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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

<https://cea.hal.science/cea-02442347v1>

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),

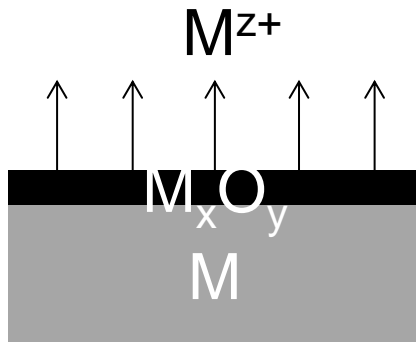
C. Sanchez-Sanchez, B. Tribollet, V. Vivier (CNRS/LISE)

AUGUST 28th 2017

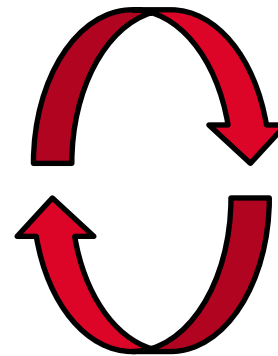
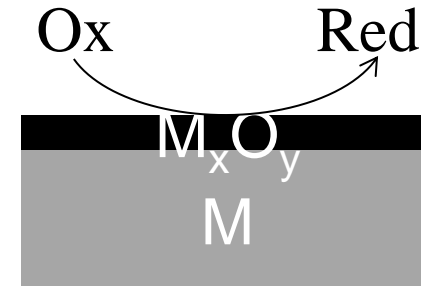
System of interest : passivated metals



Passivity
(oxidation/dissolution
of metal)



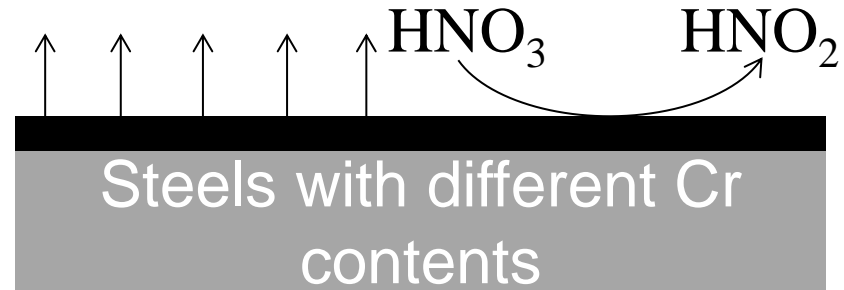
Reactivity
(reduction of
media)



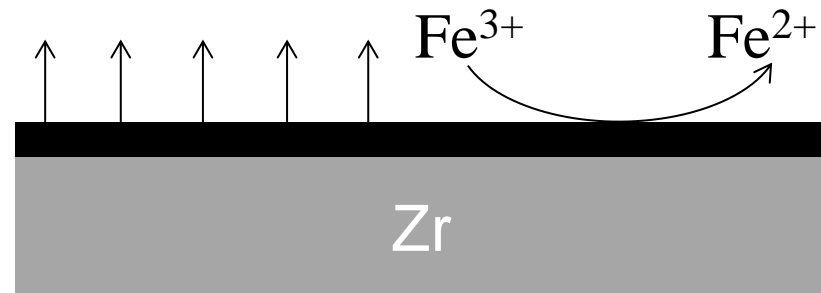
Relationship ?

SYSTEMS STUDIED

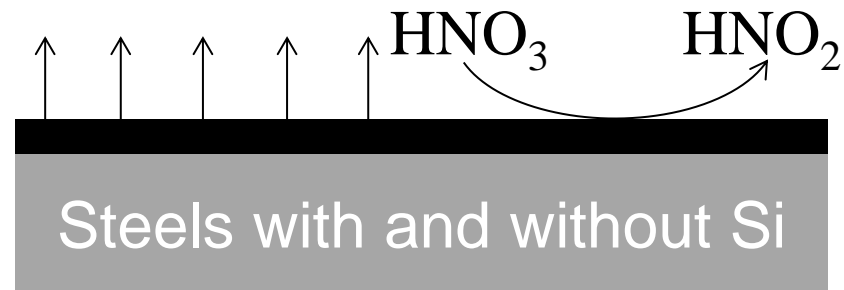
System No. 1



System No. 2



System No. 3

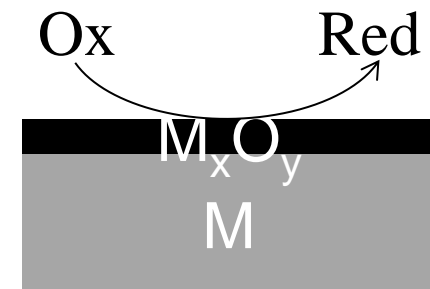
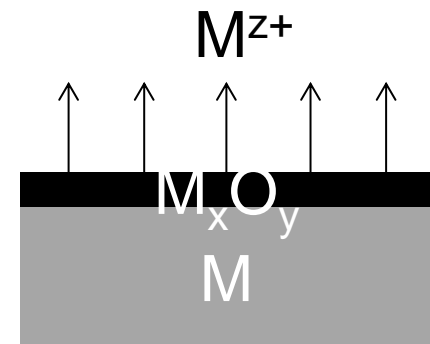


3 steps

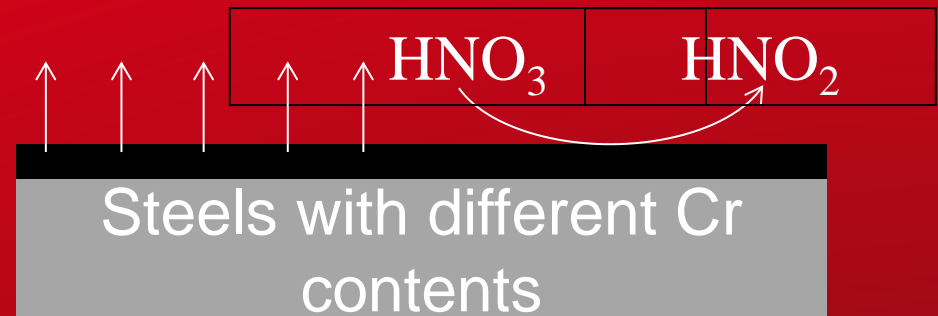
- Characterization of the oxide film

- Characterization of passivity

- Characterization of reactivity



STEELS WITH DIFFERENT CHROMIUM CONTENTS



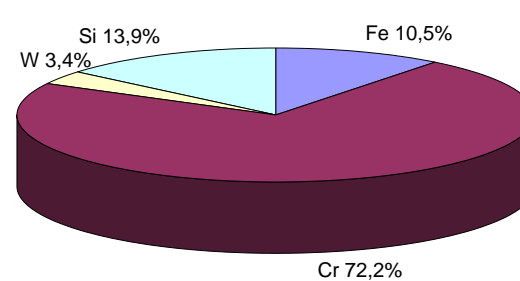
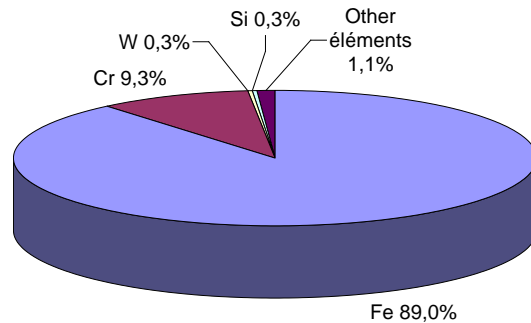
9Cr-1W-Ti ODS
14Cr-1W-Ti ODS
18Cr-1W-Ti ODS



Characterization of the oxide film

- The oxide film is enriched in chromium (XPS)

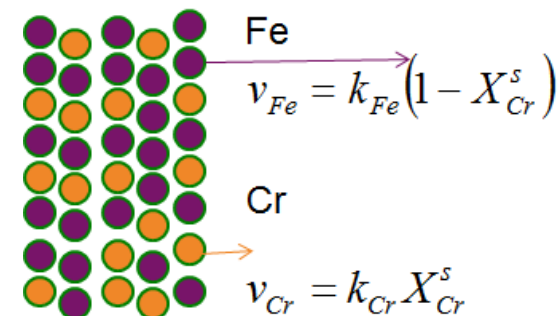
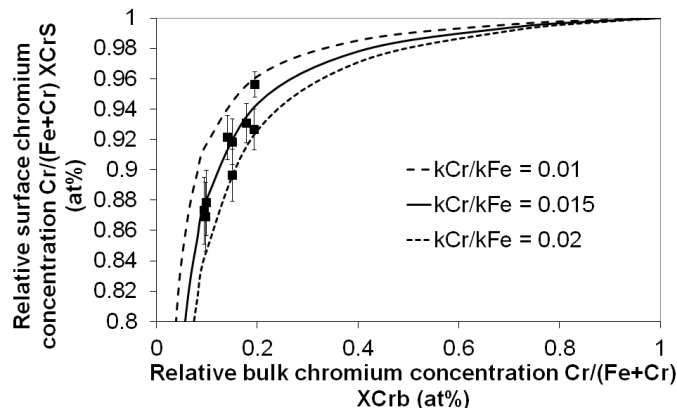
Steel composition (at%)

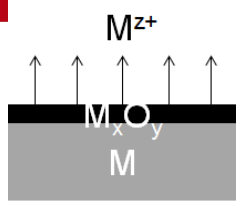


9Cr-1W-Ti ODS

Oxide layer composition (at%)

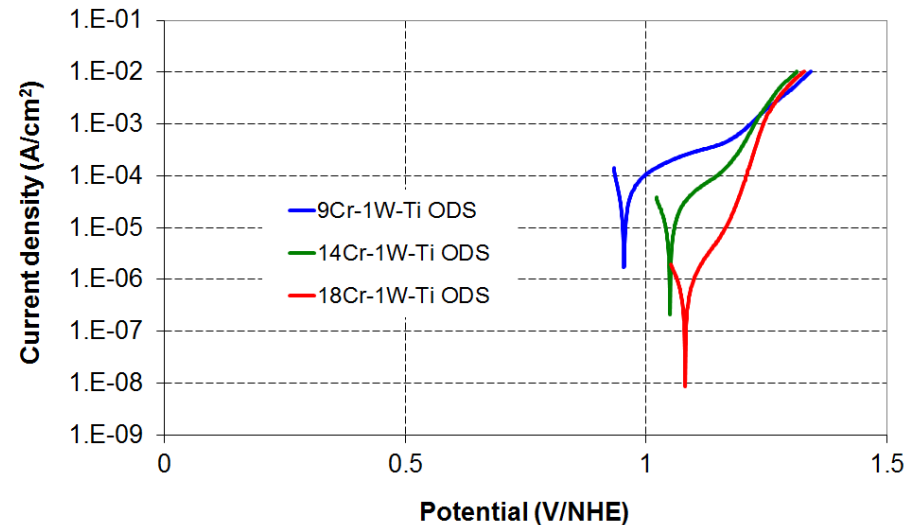
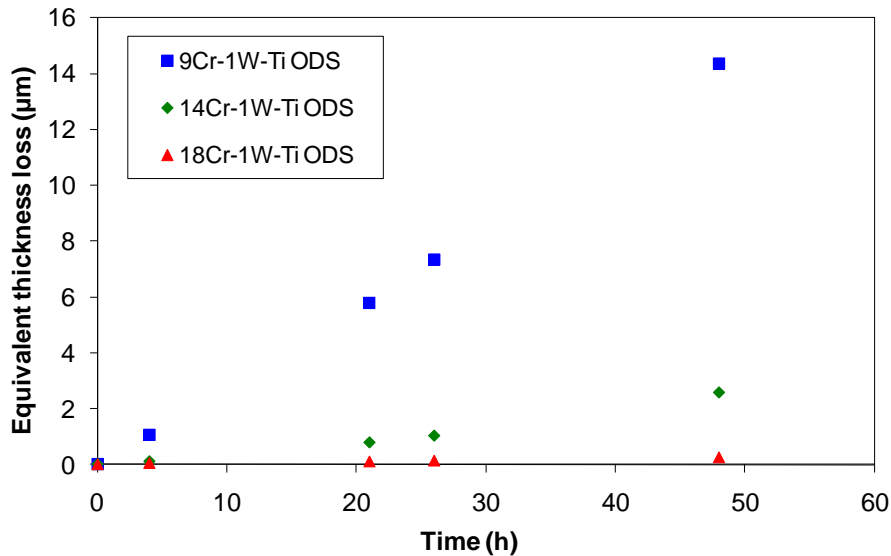
- The more steel contains chromium, the more important the concentration of chromium in the oxide

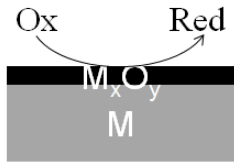




Characterization of passivity

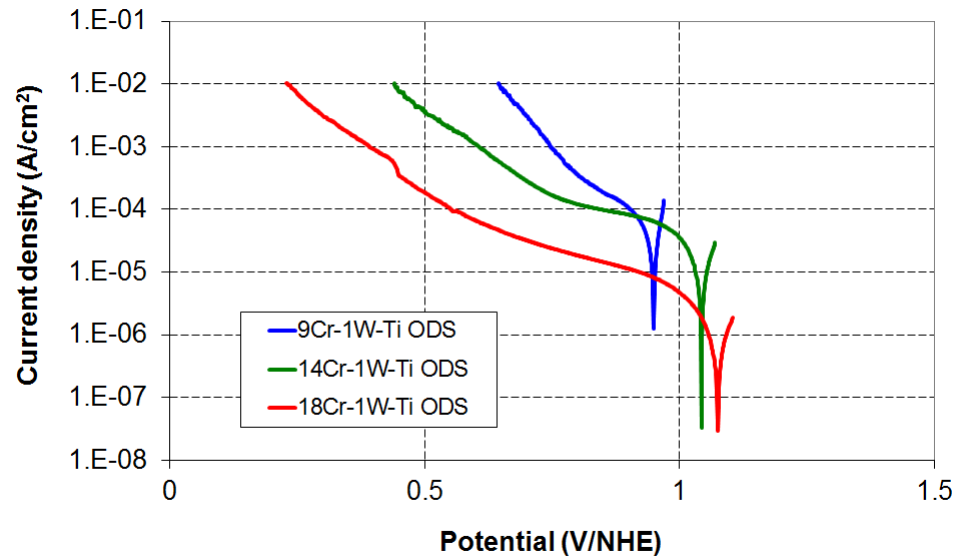
■ The more steel contains chromium, the better passivity



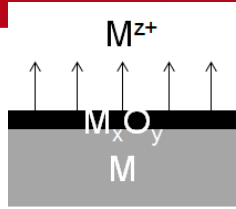


Characterization of reactivity

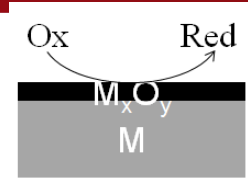
- The more steel contains chromium, the lower reactivity



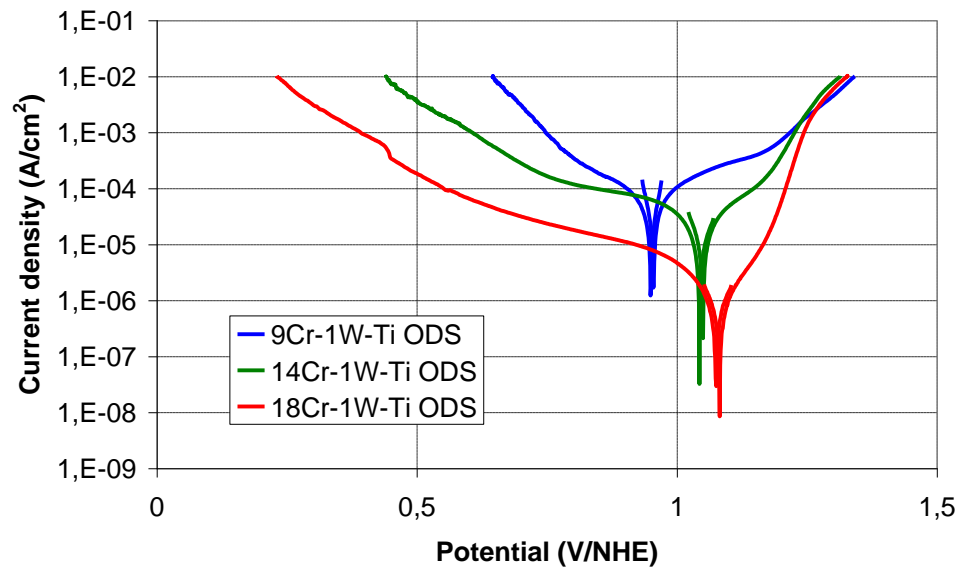
STEELS WITH DIFFERENT CHROMIUM CONTENTS



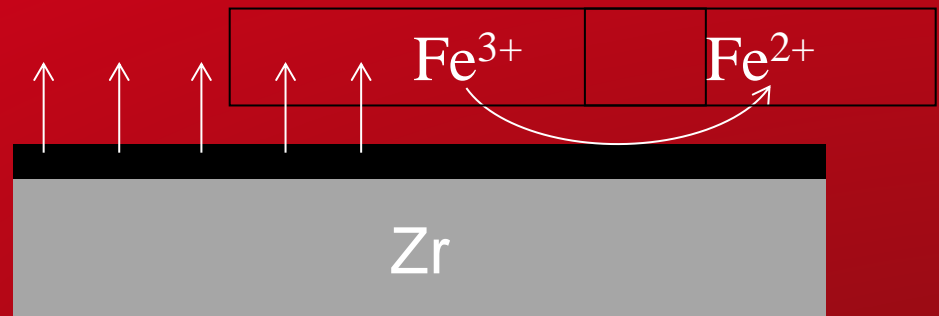
Relationship between passivity and reactivity



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



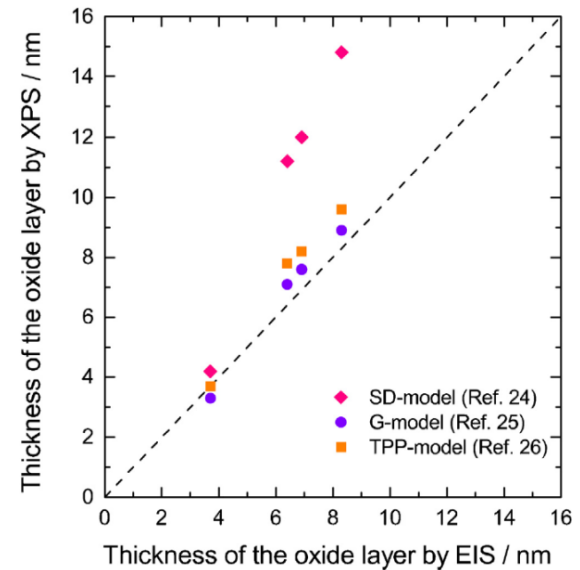
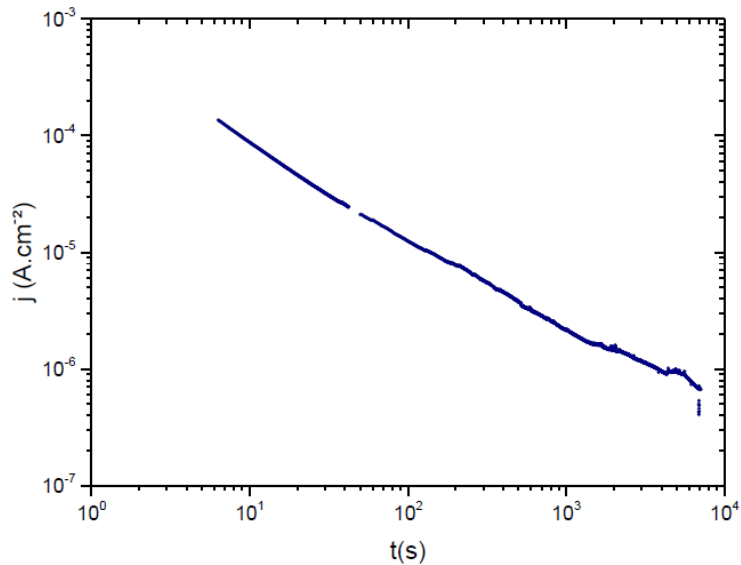
ZIRCONIUM WITH DIFFERENT THICKNESSES OF THE OXIDE FILM

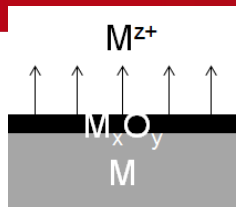




Characterization of the oxide film

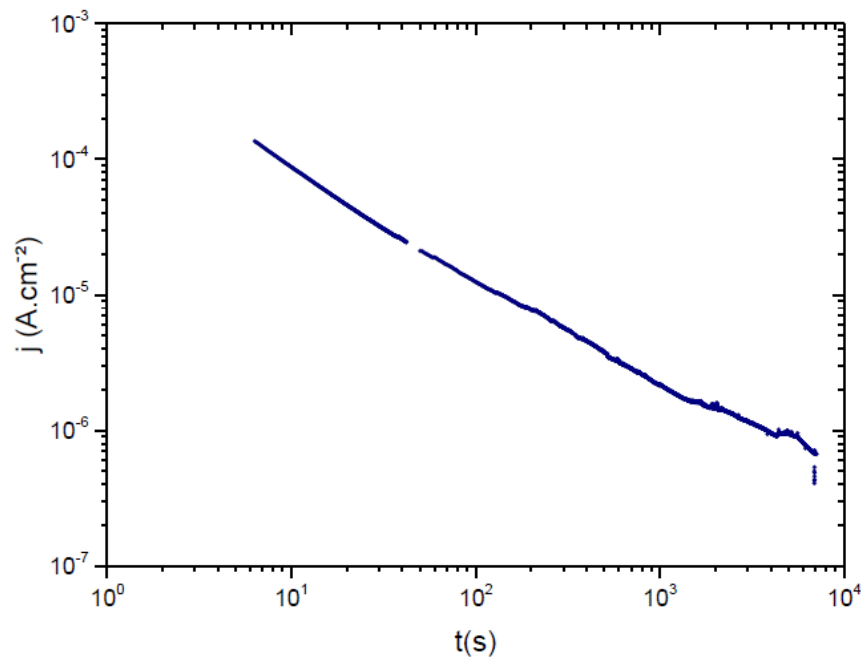
- The oxide films (ZrO₂) are prepared by polarization at the same potential but with during different durations
- The thickness of the oxide films is measured by two methods: XPS and EIS

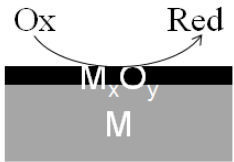




Characterization of passivity

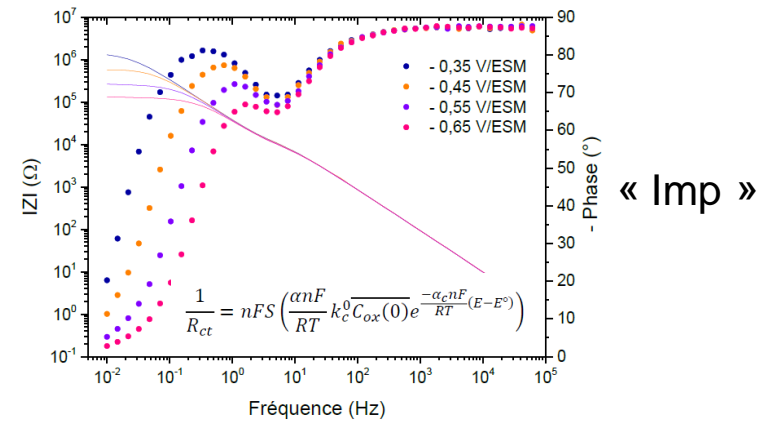
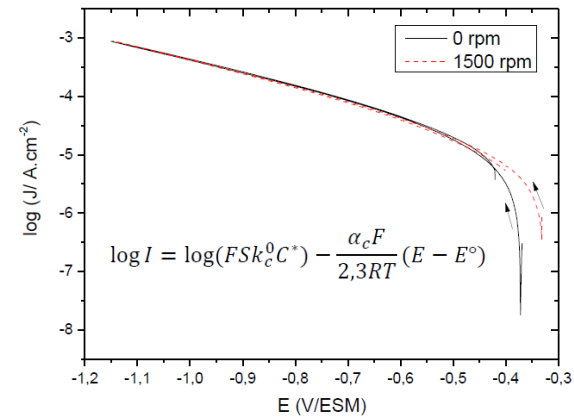
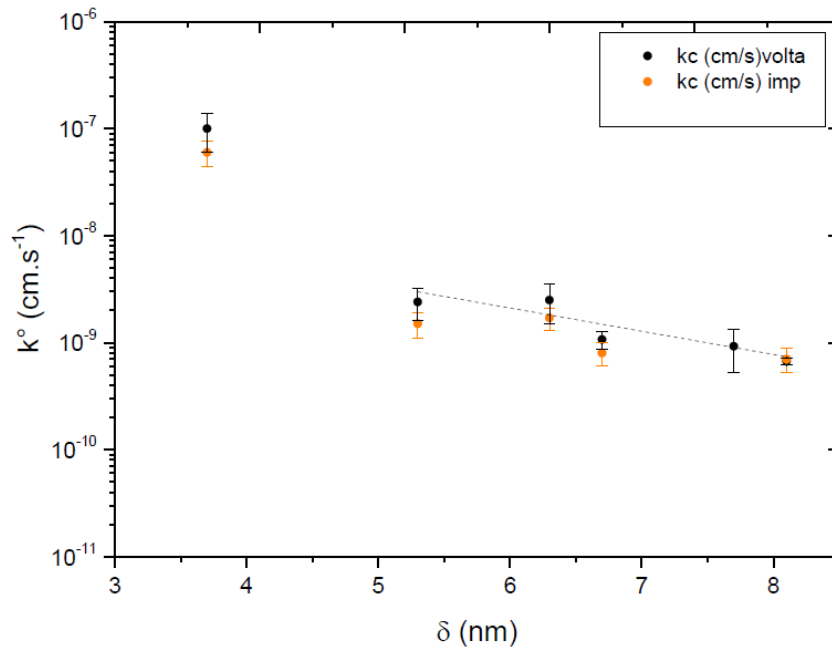
- The thicker the oxide film (the longer the polarization time), the better passivity



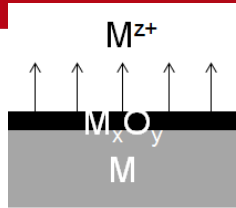


Characterization of reactivity

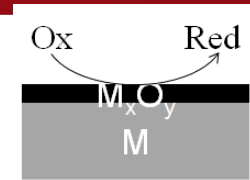
- The thicker the oxide film (the longer the polarization time), the lower reactivity



ZIRCONIUM WITH DIFFERENT THICKNESSES OF THE OXIDE FILM



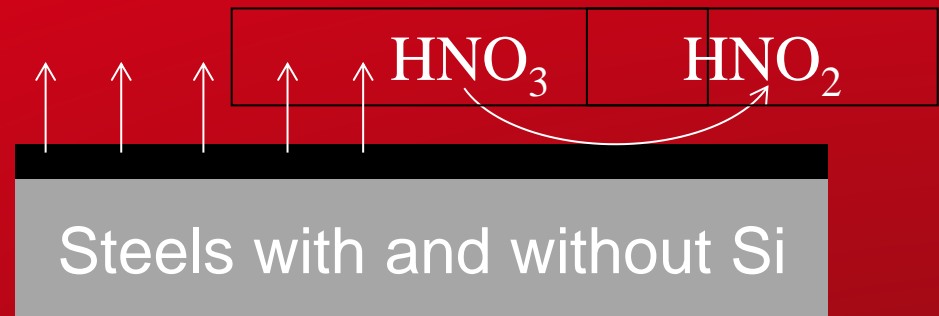
Relationship between passivity and reactivity



- 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

STEELS WITH DIFFERENT SILICON CONTENTS

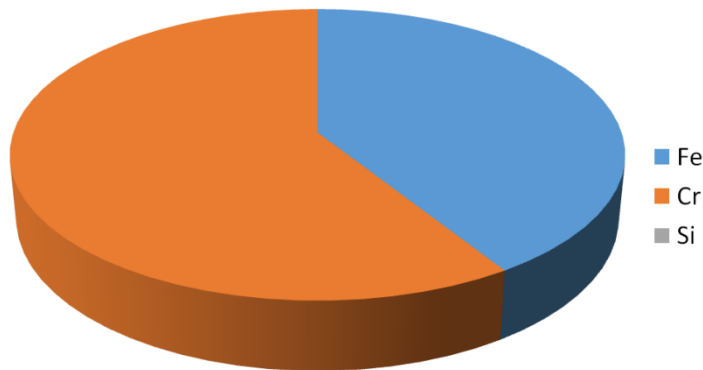


	Fe	Cr	Ni	Si	Mn	Add.
Si-rich SS	59.8	18.8	15.1	3.5	2.0	0.8
304L SS	70.3	17.8	9.5	0.3	1.5	0.6

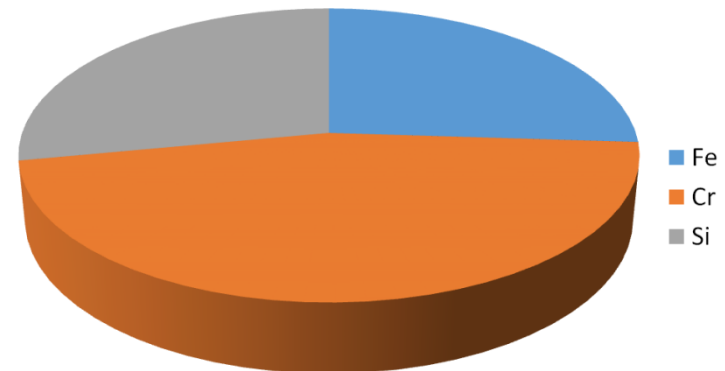


Characterization of the oxide film (XPS)

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

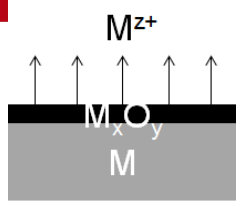


304L SS



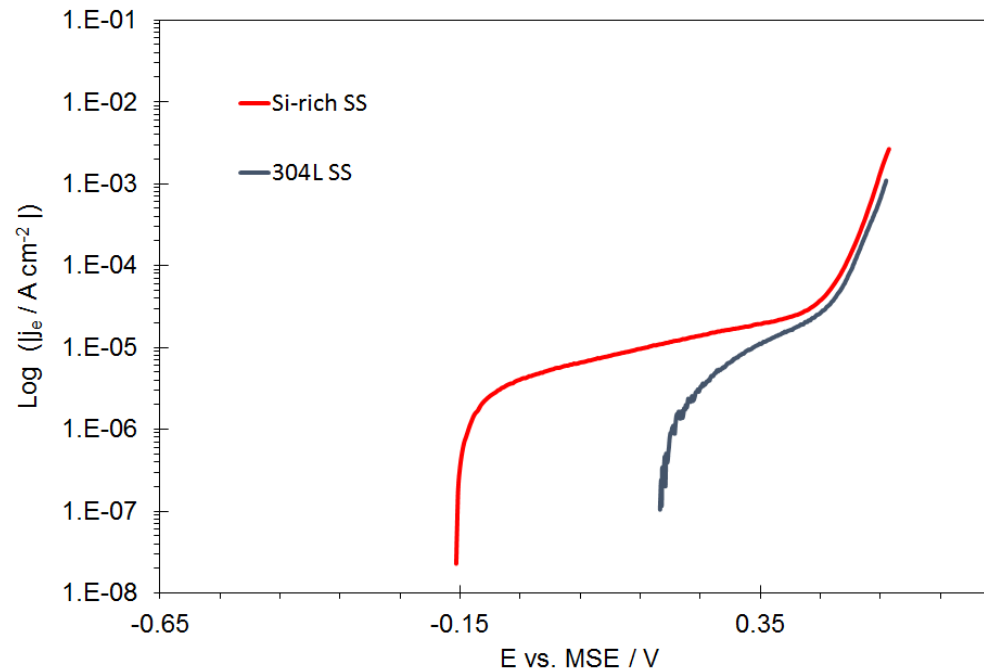
Si-rich SS

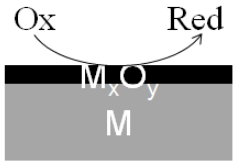
STEELS WITH DIFFERENT SILICON CONTENTS



Characterization of passivity

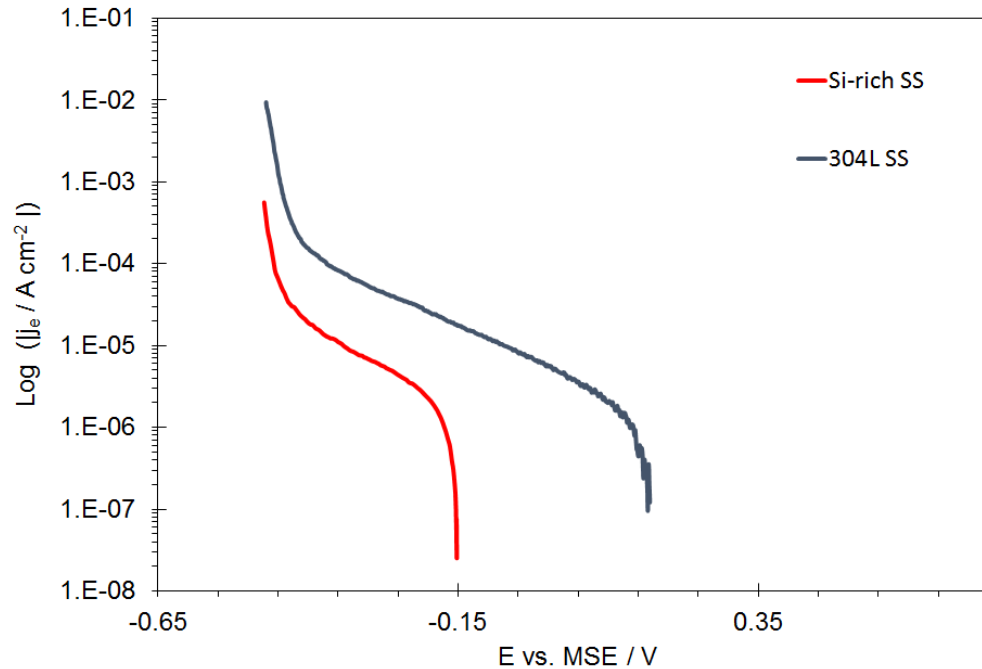
- With silicon, passivity is worse



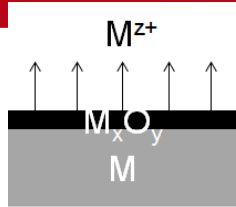


Characterization of reactivity

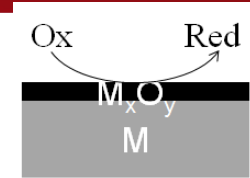
■ With silicon, reactivity is lower



STEELS WITH DIFFERENT SILICON CONTENTS

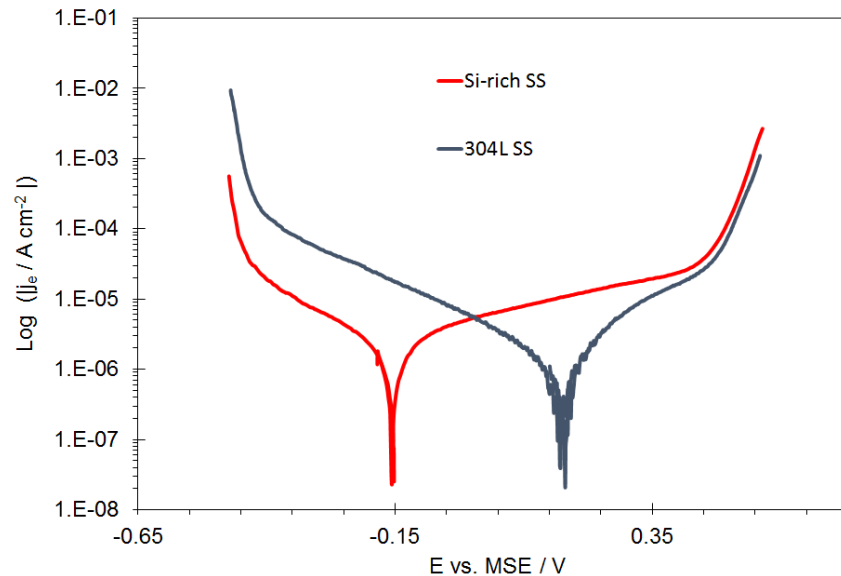


Relationship between passivity and reactivity



- With silicon:
 - Passivity is worse
 - Reactivity is lower

- In this case, the trend is the opposite of the previous two examples



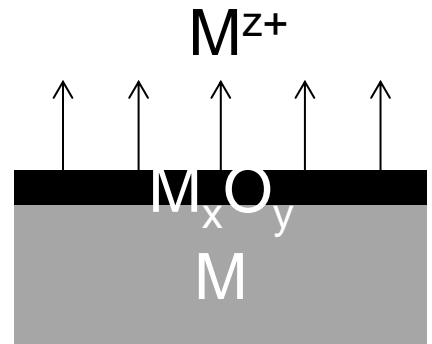
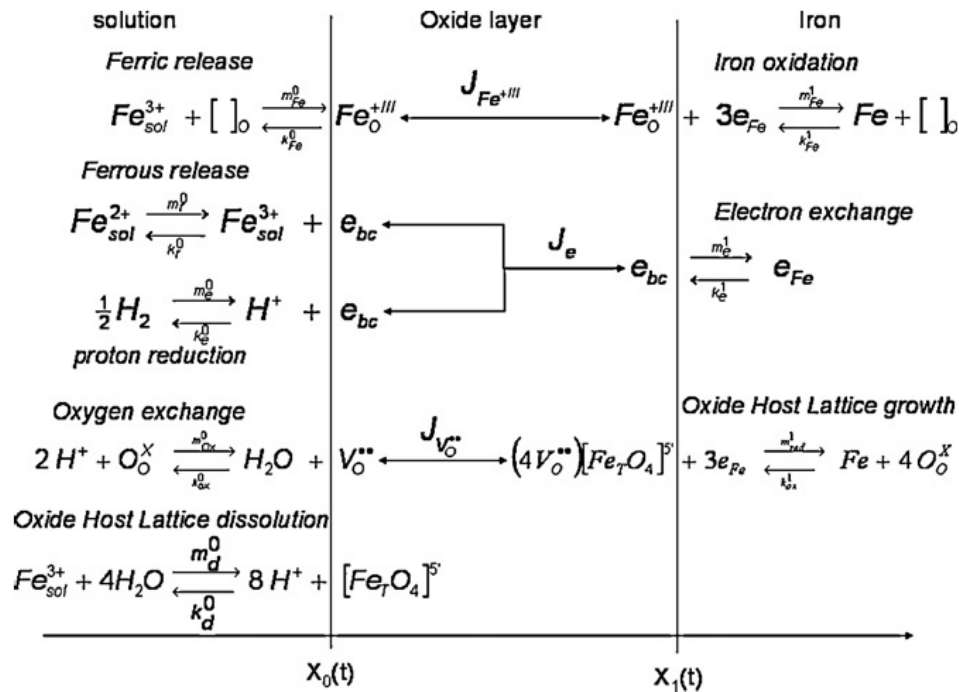
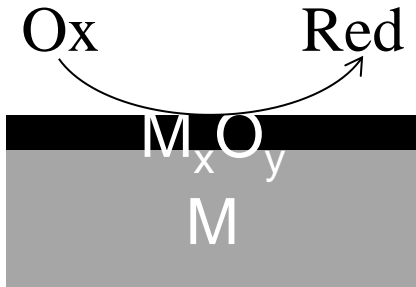
SUMMARY

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

What could that mean?



I let you give me your opinion...

Acknowledgements to :



■ You for your attention

Commissariat à l'énergie atomique et aux énergies alternatives
Centre de Saclay | 91191 Gif-sur-Yvette Cedex
T. +33 (0)1 69 08 16 40 | F. +33 (0)1 69 08 15 86

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