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Wear behavior of heat-treated (66.7-x)Ti-xHf-22.2Si-11.1B alloys (x = 2, 4, 6 and 10 at.-%) by ball cratering

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Introduction

The Co-28Cr-6Mo alloy is used in the manufacture of hip joint prosthesis components. It is internationally regulated primarily by the ASTM F75 standard (for cast components) and the ASTM F1537 standard (for forged/wrought components), which specify hardness ranges of 300–400 HV and 350–450 HV, respectively. Furthermore, it exhibits a low reduced wear coefficient close to 10^{-8} to 10^{-9} mm²/N, under metal-on-metal contact conditions.

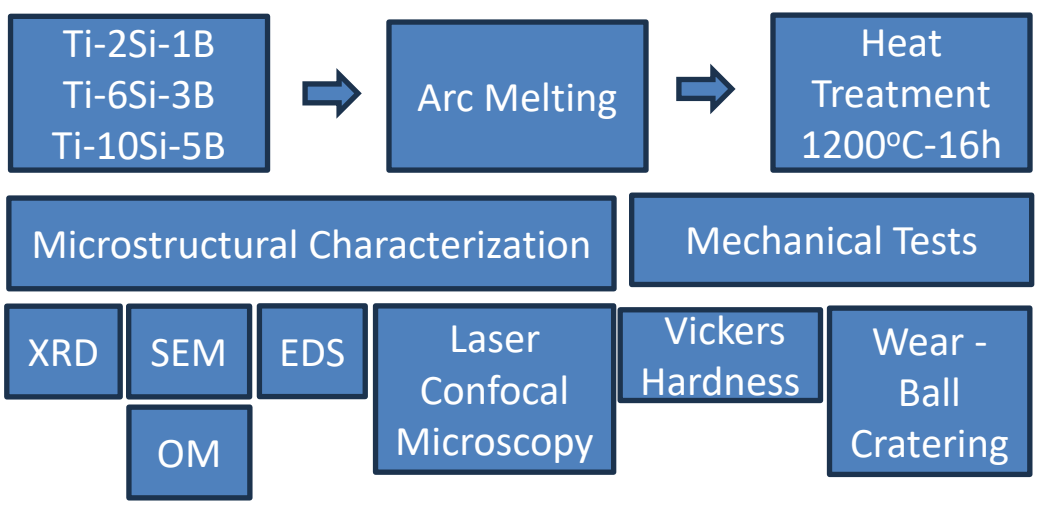
Titanium alloys based on substitutional solid solutions offer limited wear resistance. Ti_6Si_2B has a Vickers hardness of approximately 1000 HV.

Information regarding Ti-Si-B alloys containing Ti_6Si_2B precipitates remains limited in the literature.

Objective

To evaluate the wear resistance by the ball-cratering technique of Ti-2Si-1B, Ti-6Si-3B, and Ti-10Si-5B (at.%) alloys containing α-Ti+TiB and α-Ti+Ti_6Si_2B microstructures in order to compare with 66.7Ti-22.2Si-11.1B alloys containing hafnium addition.

Materials and Methods



Results and Discussion

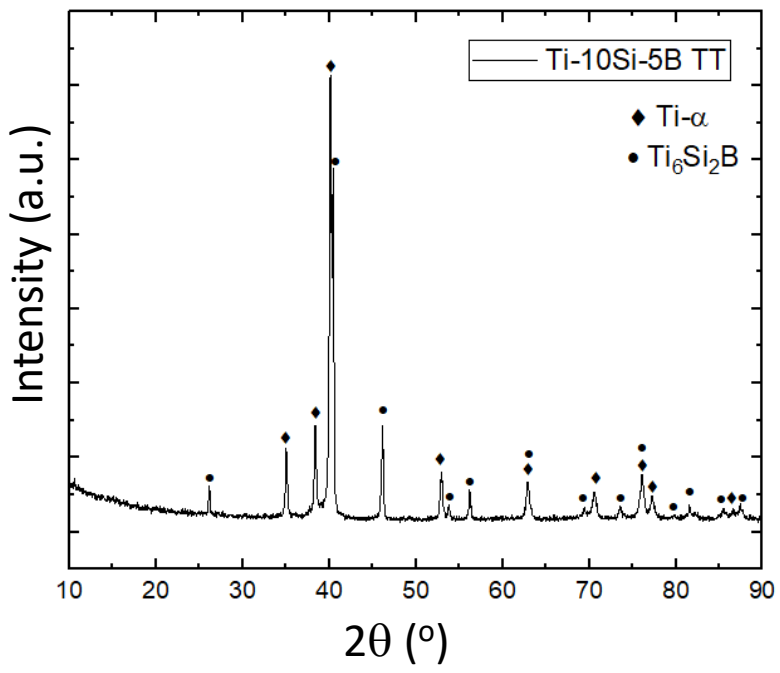


Figure 1 - X-ray difractogram of the Ti-10Si-5B (at.-%) alloy heat treated at 1200°C for 16h.

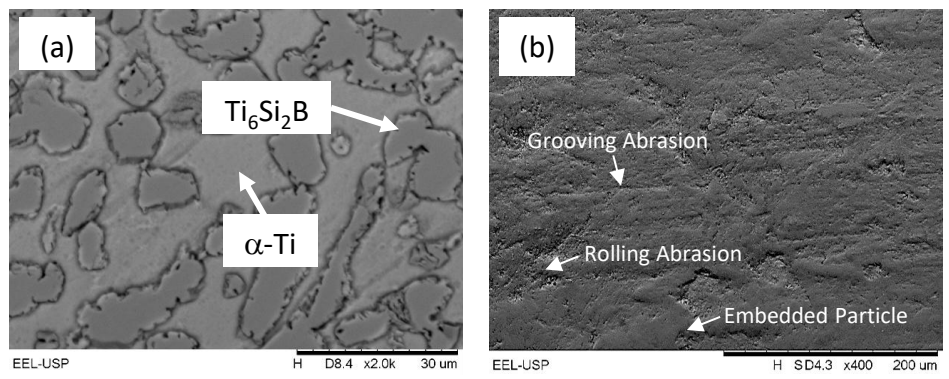


Figure 2 – SEM images of the Ti-10Si-5B (at.-%) alloy: (a) after heating at 1200°C for 16h; (b) worn surface.

Table 1 – Ti and Si contents measured by EDS analysis of heat-treated Ti-Si-B alloys.

Alloy (at.-%)	Phase	Ti (at.-%)	Si (at.-%)
Ti-2Si-1B	α-Ti	97.8 – 98.1	1.9 – 2.2
	TiB	99.6 – 99.7	0.3 – 0.4
Ti-6Si-3B	α-Ti	98.6-99.0	1.0-1.5
	TiB	97.5-99.0	1.0-2.5
	Ti_6Si_2B	73.9-74.4	25.6-26.3
Ti-10Si-5B	Ti-α	97.5-97.8	2.0-2.5
	Ti_6Si_2B	73.6-73.9	26.1-26.4

Table 2 – Ti and Si contents measured by EDS analysis of heat-treated Ti-Si-B alloys.

Alloy (at.-%)	Microhardness (HV)
97Ti-2Si-1B	264.0 ± 18.1
91Ti-6Si-3B	340.5 ± 29.5
85Ti-10Si-5B	481.5 ± 28.9

Figure 3 – Optical micrographs of wear craters on the surfaces of the heat-treated Ti-Si-B alloys: (a) Ti-2Si-1B, (b) Ti-6Si-3B and c) Ti-10Si-5B.

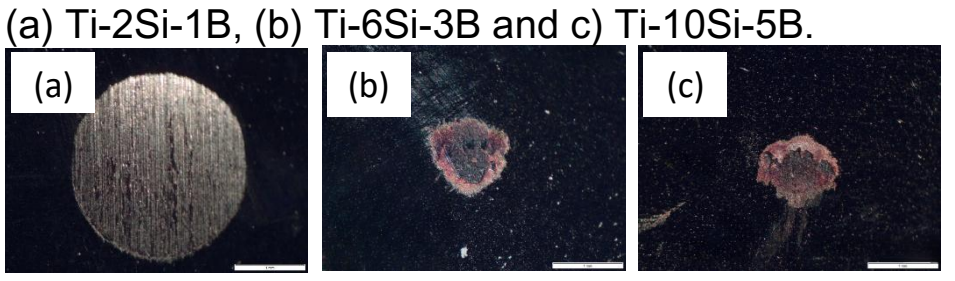


Table 3 – Wear results obtained by ball cratering of heat-treated (a) Ti-2Si-1B, (b) Ti-6Si-3B and (c) Ti-10Si-5B alloys.

	Worn Volume (mm³)	Wear Depth (mm)	Reduced Wear Coefficient (mm²/N)
(a)	0.1714 ± 0.0352	0.0653 ± 0.0070	$9.14.10^{-8} \pm 1.88.10^{-8}$
(b)	0.0062 ± 0.0021	0.0123 ± 0.0020	$3.29.10^{-9} \pm 1.10.10^{-9}$
(c)	0.0042 ± 0.0017	0.0101 ± 0.0022	$2.26.10^{-9} \pm 9.29.10^{-10}$

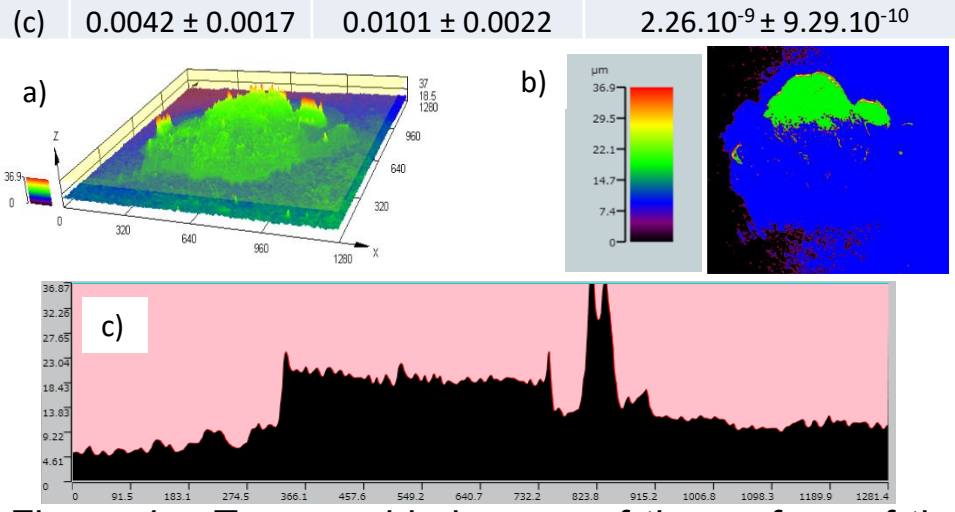


Figure 4 – Topographic images of the surface of the heat-treated Ti-10Si-5B alloy after wear test: a) 3D image of the wear track; b) 2D image of the wear track; c) Transverse roughness profile (scale in micrometers).

Conclusions

Microstructure based on the α-Ti+Ti_6Si_2B phases present similar wear behavior than the Co-Cr-Mo alloys.

Acknowledgments

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