



In-situ photometric reflectance measurements of carbon steel surfaces upon cathodic protection

Other Conference Item**Author(s):**

[Martinelli-Orlando, Federico](#) ; [Angst, Ueli](#) 

Publication date:

2023-08-31

Permanent link:

<https://doi.org/10.3929/ethz-b-000632358>

Rights / license:

[In Copyright - Non-Commercial Use Permitted](#)

Funding acknowledgement:

848794 - Towards mastering the long-standing challenge of ageing infrastructures in corrosive environments (EC)



In-situ photometric reflectance measurements of carbon steel surfaces upon cathodic protection

Eurocorr 2023 - Brussels

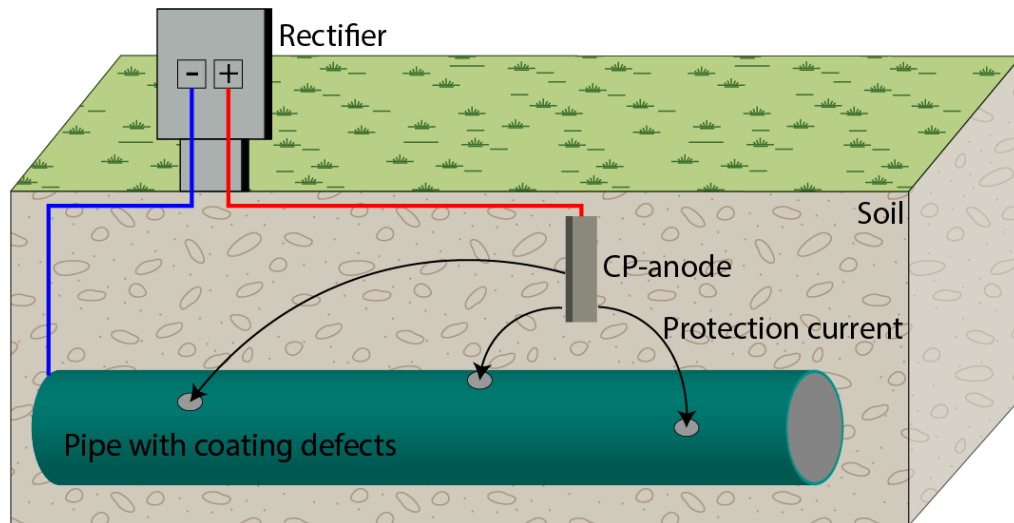
31st August 2023

Federico Martinelli-Orlando and Ueli Angst



Introduction

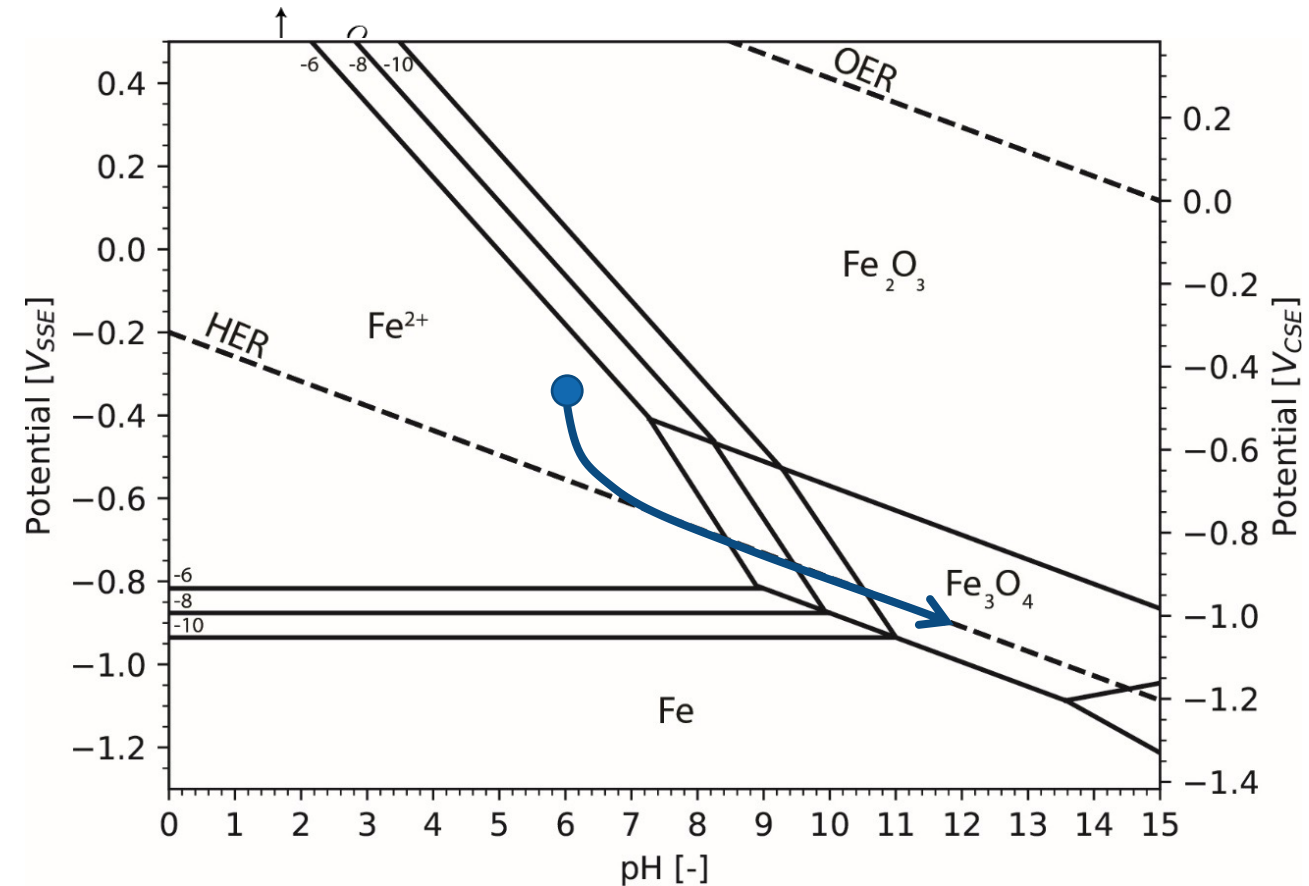
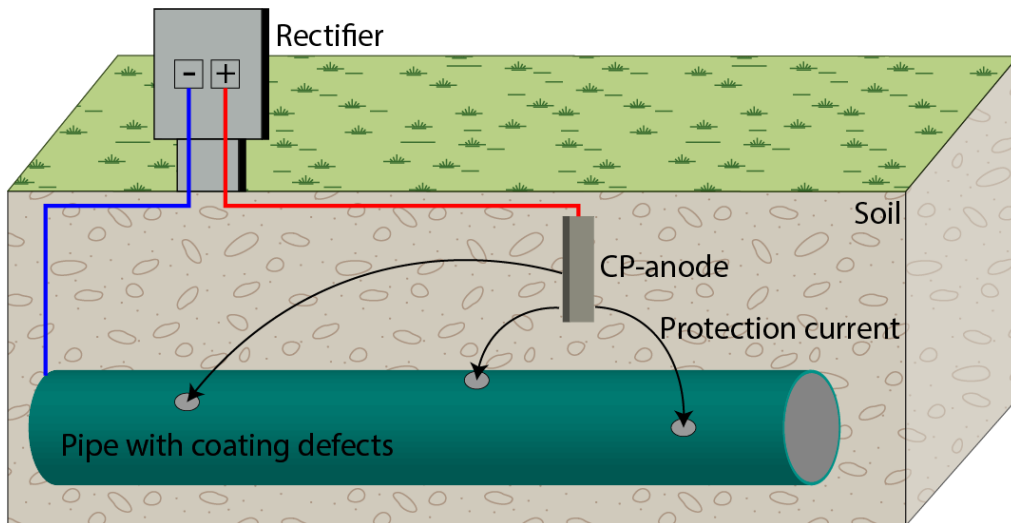
- Cathodic protection (**CP**) electrochemical technique to **limit corrosion rate**
- **Exactly 200 years from the first experiments**
- Some **protection criteria** based on **empirical findings**



Introduction

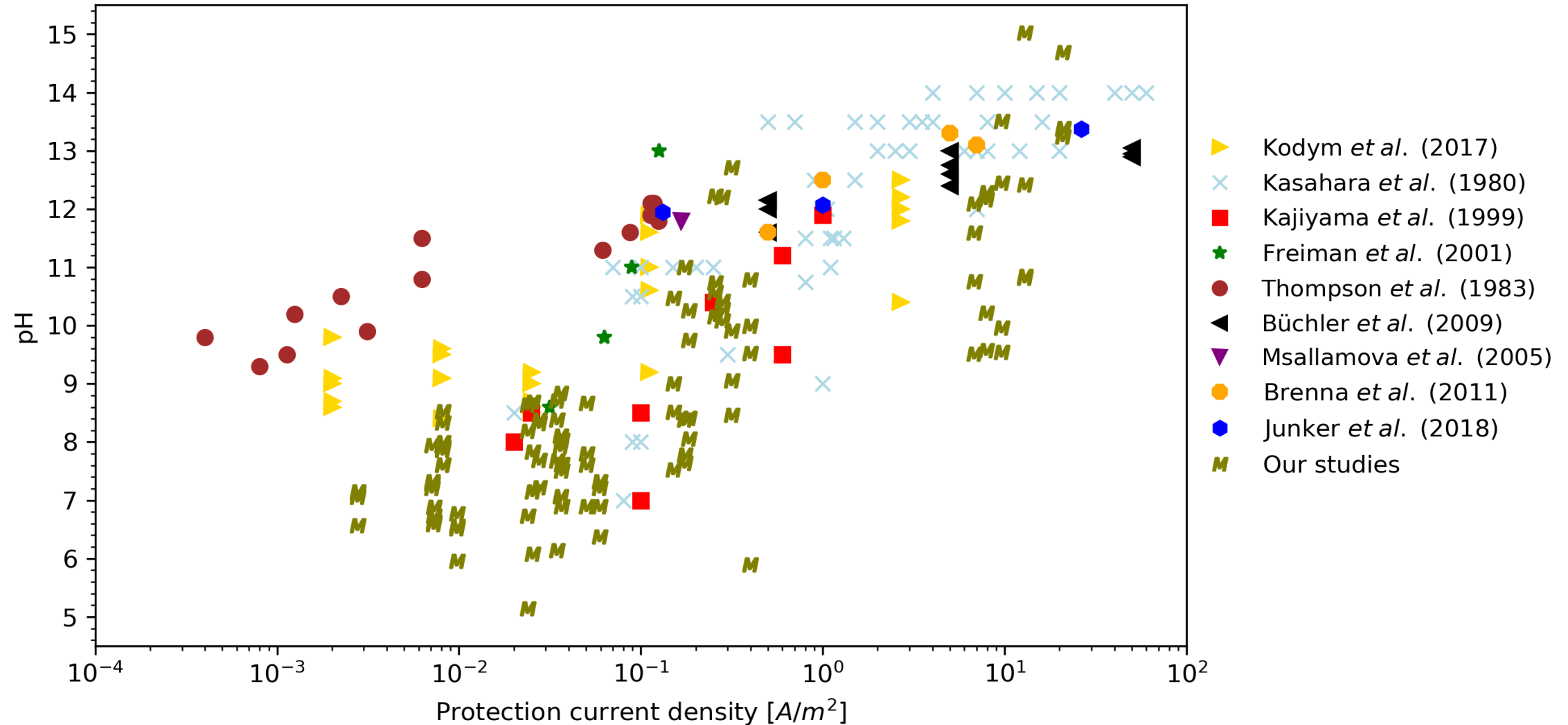
CP working mechanisms are still under debate

- Activation polarisation
- Concentration polarisation



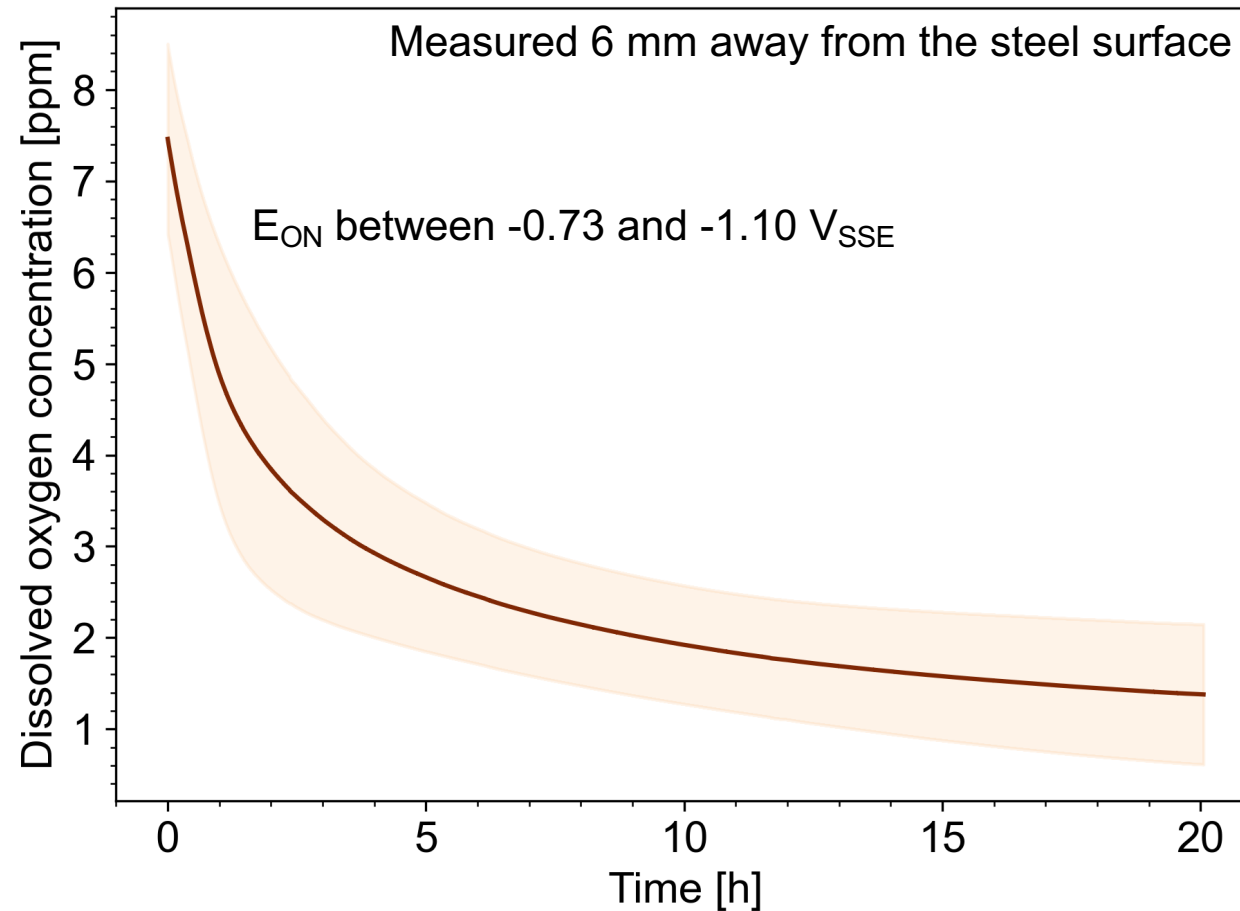
Introduction

- Several studies showed **increase in pH** as a function of the **protection current density**



Introduction

- Several studies showed **increase in pH** as a function of the **protection current density**
- A few studies reported changes in **oxygen concentration upon CP**



Introduction

- **Passive film** on steel extensively studied in alkaline electrolytes:
 - **Electrochemical** methods to monitor or induce passive film formation
 - **Characterization** techniques mostly done **ex-situ**
- A **few studies** reported **in-situ** characterization of passive film:
 - **Potentiodynamic polarization or cyclic voltammetry**
 - **Potentiostatic polarization (anodic)**

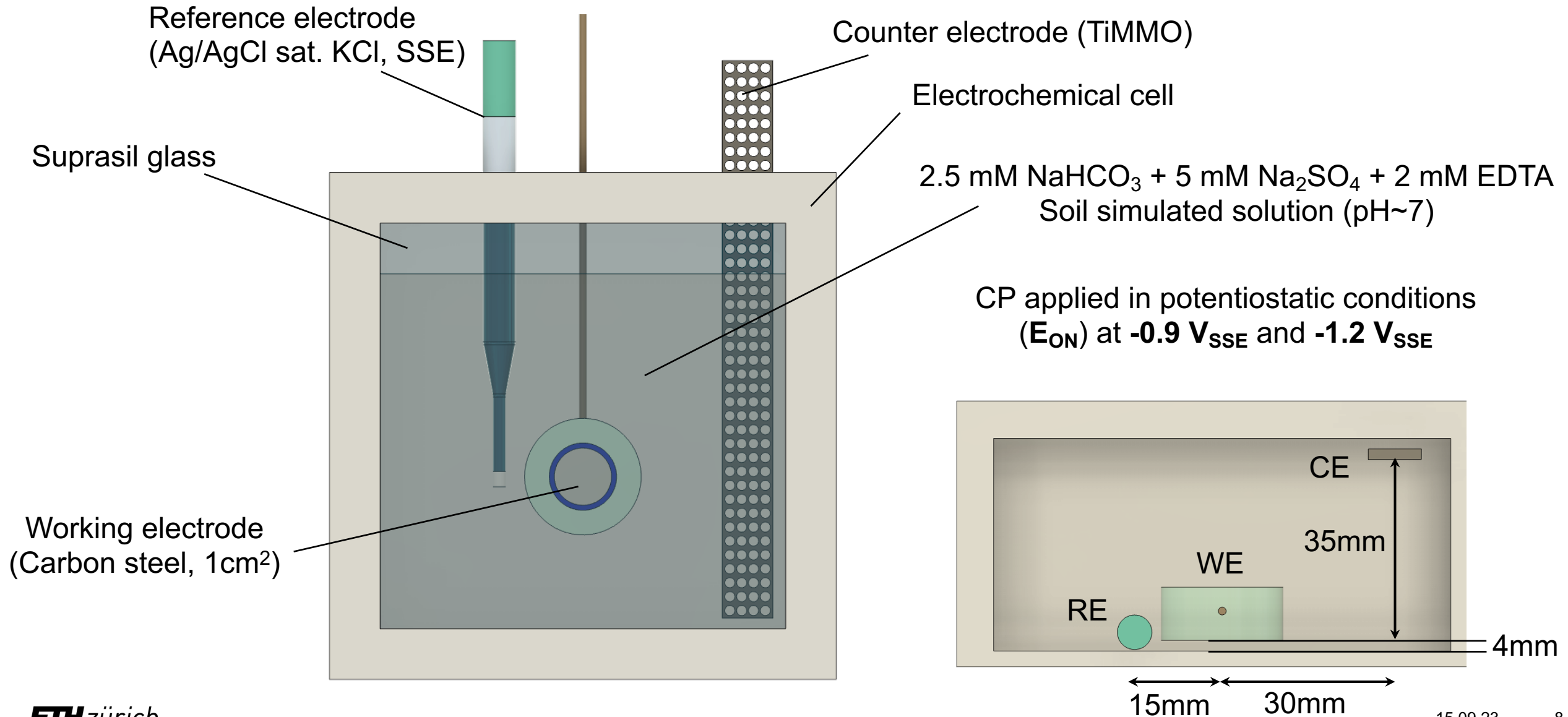
Introduction

- Passive film on steel extensively studied in alkaline electrolytes:
 - Electrochemical methods to monitor or induce passive film formation
 - Characterization techniques mostly done ex-situ

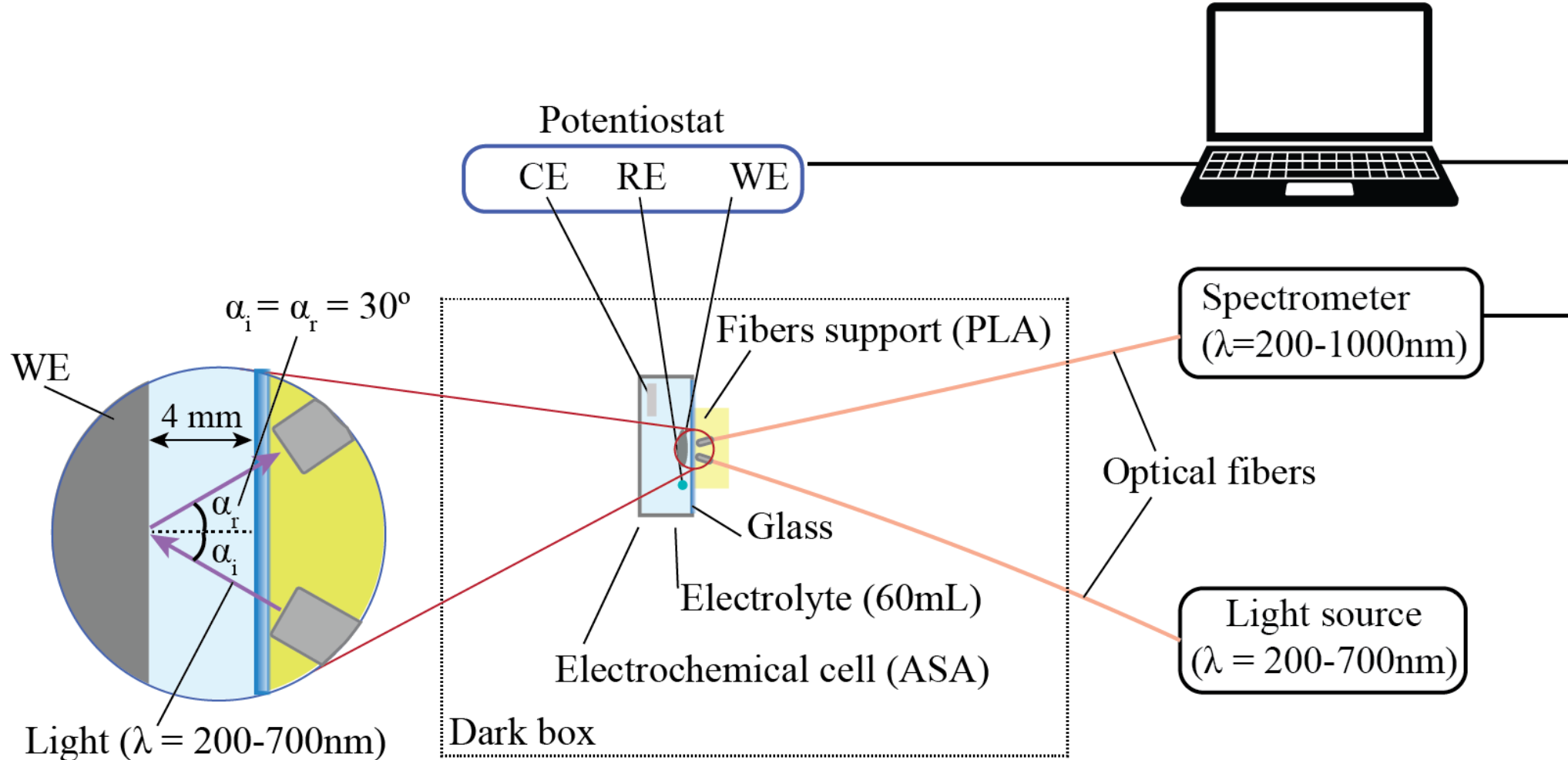
Aim of the work

Study the **oxide film** formation and growth upon application of **cathodic currents combined with in-situ light reflectance measurements**

Methods – Photoelectrochemical cell

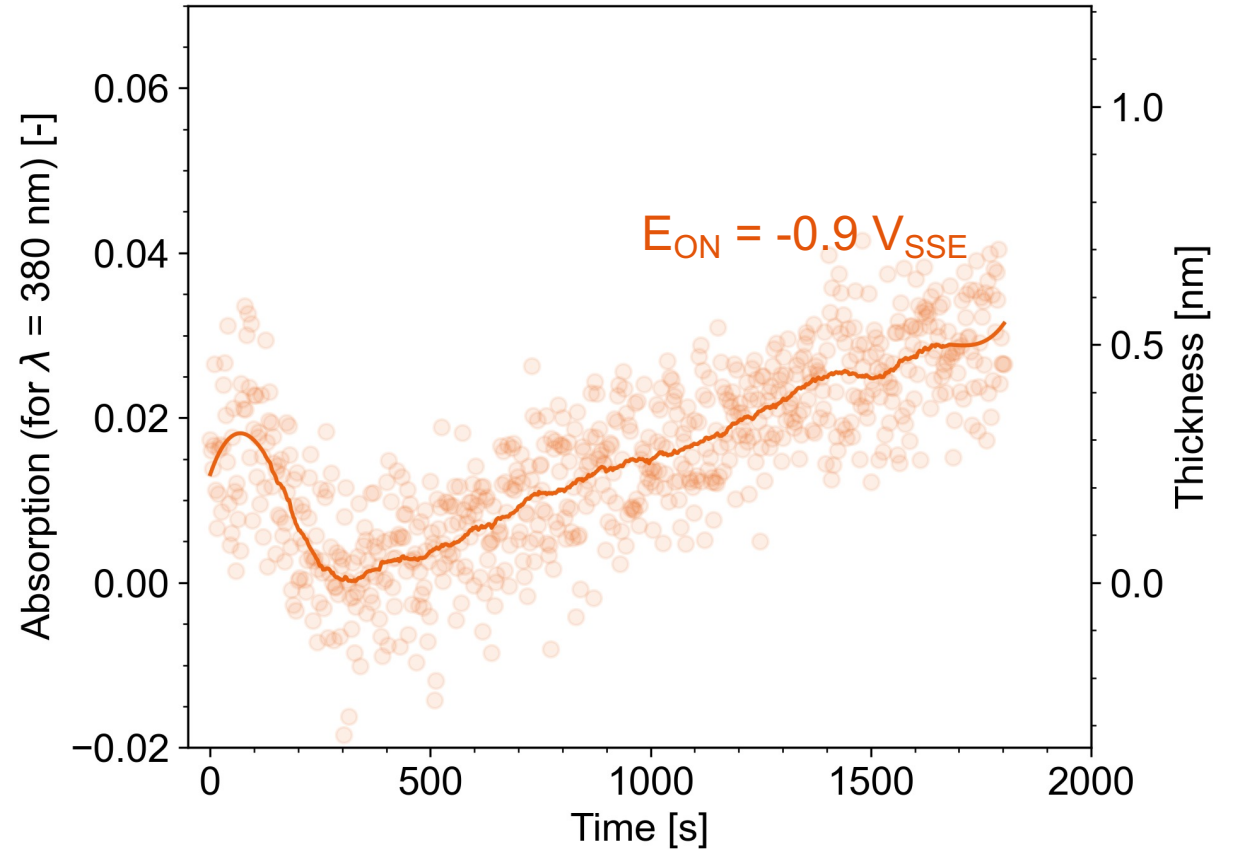
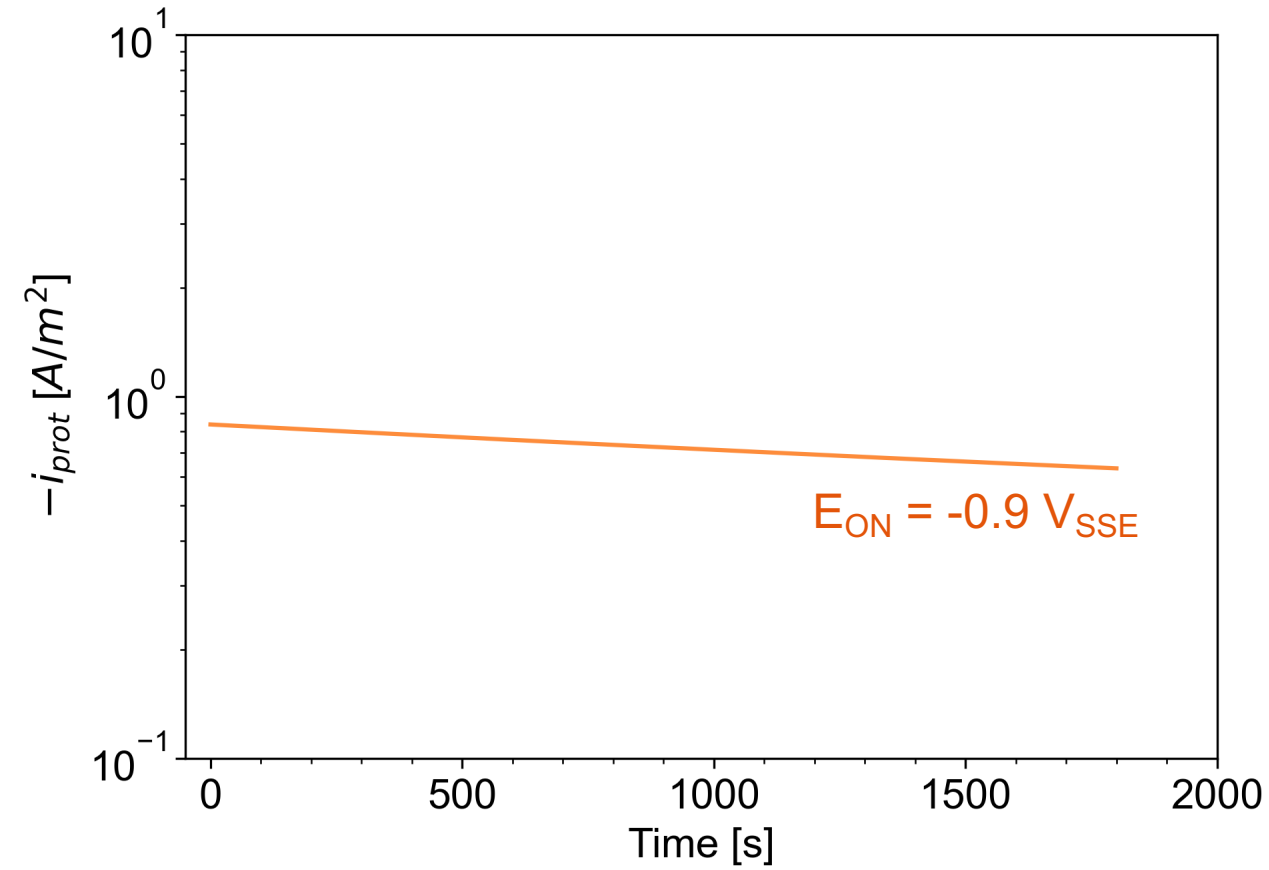


Methods – Photometric reflectance measurements (PRM)

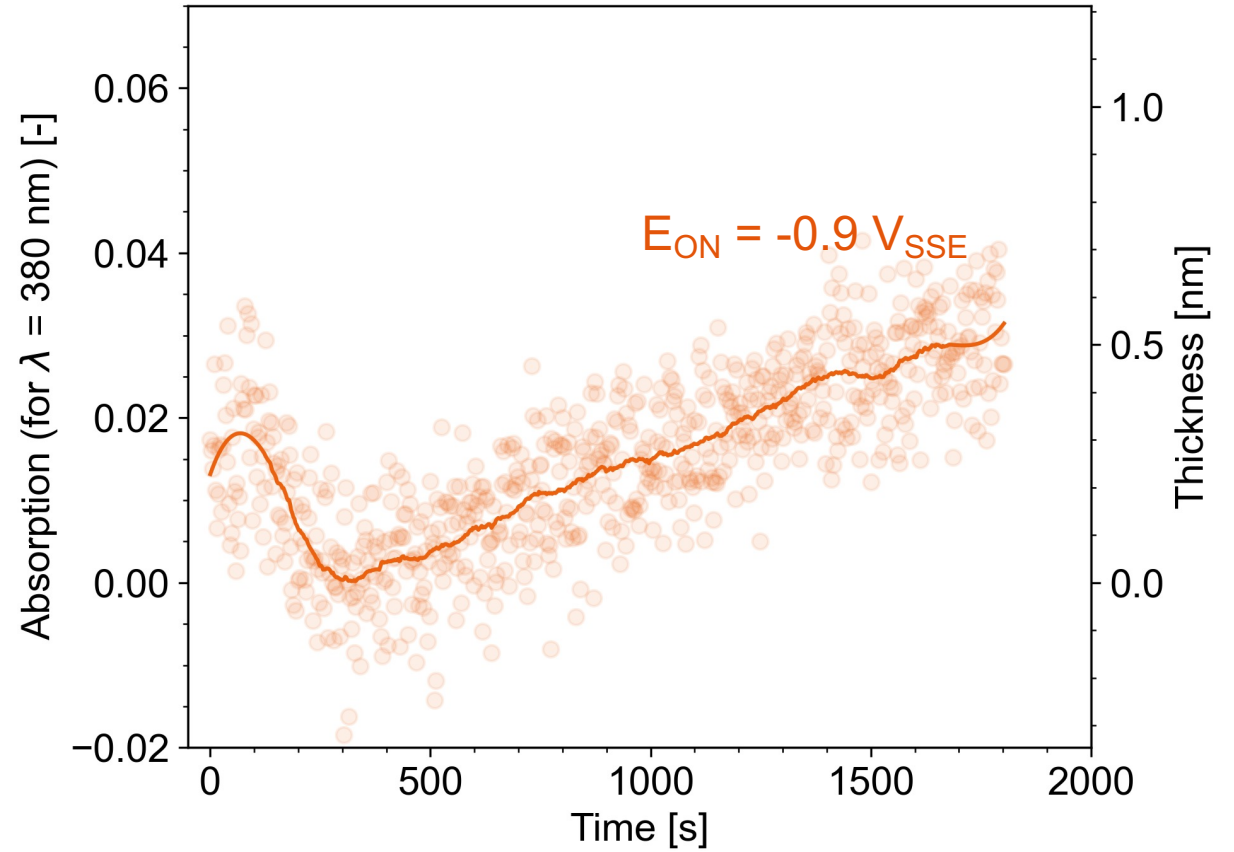
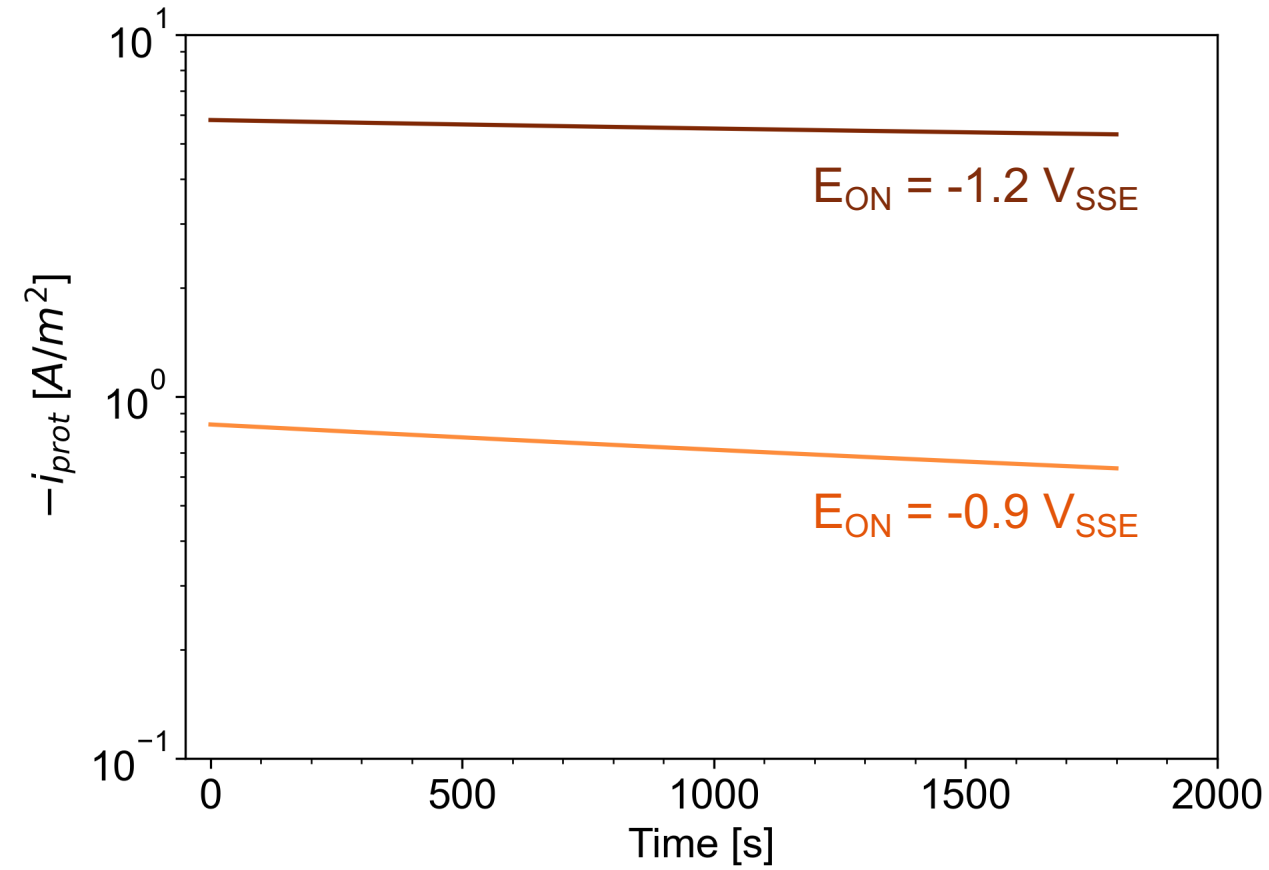


Data evaluated at 380 nm to allow estimation of oxide film thickness

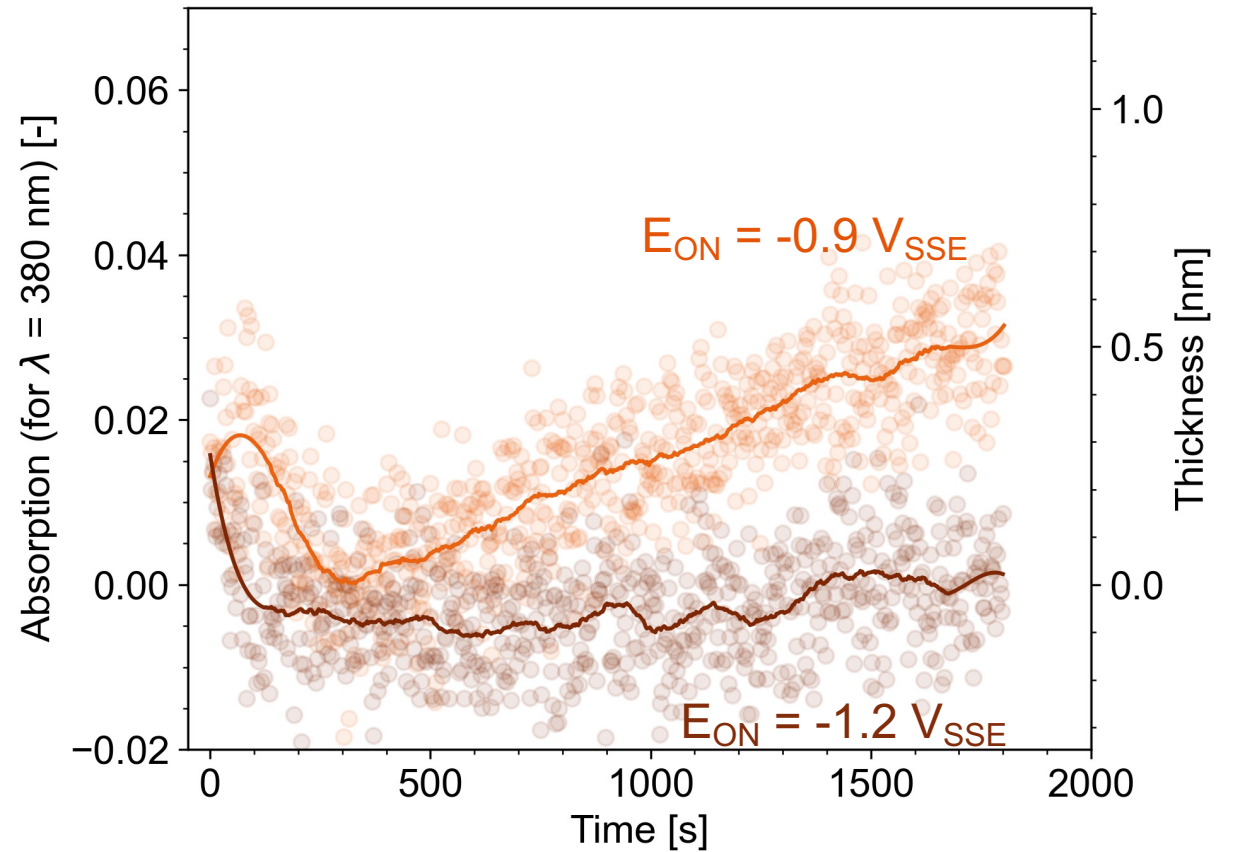
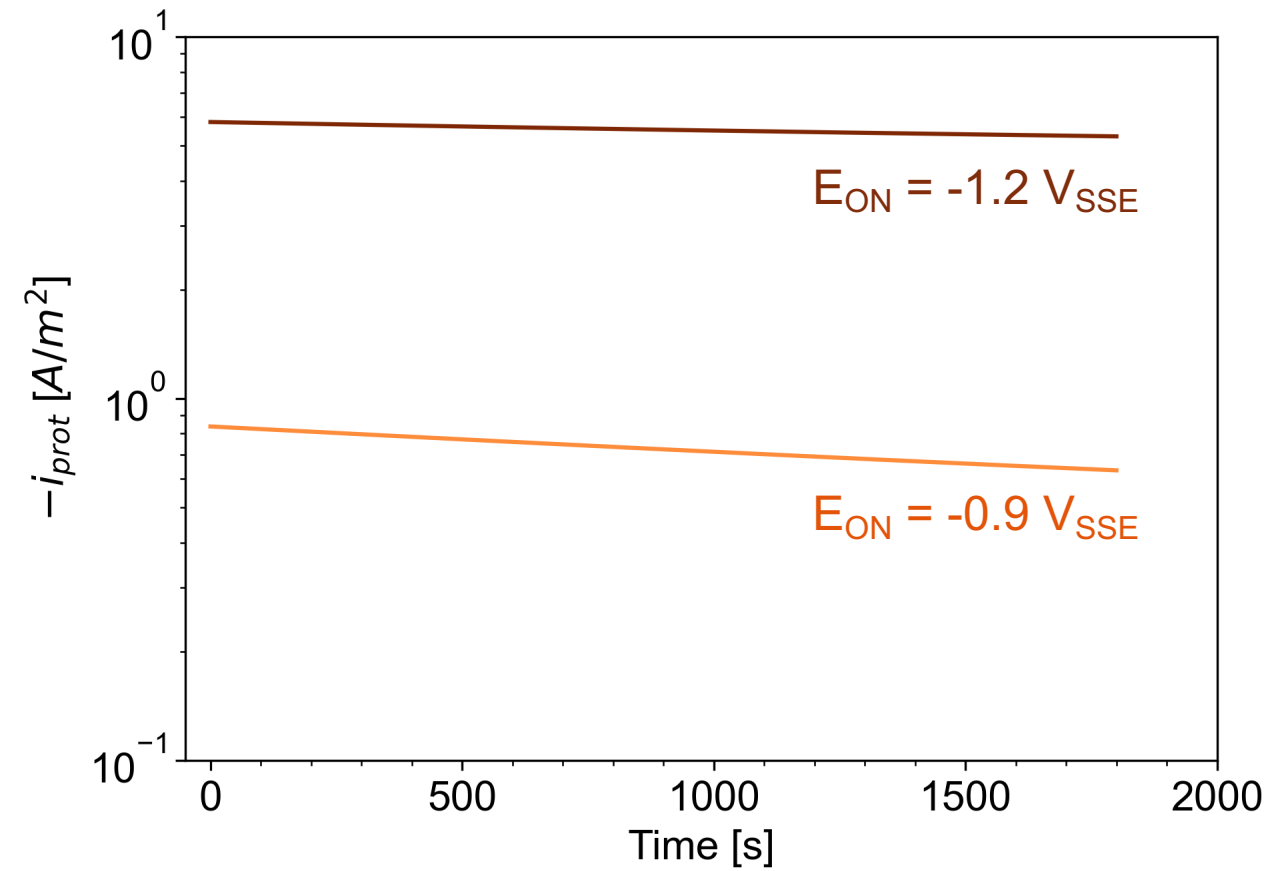
In-situ PRM upon CP



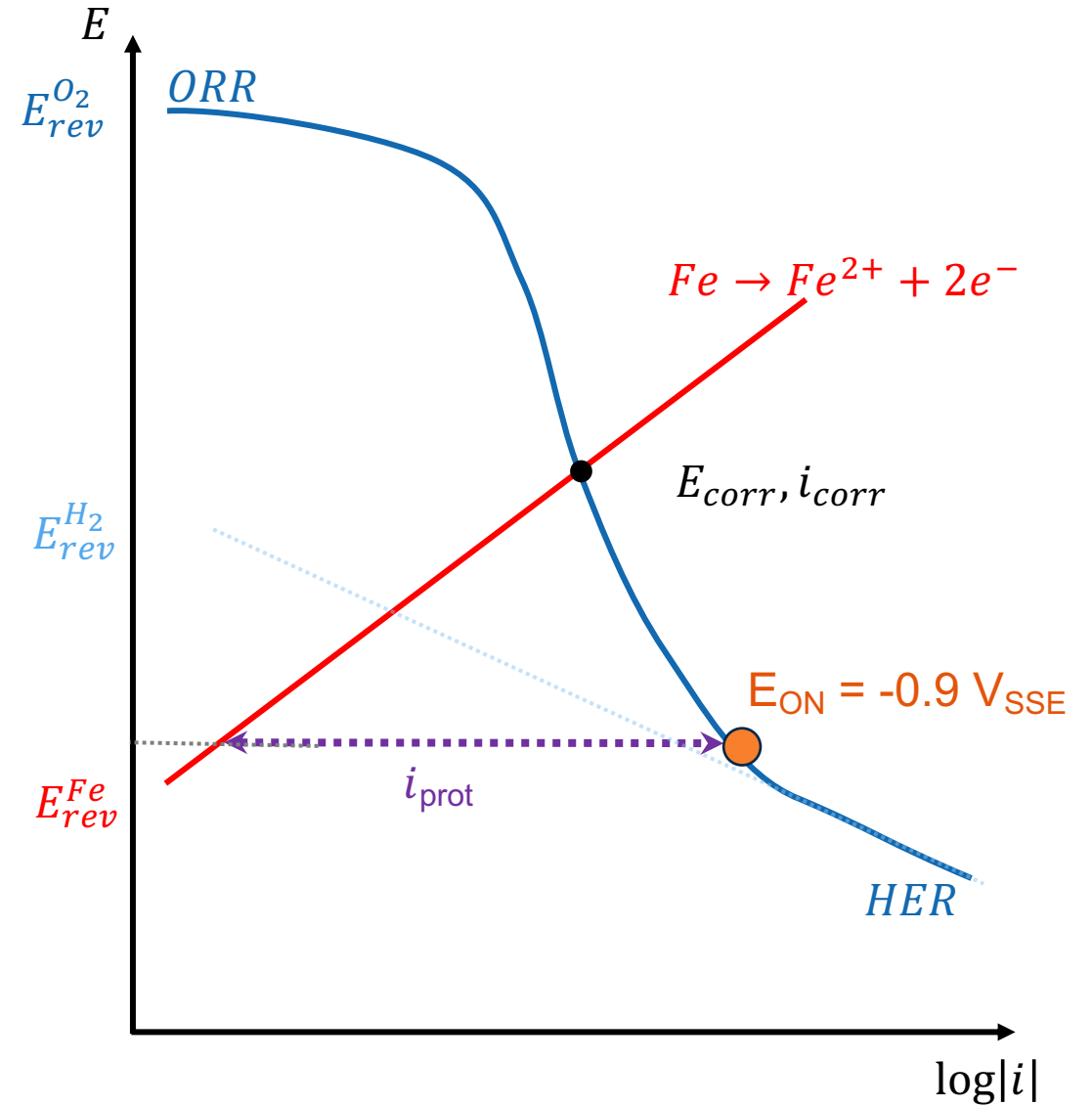
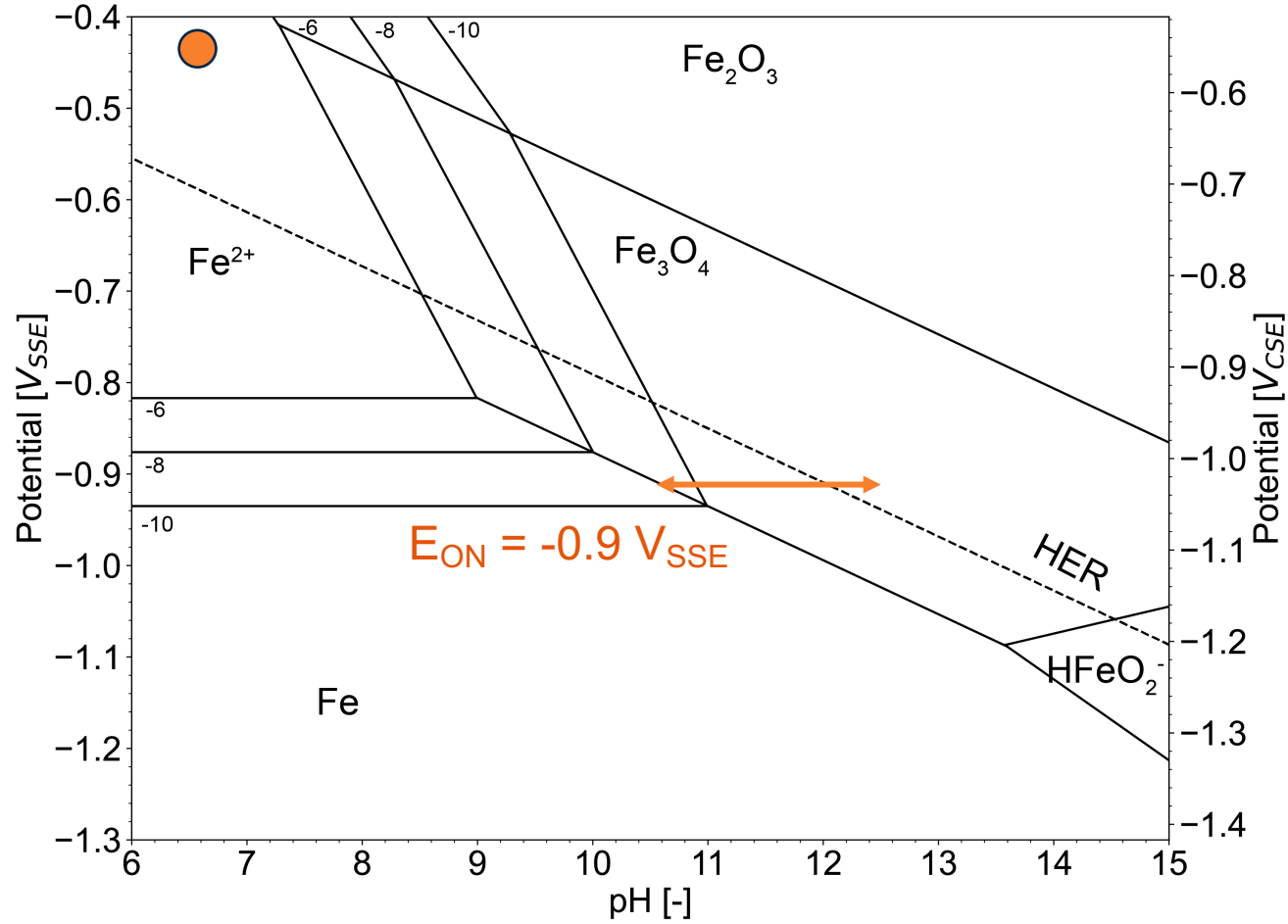
In-situ PRM upon CP



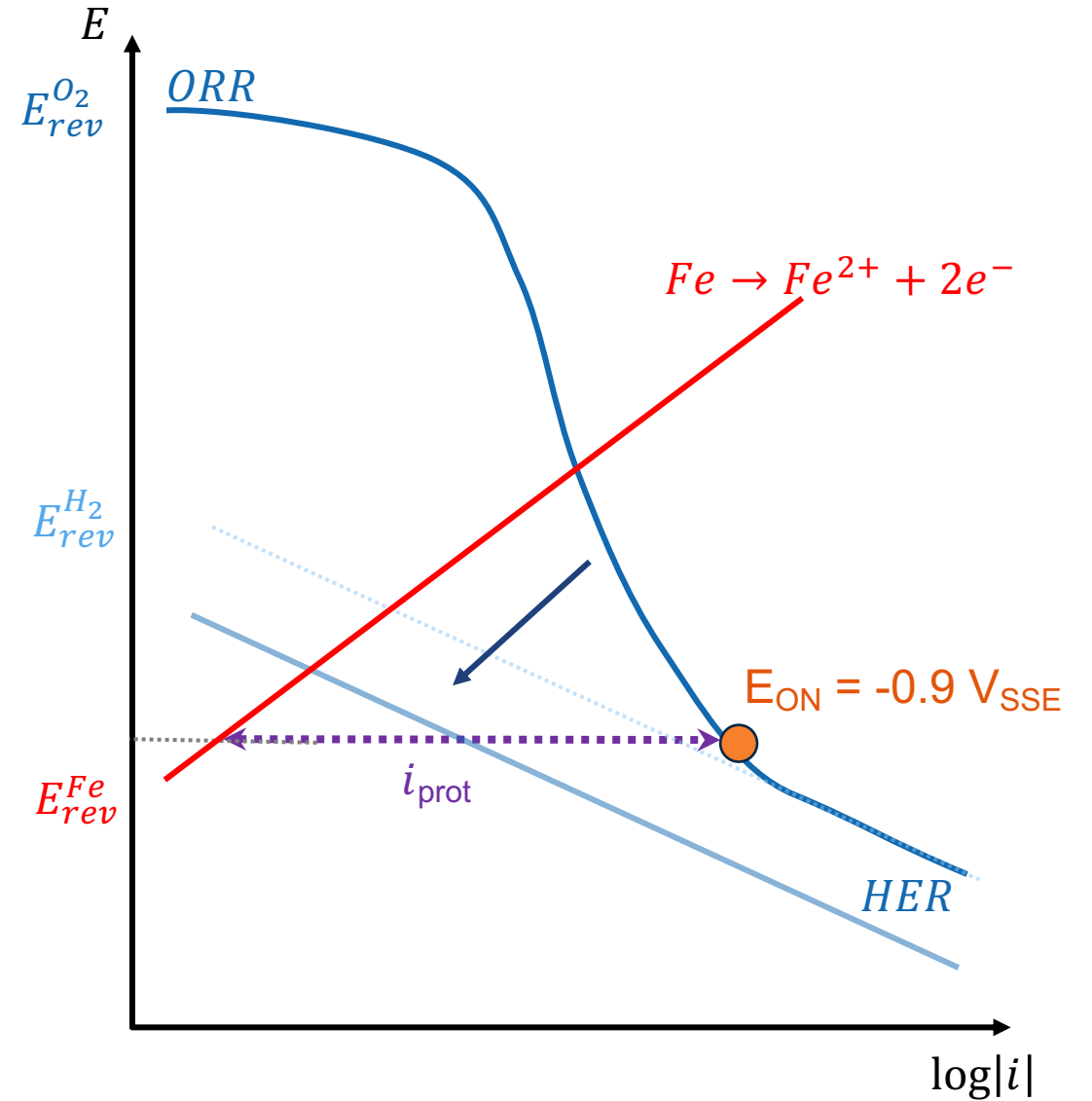
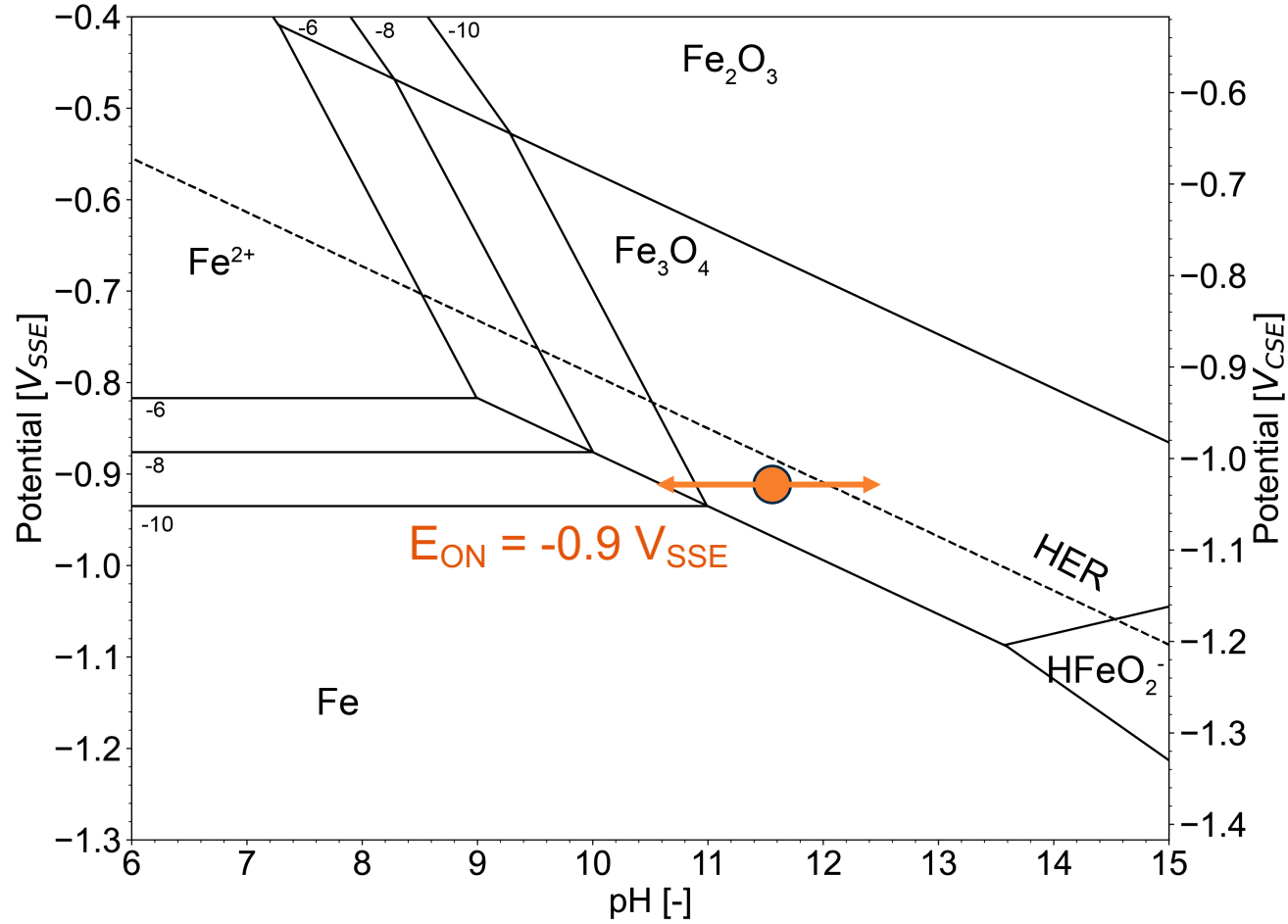
In-situ PRM upon CP



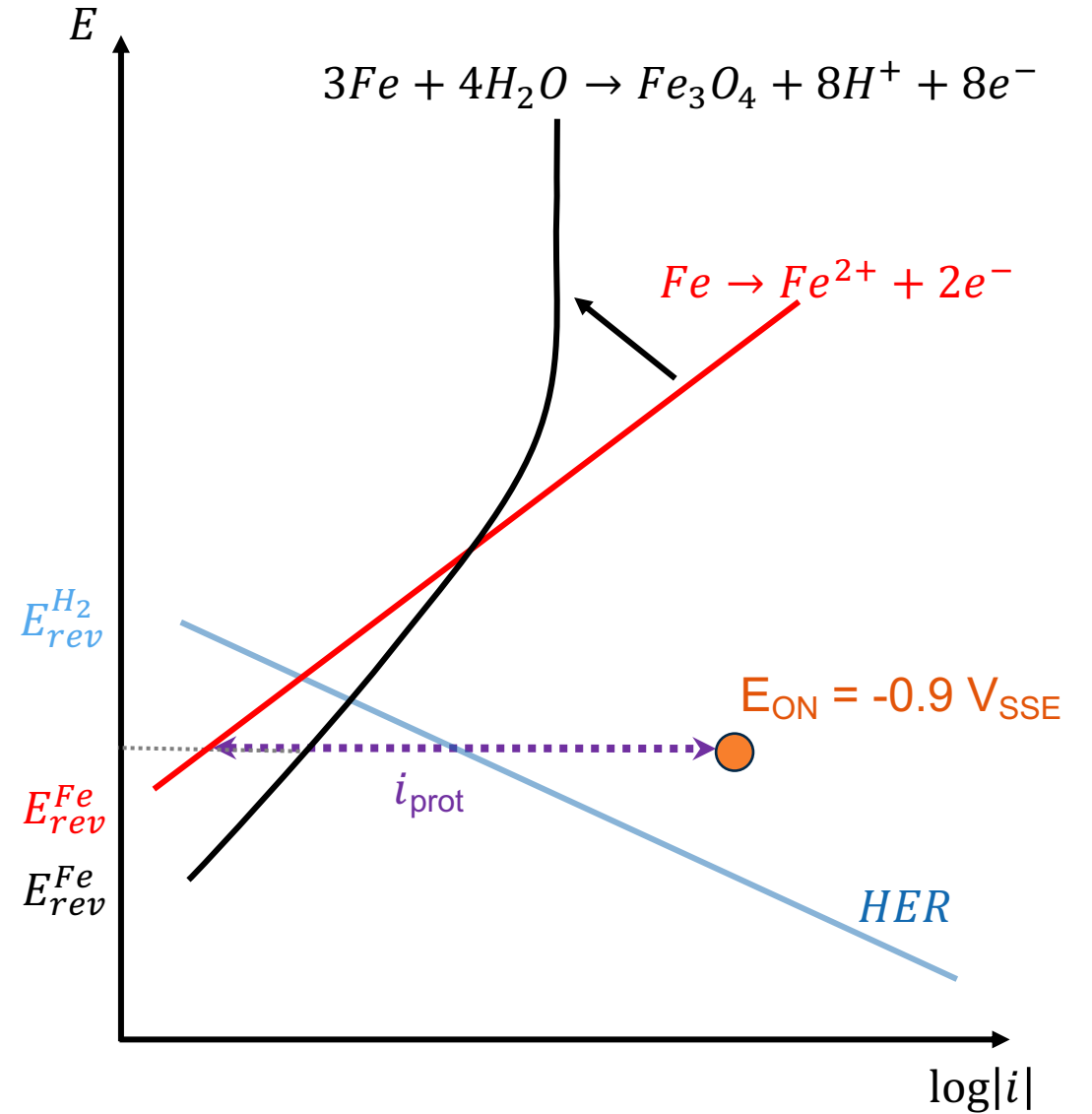
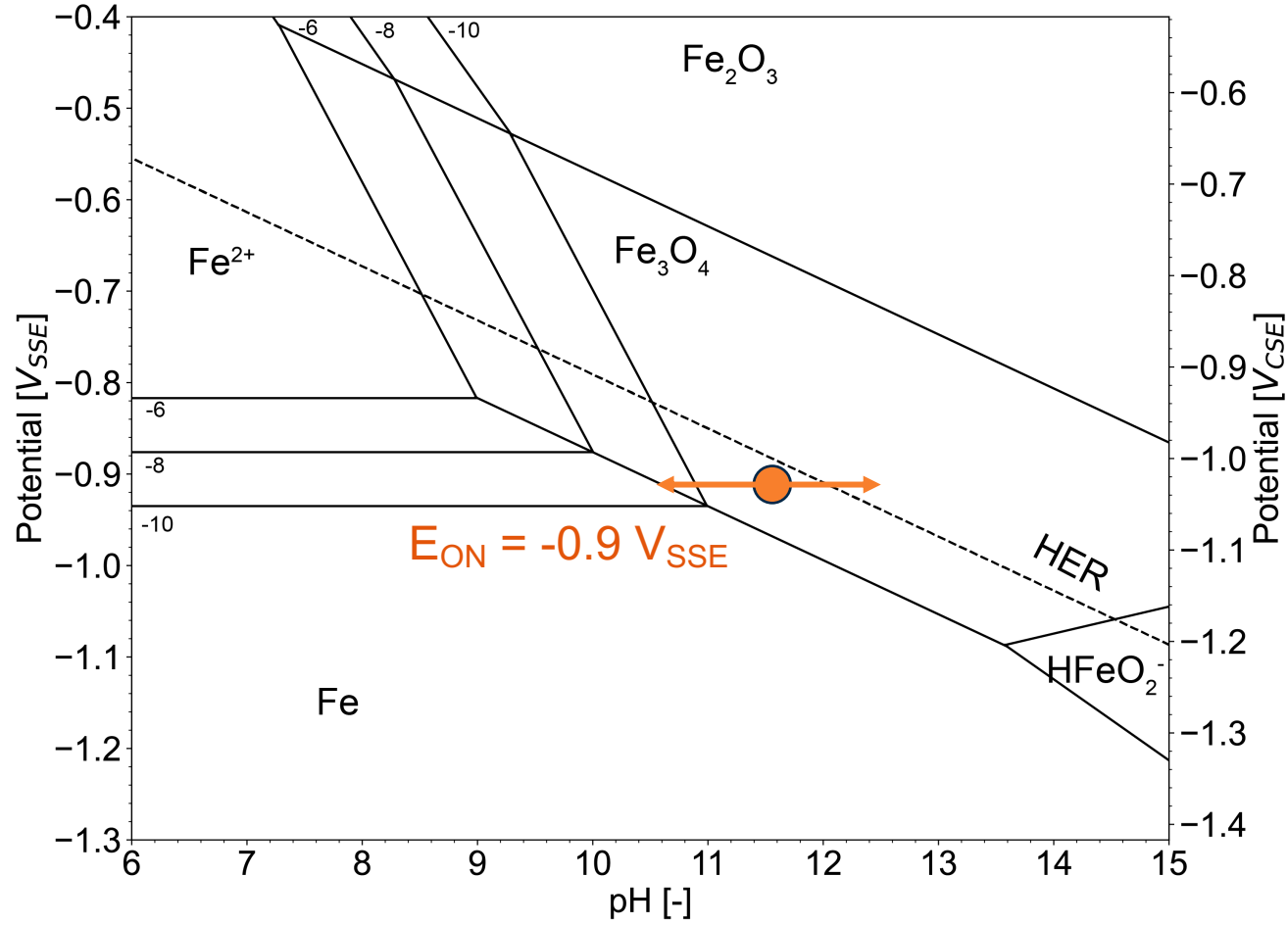
Thermodynamic and kinetic considerations



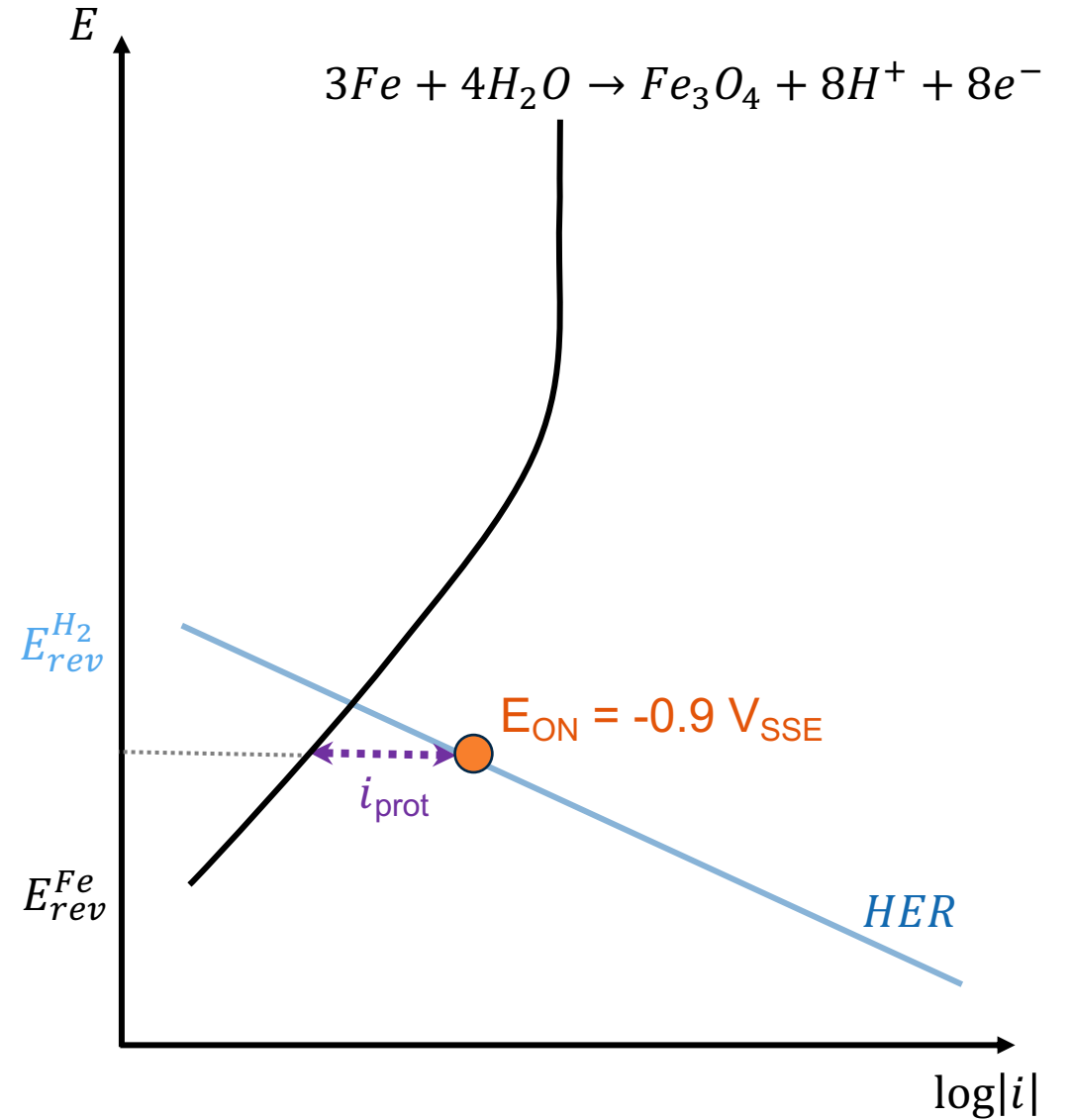
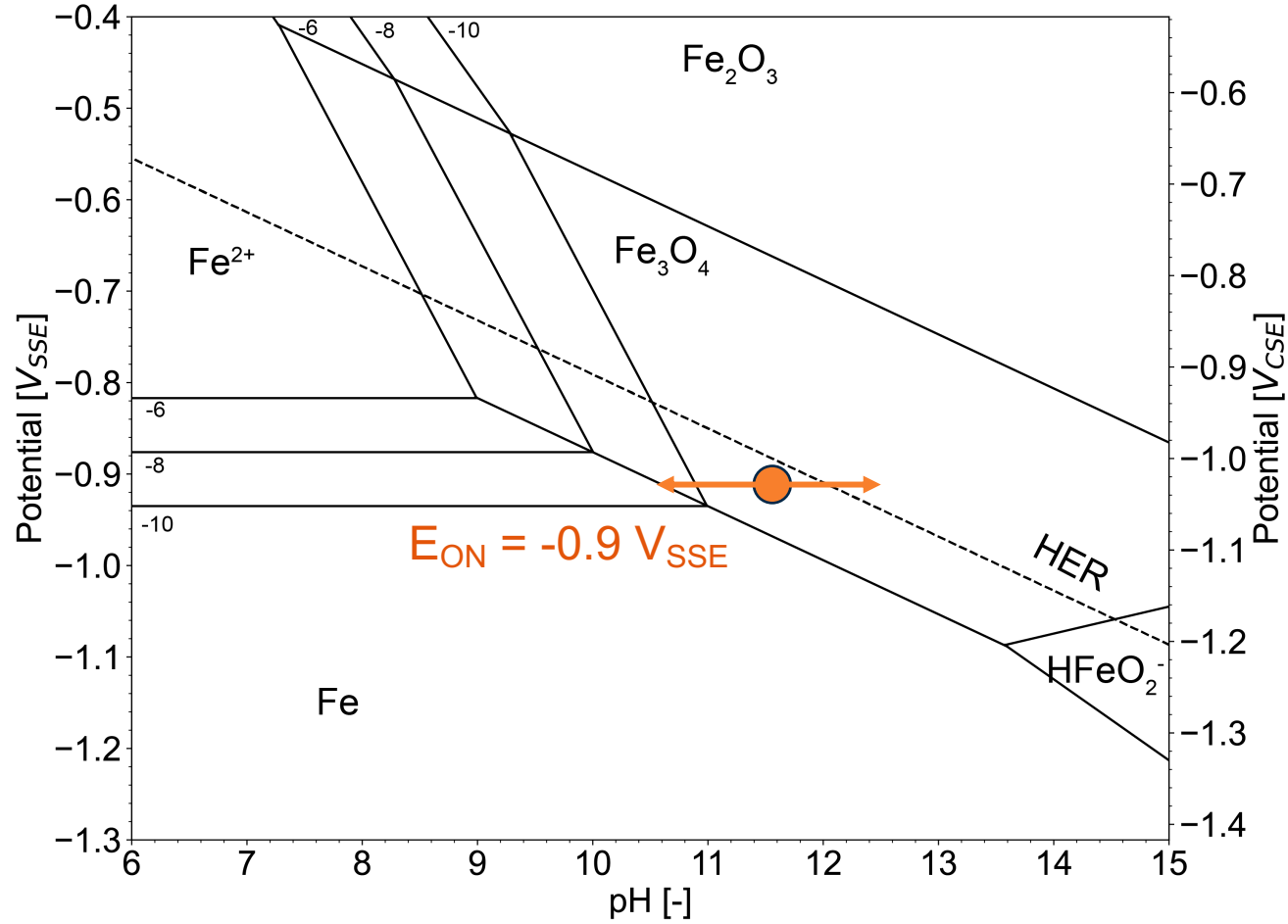
Thermodynamic and kinetic considerations



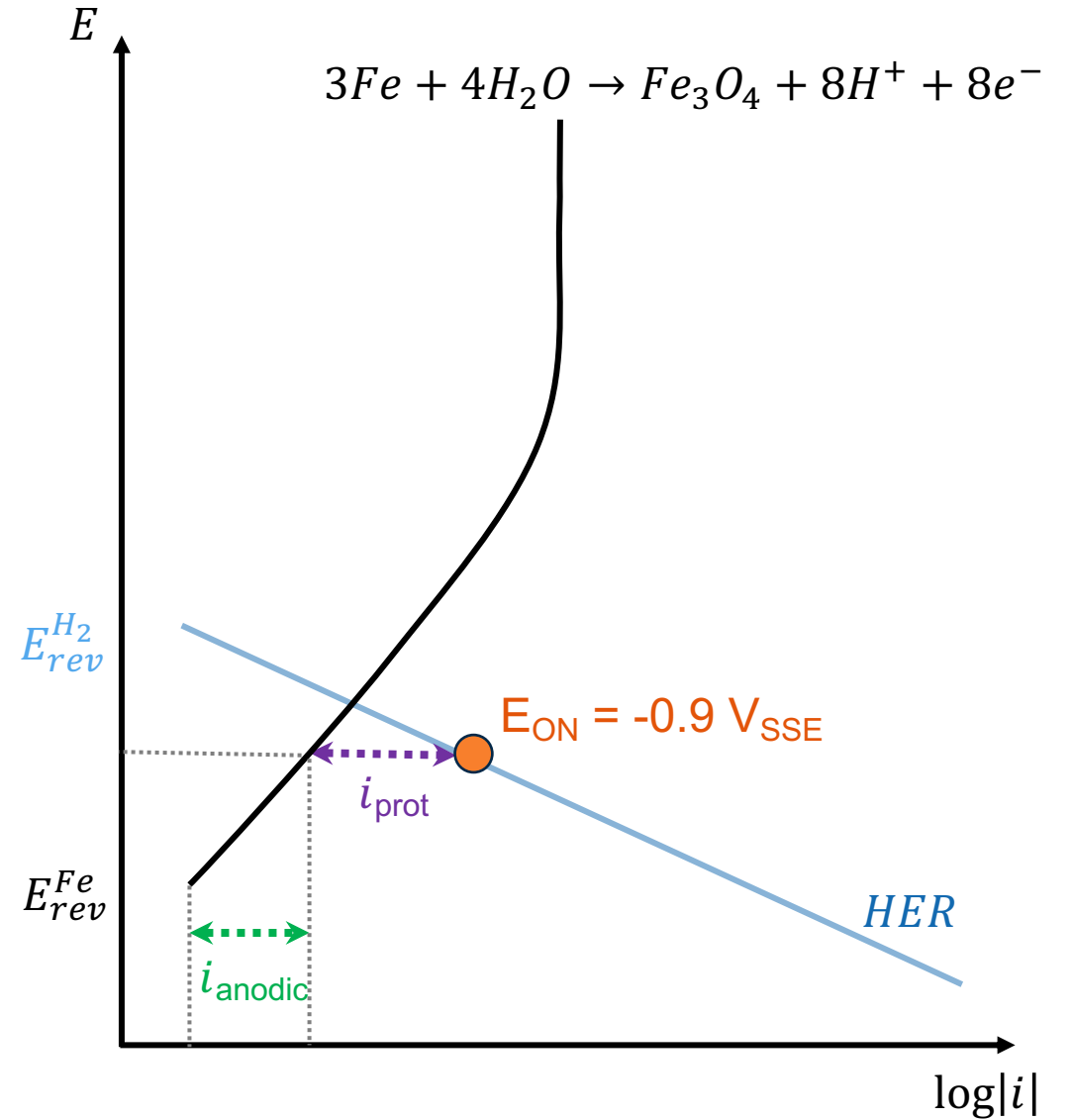
Thermodynamic and kinetic considerations



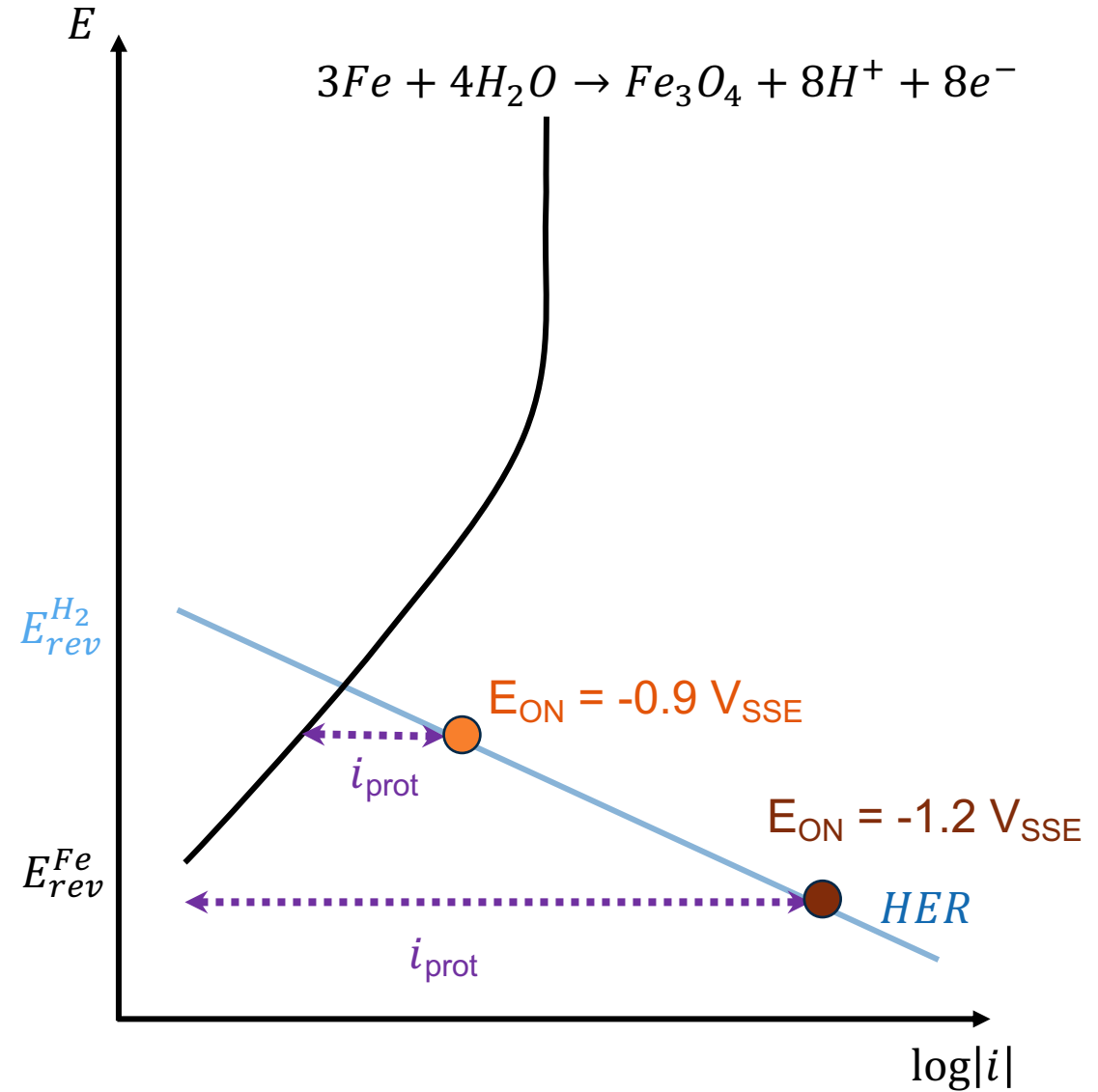
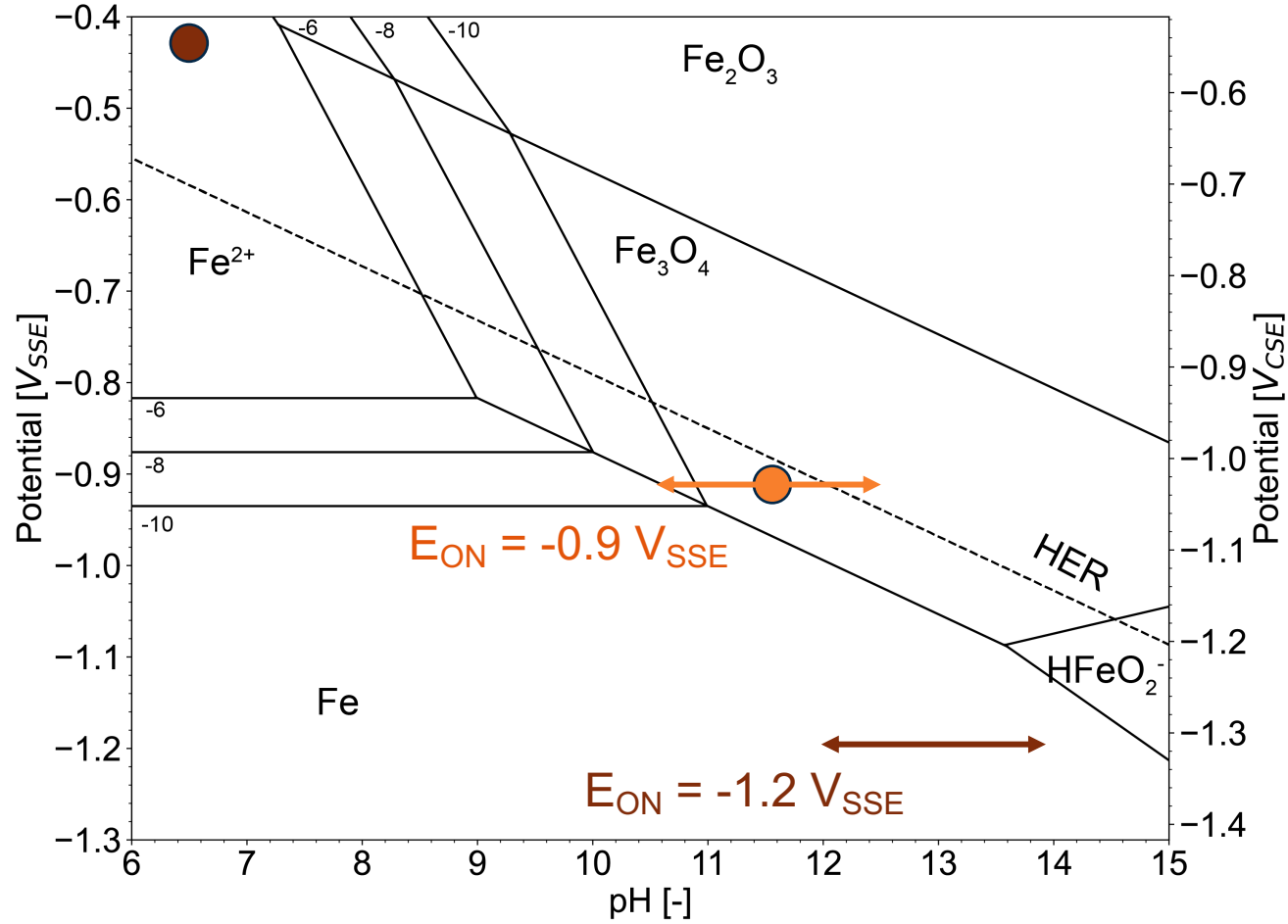
Thermodynamic and kinetic considerations



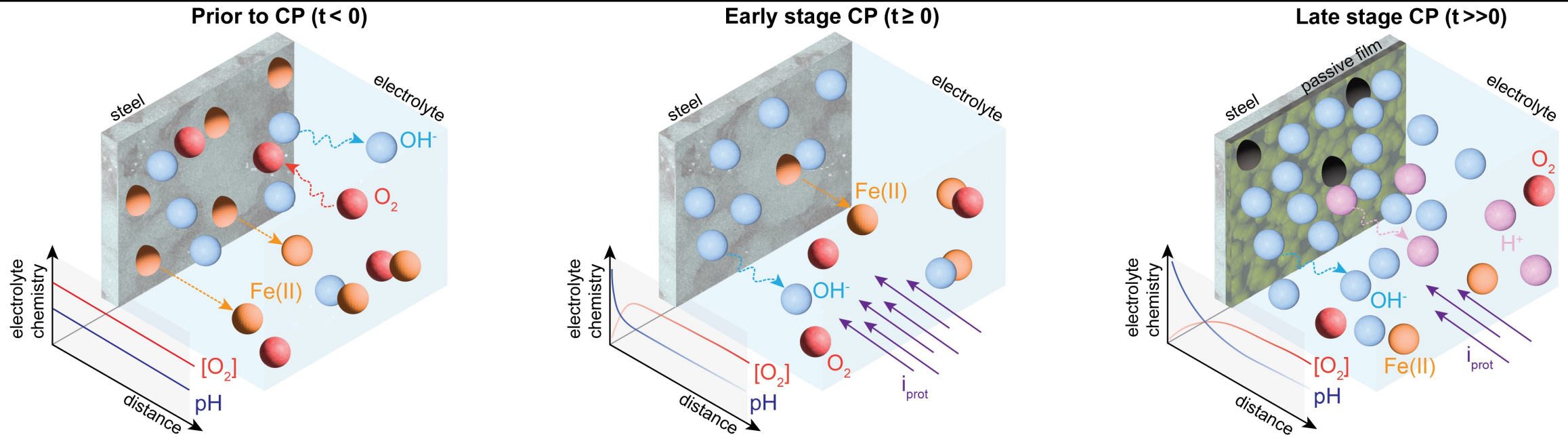
Thermodynamic and kinetic considerations



Thermodynamic and kinetic considerations



Conclusions



Pre-print available at: <http://arxiv.org/abs/2308.15953>

- Concentration polarization and activation polarization considered complementary
 - **Mechanism** described by **thermodynamic** and **kinetics** considerations
 - Possible formation of **oxide film** (mainly based on Fe_3O_4)
- If **alkalinity** is produced and the **potential** is above E_{rev}^{Fe} , the **oxide film** can be formed
- **Thickness** of the film **increases** with the **time** of the experiment (up to 0.7 nm)

Thank you for your attention

Federico Martinelli-Orlando

fmartine@ethz.ch

www.linkedin.com/in/f-martinelliorlando



Visit us on: <https://ifb.ethz.ch/durability>

