ACCELERATED CORROSION TESTING OF ALUMINUM BORON CARBIDE METAL MATRIX COMPOSITE IN SIMULATED PWR SPENT FUEL POOL SOLUTION

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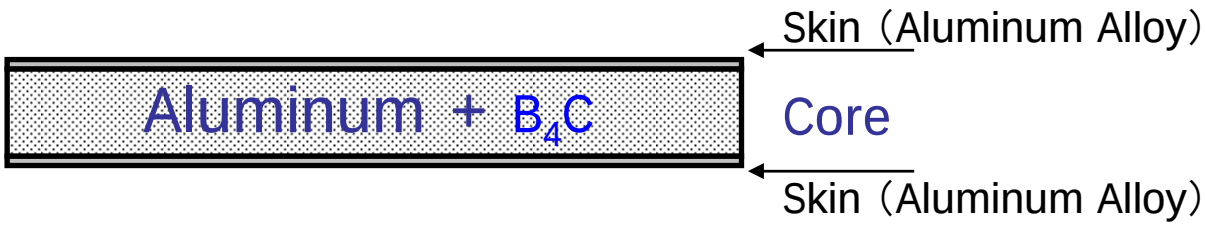
MAXUS®

- Newly developed in NLM
- Al/B_4C MMC Plate
- Neutron-absorbing material
- For both dry storage casks and wet storage racks

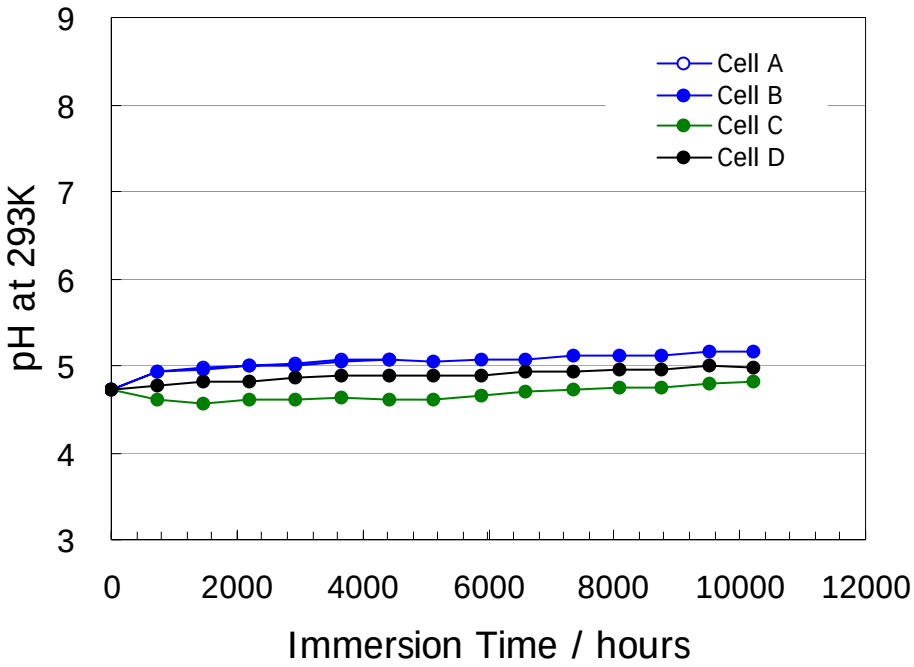


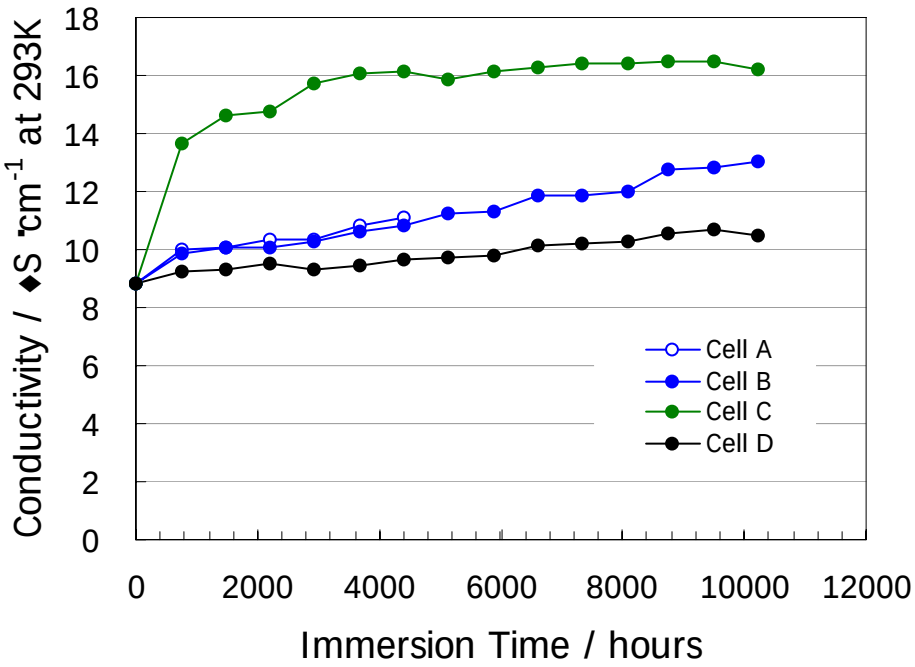
Testing Conditions

Material	MAXUS® Al/B_4C MMC Plate (15 wt%-B_4C Core) Clad Ratio: 19% (about 190 μm-thick Skins)
Solution	Simulated PWR Spent Fuel Pool Solution (including 3000 mg/kg Boron as Boric Acid)
Immersion Period	4320 h, 10080 h
Temperature	363 K (194 F)

No.	Surface Treatment	Thickness of the Anodic Films	Immersion Period	Cell
1	non-Anodized	-	4,320 h	A
2	non-Anodized	-	4,320 h	
3	non-Anodized	-	10,080 h	B
4	non-Anodized	-	10,080 h	
5	Anodized	Skin: 4-5 μm, Core: 2-3 μm	10,080 h	C
6	Anodized	Skin: 4-5 μm, Core: 2-3 μm	10,080 h	
-	(Blank Test)	-	10,080 h	D

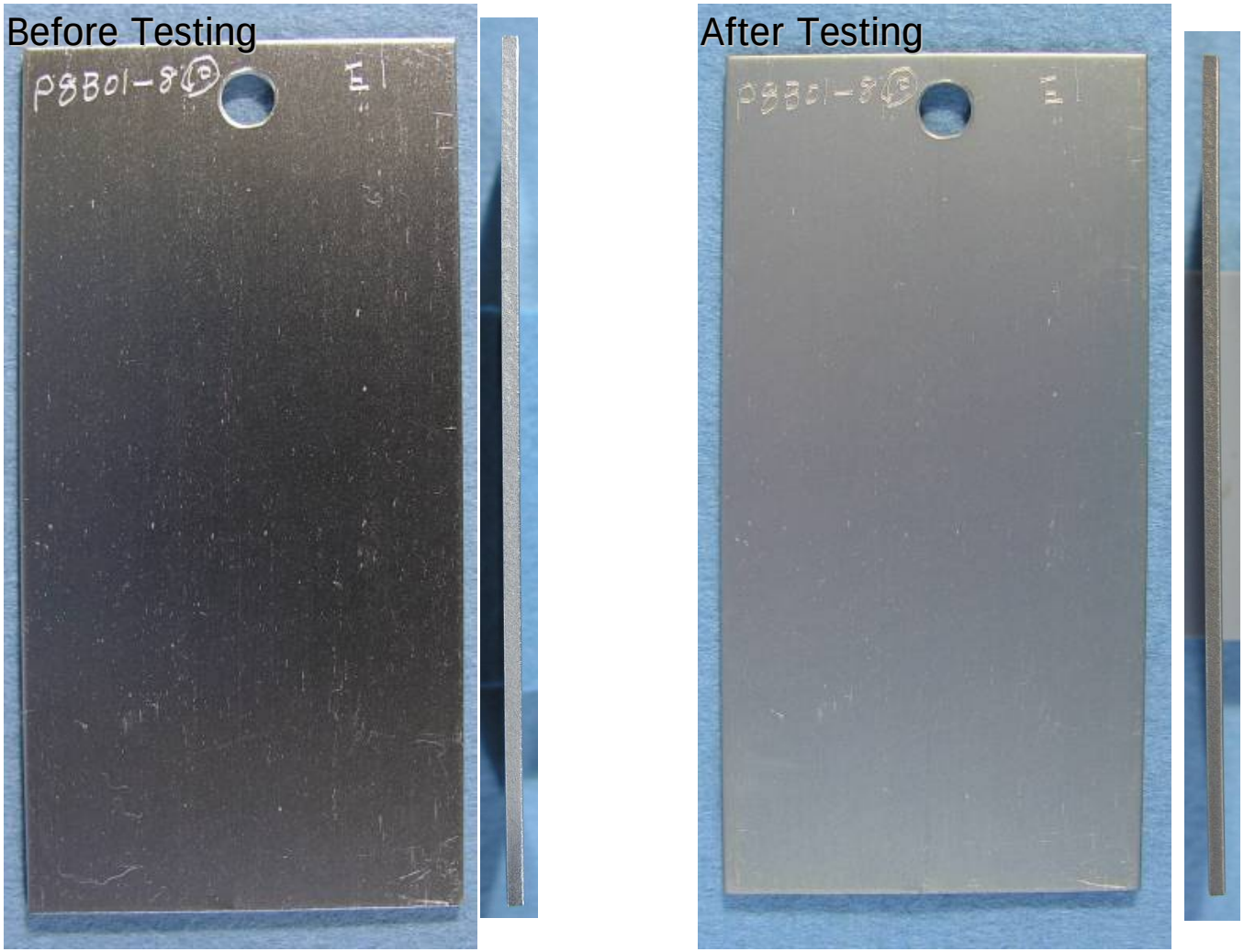
Conductivity and pH of the Bath





- The pH hardly changed though the conductivity increased a little.
- Sulfuric acid ion was detected from the bath in cell C, and there is a high possibility that this sulfuric ion dissolved from anodic films caused the increase of the conductivity.

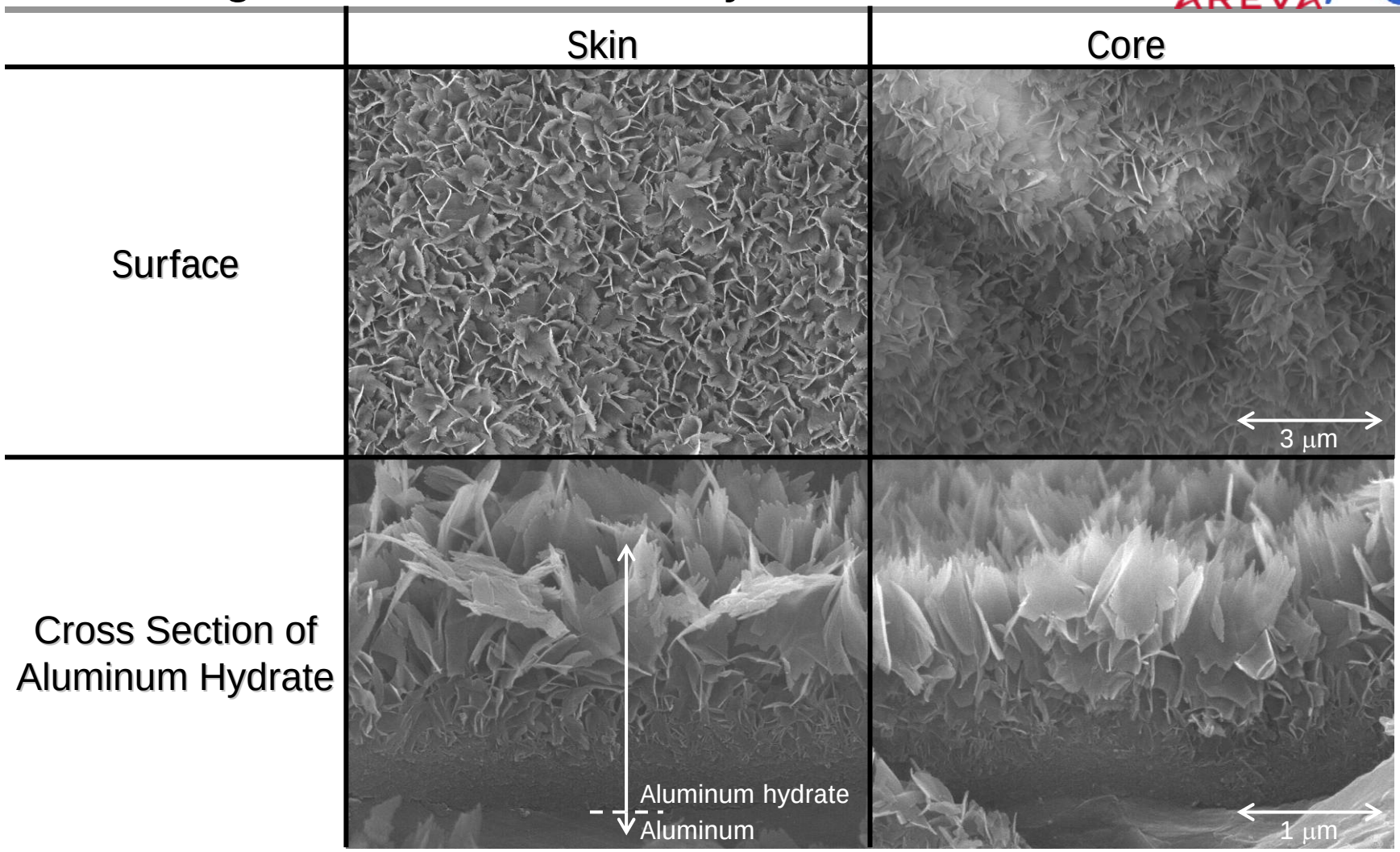
Macro Photographs before/after Immersion Testing



Coupon No.3 (non-Anodized)

- All coupons had no blisters, swelling or other abnormalities that cause loss of boron carbide.

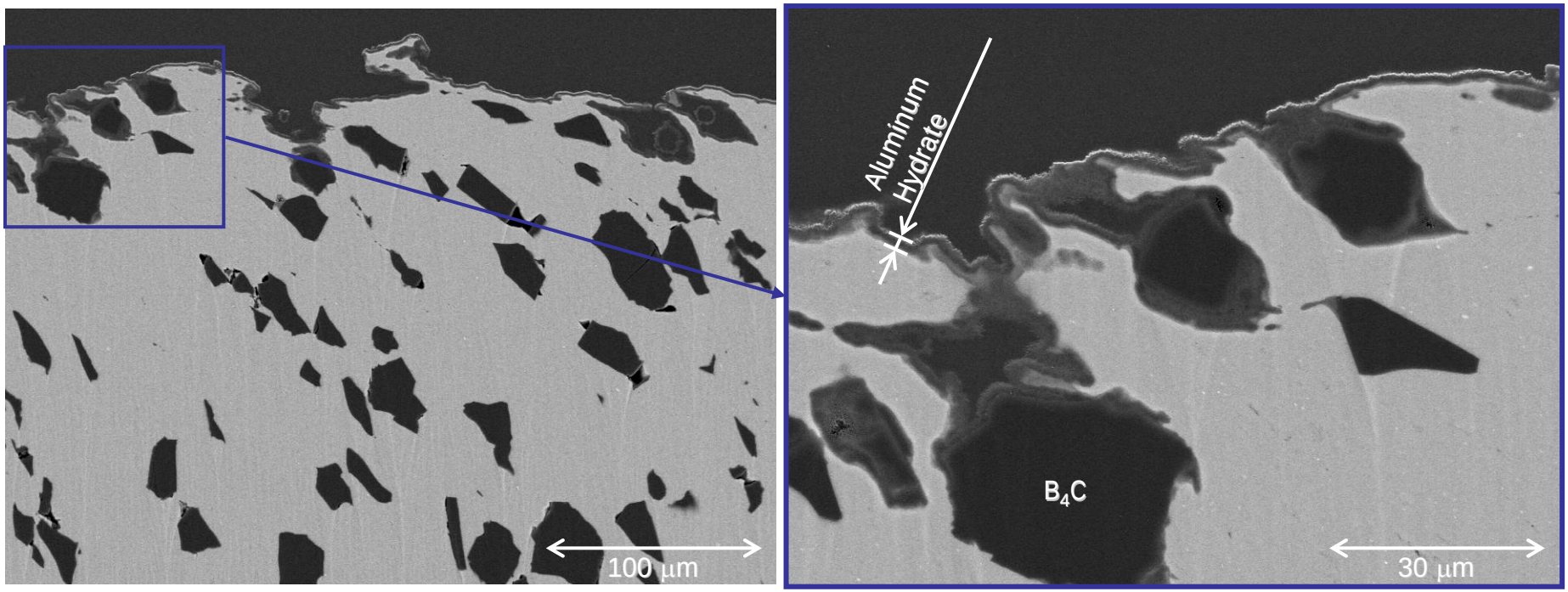
SEM Image of the Aluminum Hydrate



Coupon No.4 (non-Anodized)

- Thickness of the aluminum hydrate layer is about 2μm, and there is no difference in that formed on skin and core.

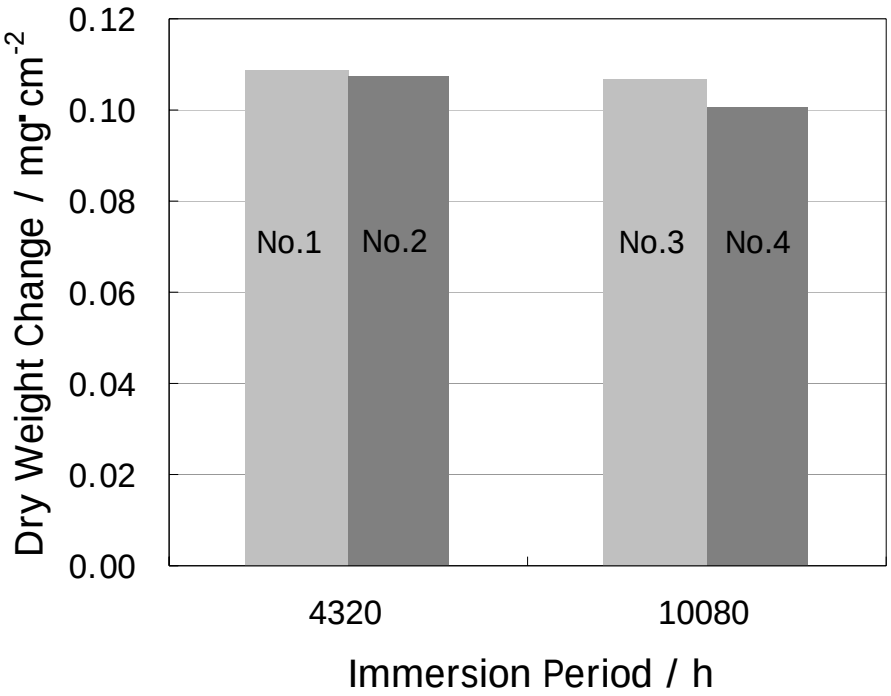
Electron Backscattered Image of the Core

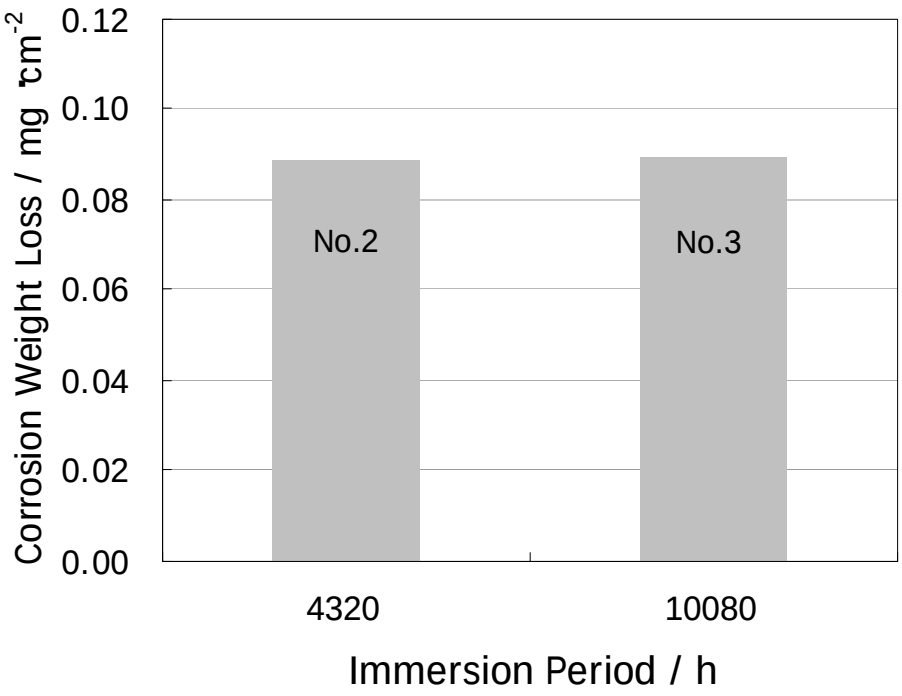


Coupon No.4 (non-Anodized)

- A thick aluminum hydrate layer was formed around exposed B_4C particles. It seems that close to B_4C particles the hydration reaction of aluminum is accelerated.
- Because clad product has skins and the exposed B_4C particles are only on the cutting plane, the hydration reaction of MAXUS® is less important than that of non-clad Al/B_4C products.

Dry Weight Change and Corrosion Weight Loss

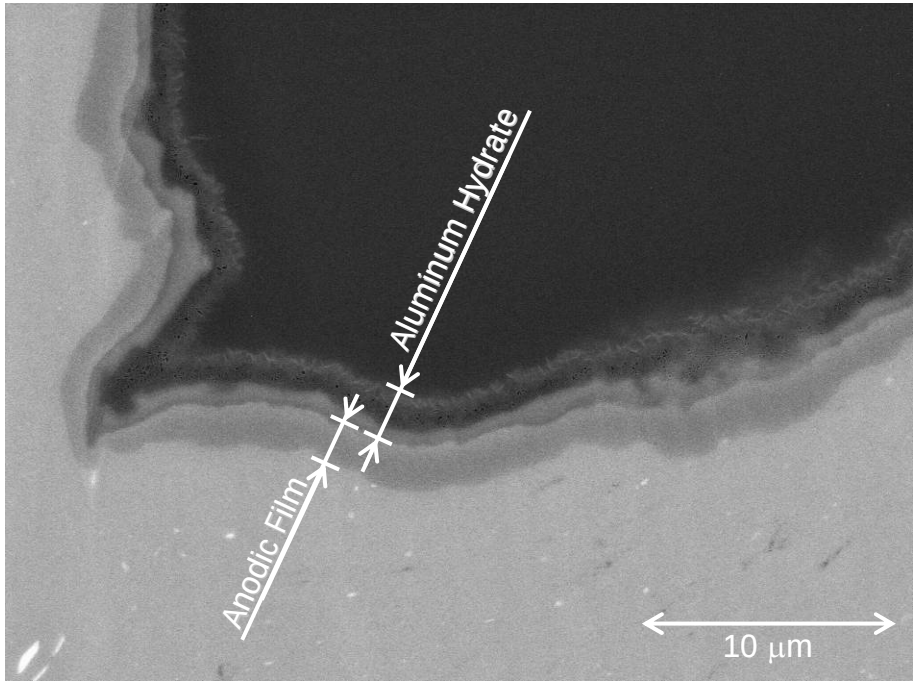




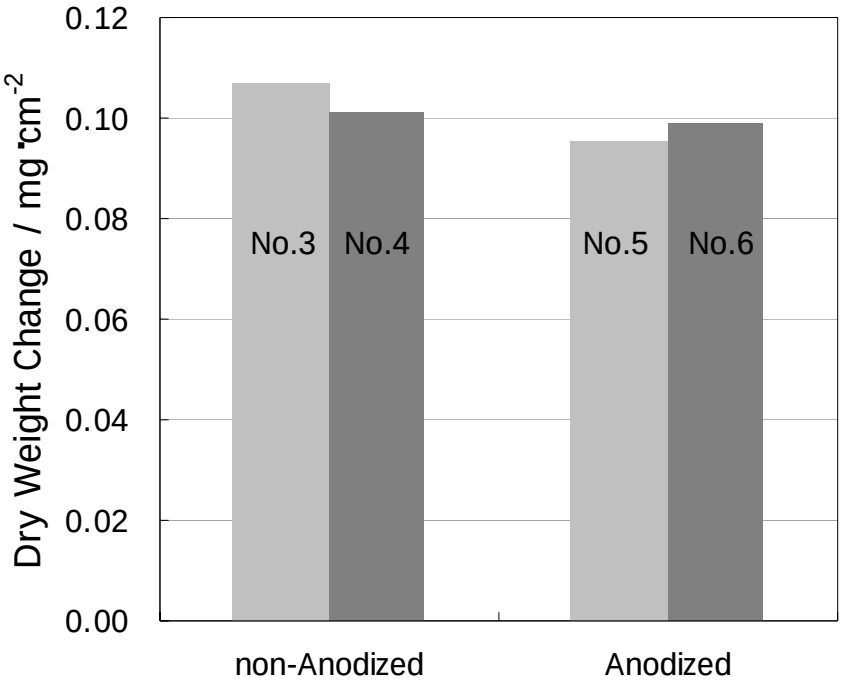
Coupon No.1~4 (non-Anodized)

- Because there is no difference between 4,320 hours and 10,080 hours in these values, it can be considered that the hydration reaction with solution has stopped after 4,320 hours.
- The corrosion weight loss is about 0.09 mg/cm^2, it corresponds to the dissolution of 0.6 μm as aluminum metal. Therefore it is not considered to be significant for practical use.

Result of the Anodized Coupons



Electron Backscattered Image of the Core



Comparison of the Dry Weight Change

- After 10,080 hours testing, the anodic film remains on the core, but there is no effect of decreasing hydration reaction.
- There is no difference in dry weight change before and after corrosion exposure for both anodized and non-anodized coupons. Therefore, using MAXUS® Al/B_4C MMC plate for wet storage racks does not require anodizing.

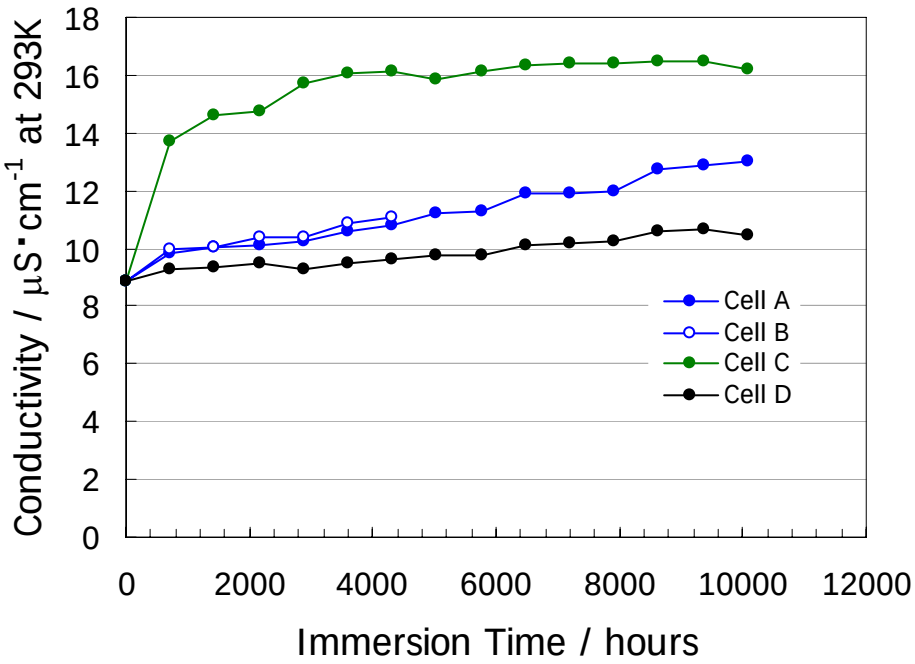
Summary

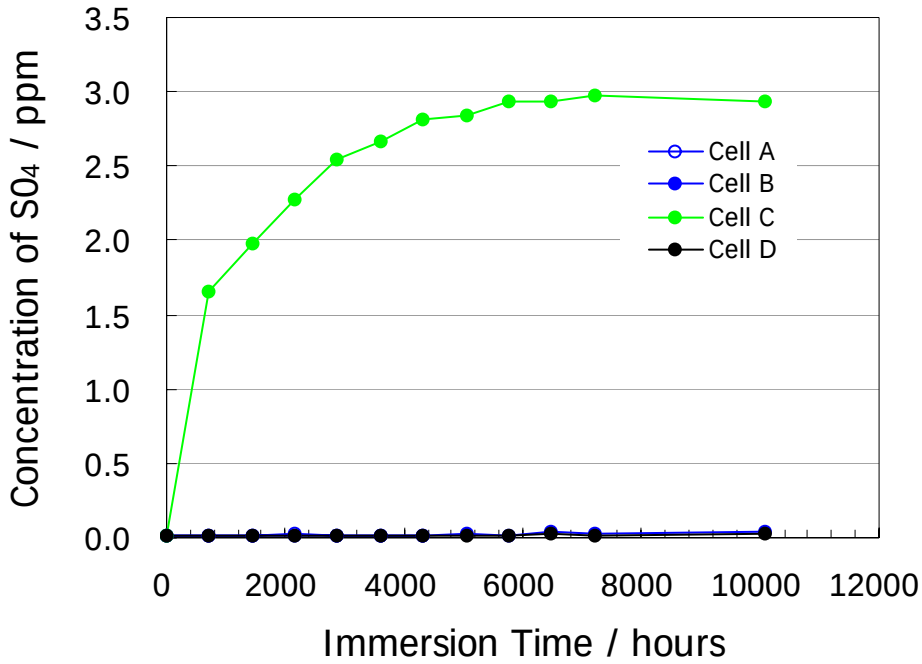
Accelerated corrosion testing was performed with MAXUS® Al/B_4C MMC plate in a simulated PWR spent fuel pool solution for 10,080 hours.

- All coupons had no blisters, swelling or other abnormalities that cause loss of boron carbide.
- Aluminum hydrate layer of about 2μm in thickness formed on the surface of both skin and core. It seems that close to B_4C particles the hydration of aluminum is accelerated.
- It can be considered that the hydration has stopped after 4,320 hours. The corrosion weight loss is about 0.09 mg/cm^2, and it is not considered to be significant for practical use.
- Using MAXUS® Al/B_4C MMC plate for wet storage racks does not require anodizing.

Support Slides

Conductivity and Concentration of SO_4^{2-} of the Bath





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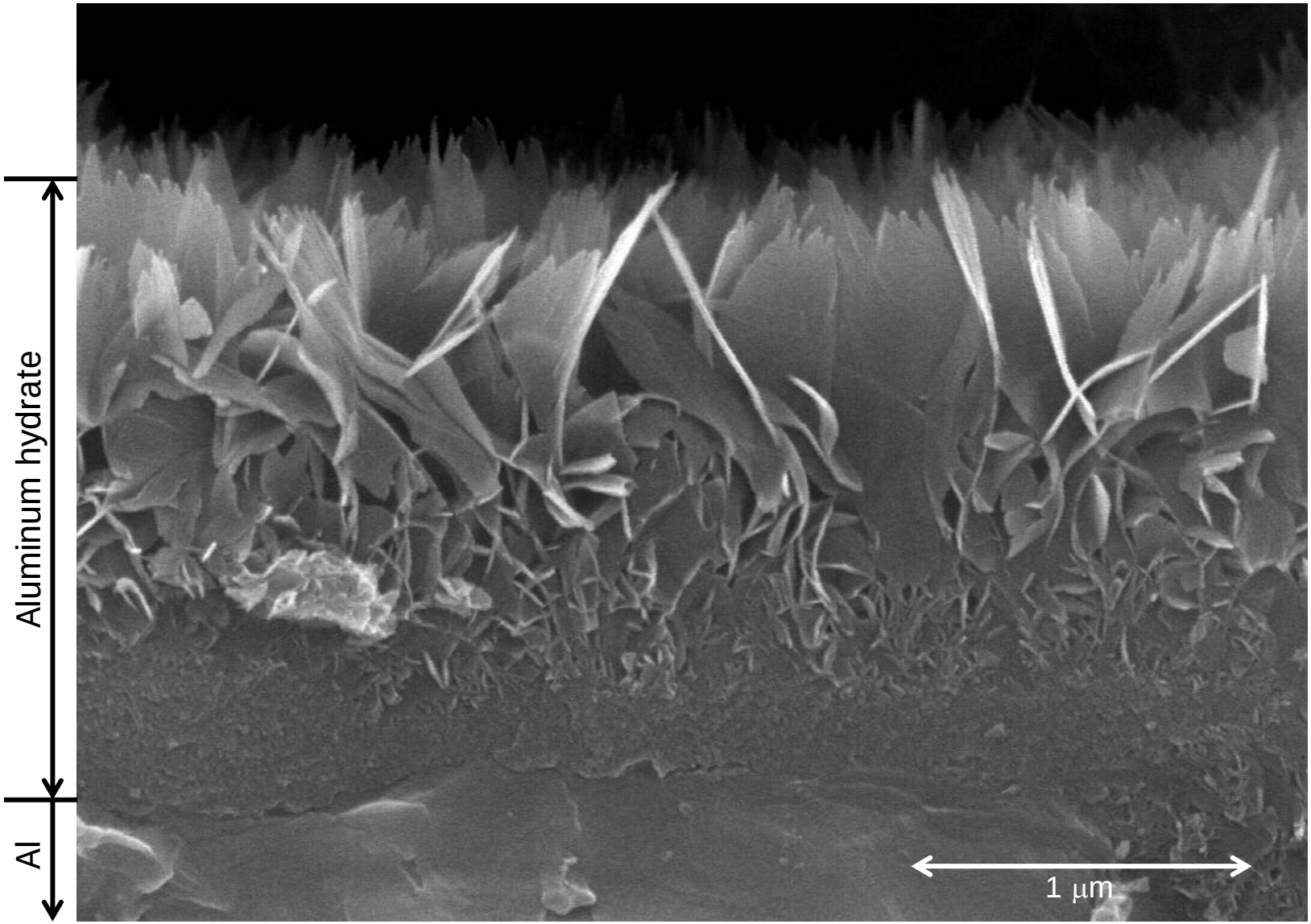
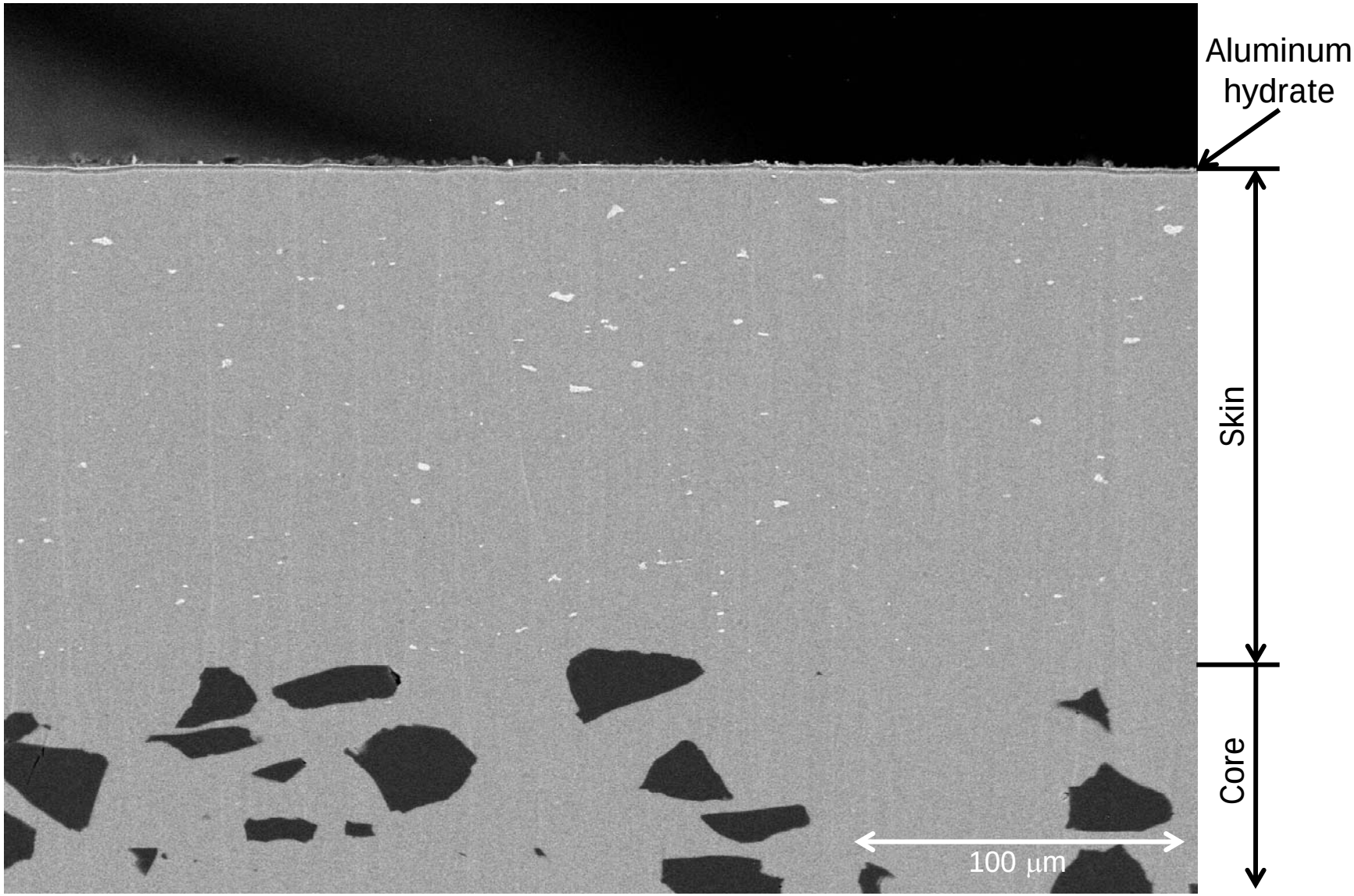
SEM Image of the Aluminum Hydrate



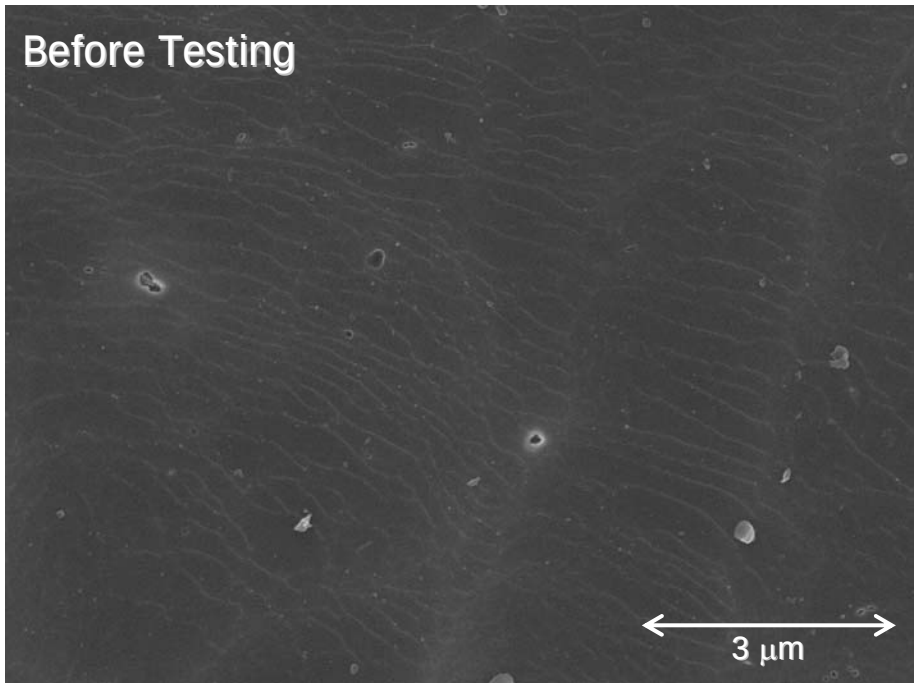
Coupon No.4 (non-Anodized, on the Core)

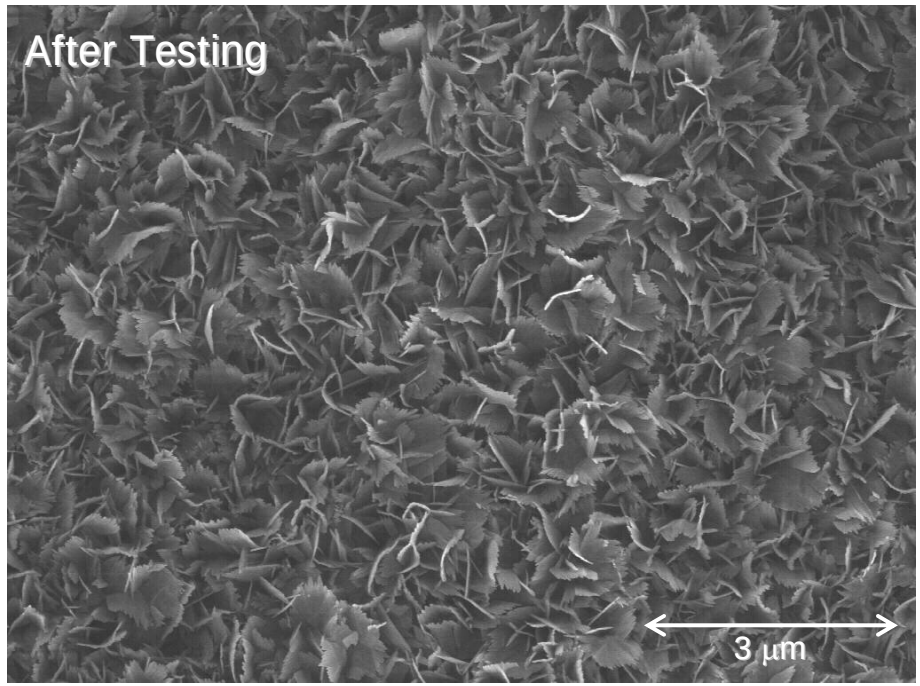
Electron Backscattered Image of the Skin



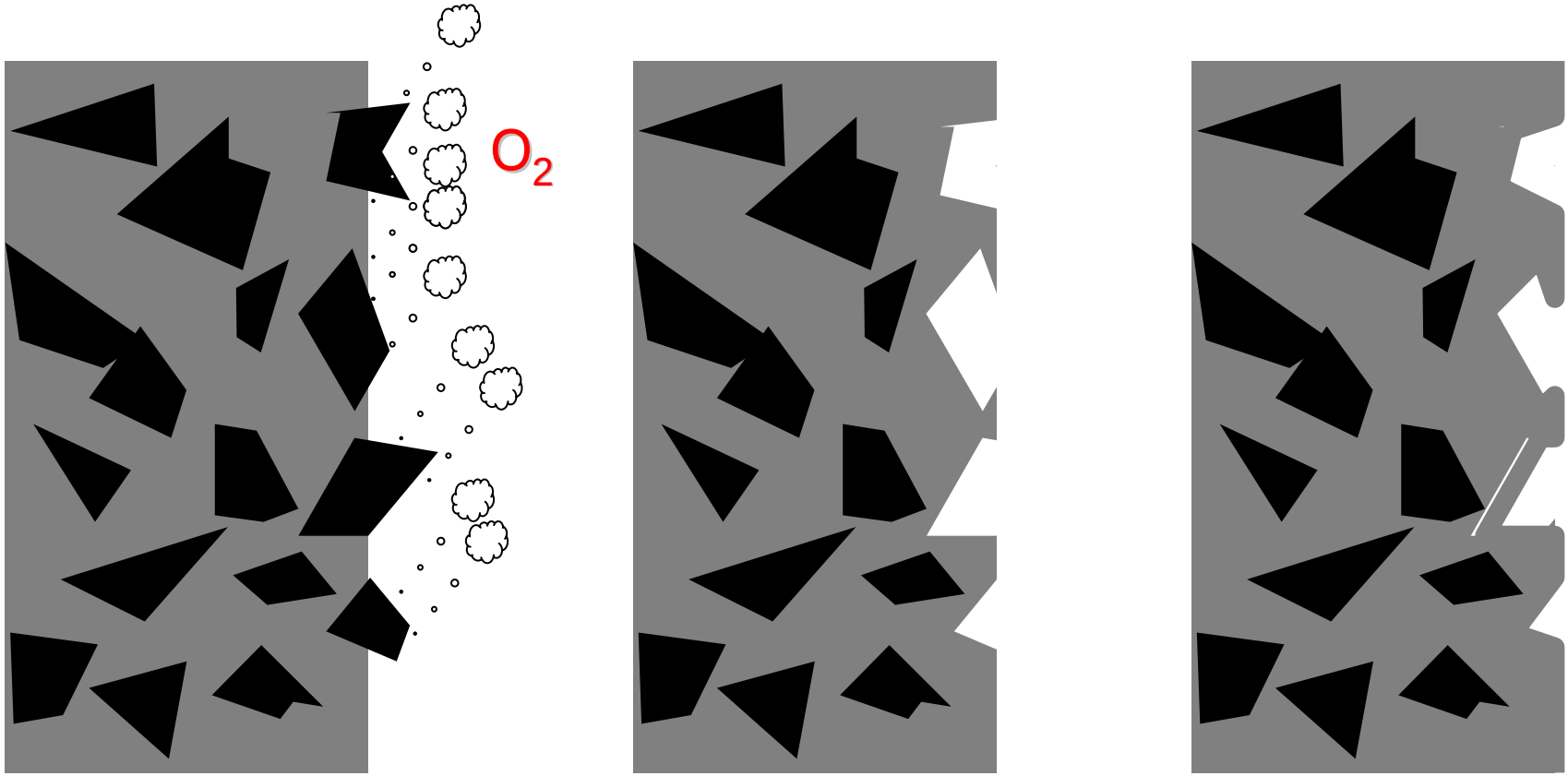
Coupon No.4 (non-Anodized)

Aluminum Hydrate formed on Anodized MAXUS®





Coupon No.5 (Anodized, Skin)



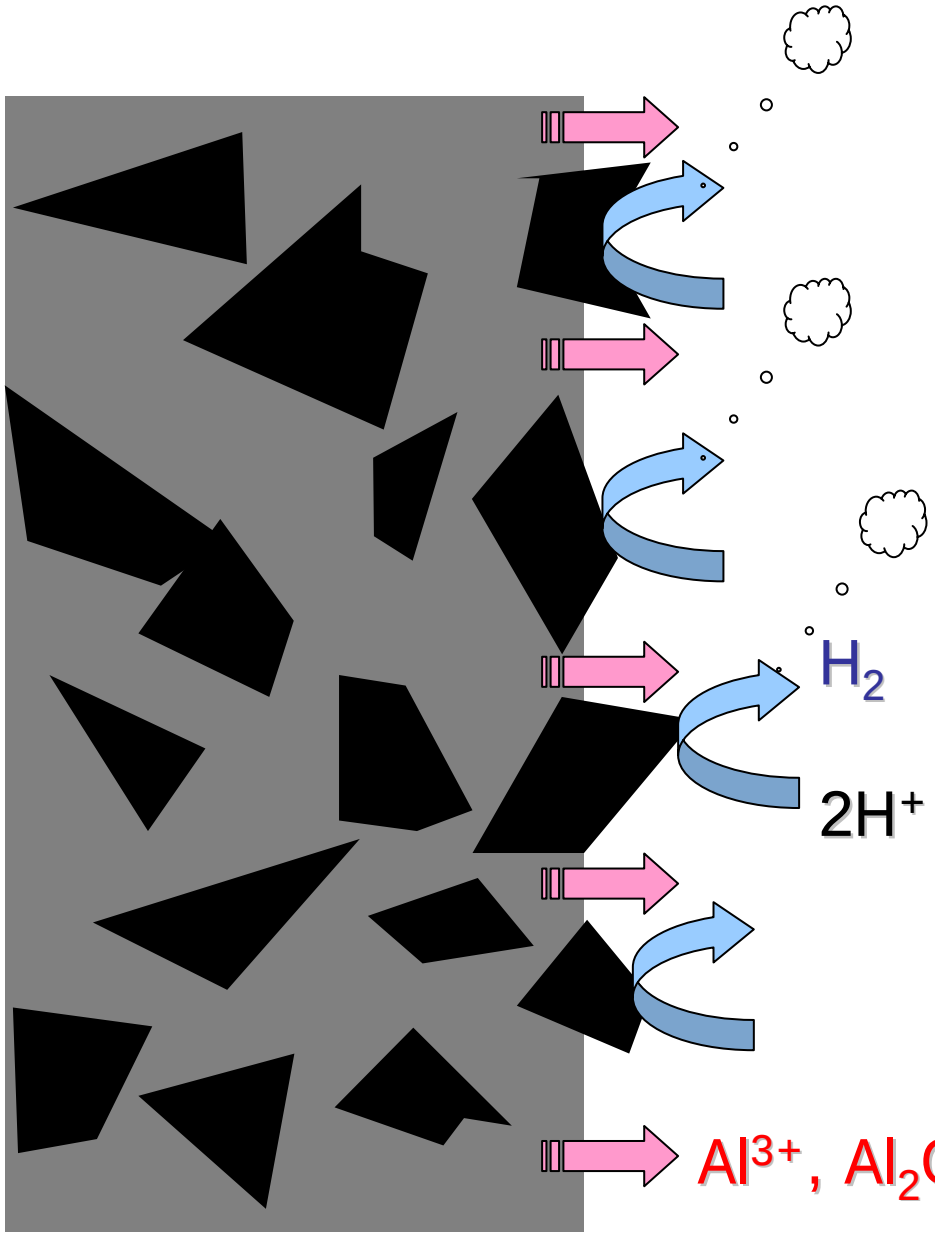
localization of current on section area
/generation of O_2 gas on B_4C
/dissolution of Al ?

drop of B_4C particles from Core

growth of the Anodic film

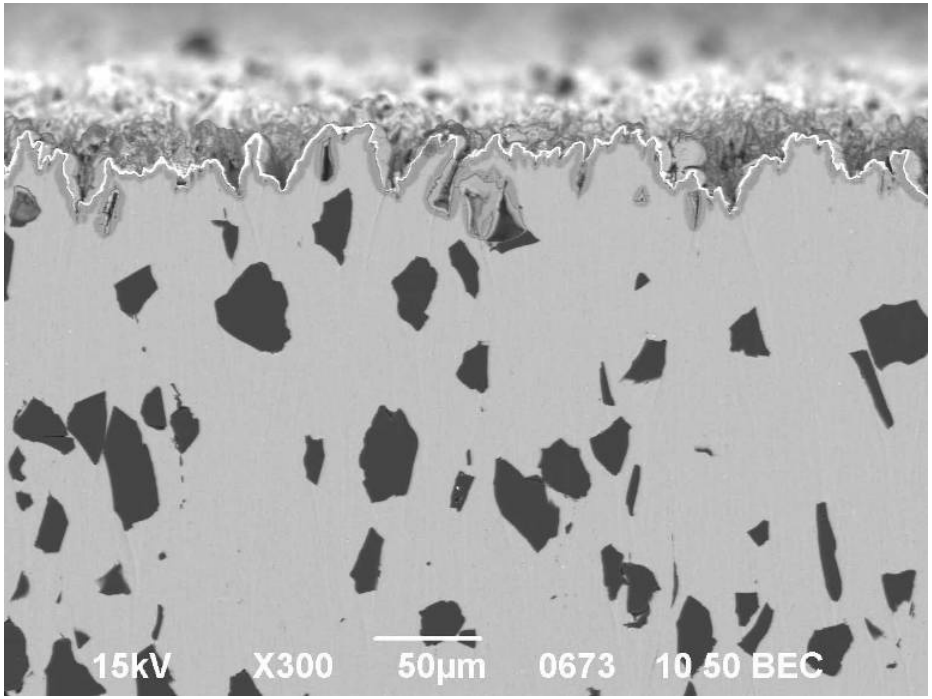
general current

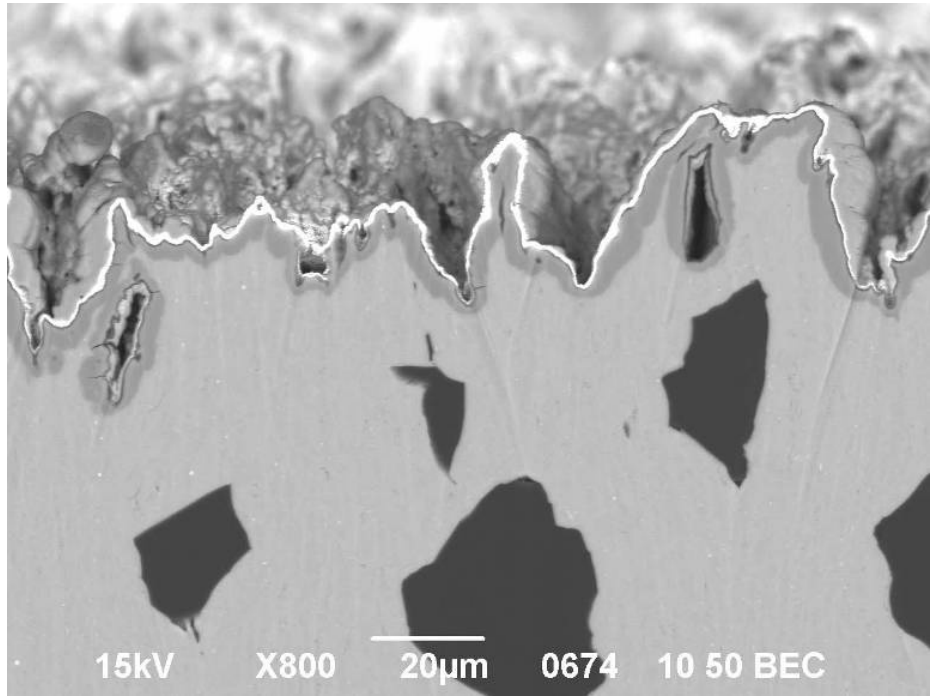
localized current on section area



On B_4C, cathodic reaction easily occurs ?

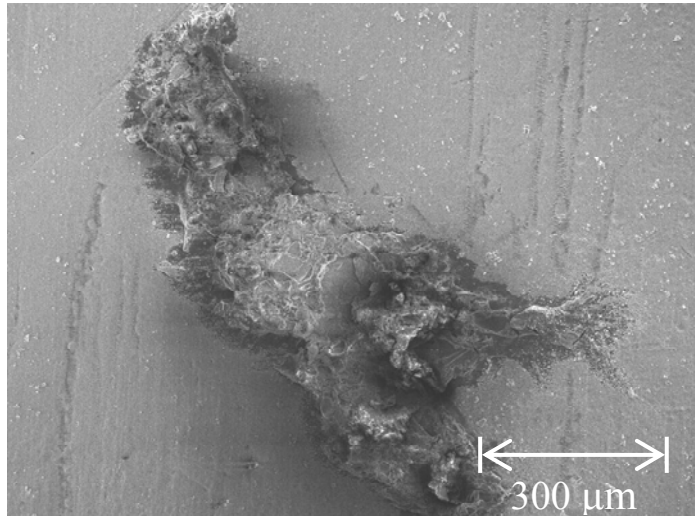
With the measurements of polarization curves, it will be verified.

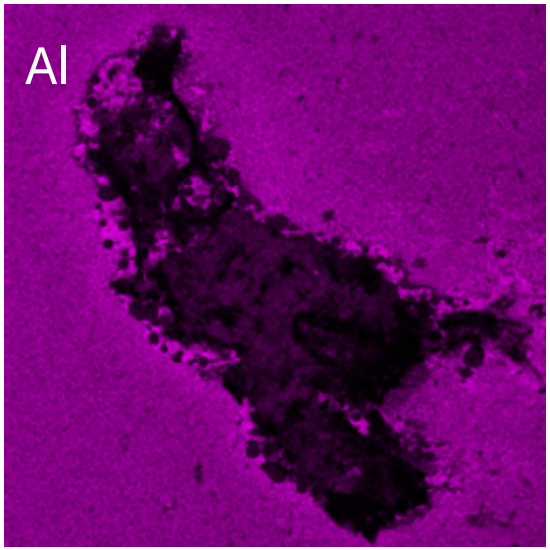

15kV X300 50µm 0673 10 50 BEC

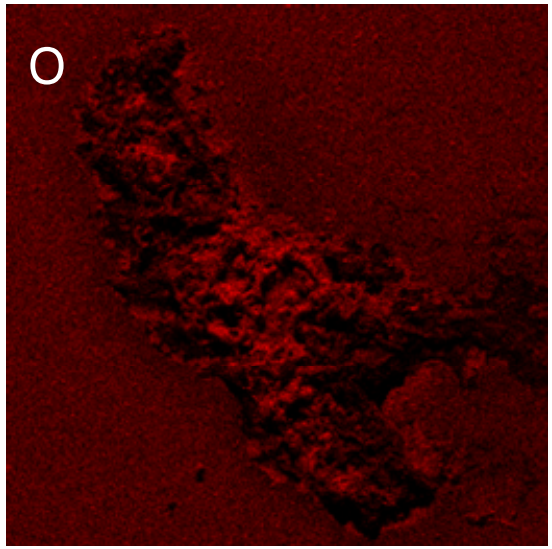

15kV X800 20µm 0674 10 50 BEC

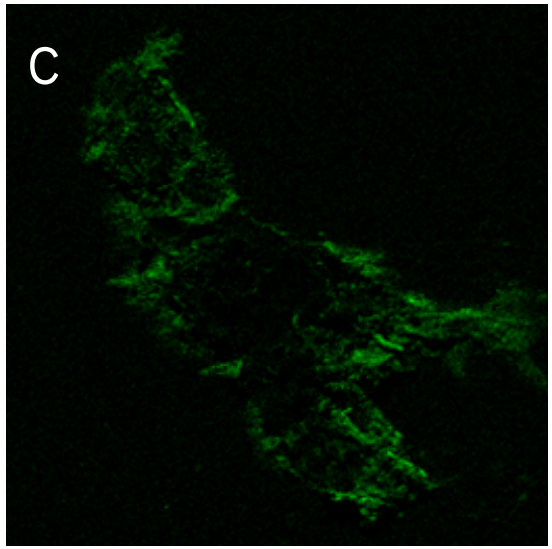

Coupon #4, before Testing

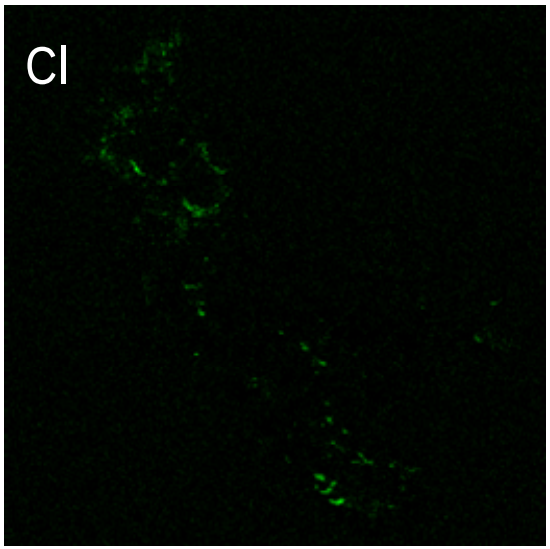

Coupon #4, after Testing

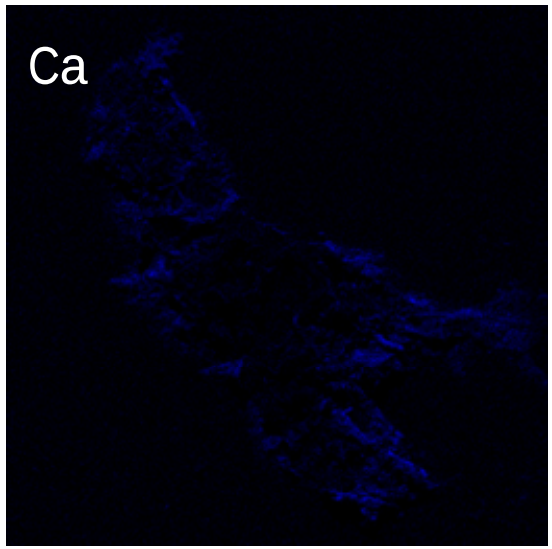

300 µm


Al


O


C


Cl


Ca