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Evaluation of Fujimi MoB/CoCr coating after dipping test at Nucor Crawfordsville GI line

Samples Hung	March 22, 2012
First Removal	April 21, 2012
Second Removal	May 29, 2012
Third Removal	June 28, 2012

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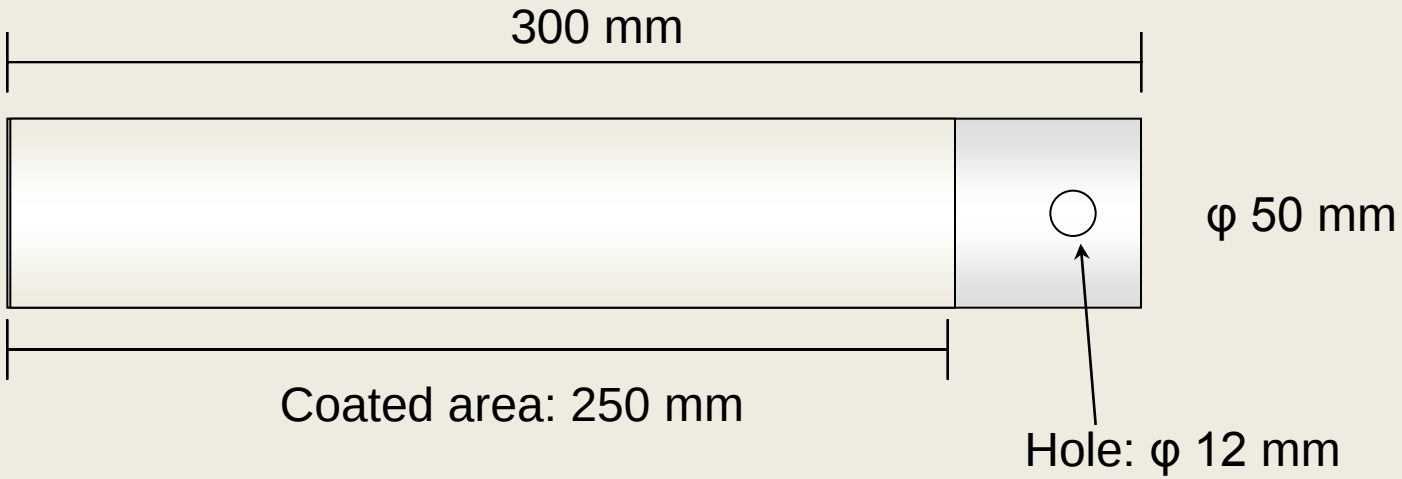
Specimen information

Substrate material: Stainless steel 316L
Coating material: MoB/CoCr
MR-100 sealant (Tyranocoat)



Specimens number: 6 pieces

2 kinds of coating (B46 and B47) x 3 pieces

Post treatment

Grinding & Sealing

Thickness after grinding: around 100 μm

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MoB_2 Coating Preparation Optimizing

MoB/CoCr coating has an excellent durability against to molten Zn. However the coating is sometimes damaged without showing its intrinsic performance due to penetration of Zn through connected pores. Inorganic sealant is used for closing the pore, and it is effective to improve the durability. Also in this case, denser coating would be preferred for the reliability.

Salt spray test

This test method is effective to evaluate the number and size of connected pore qualitatively. If the coating has connected pore, salt water is easily penetrate in the coating. And the rust from carbon steel substrate come out on the coating surface. The coating which shows good durability in this test, that means dense coating, should be also shows good performance in the molten Zn.

Coating preparation

Substrate: Carbon steel SS400 50 x 70 x 2t mm
Coating thickness: 100~120 microns (fixed)
Powder size: -45+15, -38+10, -30+5 micron
Spray parameter
Gun: JP-5000 (fixed)
Combustion: a, b, c, d (page 3)
Spray distance: 380, 340, 300 mm
Barrel length: 4, 6, 8 inches

Test condition

Concentration of NaCl: 5 wt% (pH7)
Temperature: 35 deg C
Spray rate: 1~2 ml/h
Spray pressure: 0.098 MPa
Observation time: every 24 hr

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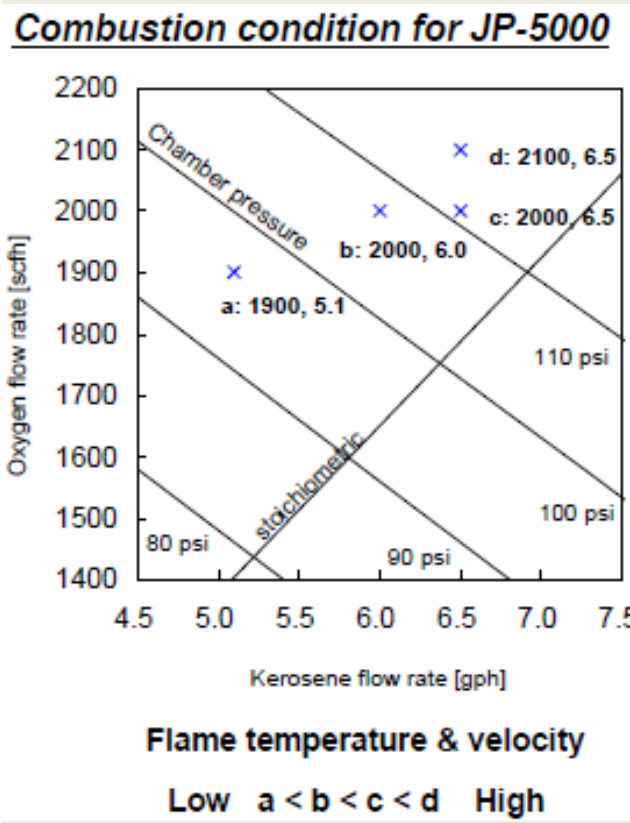
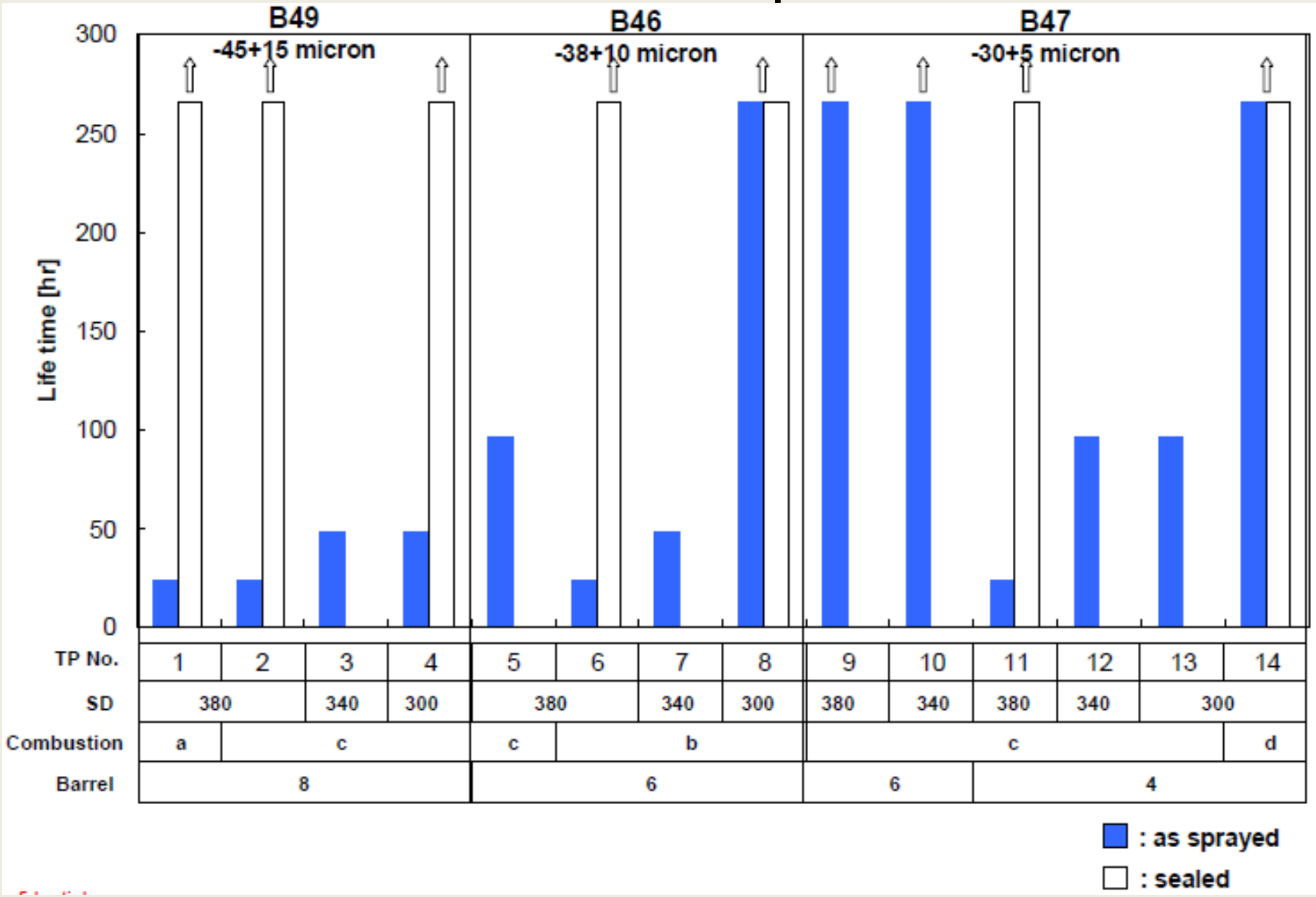
Specimens

TP. No	Powder	Combustion	BL [inches]	SD [mm]	spitting
1	DTS-B49-45/15 -45+15 micron	1900, 5.1	8	380	OK
1s*					
2		2000, 6.5		340	
2s*					
3				300	
4					
4s*					
5	DTS-B46-38/10 -38+10 micron	2000, 6.5	6	380	NG
6		2000, 6.0			OK
6s*					
7				340	
8				300	
8s*					
9	DTS-B47-30/5 -30+5 micron	2000, 6.5	6	380	NG
10				340	
11			4	380	OK
11s*					
12				340	
13				300	
14		2100, 6.5			
14s*					

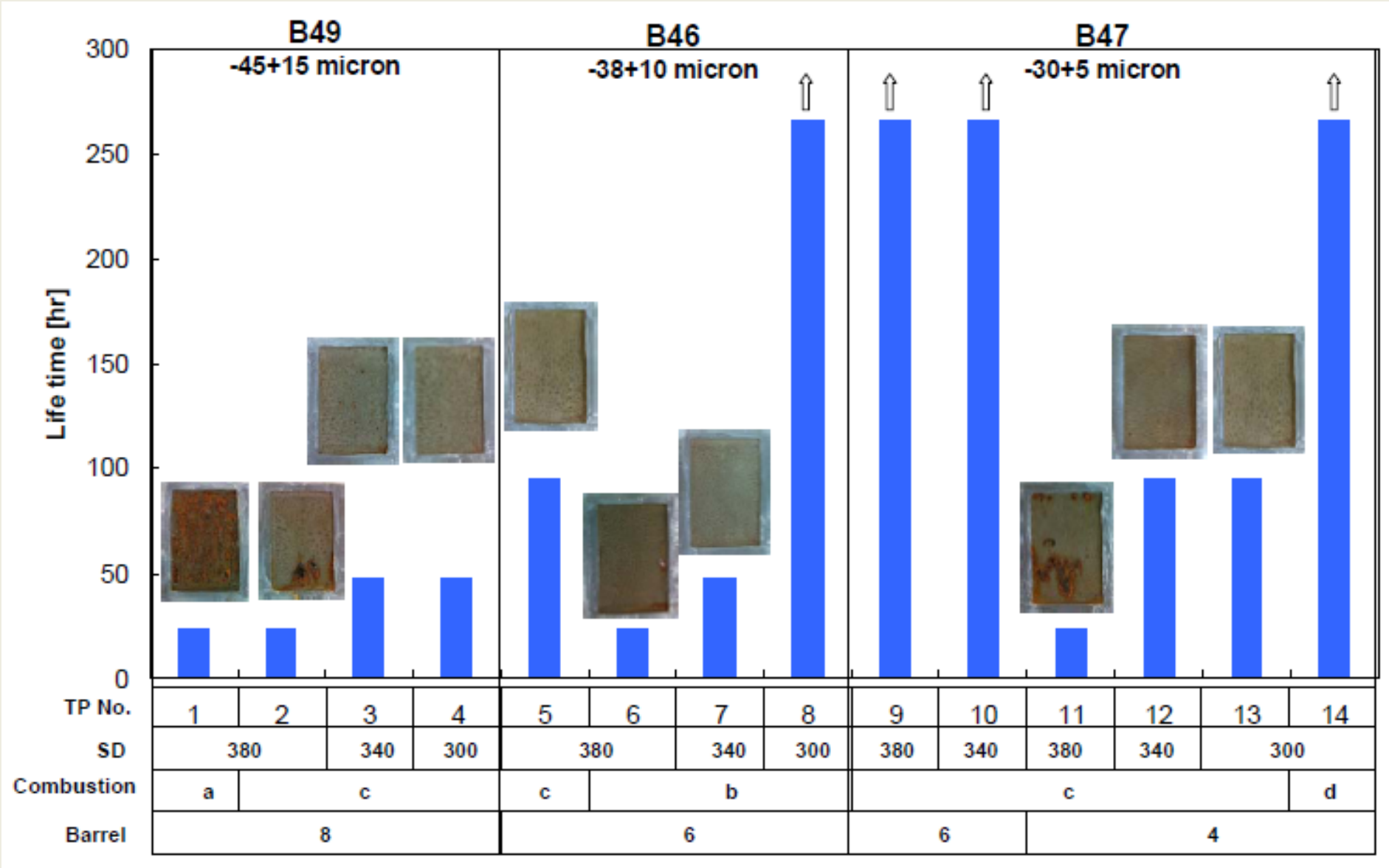
s* : sealed by MR-100, half area of sealant are removed by polishing



Results - all specimens



Results - as sprayed coatings



Summary

Durability for salt spray test

To make denser coating…

Finer powder of B46 or B47 is necessary.
And using those powder, the spray parameters which produce high temperature and velocity of in-flight particles should be established.

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Samples before Hanging at Nucor

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Samples immersed behind and aside of snout

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Another view of immersion site

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Samples immersed in GI Bath

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As-removed 1 month sample (1) B46 only

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As-removed 1 month sample (2) B46 only

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As-removed 2 month sample (1) B46 and B47

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As-removed 2 month sample (2) B46 and B47

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As-removed 3 month sample (1) B46 and B47

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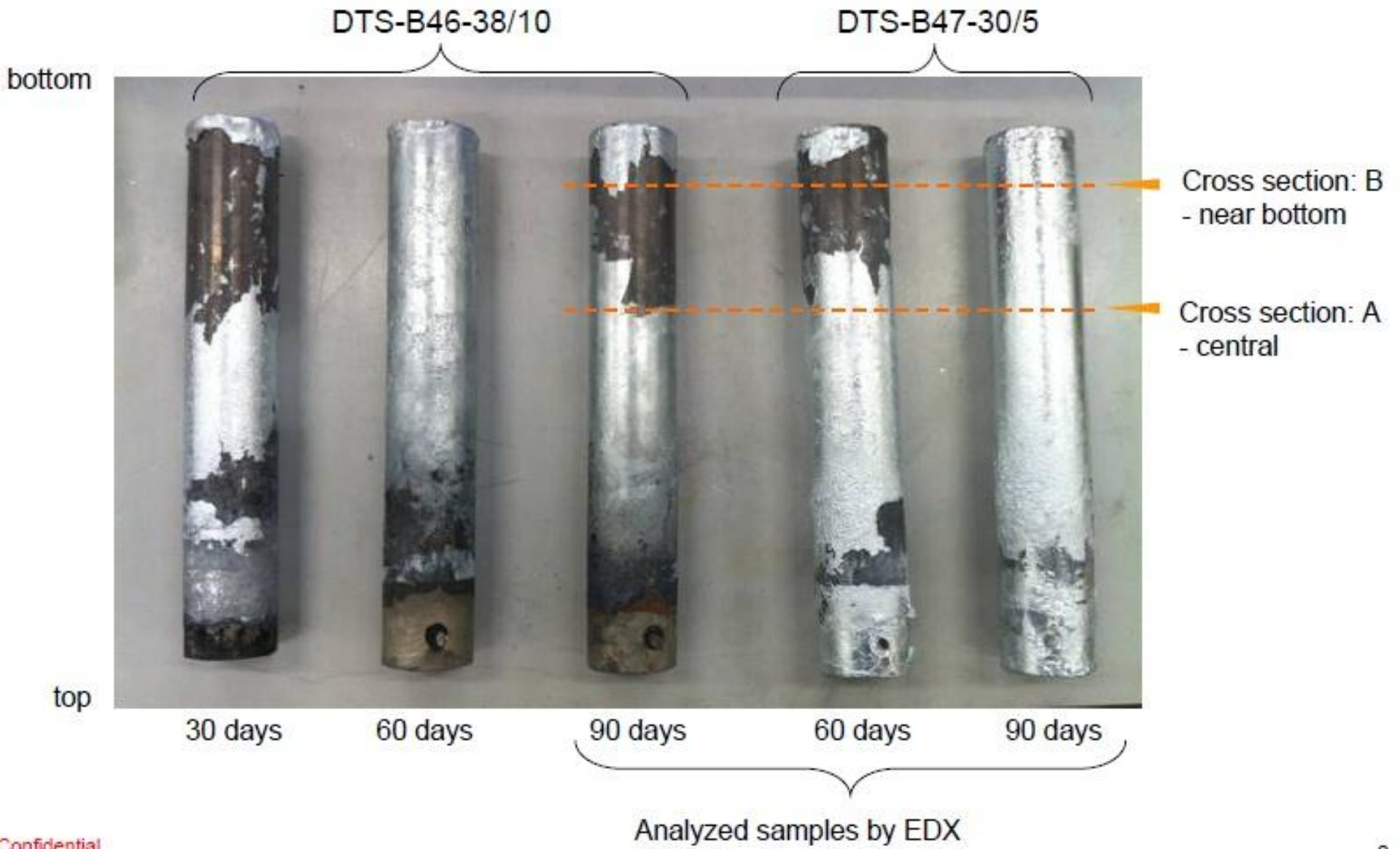
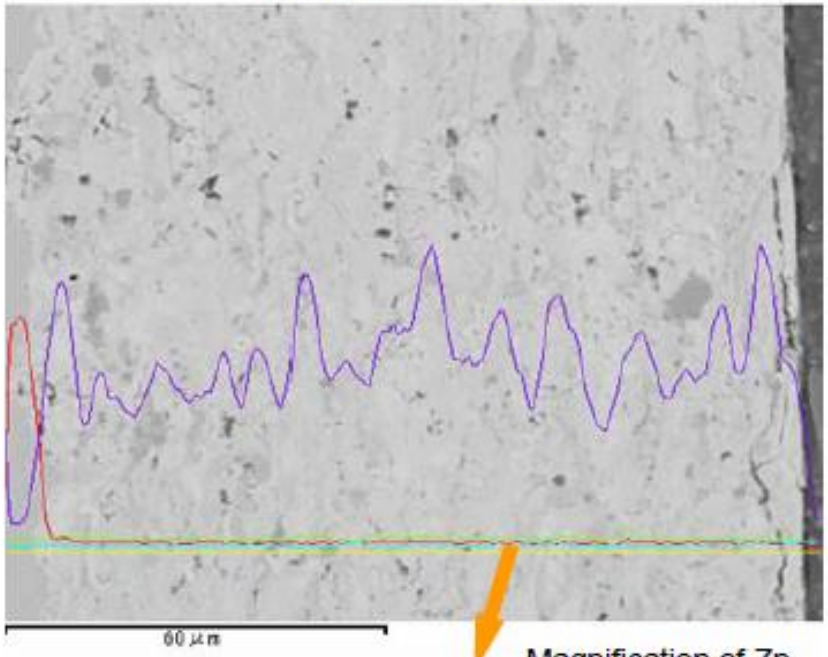
As-removed 3 month sample (2) B46 and B47

As received at Fujimi

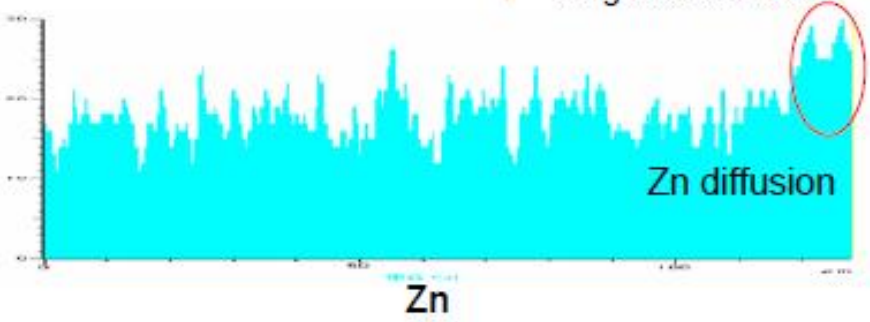


EDX analysis for cross section A (center) after dipping of 90 days

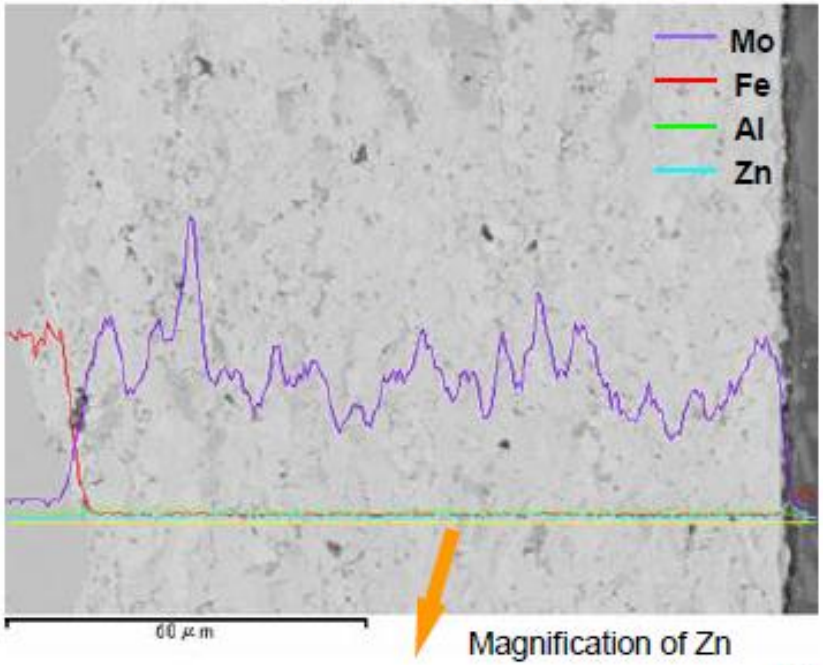
DTS-B46-38/10



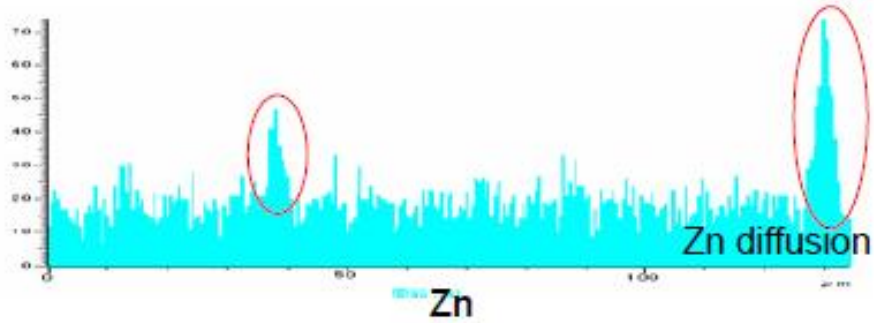
Magnification of Zn



DTS-B47-30/5

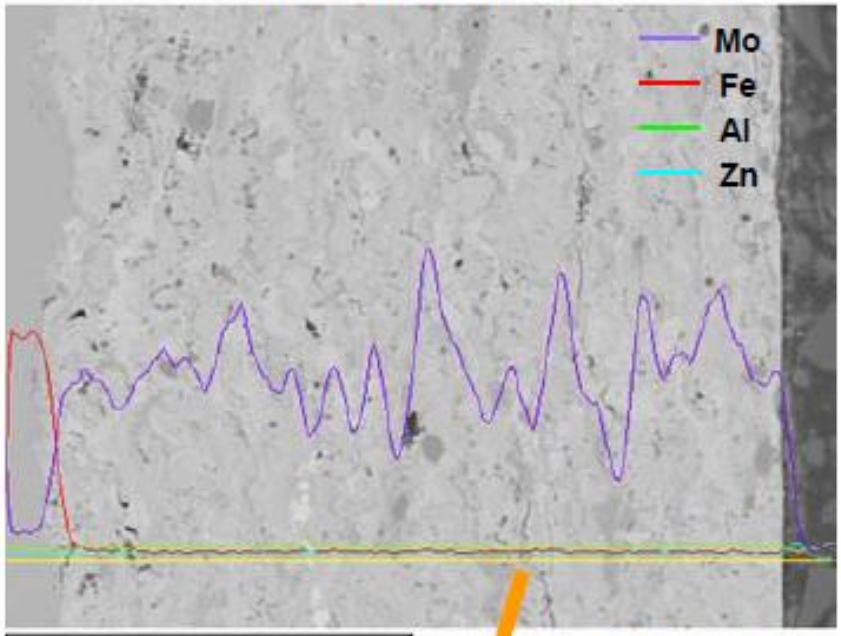


Magnification of Zn

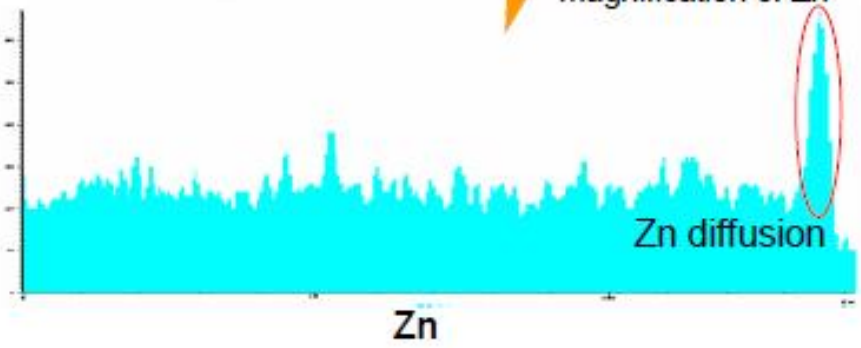


EDX analysis for cross section B (near bottom) after dipping of 90 days

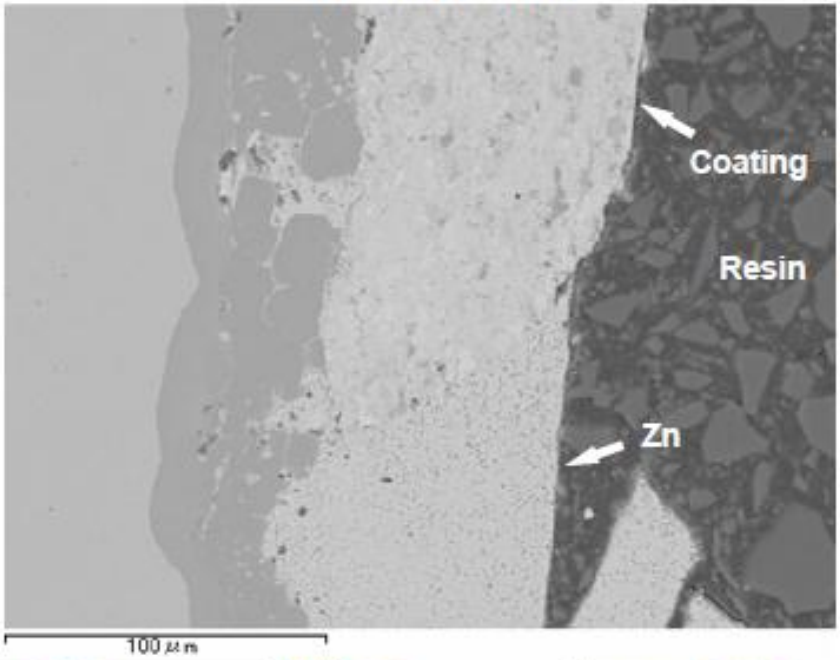
DTS-B46-38/10

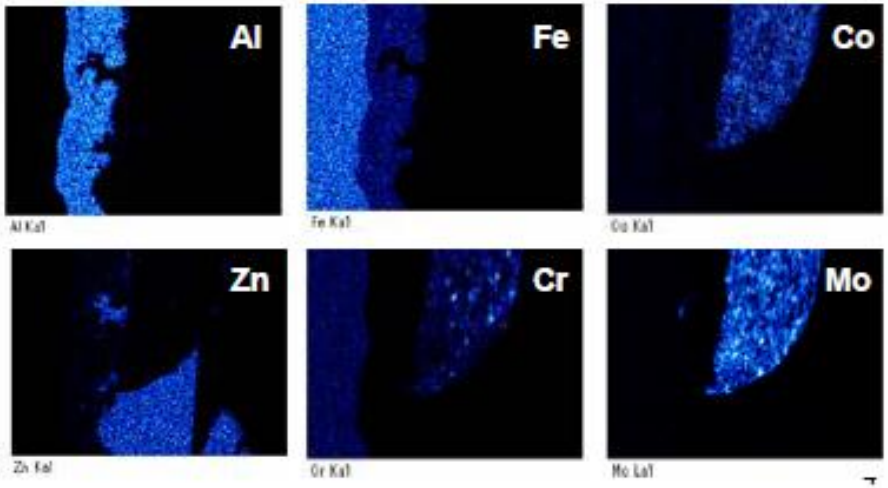


Magnification of Zn



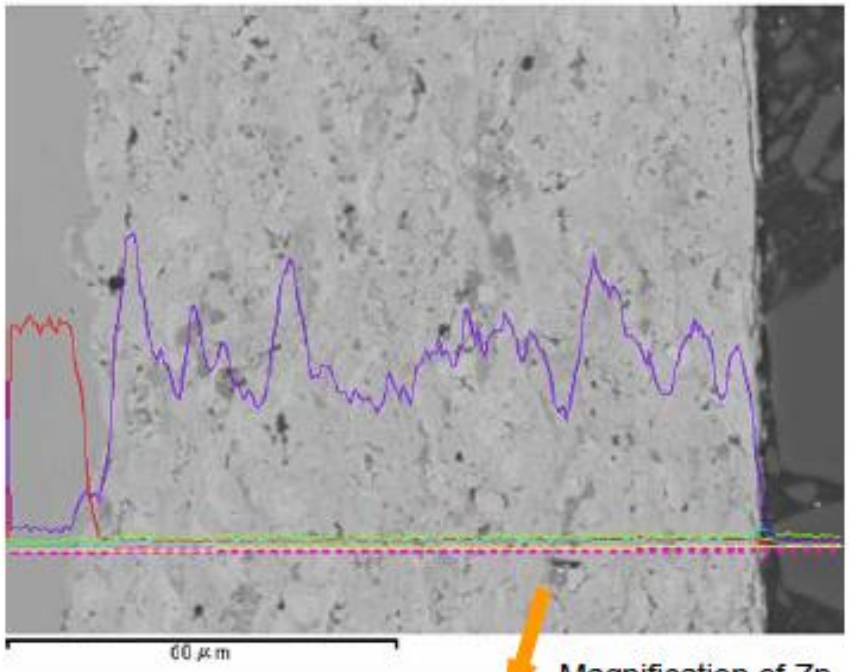
DTS-B47-30/5



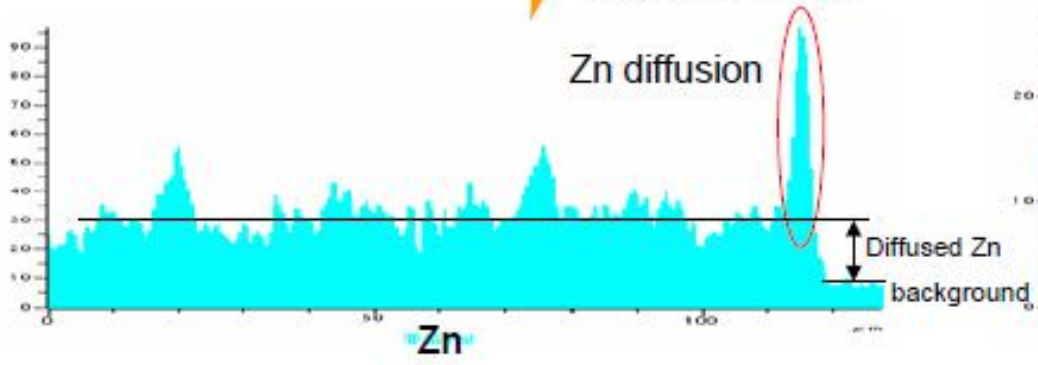


EDX analysis for cross section A & B after dipping of 60 days

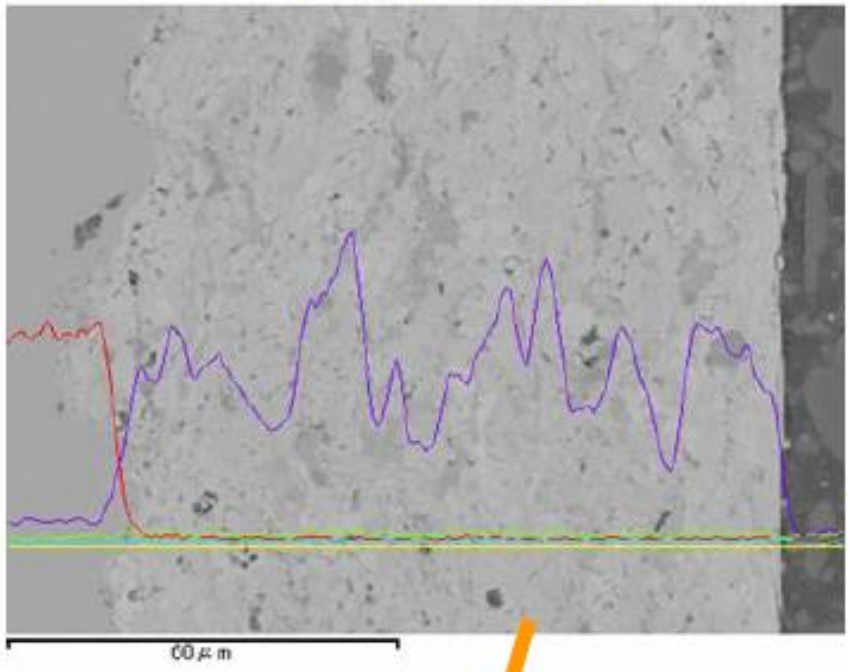
DTS-B47-30/5: A



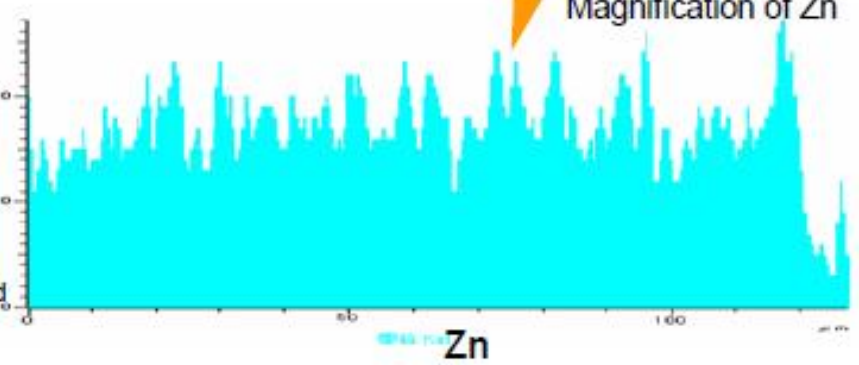
Magnification of Zn



DTS-B47-30/5: B



Magnification of Zn



Summary of EDX analysis

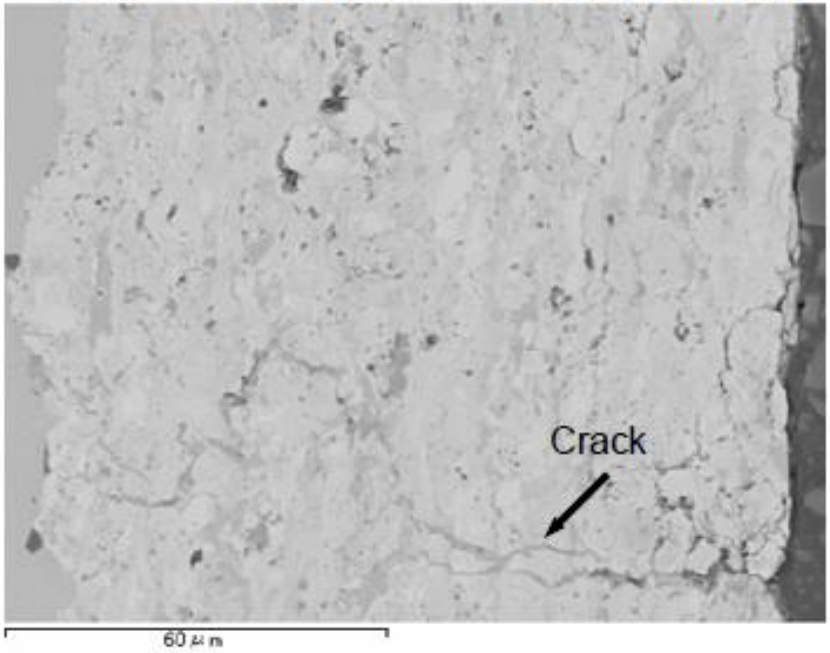
	DTS-B47-30/5		DTS-B46-38/10
	60 days	90 days	90days
A (center)	Good	Good	Good…
B (near bottom)	Good	NG	Good

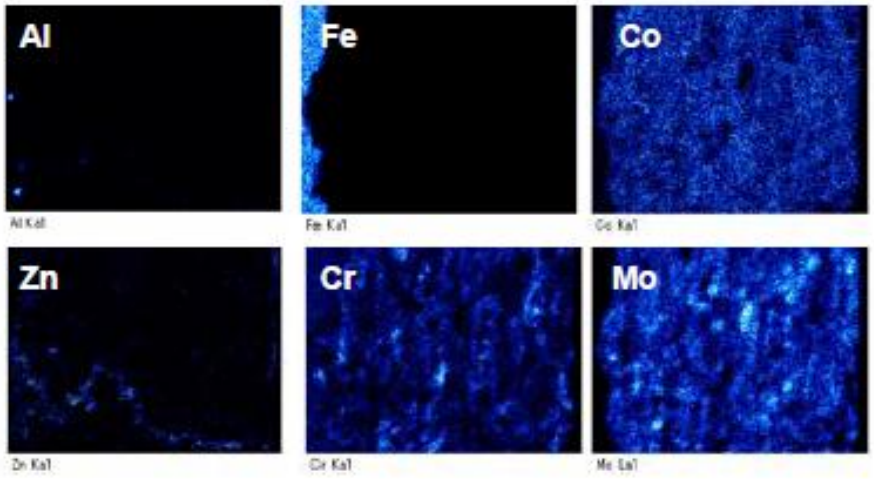
Good: dross was easily detached by hand (knife), a little Zn diffusion
NG: strong adhesion of dross. Dross reached substrate.

Coarser B46 seems to be better than finer B47 within the analysis. However, B46 might have problematic issue of cracks. See next.

Cracks, might be trigger of damage and possible solutions

DTS-B46-38/10: A after 90 days dipping





Dross removal by hand with knife
- B46_30, 60, 90 days and B47_60 days: easy
- B47_90 days: difficult

EDX
- Zn diffusion: yes in all samples
- Diffused thickness:
  very thin of less than 10 micron (B46_90 & B47_60)
  reached substrate at bottom (B47_90)
- Local Zn diffusion (see left figure)
  through cracks, might be generated heat shock?
  This might be first step of damage like B47_90 days.

Comments for further improvement

MoB/CoCr itself has good inertness but coating homogeneity is essentially important. To avoid cracks retaining low porosity (high density), careful HVOF spraying is necessary at first, where cracks might be formed before Zn dipping. Thinner coating less than 100 micron will be easier method to avoid crack generation during dipping and/or before dipping, which should be done in the next step.
This time, thickness around center and bottom was about 120 and 140 micron, respectively.

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Conclusions

No change is seen after exposure of MoB/CoCr coatings in almost all parts of the coatings

Small areas of coating loss and Zn penetration through vertical cracks were observed

Further improvement will focus on improving coating uniformity.

Because of the high durability of the coating, it should be possible to make it much thinner, probably less than 100 µm, to obtain a uniform coating

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