

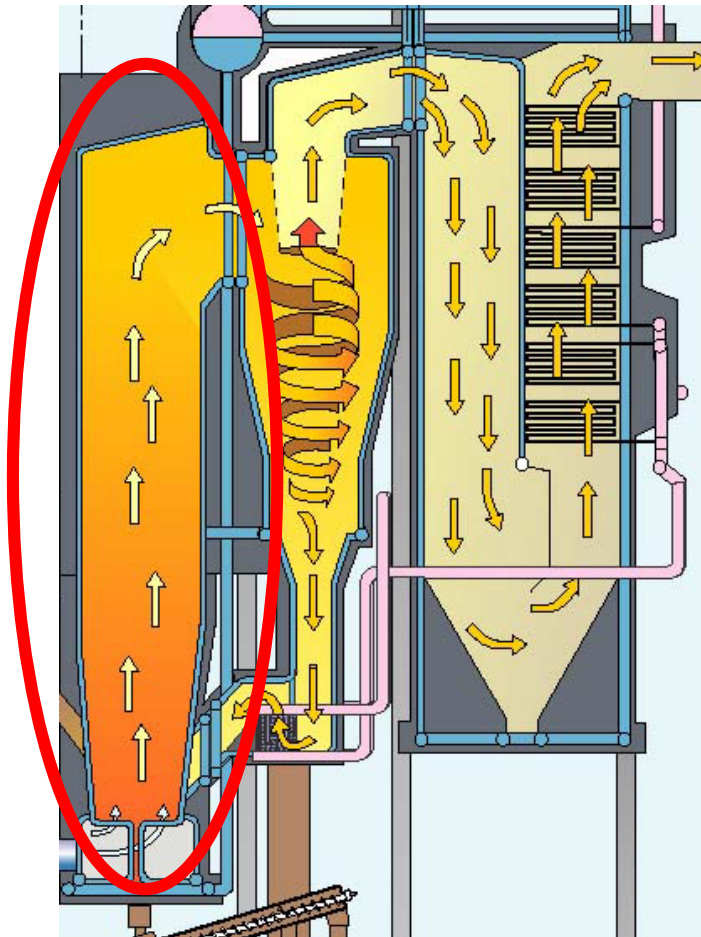


The effect of chlorine containing salts and HCl(g) on waterwall corrosion

Amanda Persdotter
amaper@chalmers.se



Waterwall corrosion



High levels of

- Chlorine (HCl, KCl, etc)
- Alkali (Na, K)
- Heavy metals (Pb, Zn)

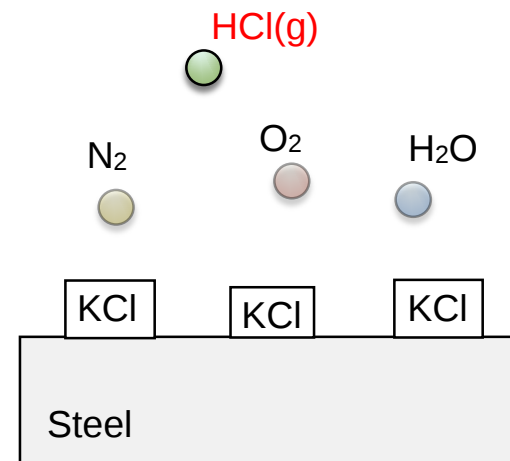
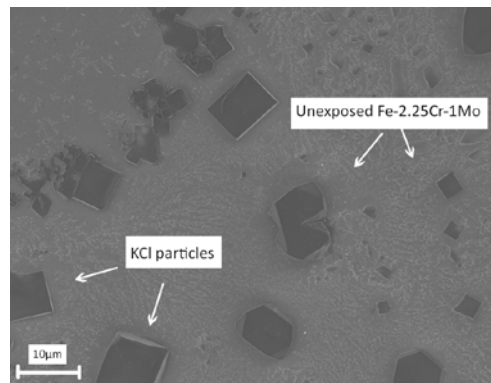
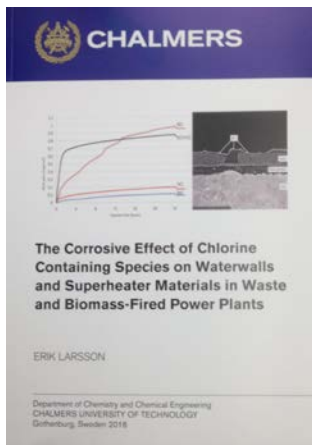
Effect of chlorine containing species

Cl containing salts

- NaCl
- KCl
- ZnCl_2
- PbCl_2

Influence of HCl(g)

- Reference (no Cl)
- HCl(g)
- KCl(s)
- $\text{KCl(s)} + \text{HCl(g)}$



Laboratory setup

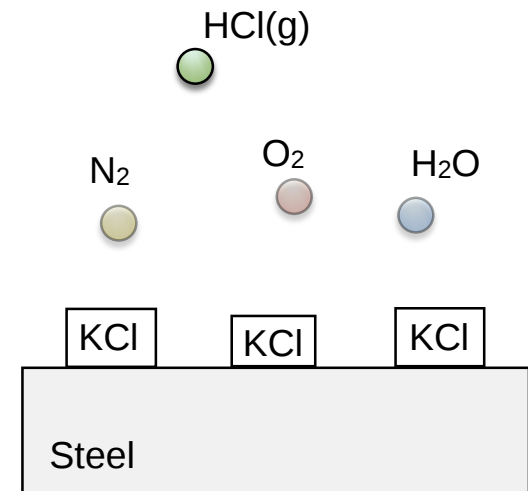
Material:

Fe-2.25Cr-1Mo (T22)

T22	Fe	Cr	Mn	Mo	P	S	Si	C
at%	96	2.2	0.5	0.9	0.09	0.09	0.3	0.09

Exposures:

- Temperature: 400° C, 24 hours
- Reference (Ref) : 5% O₂ + 20% H₂O + N₂ (bal)
- HCl: Ref + 500vppm HCl(g)
- KCl: Ref + 0.1 mg/cm² KCl(s)
- KCl+HCl: Ref + 0.1 mg/cm² KCl(s) + 500 vppm HCl(g)





Why is this interesting?

Research strategy

Oxidation kinetics



Dynamic exposures

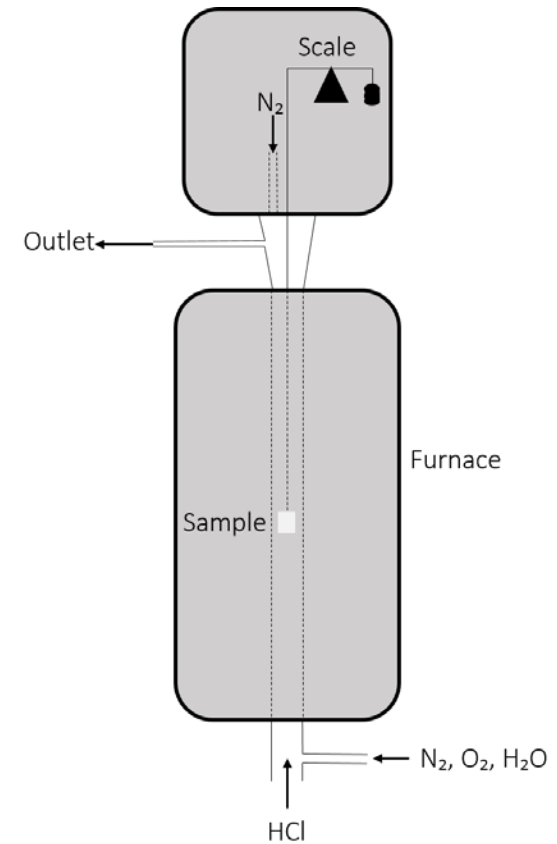
Corrosion
mechanisms

Scale microstructure



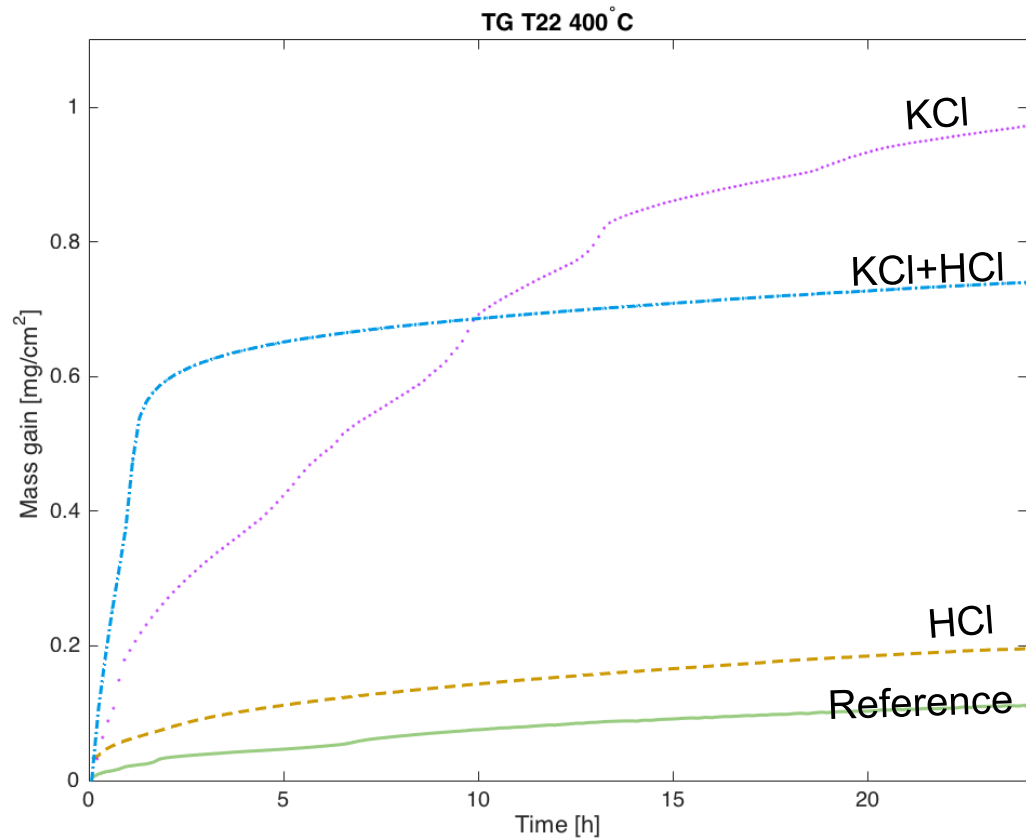
State of the art
analytical tools

Oxidation kinetics (thermogravimetric analysis)

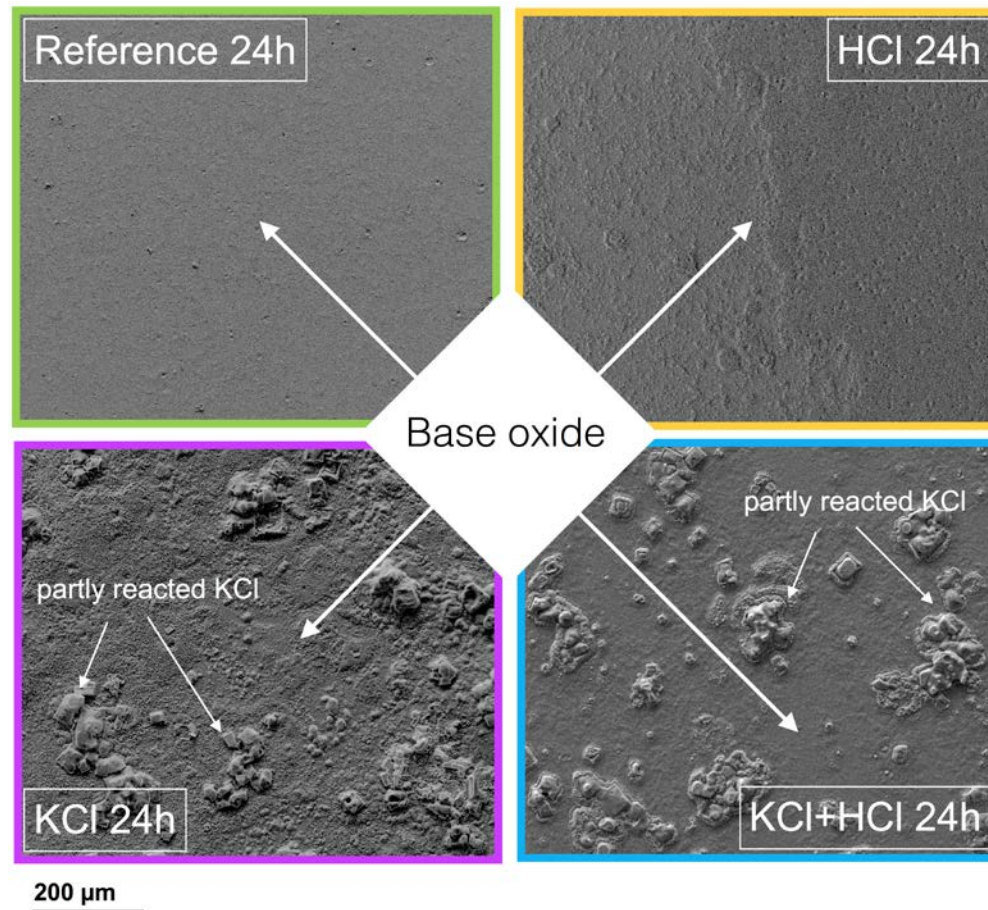


Oxidation kinetics

- **Ref:** parabolic
- **HCl:** ~ parabolic
- **KCl:** bumps in TG-curve
- **KCl+HCl:**
Rapid initial growth.
Levels off after 2h

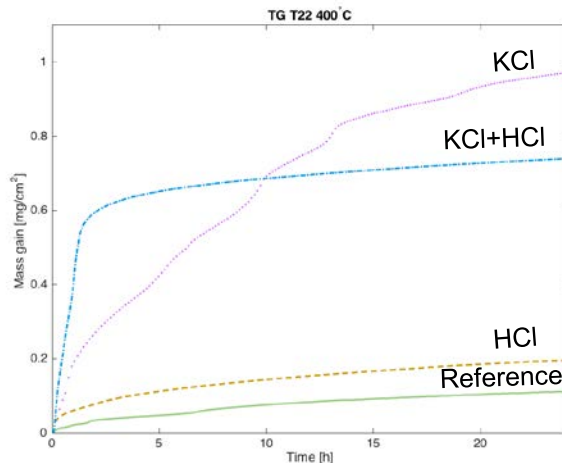
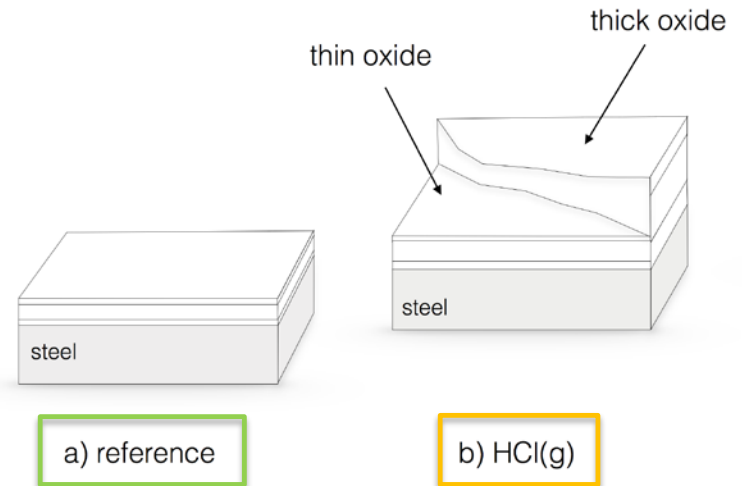


Surface morphology of oxidised samples

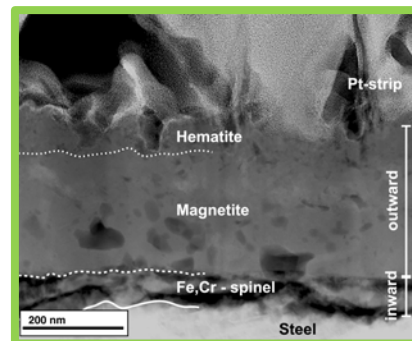


Reference vs HCl

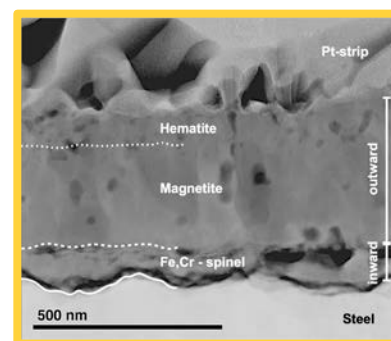
- HCl: modest increase in corrosion
- Similar microstructure
- HCl: incubation time (thin + thick scale)



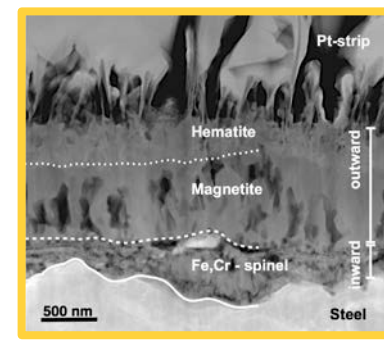
Reference



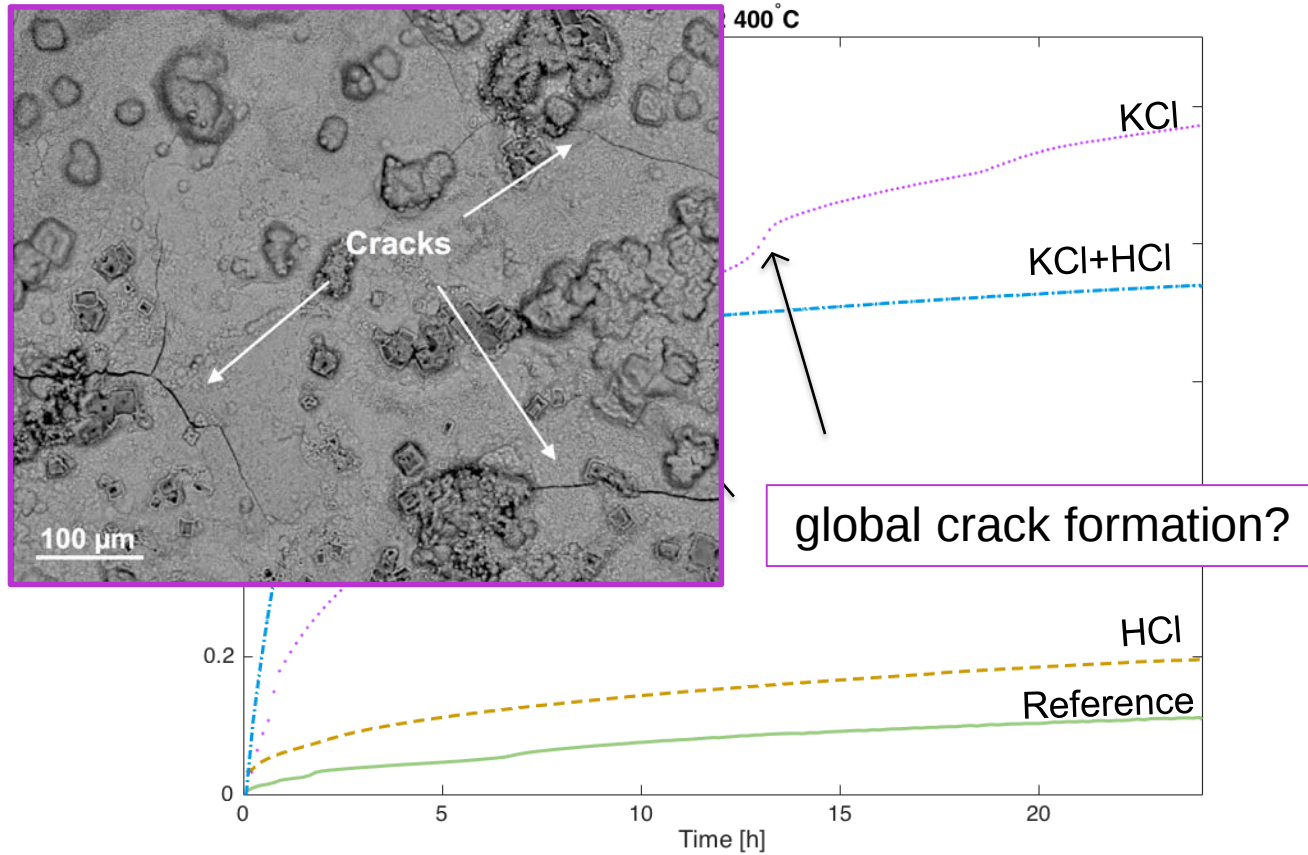
Thin oxide

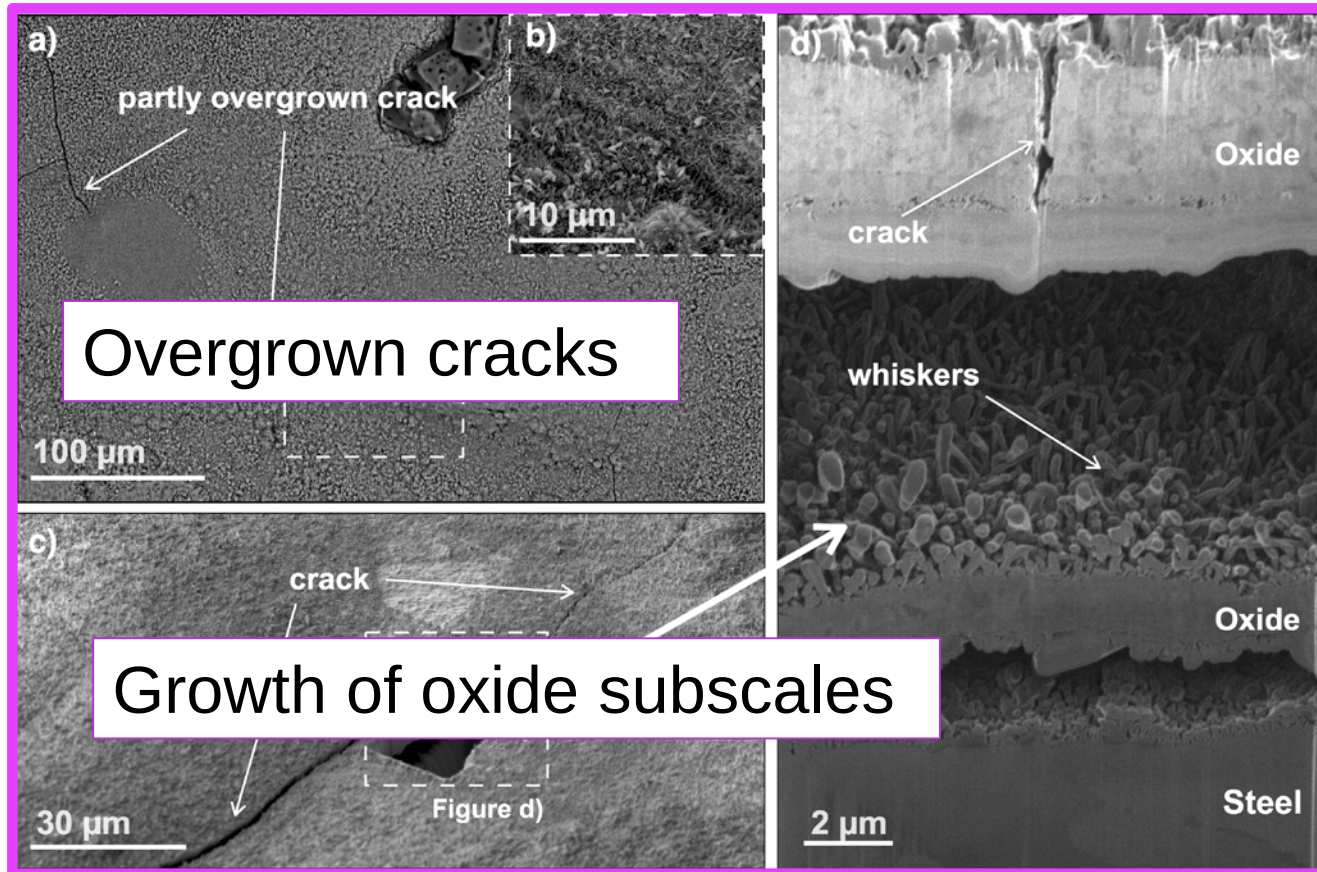


Thick oxide



KCl (only)

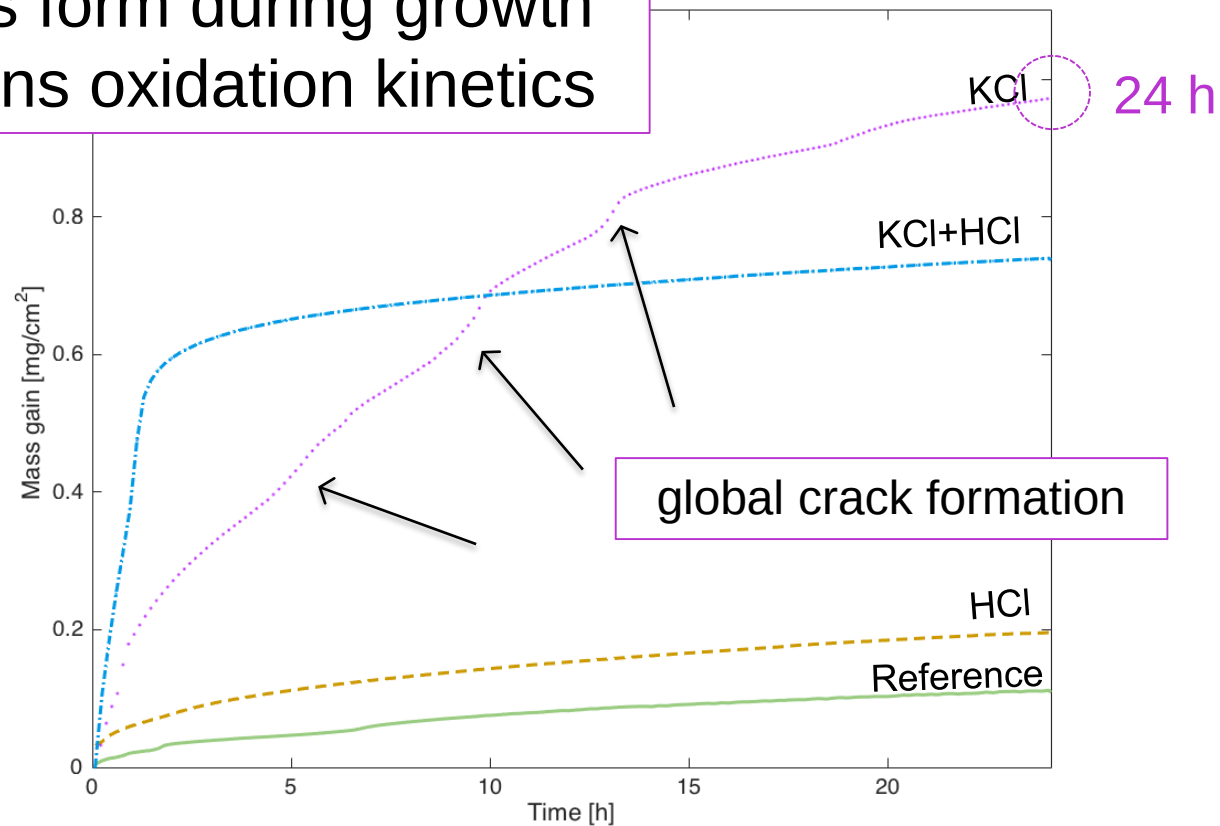




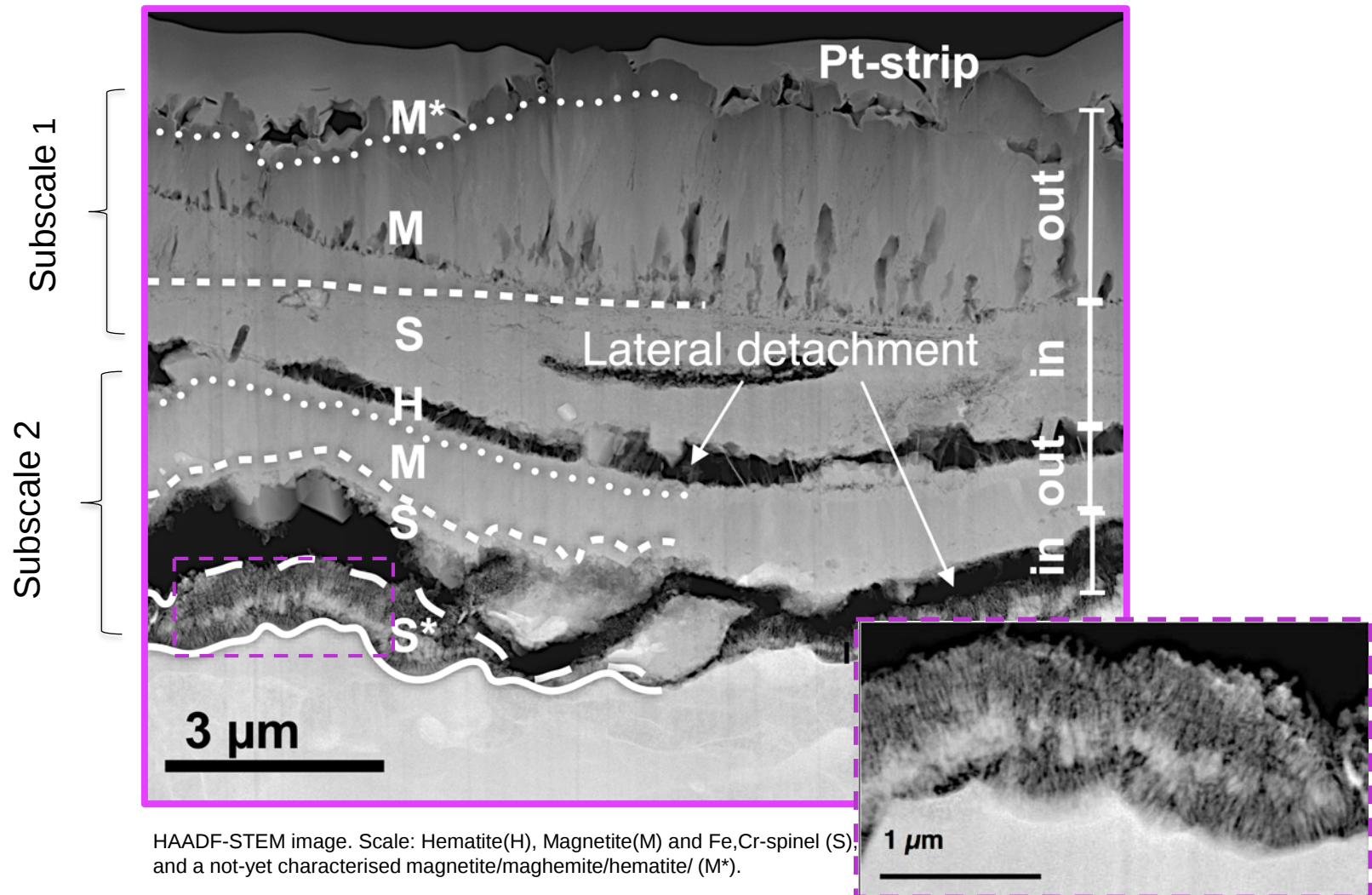
a-c) electron induced SE images. d) ion induced SE image.

KCl (only)

- cracks form during growth
- explains oxidation kinetics

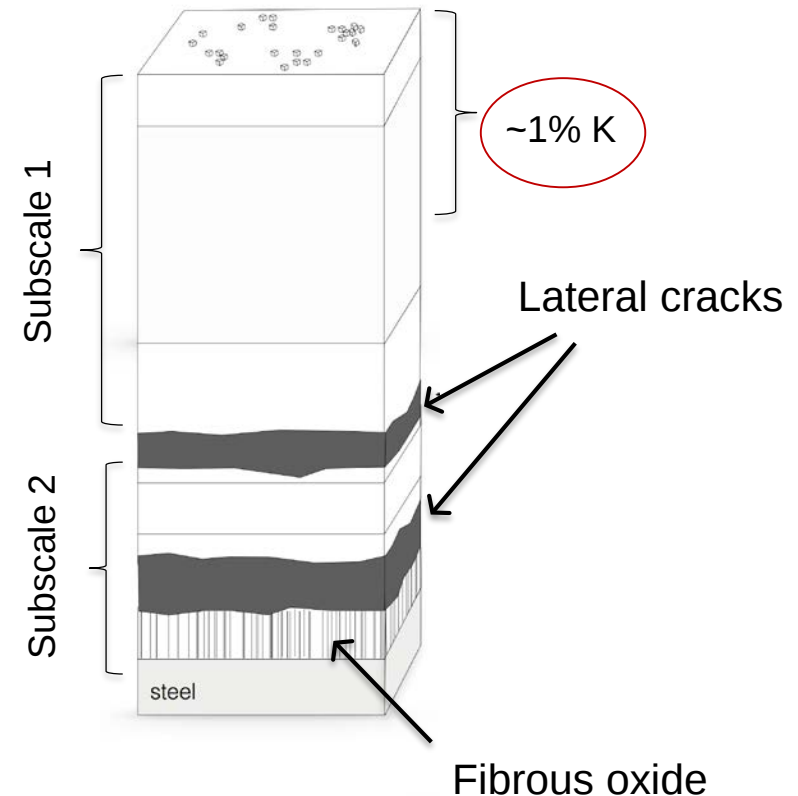
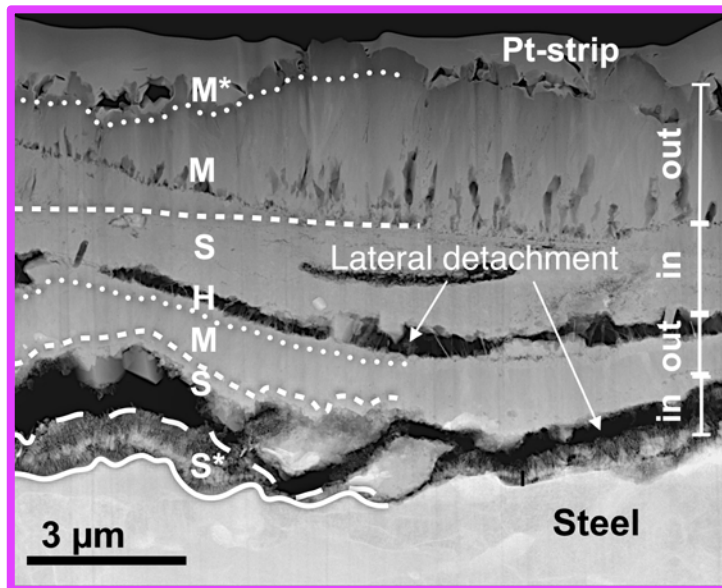


KCl (only)

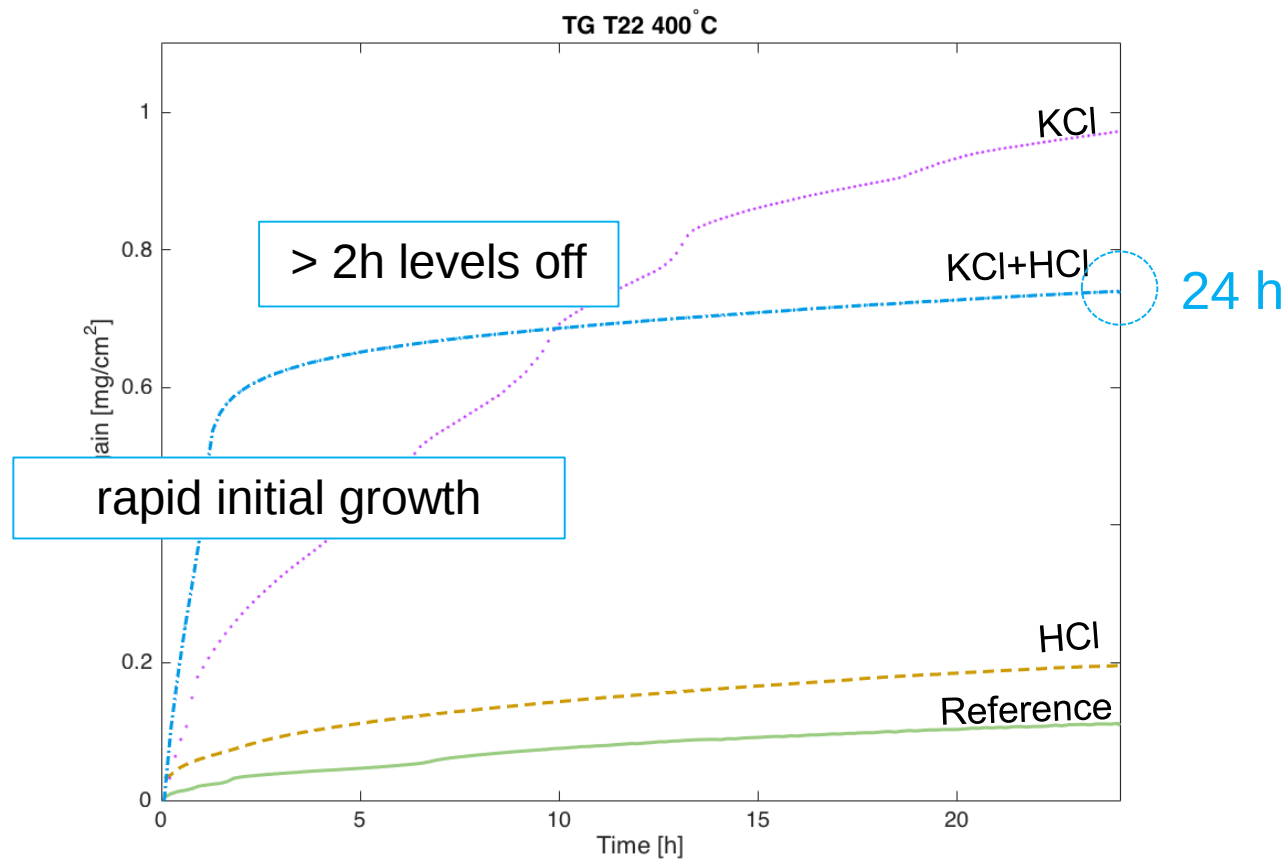


KCl (only)

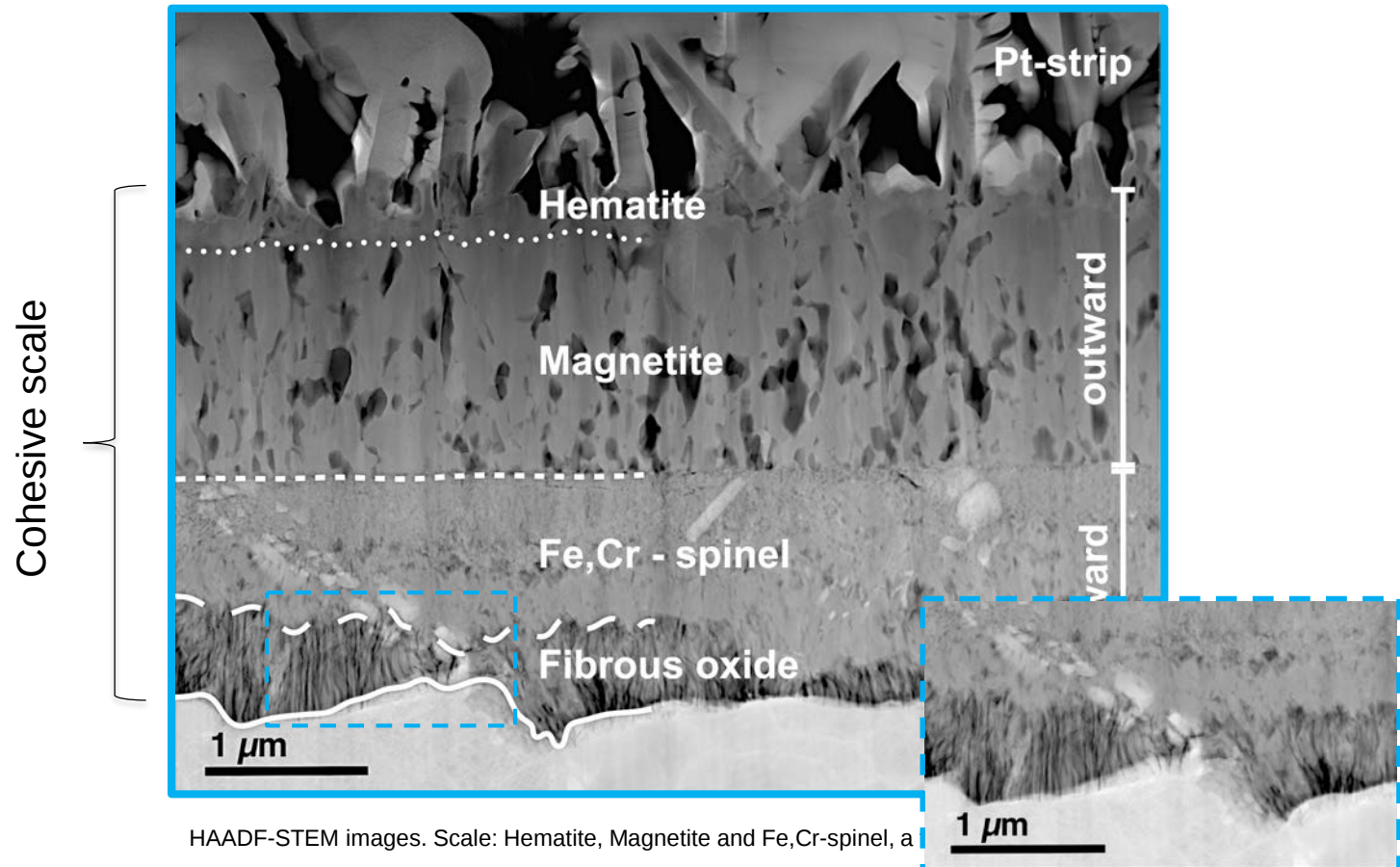
- Thick oxide scale
- Growth of subscales
- Lateral detachment/cracks
- Fibrous oxide at scale/metal interface
- K in top scale



KCl + HCl

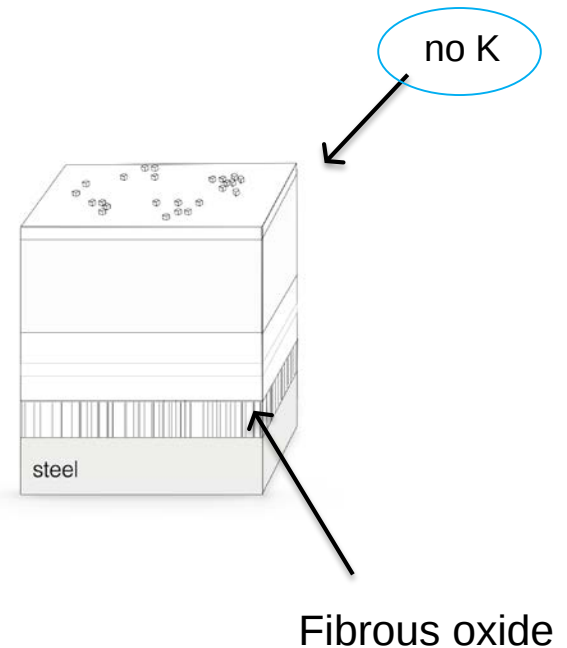
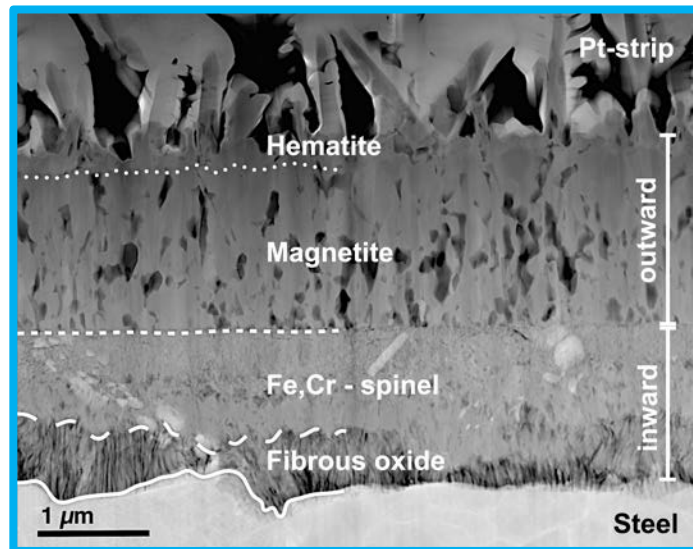


KCl + HCl



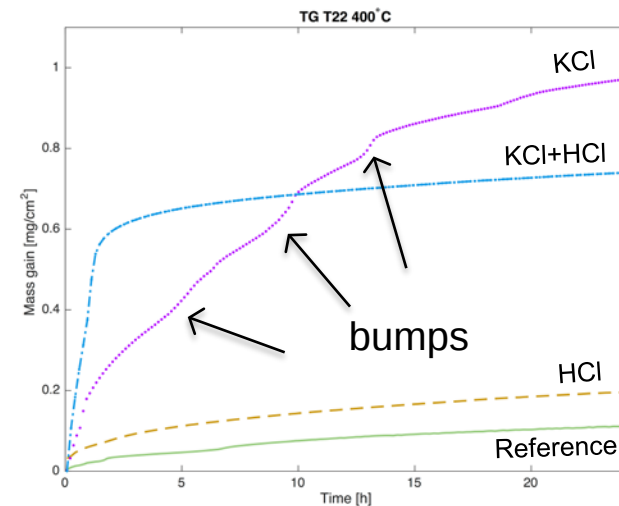
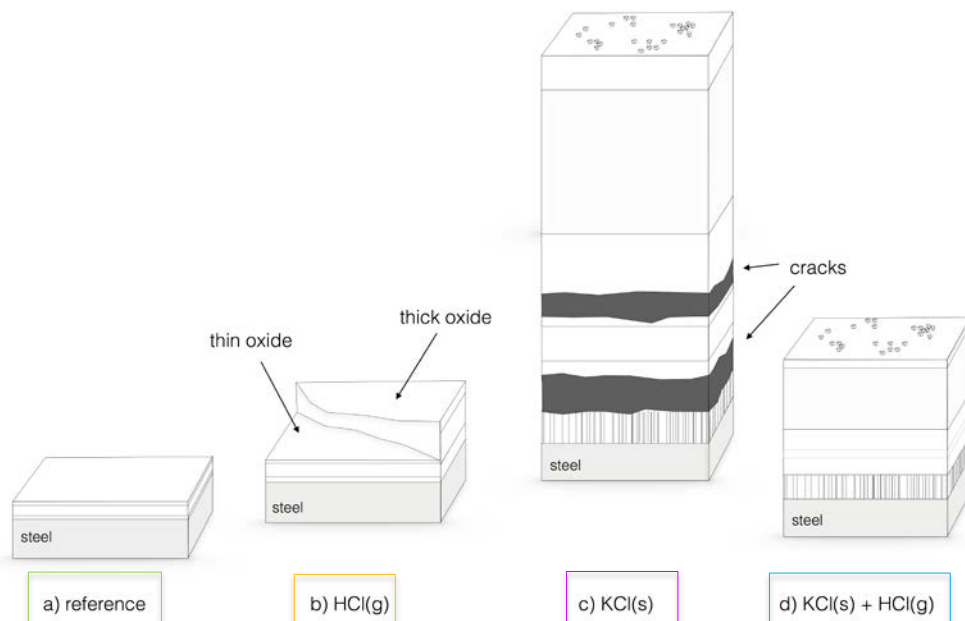
KCl + HCl

- Thinner oxide scale (compared to KCl)
- Cohesive scale
- Fibrous oxide at scale/metal interface
- No K in top scale

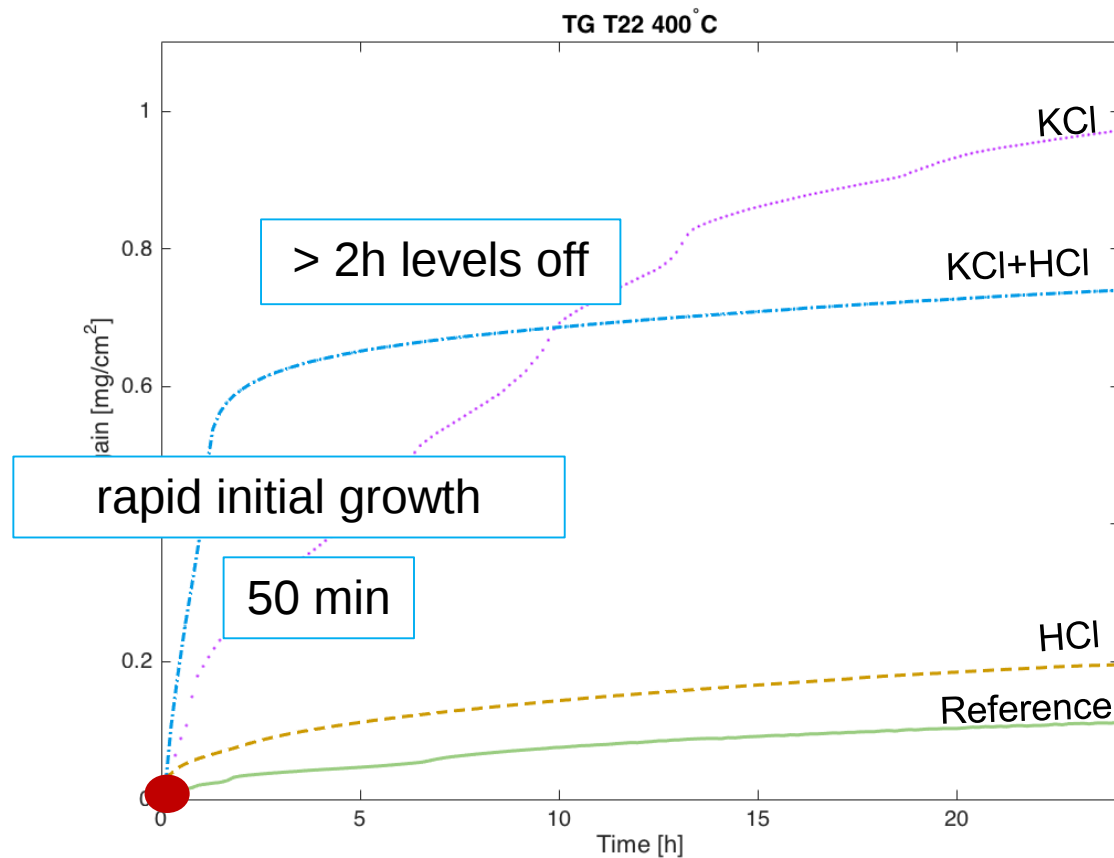


Summary (24h)

	Cracks	K	Fibrous oxide
Ref	no	-	no
HCl	no	-	no
KCl	yes	~ 1%	yes
KCl+HCl	no	-	yes

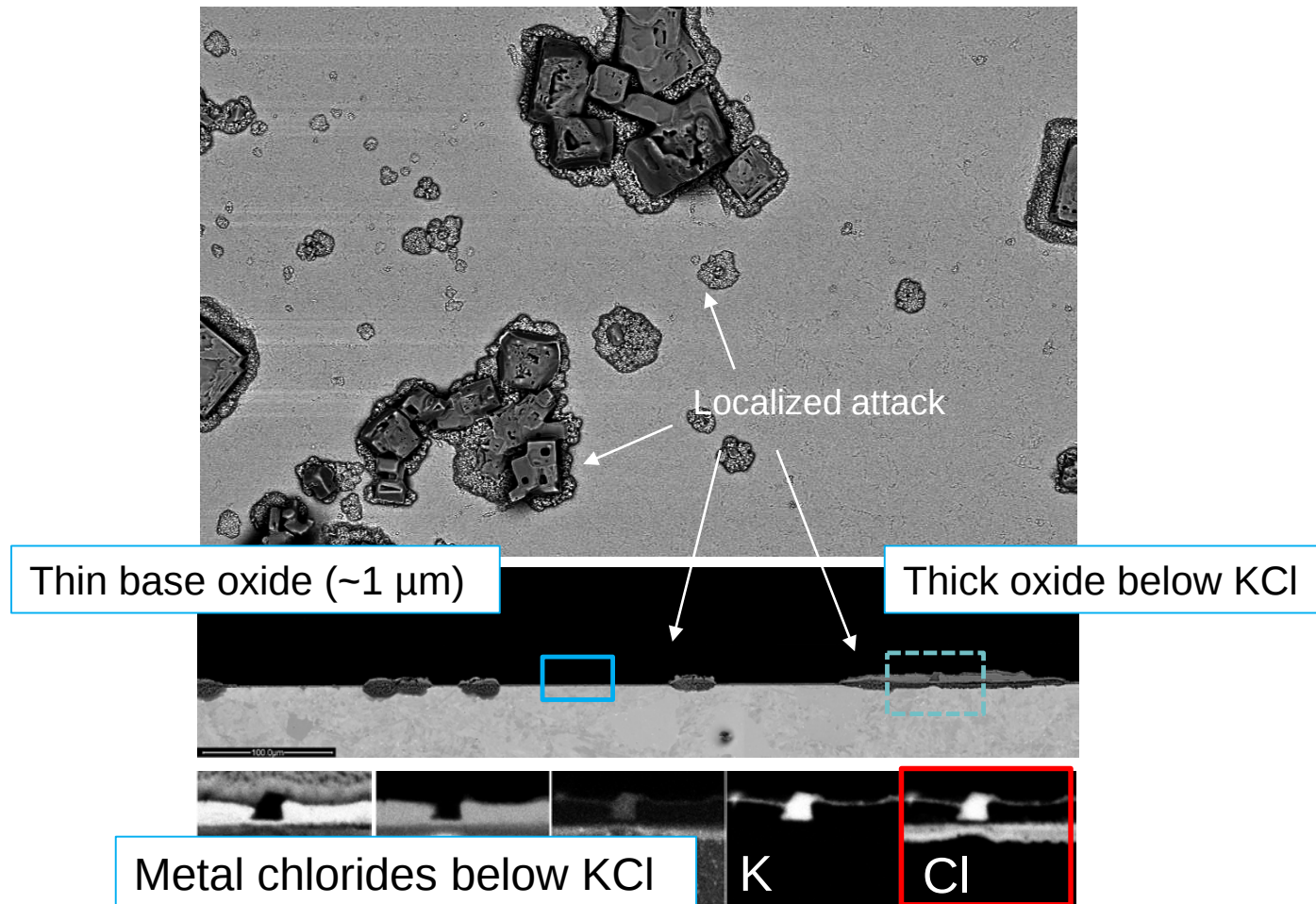


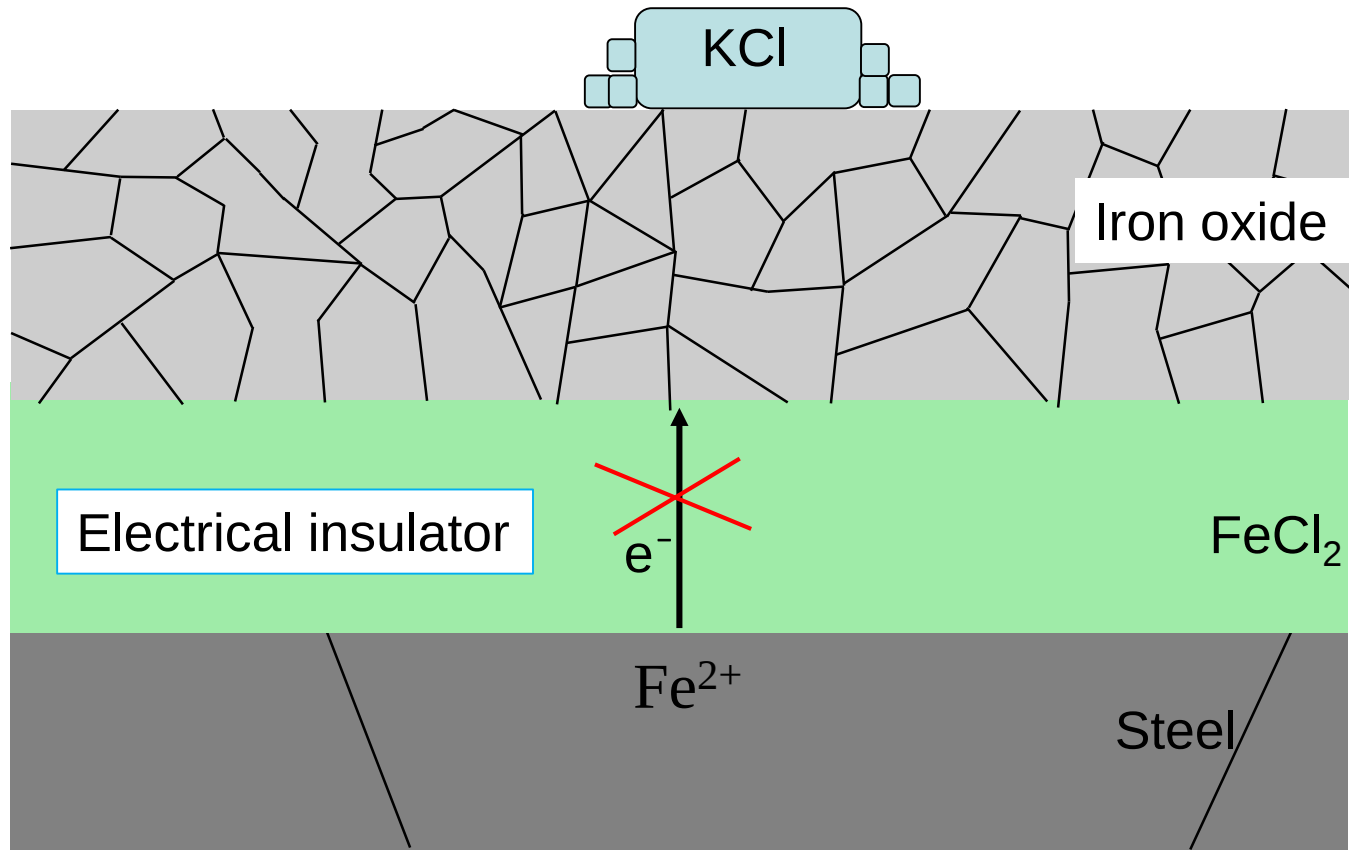
KCl + HCl



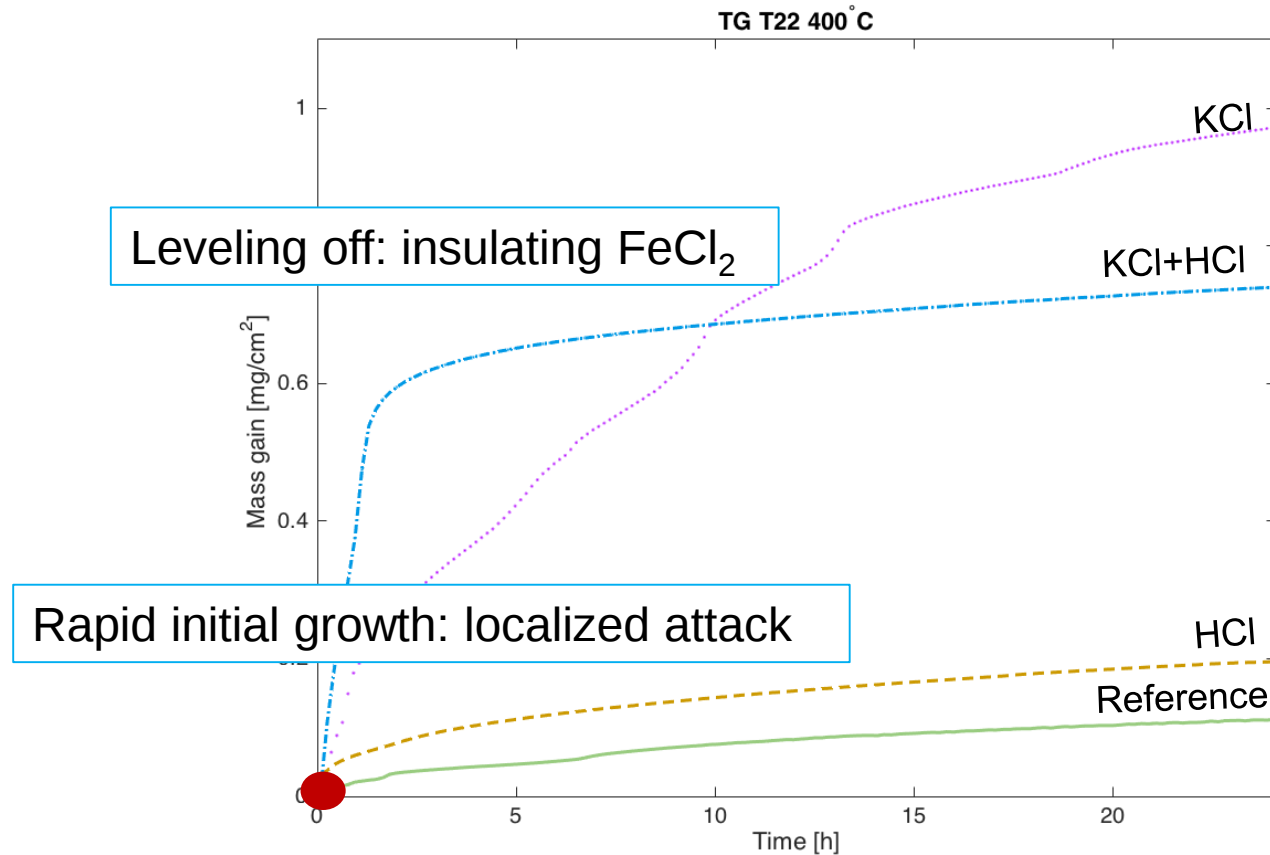
KCl + HCl

t = 50 min:





KCl + HCl



Propagation

Next step

- Longer exposures (propagation)
- Influence of K on crack formation
- Addition of more HCl(g)
- Influence of HCl(g) on other salts
- Mechanism of formation of fibrous oxide



Thanks for your attention!

