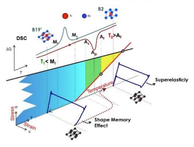
Shape memory alloy-based composites fabricated by severe plastic deformation



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

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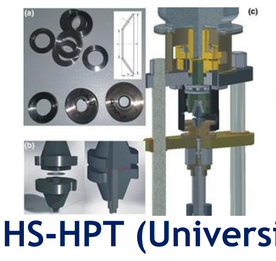
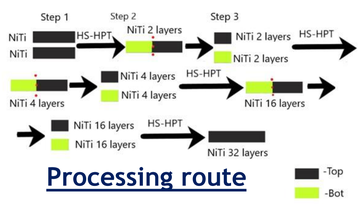
Abstract

Following previous studies [1-2], High-Speed High Pressure Torsion (HS-HPT) has been used to promote severe plastic deformation of Ni-rich and Ti-rich Ni-Ti shape memory alloys, fabricating multiple layered structures (up to 32 layers), embedding other metallic alloys, such as Mg alloy. The phases present at room temperature were identified by synchrotron radiation based X-ray diffraction. The transformation characteristics were determined by Differential Scanning Calorimetry (DSC) using a series of thermal cycles comprising 2 heating ramps up to 500ºC intercalated by 3 conventional cooling / heating cycles between +150 and -150 ºC in order to assess the relevance of recrystallization and precipitation phenomena.

Experimental Details

Material:
Ni-rich and Ti-rich NiTi alloys
Mg alloy





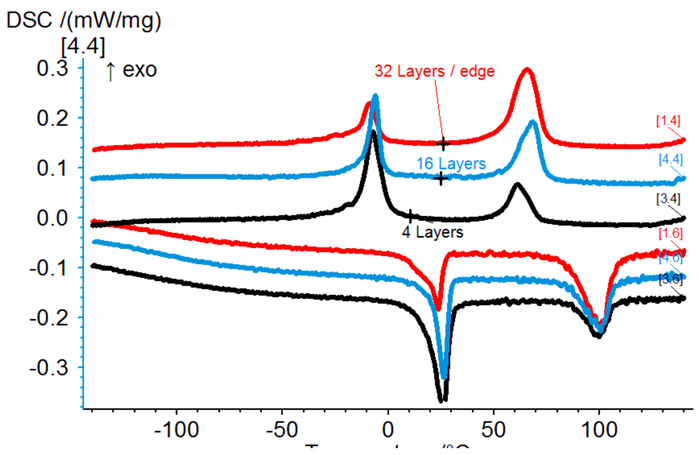
Equipment:
DSC (F-104, Netzsch)

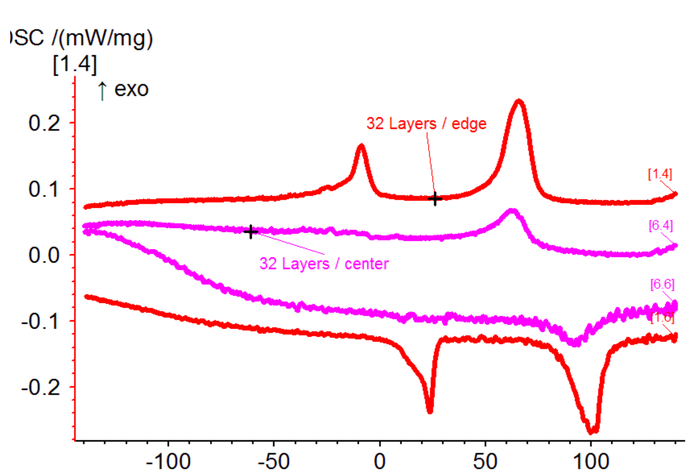
HS-HPT (University Galati)

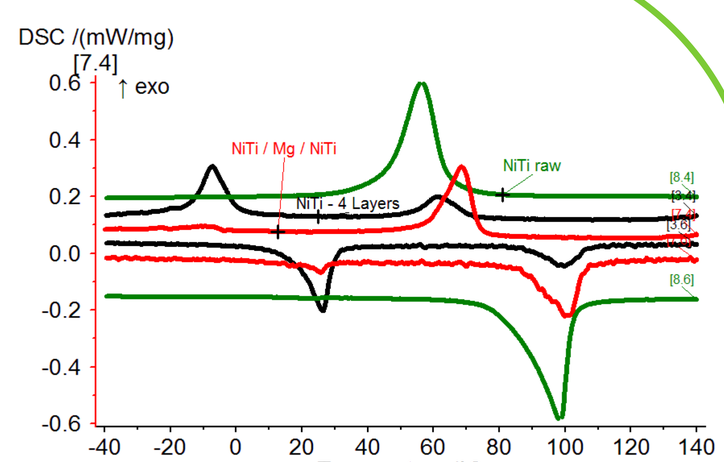
Processing route

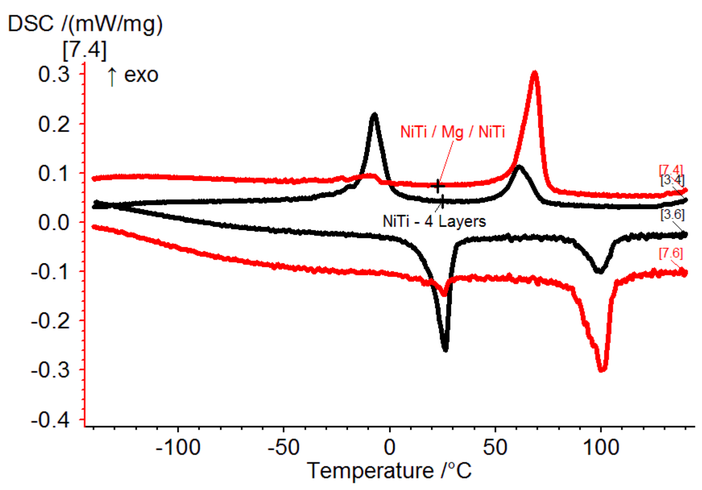
Synchrotron radiation based XRD (DESY/PETRA III, Germany)
- Spot size: 200 x 200 µm; wavelength: 0.124 Å (98 keV)

Experimental Results









Conclusions

- ✓ Making successive "foldings" to produce 4, 16, 32 layers did not change significantly the transformation temperatures. It is possible to identify the transformation temperatures corresponding to the Ni-rich (lower temperatures) and Ti-rich (higher temperatures).
- ✓ Incorporation of another metal alloy (such as Mg alloy) also did not change significantly the transformation temperatures.
- ✓ Heating up to 500ºC puts in evidence:
  - a fraction of martensite is stabilized by the severe plastic deformation, giving a reverse transformation to austenite that takes place in the temperature range of 160 to 200ºC,
  - recrystallization of deformed material and precipitation of Ni_4Ti_3 taking place above 300ºC, more notoriously for the first heating ramp.
- ✓ As a result of Ni_4Ti_3 precipitation on the Ni-rich layers during heating to 500ºC, corresponding transformation temperatures increase slightly after both the first and the second heating ramp.

References

1 Phase Transformation in Ni-Ti Shape Memory and Superelastic Alloys Subjected to High Pressure Torsion. K. K. Mahesh, F. M. Braz Fernandes, G. Gurau. Advanced Materials Research Vols. 123-125 (2010) pp 1007-1010.
2 Effect of high speed high pressure torsion parameters on grain refinement of coned shape Fe based SMA active elements. G. Gurau, C. Gurau, F. M. Braz Fernandes, L. G. Bujoreanu. International Conference on Martensitic Transformations, ICOMAT-2014. Materials Today: Proceedings 2S (2015) S897 – S900.

Acknowledgments

Funding of CENIMAT/I3N by COMPETE 2020, through FCT, under the project UID/CTM/50025/2013 and the project CALIPSOplus under the Grant Agreement 730872 from the EU Framework Programme for Research and Innovation HORIZON 2020. Parts of this research were carried out at beamline P-07-HEMS at DESY, a member of the Helmholtz Association (HGF).

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