DSC Study of Martensite Transformation in TiPt alloys

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Council for Scientific and Industrial Research
Material Science and Manufacturing
Light Metals

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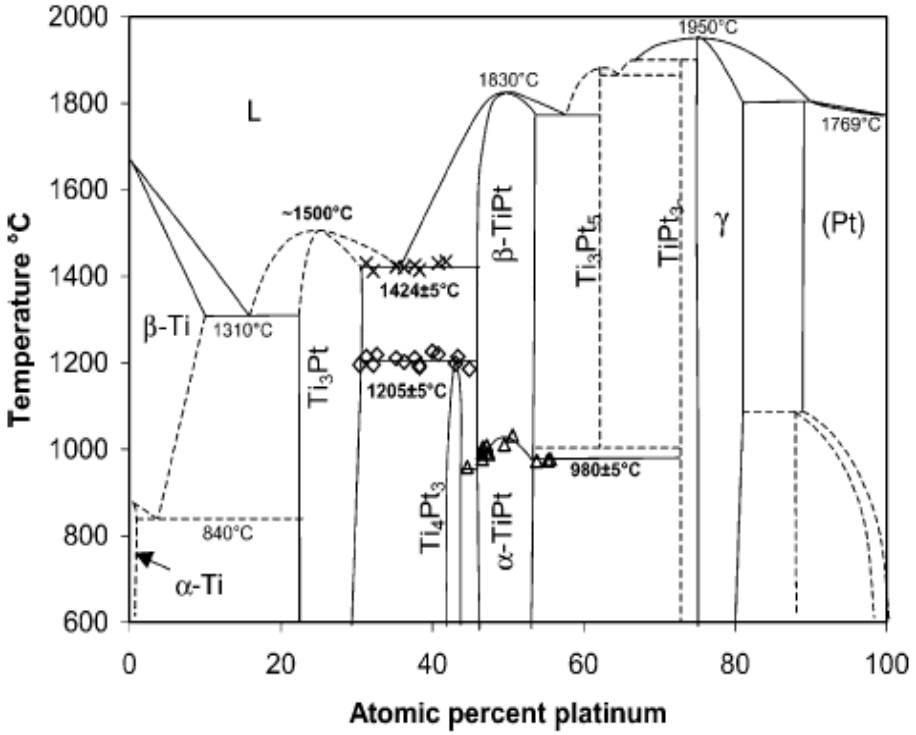
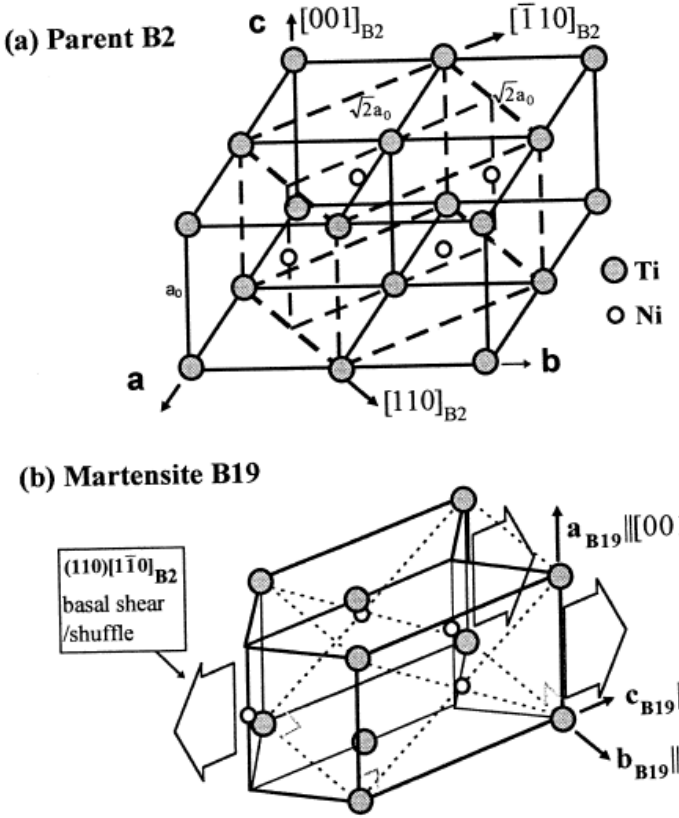
TiPt Martensite transformation





- TiPt exists as: β-B2 austenite above A_f, α-B19 or martensite below M_f
- Equiatomic composition: $M_S \approx 1030$ °C, $A_S \approx 1050$ °C
- Reversible displacive transformation makes TiPt candidate material for high temperature SMA

T. Biggs, M.B. Cortie, M.J. Witcomb, L.A. Cornish, Metall. & Mat. Trans. A , 2001, 32A:1881-86
K. Otsuka & X Ren, Intermet. 1999, 7:511-28

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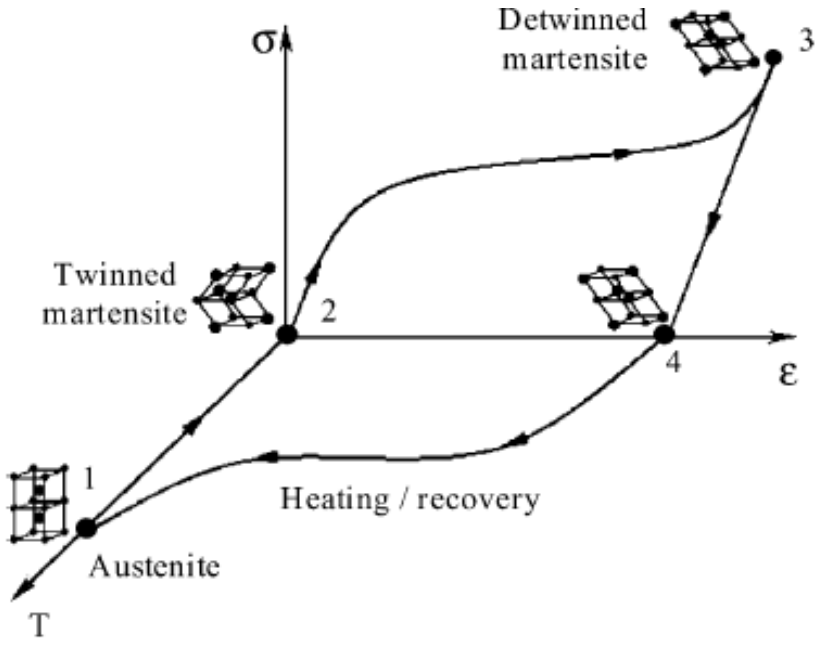
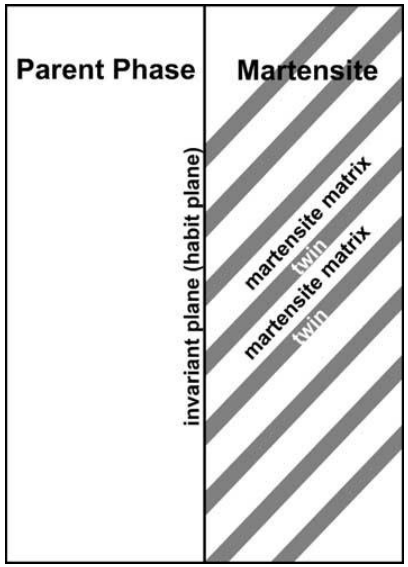
Shape Memory Effect





- Three forms of SMA depending on thermomechanical history: A, TM and DM
- Invariant plane between austenite and martensite phase maintains coherency between the phases and result in shape memory

Patoor et. al., Mechanics of Matt., 2006, 38::391-429
K. Otsuka & X Ren, Intermet. 1999, 7:511-28

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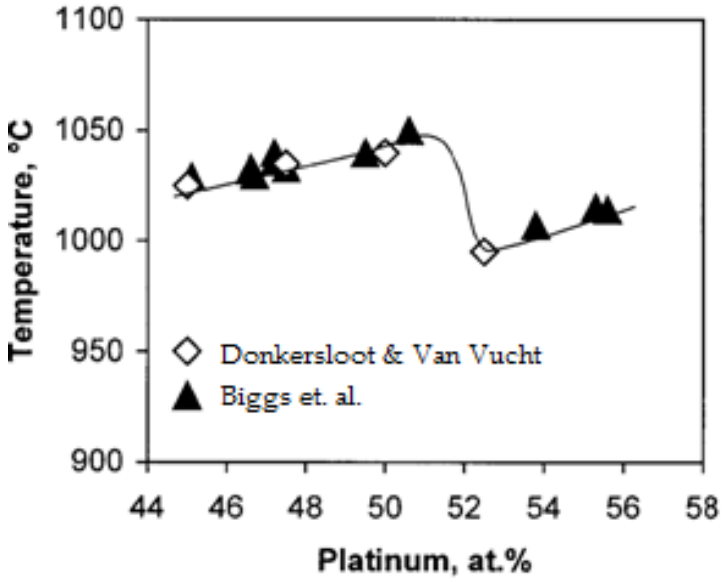
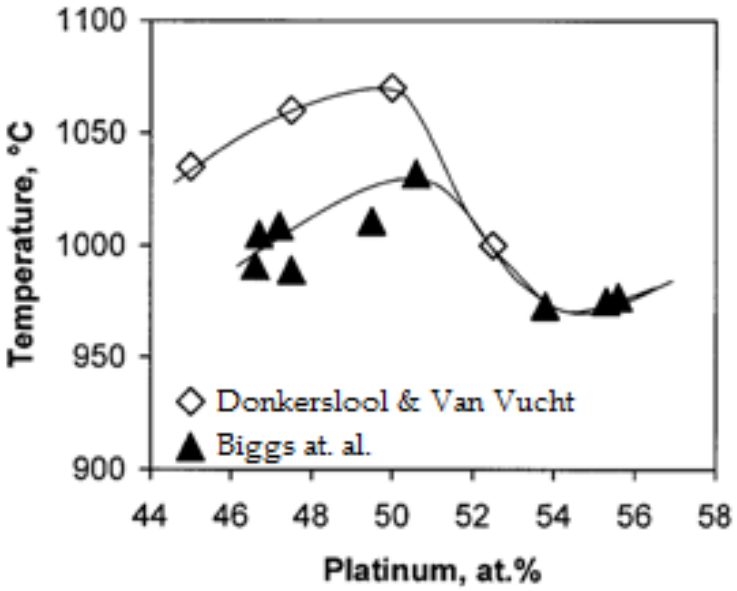
Composition dependence of transformation temperatures

- Variation of A_s with composition



- Variation of M_s with composition



T. Biggs, M.B. Cortie, M.J. Witcomb, L.A. Cornish, Metall. & Mat. Trans. A , 2001, 32A:1881-86

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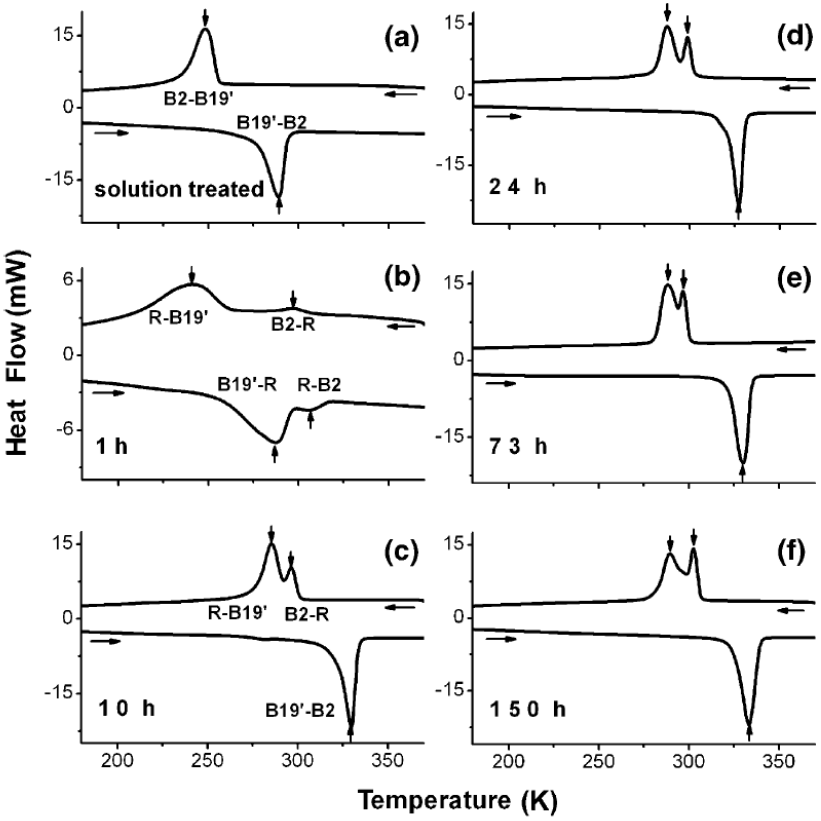
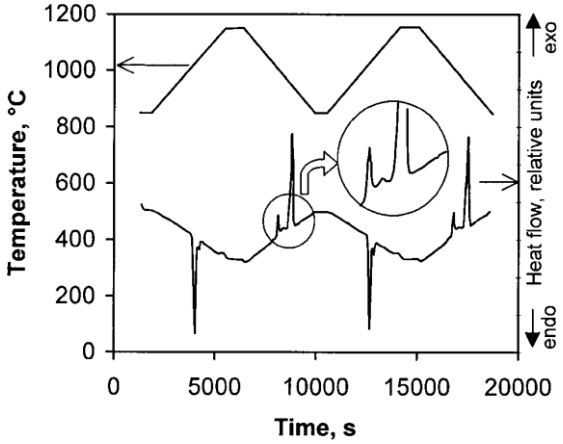
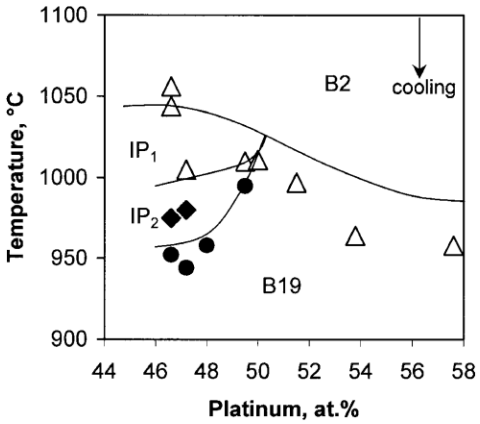
Intermediate phases during martensite transformations

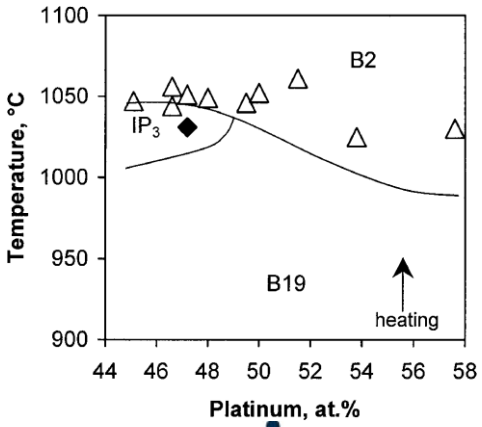
B2↔B19' TiNi transformation



B2↔B19 TiPt transformation







T. Biggs, M.B. Cortie, M.J. Witcomb, L.A. Cornish, Metall. & Mat. Trans. A , 2001, 32A:1881-86
K. Otsuka & X Ren, Prog. Mat. Scie., 2005, 50:511-75

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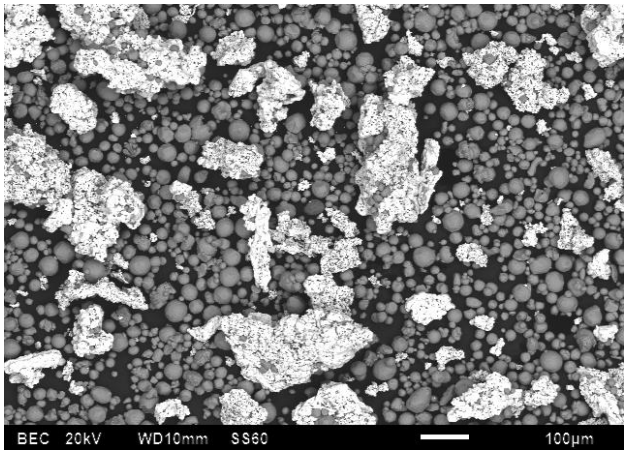
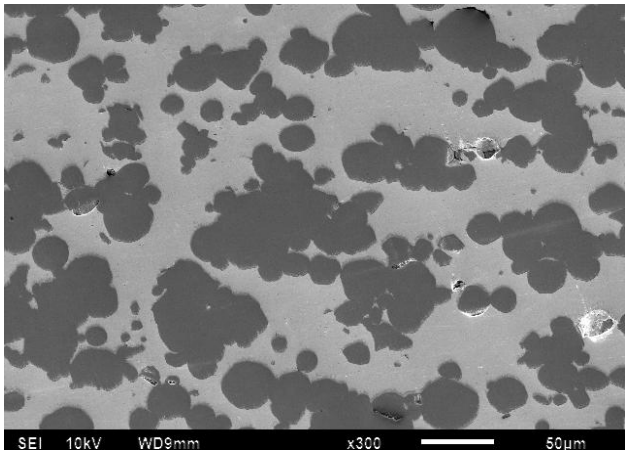
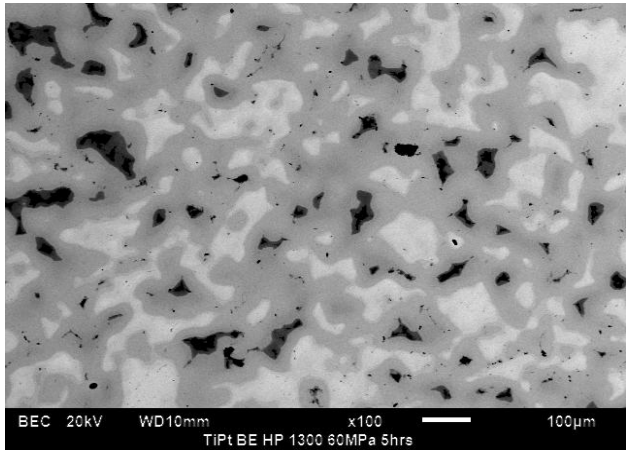
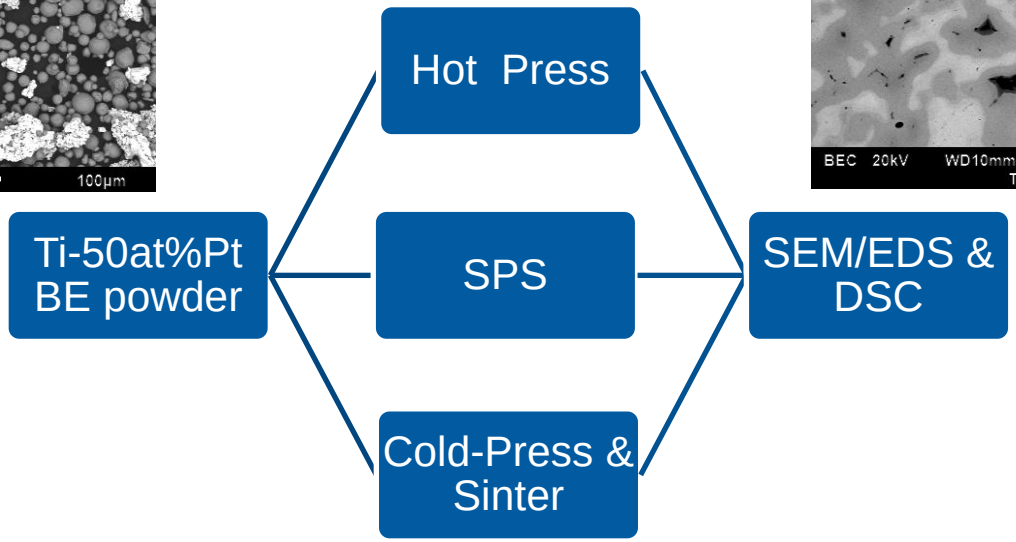
Experimental Procedure









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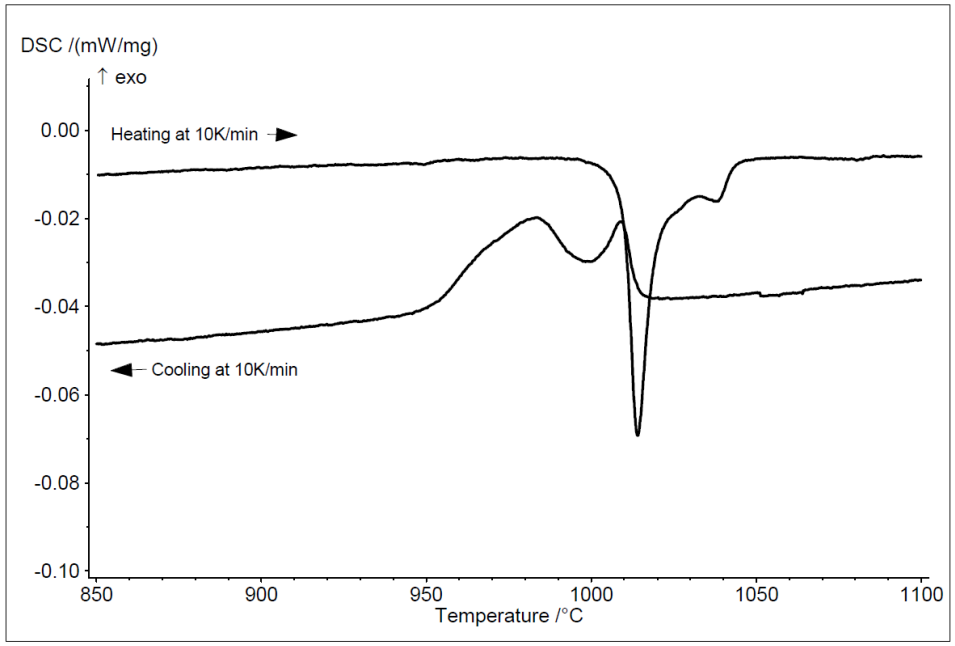
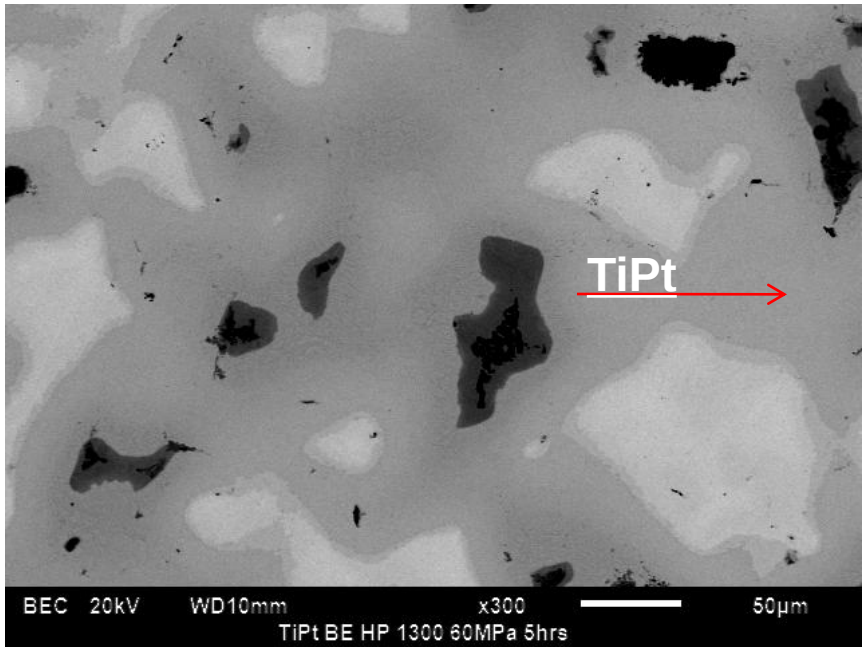
Spark Plasma Sintering

1200°C, 60 MPa



Element Line	Element Wt.%	Wt.% Error	Atom %	Atom % Error
Ti K	17.82	+/-0.17	46.90	+/- 0.45
Ti L	---	---	---	---
Pt L	82.18	+/-1.68	53.10	+/- 1.08
Pt M	---	---	---	---
Total	100.00		100.00	



- Incomplete homogenisation of the bulk
- Pt-rich TiPt phase is formed, coexisting with other phases
- DSC shows two overlapping peaks instead of one, possible two-stage TiPt martensite transformation

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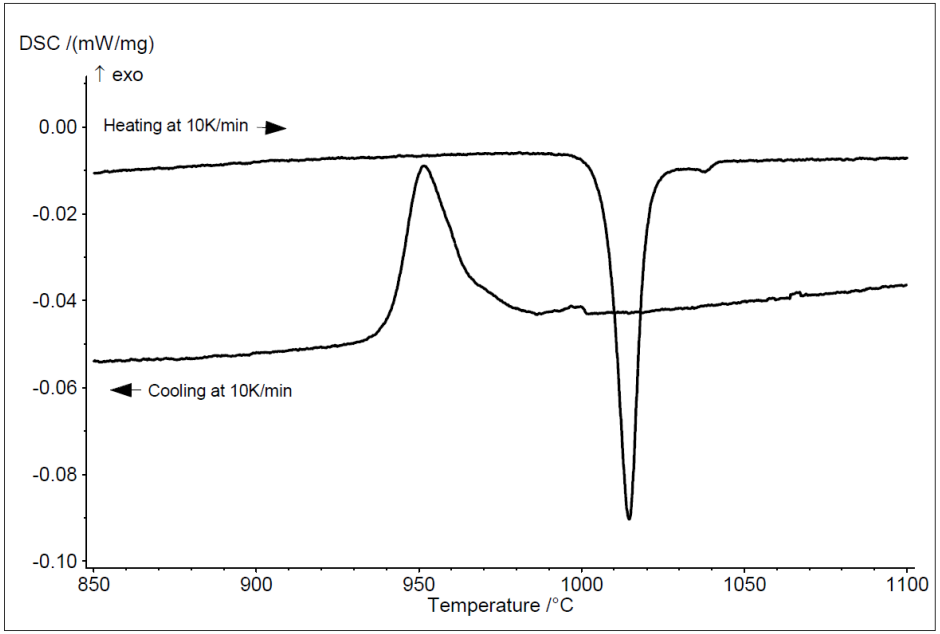
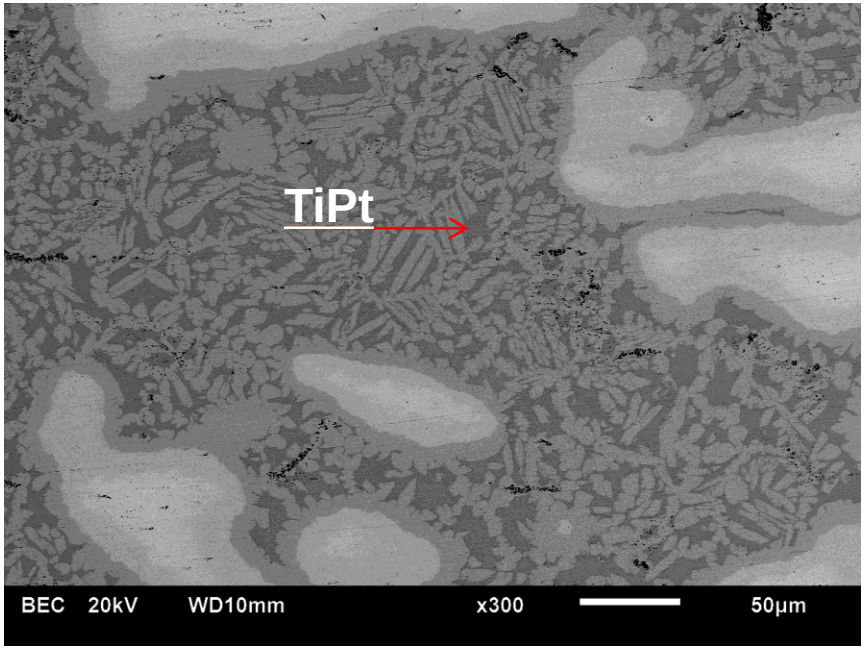
Spark Plasma Sintering

1400°C, 60 MPa



Element Line	Element Wt.%	Wt.% Error	Atom %	Atom % Error
Ti K	18.36	+/-0.43	47.81	+/- 1.13
Pt M	81.64	+/-0.92	52.19	+/- 0.59
Total	100.00		100.00	



- Second endothermic peak on heating and first exothermic peak on cooling become less prominent with increasing sintering (T)
- Ti-rich and Pt-rich phases still present, alloy not fully martensitic

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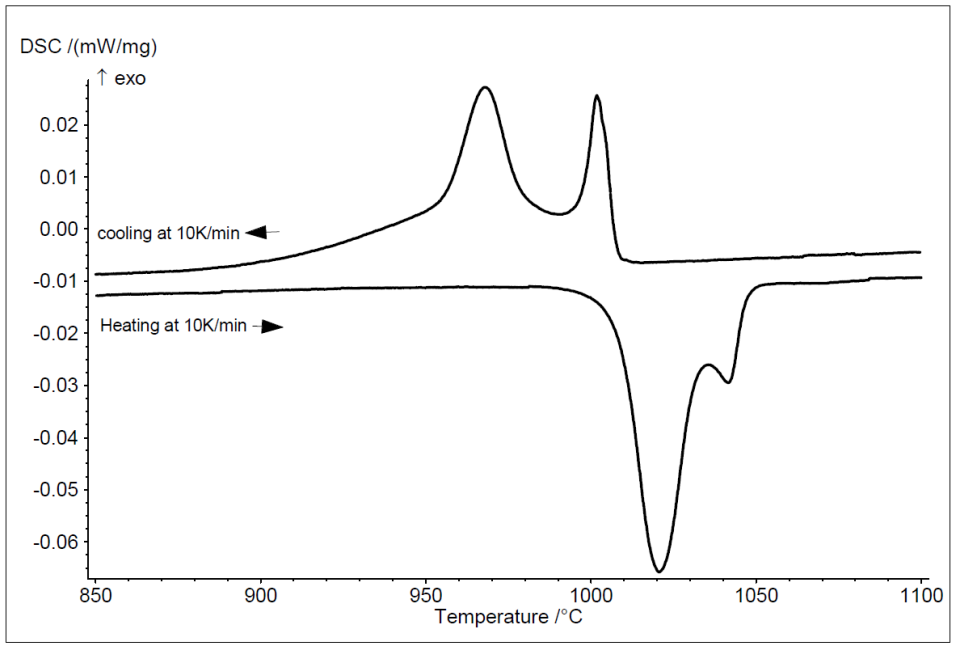
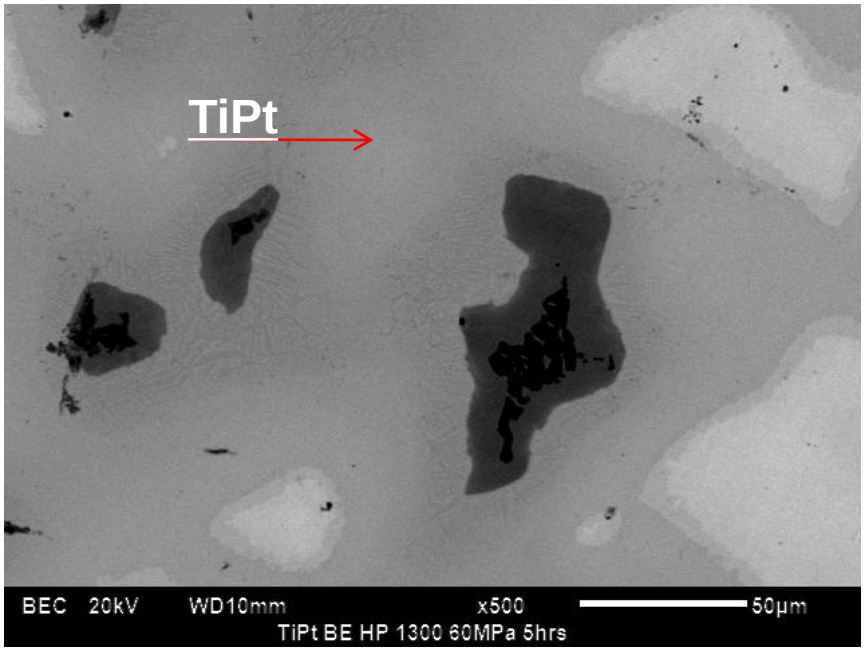
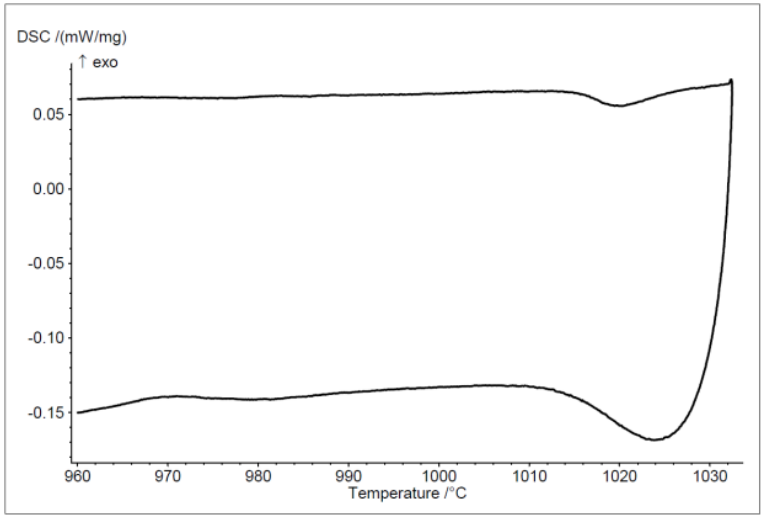
Hot Press Sintering

1300°C, 5hrs, 60MPa

Element Line	Element Wt.%	Wt.% Error	Atom %	Atom % Error
Ti K	18.34	+/-0.20	47.77	+/- 0.53
Pt L	81.66	+/-1.92	52.23	+/- 1.23
Total	100.00		100.00	







- Isolation of overlapping peaks showing relation between first endothermic peak and second exothermic peak

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Conclusions

- Pt-rich TiPt phase was formed by HP and SP sintering, the press and sinter method was less successful. Presence of Ti-rich and Pt-rich phases coexisting with TiPt phase shows incomplete homogenisation.

- Volume fraction of TiPt phase formed by various solid-state diffusion methods ranges from 40-55%.

- DSC shows two-stage B2↔B19 transformation, an intermediate phase of unknown structure forms during the phase transition.

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