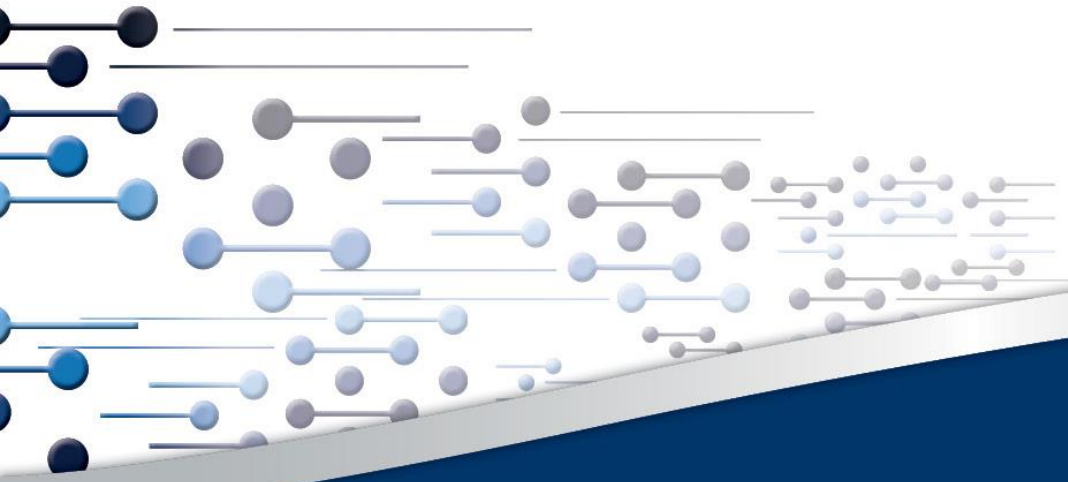
Evaluating densification of blended elemental (BE) TiPt through pressureless sintering

Zizo Gxowa, Dr S. Chikosha & Dr H.K Chikwanda



Outline

- Introduction
  - Background
- Objective
- Experimental Procedure
  - Materials
  - Method
- Results and discussion
- Conclusions
- Acknowledgements

Introduction: Overview

Densification

- Increase in density
- Decrease in porosity
- Expressed in terms of relative density/%porosity

Blended elemental(BE) TiPt

- Mixing of elemental Ti & Pt powders to form TiPt powder.
- Not pre-alloyed

Pressureless sintering

- Conventional sintering *i.e.* densifying by exposing sample to heat only.

TiPt HTSMA

CSIR
our future through science

Introduction: Background

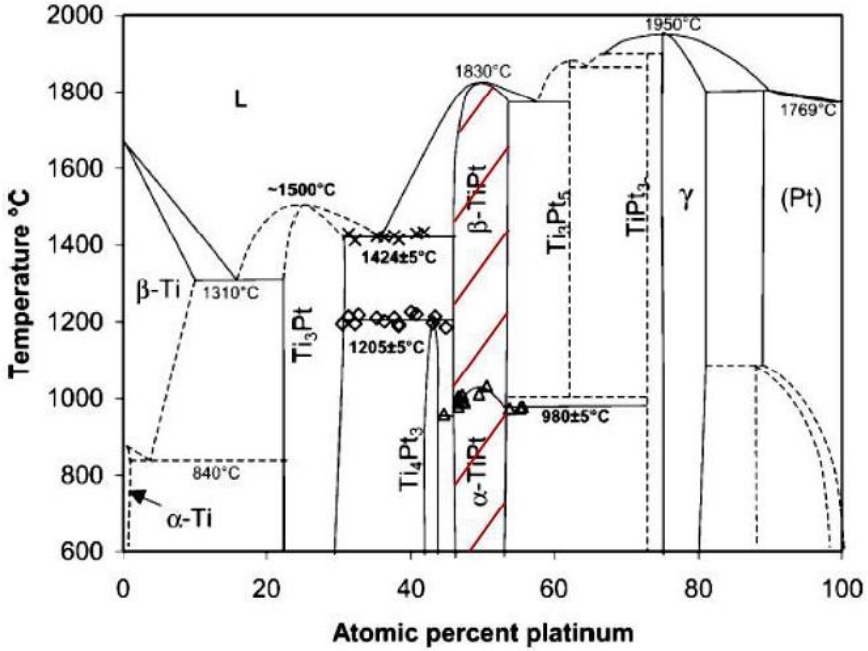
- Shape memory alloys (SMAs) are materials that have the ability to revert to their original shape if, after deformation, they are heated at the correct transition temperature (unique to each SMA) *(Araya,2012).*

- SMAs application temps = Automotive industry 100-300ºC and 1000ºC in aerospace *(Padula et al.,2006).*

- Commercially available SMAs = NiTi based alloys
  - maximum application temp = 100ºC *(Jani et al.,2014)*
  - *application limited ⟶ HTSMAs*

Introduction: Background

- TiPt alloys = perfect candidates for application as high temperature shape memory alloys (HTSMAs) due to presence of a martensitic transformation at 1050ºC.



Mahlatji,2015

Introduction: Background

Producing HTSMAs

Melting

- High energy costs
- Challenges with producing homogeneous alloy

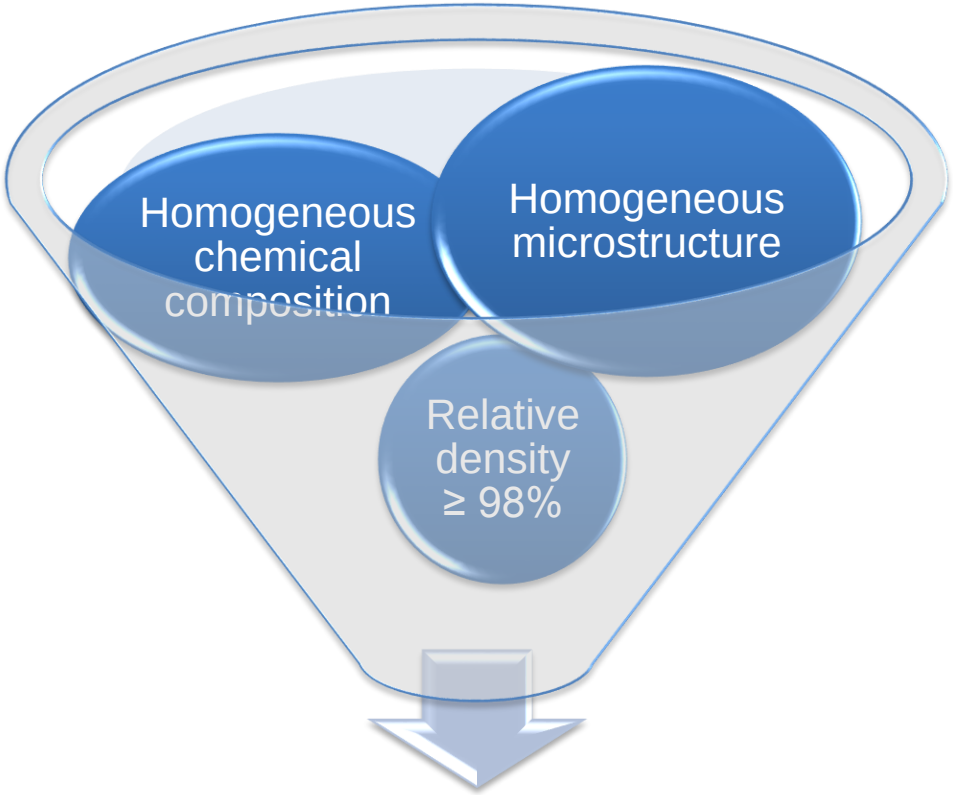
Powder metallurgy

- Lower energy costs
- Minimal machining
- Reduced oxidation

CSIR
our future through science

Introduction: Background

- *Ivasishin et al. (2002)* stated that :



Good mechanical properties

Introduction: Background

- Poor densification = poor mechanical properties
- Evident that properties such as strength and performance are directly influenced by density*(Suresh et al.,2015).*
- It can be said that densification determines structural integrity of products *(Eck et al.,2014).*
- Thus, in developing TiPt HTSMAs using PM attention has to be paid to amount of densification achieved.

Objective

- To evaluate the densification of blended elemental (BE) Ti-50at.%Pt through pressureless sintering.

- Results obtained are significant because they :

  - will give indication of how much densification can be achieved through pressureless sintering.

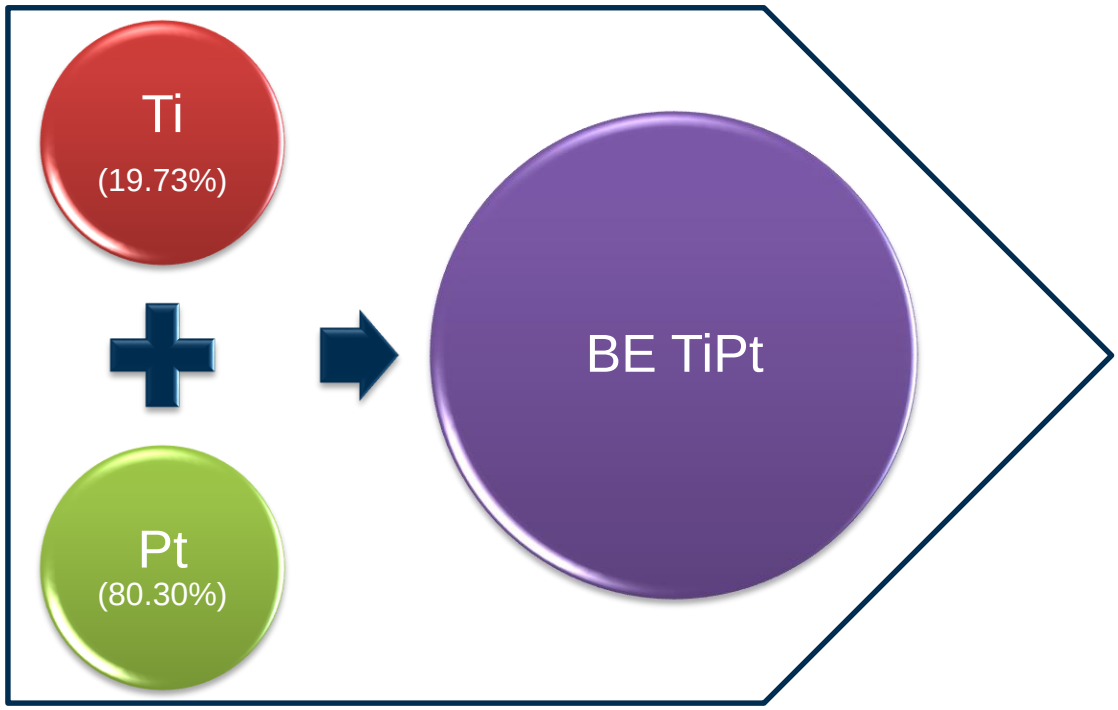
  - will help assess if PM technique of press and sinter is suitable for densification and if it can be used as alternative to melting.

Experimental procedure

- **Materials :**

  - TiHDH (-45µm) powder supplied by Baoji, Lihua Non- Ferrous Metals Co.,Ltd.
  - Pt (-250µm) powder supplied by Anglo American-Platinum.

Experimental procedure



Blending

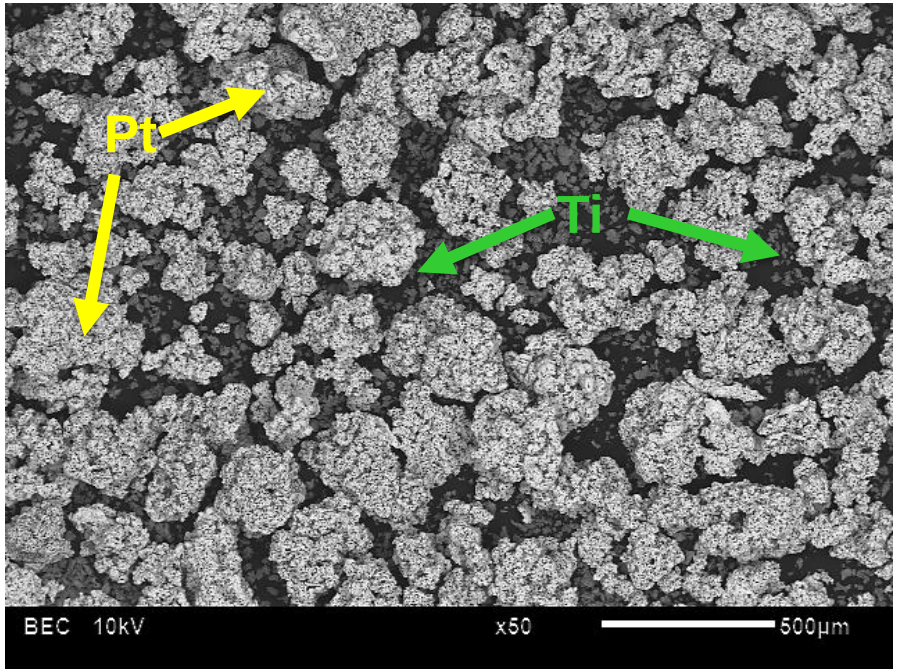
Cold (*i.e.* ambient temp) compaction

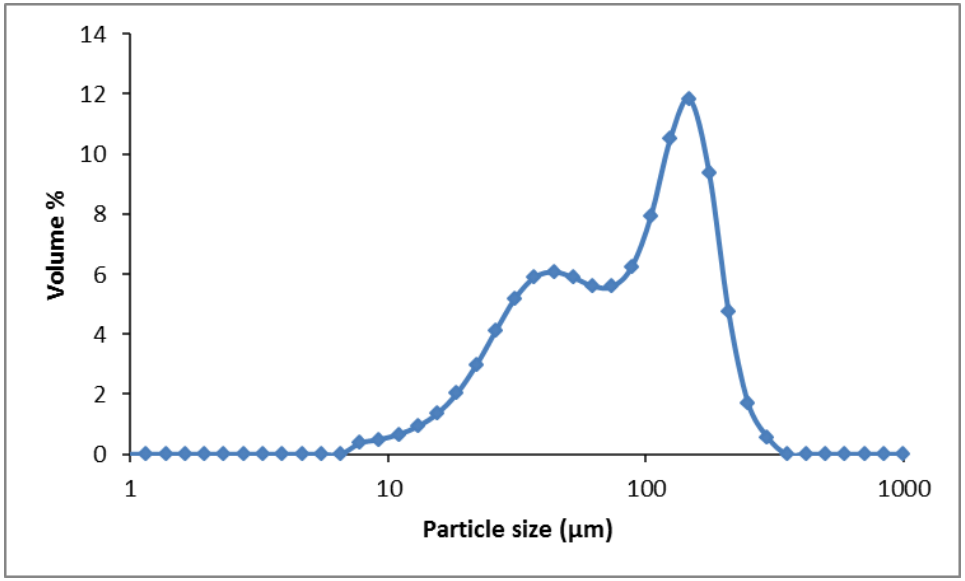
Sintering:
Temp = 1300 & 1400ºC
Time = 6,12 & 24 hrs

Metallographic evaluation & density determination

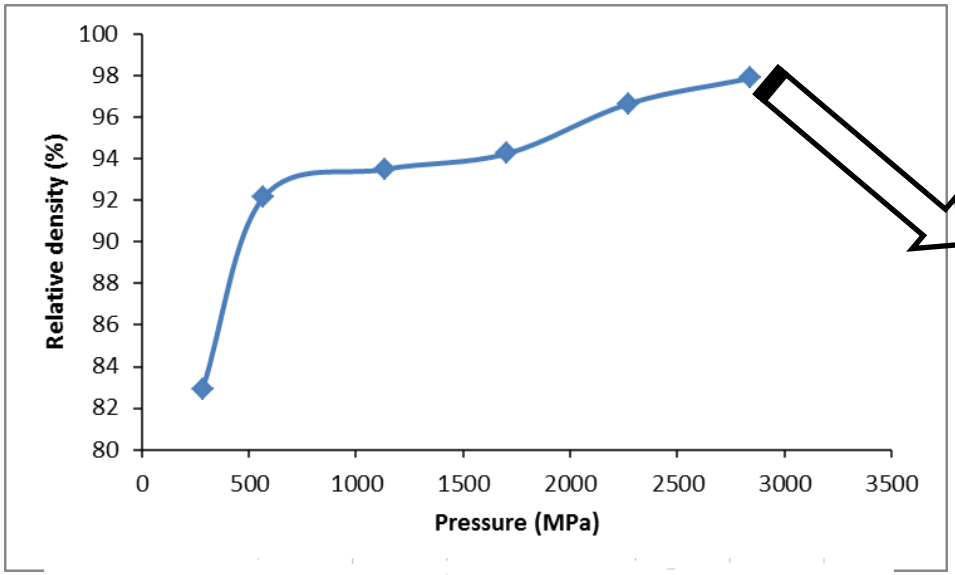
CSIR
our future through science

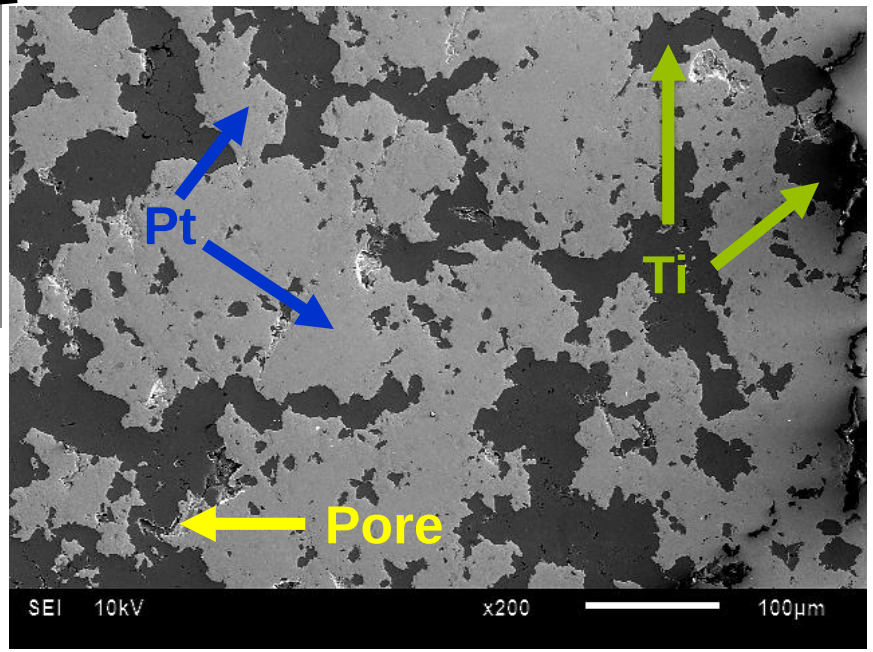
Results and discussion: Characterisation of BE powder

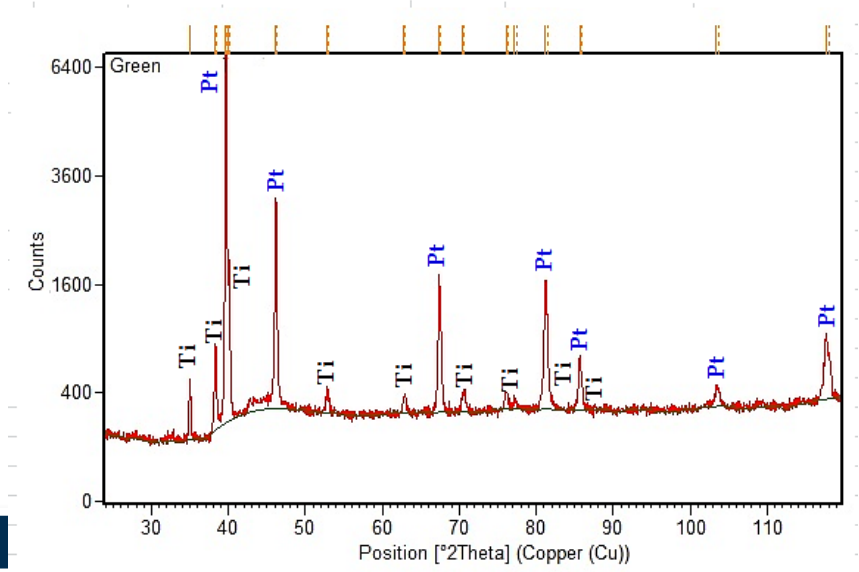




Results and discussion: Compaction

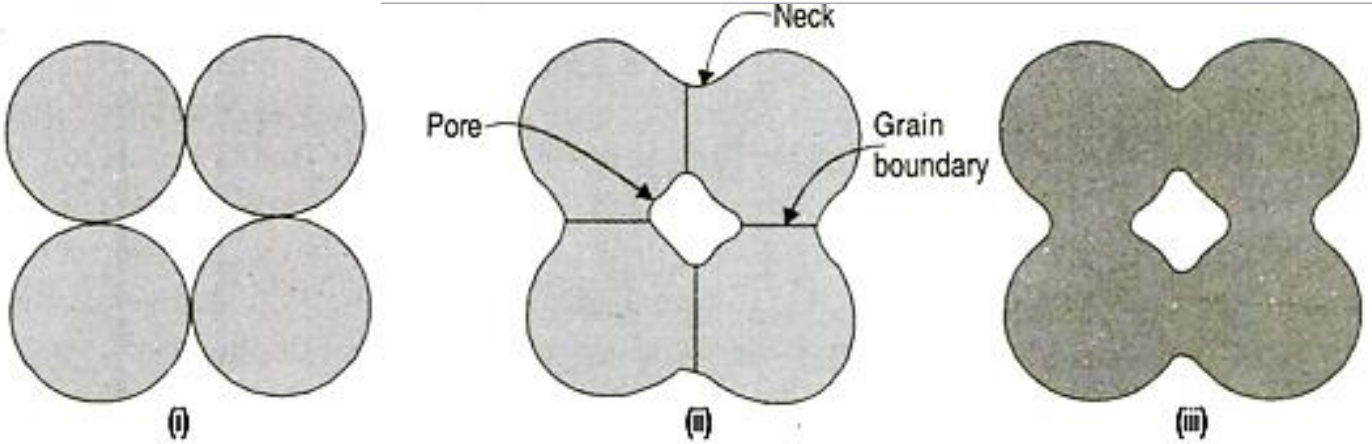




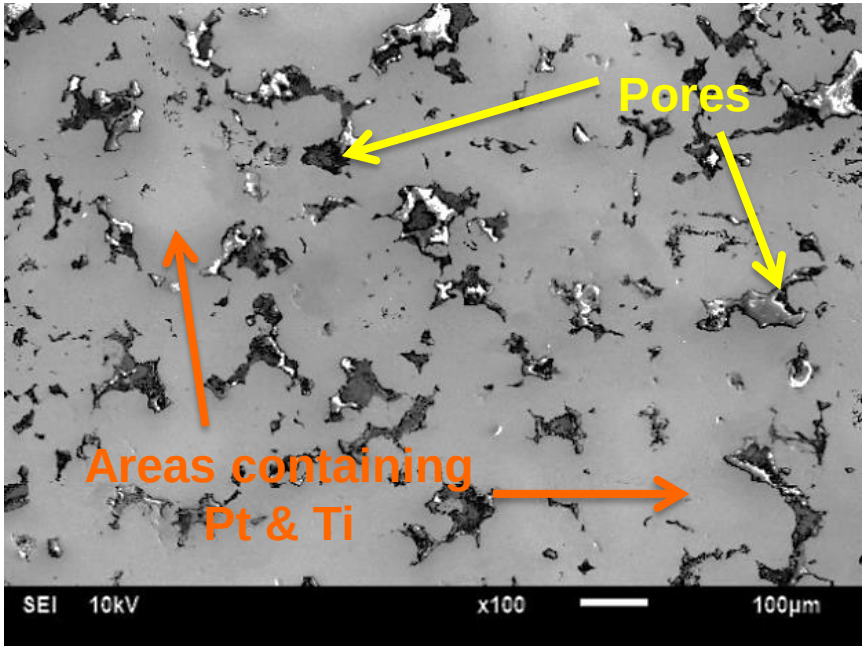


our future through science

Results and discussion: Sintering

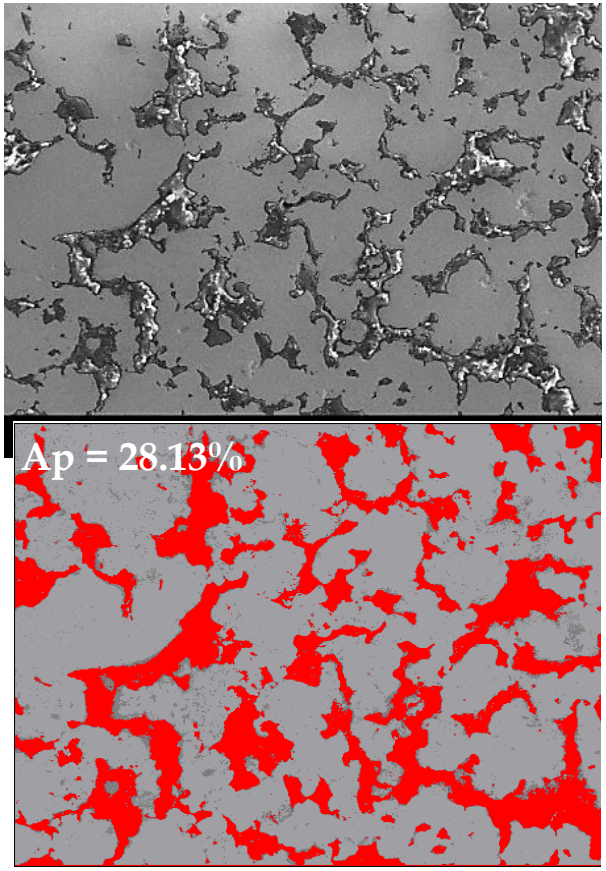


Angelo & Subramanian,2009

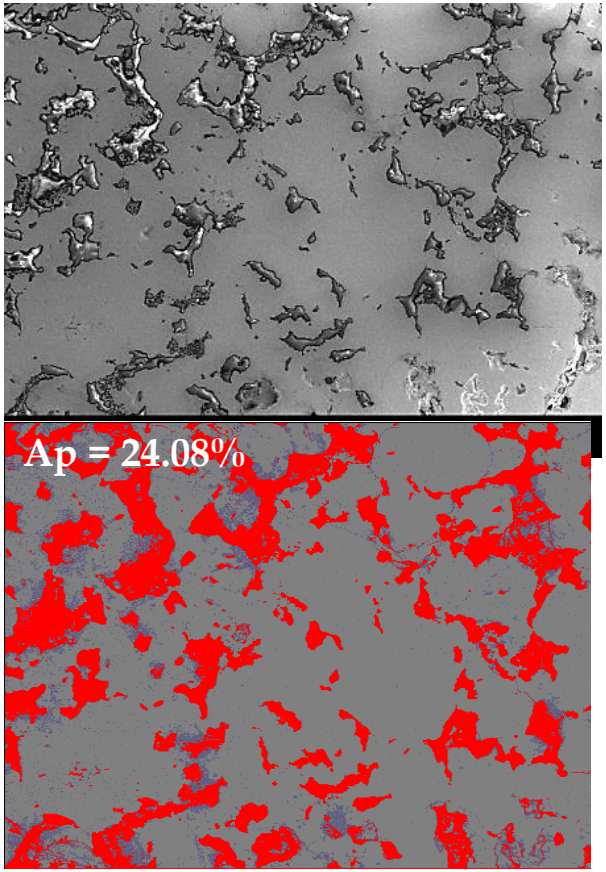


Results and discussion: Sintering

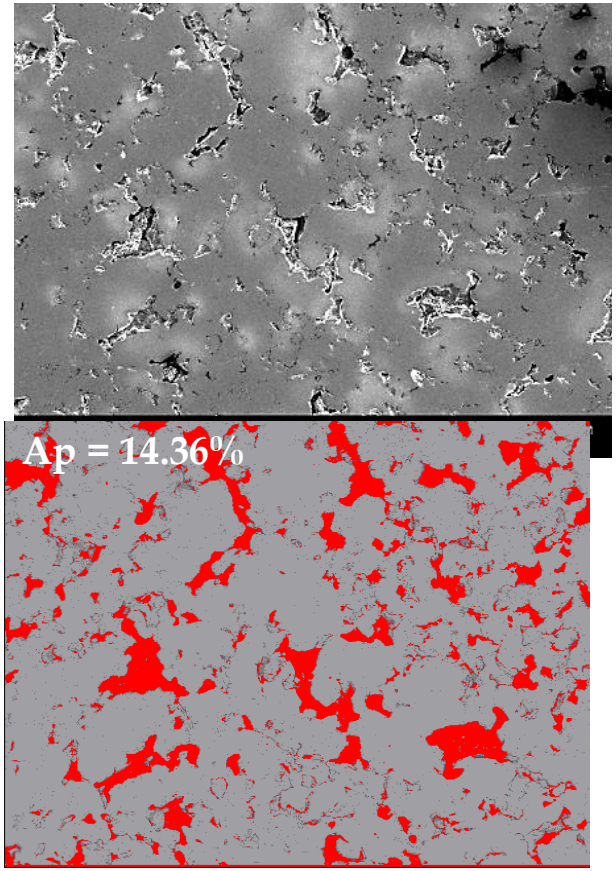
1300ºC



a



b

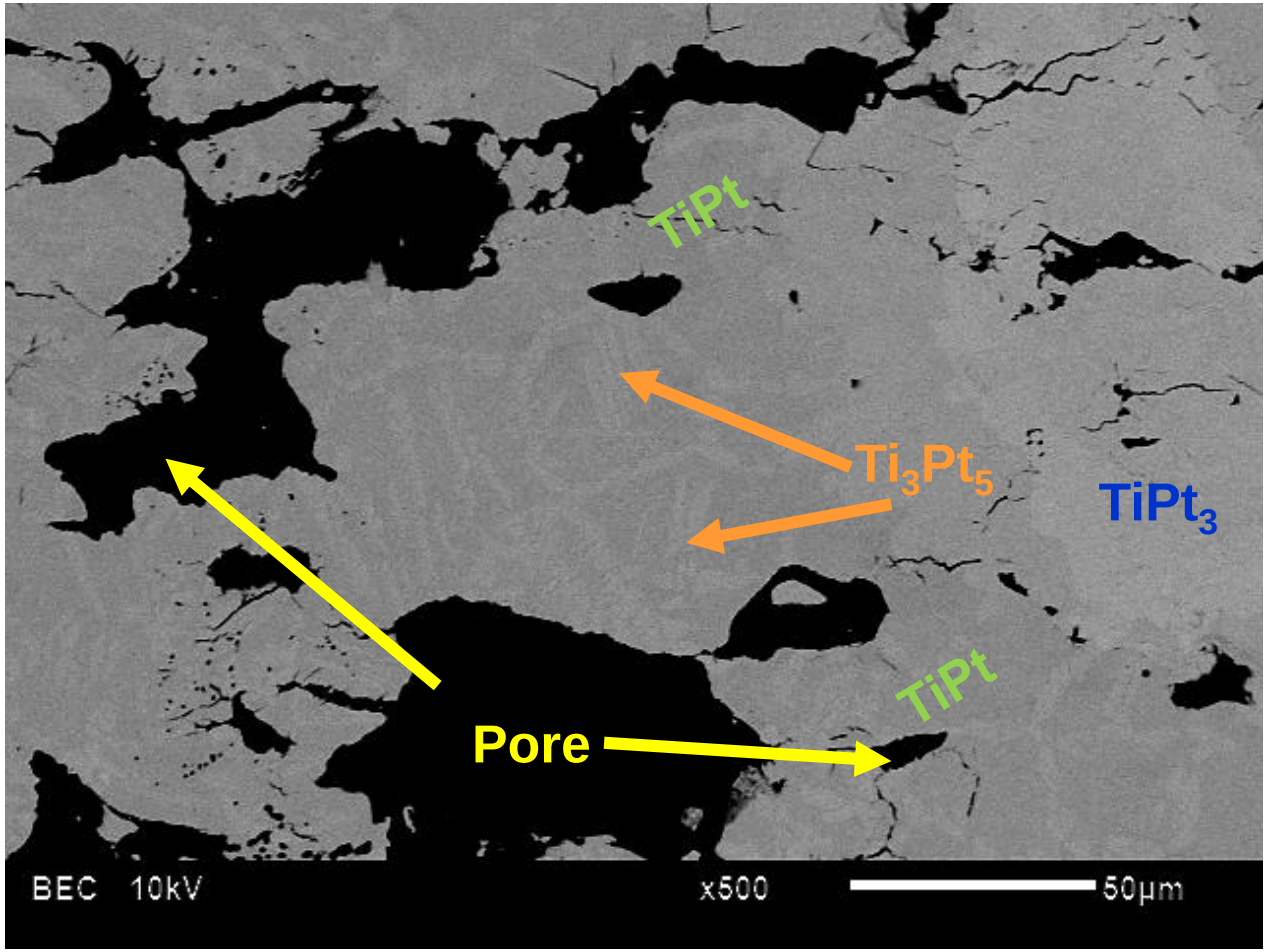


c

CSIR
our future through science

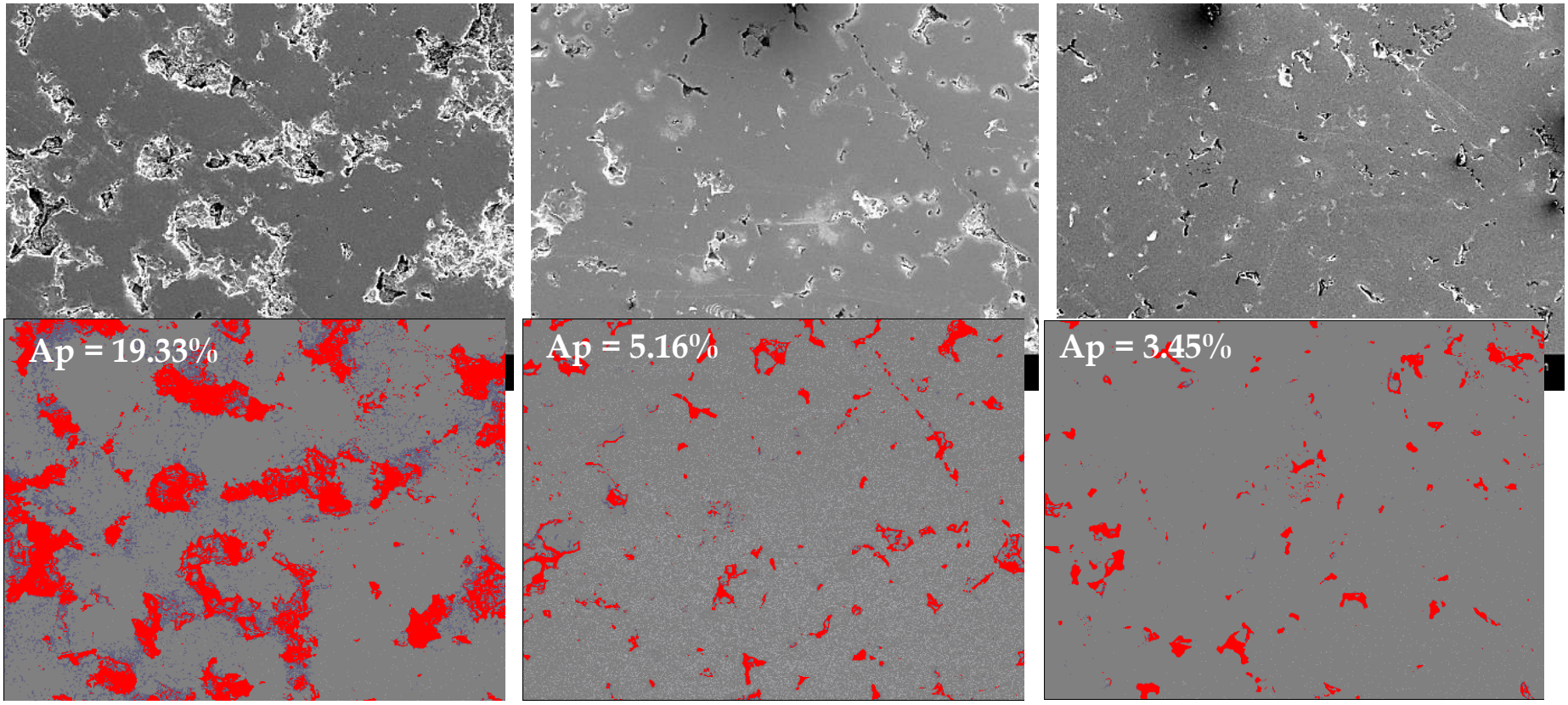
Results and discussion: Sintering

1300,6hrs



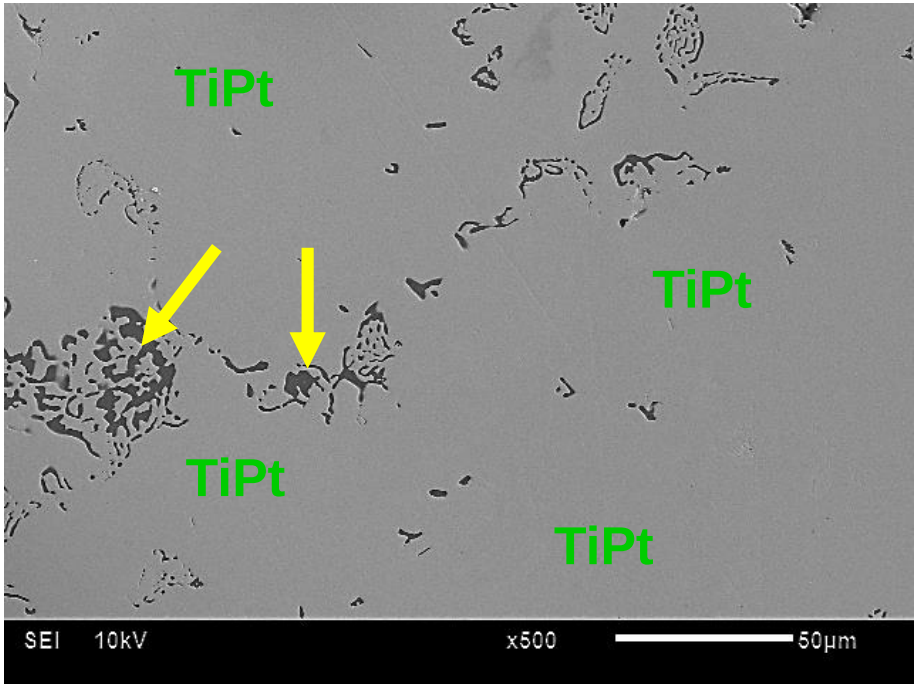
Results and discussion: Sintering

1400ºC



Results and discussion: Sintering

1500ºC



RD = 96%

Conclusions

- High (*i.e.* at least 98%) or full (100%) densities were not achieved through pressureless sintering of Ti-50at.%Pt blended elemental alloy powders, which suggested that pressureless sintering is not a suitable densification technique for Ti-50at. %Pt alloys.

- Kirkendall voids formed as a result of pressureless sintering; however, at both 1300 and 1400ºC an increase in sintering time from 6 to 24 hours seemed to reduce the quantity and size of the Kirkendall voids.

- Sintering at 1500ºC for 24 hours resulted in a fairly homogeneous microstructure

Future work

- Microfocus X-ray computer tomography (CT) to quantify porosity.
- SPS on BE TiPt for comparison.
- Development of homogenisation model.

Acknowledgements

- The CSIR
- The DST
- Anglo American Platinum
- Mr Ndumiso Mnguni

Thank you

Zizo Gxowa (ZGxowa@csir.co.za)