Investigation of corrosion level on weathering steel using hyperspectral imaging

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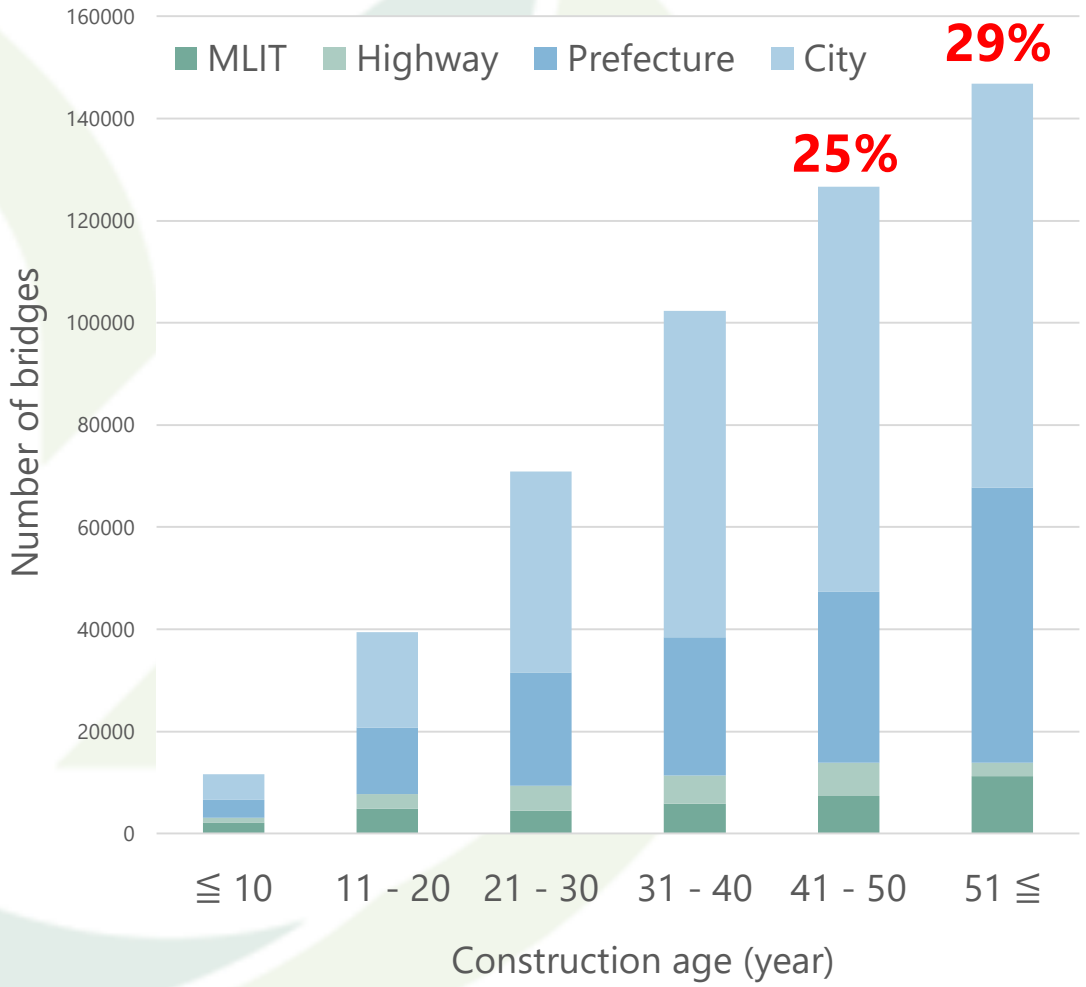
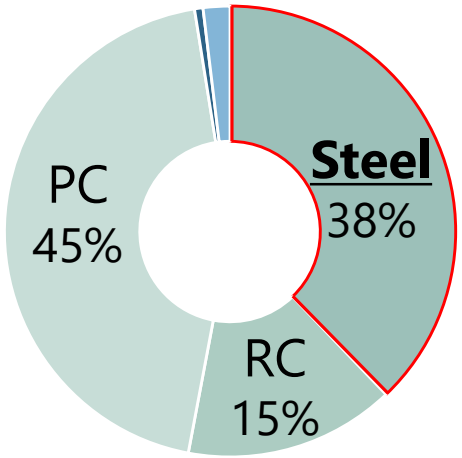
Introduction

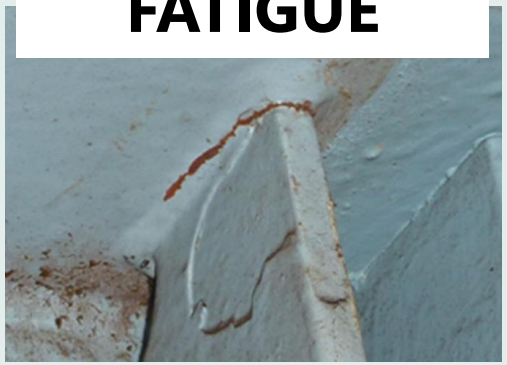
Introduction



Materials of bridges (superstructure)



FATIGUE

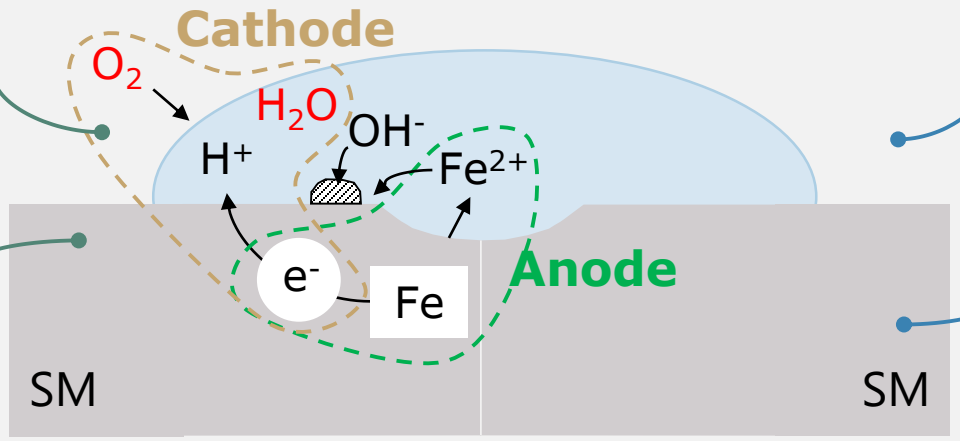


CORROSION

Corrosion Deterioration

PREVENTION

- Removing H_2O/O_2 from steel surface
- Painting steel surface
- Using high corrosion resistance material



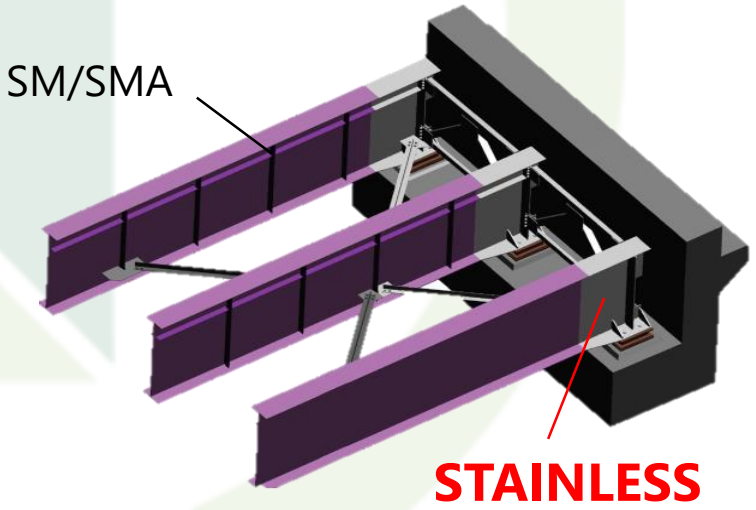
MAINTENANCE

- Detecting and monitoring H_2O/O_2
- Classifying corrosion level
- Repairing

Research Focus

High corrosion resistance material

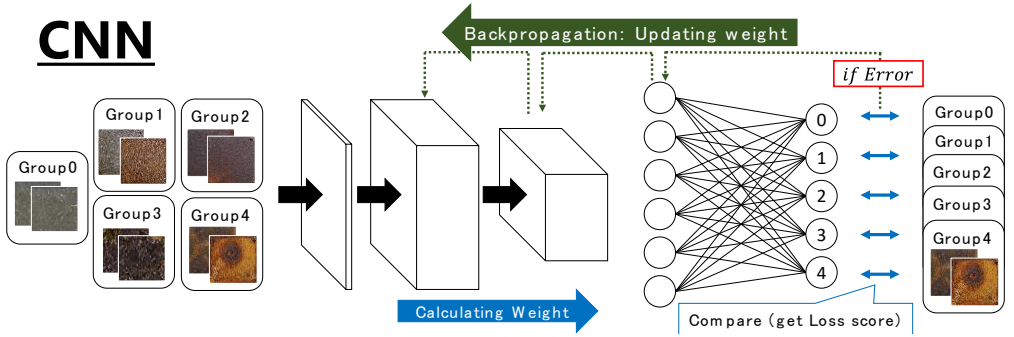
Combine Stainless steel (SUS)
& Mild steel (SM/SMA)



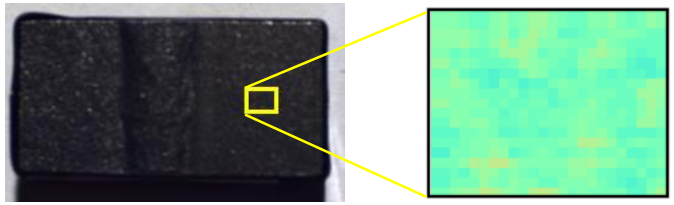
Simple maintenance/monitoring

Classifier based on Images

CNN



Hyper Spectrum



Goal and Objectives

GOAL

Proposing **simple monitoring methods** for steel bridges

OBJECTIVES

01 To confirm the ability of **Hyper Spectral Camera (HSC)** for steel bridge

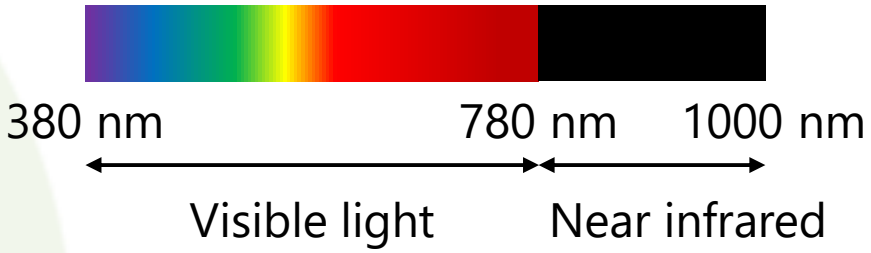
- Requirements to obtain hyper spectrum

02 To clarify the relationship between hyper spectrum (HS) and corrosion level

- Compering HS with Rust thickness/elements on the surface

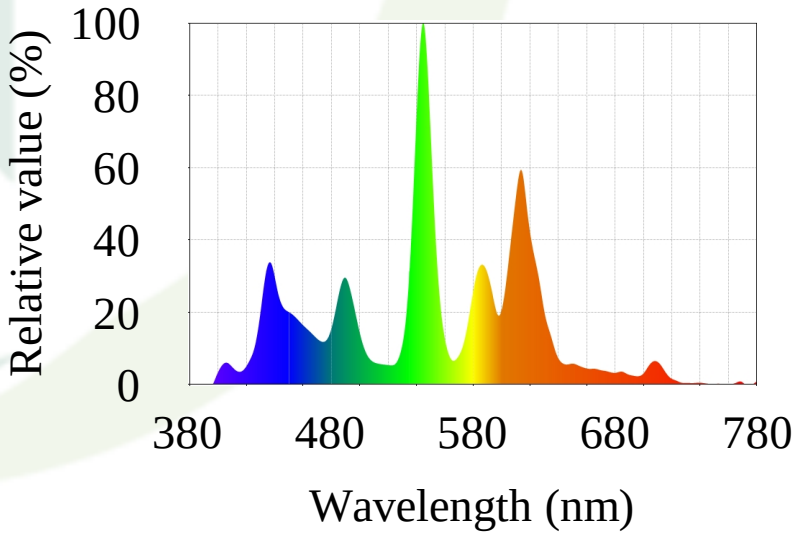
01 Hyper Spectral Camera (HSC)

Photos : DHT Corporation

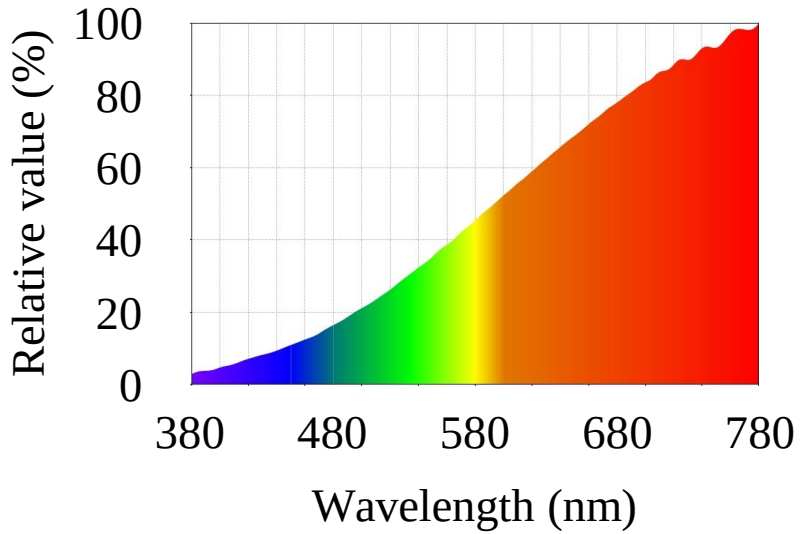


Wavelength resolution (nm)	7
Spectrum Bands	204
Working distance	150 - ∞ mm

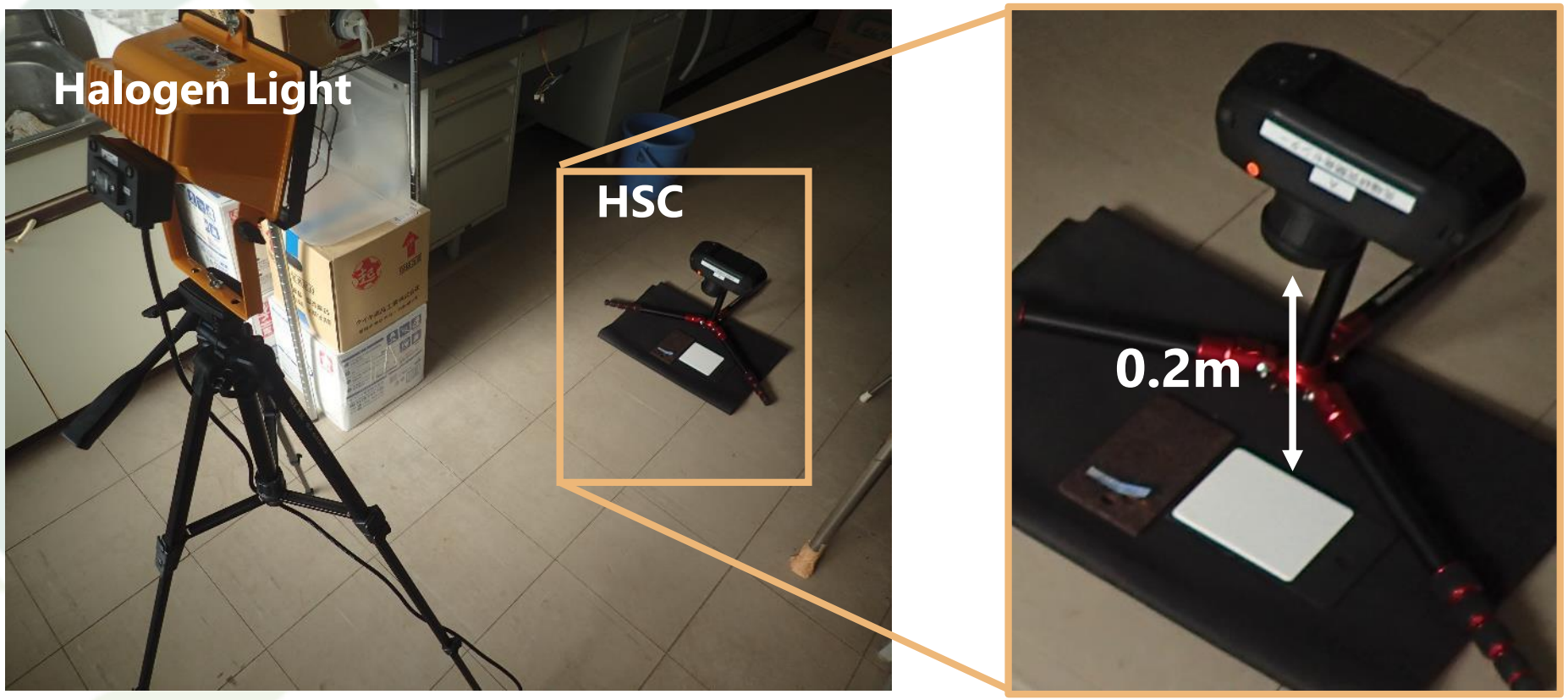
Fluorescent Light



Halogen Light

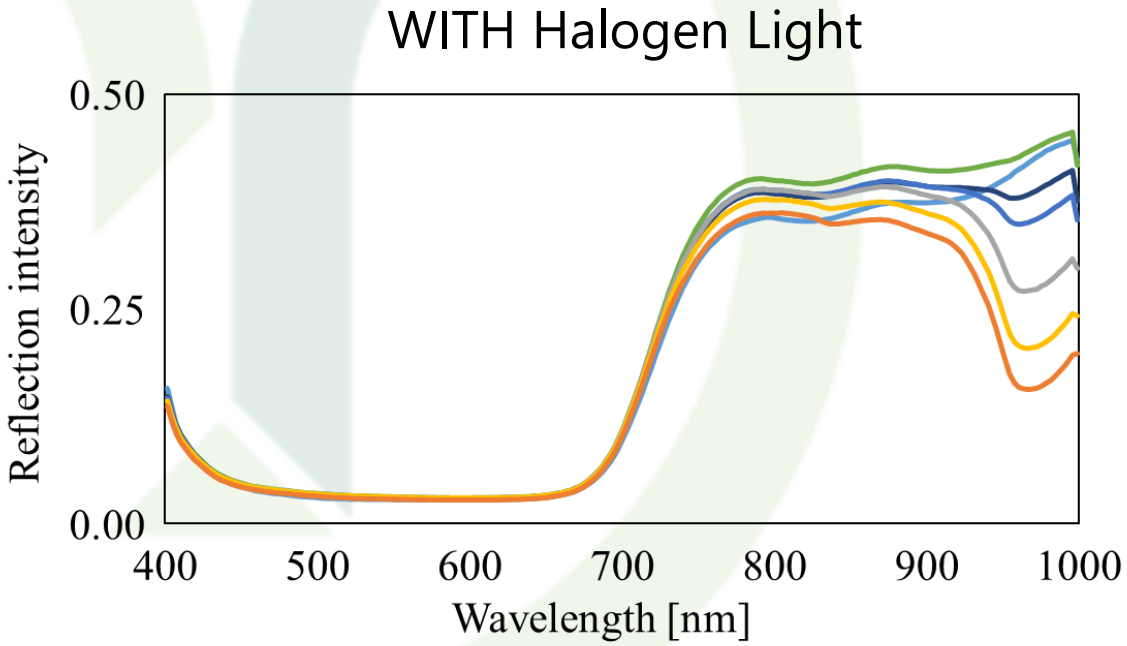


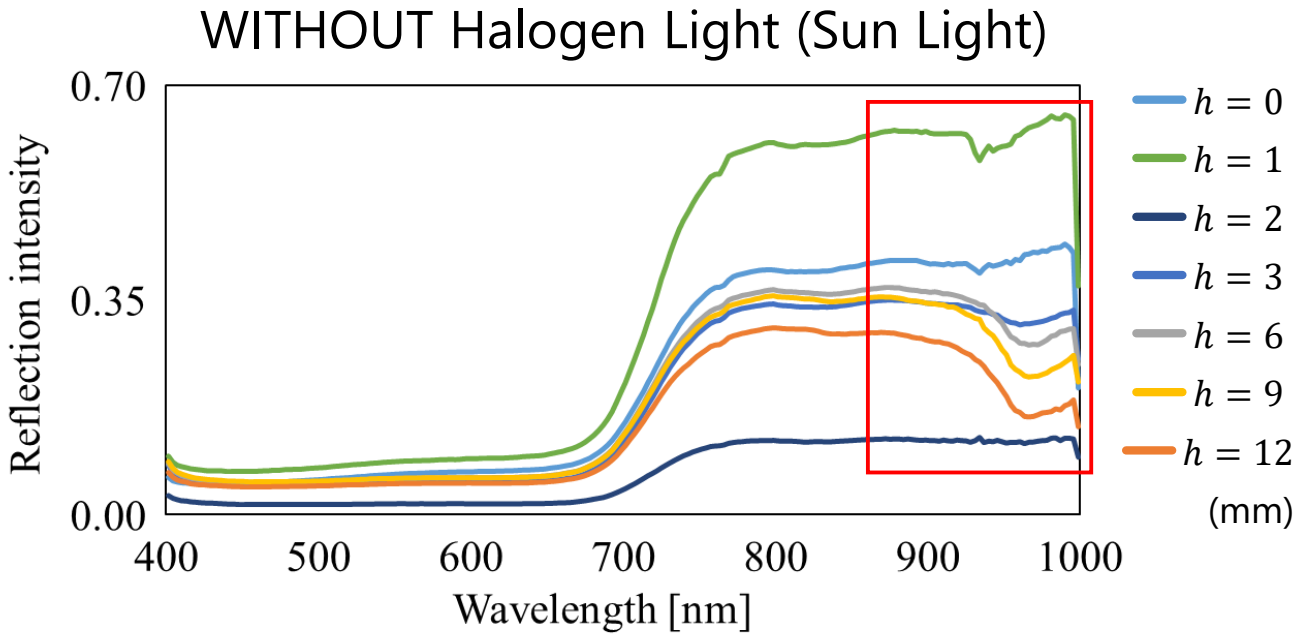
01 Obtaining Hyper Spectrum



01 Obtaining Hyper Spectrum

e.g. Hyper Spectrum : different depth of water

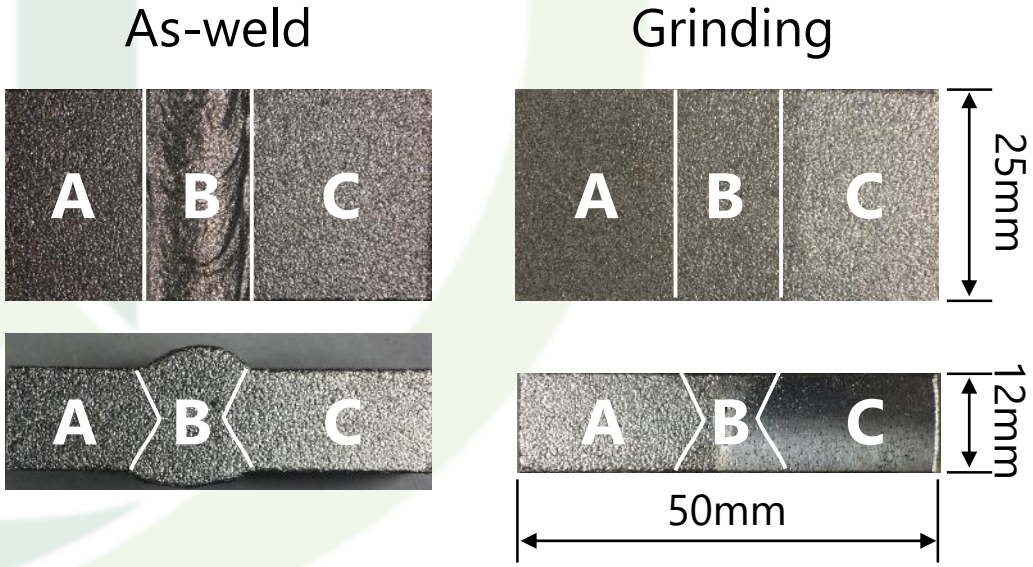




02 Hyper spectrum and Corrosion

(1) Conducting corrosion test for the welded specimens (SUS-SM)

(2) Obtaining HS, Surface appearance, Rust thickness and Elements distribution



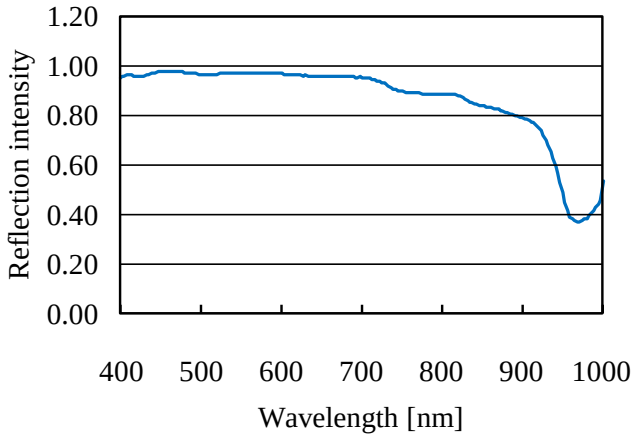
A	B (Welding)	C
SUS304	GFW309	SM400
SUS821L	GFW309	SM490
SM400	YM55C	SM400

02 HS and Corrosion

Surface & Rust thickness

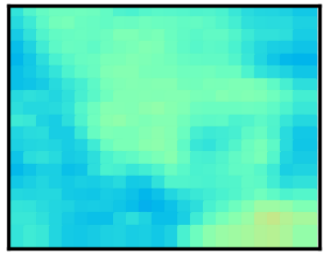
* elecometer

Hyper spectrum

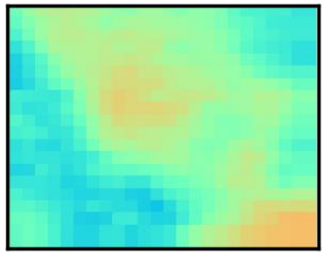


Hyperspectral imaging

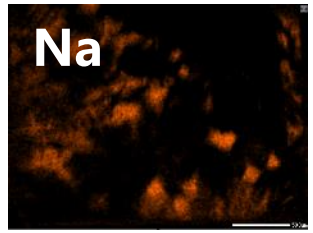
52 band

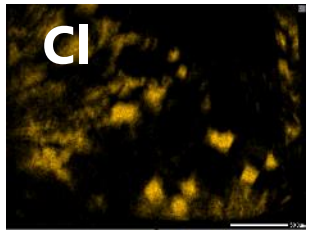


104 band



Elements map

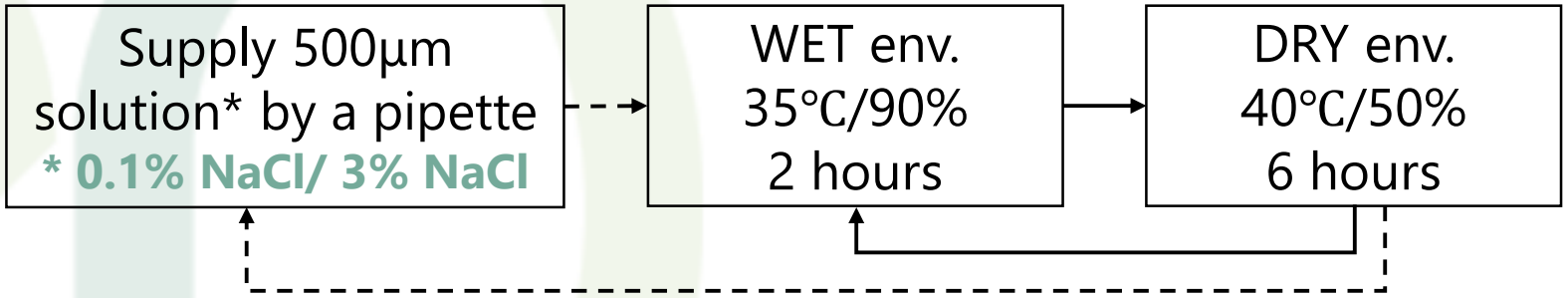




SEM/EDS

02 Corrosion Acceleration Test

TEST CYCLE



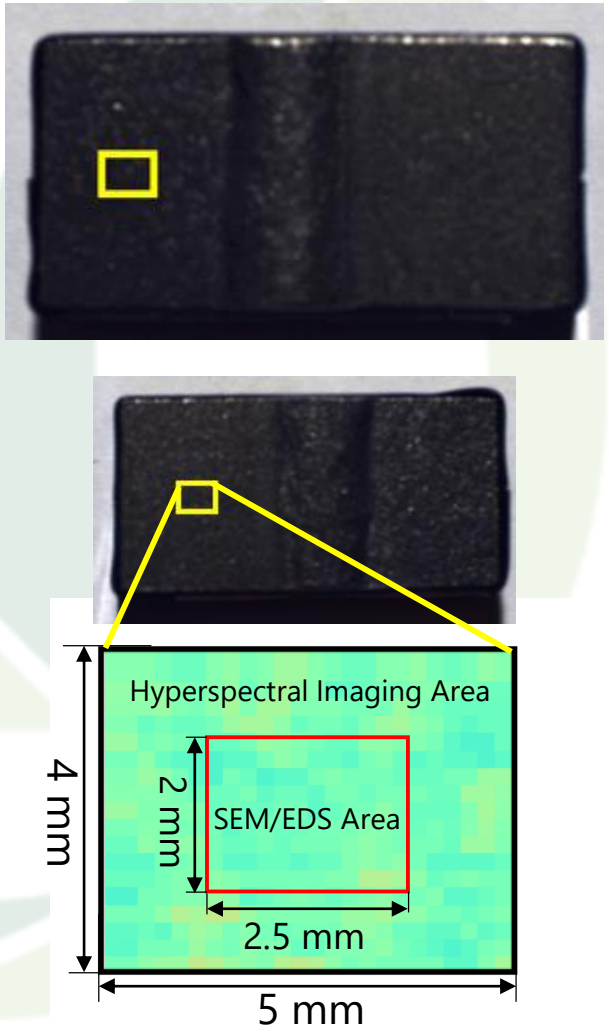
Supplying once per several cycles

0 to 24 cycles: once per 3 cycles
25 to 48 cycles: once per 12 cycles
after 49 cycles: no supplying

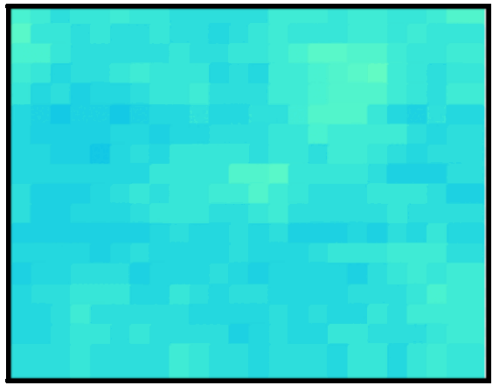
Temperature & humidity chamber

02 Hyper Spectrum

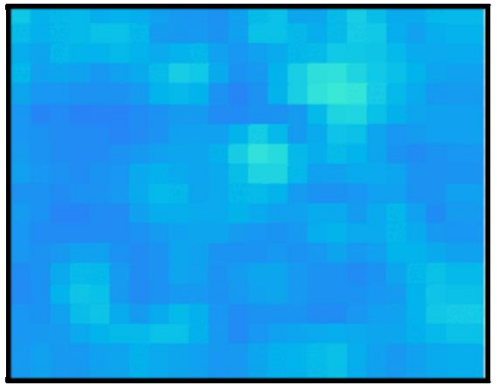
Surface appearance : 0 to 15 cycles



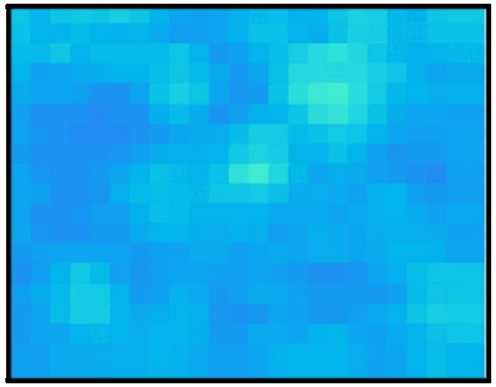
14 band (Blue)



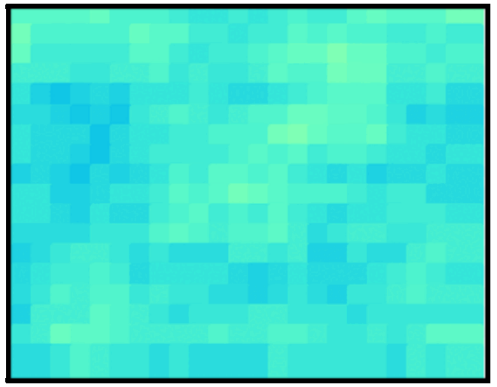
52 band (Green)

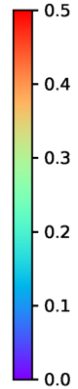


104 band (Red)



190 band
(Near Infrared)

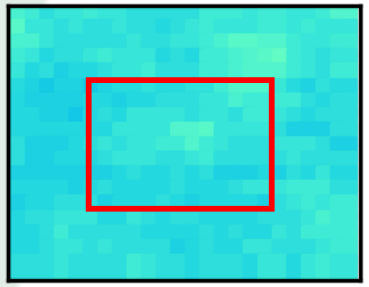




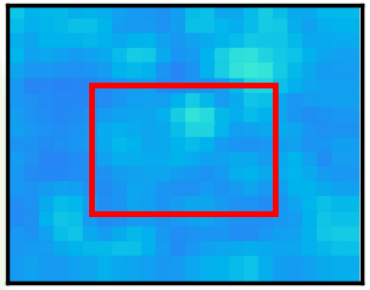
02 HS and Elements

0 cycle : SM（0.1% NaCl）

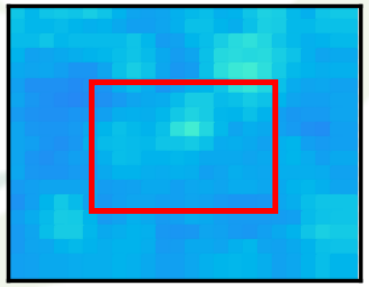
14 band (Blue)



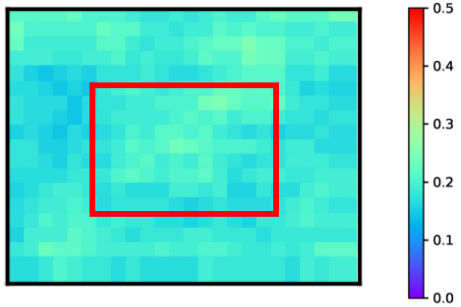
52 band (Green)

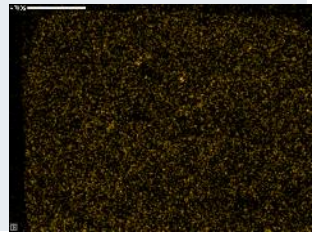


104 band (Red)



190 band
(Near Infrared)

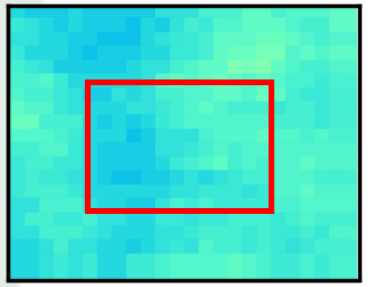


Na	Cl
No data	

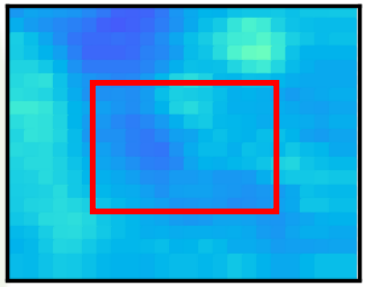
02 HS and Elements

3 cycle : SM（0.1% NaCl）

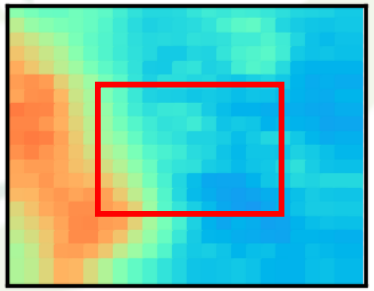
14 band (Blue)



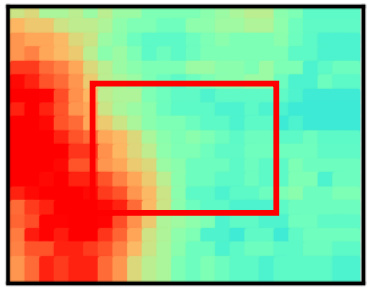
52 band (Green)

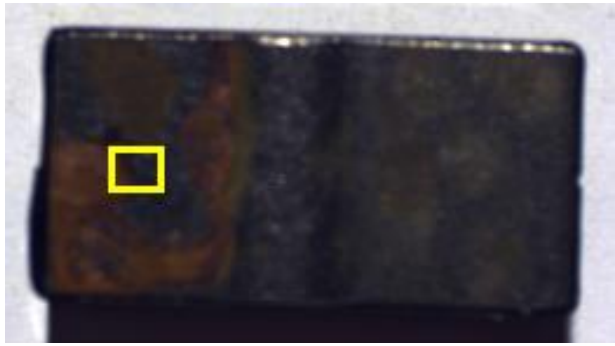


104 band (Red)



190 band
(Near Infrared)





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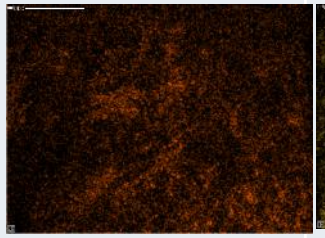

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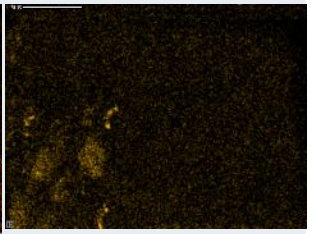
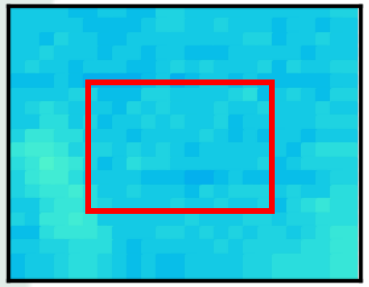


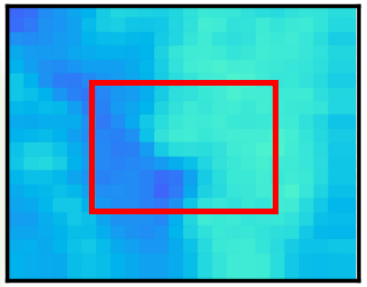
02 HS and Elements

6 cycle : SM（0.1% NaCl）

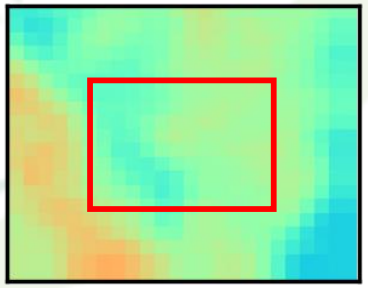
14 band (Blue)



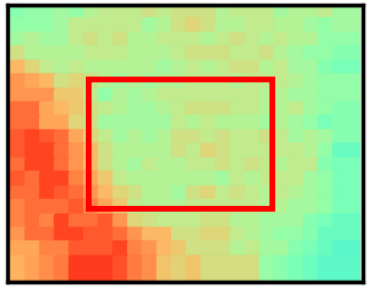
52 band (Green)

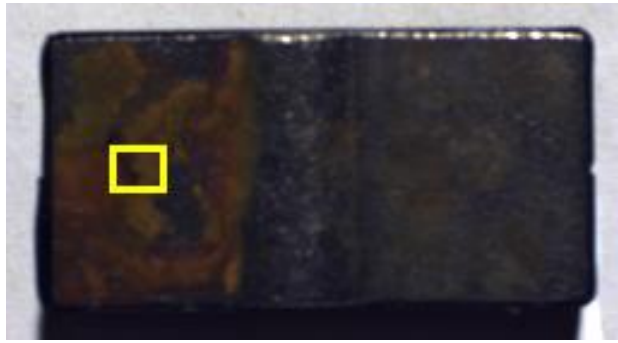


104 band (Red)



190 band
(Near Infrared)





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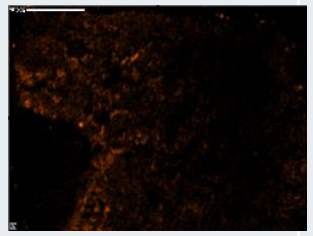

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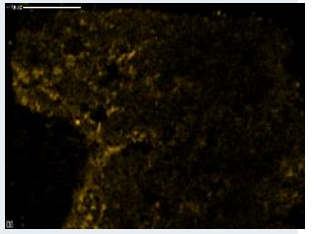
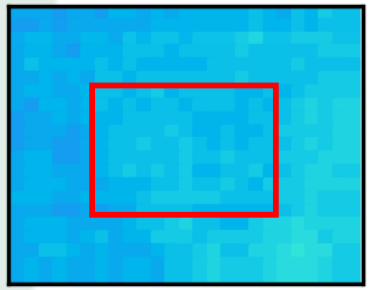


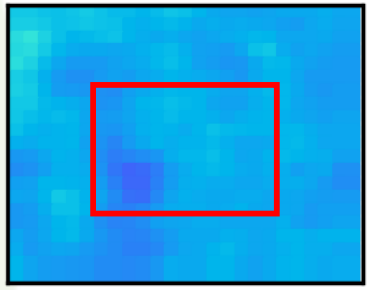
02 HS and Elements

9 cycle : SM（0.1% NaCl）

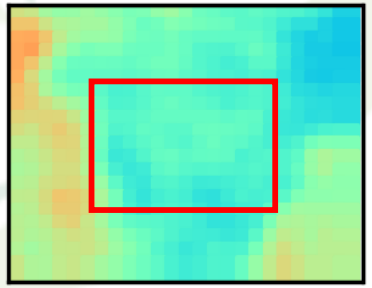
14 band (Blue)



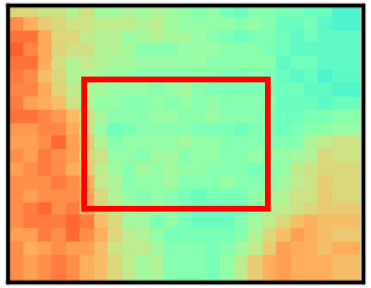
52 band (Green)

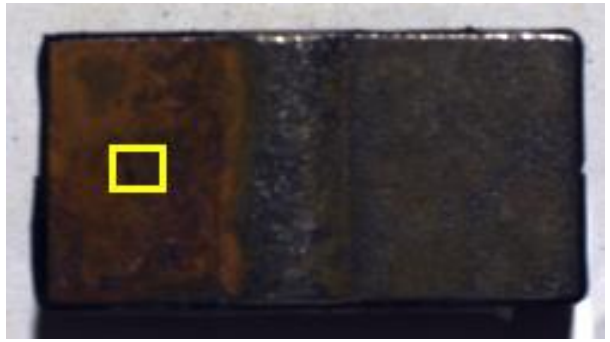


104 band (Red)

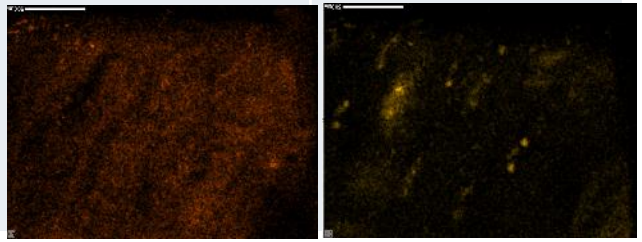


190 band
(Near Infrared)





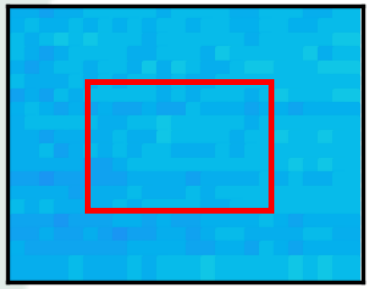
Na	Cl



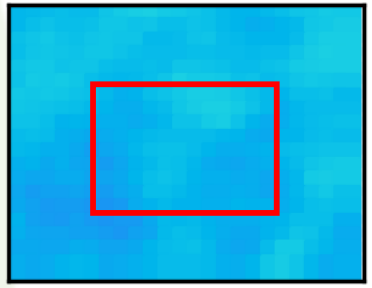
02 HS and Elements

12 cycle : SM（0.1% NaCl）

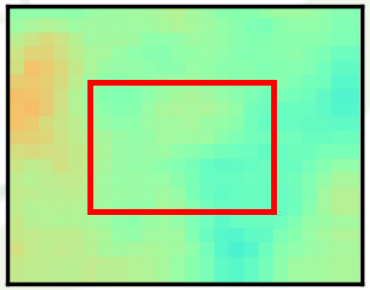
14 band (Blue)



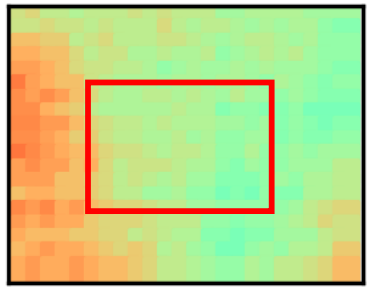
52 band (Green)

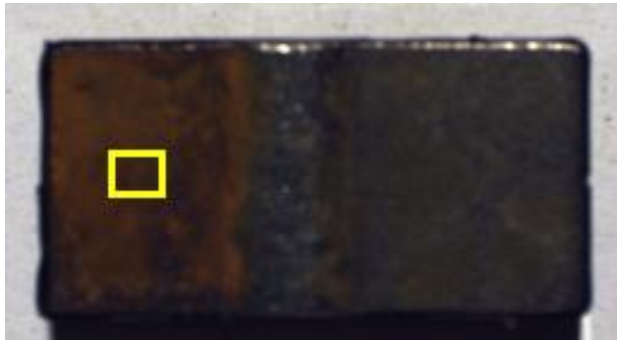


104 band (Red)

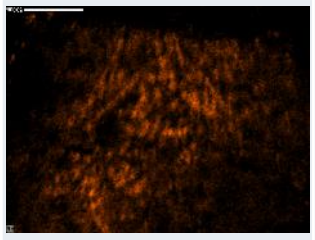


190 band
(Near Infrared)

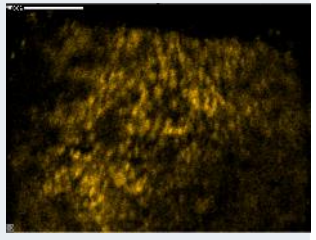




Na



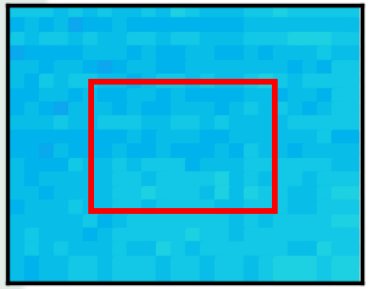
Cl



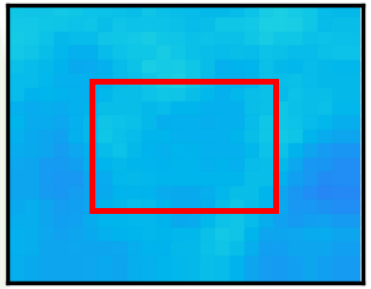
02 HS and Elements

15 cycle : SM（0.1% NaCl）

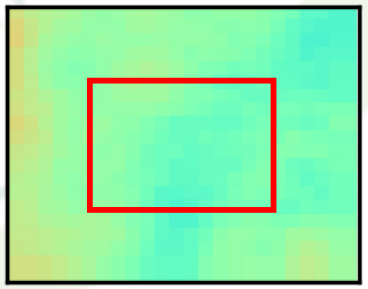
14 band (Blue)



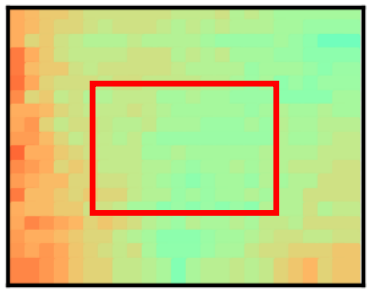
52 band (Green)

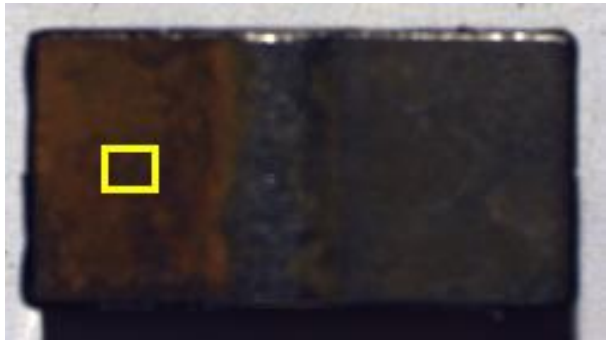


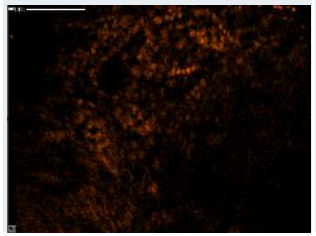
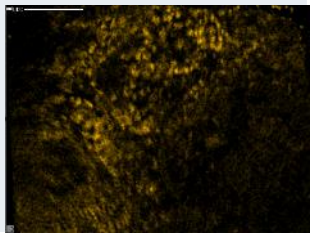
104 band (Red)



190 band
(Near Infrared)





Na	Cl
	

Conclusion and Future works

1. Hyper Spectrum Camera has the ability for obtaining some additional information from corroded steel surface
2. Halogen light is required to obtain HS of near-infrared
   … How to control the light on actual bridges?
3. The hyperspectral images (distributions of reflection intensity) of near-infrared band have been changing with corrosion progress
   … What is the main reason for the change?
4. Reflection intensity of near-infrared band may show the corrosion level (progress, stage)

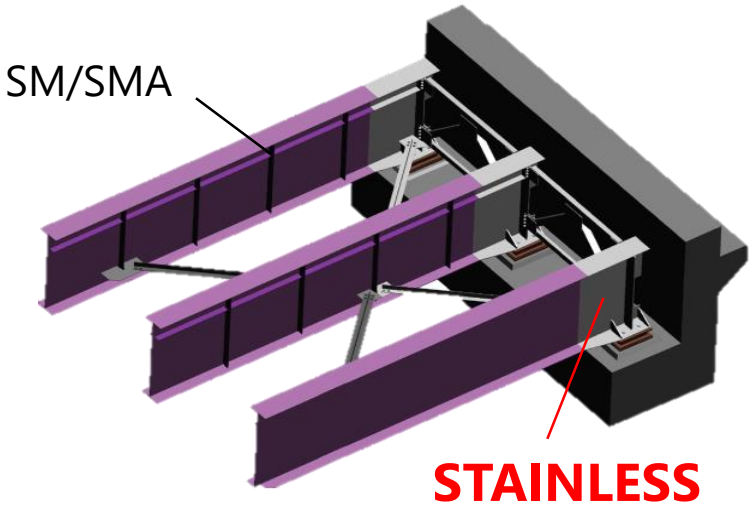
Preventing Corrosion Deterioration

Using high corrosion resistance material e.g. **STAINLESS STEEL***
* material cost is about **3 to 4 times** of mild steel/weathering steel

MILD/WEATHERING STEEL(SM/SMA) + **STAINLESS STEEL**(SUS)

Centre of the girder

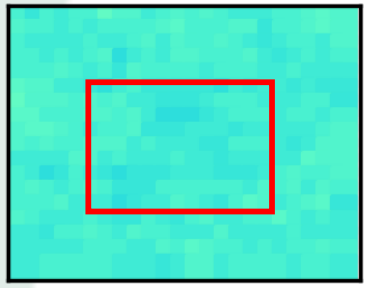
End of the girder



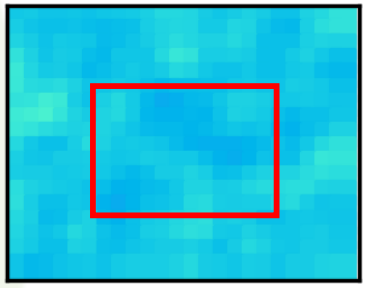
02 HS and Elements

0 cycle : SUS（0.1% NaCl）

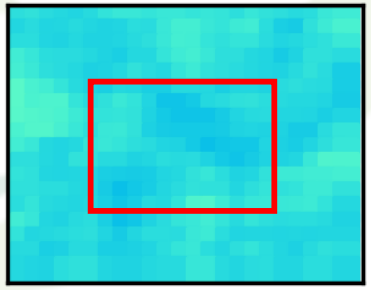
14 band (Blue)



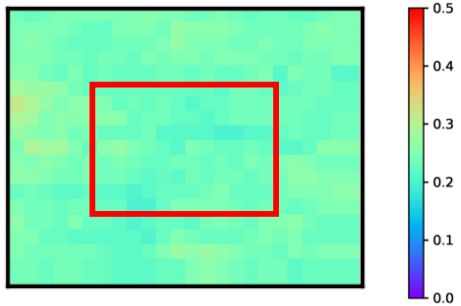
52 band (Green)

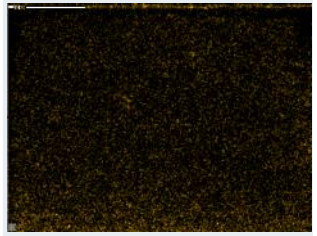


104 band (Red)



190 band
(Near Infrared)

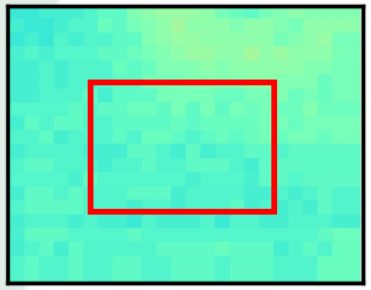


Na	Cl
No data	

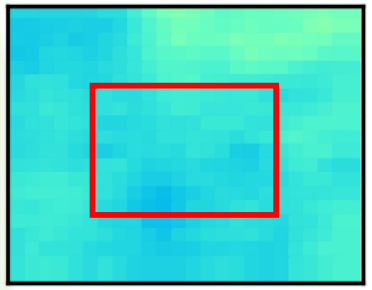
02 HS and Corrosion

3 cycle : SUS（0.1% NaCl）

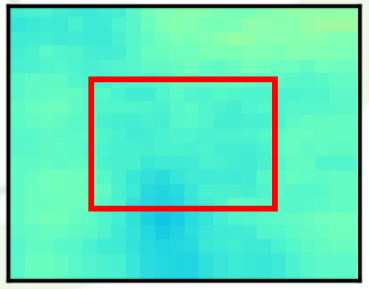
14 band (Blue)



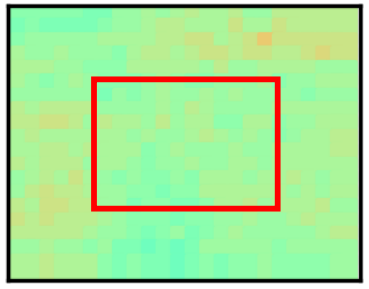
52 band (Green)

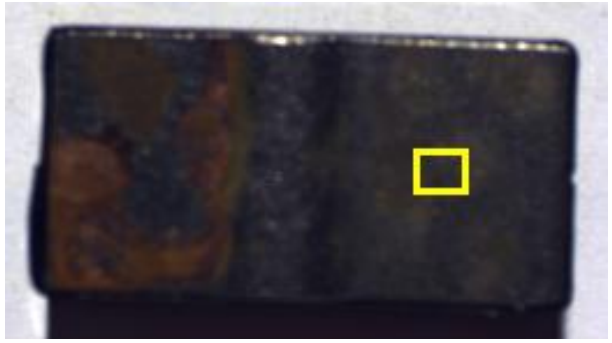


104 band (Red)

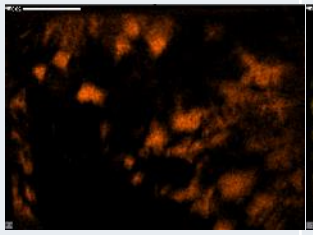


190 band
(Near Infrared)

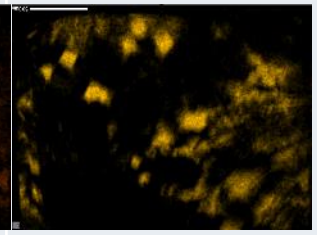




Na

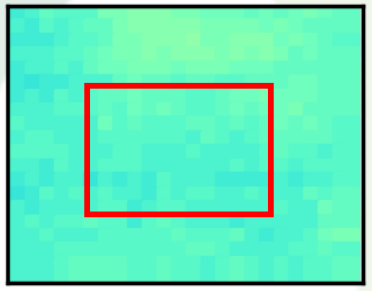


Cl

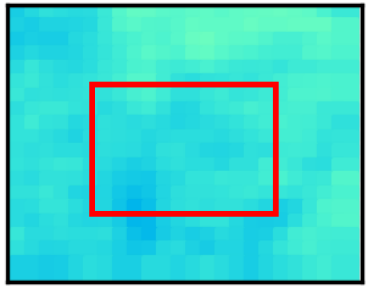


02 HS and Corrosion

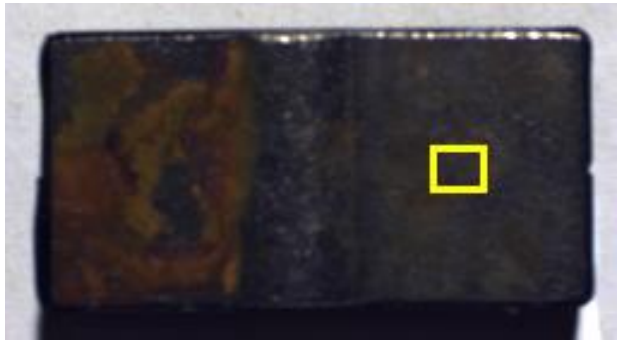
6 cycle : SUS（0.1% NaCl）

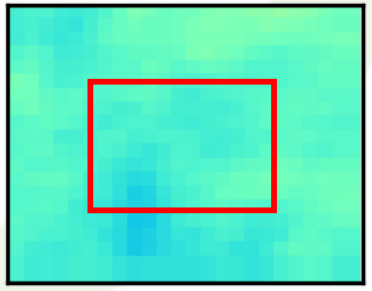


14バンド

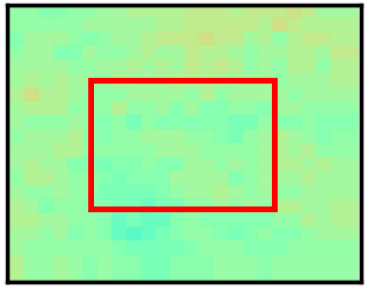


52バンド

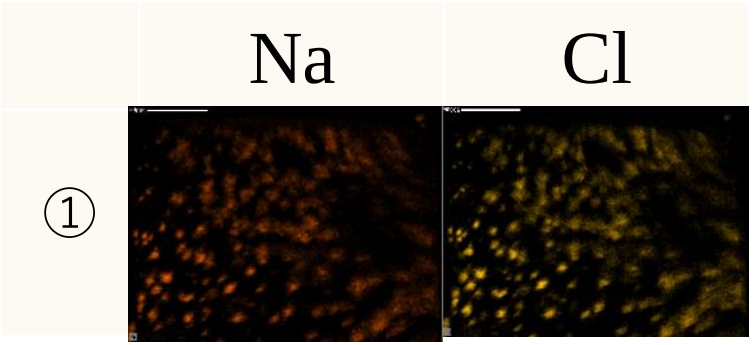




104バンド

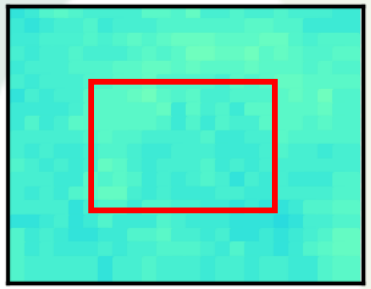


190バンド

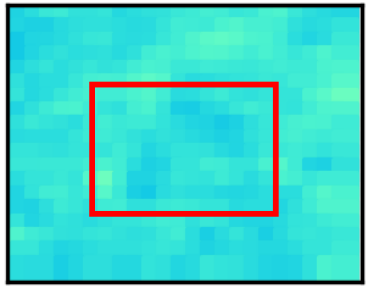


02 HS and Corrosion

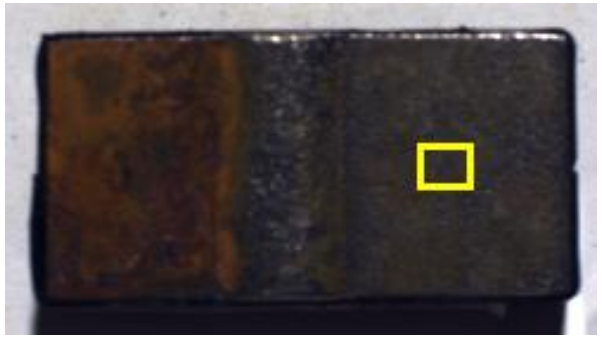
9 cycle : SUS（0.1% NaCl）

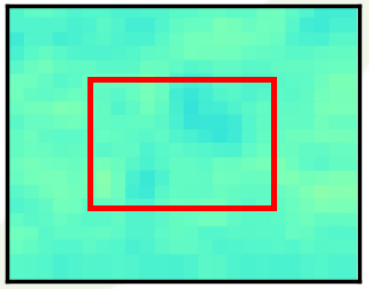


14バンド

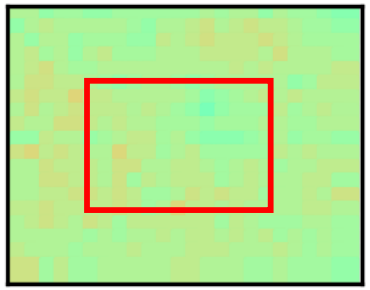


52バンド

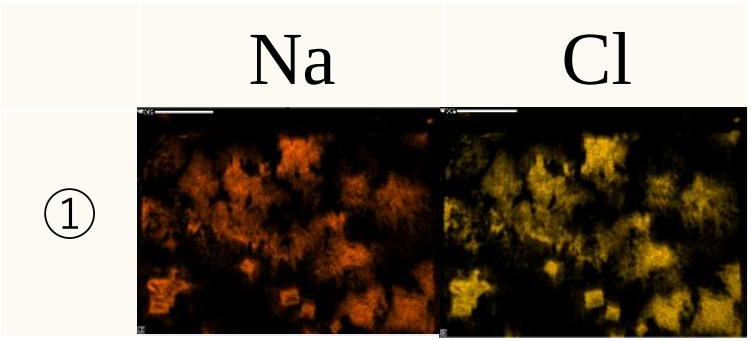




104バンド

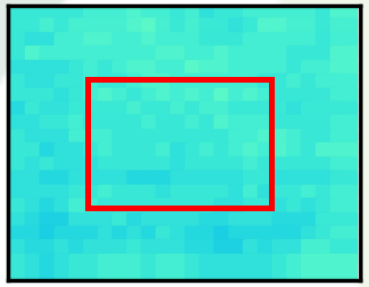


190バンド

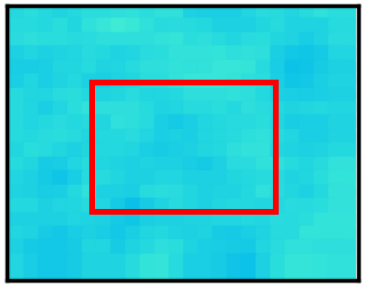


02 HS and Corrosion

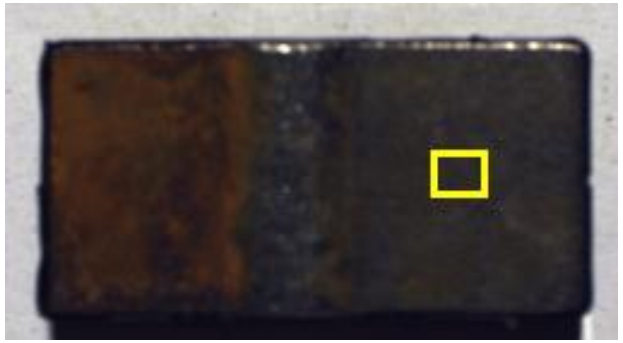
12 cycle : SUS（0.1% NaCl）

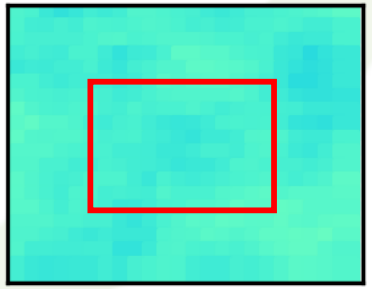


14バンド

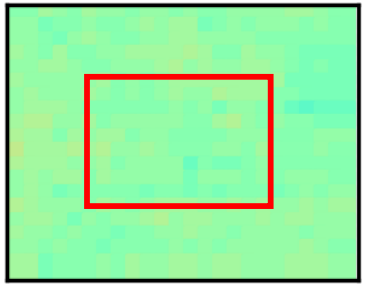


52バンド

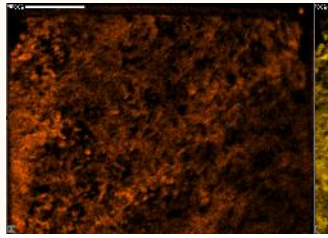
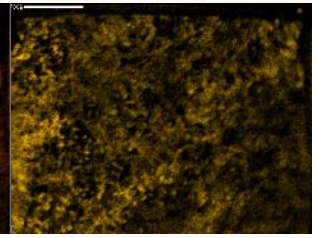




104バンド

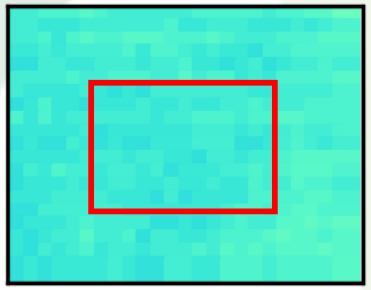


190バンド

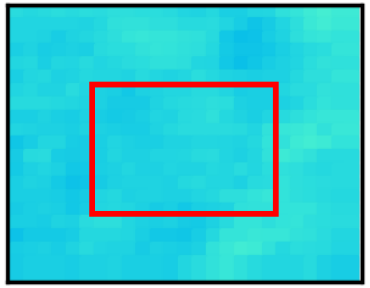
	Na	Cl
①		

02 HS and Corrosion

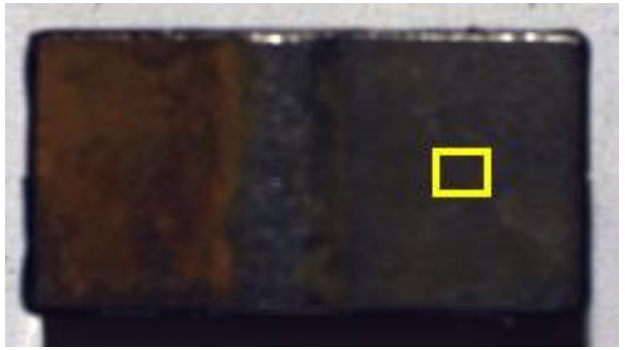
15 cycle : SUS（0.1% NaCl）

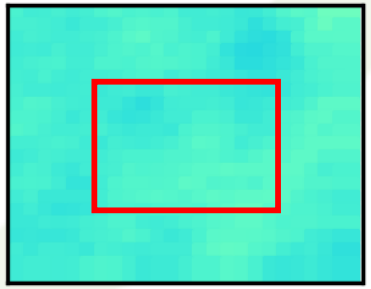


14バンド

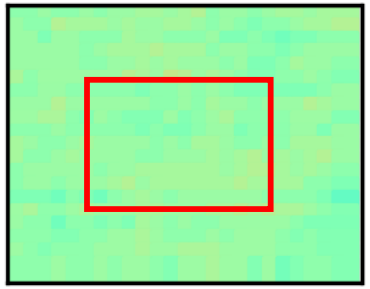


52バンド

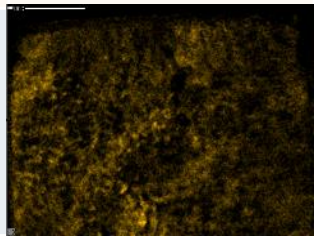




104バンド



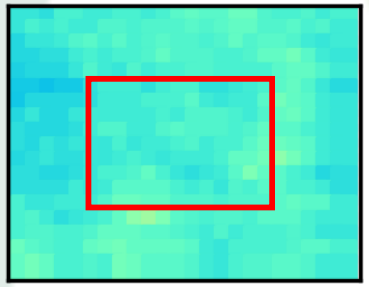
190バンド

	Na	Cl
①		

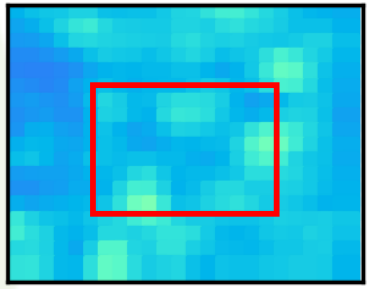
02 HS and Corrosion

0 cycle（0.1% NaCl）

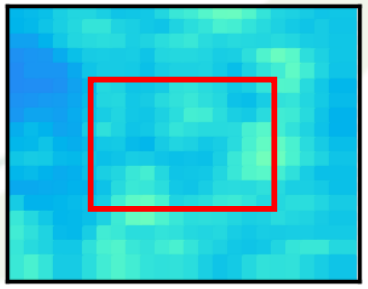
14 band (Blue)



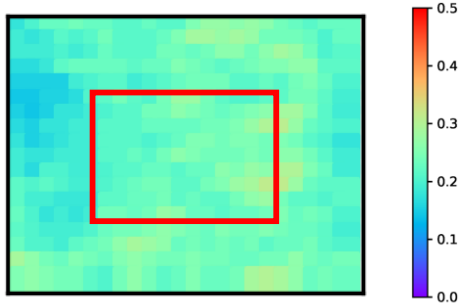
52 band (Green)

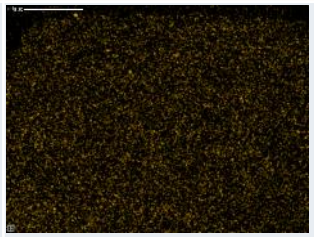


104 band (Red)



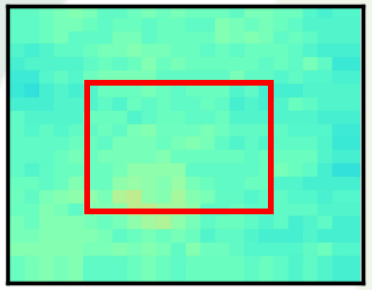
190 band
(Near Infrared)



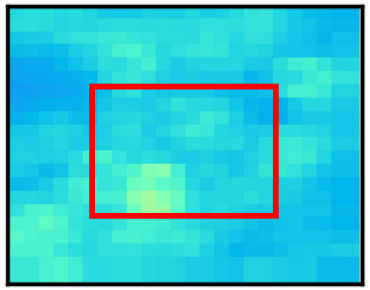
Na	Cl
No data	

02 HS and Corrosion

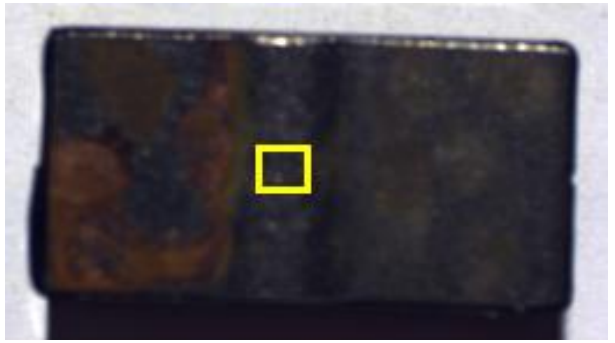
3 cycle（0.1% NaCl）

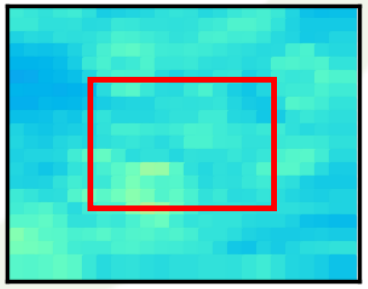


14バンド

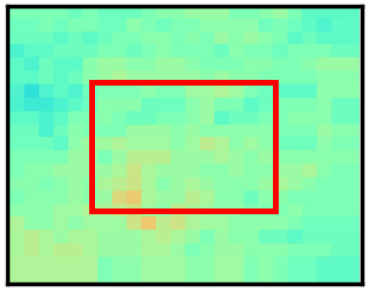


52バンド

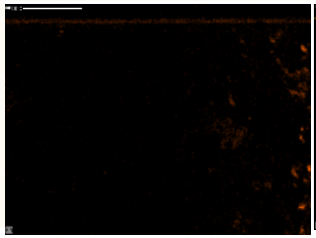
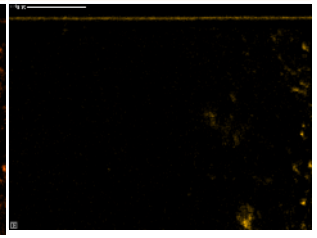




104バンド

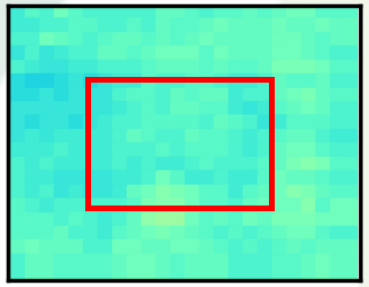


190バンド

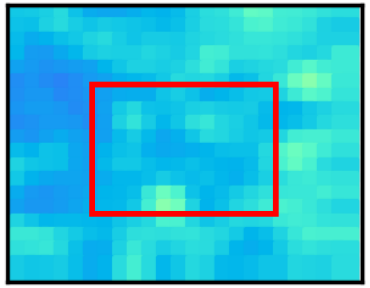
	Na	Cl
②		

02 HS and Corrosion

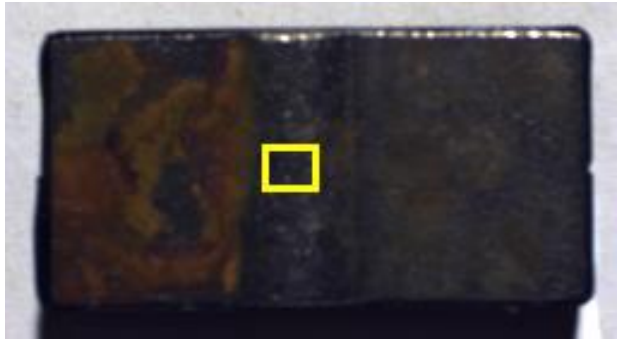
6 cycle （A0.1%_1）

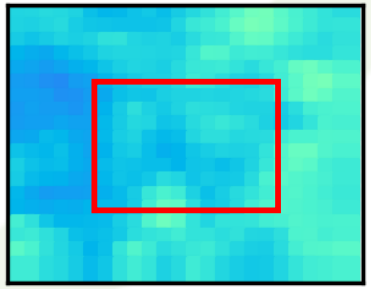


14バンド

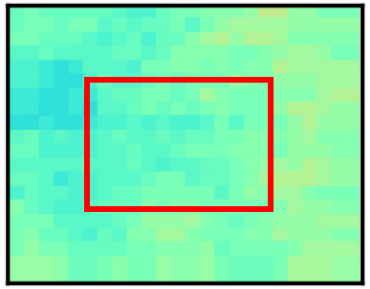


52バンド

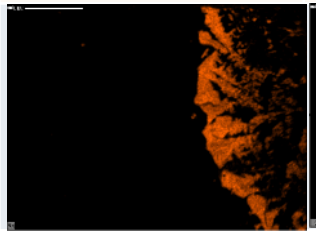
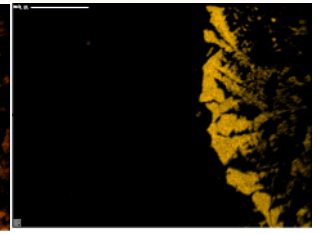




104バンド

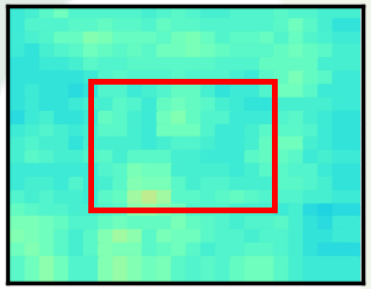


190バンド

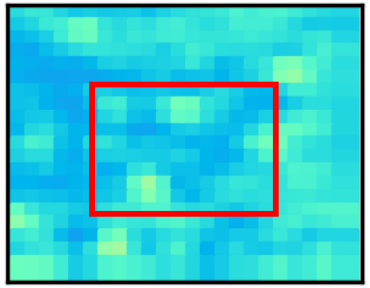
	Na	Cl
②		

02 HS and Corrosion

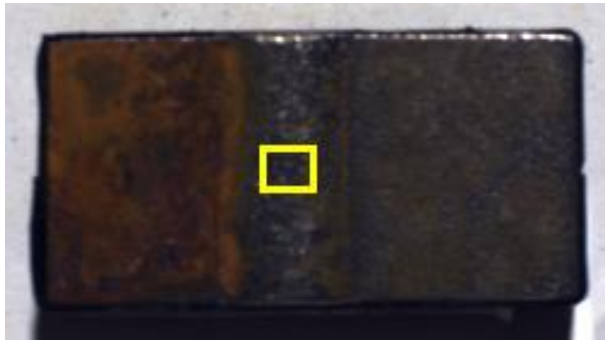
9 cycle （A0.1%_1）

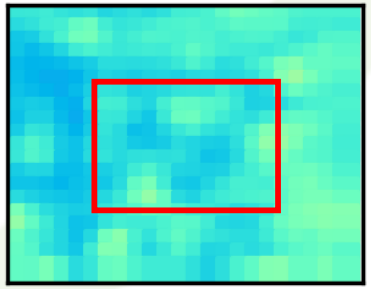


14バンド

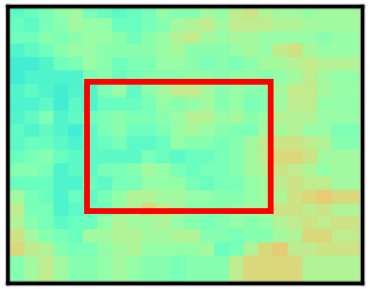


52バンド

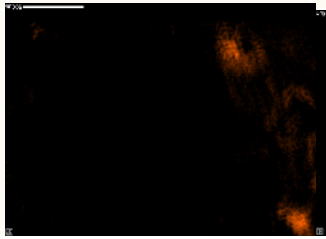
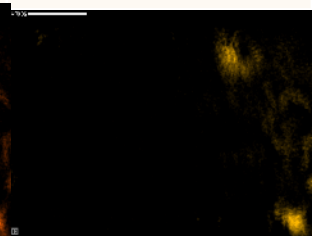




104バンド

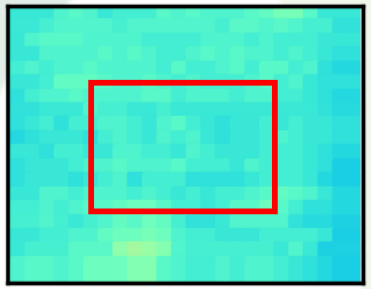


190バンド

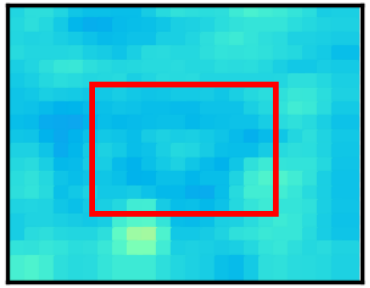
	Na	Cl
②		

02 HS and Corrosion

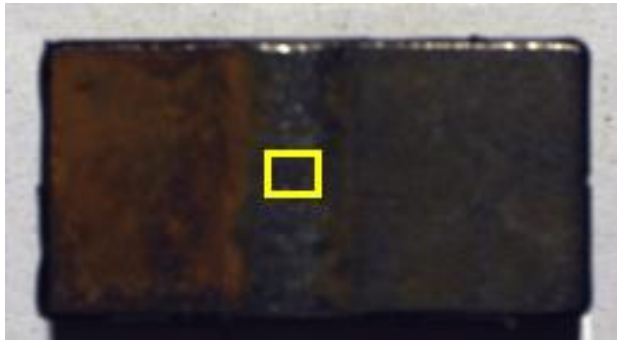
12 cycle （A0.1%_1）

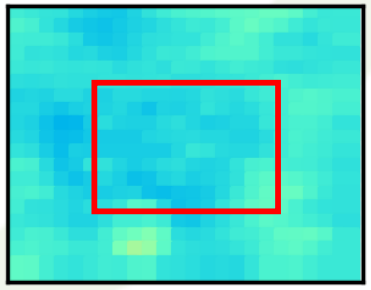


14バンド

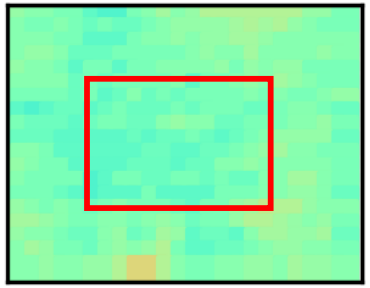


52バンド

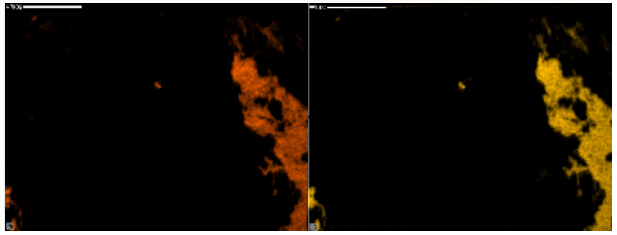




104バンド

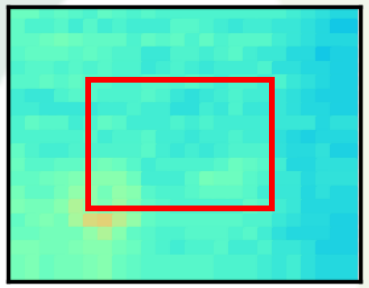


190バンド

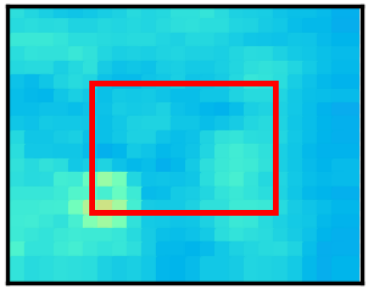
	Na	Cl
②		

02 HS and Corrosion

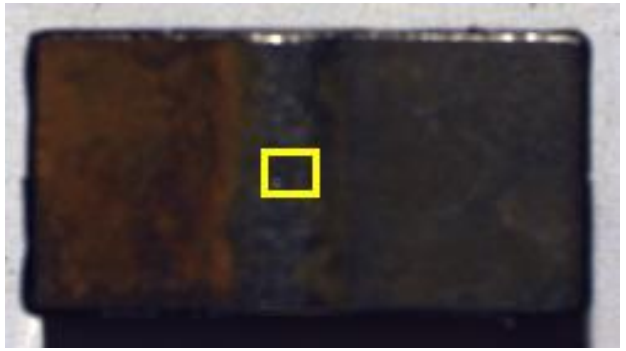
15 cycle （A0.1%_1）

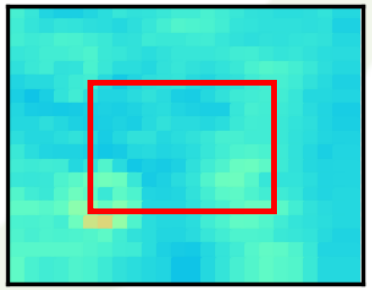


14バンド

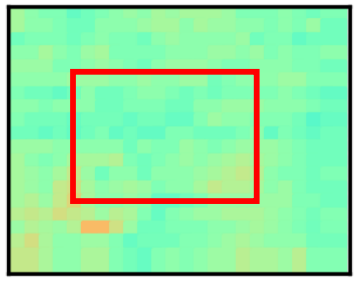


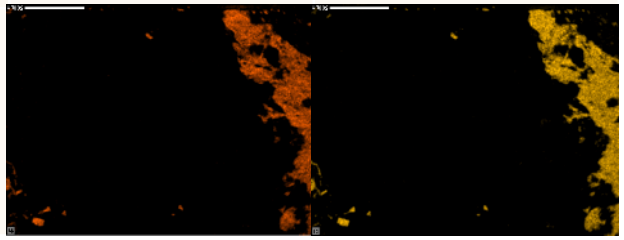
52バンド





104バンド



190バンド

	Na	Cl
②