Porosity and Micro-hardness of Shrouded Plasma Sprayed Titanium Coatings

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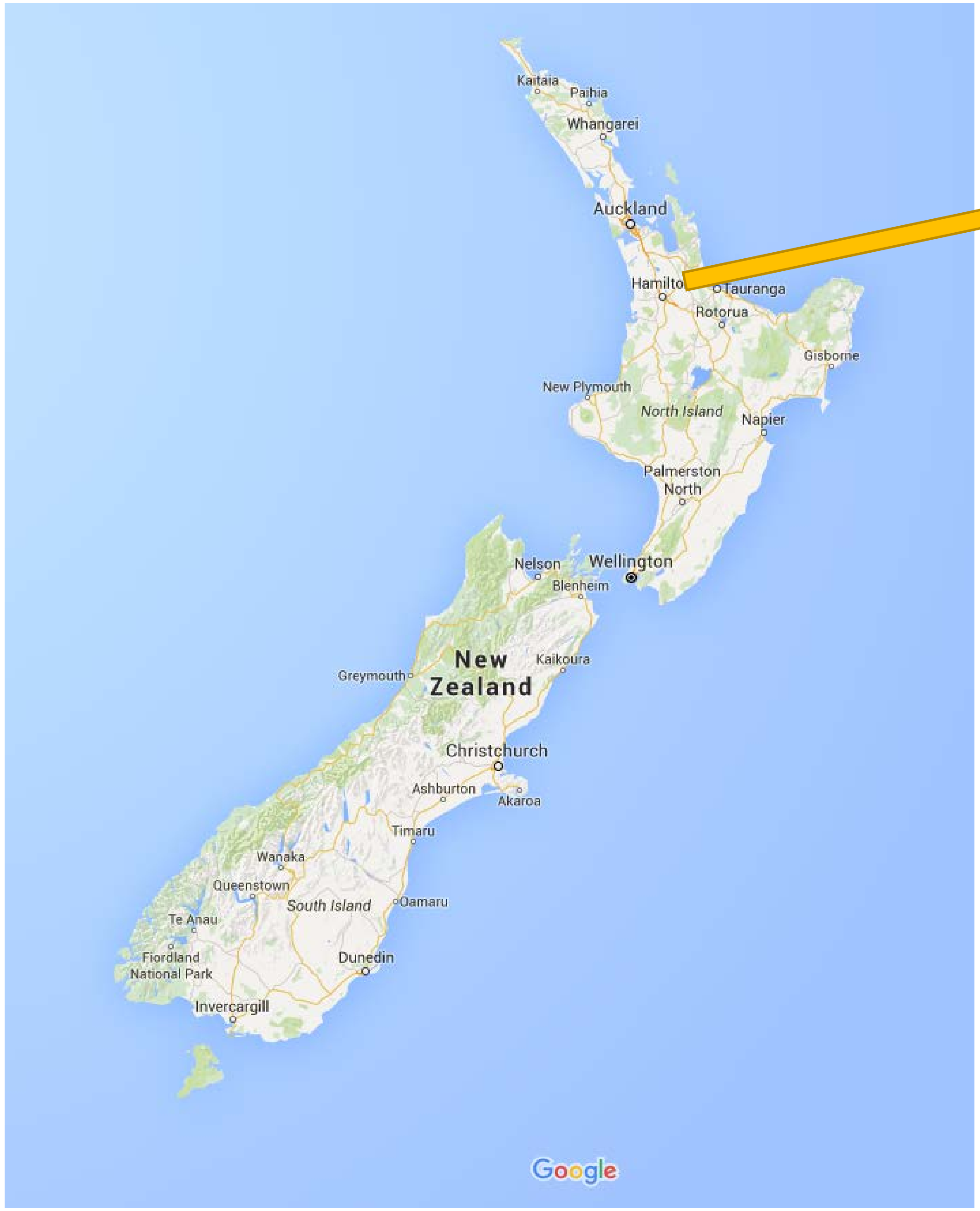

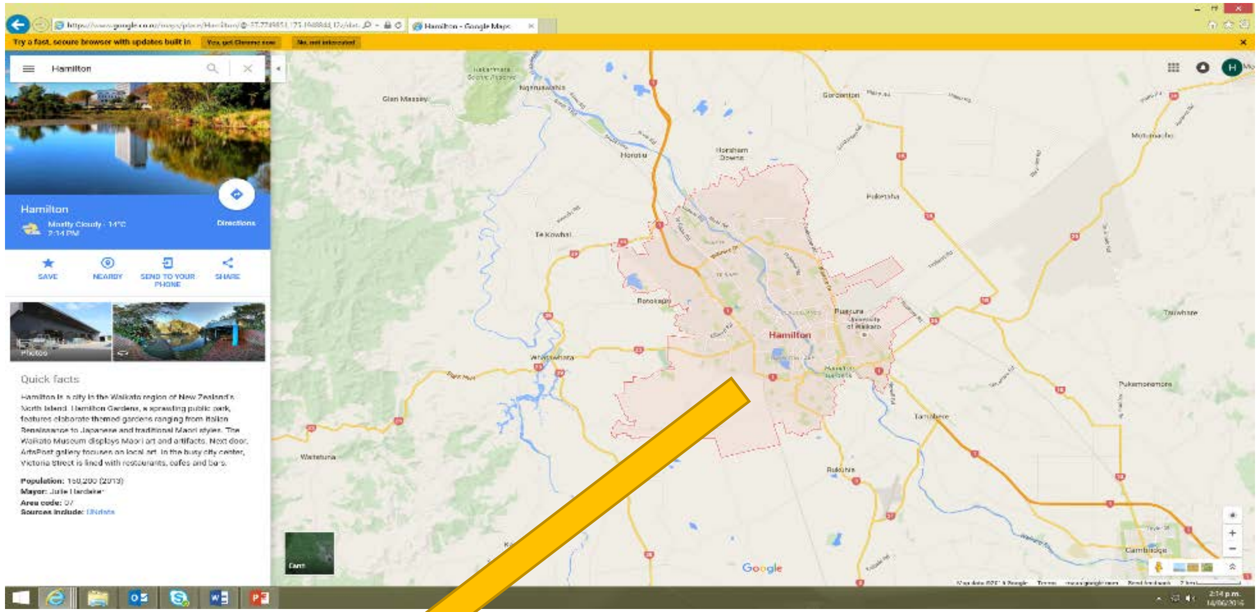

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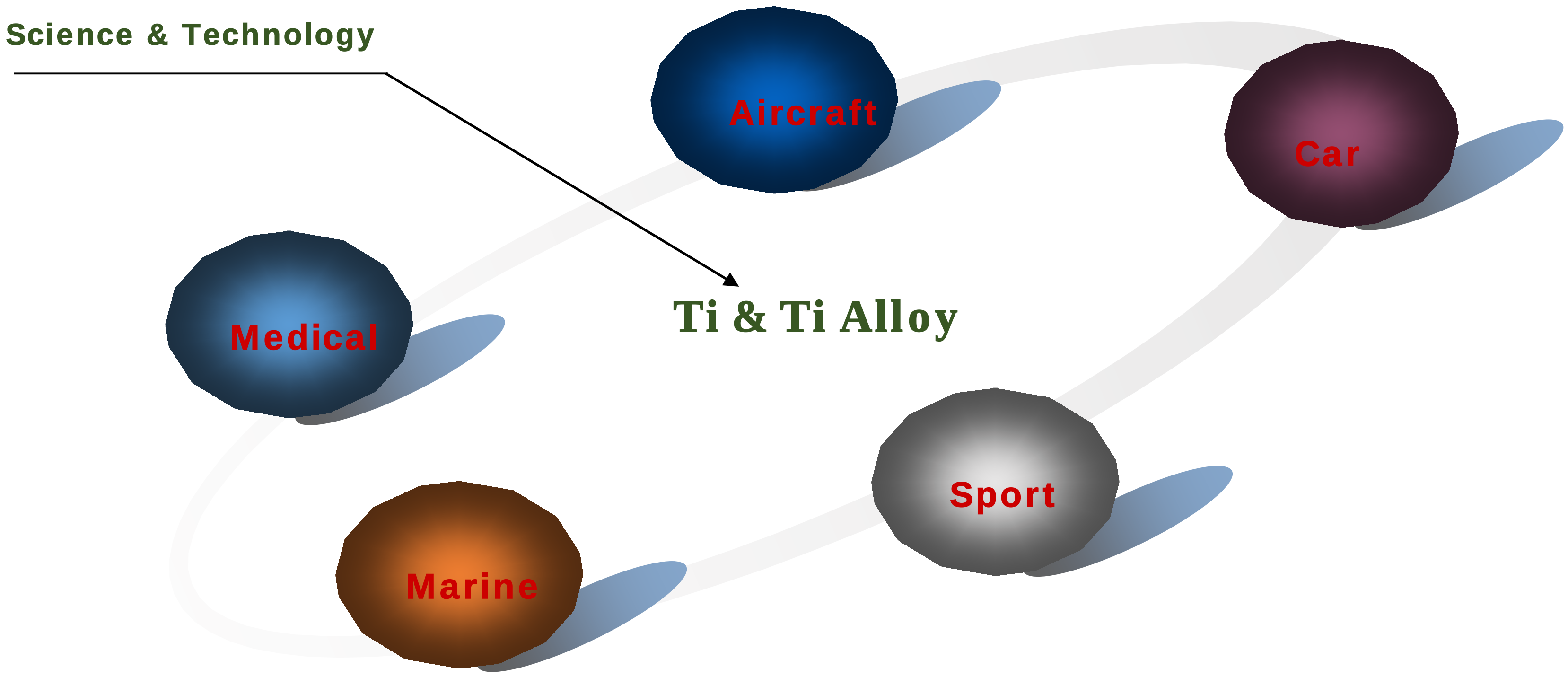
OUTLINE

- Introduction
- Experimental
- Results
- Discussion
- Conclusion

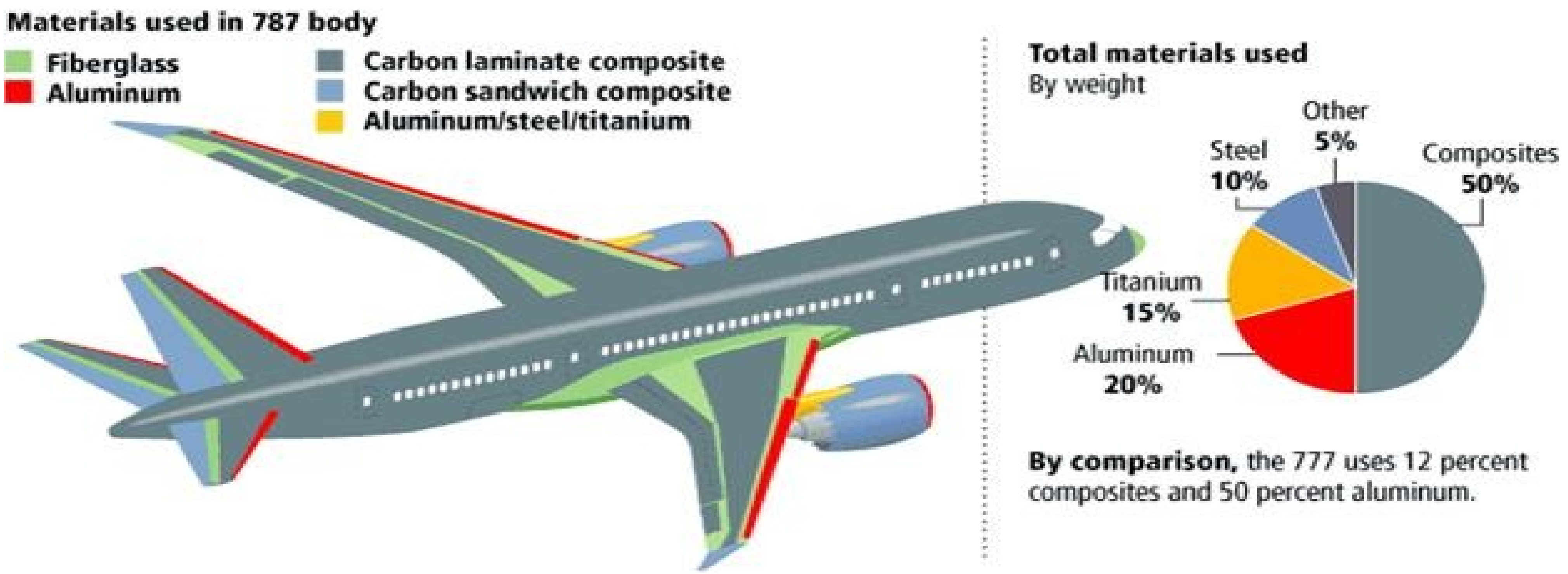
Introduction

Titanium and its alloys play important roles in industries as light metals



Introduction

Titanium and its alloys play important roles in industries as light metals



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Introduction

Nowadays, titanium and its alloys are often used as key materials for corrosion protection

because of the spontaneous and instant formation of a very chemically stable, highly adherent, and continuous protective oxide film on the surface.

Dental implant

Artificial joint

China API 600 Corrosion Resistant Titanium Gr2 Gr3 Flexible Wedge Gate Valve

Introduction

Coating Technology

A promising approach to optimize both mechanical properties and corrosion resistance since corrosion attack is mainly limited to the outer region

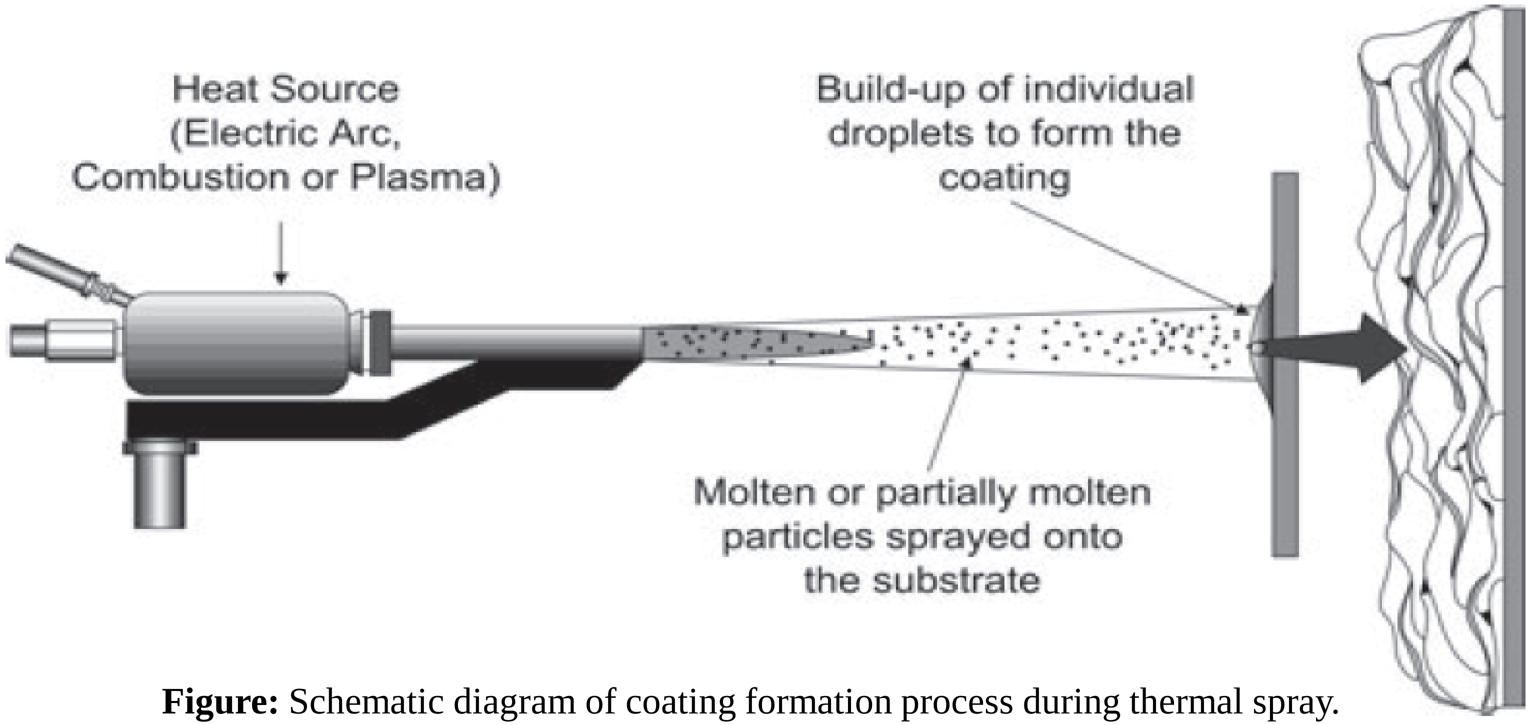


Figure: Schematic diagram of coating formation process during thermal spray.

Introduction

Titanium coating by shrouded/air plasma spraying technology

Objectives:

The difference between the two types of coating has been investigated in terms of porosity, microhardness, and microstructure.

Experimental

Powder

Commercially available HDH pure titanium powder (Xi'an Lilin International Trade Co., Ltd., Xi'an, China),

Table 1. Chemical composition of HDH titanium powder

Element	H	O	N	C	Fe	Ti
HDH Ti powder [wt%]	0.23	0.35	<0.03	0.07	<0.11	Bal

Experimental

Shroud Design

Titanium is a very reactive metal at high temperatures due to its strong affinity with gases such as oxygen, nitrogen and hydrogen

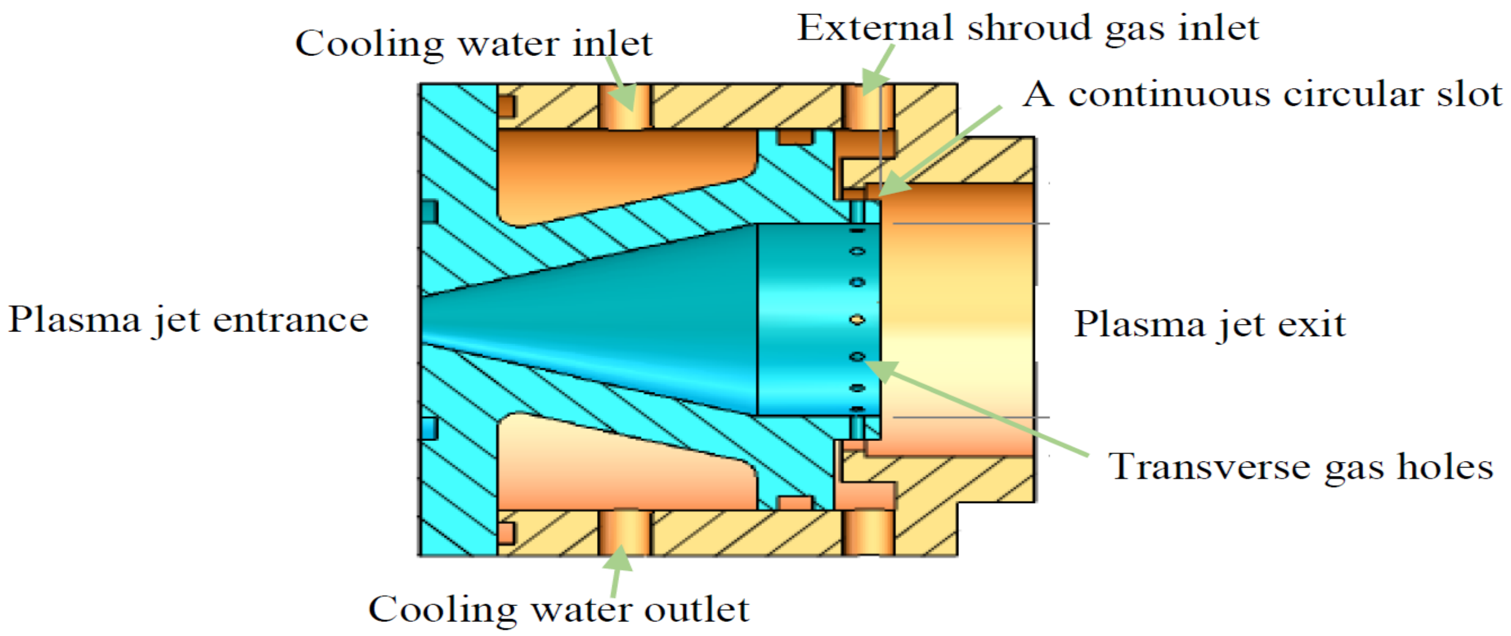


Figure: Schematic cross section illustrating the key features of the shroud.

Experimental

Plasma spraying

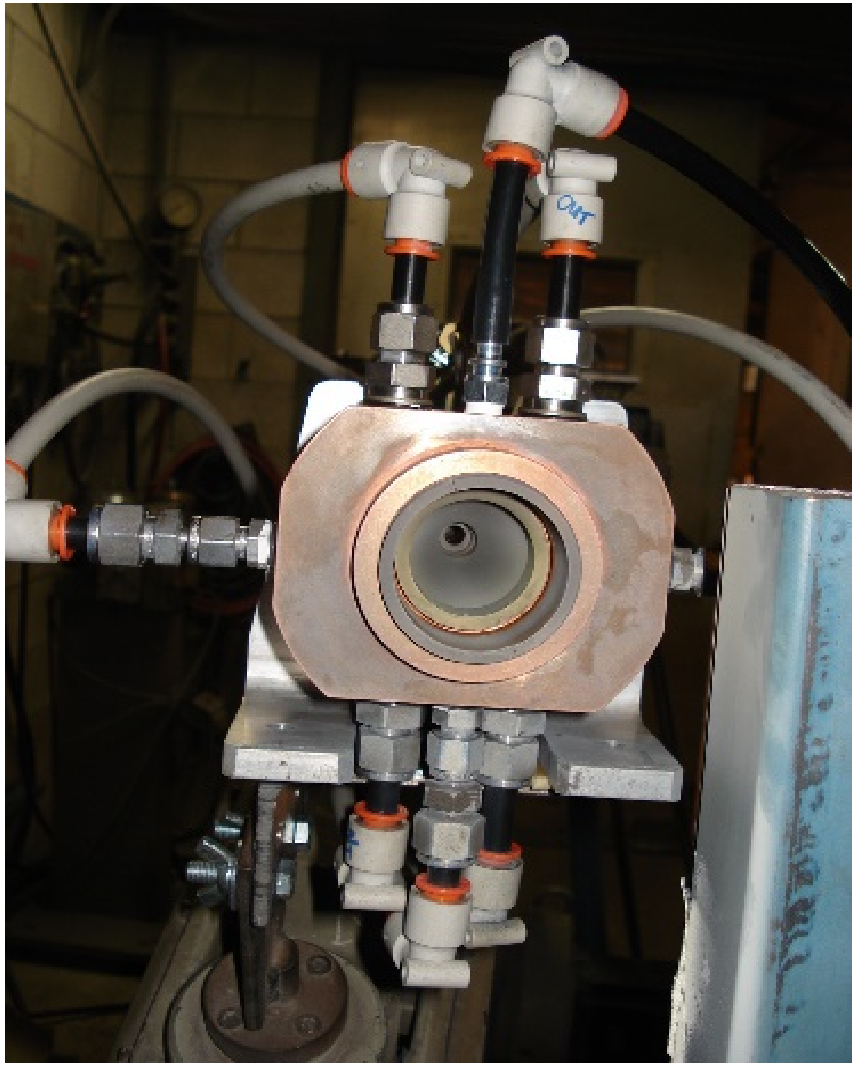
SG-100 plasma gun (Praxair surface technologies, USA) with the shroud attachment.

Table 2. The spraying parameters for the titanium coatings with and without the shroud

Spray parameter	setting	Spray parameter	setting
Current, [A]	800	Powder feed rate, [g/min]	30
Voltage, [V]	80	Spray passes	10
Primary gas, Argon, [slpm]	85	Spray distance, [mm]	100
Auxiliary gas, Helium, [slpm]	18	Transverse speed, [mm/s]	500

Experimental

Plasma spraying



Shroud gas (argon) flow rate: 300 slpm

Special attention was given to adjusting the powder carrier gas flow rate within the shroud to generate an inflight particle trajectory with a low angle of deviation from the central axis to prevent build-up of powder on the inside wall of the shroud.

Figure: The shroud attachment for plasma sprayed Titanium coatings

Experimental

Microstructure Characterization

Microstructure Observation

SEM, Hitachi S4700, Janpan, with second electron imaging was operated at 20 kV to observe the microstructures and morphology of specimens.

Porosity

An Olympus BX60 optical microscope equipped with a digital camera was used to capture images for the porosity analysis of the titanium coatings. Porosity was then examined by using IQ image analysis software.

Experimental

Microstructure Characterization

Microhardness

Test was performed by using a Vickers indentor (LECO, Mechigan, USA) with a load of 300 g for 15 seconds on the coatings cross sections. The cross sections of the titanium coatings were polished before indentations, and the distance between two indentations was at least three times the diagonal to prevent stress-field effects from nearby indentations. The Vickers microhardness was averaged from 10 indents per sample.

Results and Discussion

Powder morphology

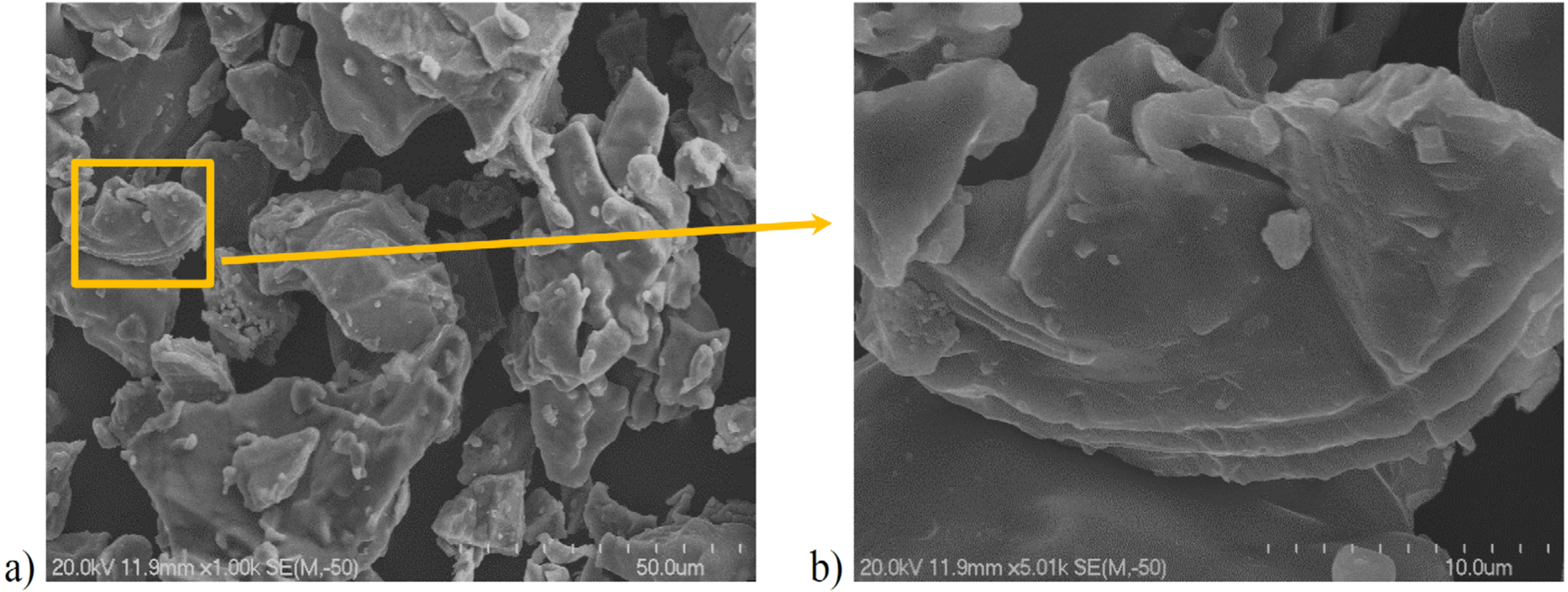


Figure 1. SEM images showing the particle morphology of the HDH titanium powders. a) The HDH titanium powders with irregular shape; b) magnified region within the rectangle in a)

Results and Discussion

Titanium Powders

Phase composition

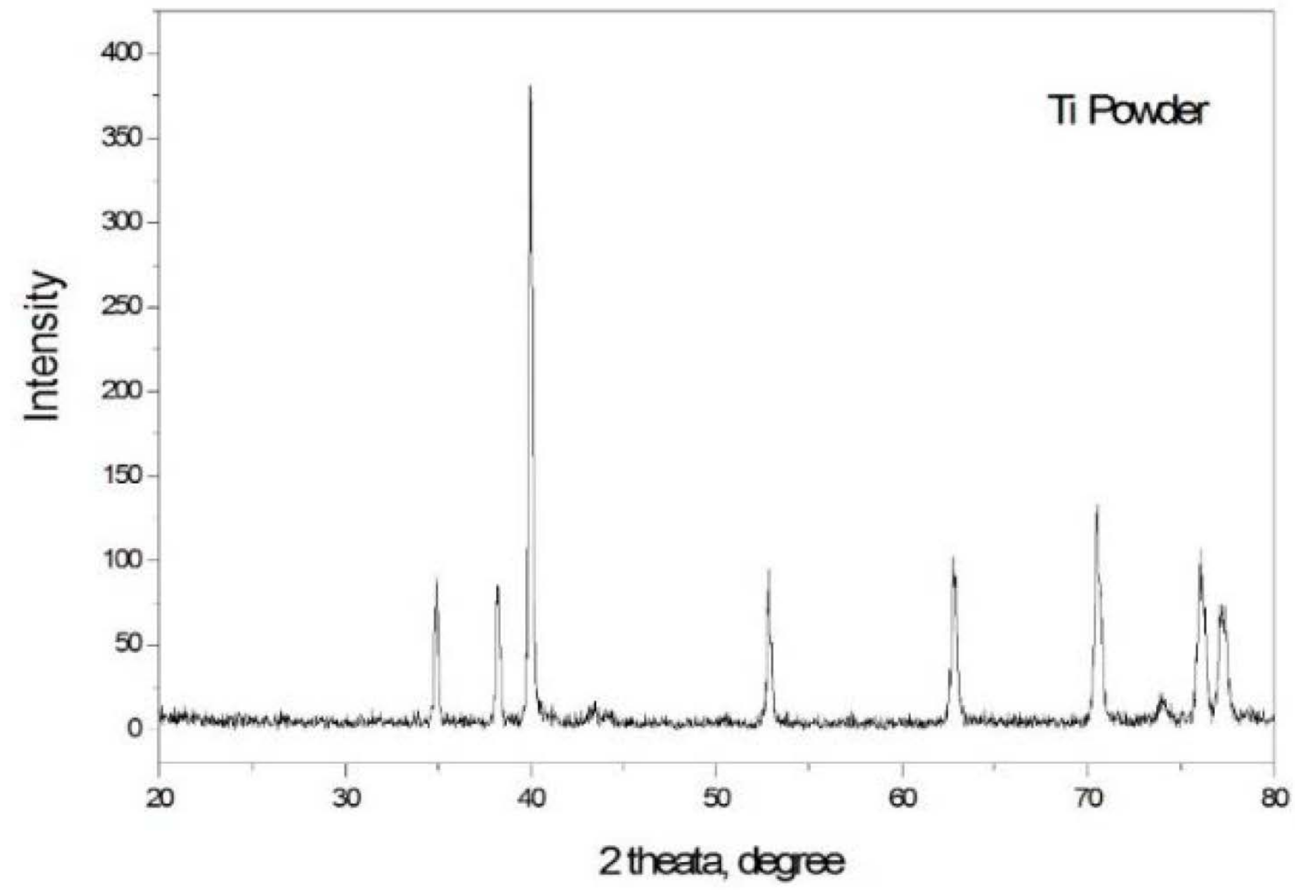


Figure: XRD pattern of the HDH titanium powder in the range of $2\theta=20^{o}-80^{o}$

Results and Discussion

Powder size distribution

Table. The particle size distributions of the HDH titanium powders

d (0.1), μm	d(0.5), μm	d(0.9), μm
20.986	47.777	90.931

Note: The d (0.1), d (0.5) and d (0.9) mean that 10%, 50% and 90% of the volume fraction of the powder particles have particle sizes (in micrometre) below a particular value respectively.

Results and Discussion

Powder size distribution

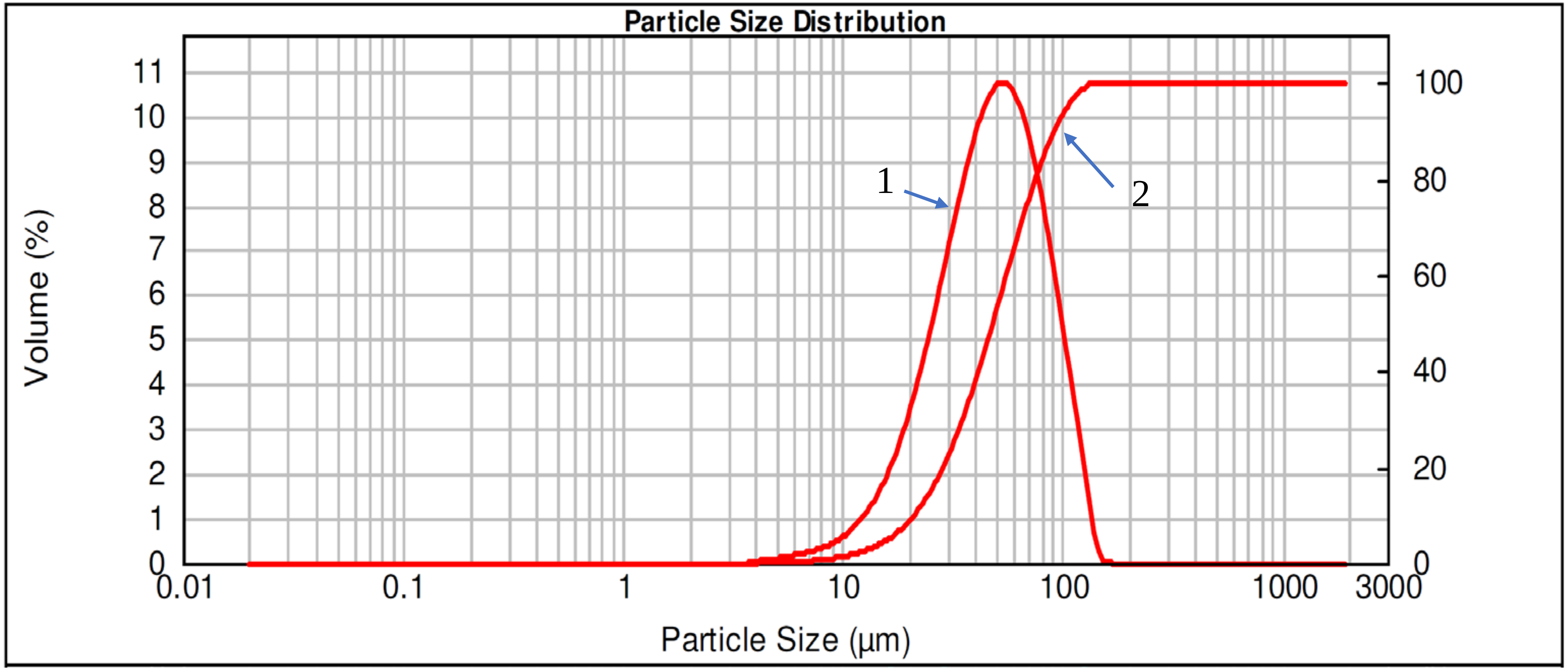


Figure: Particle size distributions for the HDH titanium powder, curve (1) shows the volume percent at the corresponding particle size, and curve (2) shows the accumulated volume percent under the corresponding particle size.

Results and Discussion

Titanium coatings

Microstructure and coating porosity

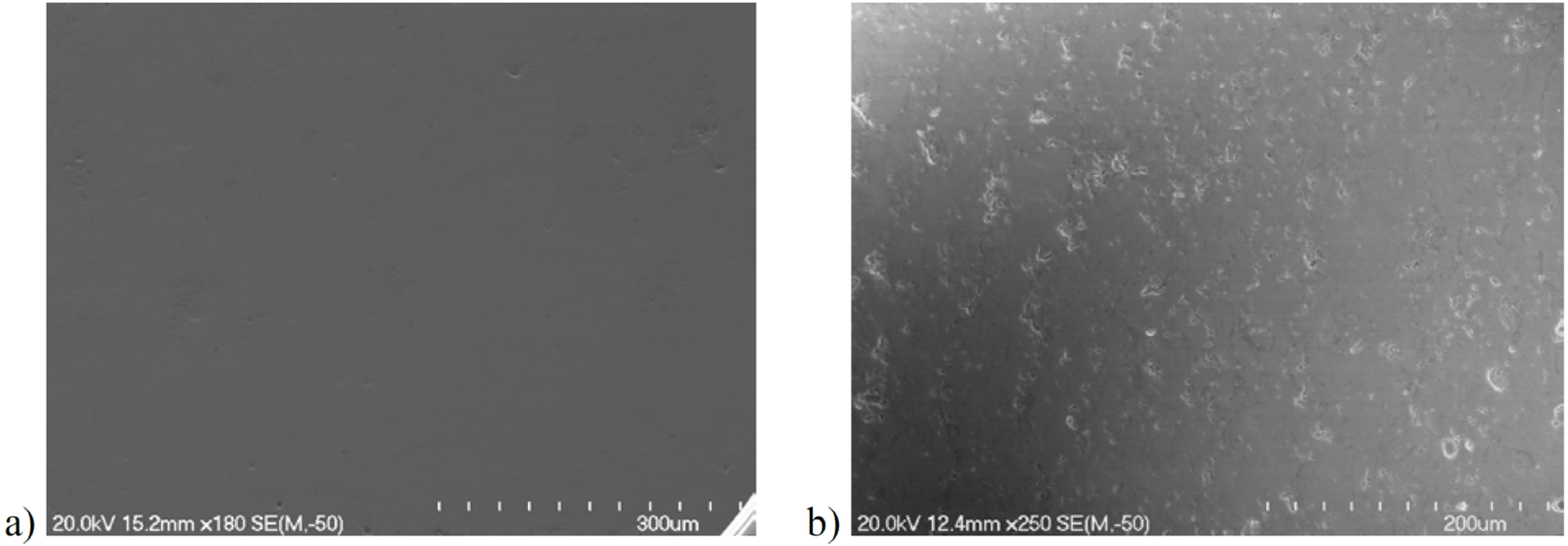


Figure 2. SEM images showing the polished cross sections for a) plasma sprayed Ti coating with the shroud and (b) air plasma sprayed Ti coating without the shroud.

Results and Discussion

Titanium coatings

Microstructure and coating porosity

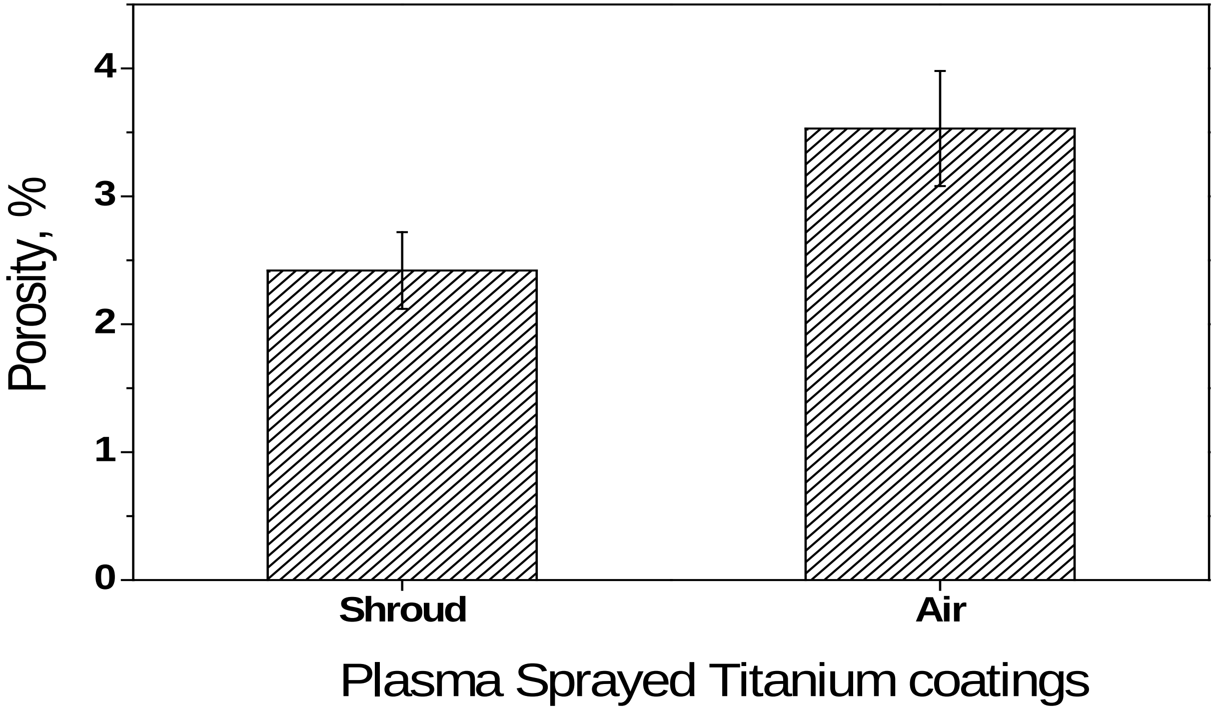
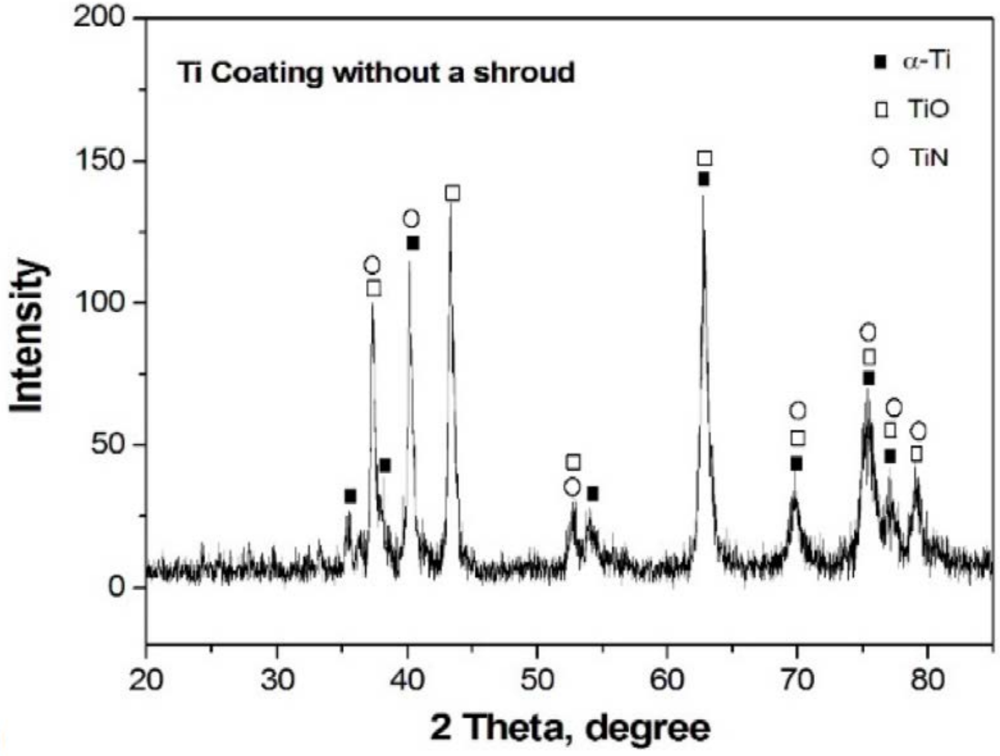


Figure: The porosity of the as-sprayed titanium coatings deposited with and without the shroud. The error bars represent the standard deviation

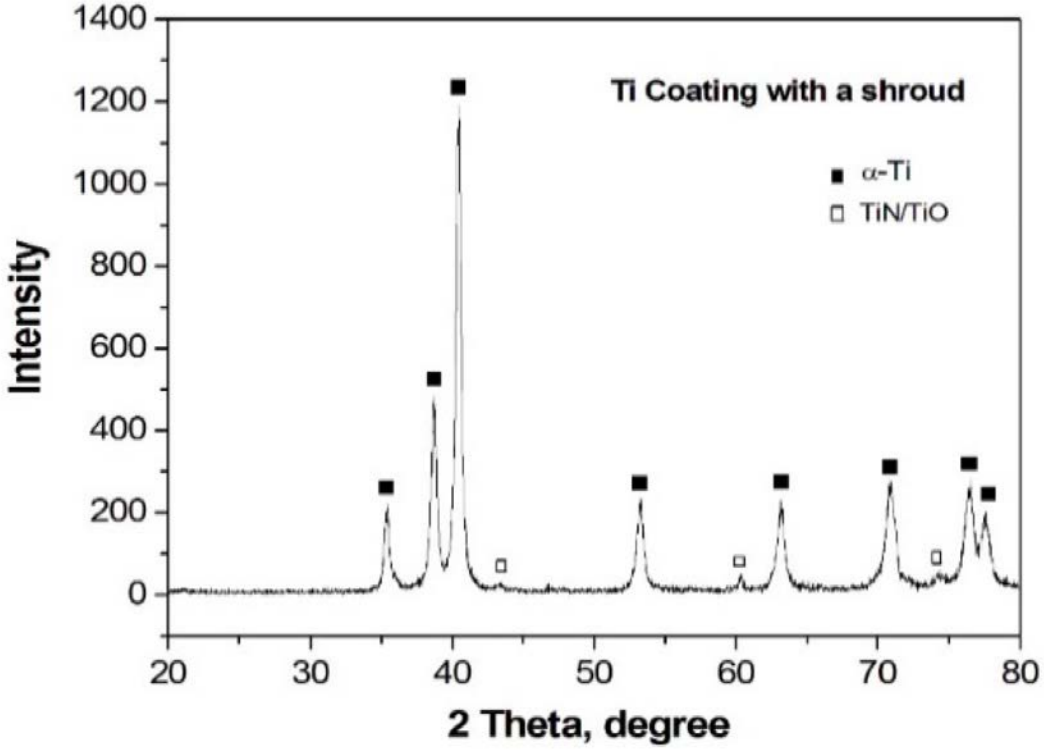
Results and Discussion

Titanium coatings

Phase composition



a)



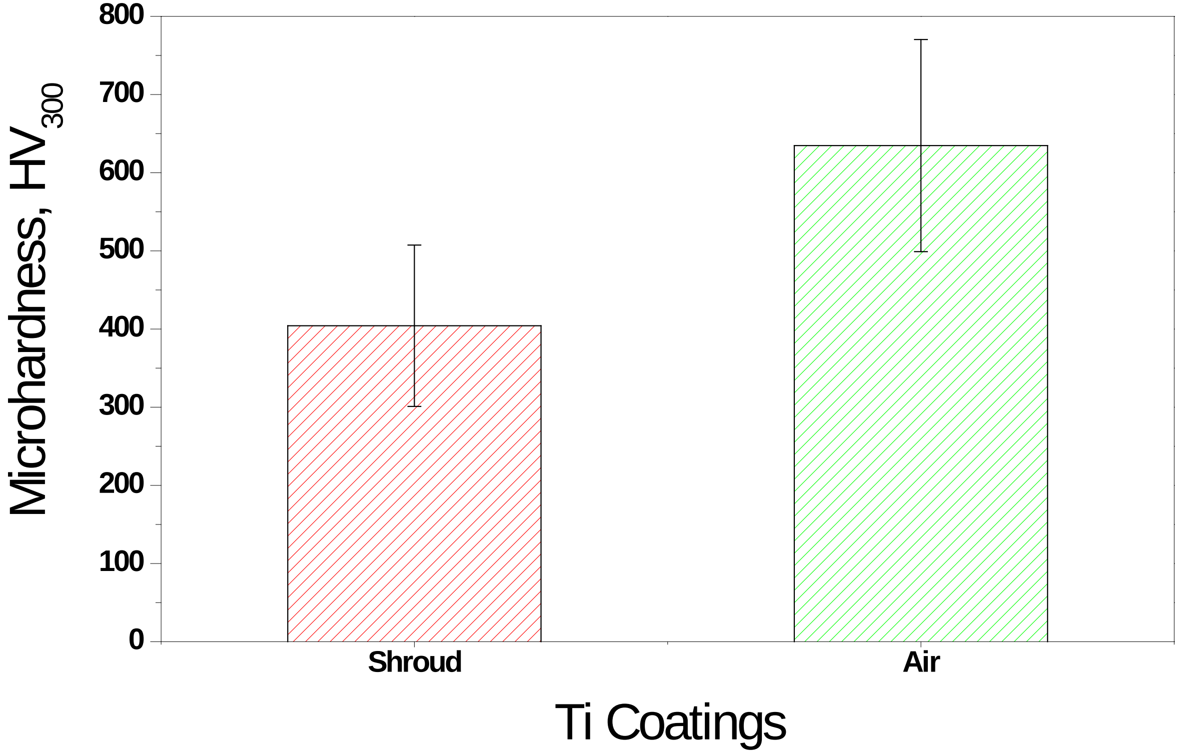
b)

Figure: XRD patterns in the range of 2θ=20°-80° of a) the titanium coating plasma-sprayed without the shroud, (b) the titanium coatings plasma-sprayed with the shroud.

Results and Discussion

Titanium coatings

Vickers microhardness.



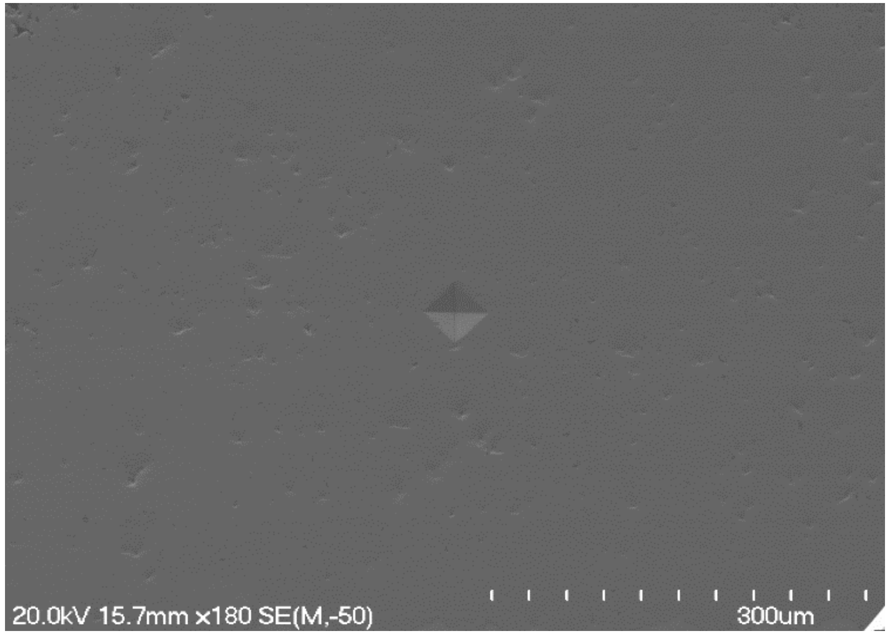


Figure: Vickers microhardness of titanium coatings deposited with and without the shroud. The error bars represent the standard deviation

Conclusion

This work presents the feasibility of using the shrouded plasma spraying to fabricate titanium coatings, and air plasma sprayed titanium coatings were also deposited under the same conditions.

- The presence of the shroud and shroud gas flow led to a significant reduction in coating porosity.
- The shrouded titanium coating had a dense microstructure with a very low porosity; whereas the air plasma sprayed titanium coating possessed a high porosity.
- The air plasma sprayed titanium coating had a much higher Vickers microhardness and a relative larger standard deviation than the shrouded titanium coating.

Thanks for your attention