

LASER COATING OF HAFNIUM ON Ti6Al4V FOR BIOMEDICAL APPLICATIONS

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OBJECTIVES

To investigate laser surface coating of Ti6Al4V with preplaced Hafnium powder, to determine the influence of the energy density on the characteristics of bonding and the microstructure.

BACKGROUND

Materials used for biomedical applications must possess specific properties, in particular biocompatibility and corrosion resistance¹. Metallic materials are used extensively for biomedical applications. Main metallic biomaterial used are stainless steels, Cobalt based alloys, titanium and its alloys². Titanium alloys are considered to be the most attractive metallic materials for biomedical applications¹. This is due to their excellent specific strength, lower modulus, superior tissue compatibility, and higher corrosion resistance³. Commercially pure titanium is considered to be the best biocompatible metallic material due to its surface properties resulting in the spontaneous build-up of a stable and inert oxide layer. Commercially pure titanium and Ti6Al4V have both been used as implant materials. Though Ti6Al4V has been used as implant material, Matsuno et al has reported that vanadium (V) and aluminium (Al) can dissolve from the alloy and cause growth inhibition and possibly Alzheimer's disease respectively⁴.

Coating of Ti6Al4V is being investigated to minimise the dissolution of aluminium and vanadium into surrounding tissue. Group 4A metals have received some attention in coating of the titanium alloy or even developing alloys with less toxicity⁴ and low modulus-high strength⁵. Hafnium is relatively expensive, but the excellent characteristics that Hafnium yields reimburse the manufacturing of material comprising Hafnium. These characteristics include excellent biocompatibility, hardness, and wear and corrosion resistance⁴.

METHODOLOGY

Hafnium powder was preplaced on Ti6Al4V substrates and single laser tracks were made by irradiating the preplaced powder with an Nd:YAG laser ($\lambda=1.064\mu\text{m}$).



Figure 1: Rofin Nd:YAG laser used for irradiation of the powder on the substrate.

Table 1: Parameters used to irradiate the preplaced powder to form thin coatings.

	Power (W)	Scan speed (mm/s)	Beam spot size (mm)
Sample 1	1 000	10	1
Sample 2	1 000	10	4

The parameters were chosen to assess the influence of the energy density on the characteristics of bonding and the microstructure. The surface coating process was carried out under an inert Argon gas, to prevent oxidation and contamination of the laser generated melt-pool. The surface and cross-sections of the laser deposited coatings were examined using a Scanning Electron Microscope and an Optical Microscope.

RESULTS AND DISCUSSION

Observation of the top layer of the coating created by laser melting of the Hf powder showed incomplete melting and discontinuous coating along the laser track for all the process parameters. The polished cross-sections of the coatings revealed that the thickness of the adhered coated layers was between 0.1 and 0.15mm shown in Figure 2.

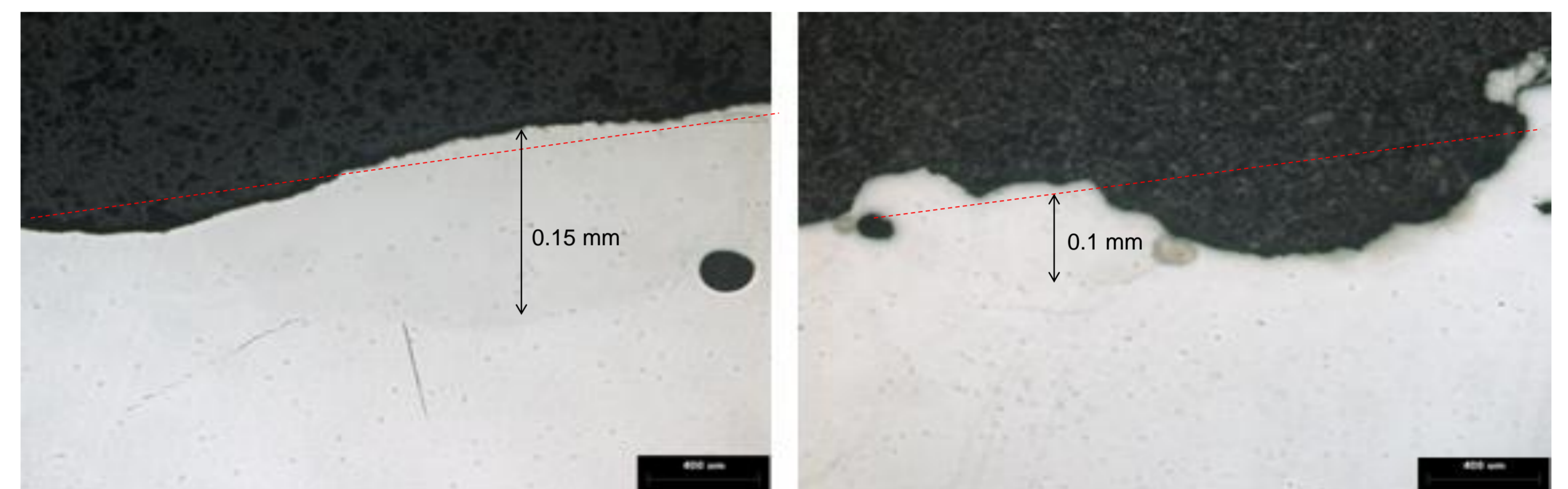


Figure 2: OM micrograph of coating, showing discontinued coatings

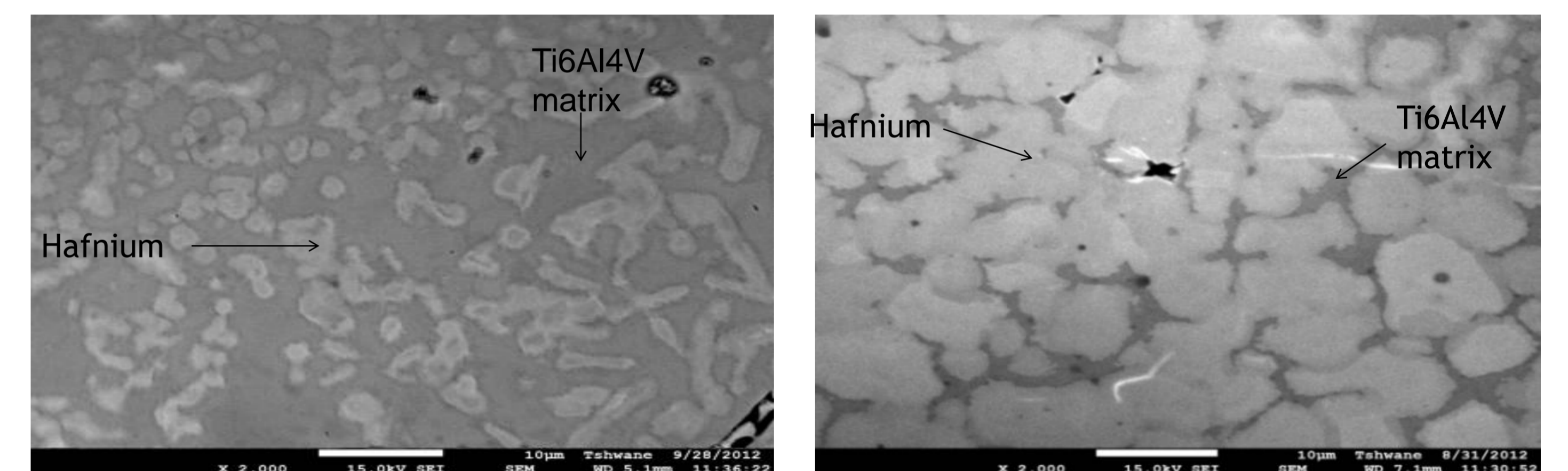


Figure 3: SEM micrograph of coating obtained with 1kw laser power and 1 and 4mm laser beam, respectively

Figure 3a shows the microstructure of the layer obtained after irradiating with 1kW, 10 mm/s and 1mm laser process parameters, translating to energy density of $100\text{J}/\text{mm}^2$ and 0.1s interaction time. The microstructure shows acicular particles distributed on the titanium substrate, EDX analysis of these particles revealed that they are Hf. Figure 3b shows larger agglomerated Hafnium structure which had less energy density of $25\text{J}/\text{mm}^2$ over 0.4s. The longer interaction of the beam with Hf powder allowed the generated melt of Hf particles to coalesce and form larger closely packed agglomerates.

CONCLUSION

In summary, Hf coating of titanium was achieved by the laser surface coating method. The increase in the beam spot size decreased the energy density delivered by the beam and increased the dwell time of the beam on the substrate; which resulted in the different structures formed. The coatings show some relatively continuous microstructure when exposed to low energy density and longer interaction time.

Further tests are planned to overcome the discontinuous coating that occurred.

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ACKNOWLEDGEMENTS

We wish to thank colleagues at Tshwane University of Technology and National Research Foundation for providing us with the support and resources to conduct this research.