KME703/713-**Durable MCrAlX coatings**

For gas turbines with operational flexibility

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Project Team for KME 703/713

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- Reference group

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Swedish Energy Agency

KME

CONSORTIUM MATERIALS TECHNOLOGY

for development and demonstration of thermal energy processes

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SIEMENS

OUTLINE

- Background
  - Gas turbine and high temperature coatings
  - The project (2015-2018) & aim
  - Experiment method

- Results
  - Oxidation
  - Hot corrosion
  - TMF
  - Substrate interdiffusion
  - Bond coat in TBC

- Future work

GAS TURBINE

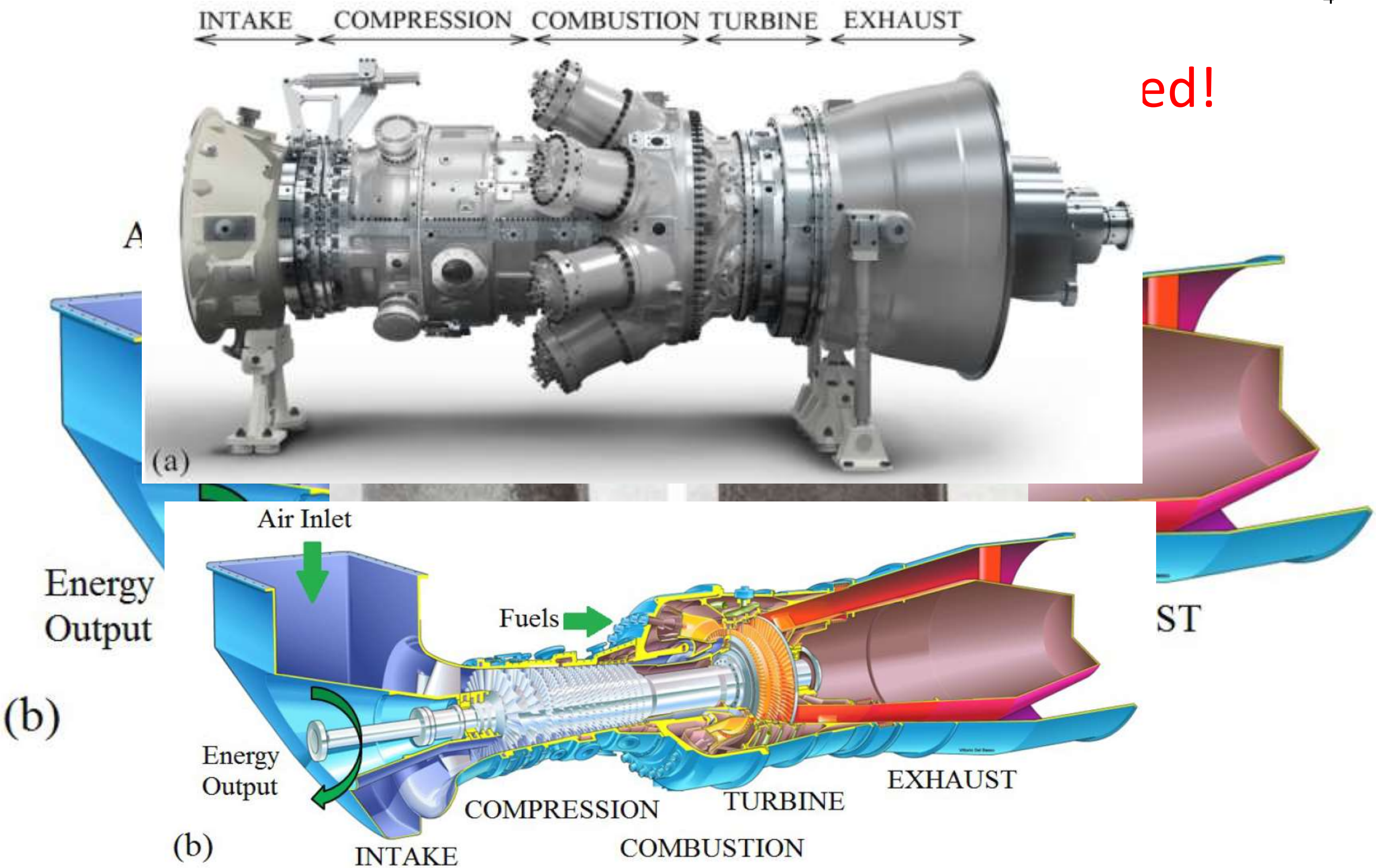

Fig. Two Siemens gas turbines (produced in Finspång, Sweden): (a) SGT-750 (38 MW), (b) SGT-800 (47 MW).

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HIGH-TEMPERATURE COATINGS

- **Metallic coatings** (oxidation and hot corrosion resistance)
- **Ceramic coatings** (heat insulation)

MCrAlX or MCrAlY

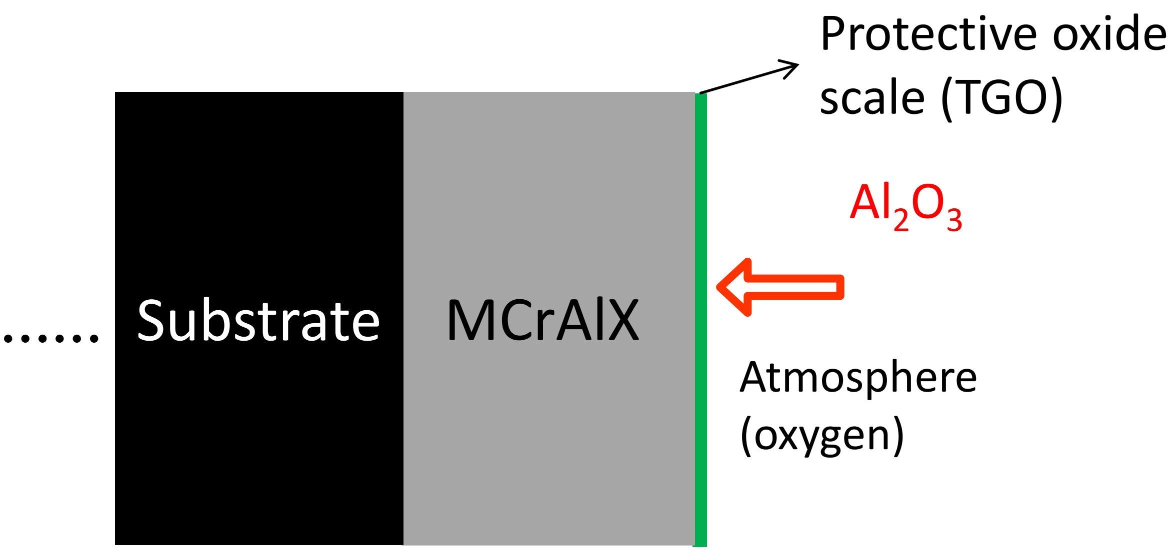
Nickel+Cobalt

Chromium

Aluminum

others

Yttrium



Overlay

Bond coat

CHALLENGE TO MCRALY

Oxidation

Hot Corrosion

TMF (DBTT)

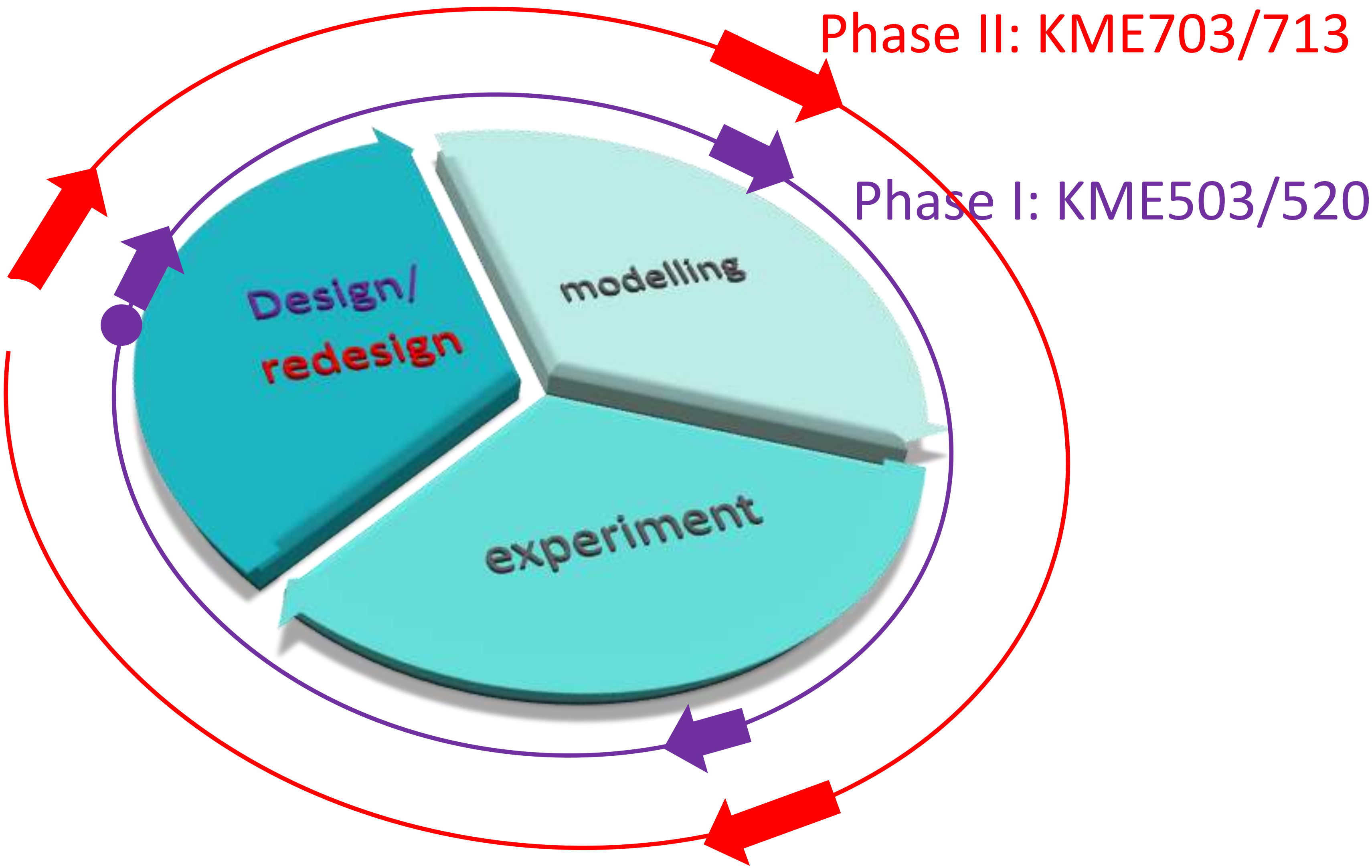
Substrate interdiffusion

bond coat in TBC

KME703/713-Durable MCrAlX coatings

For gas turbines with operational flexibility

STRATEGY-ALLOYING COMPOSITION DESIGN



Oxidation

Modelling

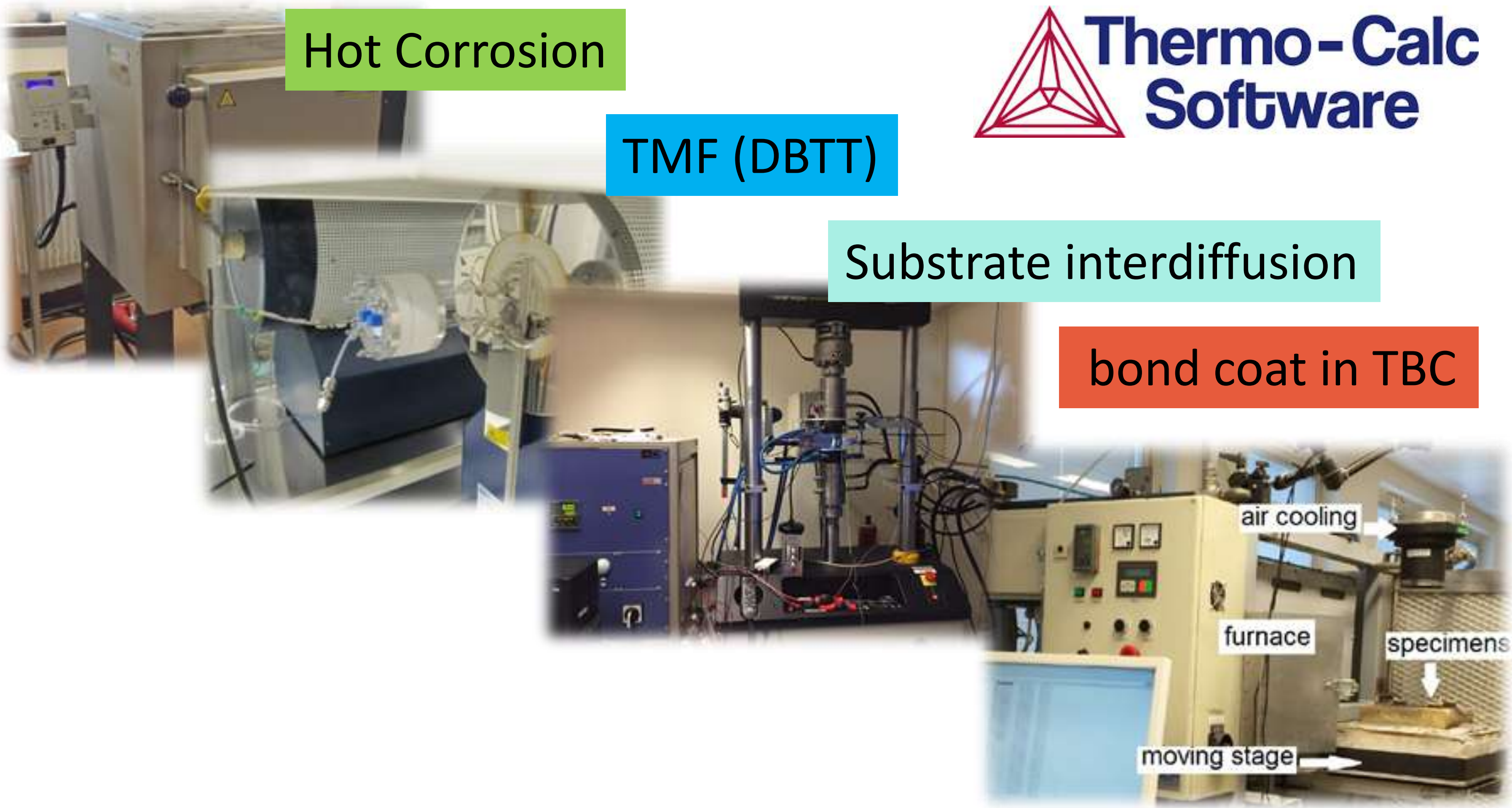
Hot Corrosion

Thermo-Calc Software

TMF (DBTT)

Substrate interdiffusion

bond coat in TBC



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Oxidation

Hot Corrosion

Improve oxidation reistance? T)

Substrate interdiffusion

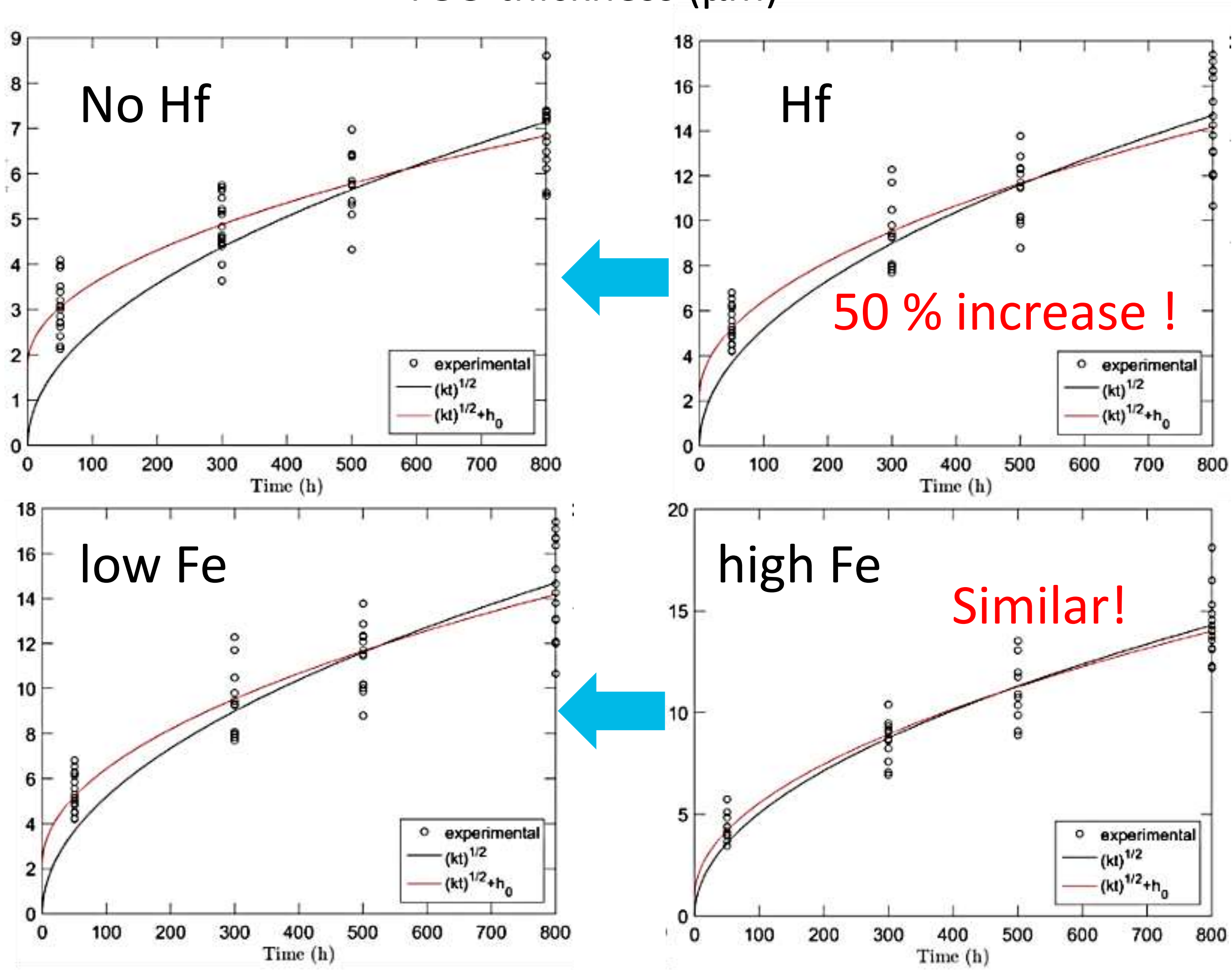
- Alloying element
- Coating microstructure
- Surface treatment
- Deposition technique

bond coat in TBC

Coating life prediction?

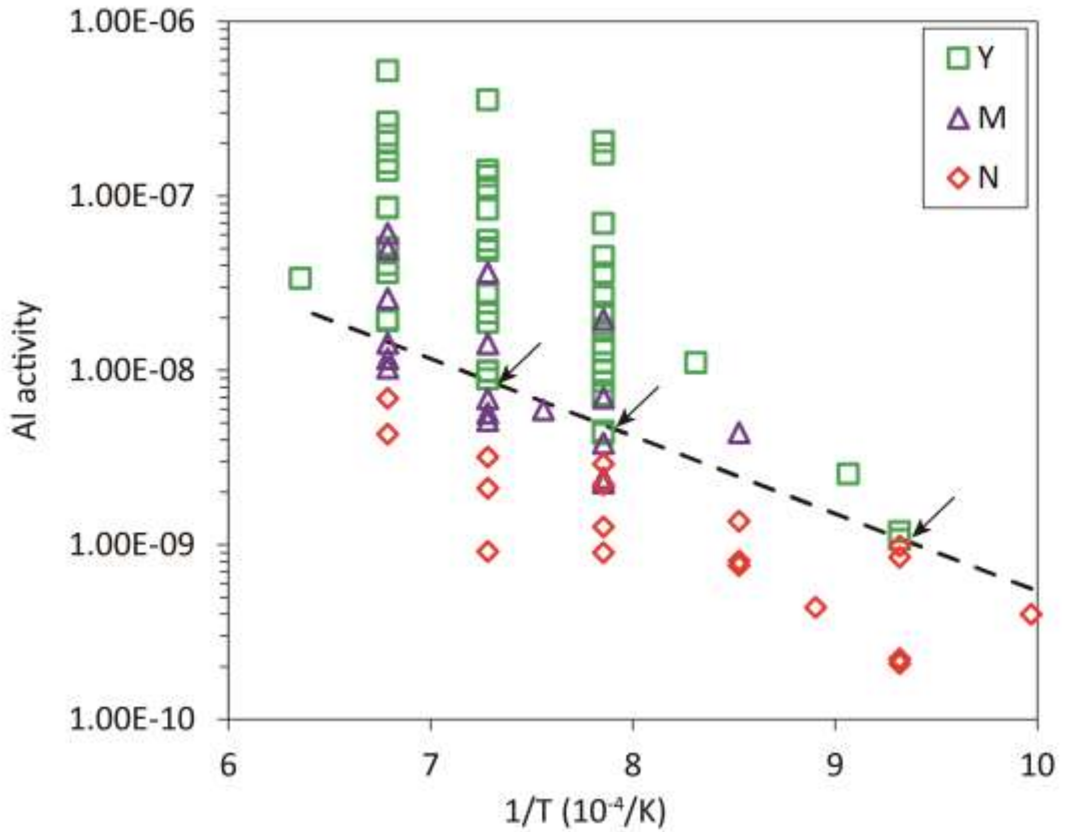
OXIDATION- ELEMENT EFFECT

TGO thickness (µm)



OXIDATION-LIFE PREDICTION

□ Y: alloys are able to form a single scale of alumina;
△ M: alloys are able to form an alumina scale with other oxides;
◇ N: alloys are unable to form a continuous alumina (internal alumina).



A good life criterion: $a_{Al,cri} = \exp(-10235/T - 11.1)$

Please find more details in my poster

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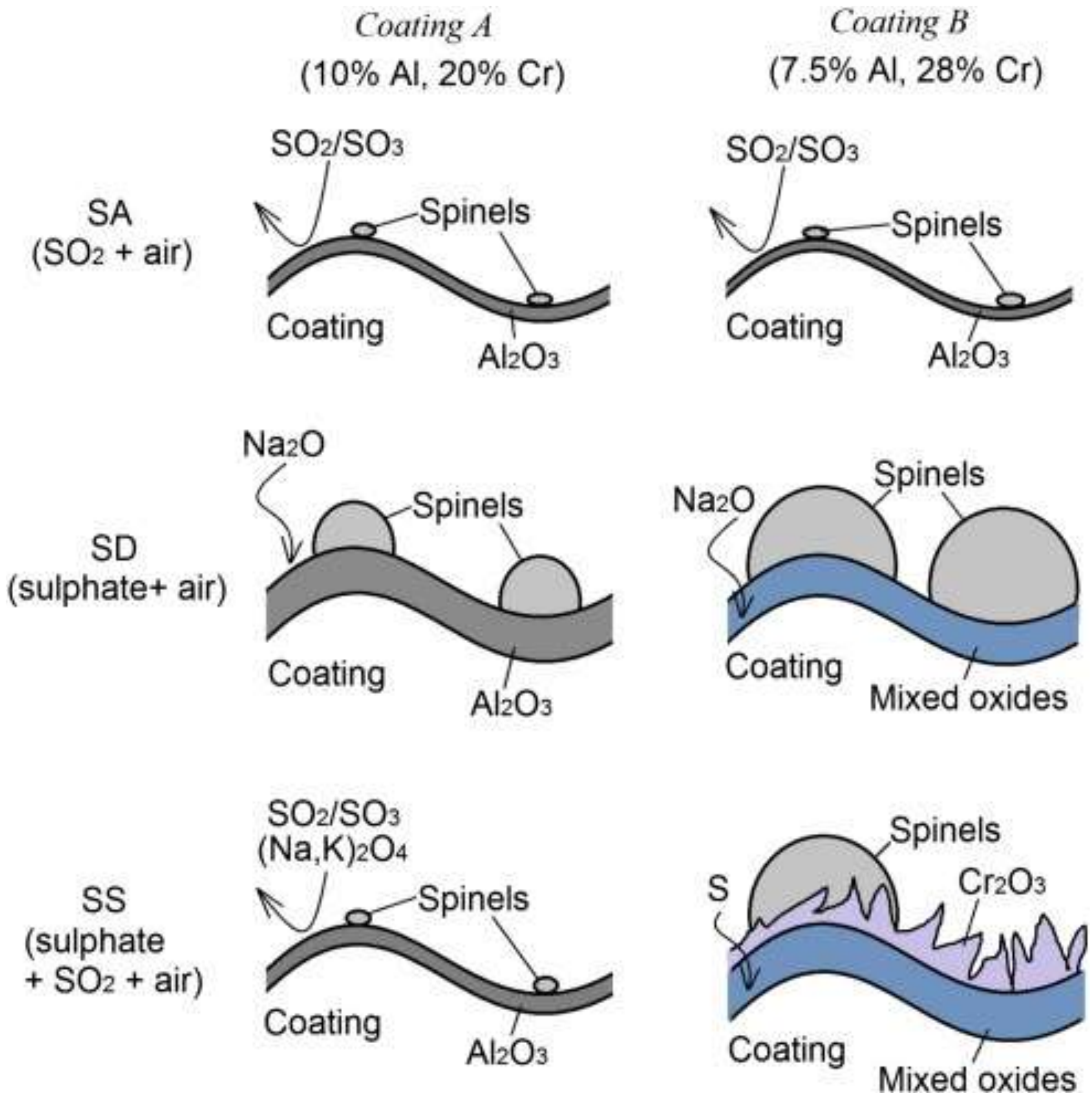
Oxidation

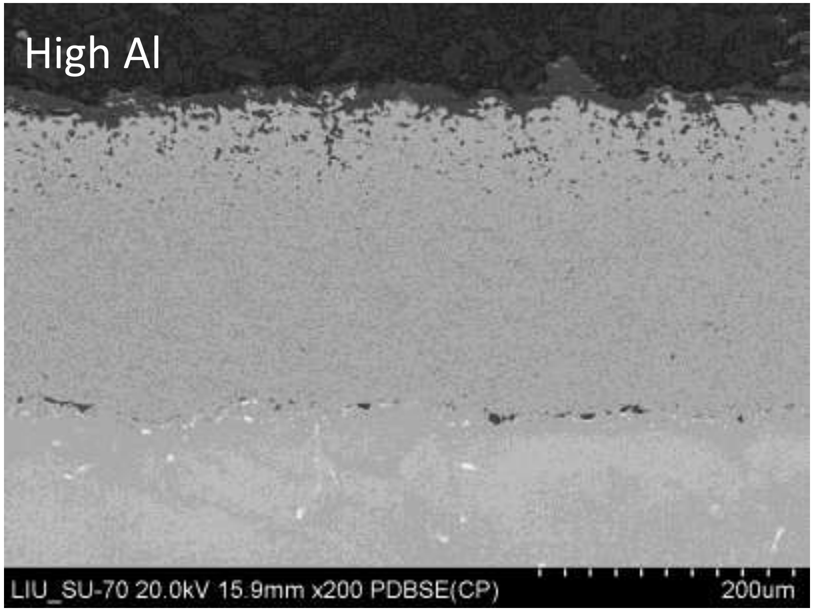
Hot Corrosion

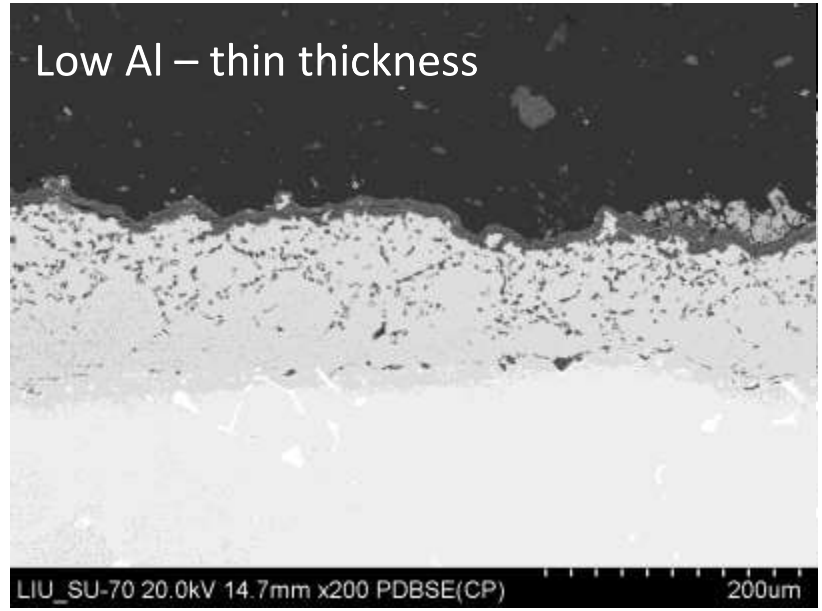
n TBC

HOT CORROSION-MIXED GAS



HOT CORROSION-SALT DEPOSITION





A better resistance against type I?

- ✓ High Al
- ✓ Proper thickness
- ✓ Less defects
- ✓ Y, Si helps

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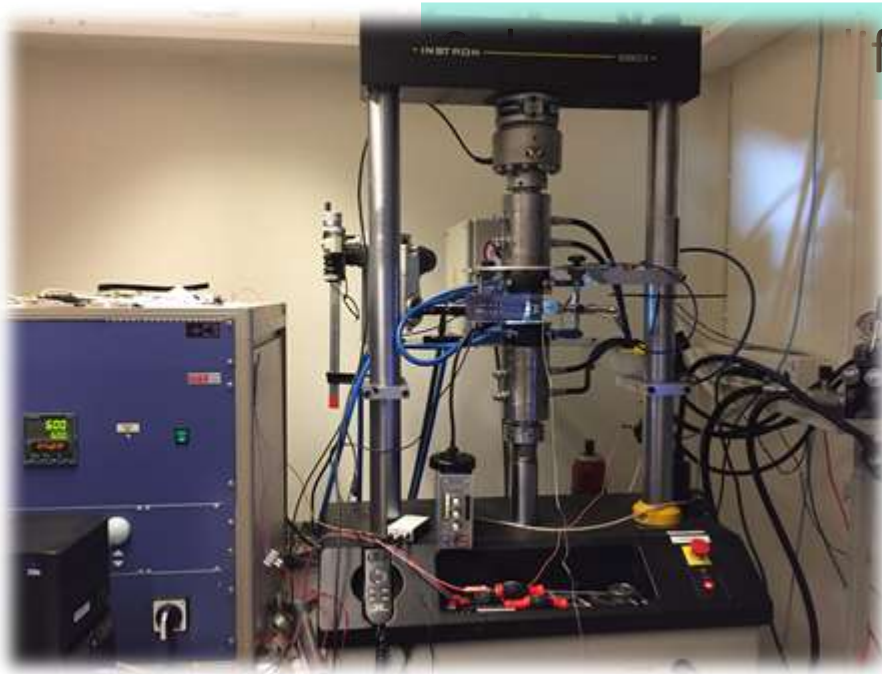
TEST

Oxidation

Hot Corrosion

TMF (DBTT)

ffusion

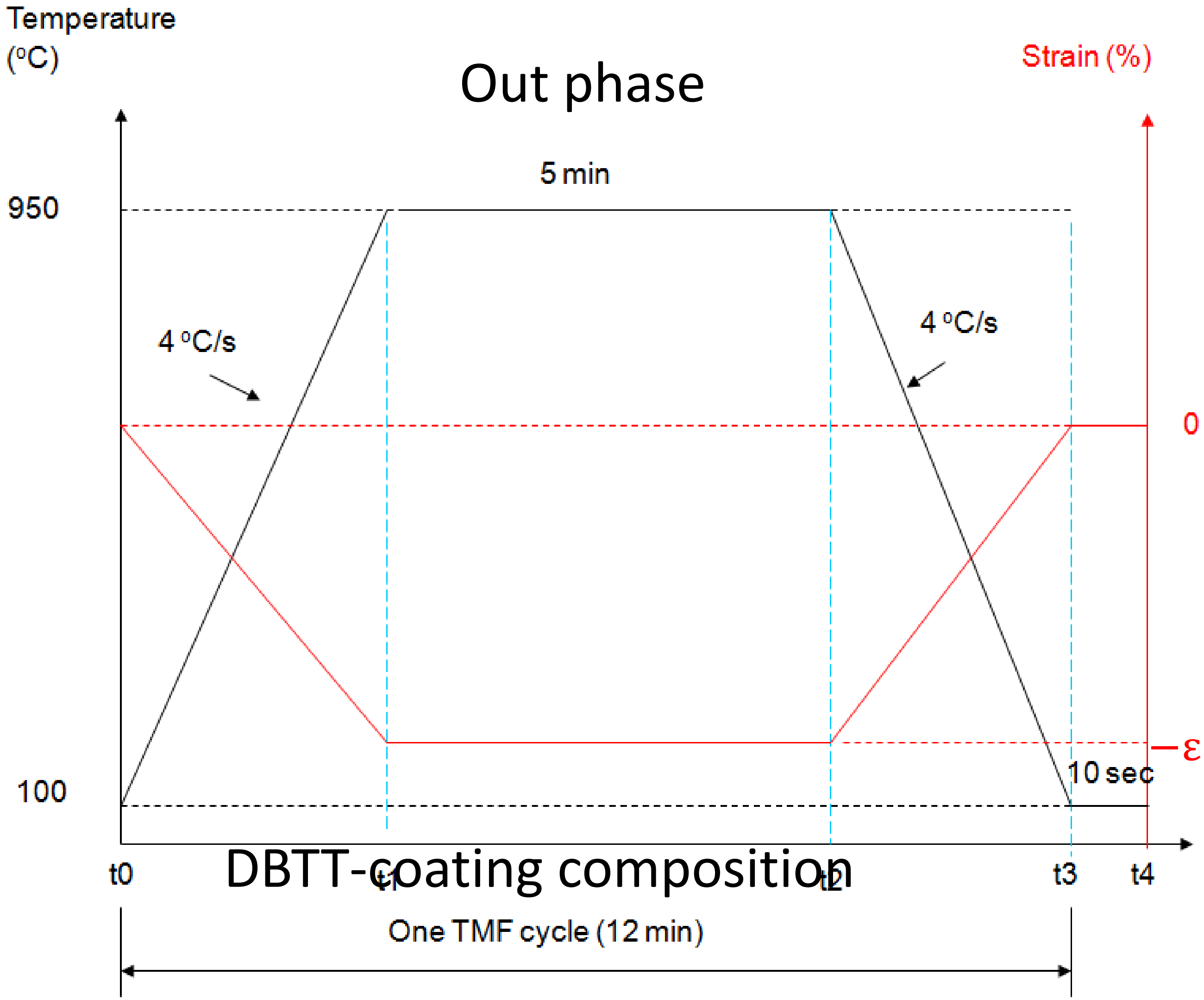


bond coat in TBC

Out phase

low DBTT

high DBTT



DBTT-coating composition

Oxidation

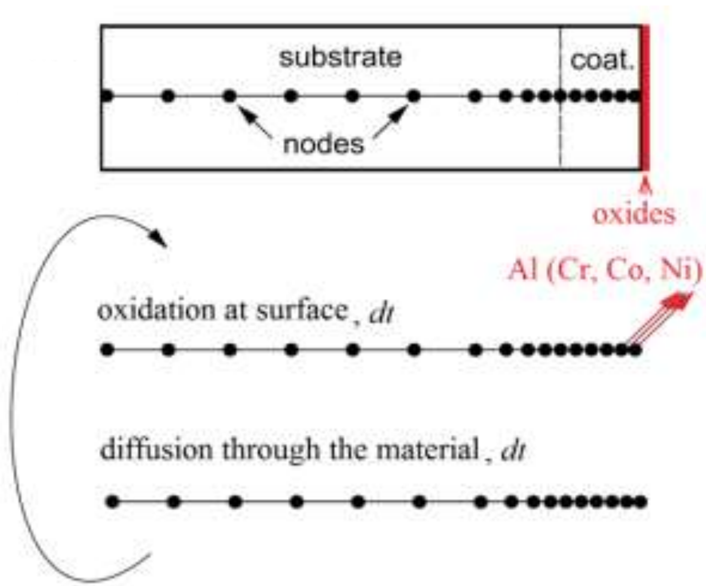
Hot Corrosion

TMF (DBTT)

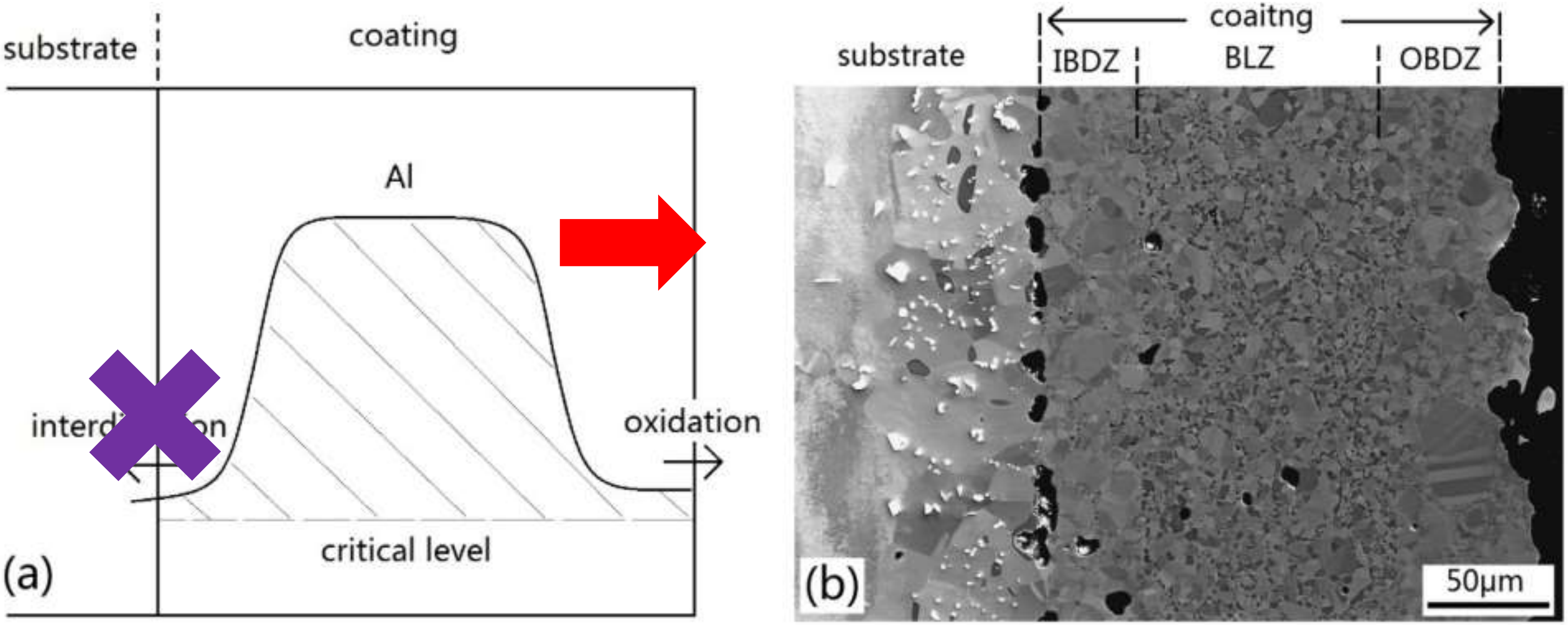
Substrate interdiffusion

coat in TBC

DICTRA



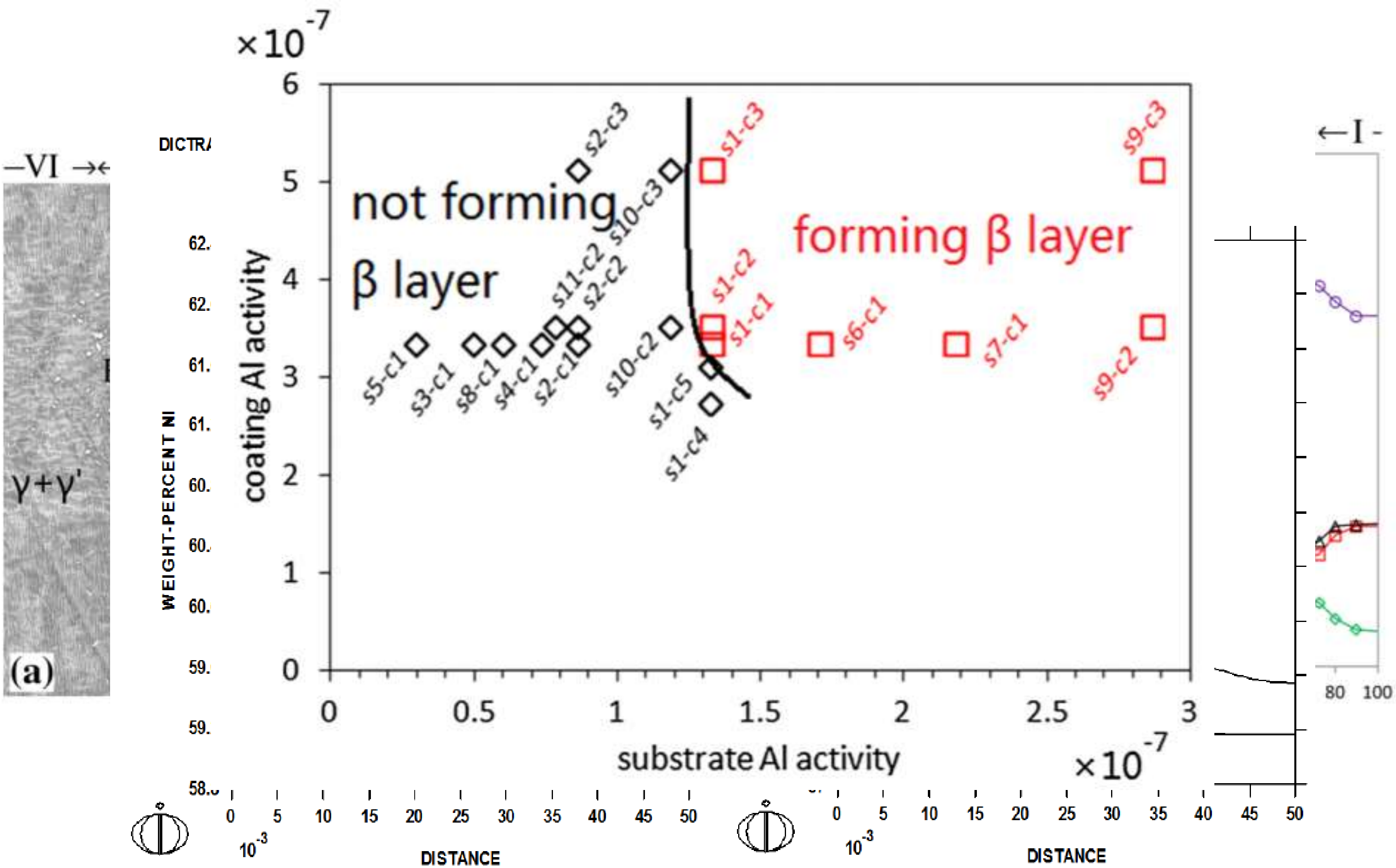
SUBSTRATE INTERDIFFUSION



Interdiffusion?

- Reduce coating life
- Reduce substrate mech properties
- Negative elements from substrate

SUBSTRATE INTERDIFFUSION



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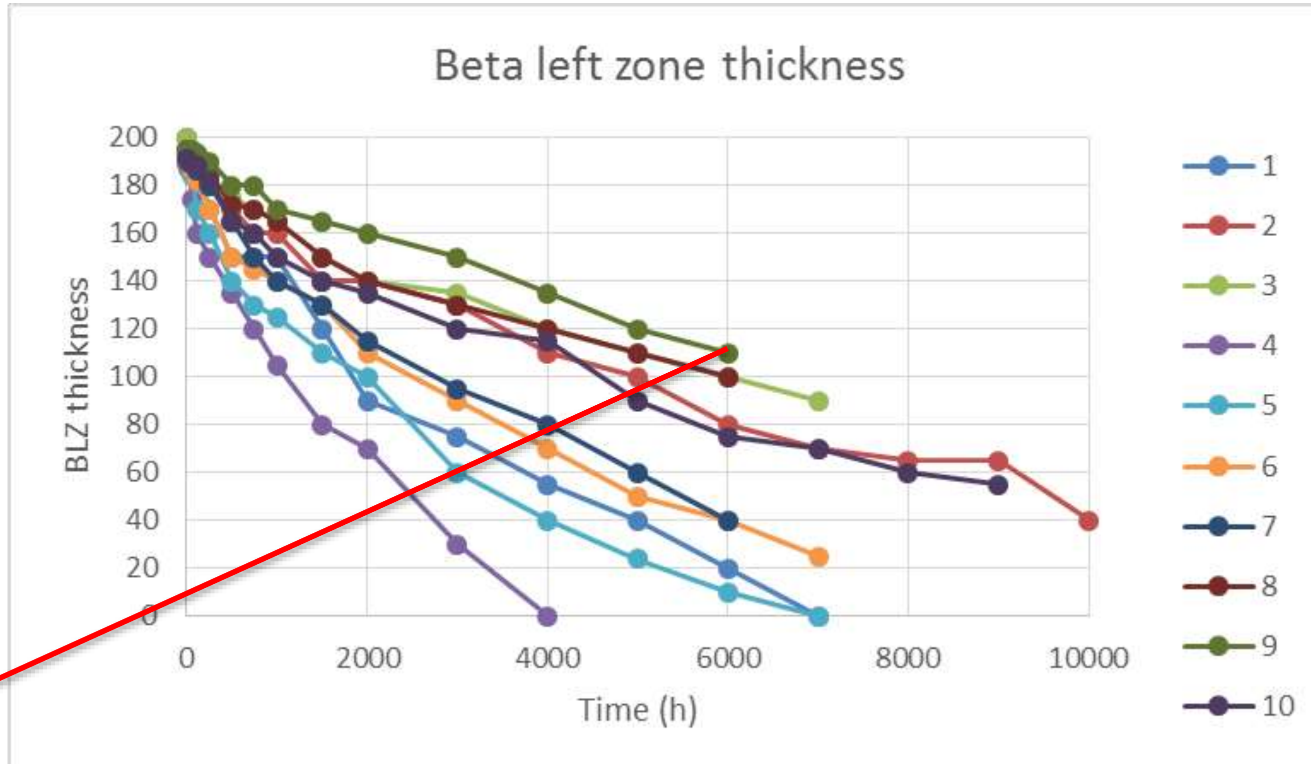
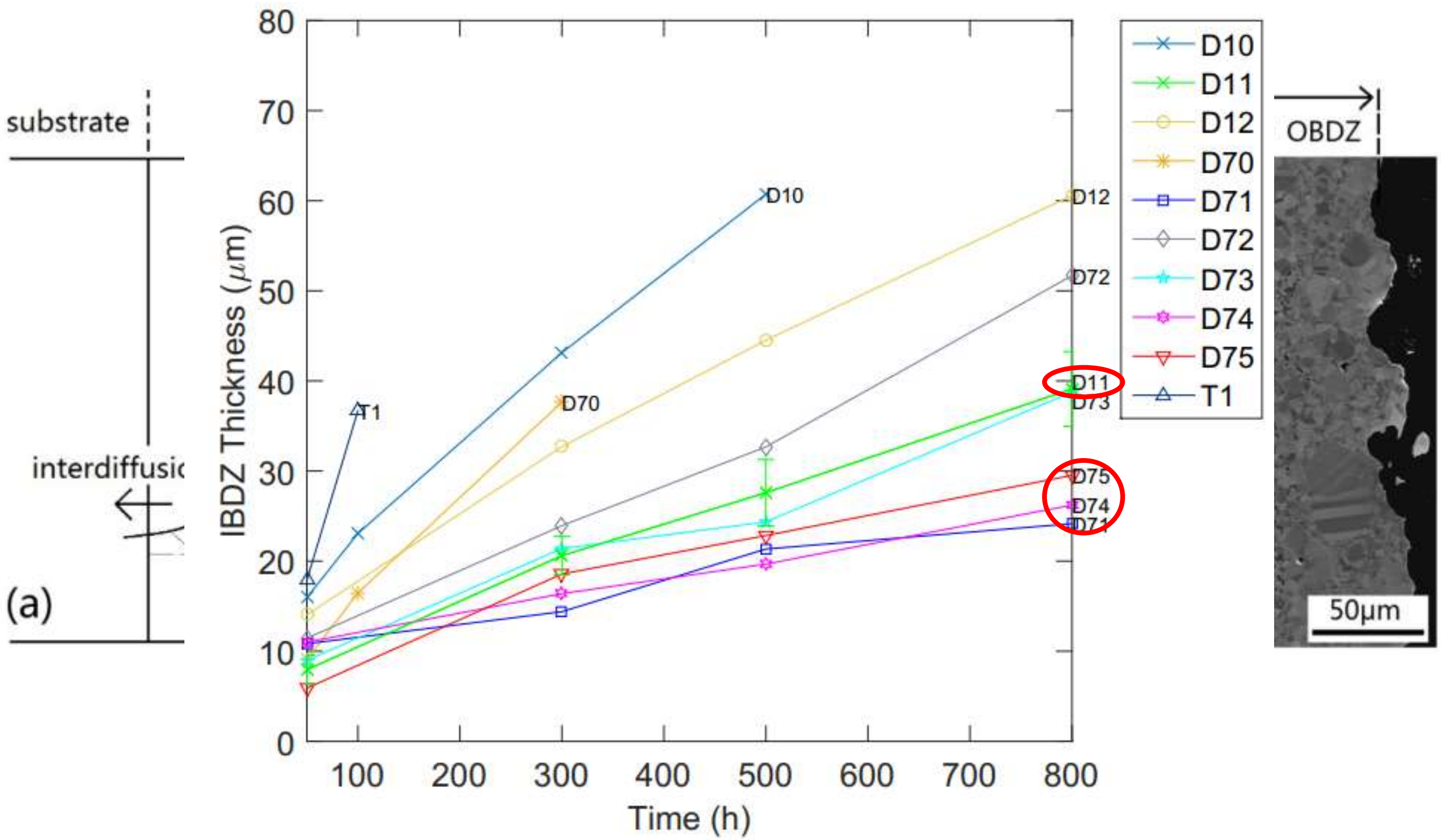
SUBSTRATE INTERDIFFUSION-MATCHING

No	COAT	SUB
1	high c(Al)	Low
2		Med
3		High
4	low c(Al)	Low
5		Med
6		High
7	med c(Al) high ac(Al)	Low ac
8		Med ac
9		High ac



Al activity (coating & substrate) important

SUBSTRATE INTERDIFFUSION



Ru, Fe reduce substrate interdiffusion

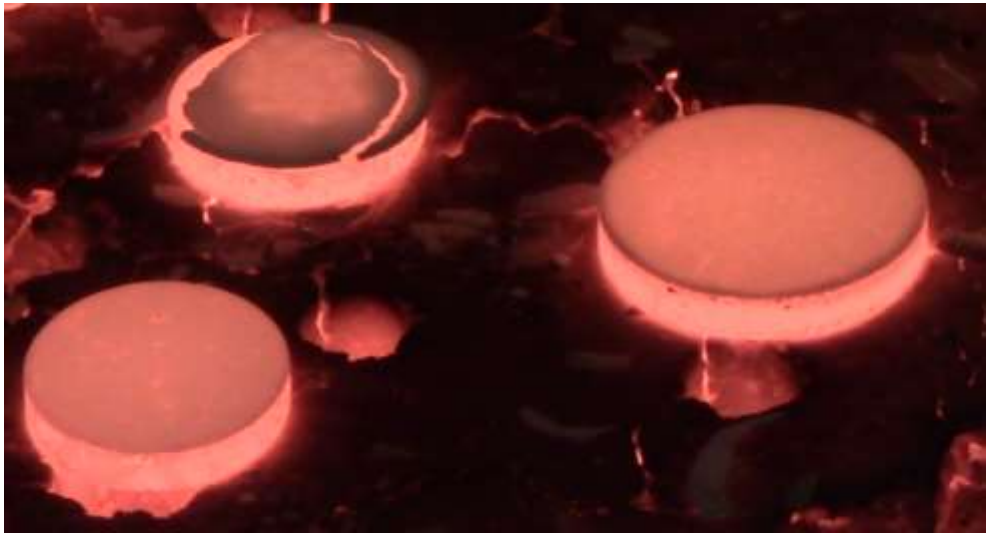
Oxidation

Hot Corrosion

TMF (DBTT)

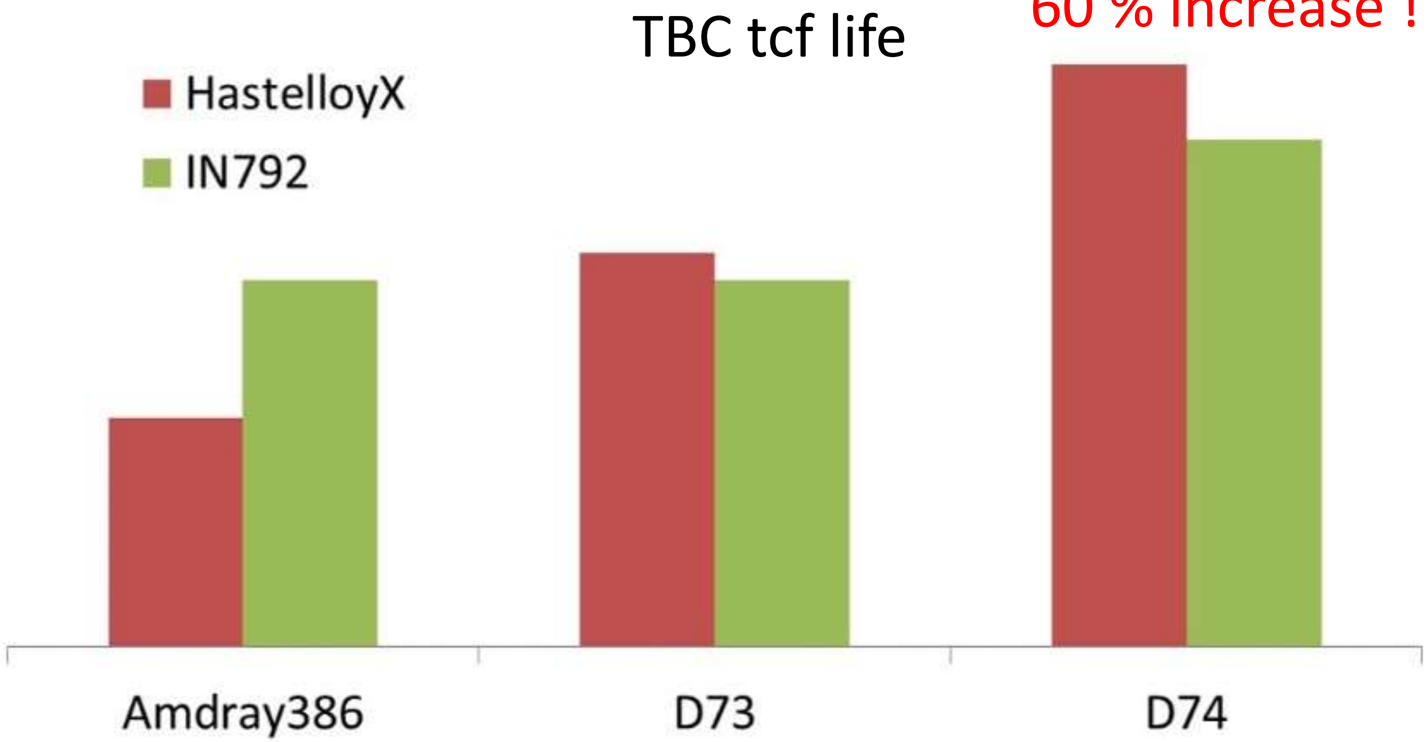
Substrate interdiffusion

bond coat in TBC



BOND COAT IN TBC

60 % increase !

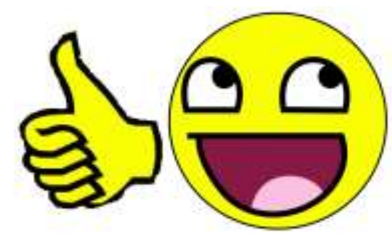


Good performance!

CONCLUSIONS

1. Surface treatment improves oxidation resistance
2. A reliable coating life criterion is established
3. Hot corrosion
   - Al content
   - Coating thickness
   - Corrosive environment
4. TMF: coating ductility
5. Al-activity is important in both substrate and coating
6. Element function
   - Hf: accelerate oxidation
   - Fe: reduce interdiffusion
   - Ru: reduce interdiffusion
7. A better tcf life of new MCrAlX coating in TBC system

Good performance of new MCrAlX coating!!



FUTURE WORK

- Refine parameters of surface treatment
- Extend the scope of the criterion – life modelling
- TMF testing – crack propagation behavior
- Experiment on coating/sub matching
- Improve hot corrosion resistance

Acknowledgment

Swedish Energy Agency

KME
CONSORTIUM MATERIALS TECHNOLOGY
for development and demonstration
of thermal energy processes

Energiforsk

Thanks for your attention!

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