

Oct 3rd, 2013

Composite Coatings

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Contents



1

Solid Diffusion Boronizing Coatings

2

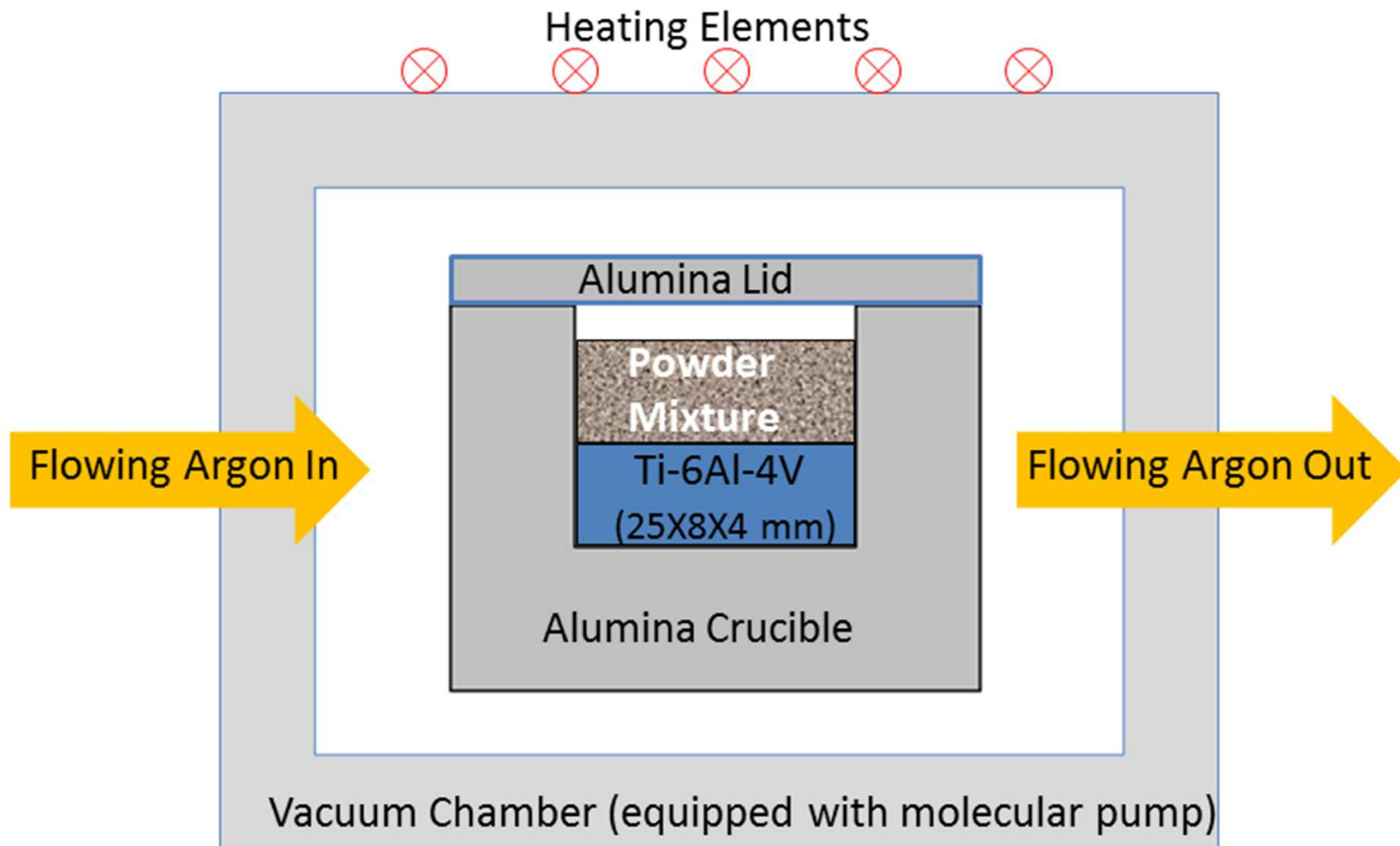
Laser Cladding Coatings



1. Solid diffusion boronizing coatings

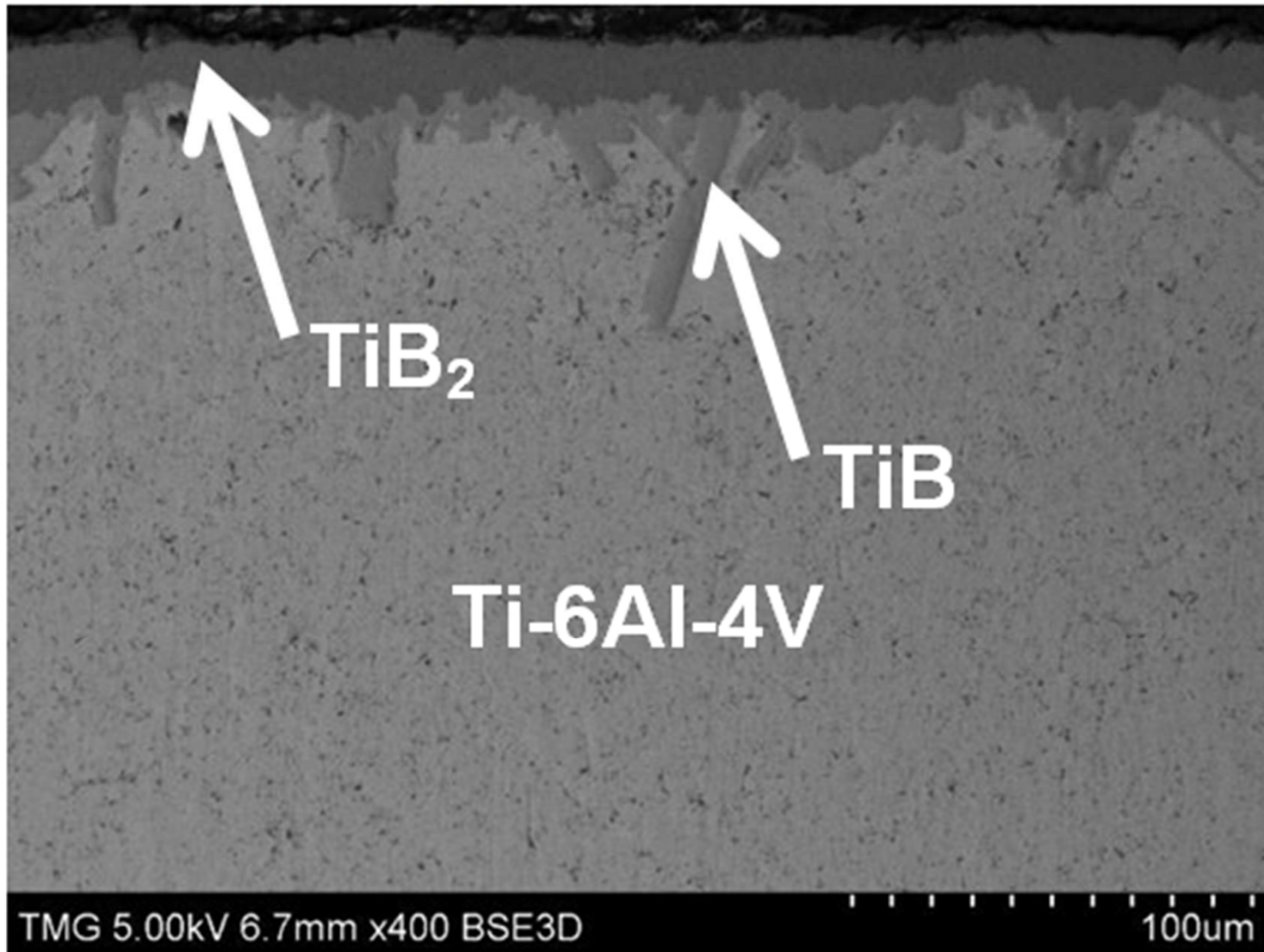
1. Solid diffusion boronizing coatings

Experiment Setup



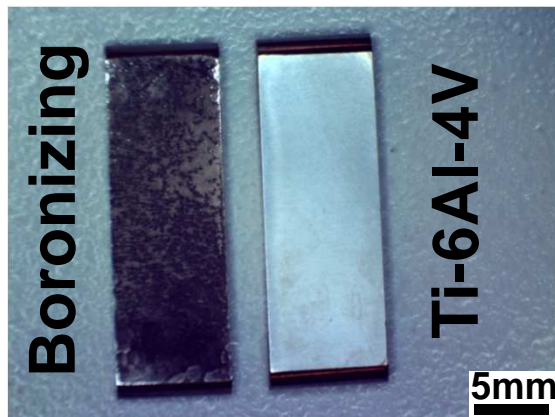
1. Solid diffusion boronizing coatings

Boronizing coating microstructure

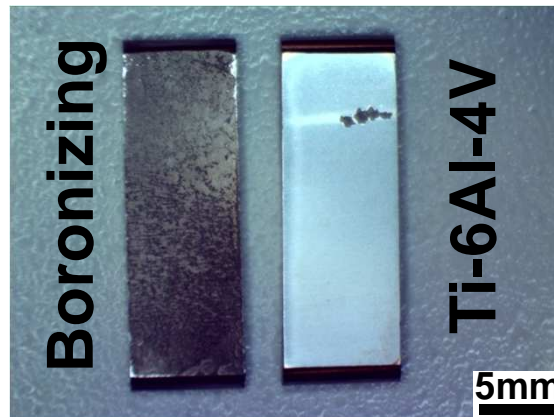


1. Solid diffusion boronizing coatings

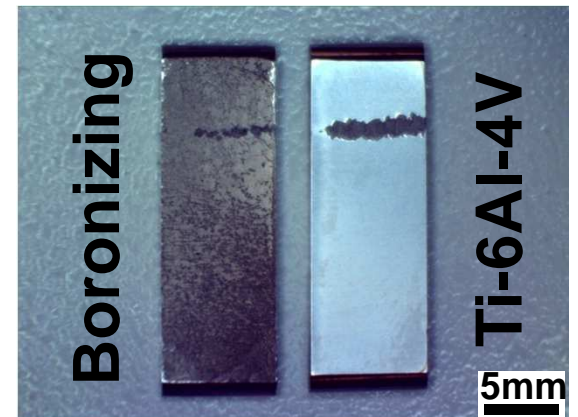
Eroded surfaces: boronizing coatings vs Ti-6Al-4V



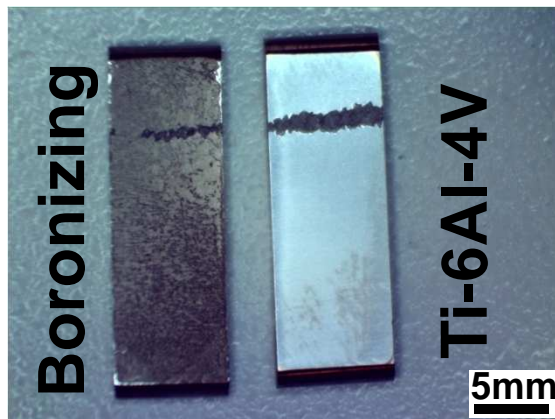
Before erosion



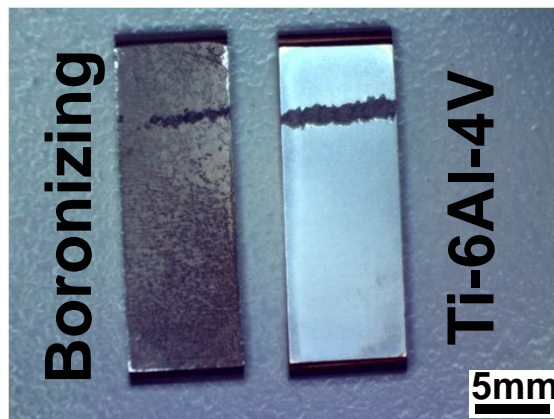
2 min



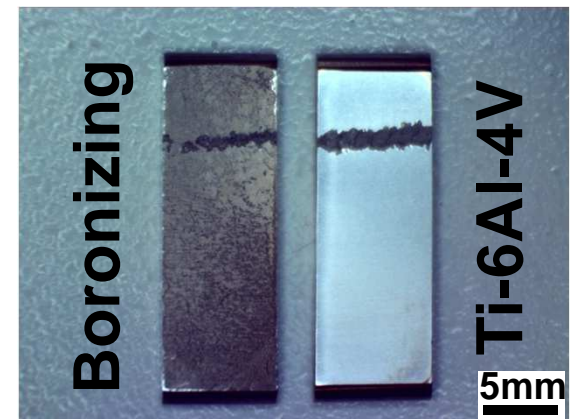
5 min



7 min



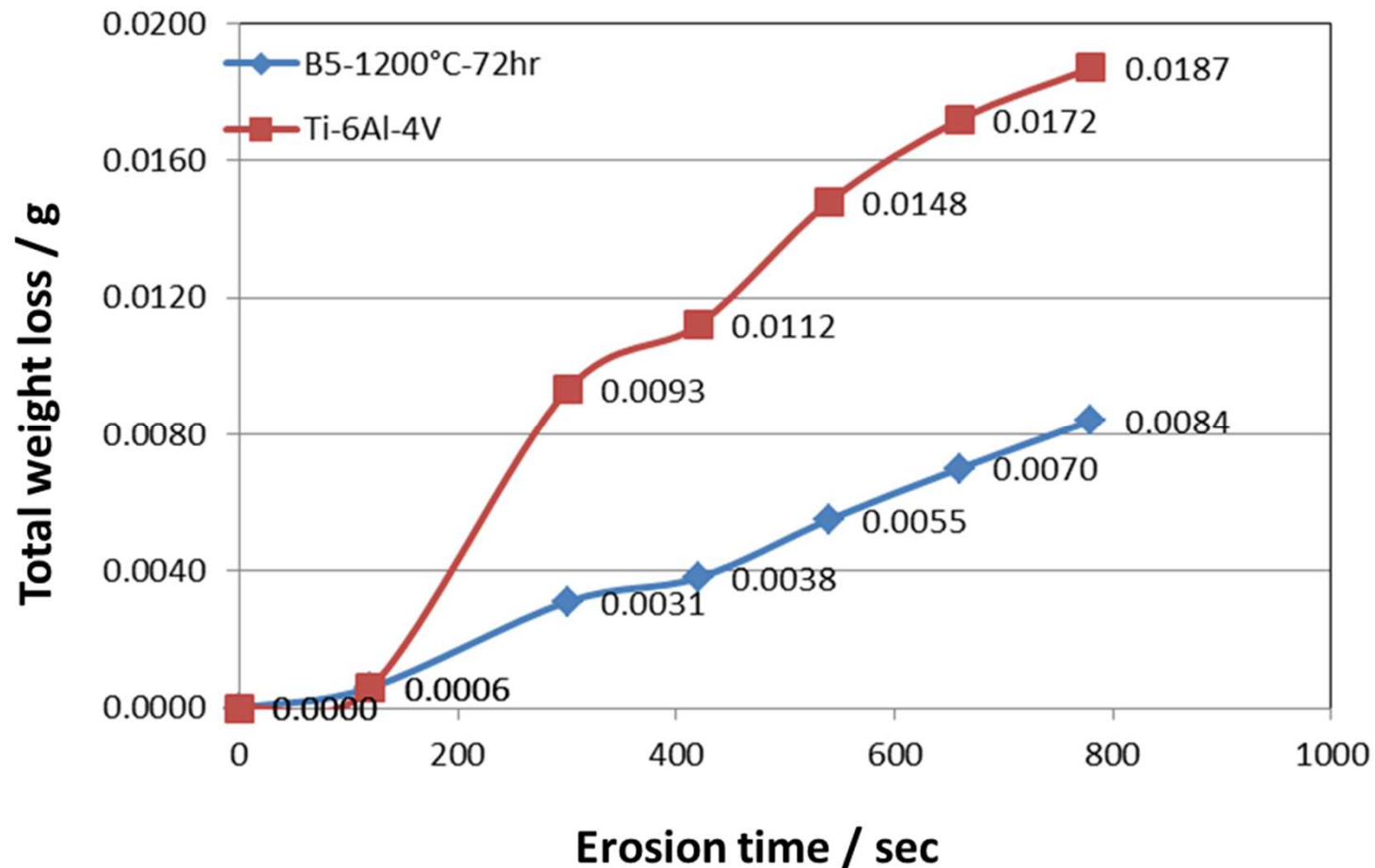
9 min



13 min

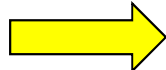
1. Solid diffusion boronizing coatings


Erosion curves: boronizing coatings vs Ti-6Al-4V



1. Solid diffusion boronizing coatings

Major technique modification
& difficulty & reason of delay

Small crucible (20ml)  Large crucible (70ml)

Amorphous boron  Boron carbide

1. Solid diffusion boronizing coatings

Response surface experiment design

	Factor 1 B4C %wt	Factor 2 Na2CO3 %wt	Factor 3 Temperature/°c	Factor 4 Time / hr
Low	45	5	1050	24
Medium	50	25	1200	72
High	55	45	1350	120

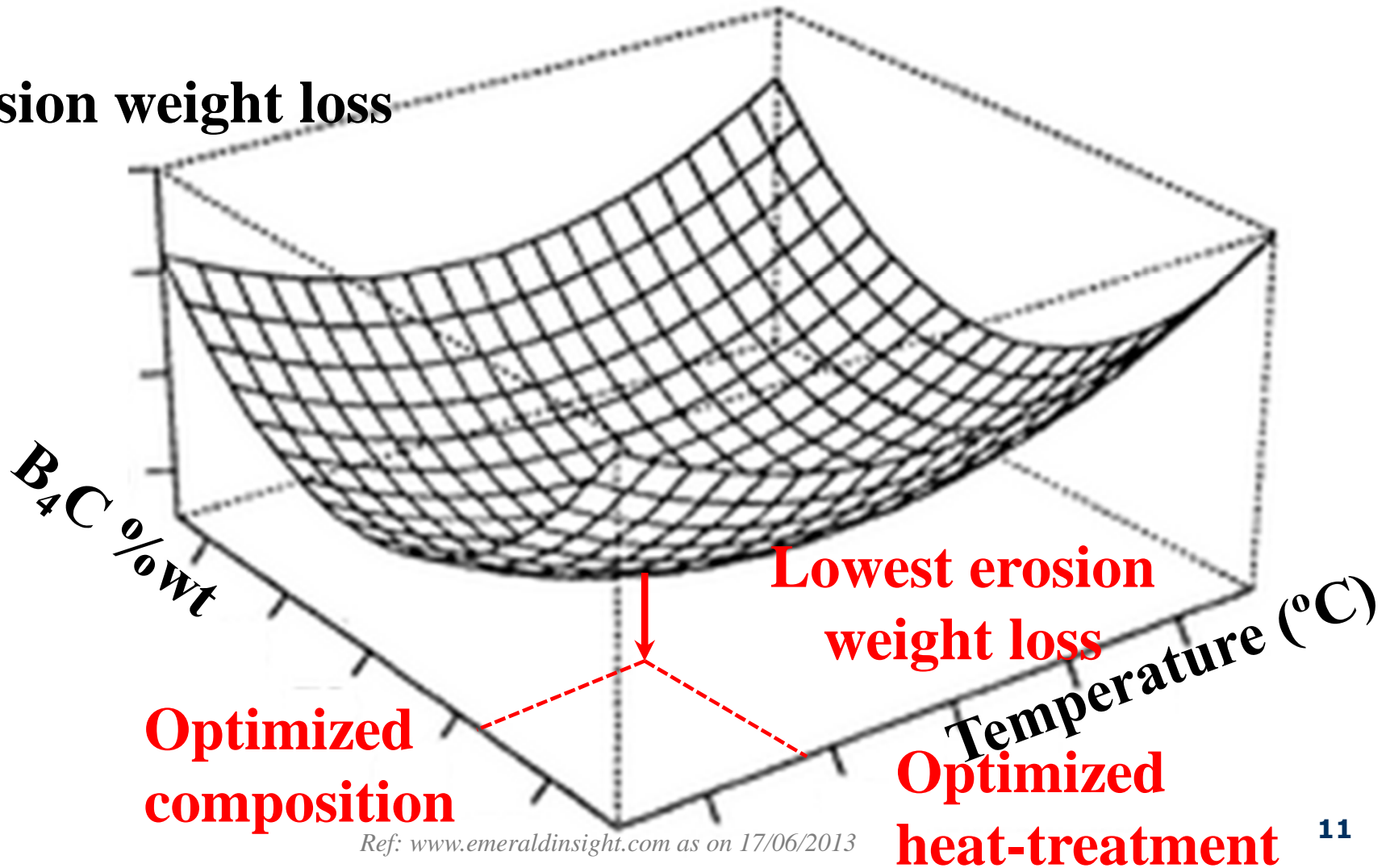
Response:

- Erosion weight loss

1. Solid diffusion boronizing coatings

Expected response surface output

Erosion weight loss



Ref: www.emeraldinsight.com as on 17/06/2013

1. Solid diffusion boronizing coatings

Lot #	B ₄ C (%wt)	Na ₂ CO ₃ (%wt)	Temperature (°C)	Time (hrs)	Status
1	55	5	1050	24	DONE
1	45	45	1050	24	
1	55	45	1050	24	
1	45	5	1050	24	
2	50	25	1050	72	DONE
3	55	5	1050	120	Under Preparation
3	45	5	1050	120	
3	45	45	1050	120	
3	55	45	1050	120	
4	50	25	1200	24	DONE
5	55	25	1200	72	Under Pre
5	45	25	1200	72	
5	50	25	1200	72	
5	50	25	1200	72	
5	50	5	1200	72	
5	50	25	1200	72	

Lot #	B ₄ C (%wt)	Na ₂ CO ₃ (%wt)	Temperature (°C)	Time (hrs)	Status
6	50	45	1200	72	
6	50	25	1200	72	
6	50	25	1200	72	
6	50	25	1200	72	
6	50	25	1200	72	
7	50	25	1200	120	
8	55	45	1350	24	
8	45	5	1350	24	
8	55	5	1350	24	
8	45	45	1350	24	
9	50	25	1350	72	
10	45	5	1350	120	
10	55	5	1350	120	
10	45	45	1350	120	
10	55	45	1350	120	

1. Solid diffusion boronizing coatings

Schedule:

Sample preparation:

September - November, 2013

Rig testing:

October - December, 2013

Characterization:

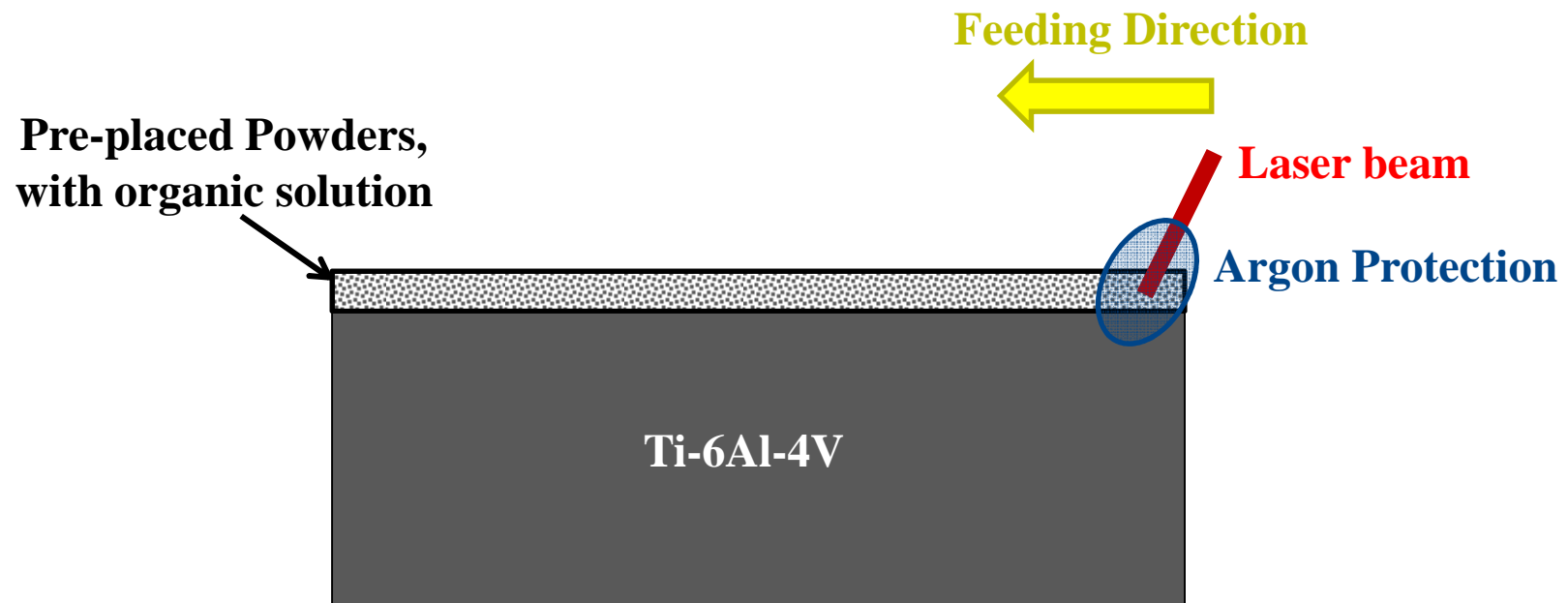
October – December, 2013



2. Laser Cladding Coatings

2. Laser Cladding Coatings

Laser Cladding Setup



2. Laser Cladding Coatings

Desired Powders & Chemical Reaction & Strengthening Phases

Sample #	Priority	Composition wt%	Desired Chemical Reaction	Desired strengthening phases
1-5	★★★	TiB ₂ 100%	Ti + TiB ₂ = 2TiB [5]	TiB, TiB ₂
21-25	★★★	Ti 20% + TiB ₂ 80%		
	★★★	Ti 41% + TiB ₂ 59% [5]		
6-10	★	B ₄ C 100%	3Ti + B ₄ C = 2TiB ₂ + TiC [1] 5Ti + B ₄ C = 4TiB + TiC [2]	TiB ₂ , TiB, TiC
	★	Ti 50% + B ₄ C 50%		
	★★	Ti 72% + B ₄ C 28% [1]		
	★	Ti 81% + B ₄ C 19% [2]		
11-15	★★★	h-BN 100%	3Ti + 2BN = TiN ₂ + 2TiB [3] 2Ti + BN = TiN + TiB [4]	TiN, TiN ₂ , TiB
	★★	Ti 40% + h-BN 60%		
	★★	Ti 74% + h-BN 26% [3]		
	★★	Ti 79% + h-BN 21% [4]		
16-20	★★★	Al 100%	Ti + Al = TiAl [6] 3Ti + Al = Ti ₃ Al [7]	TiAl, Ti ₃ Al
	★	Ti 50% + Al 50%		
	★★★	Ti 64% + Al 36% [6]		
	★	Ti 84% + Al 16% [7]		

**Experiment
Plan
Finalized!**

2. Laser Cladding Coatings

Powders Choosing & Purchase

☺ Mengtai Jingdian Metallic Materials Ins. (Beijing, China)

<http://detail.1688.com/offer/1134349694.html>

TiB₂, B₄C, (Al, Ti, h-BN)

CNPC POWDER Co. (Shanghai, China)

<http://detail.1688.com/offer/660687195.html>

(Al, Ti)

Xinfukang Special Material Co. (Zibo, China)

<http://detail.1688.com/offer/1174318902.html>

(h-BN)

Purity: 99 - 99.999% wt

Grit size: ~50 μm

Powders Ready!

2. Laser Cladding Coatings



Laser Generator (Jiangsu University, Zhenjiang, China)

2.5KW CO₂

Transverse,

Fast Axial Flow,

Gate Pulse & Continuous Laser Beam

**Laser Cladding
Machine Ready!**

2. Laser Cladding Coatings

Laser Cladding Parameters

Sample No. #	Laser Power (kW)	Pre-placed Powder Thickness (mm)	Feeding Speed (mm/s)
1-5	2	2	2
6-10	2	2	3
11-15	2.5	2	2
15-20	2.5	2	3
21-25	2	2	4

**Laser Cladding
Parameters Finalized!**

2. Laser Cladding Coatings

Pre-treatment & Pre-heat & Post-cladding Treatment

Pre-treatment:

Grind, polish, ethonol rinse

Pre-heat prior laser cladding: @400°C

Post-cladding treatment:

Hold @ 400°C + slow cooling

To avoid cracks due to thermo-stress.

**Pre-heat & Post-cladding-treatment
Finalized!**

2. Laser Cladding Coatings



Schedule:

Laser cladding preparation:

~20 working hours

October: DONE!

Rig testing:

November-December 2013.

Characterization:

November-December 2013.



Thank you