

Increased steam temperature with Steamboost superheater in grate fired boilers – linking deposit formation and high temperature corrosion (KME709)



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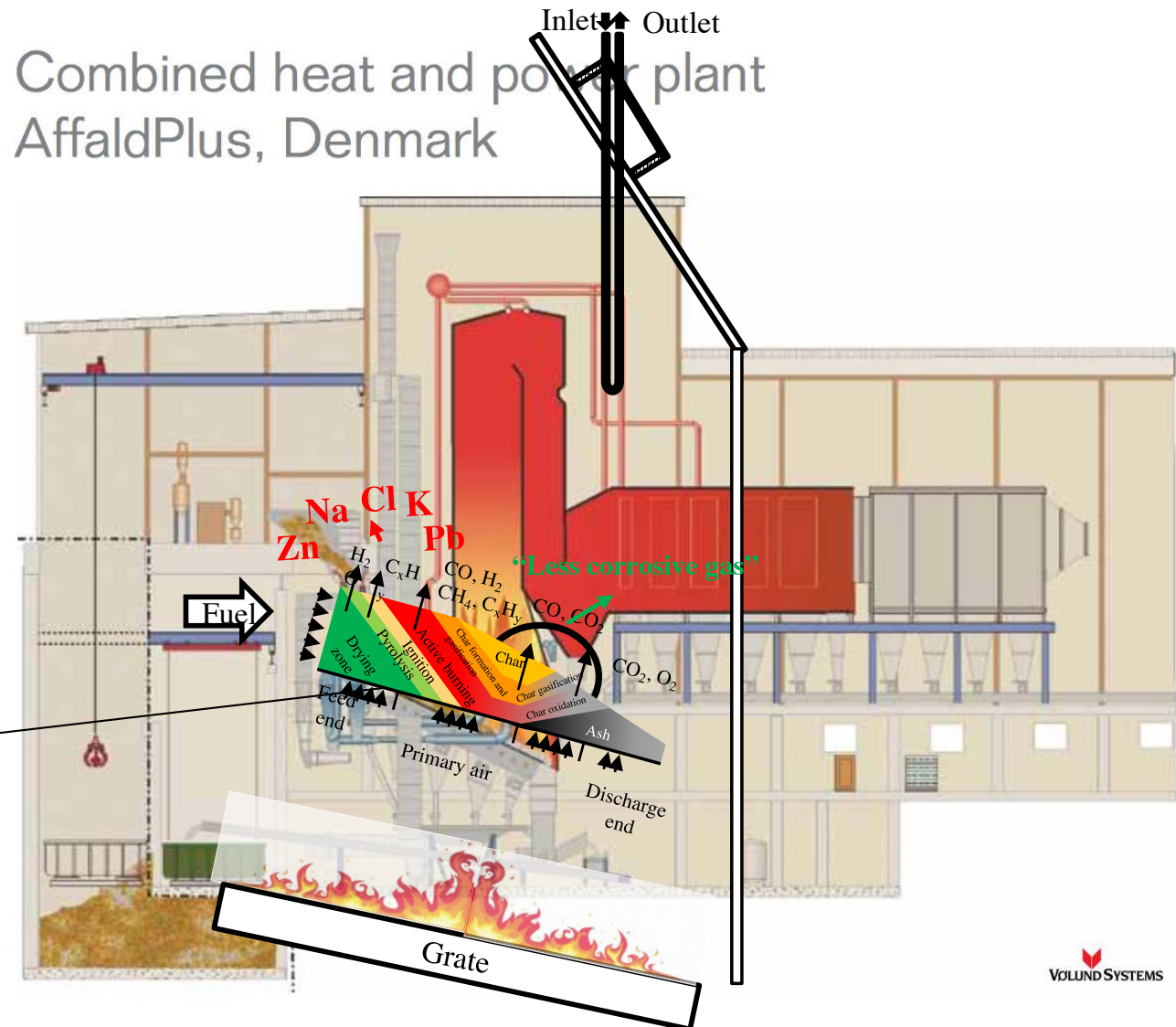
Autumn-Winter 2016/17

Field exposures



Grate fired boiler

- What's the idea behind Steamboost?



- Waste fired boiler.
- Different processes over the grid.
- CFD calculations indicates a position over the grid with less corrosive species.
- **New position of superheaters!**

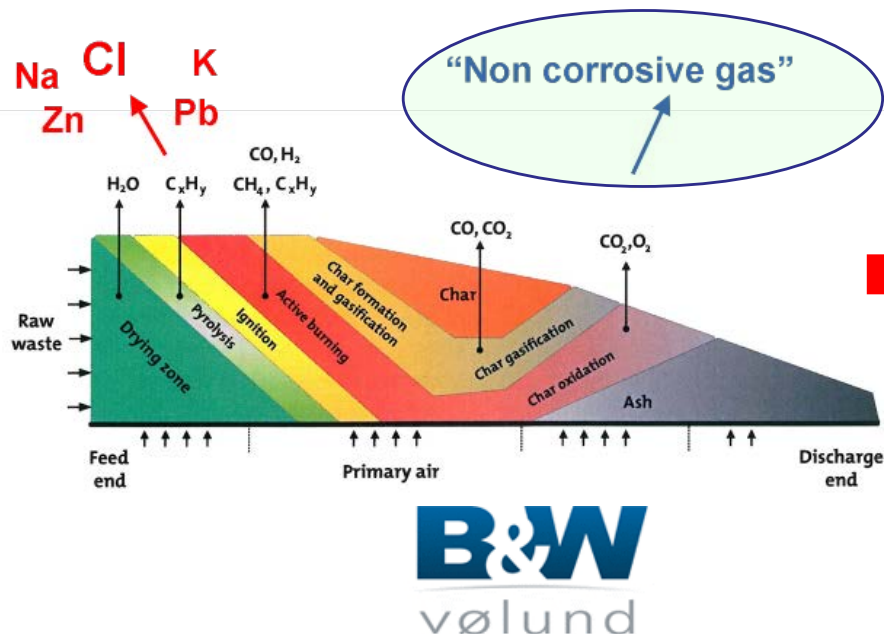
What's the idea behind Steamboost?

Waste incineration is a complex combustion process



Several processes over the grate

KME709 strategy field exposures



CFD calculations → Gas composition



Deposit probes → Deposit composition

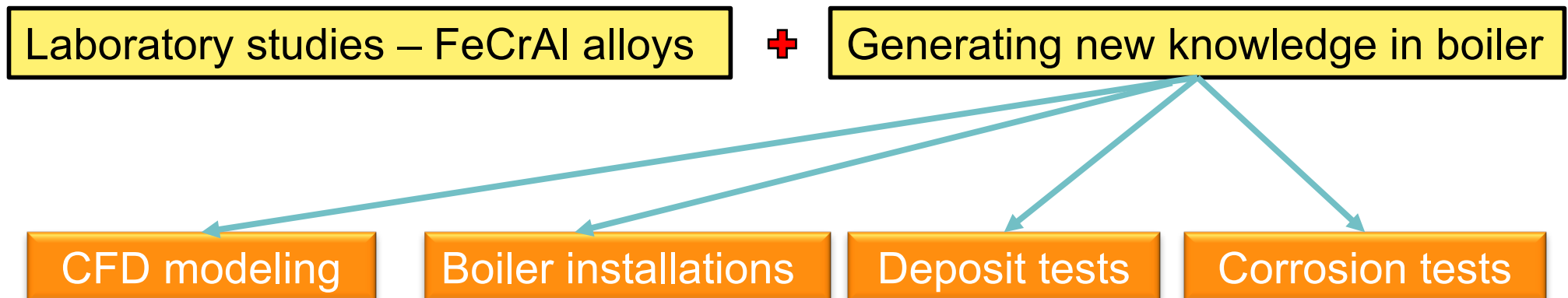


Deposit composition → Corrosion attack

Overall Goal of KME709

- Research strategy and correlation to KME goals

Increase energy production in grate fired boilers



KME goals:

- Higher steam parameters & high electrical efficiency
- Development of novel solutions where steam is superheated in the furnace
- Develop improved material solutions – including alumina formers

Overview

AffaldPlus Denmark

- **First fixed installation Steamboost** ✓
- **FeCrAl tube. Three outages** ✓
- **Second fixed installation Steamboost** ✓
- **Deposit tests** ✓
- **Corrosion test** Ongoing
- **Half way report. Approved!** ✓

Upcoming

- New corrosion test model alloys. Date: Spring 2017
- Lab work – Johan Eklund/Julien Phother

Research plan KME709

Aim deposit test:

Understand the link between settings of the boiler and deposit composition

Aim short/long time corrosion test:

Link the deposit to the corrosion mechanisms for different types of materials

**Material
suggestion for
Steamboost**

Aim laboratory work:

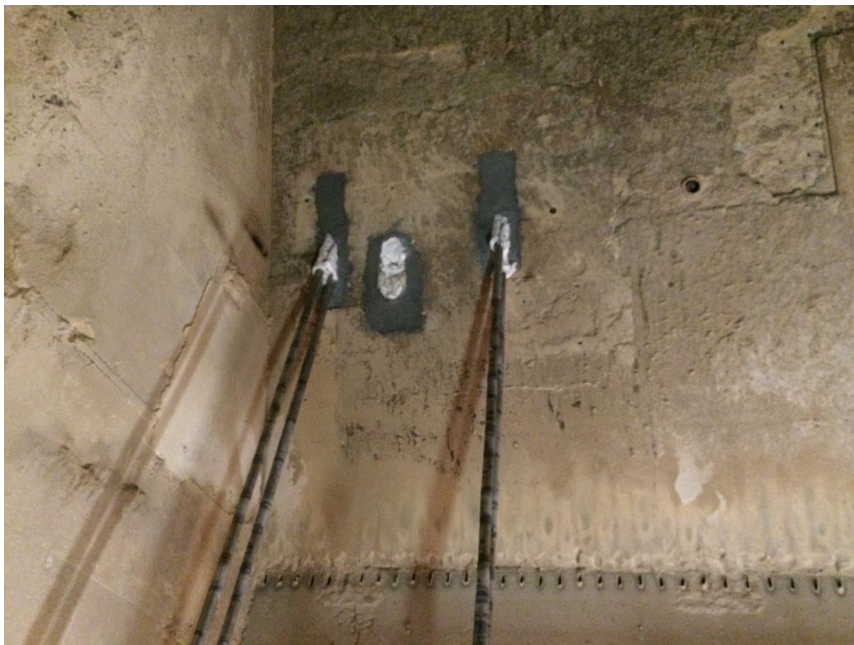
Generate knowledge about the corrosion mechanisms of FeCrAl materials

Boiler exposures (fixed installations)

Ongoing exposures performed in Denmark

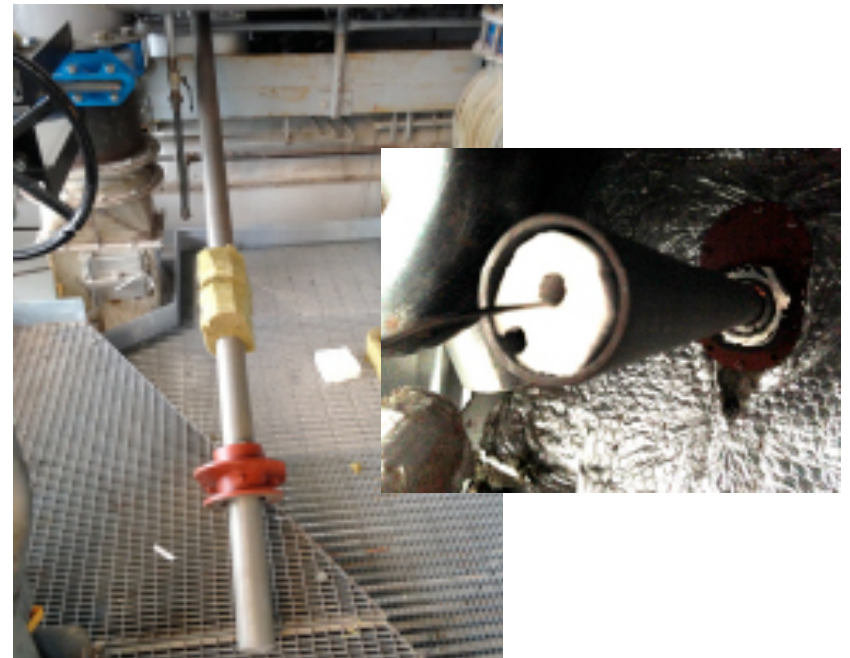
Steamboost

- Steamboost tubes installed (several materials)



FeCrAl tube

- FeCrAl tubes installed inside boiler



Boiler exposures (probe exposures)

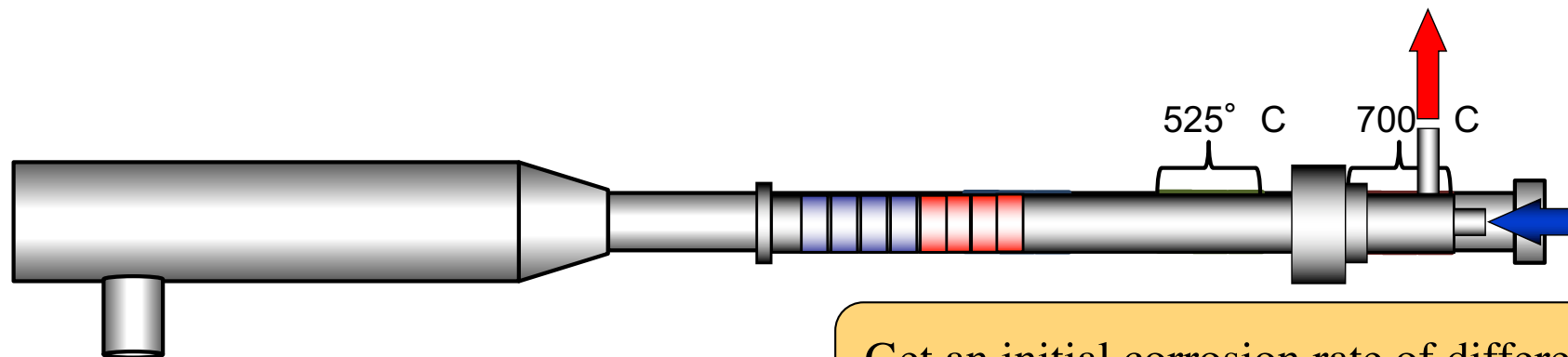
Deposit test

- Deposit/corrosion test
- Temperatures 525 and 700 ° C

Run the boiler to get the least corrosive deposit in the region of the Steamboost

Corrosion test

- Short time exposures
- Long time corrosion test – 1000h
- Different materials
- New probe design



Get an initial corrosion rate of different materials in the region of the Steamboost

Research plan KME709

Aim deposit test:

Understand the link between settings of the boiler and deposit composition

Aim short/long time corrosion test:

Link the deposit to the corrosion mechanisms for different types of materials

Material suggestion for Steamboost

Aim laboratory work:

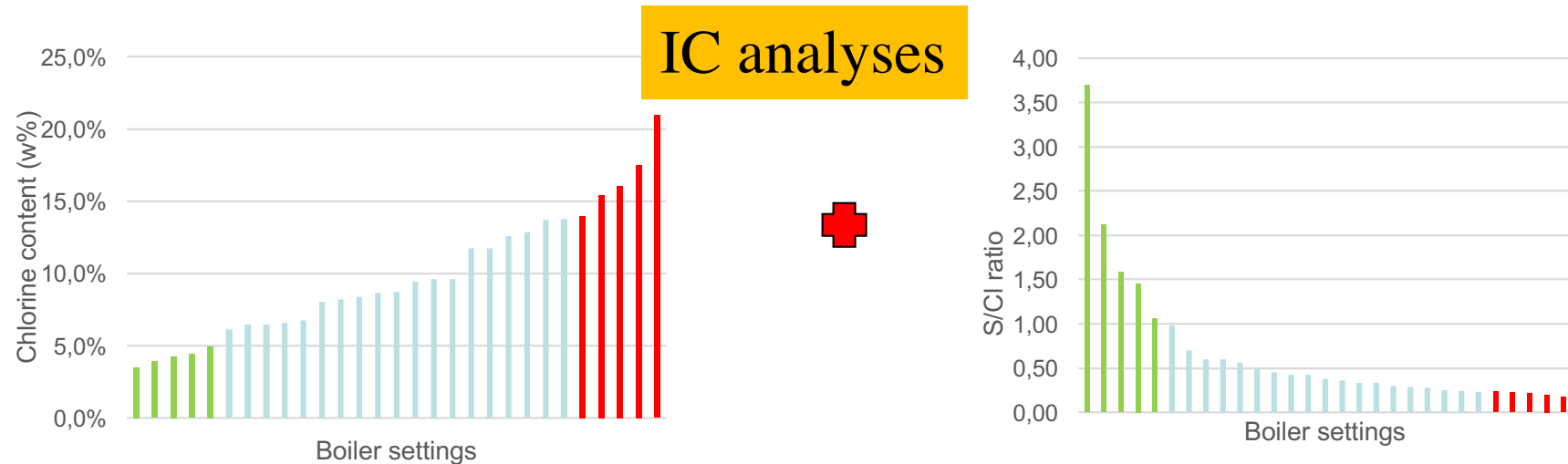
Generate knowledge about the corrosion mechanisms of FeCrAl materials

Boiler exposures - installation



Grate

Deposit test – analyses



XRD analyses

SEM/EDX analyses

Boiler settings suggestion

Heat data calculations

Corrosion test

Research plan KME709

Aim deposit test:

Understand the link between settings of the boiler and deposit composition

Aim short/long time corrosion test:

Link the deposit to the corrosion mechanisms for different types of materials

Material suggestion for Steamboost

Aim laboratory work:

Generate knowledge about the corrosion mechanisms of FeCrAl materials

Boiler exposures (corrosion probe)

Corrosion probe

- Short time exposures (**24h**)
- Long time **corrosion test – 1000h**
- Different materials
- New probe design and temperature controller

Sample material

SANDVIK



- 7RE10 (310)
- TP347H (6R44)
- Sanicro 33

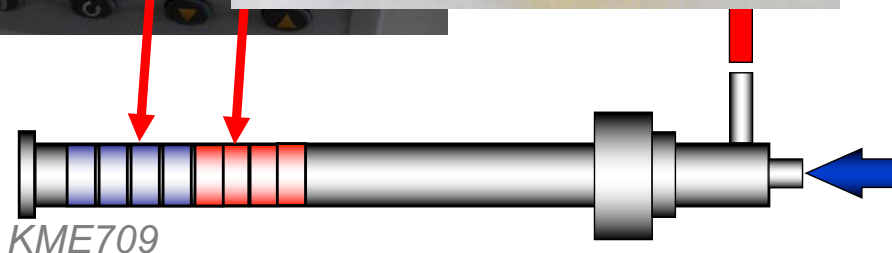


B&W
vølund

625 over weld

SANDVIK

- APMT
- Nikrothal PM58
- Model alloy



Corrosion probe

Before exposure



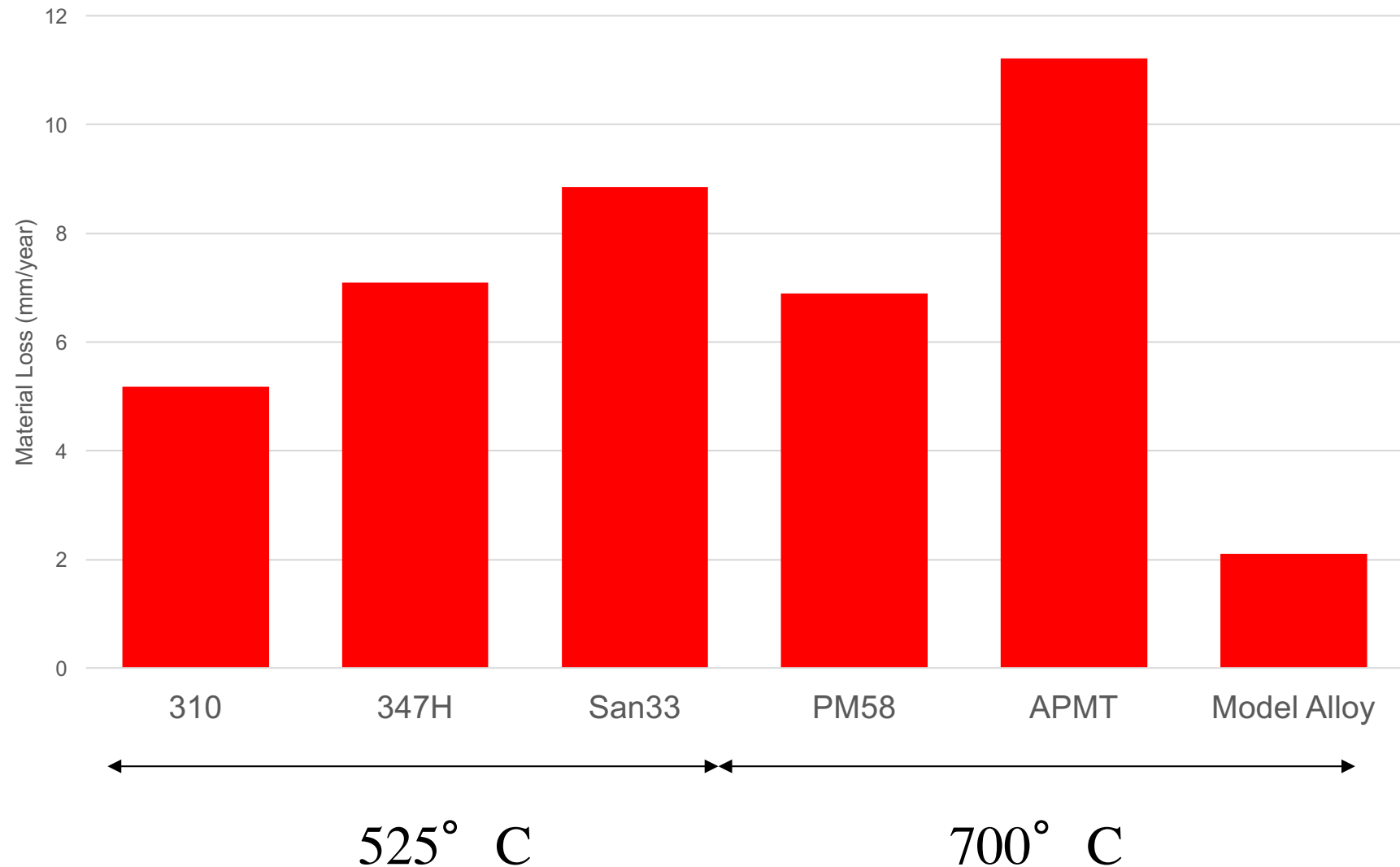
After 24h exposure



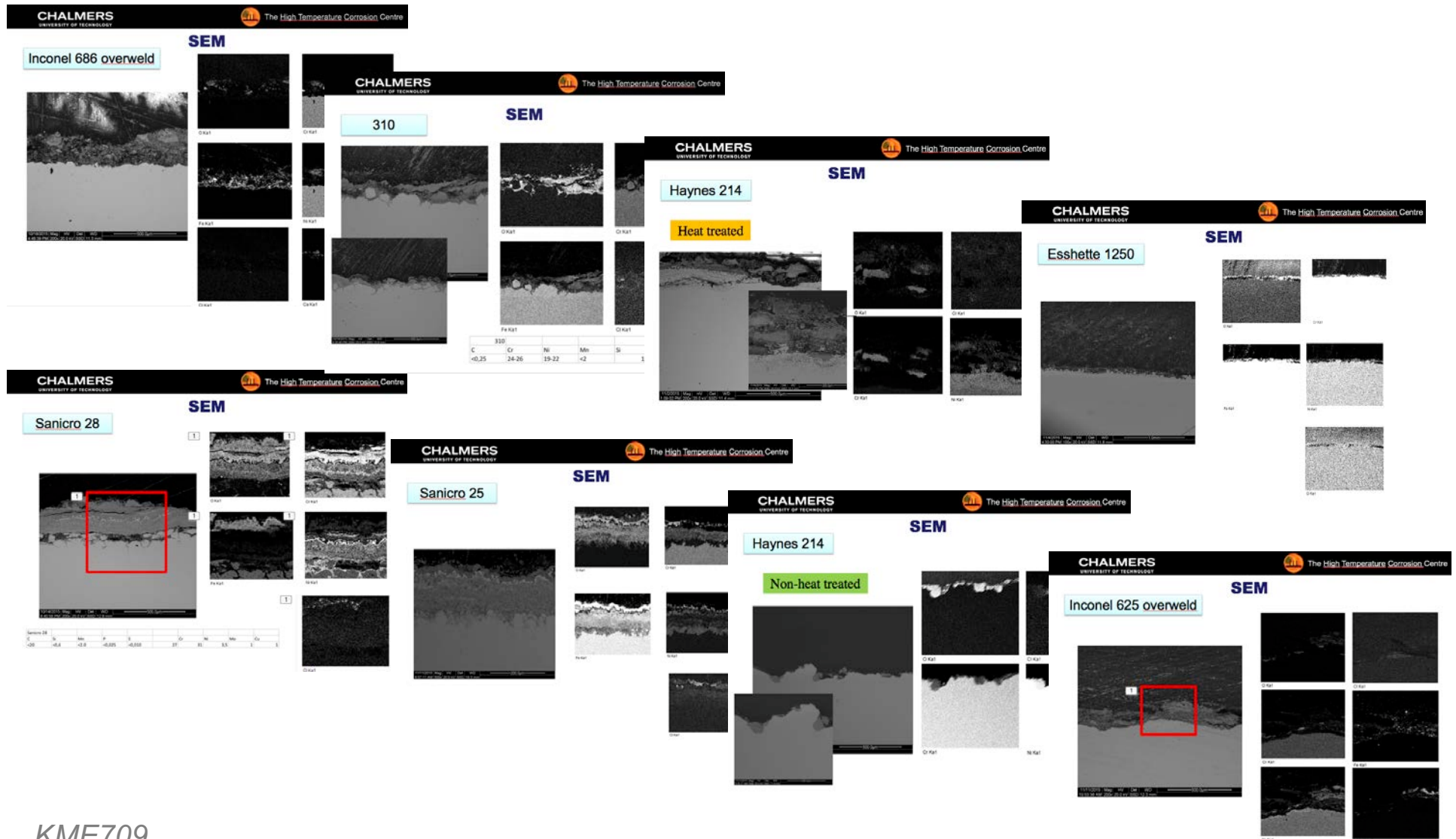
After 1000 h exposure



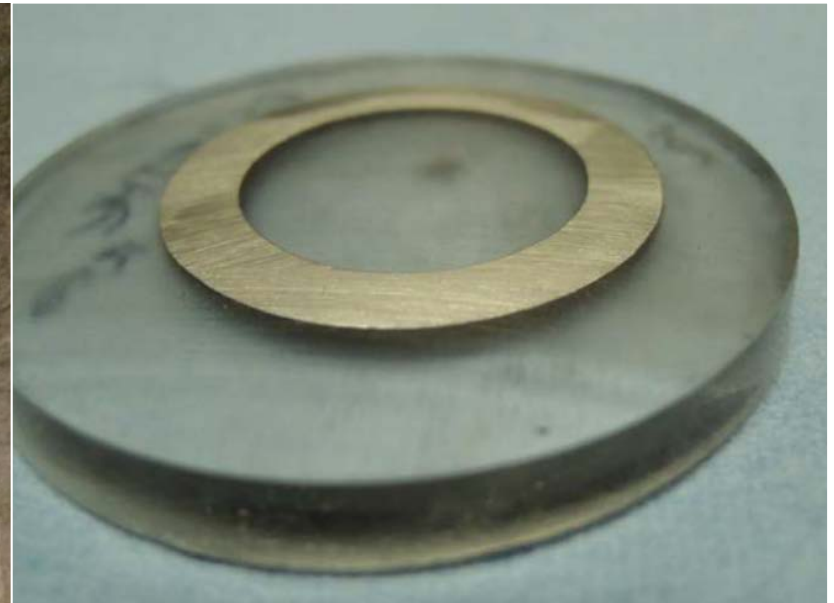
Material loss (corrosion probe 1000h)



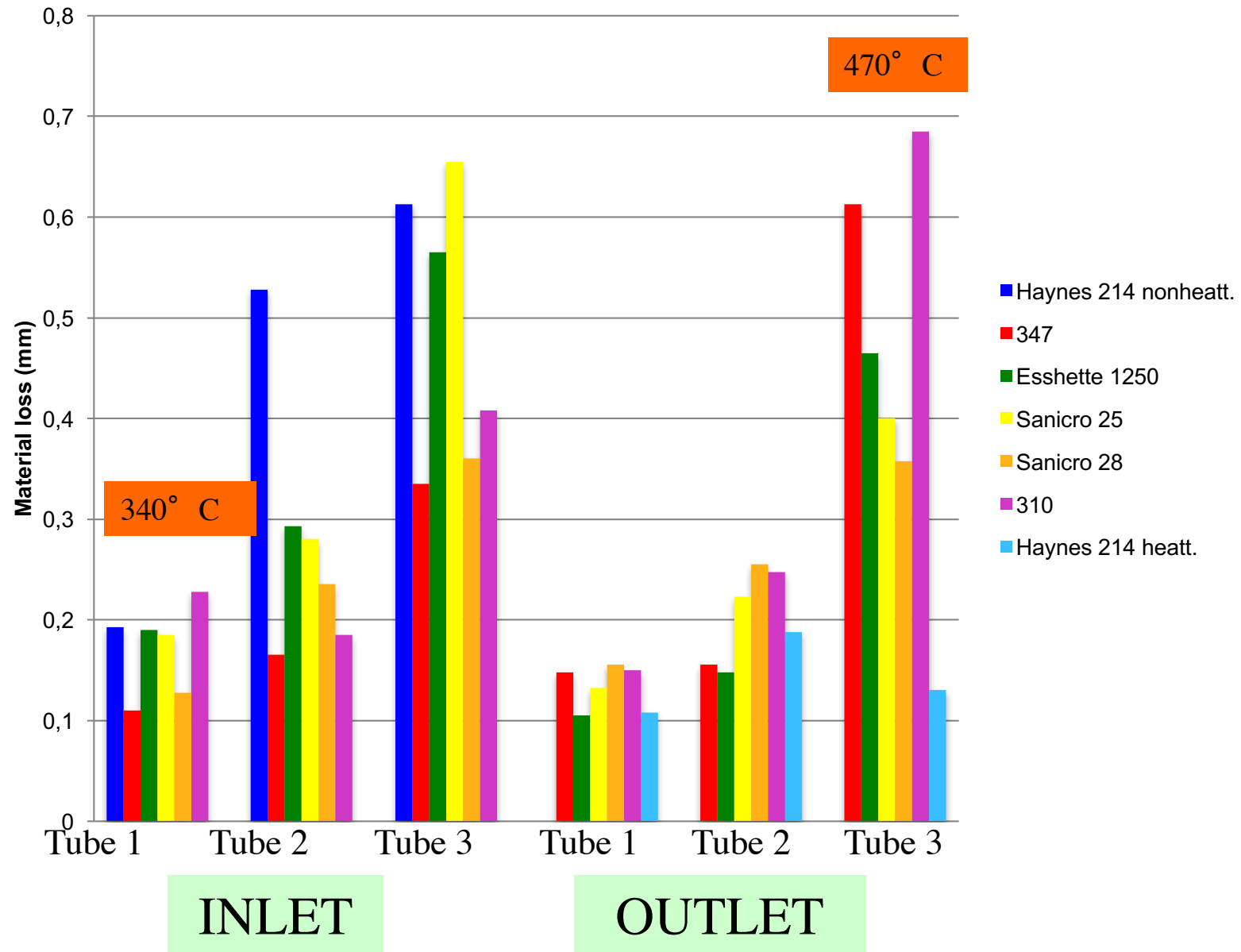
Characterizing the corrosion attack (SEM/EDX analyses)



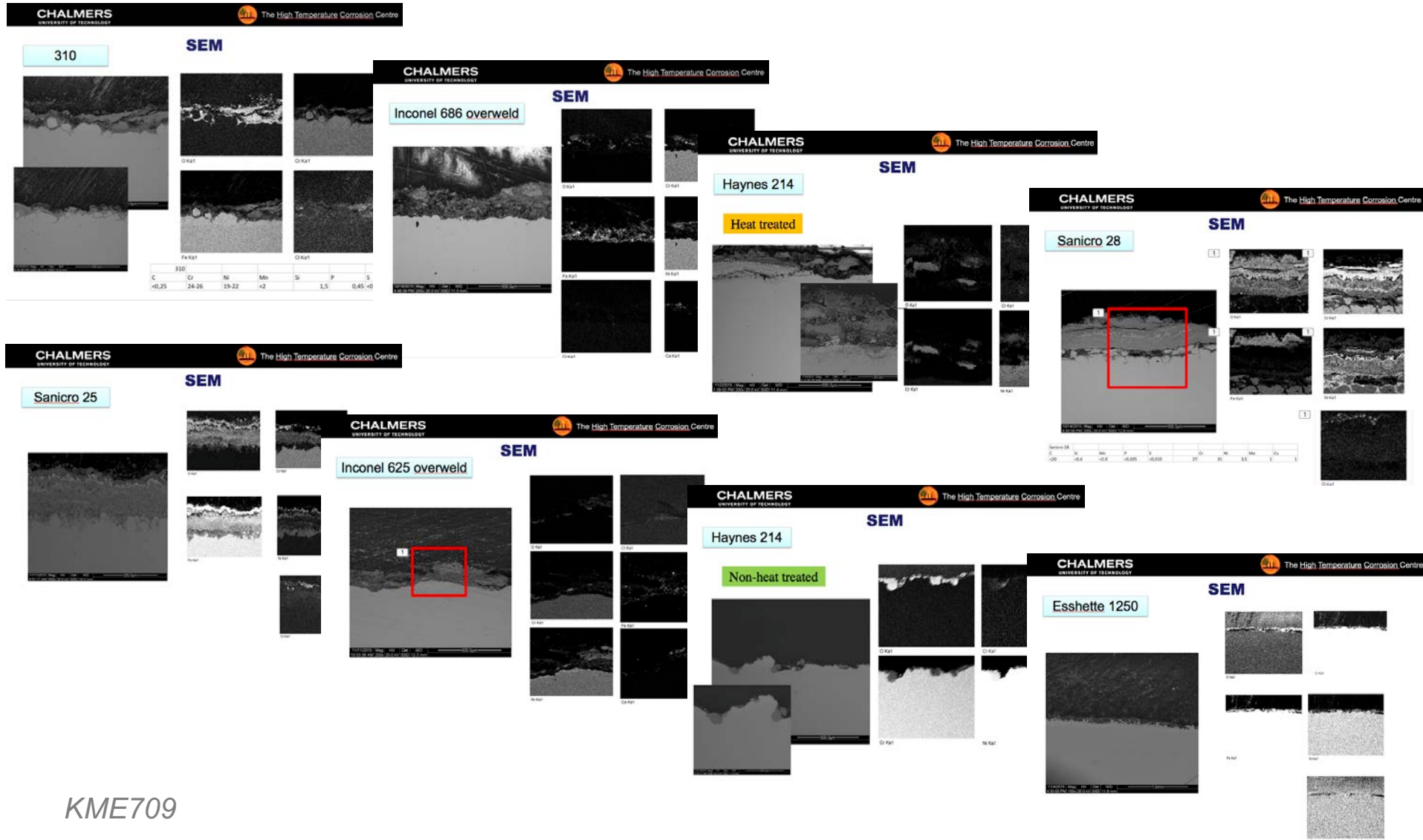
Boiler exposures (installations-Steamboost)



Material loss (Steamboost 8000 h)



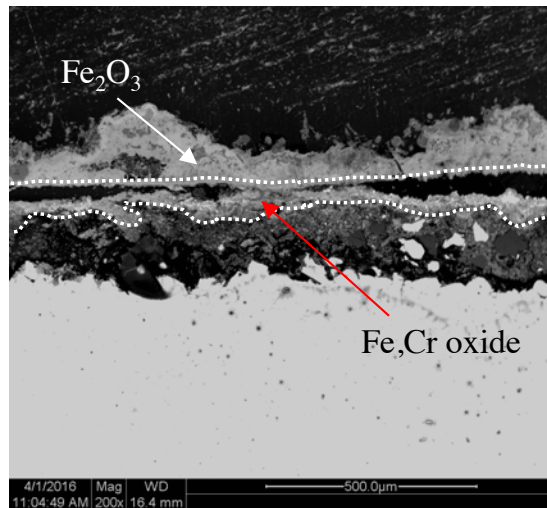
Characterizing the corrosion attack (SEM/EDX analyses)



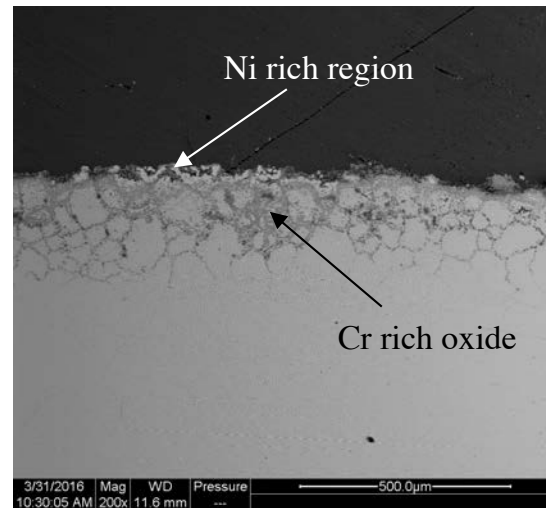
Summary of the results

Example 347

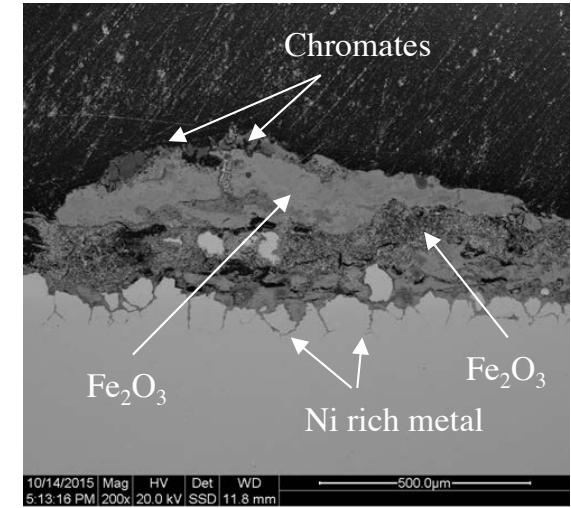
24h 525C



1000h 525C



8000h 525C

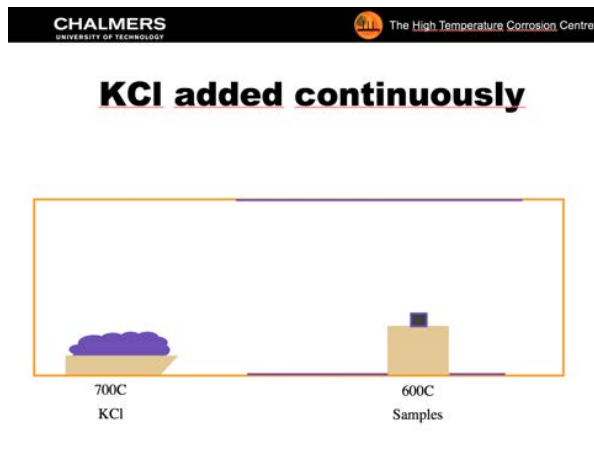


Corrosion probe

Steamboost

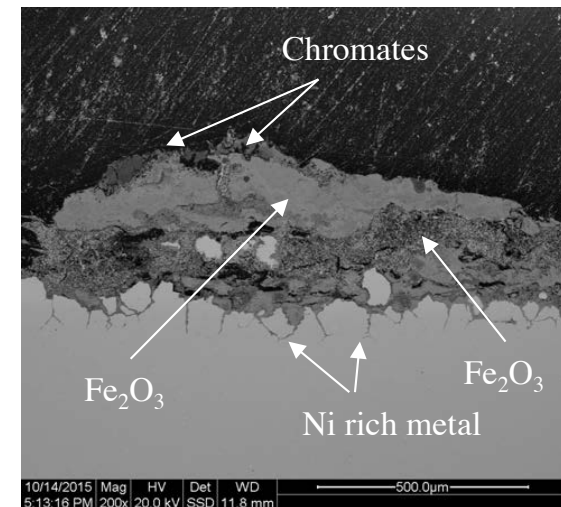
Research strategy

Fundamental research



Fundamental
understanding of
the corrosion
process in boilers

8000h 525C



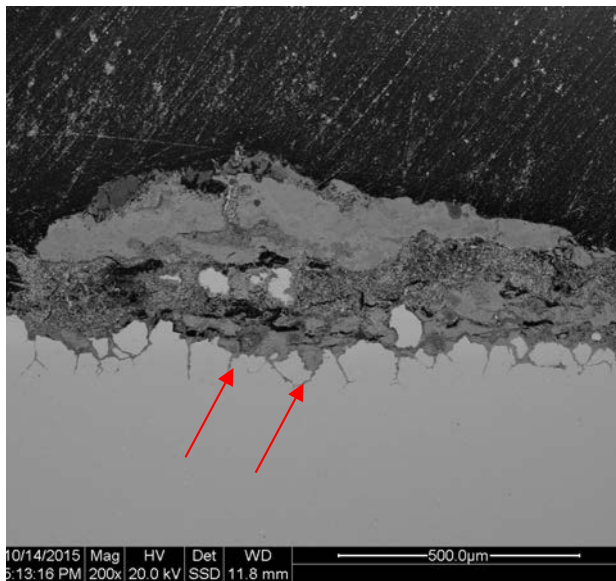
Applied research

Laboratory
studies

Field
studies

Collaboration: HTC/KME709/KME714

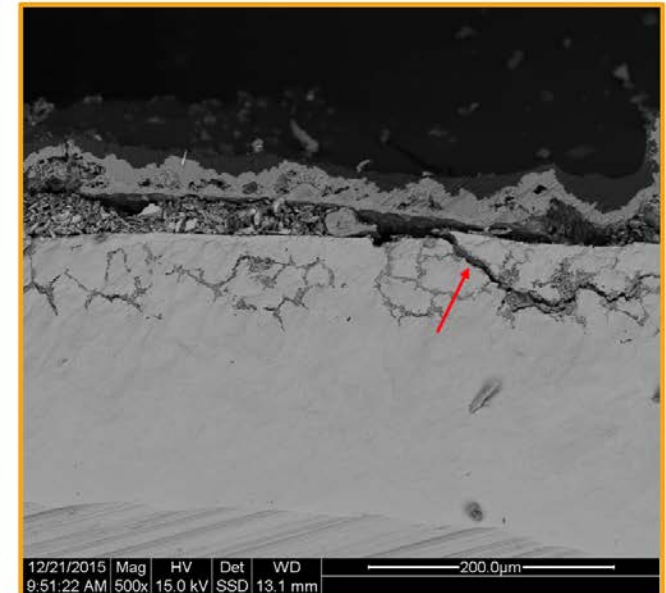
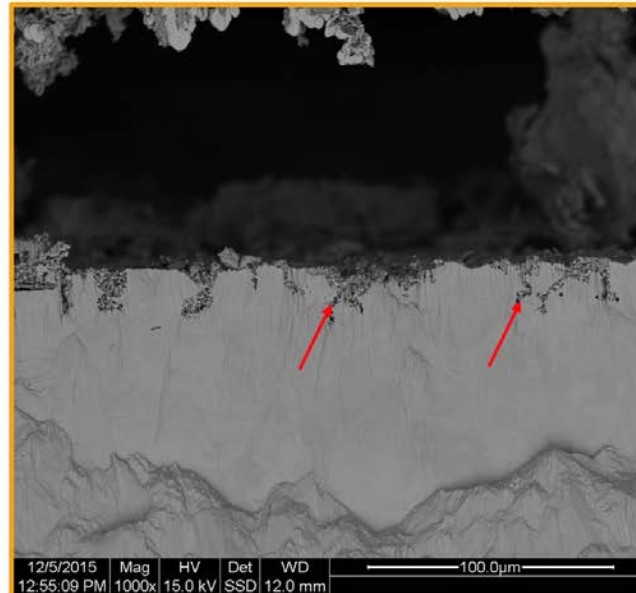
8000h 525C



Most KCl Cross-section



BSE



Next step :
Add SO₂

Research plan KME709

Aim deposit test:

Understand the link between settings of the boiler and deposit composition

Aim short/long time corrosion test:

Link the deposit to the corrosion mechanisms for different types of materials

Material suggestion for Steamboost

Aim laboratory work:

Generate knowledge about the corrosion mechanisms of FeCrAl materials

Boiler exposures (un-cooled FeCrAl tube)



Three exposure times!

Characterizing the corrosion attack (SEM/EDX analyses)

FeCrAl tube (first sample)

Region 1 (50%)

10/16/2015 Mag HV Det WD
3:02:12 PM 200x 20.0 kV SSD 11.2 mm

500.0µm

FeCrAl tube (first sample)

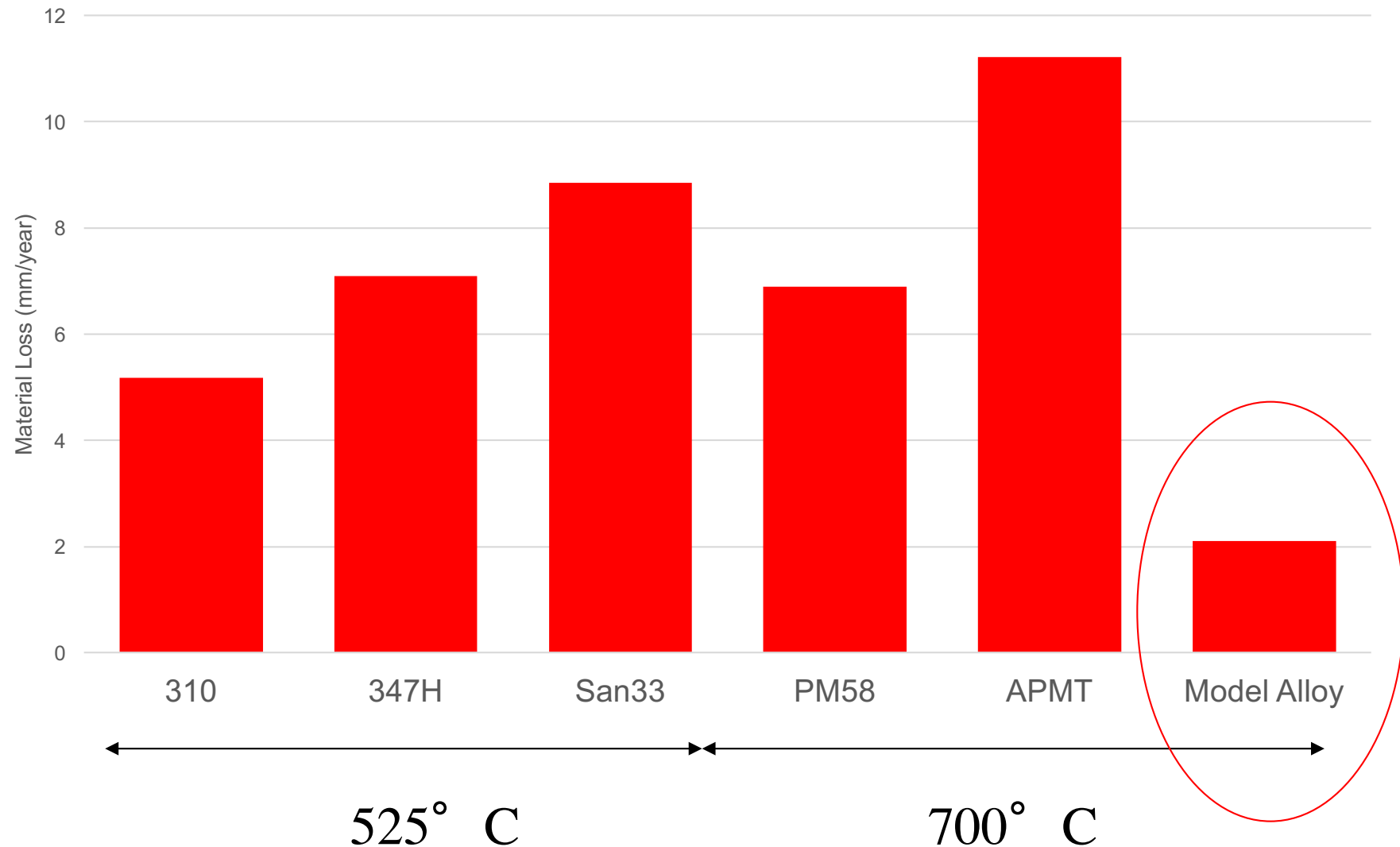
Region 2 (50%)

10/16/2015 Mag HV Det WD
3:45:24 PM 200x 20.0 kV SSD 10.7 mm

500.0µm

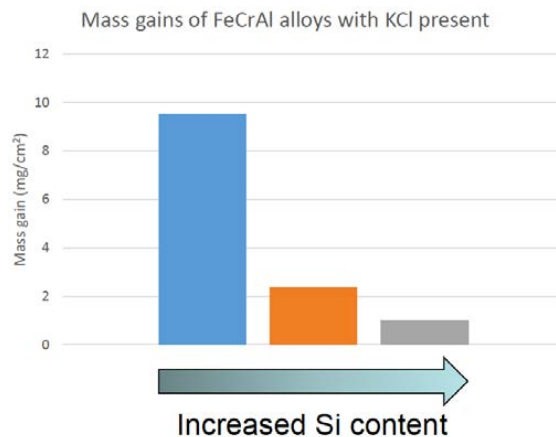
Temperature $\approx 900^{\circ}\text{C}$ Time ≈ 4500 h

Material loss (corrosion probe 1000h)



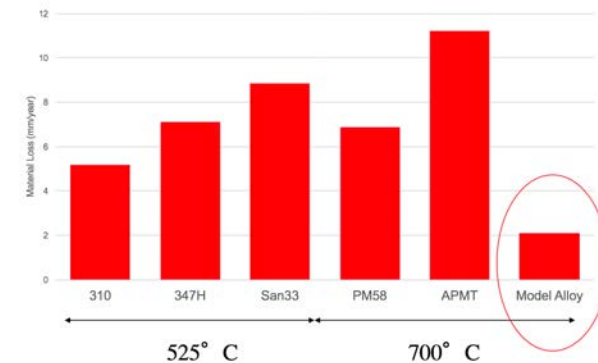
Research strategy

Fundamental research



Fundamental understanding of the corrosion process in boilers

Material loss (corrosion probe 1000h)



Applied research

Laboratory studies

Field studies

Collaboration: HTC/KME709

The Effect of Silicon on Corrosion Properties of FeCrAl Model Alloys in Alkali Chloride-rich Environments at Low Temperatures (600 °C)

Introduction

- Biomass and municipal waste as fuels to decrease greenhouse gas emissions
- Results in corrosive environment and degradation of boiler equipment
 - Due to alkali chlorides
- FeCrAl alloys may increase corrosion resistance of boilers
- Small amounts of silicon may have great beneficial effects on corrosion properties of FeCrAl alloys
- Deeper understanding of the effect of silicon needed

Conclusions

- Addition of Si shows great beneficial effects on corrosion resistance
- The role of Si on the corrosion resistance is unclear
 - No visible formation of SiO_2 layer
 - No difference in incubation time of breakaway oxidation
- Continuous thermogravimetric analysis needed to investigate initiation kinetics

Experimental Procedure

Alloy	Cr	Al	Si
1	10	4	2
2	10	4	1
3	10	4	0

Exposure Conditions:

Gas composition: 5% O_2 + 20% H_2O + N_2
 Deposition of KCl: 1 mg/cm^2
 Temperature: 600 °C
 Time interval: 168 h

What is the role of Si?

0%Si

Effect of Silicon on Corrosion Behavior of FeCrAl alloys

Great beneficial effect of Si

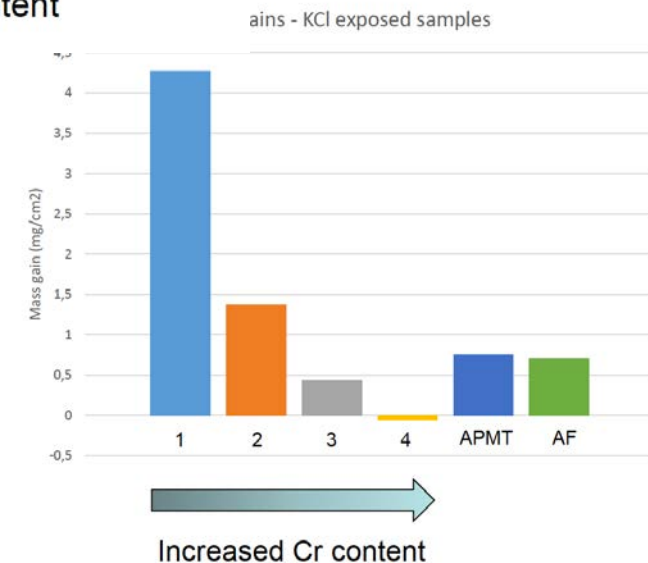
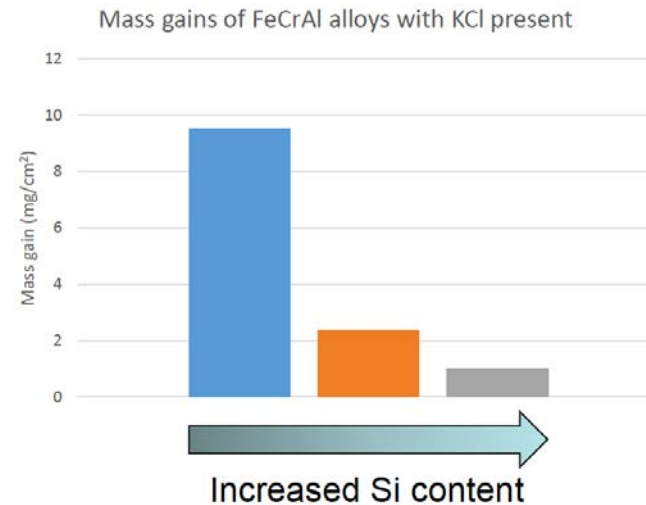
0%Si

1%Si

2%Si

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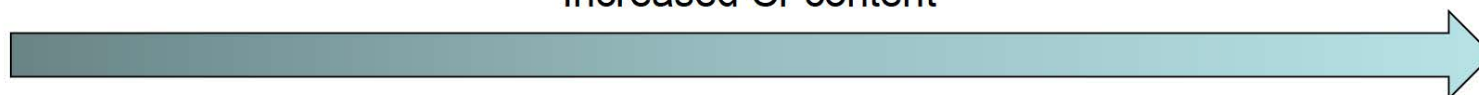


Upcoming: Corrosion probe 1000h



ref	1	2	3	4	5	6	7	
Alloy 625	5 3 2	10 3 2	15 3 2	20 3 2	10 3 0	Exp 1	Exp 2	
	Cr Al Si							

Increased Cr content

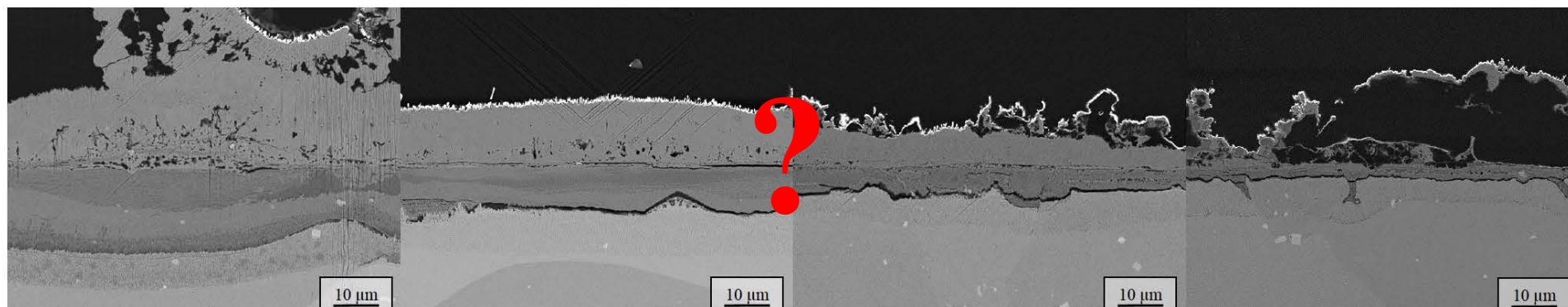


5%

10%

15%

20%



Summary

- A setting of the boiler has been selected after the deposit tests
- A wide range of materials has been exposed both in Steamboost the installation and with a Corrosion Probe
- A FeCrAl tube has been exposed and partly analysed (still ongoing)
- New FeCrAl model alloys has been exposed

Future work

- More materials from the corrosion test will be analysed
- A new 1000h corrosion probe exposure will be performed in Naestved to test new model alloys – ***based on lab results***
- ***The results from different investigations will be correlated in order to link the environment – deposit – corrosion at the Steamboost position***