PHASE CHARACTERISATION IN SPARK PLASMA SINTERED TiPt ALLOY

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CSIR/MSM/MMP

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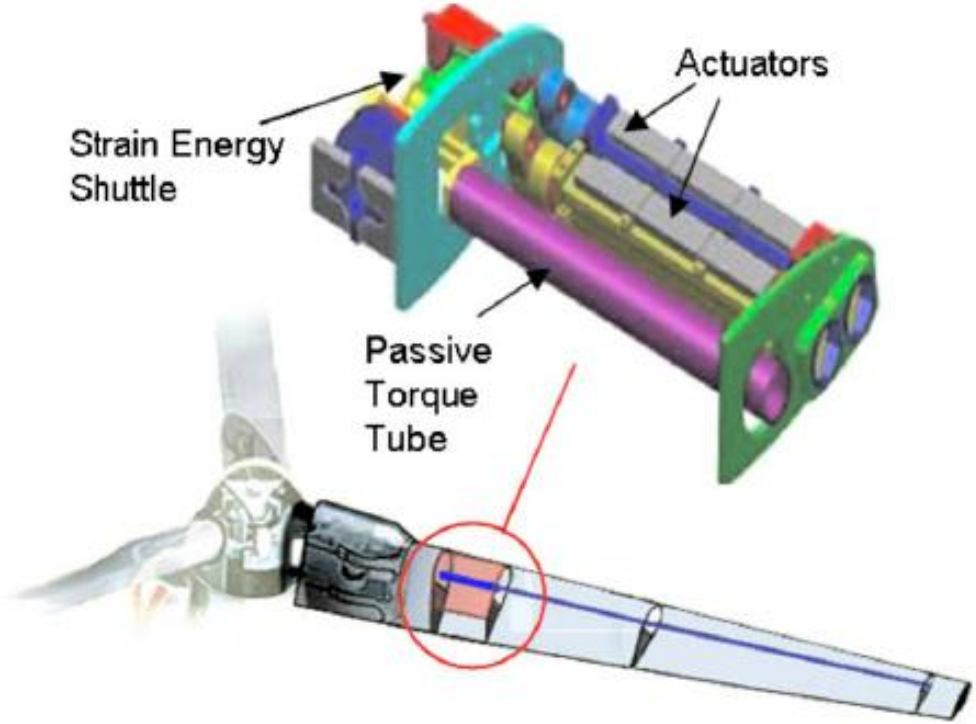
Shape Memory Alloys (SMAs)

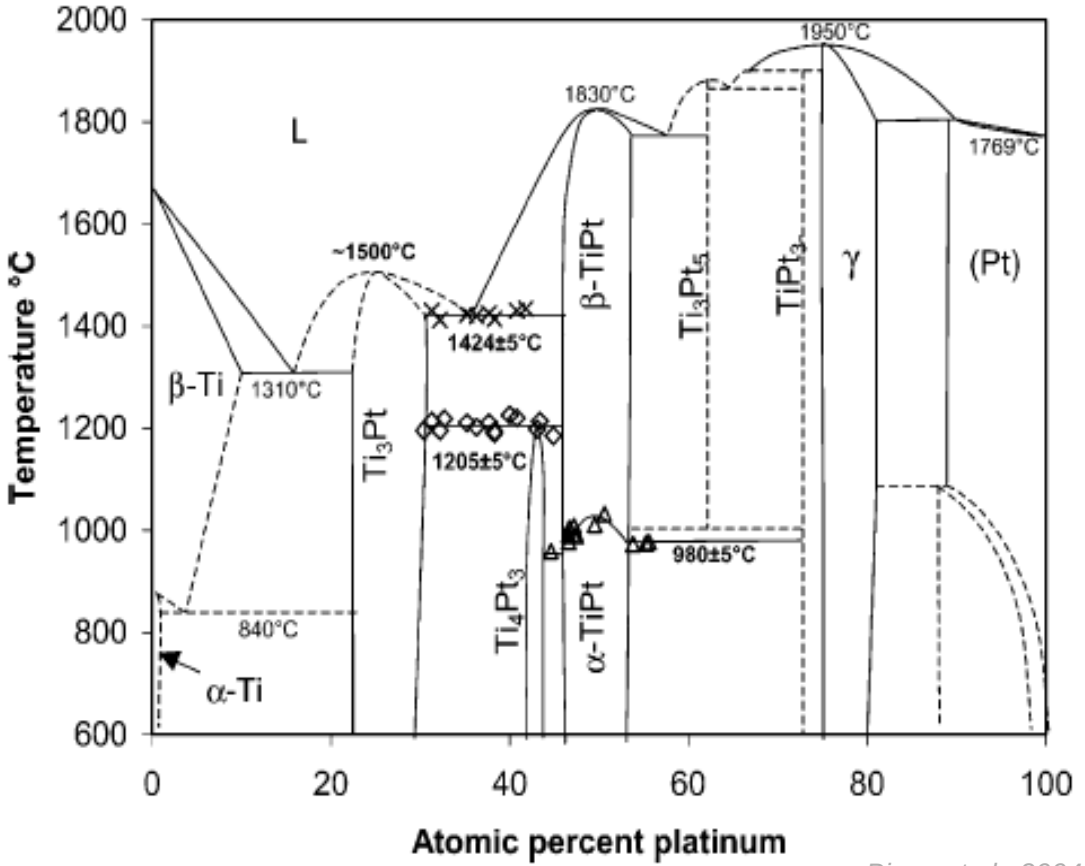
- SMAs are capable of “remembering” their original shape after deformation and subsequent input of thermal energy
- Shape memory depends on a *displacive phase transformation*
- Used for couplings, seals, actuators, fire safety valves



Calkins, 2010

TiPt High Temperature SMAs

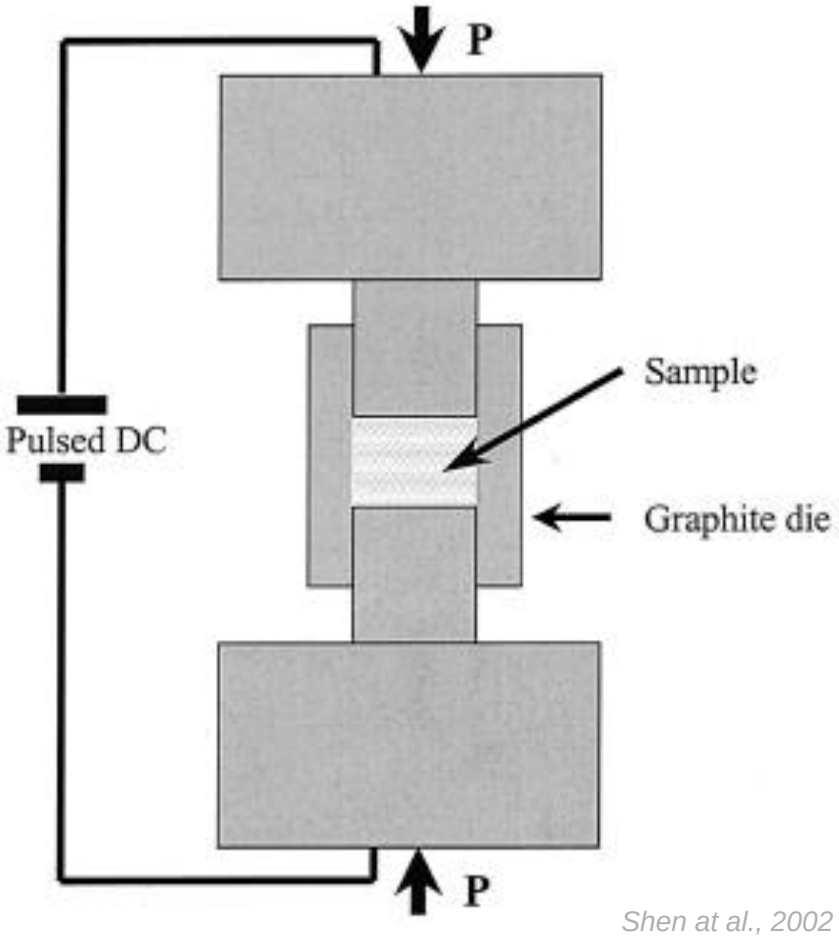
- Equiatomic TiPt exists as:
  - high temperature BCC austenite β-phase
  - low temperature orthorhombic martensite α-phase
- $T_M \approx 1050^\circ C$ at equiatomic composition
- Possible use in actuation for jet engines and other high temperature process control applications



Biggs et al., 2004

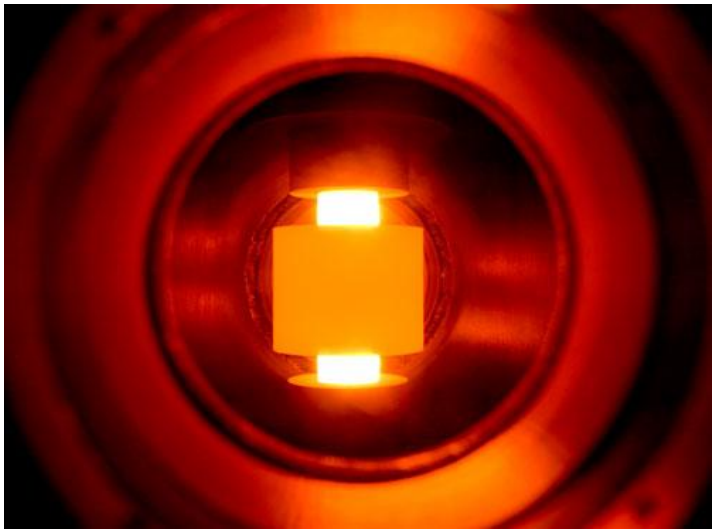
Spark Plasma Sintering

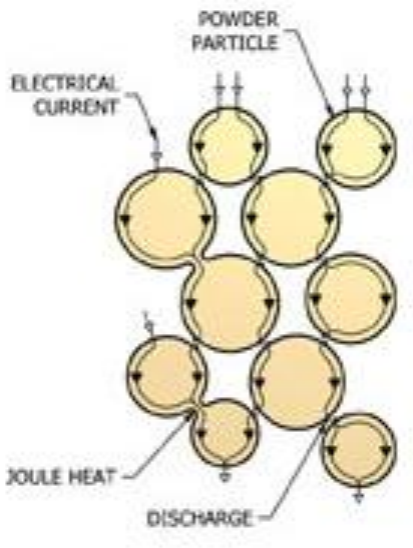
- Low voltage, pulsed high DC current to activate consolidation
- High uniaxial pressure for compaction
- Spark plasma between particles and Joule heating (up to 10 000° C)
- Fast heating rates and minimum grain growth, better than PLS, HP or HIP.
- SPS is easy to operate, requires no binders, high capital cost is offset by low running cost



Shen at al., 2002

Spark Plasma Sintering



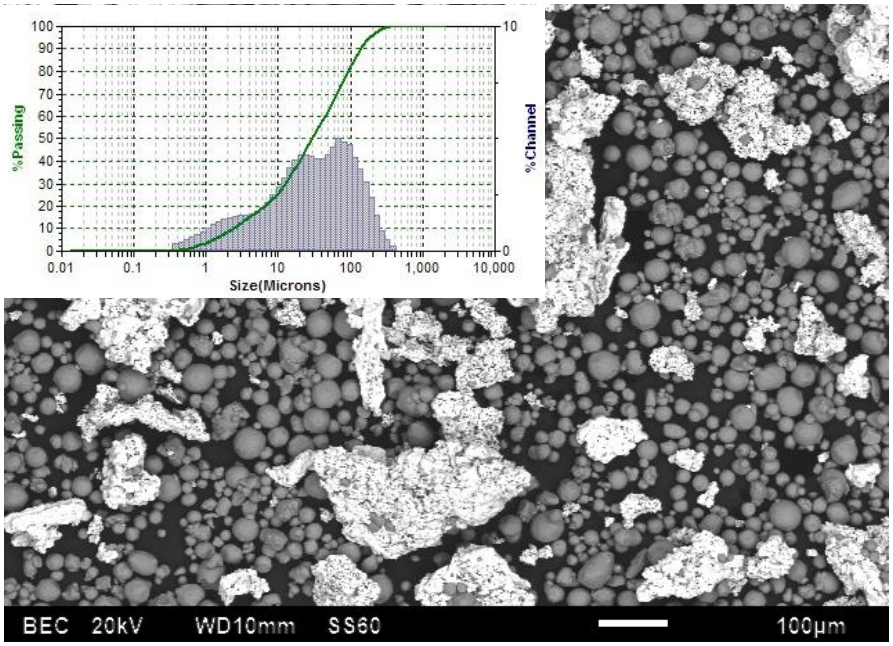


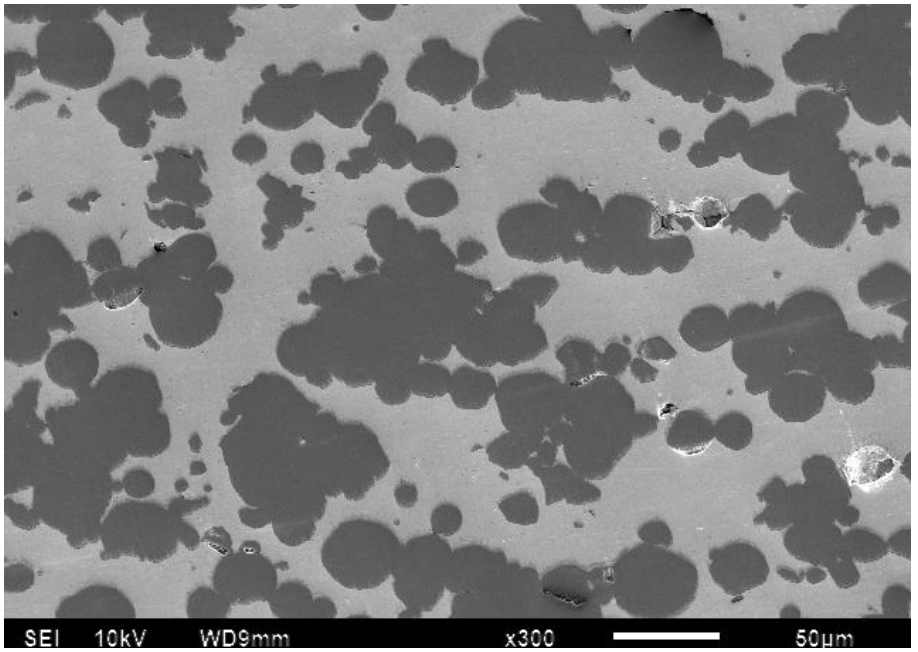
- Spark plasma and Joule heating results in vaporisation of particle surface and surface melting of particle just behind the vaporised layer
- Liquid surfaces are drawn together to form “necks”
- Radiant Joule heat and pressure drives “neck” growth and material transfer

Objective

- Produce TiPt alloy compacts by Spark plasma sintering (SPS) of equiatomic blended elemental (BE) Ti and Pt powders
- Produce homogenous TiPt alloy phase

Starting Powder





- $Ti_{50}Pt_{50}$ (atomic %)
- ≥ 99.5 % purity powders

- $Ti_{50}Pt_{50}$ (atomic %) as pressed

Sintering Conditions

- Place powder in graphite die setting

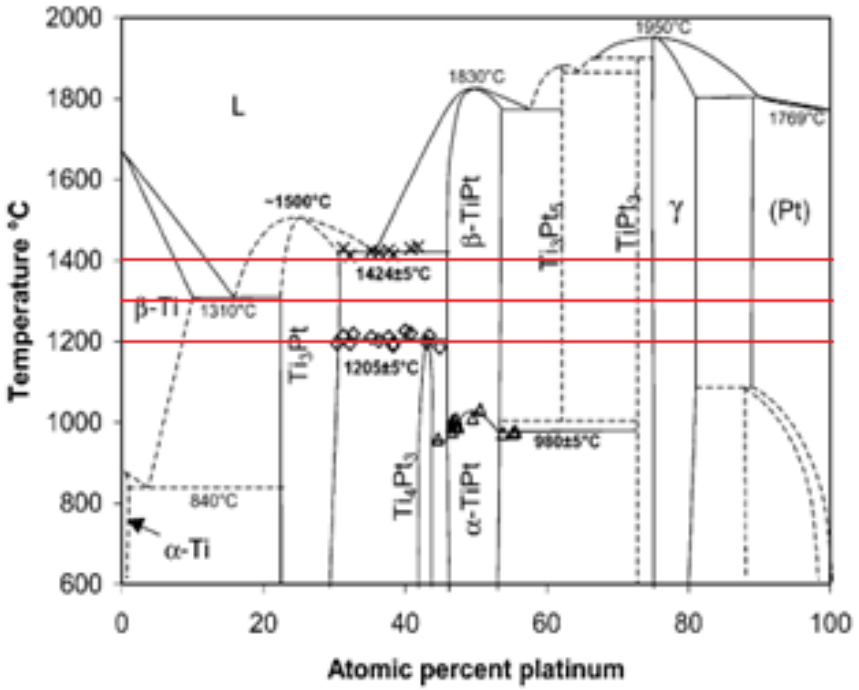
- Program temperature-pressure ramp up and hold settings according to the values below:

	Temperature (° C)	Time (minutes)	Pressure (MPa)
Sample 1	1200	25	60 MPa
Sample 2	1300	15	60 MPa
Sample 3	1300	25	60 MPa
Sample 4	1300	30	60 MPa
Sample 5	1400	10	60 MPa

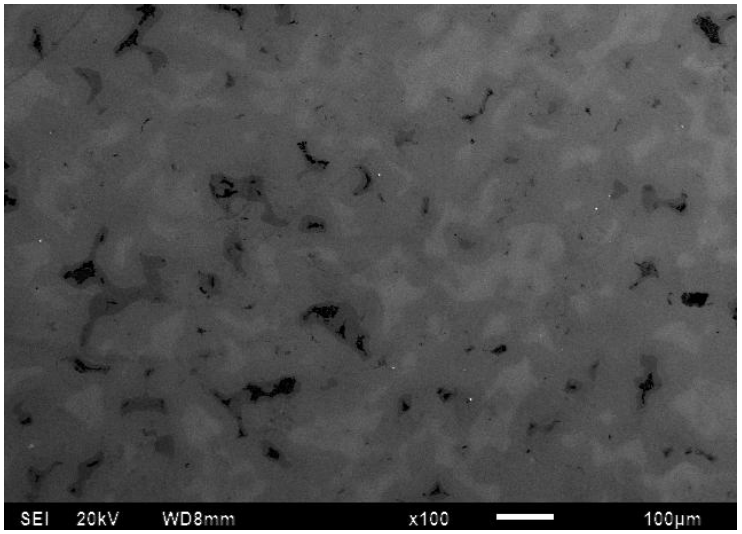
- Full density was achieved in all samples

Solid State Sintering

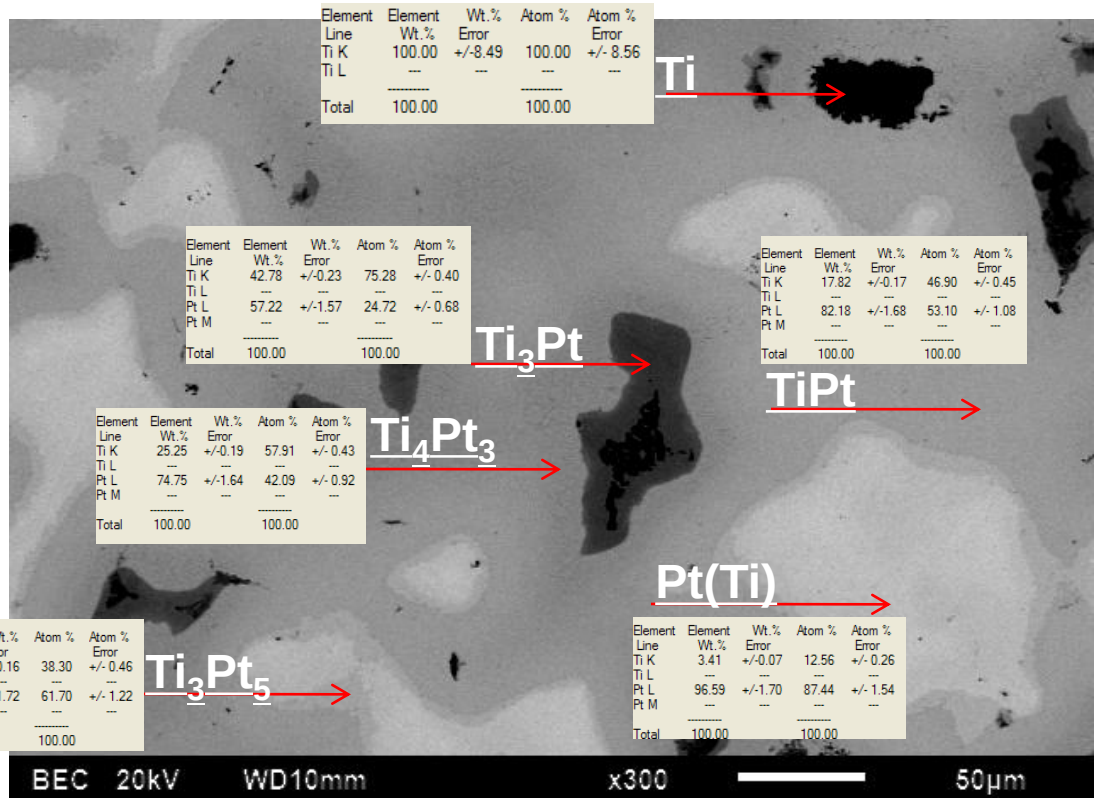
- During solid state sintering of Ti and Pt, sintering is controlled by interdiffusion of the components
- All equilibrium and non-equilibrium phases at the sintering temperature are expected to form
- With time, the alloy will homogenise to the bulk starting composition



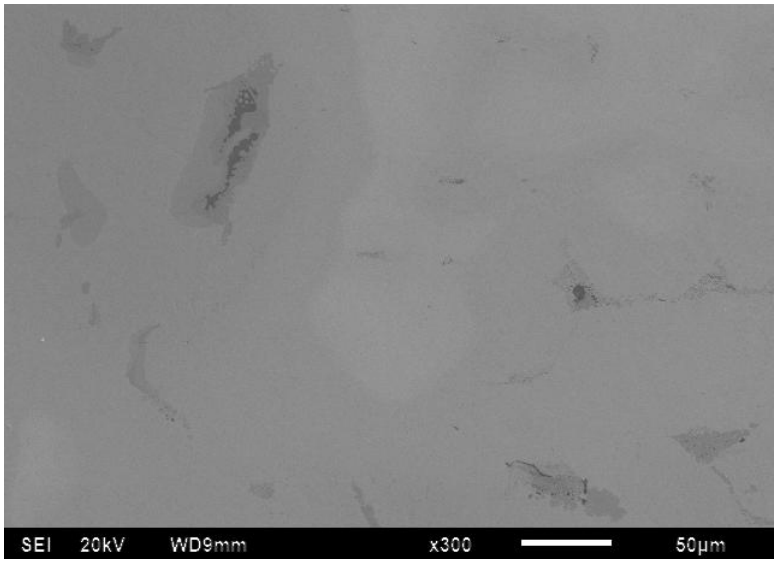
SPS: 1200 ° C_25mins_60MPa



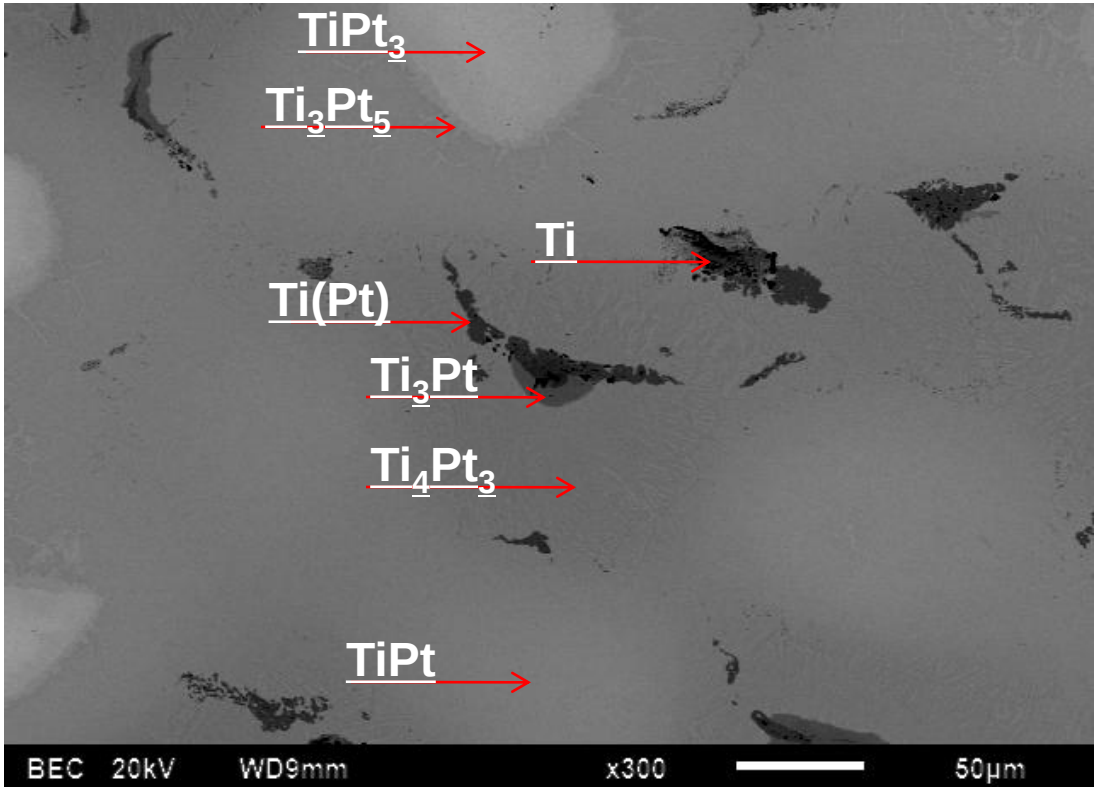
- Fully sintered
- Solid state reaction controlled



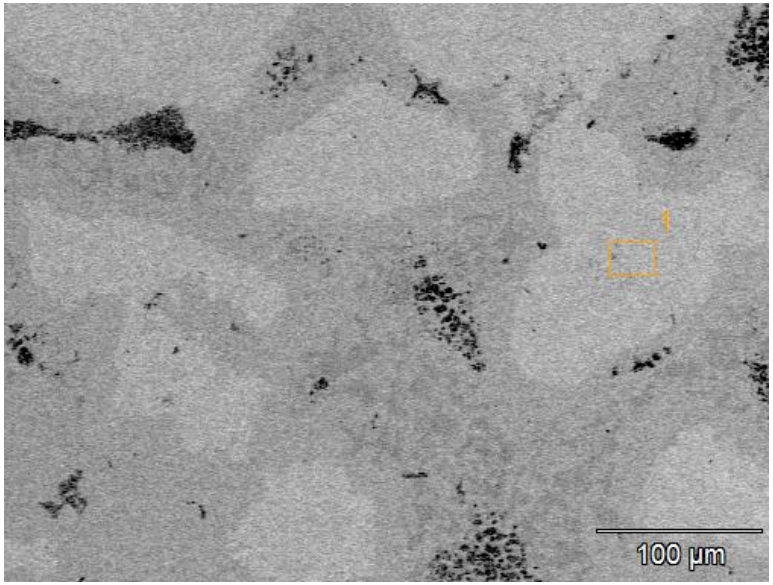
SPS: 1300 ° C_25mins_60MPa



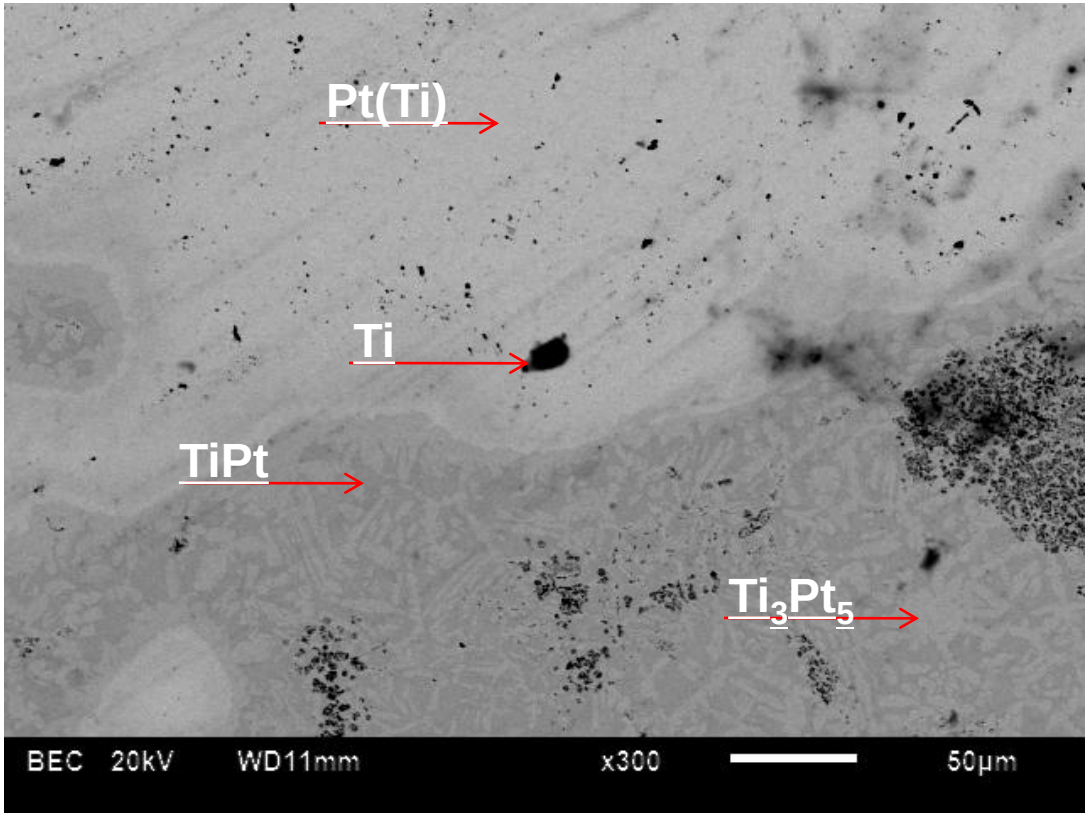
- Fully sintered
- Solid state reaction controlled



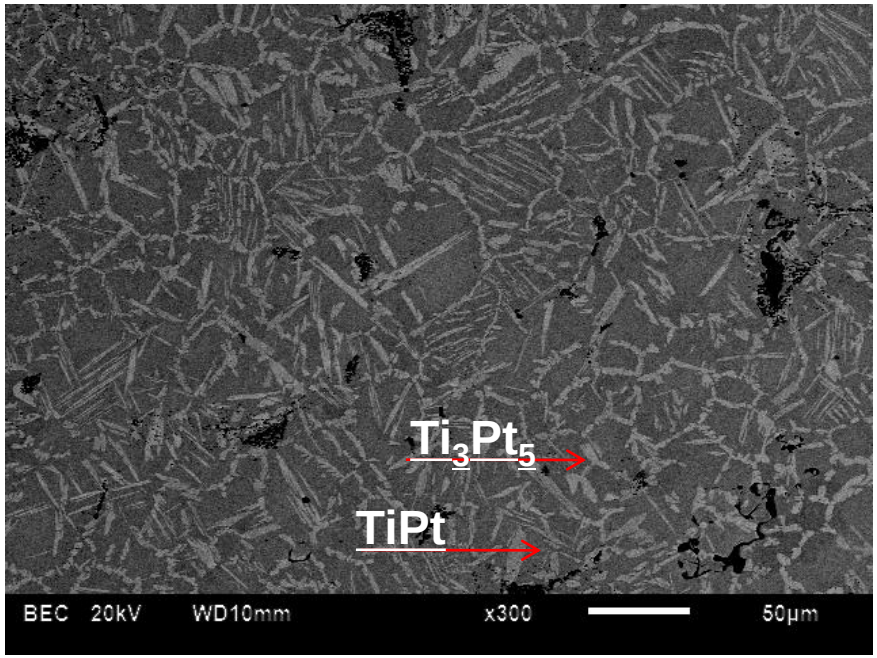
SPS: 1400 ° C_10mins_60MPa

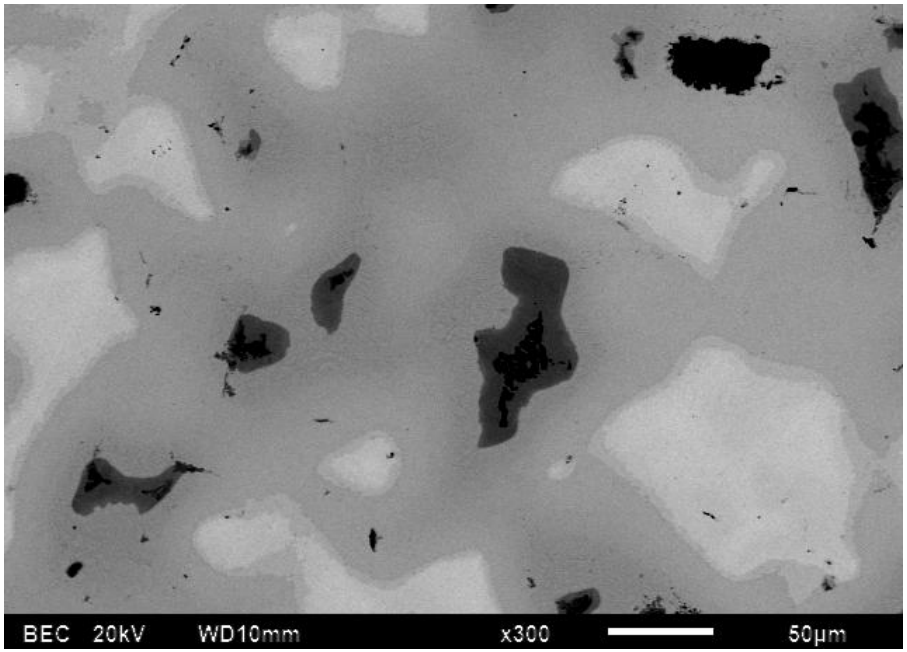


- Fully sintered



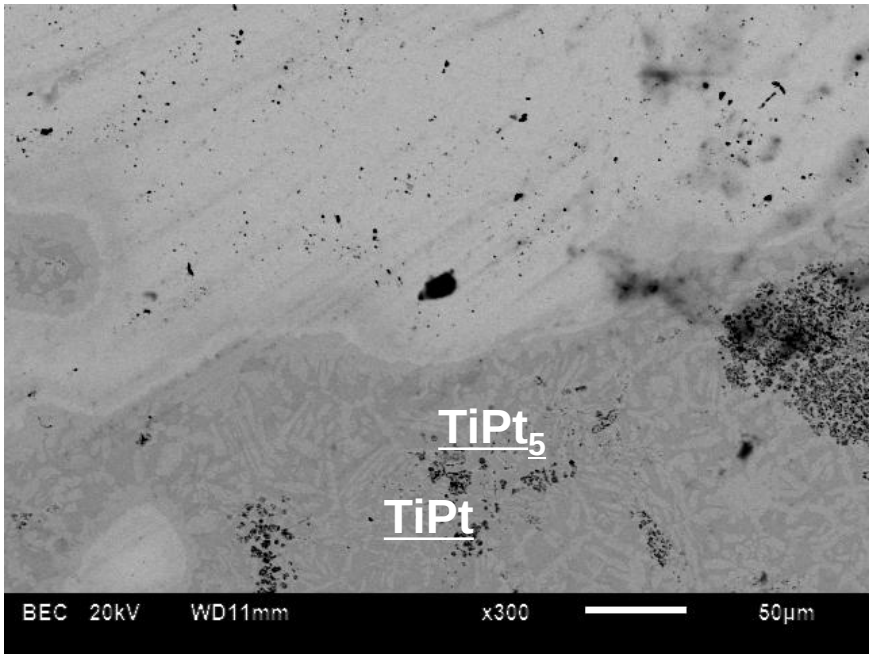
Homogenising: 1300˚C_10hrs_FC

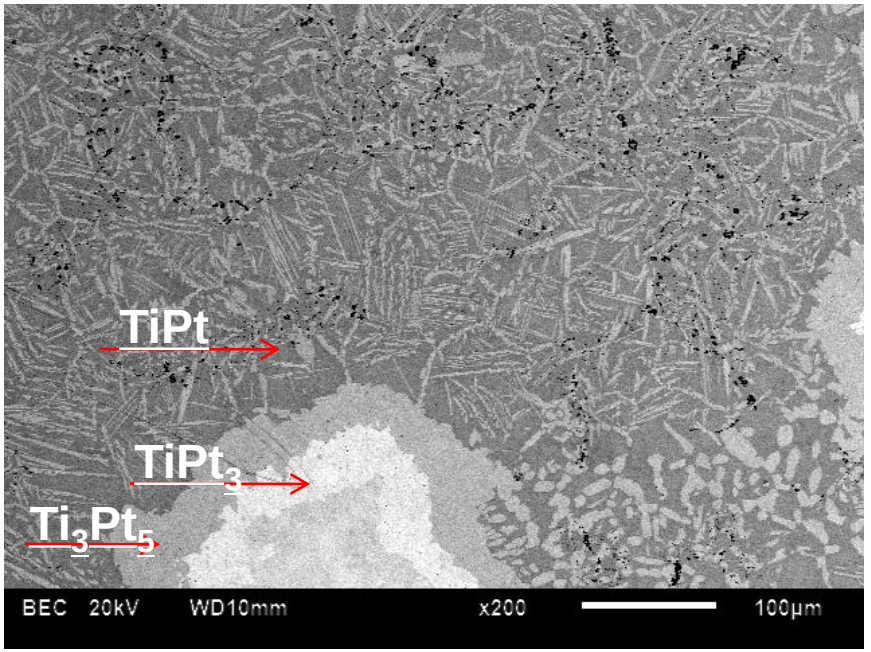




Sintering condition: 1200 ˚C_25mins_60MPa

Homogenising: 1300˚C_10hrs_FC





Sintering condition: 1400 ˚C_10mins_60MPa

Conclusions

- SPS of BE TiPt powder produces fully sintered specimens, with incomplete homogenisation
- TiPt phase is formed from the BE powder
- Post sintering heat treatment is required to homogenise the microstructure
- There is a need for improved furnace atmosphere control so that contamination can be eliminated as a possible reason for deviation of the final microstructure from the expected equiatomic TiPt composition.