase transformations had a very significant component of reversibility during load/ unload.

REFERENCES

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