

Discussion on the relationship between passivity and reactivity of metals

V. Vivier, B. Gwinner, M. Benoit, B. Laurent, Christian Bataillon, N. Gruet, F. Miserque, K. Ogle, C. Sanchez-Sanchez, B. Tribollet

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V. Vivier, B. Gwinner, M. Benoit, B. Laurent, Christian Bataillon, et al.. Discussion on the relationship between passivity and reactivity of metals. 68th annual meeting of the international society of electrochemistry, Aug 2017, Providence, United States. cea-02442347

HAL Id: cea-02442347
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Submitted on 16 Jan 2020

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FROM RESEARCH TO INDUSTRY



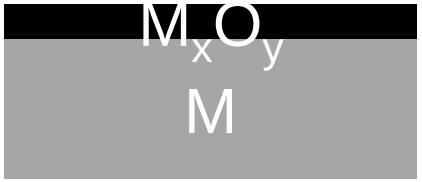
DISCUSSION ON THE RELATIONSHIP BETWEEN PASSIVITY AND REACTIVITY OF METALS

ISE 2017 |
B. Gwinner, M. Benoit, B. Laurent, C. Bataillon, N. Larabi-Gruet, F. Miserque (Paris-Saclay University/CEA),
K. Ogle (CNRS/Chimie-ParisTech),
C. Sanchez-Sanchez, B. Tribollet, V. Vivier (CNRS/LISE)

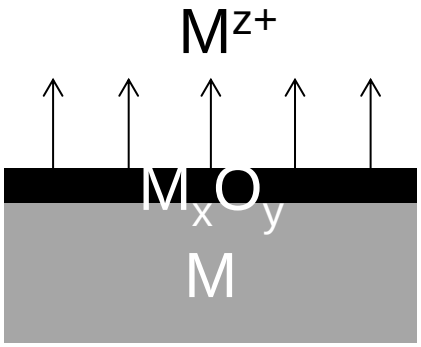
AUGUST 28th 2017

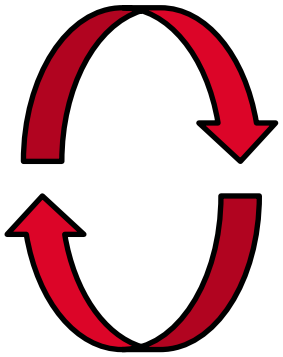
OBJECTIVE

System of interest : passivated metals

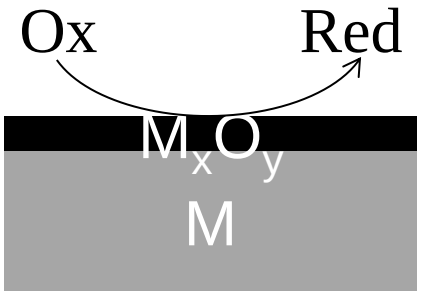


Passivity (oxidation/dissolution of metal)





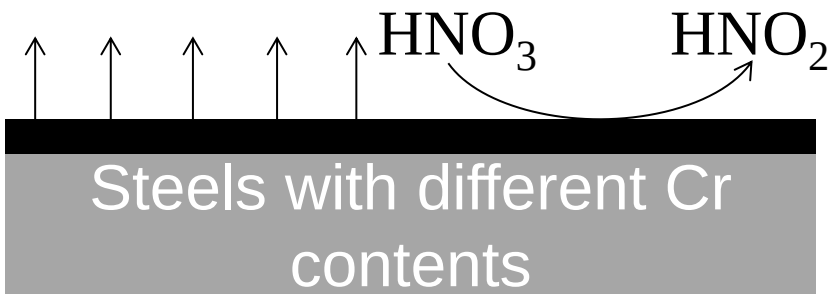
Reactivity (reduction of media)



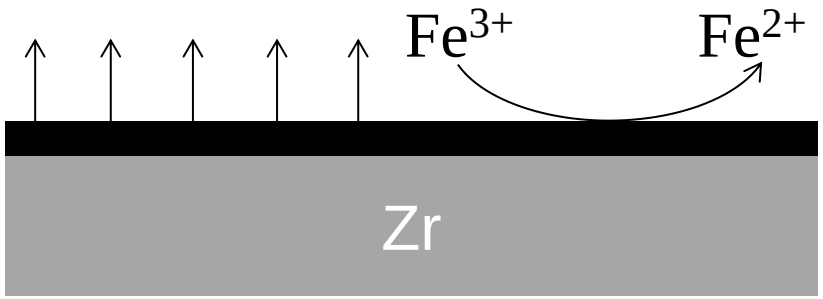
Relationship ?

SYSTEMS STUDIED

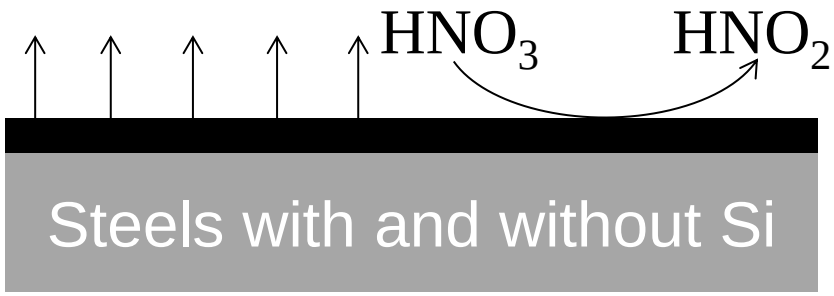
System No. 1



System No. 2



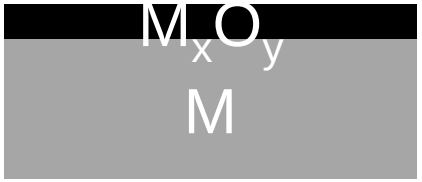
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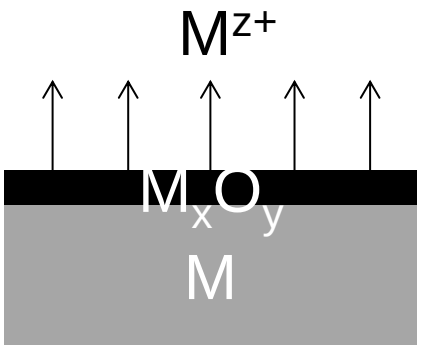
PROCEDURE

3 steps

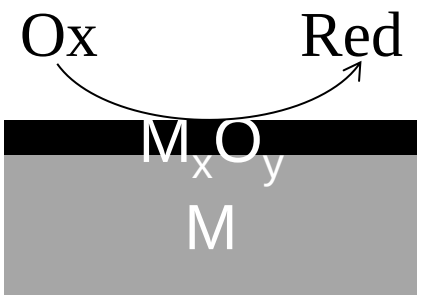
- Characterization of the oxide film



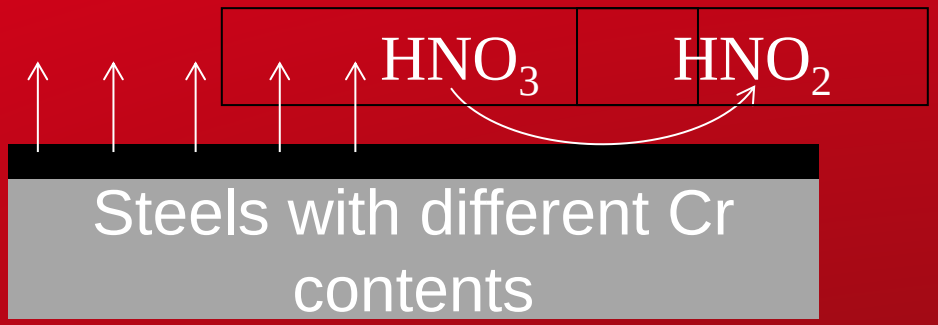
- Characterization of passivity



- Characterization of reactivity



STEELS WITH DIFFERENT CHROMIUM CONTENTS



9Cr-1W-Ti ODS
14Cr-1W-Ti ODS
18Cr-1W-Ti ODS

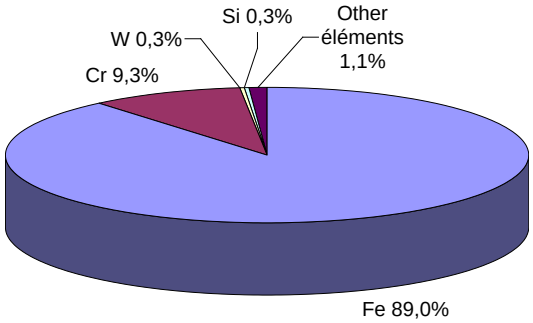
STEELS WITH DIFFERENT CHROMIUM CONTENTS



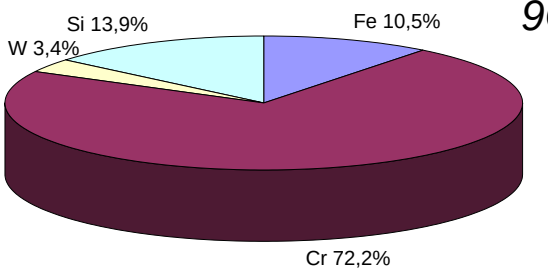
Characterization of the oxide film

- The oxide film is enriched in chromium (XPS)

Steel composition (at%)

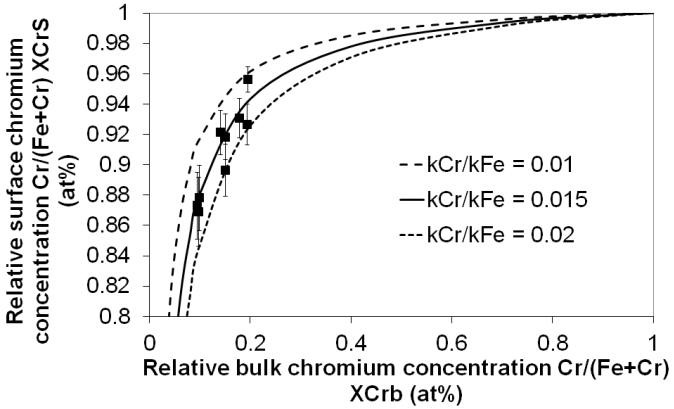


9Cr-1W-Ti ODS

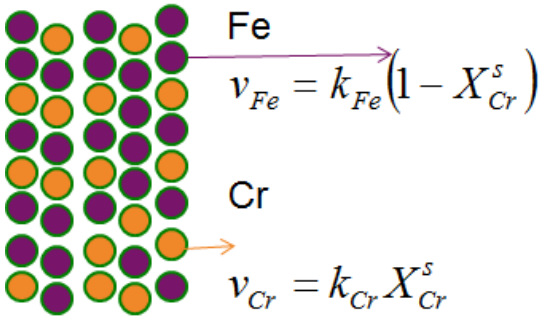


Oxide layer composition (at%)

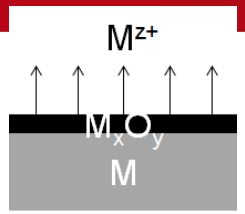
- The more steel contains chromium, the more important the concentration of chromium in the oxide



B. Gwinner et al. / Journal of Nuclear Materials 428 (2012) 110–116

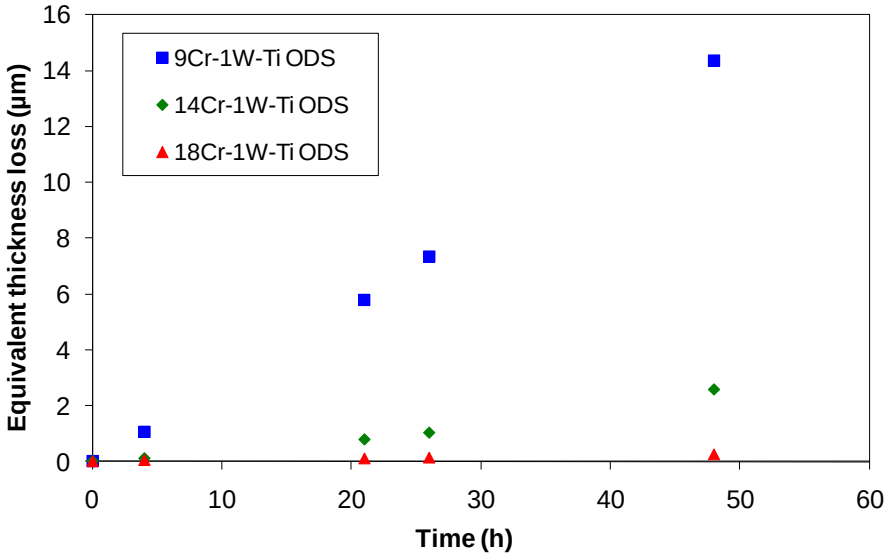


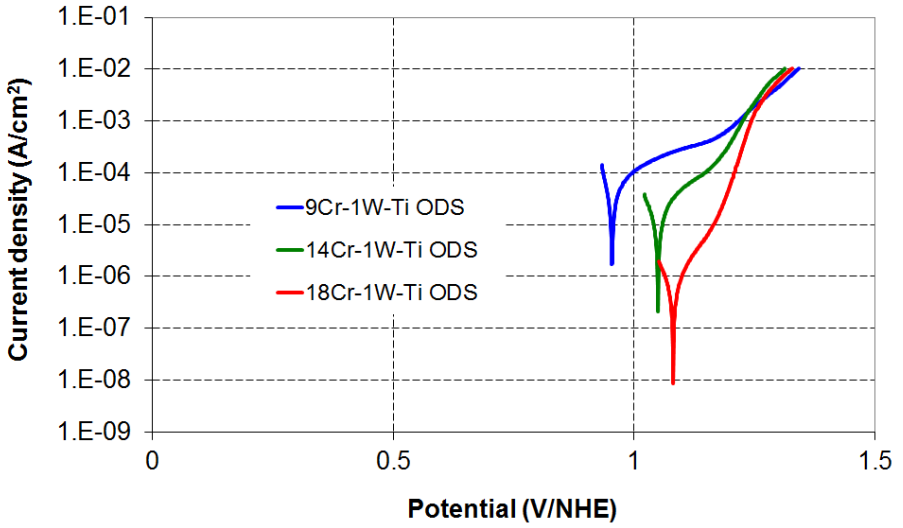
M. Seo, N. Sato, Langmuir 3 (1987) 917
P. Marcus, J.M. Grimal, Corrosion Science 33 (1992) 805



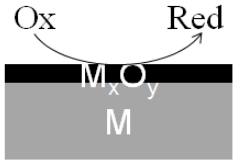
Characterization of passivity

- The more steel contains chromium, the better passivity



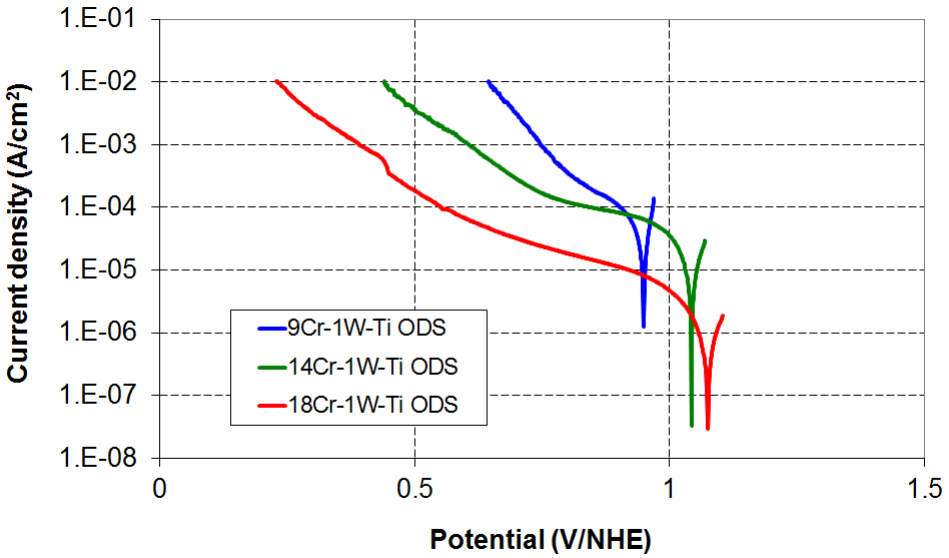


B. Gwinner et al. / Journal of Nuclear Materials 428 (2012) 110–116



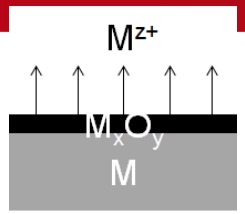
Characterization of reactivity

- The more steel contains chromium, the lower reactivity

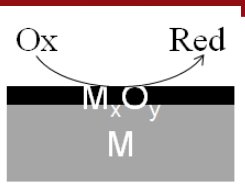


B. Gwinner et al. / Journal of Nuclear Materials 428 (2012) 110–116

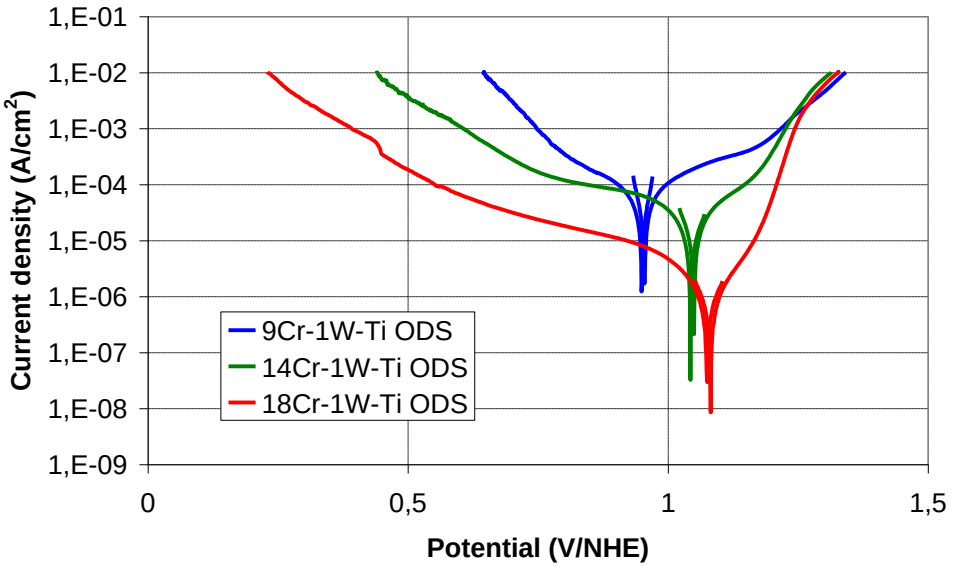
STEELS WITH DIFFERENT CHROMIUM CONTENTS



Relationship between passivity and reactivity

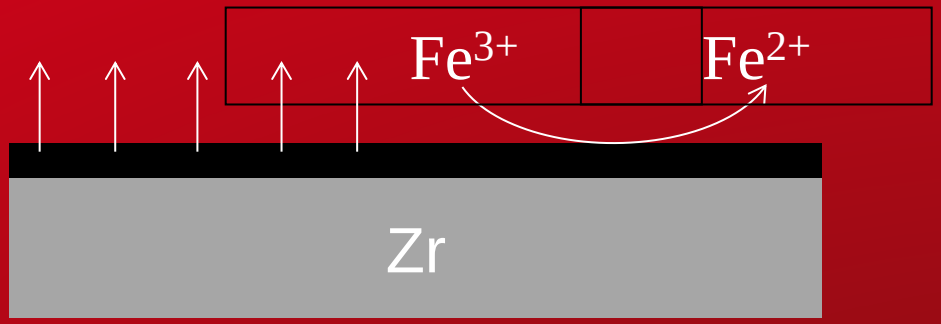


- In this case, the more steel contains chromium:
  - The better passivity
  - The lower reactivity



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ZIRCONIUM WITH DIFFERENT THICKNESSES OF THE OXIDE FILM

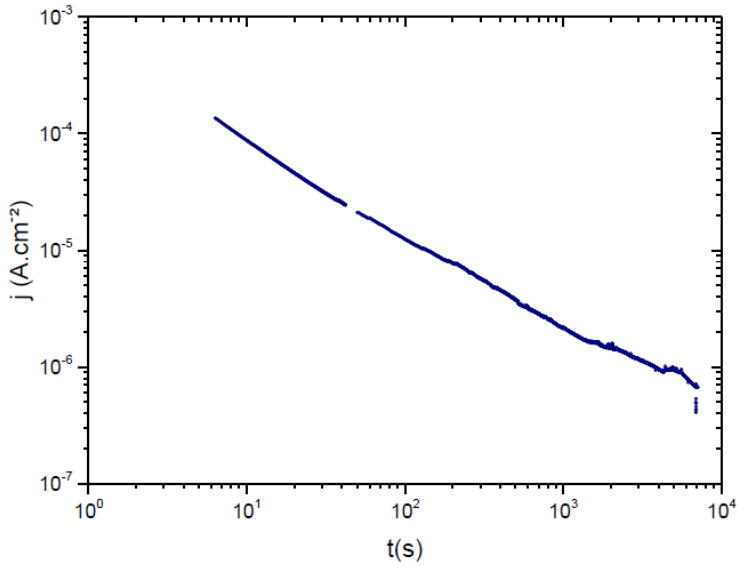


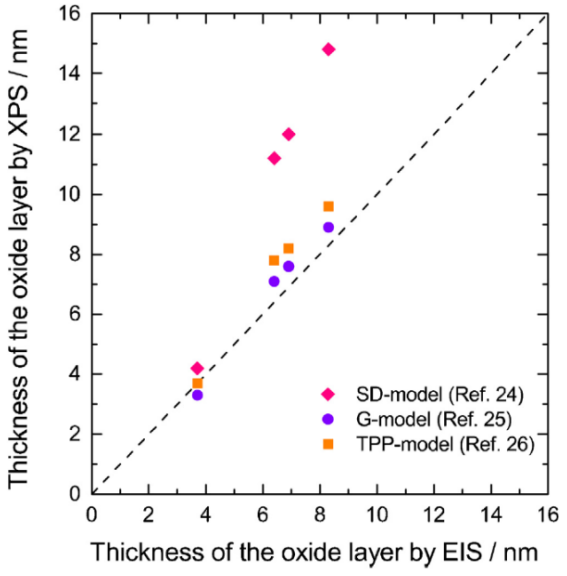
ZIRCONIUM WITH DIFFERENT THICKNESSES OF THE OXIDE FILM



Characterization of the oxide film

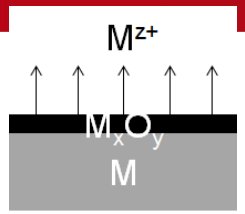
- The oxide films (ZrO_2) are prepared by polarization at the same potential but with during different durations
- The thickness of the oxide films is measured by two methods: XPS and EIS





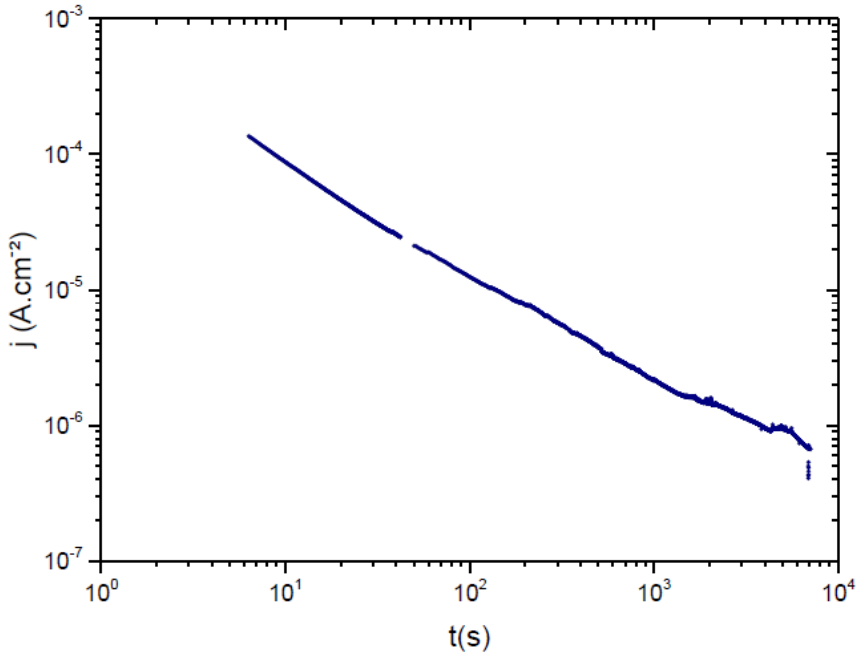
M. Benoit et al. / Electrochimica Acta 201 (2016) 340–347

ZIRCONIUM WITH DIFFERENT THICKNESSES OF THE OXIDE FILM



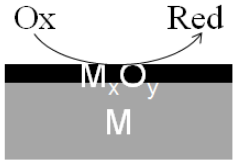
Characterization of passivity

- The thicker the oxide film (the longer the polarization time), the better passivity



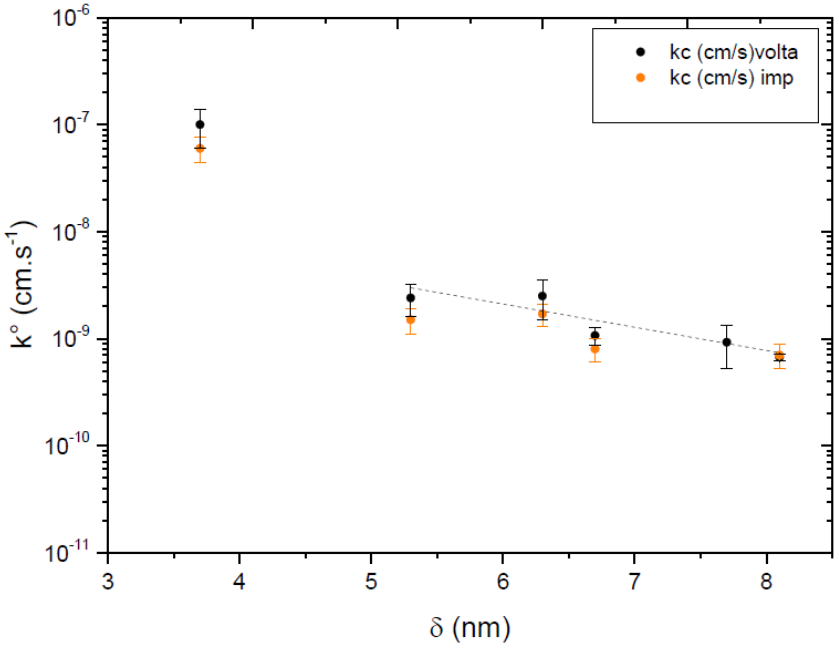
M. Benoit et al. / Electrochimica Acta 201 (2016) 340–347

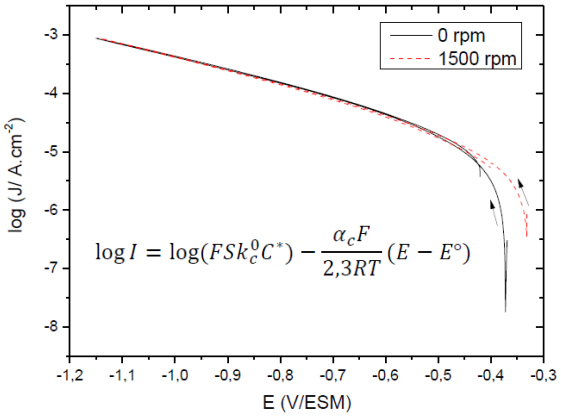
ZIRCONIUM WITH DIFFERENT THICKNESSES OF THE OXIDE FILM



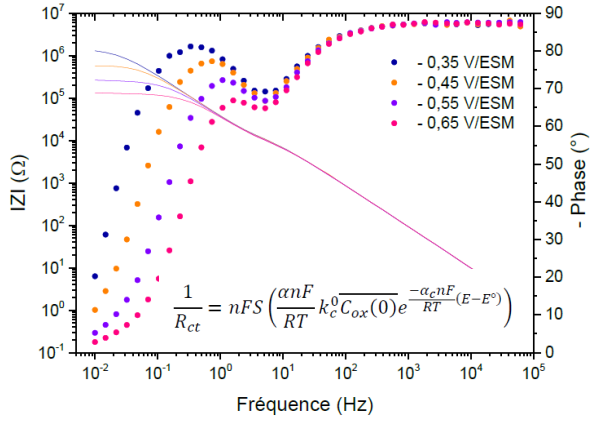
Characterization of reactivity

- The thicker the oxide film (the longer the polarization time), the lower reactivity





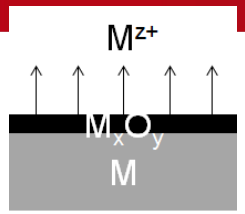
« Volta »



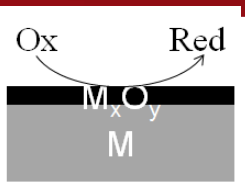
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M. Benoit et al. / Electrochimica Acta 201 (2016) 340–347

ZIRCONIUM WITH DIFFERENT THICKNESSES OF THE OXIDE FILM



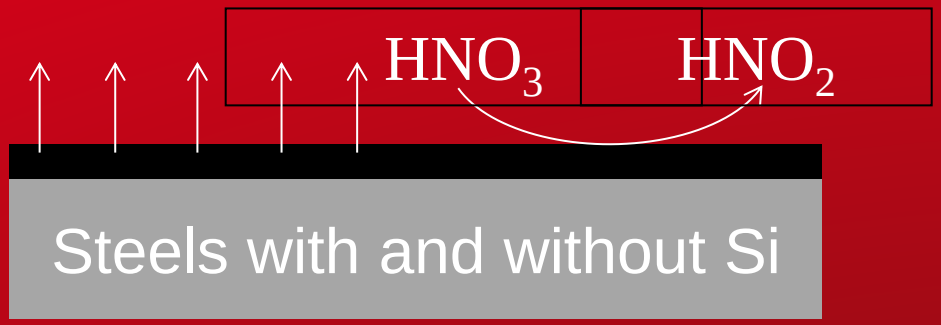
Relationship between passivity and reactivity



- The thicker the oxide film (the longer the polarization time):
  - The better passivity
  - The lower reactivity
- In this case, the trend is similar to the previous example

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STEELS WITH DIFFERENT SILICON CONTENTS

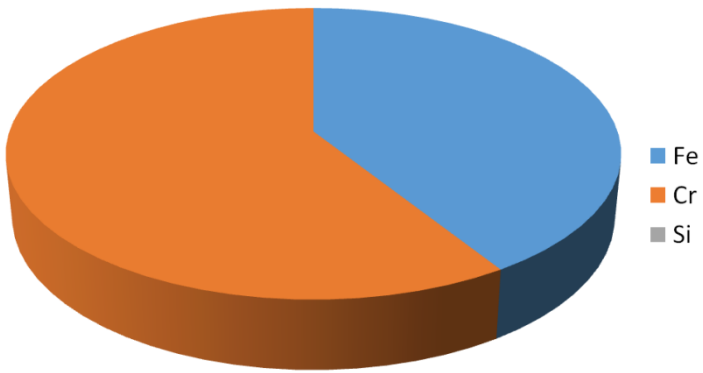


	Fe	Cr	Ni	Si	Mn	Add.
Si-rich SS	59.8	18.8	15.1	3.5	2.0	0.8
304L SS	70.3	17.8	9.5	0.3	1.5	0.6

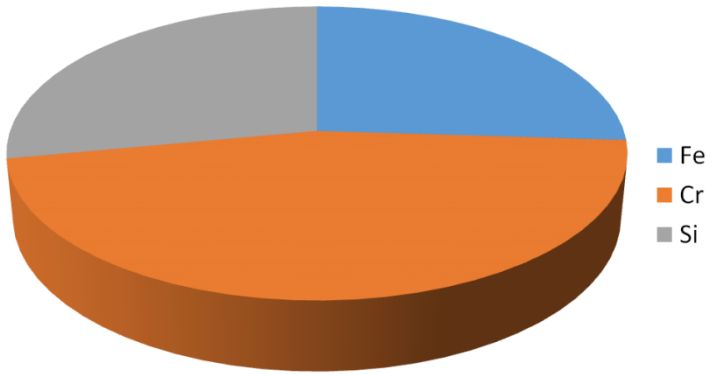


Characterization of the oxide film (XPS)

- For 304L SS, the oxide is enriched in chromium (no silicon measured)
- Si-rich SS, the oxide is enriched in chromium and silicon



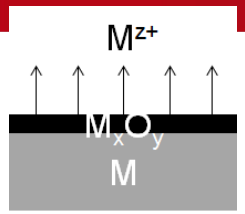
304L SS



Si-rich SS

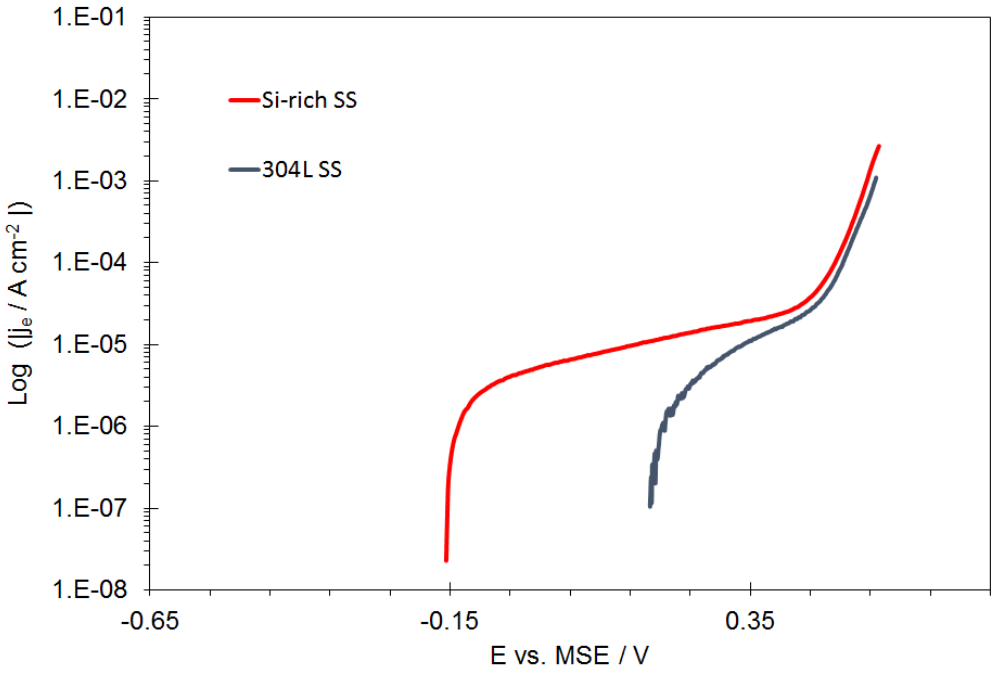
B. Laurent et al. / To be submitted

STEELS WITH DIFFERENT SILICON CONTENTS



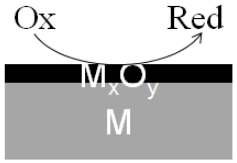
Characterization of passivity

- With silicon, passivity is worse



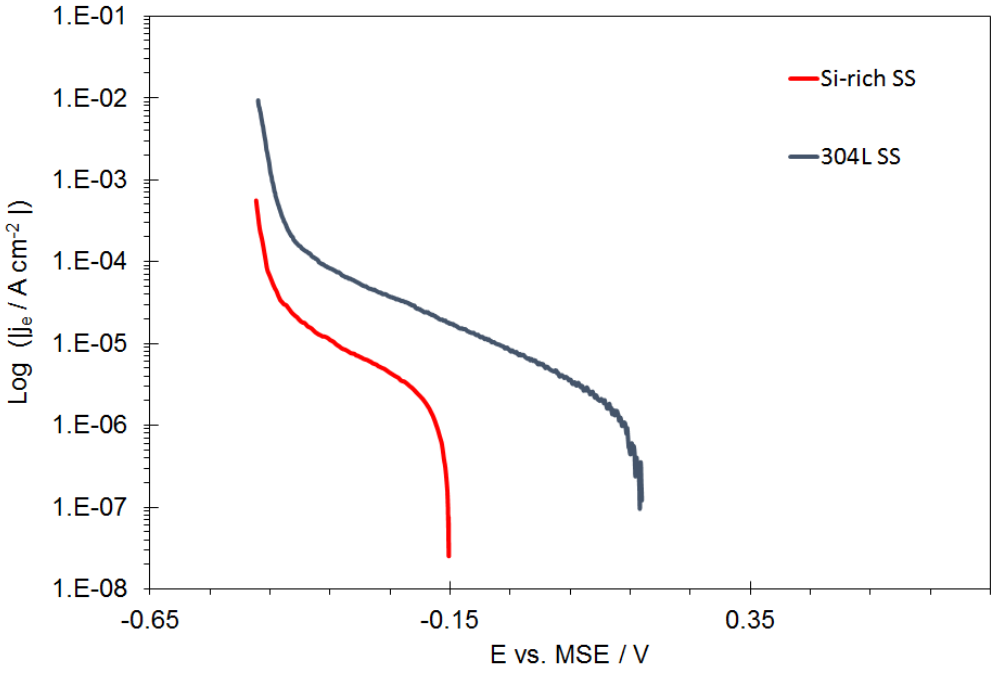
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STEELS WITH DIFFERENT SILICON CONTENTS



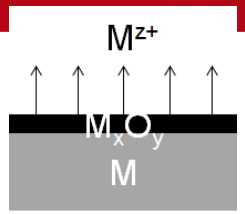
Characterization of reactivity

- With silicon, reactivity is lower

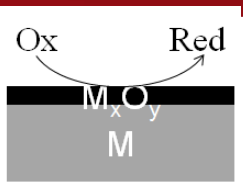


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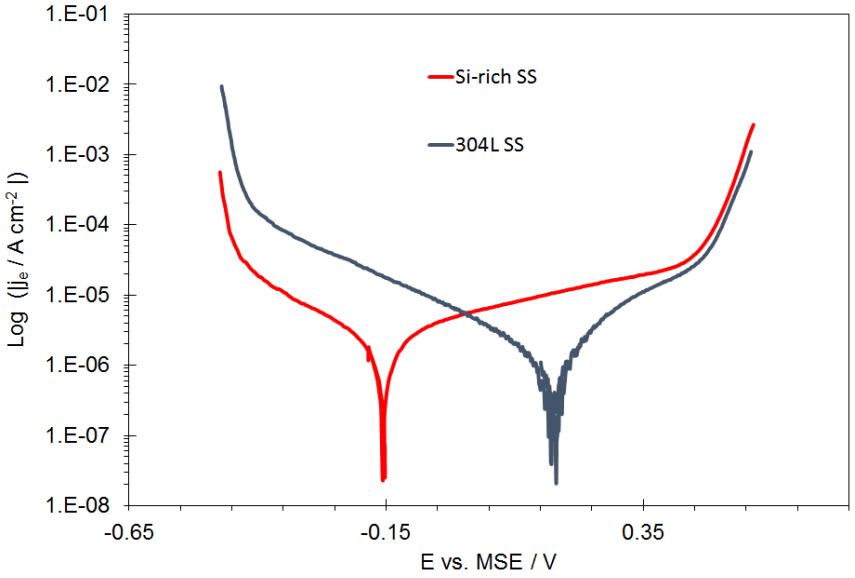
STEELS WITH DIFFERENT SILICON CONTENTS



Relationship between passivity and reactivity



- With silicon:
  - Passivity is worse
  - Reactivity is lower
- In this case, the trend is the opposite of the previous two examples

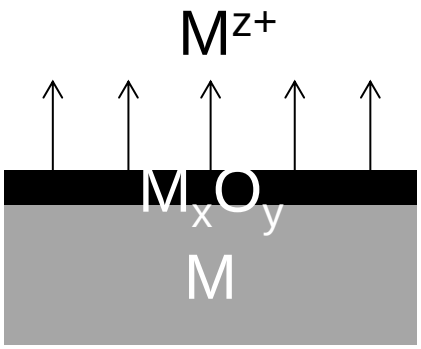


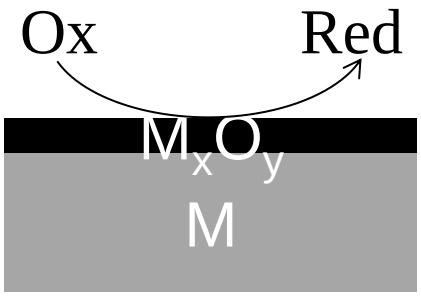
B. Laurent et al. / To be submitted

SUMMARY

SUMMARY

What kind of relationship is there between passivity and reactivity of metals?

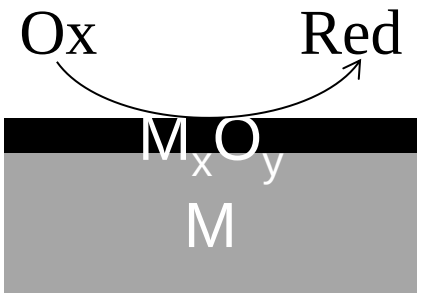


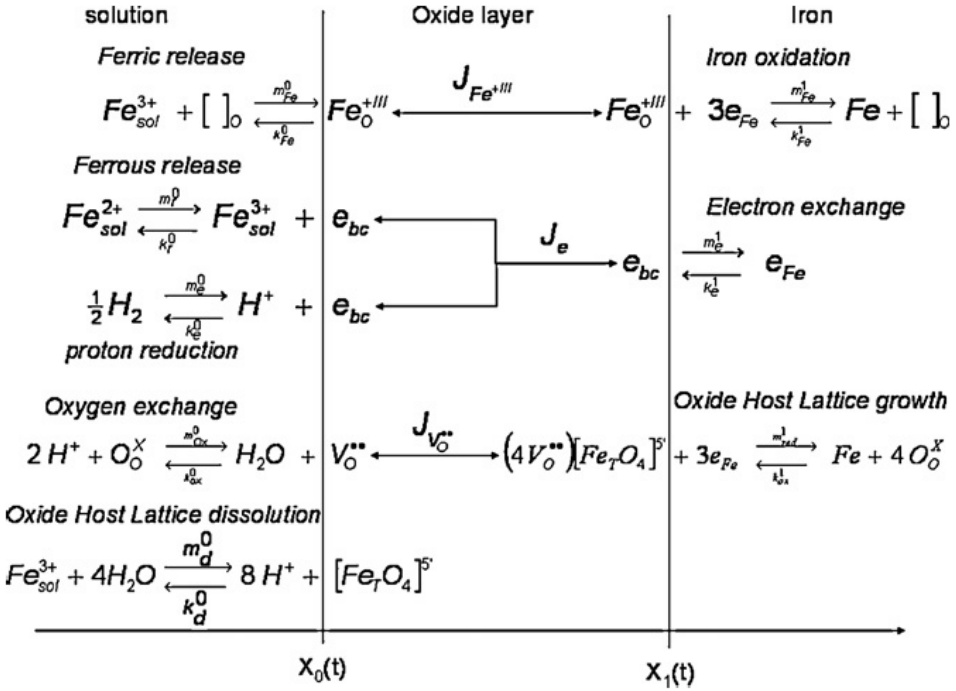


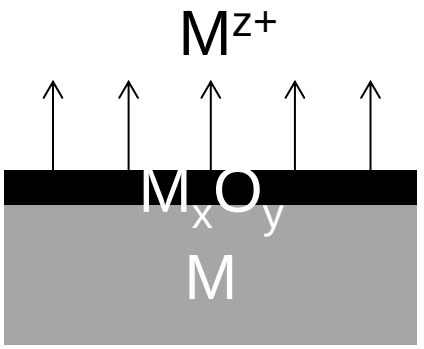
- Depending on the system, the relationship can in one direction or in the other

DISCUSSION

What could that mean?







I let you give me your opinion…

C. Bataillon et al. / Electrochimica Acta 55 (2010) 4451–4467

Acknowledgements to :



- You for your attention

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