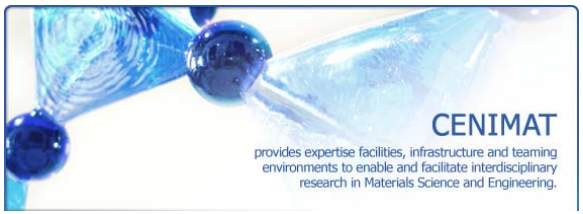
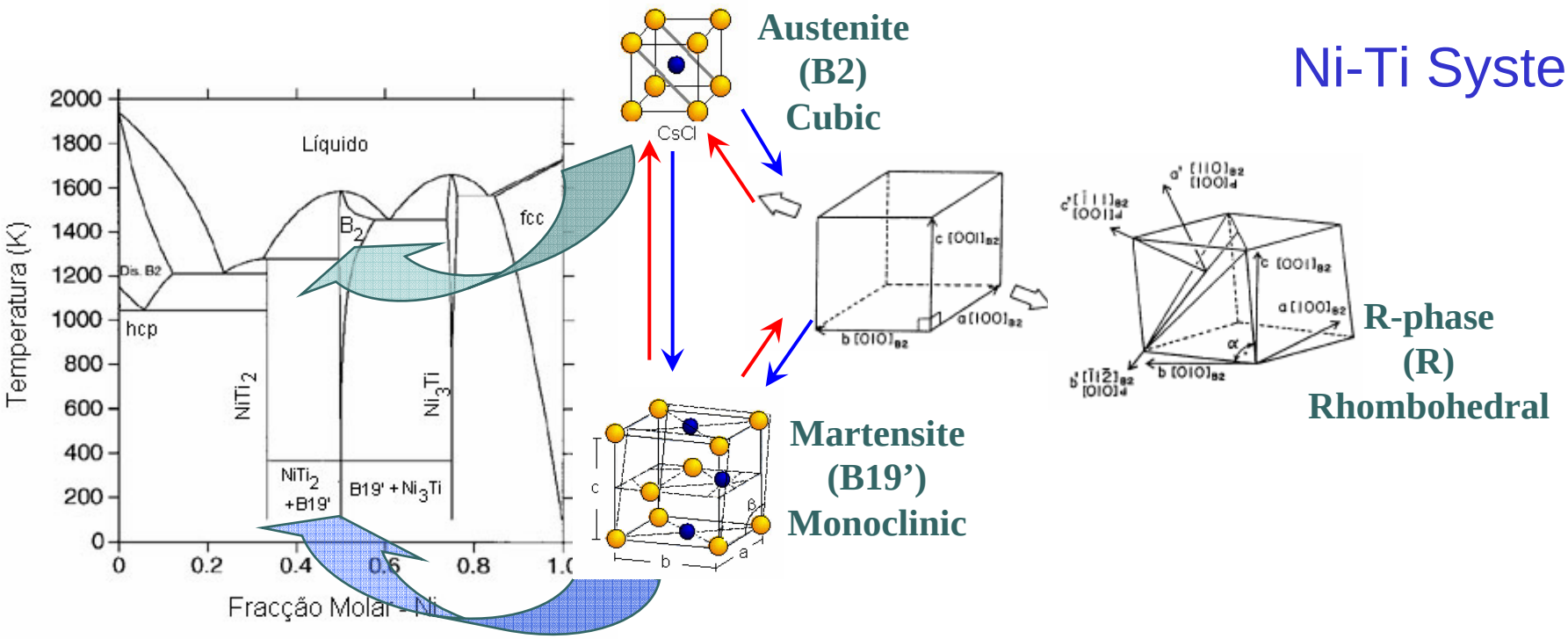
Heat Treating of NiTi Shape Memory Alloys

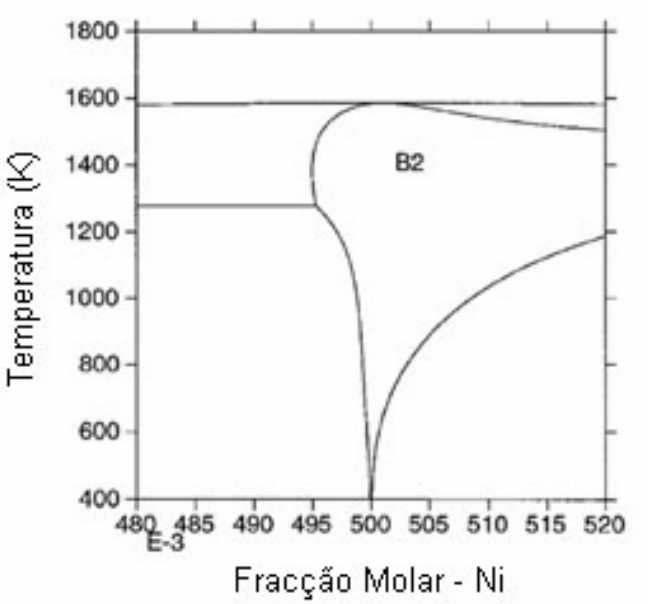
Francisco M. Braz Fernandes

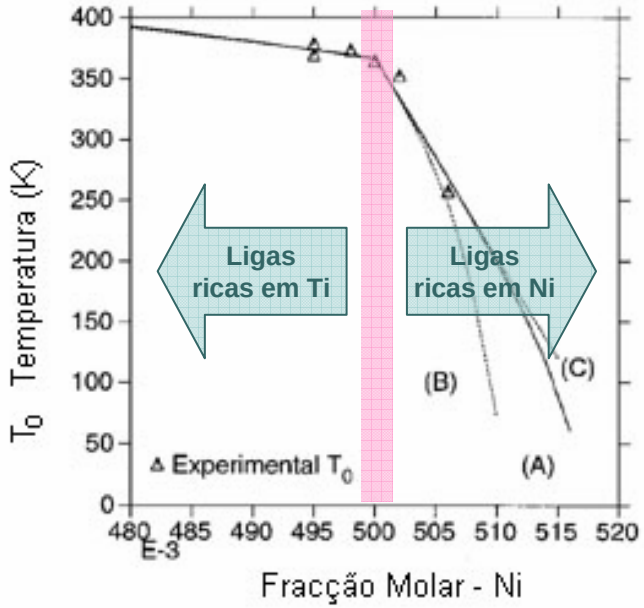


FACULDADE DE CIÊNCIAS E TECNOLOGIA
UNIVERSIDADE NOVA DE LISBOA

Ni-Ti System

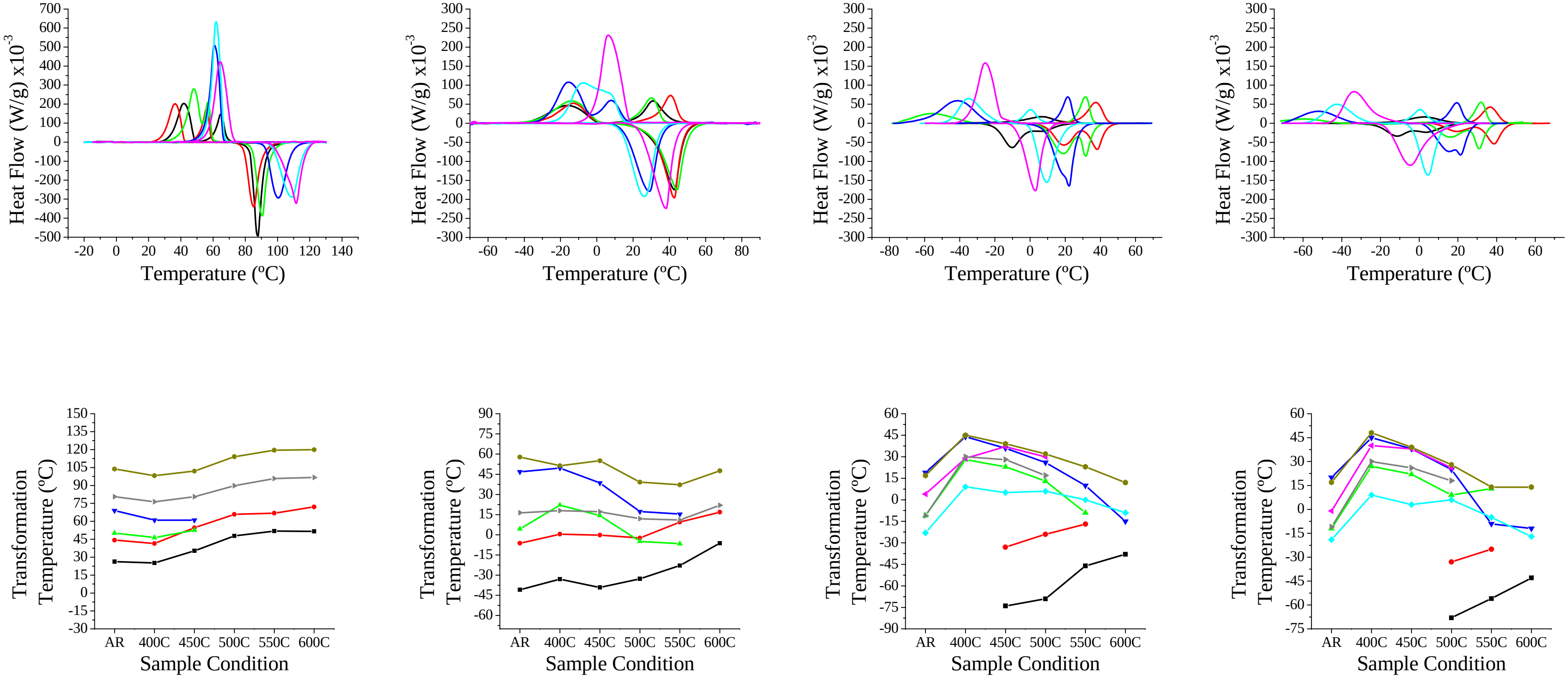






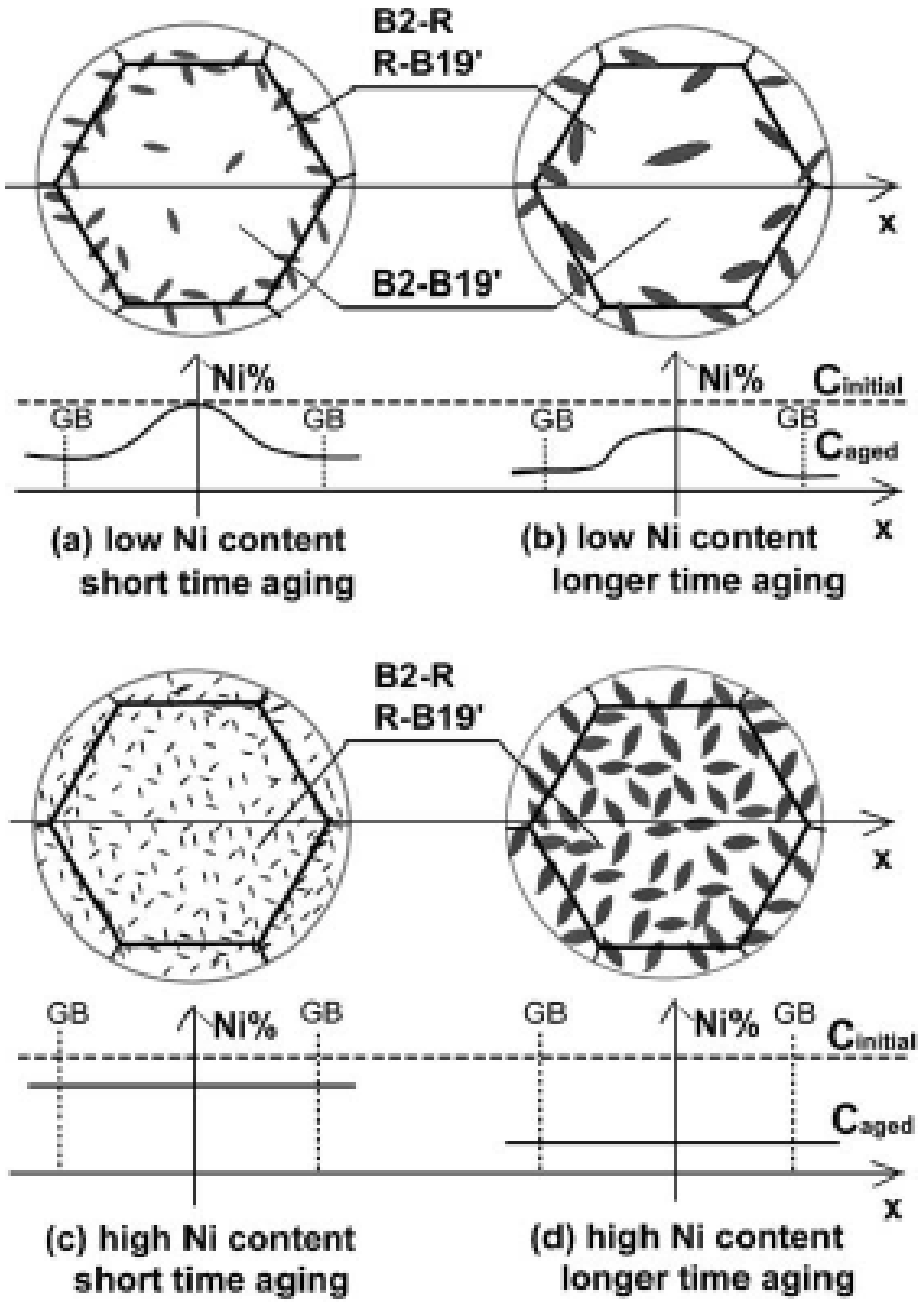
W. Tang, B. Sundman, R. Sandström, C. Qiu. *Acta materialia* **47** (1999) 3457-3468

Heat treatments / chemical composition



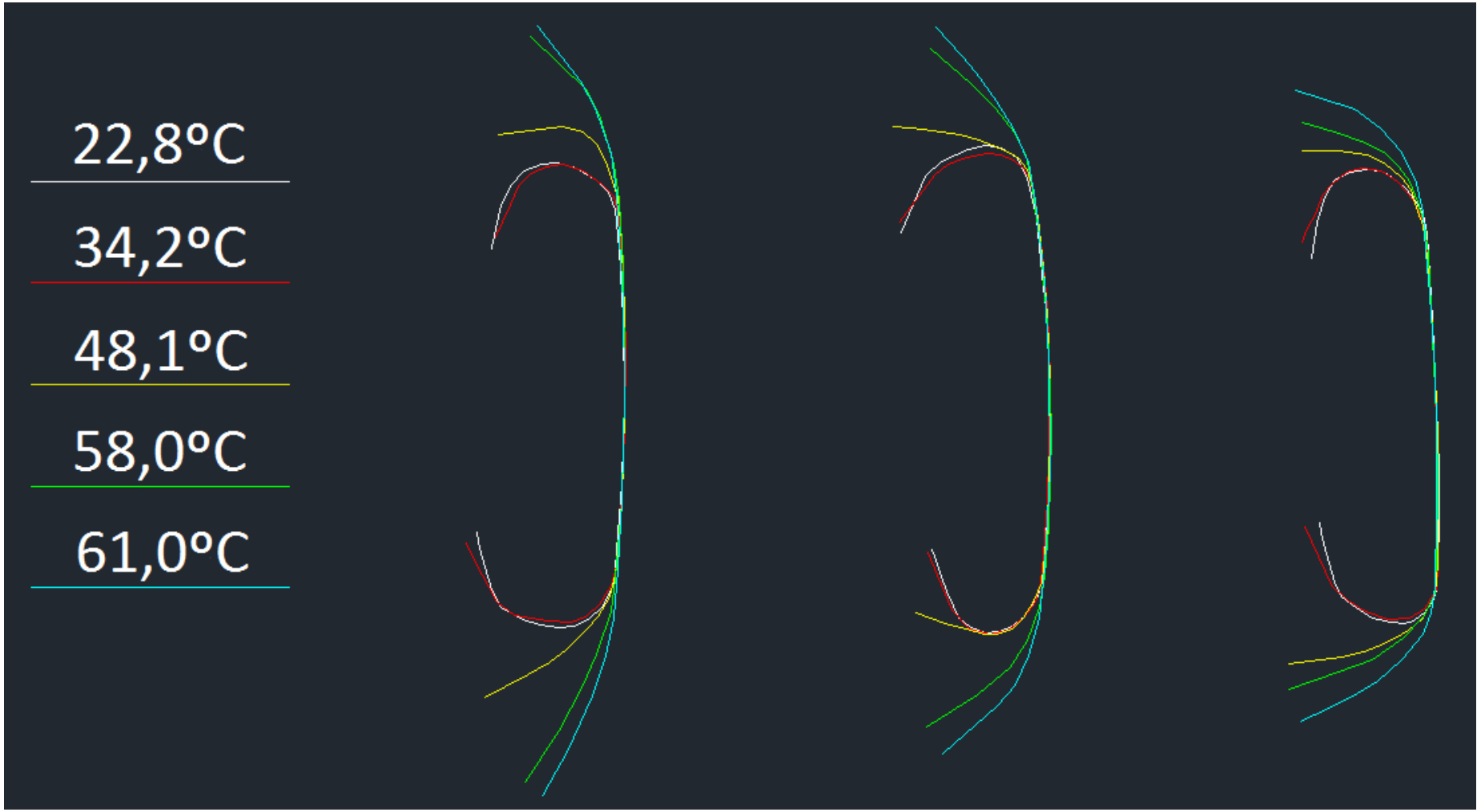
Increasing Ni content

Precipitation



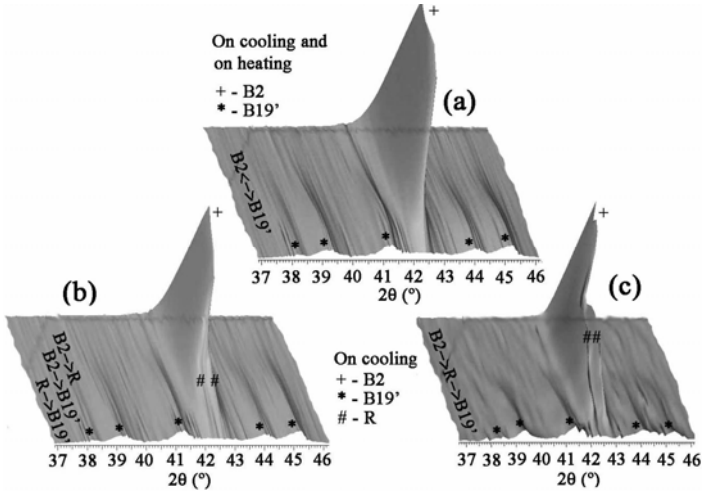
[347] FanG, ChenW, Yang S, Zhu J, RenX, Otsuka K. Acta Mater 2004;52:4351.

Functionally Graded Materials

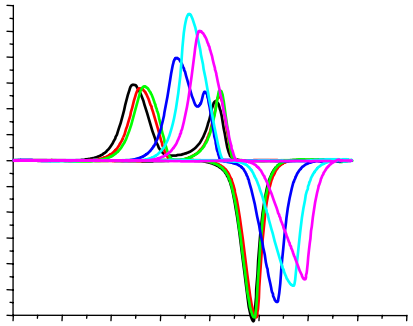


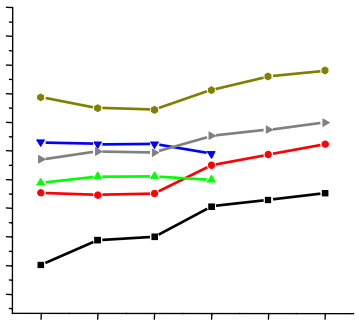
Heat Treatment Temperature: **350ºC** **450ºC** **550ºC**

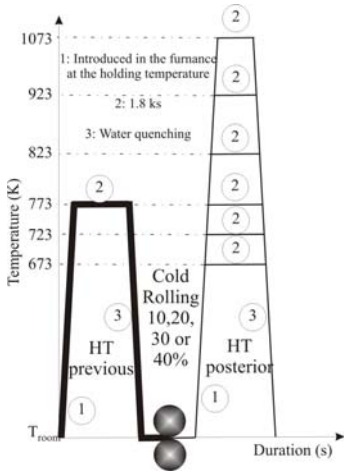
Thermomechanical treatments

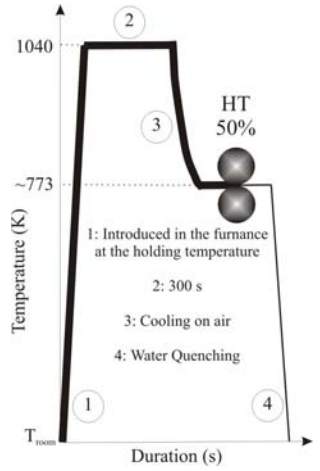


Sample Condition	Phase Transformation on Cooling / on Heating				
	Alloy "H" (49.4 – 49.6 at% Ni)	Alloy "M" (49.8 – 50.0 at% Ni)	Alloy "B" (50.2 – 50.4 at% Ni)	Alloy "S" (50.8 at% Ni)	Alloy "N" (51.0 at% Ni)
AR	×× / ⊕	×× / +	×× / +	×× / +	×× / +
400°C	×× / ⊕	×× / +	×× / +	×× / +	×× / +
450°C	× / ⊕	×× / +	×× / +	×× / +	×× / +
500°C	⊗ / ⊕	× / ⊕	× / +	×× / +	×× / +
550°C	⊗ / ⊕	× / ⊕	× / +	×× / +	×× / +
600°C	⊗ / ⊕	⊗ / ⊕	⊗ / ⊕	× / +	× / +

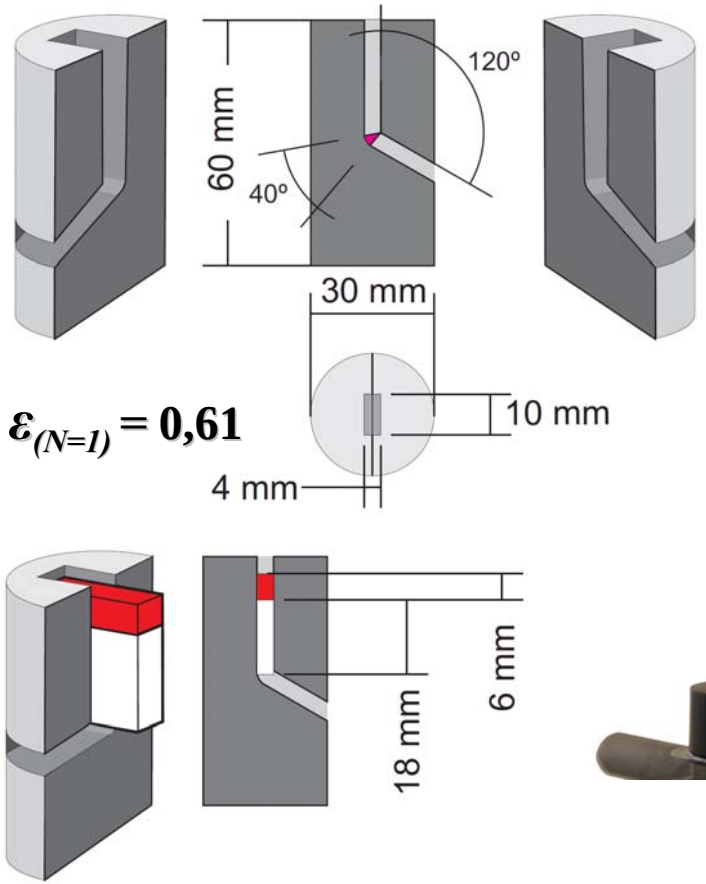






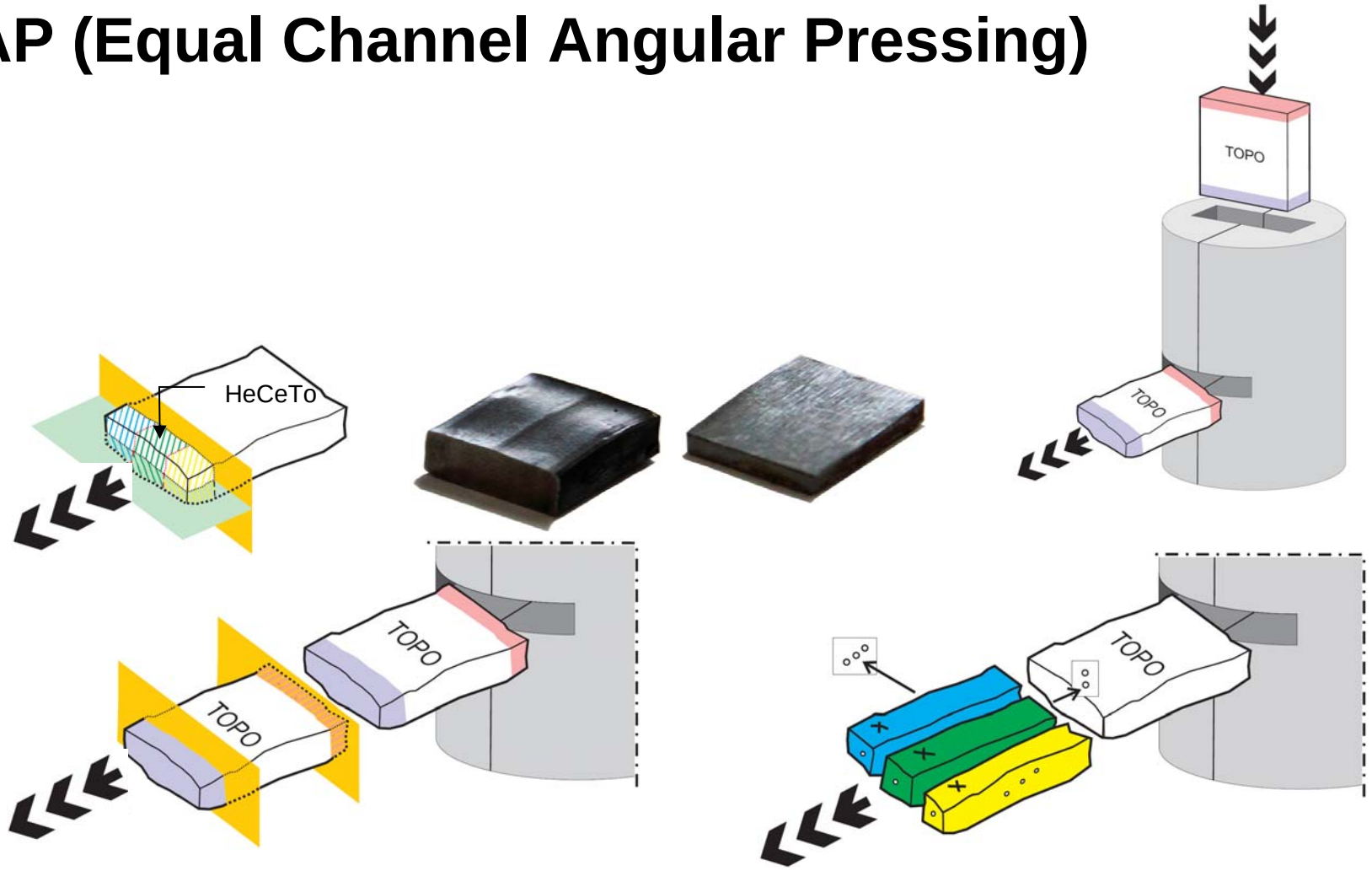


Severe Plastic Deformation
ECAP (Equal Channel Angular Pressing)

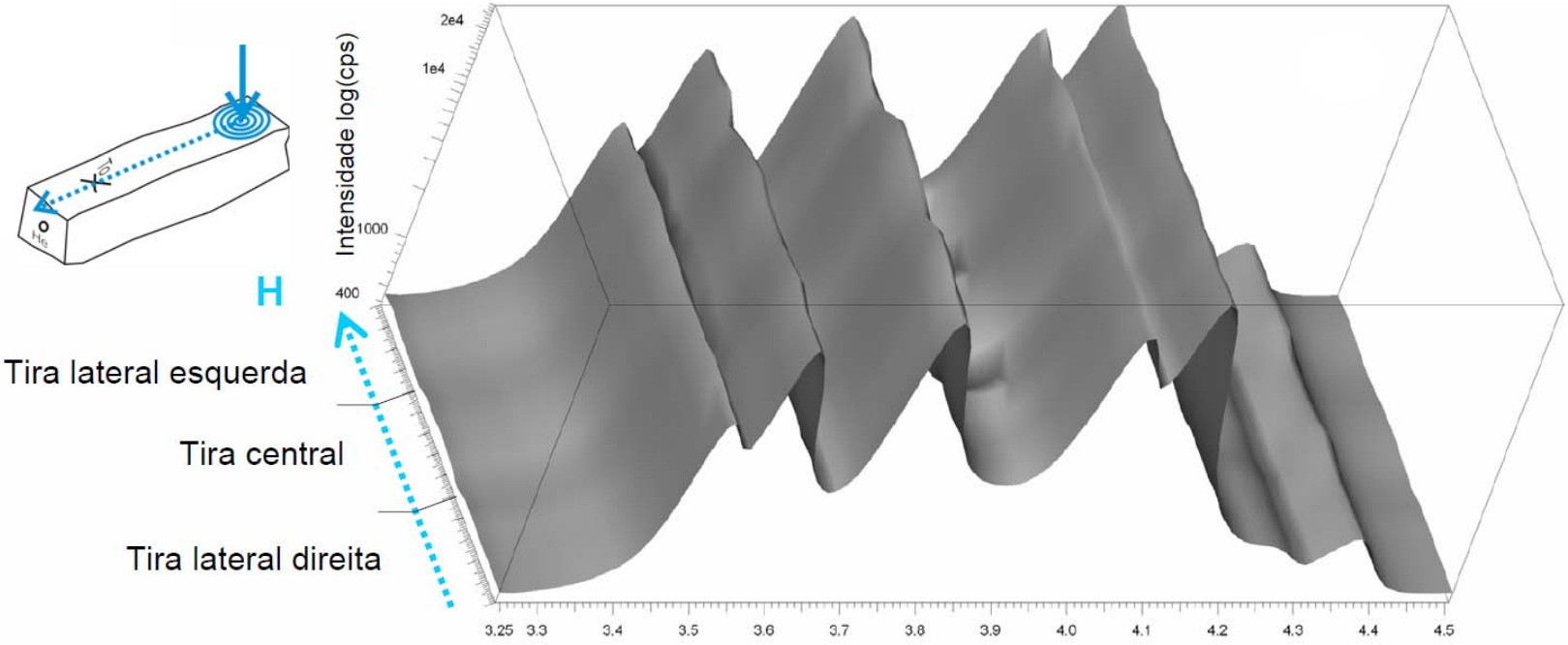


$\varepsilon_{(N=1)} = 0{,}61$

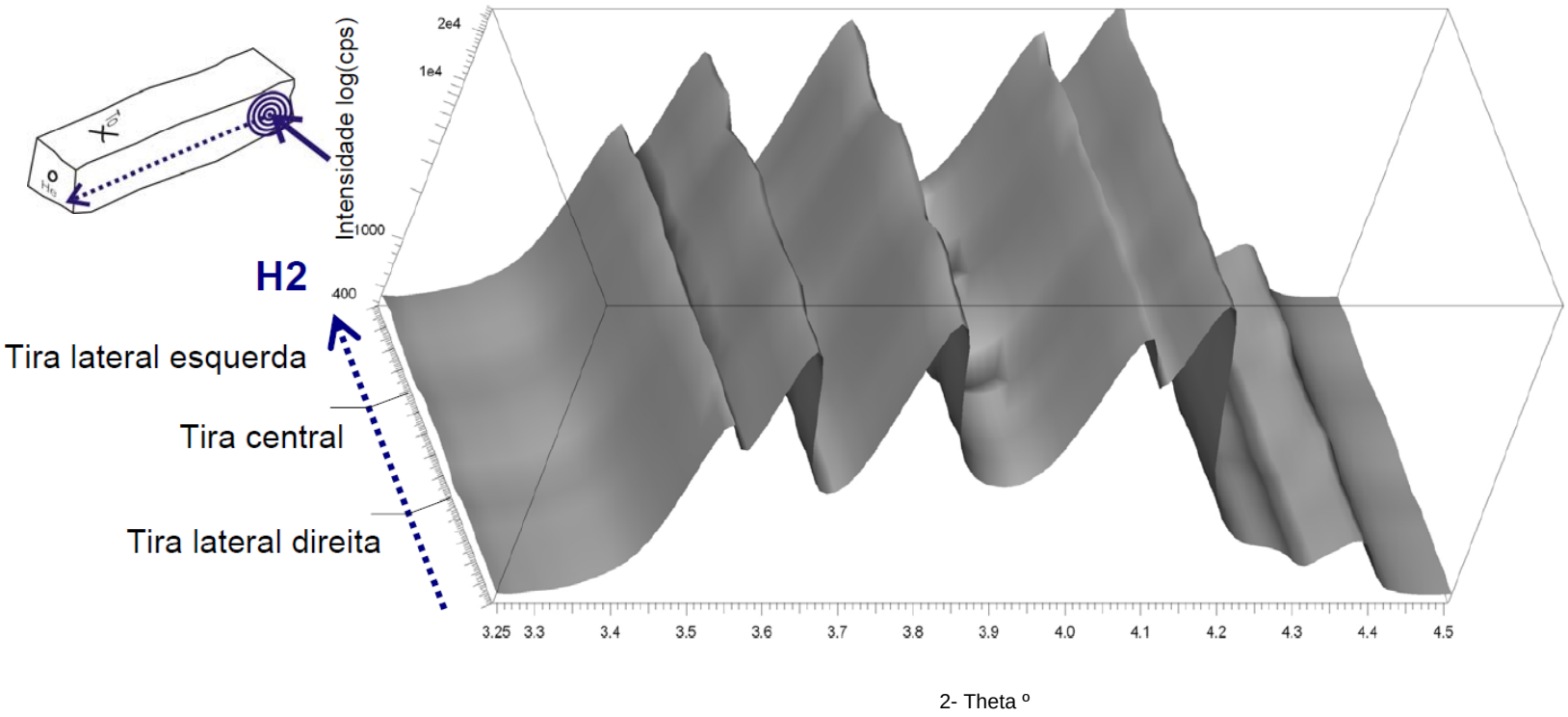
Severe Plastic Deformation
ECAP (Equal Channel Angular Pressing)



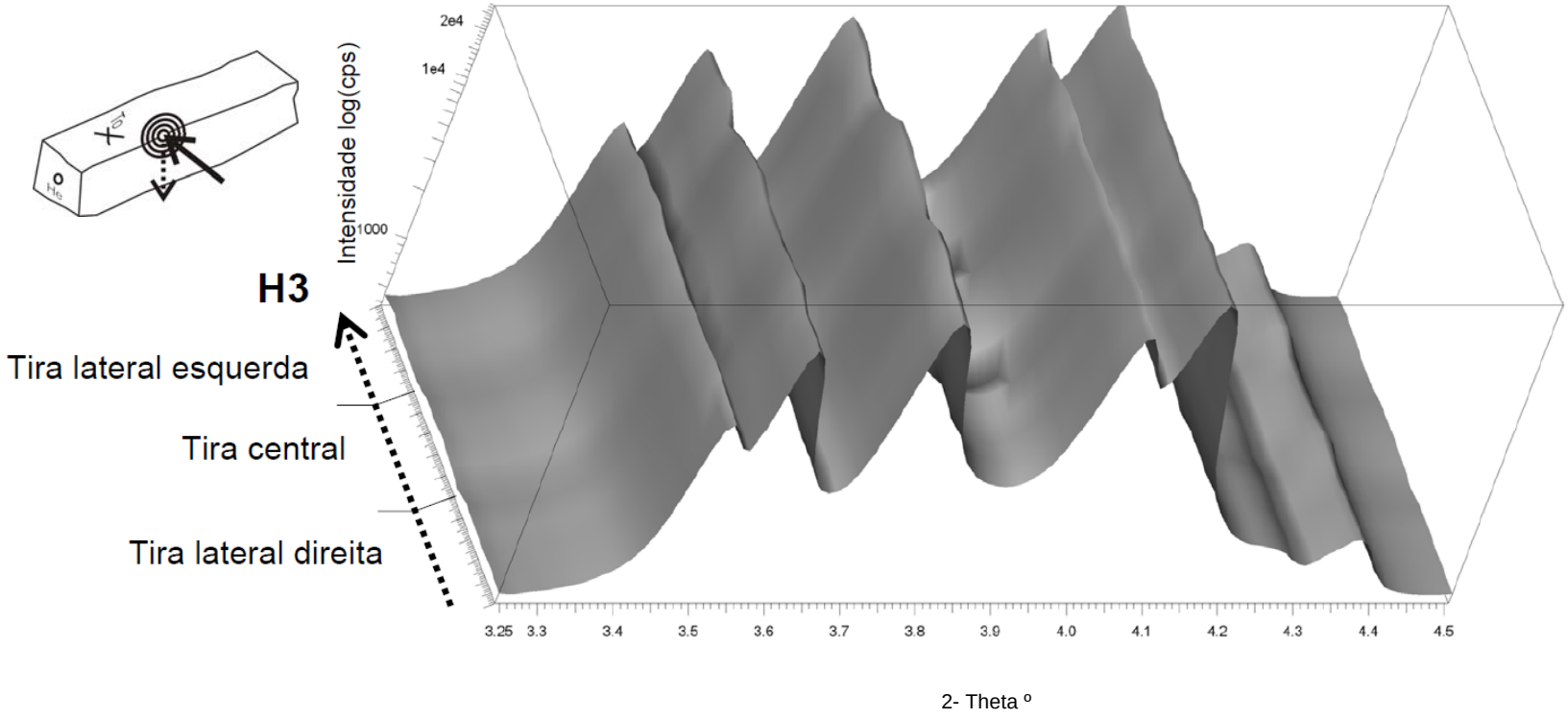
XRD


H
Tira lateral esquerda
Tira central
Tira lateral direita
Intensidade log(cps)
2e4
1e4
1000
400
3.25
3.3
3.4
3.5
3.6
3.7
3.8
3.9
4.0
4.1
4.2
4.3
4.4
4.5
2- Theta º

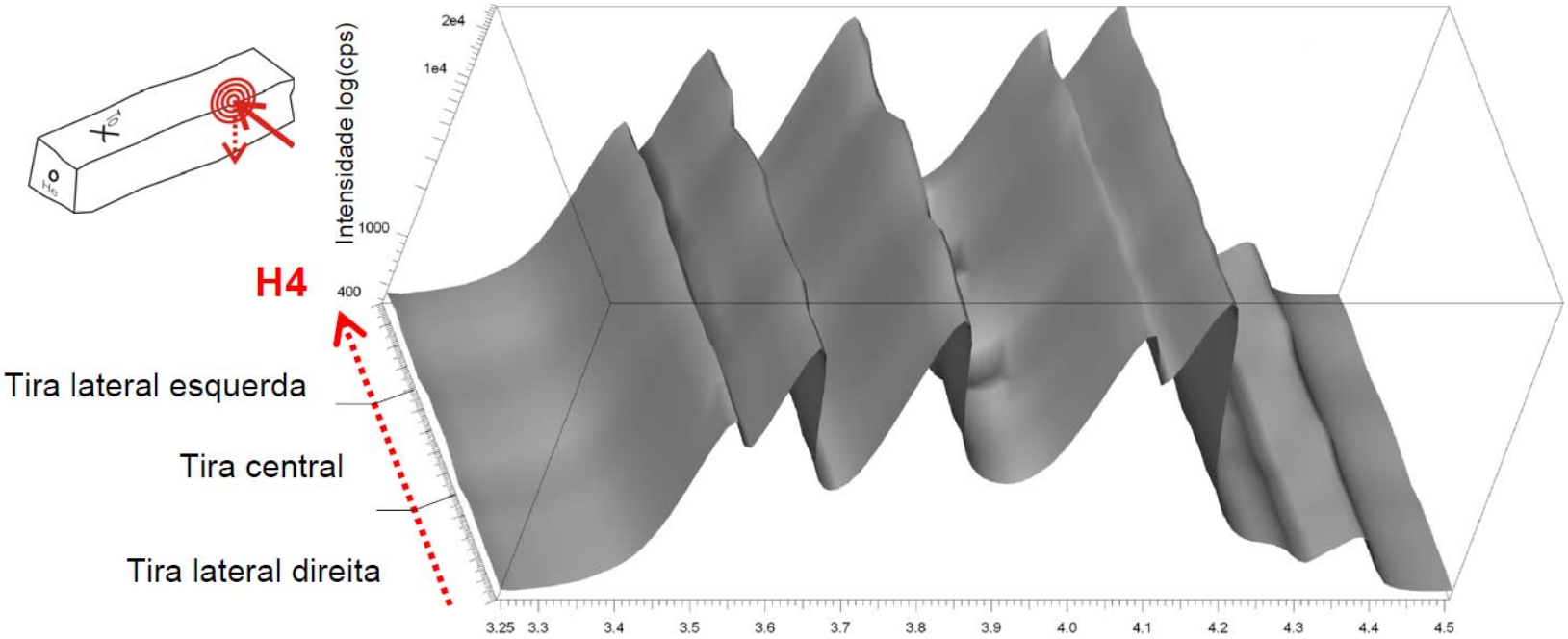
Resultados


H2
Tira lateral esquerda
Tira central
Tira lateral direita
Intensidade log(cps)
2e4
1e4
1000
400
3.25
3.3
3.4
3.5
3.6
3.7
3.8
3.9
4.0
4.1
4.2
4.3
4.4
4.5
2- Theta º

Resultados


H3
Tira lateral esquerda
Tira central
Tira lateral direita
Intensidade log(cps)
2e4
1e4
1000
3.25 3.3 3.4 3.5 3.6 3.7 3.8 3.9 4.0 4.1 4.2 4.3 4.4 4.5
2- Theta º

Resultados


H4
Tira lateral esquerda
Tira central
Tira lateral direita
Intensidade log(cps)
2e4
1e4
1000
400
3.25
3.3
3.4
3.5
3.6
3.7
3.8
3.9
4.0
4.1
4.2
4.3
4.4
4.5
2- Theta º

Powder Metallurgy

MARES — Mechanically Activated Reactive Extrusion Synthesis

MARFOS — Mechanically Activated Reactive FOrging Synthesis

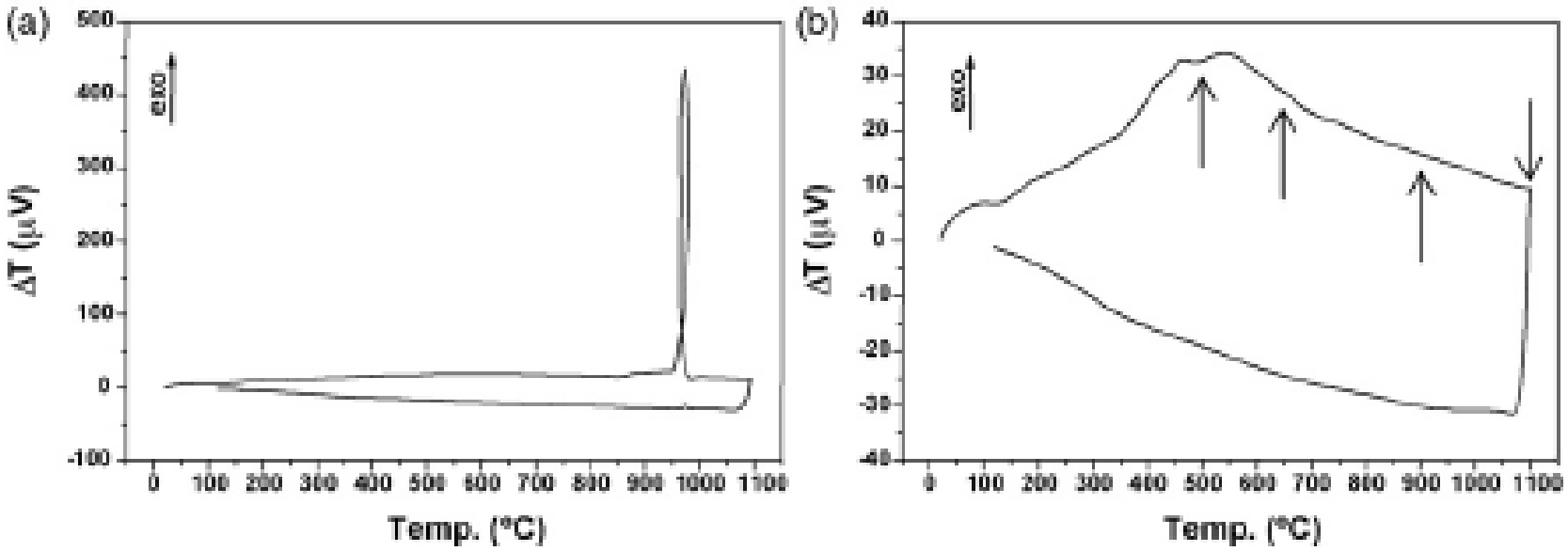


Fig. 4. DTA curves for (a) initial Ni–50Ti powder mixture and (b) the mechanically alloyed powder for 4 h.

Acknowledgements

A. Pereira (CENIMAT)
A.S. Paula (CENIMAT, now with Universidade Federal Fluminense – UFF),
C. Baetz (ROBL – ESRF; HZDR),
F. Neves (CENIMAT, now with LNEG),
K.K. Mahesh (CENIMAT, now with Vivekananda College of Engineering & Technology),
M.T. Nogueira (CENIMAT),
N. Schell (P07-PETRA, HZG),
R.J.C. Silva (CENIMAT),
R.M.S. Martins (CENIMAT, ITN),

FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR


A METALURGIA NO CENIMAT
Portugal CTT
N20grs
A METALURGIA NO CENIMAT
Portugal CTT
N20grs
Portugal CTT
N20g

Thank you !