Corrosion Assessment of Additively Manufactured Metals for Carbon Capture & Storage (CCS) Infrastructure

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9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION

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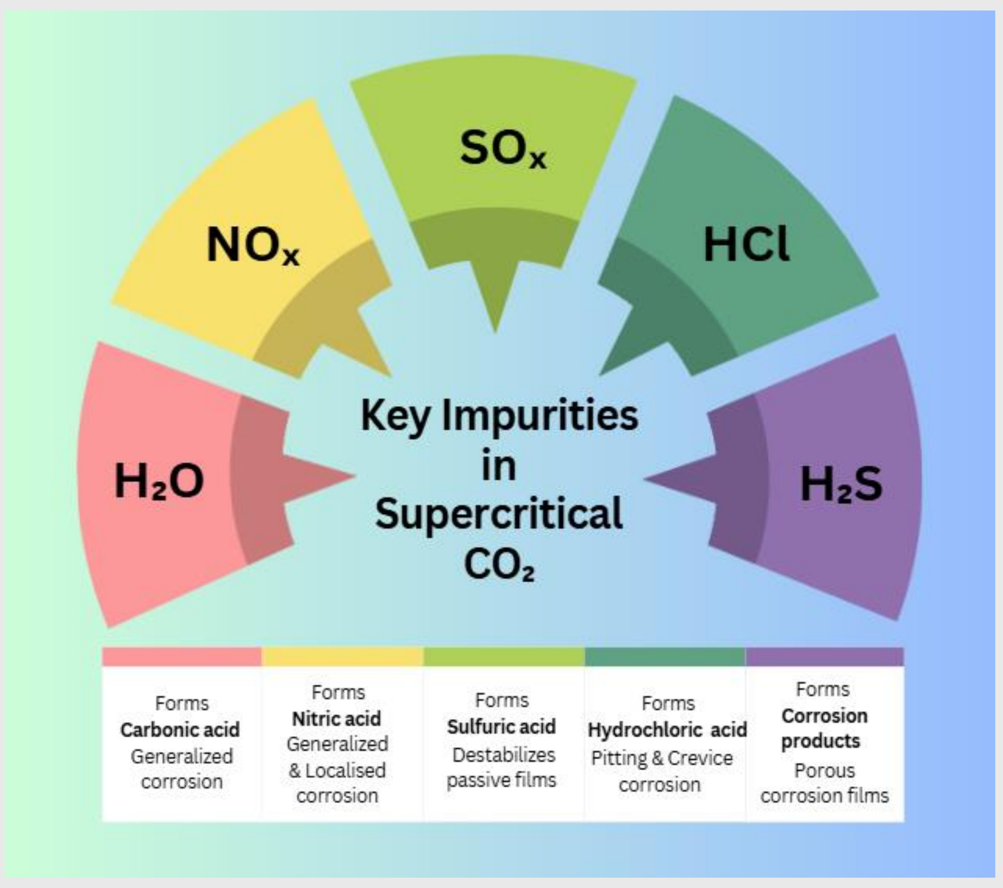
INTRODUCTION

CCS infrastructure is essential for achieving net-zero emissions but demands materials resistant to harsh CO_2-rich environments.

Conventional corrosion-resistant alloys (CRAs) face limitations due to impurity variations and limited data on performance in CCS conditions.

Additive manufacturing (AM) enables on-site, on-demand production with complex geometries, improved corrosion resistance, and supply chain independence, but its corrosion behavior remains unclear.



WHY CRAs ?

- Enhanced corrosion resistance in water + impurities
- Stable protective passive films
- Prevents localized corrosion
- Reduced downtime, maintenance and risk of failure

EMERGING TREND

Metal AM enables novel materials to be manufactured to address the corrosion challenges

RESEARCH GAPS / MOTIVATION

Lack of standardization in **corrosion testing methodologies** in impure CO_2–containing aqueous environments and **difficulty in replicating** and **translating lab results** to the **field conditions**

Challenging material selection - Corrosion behaviour varies with impurity interactions and conditions

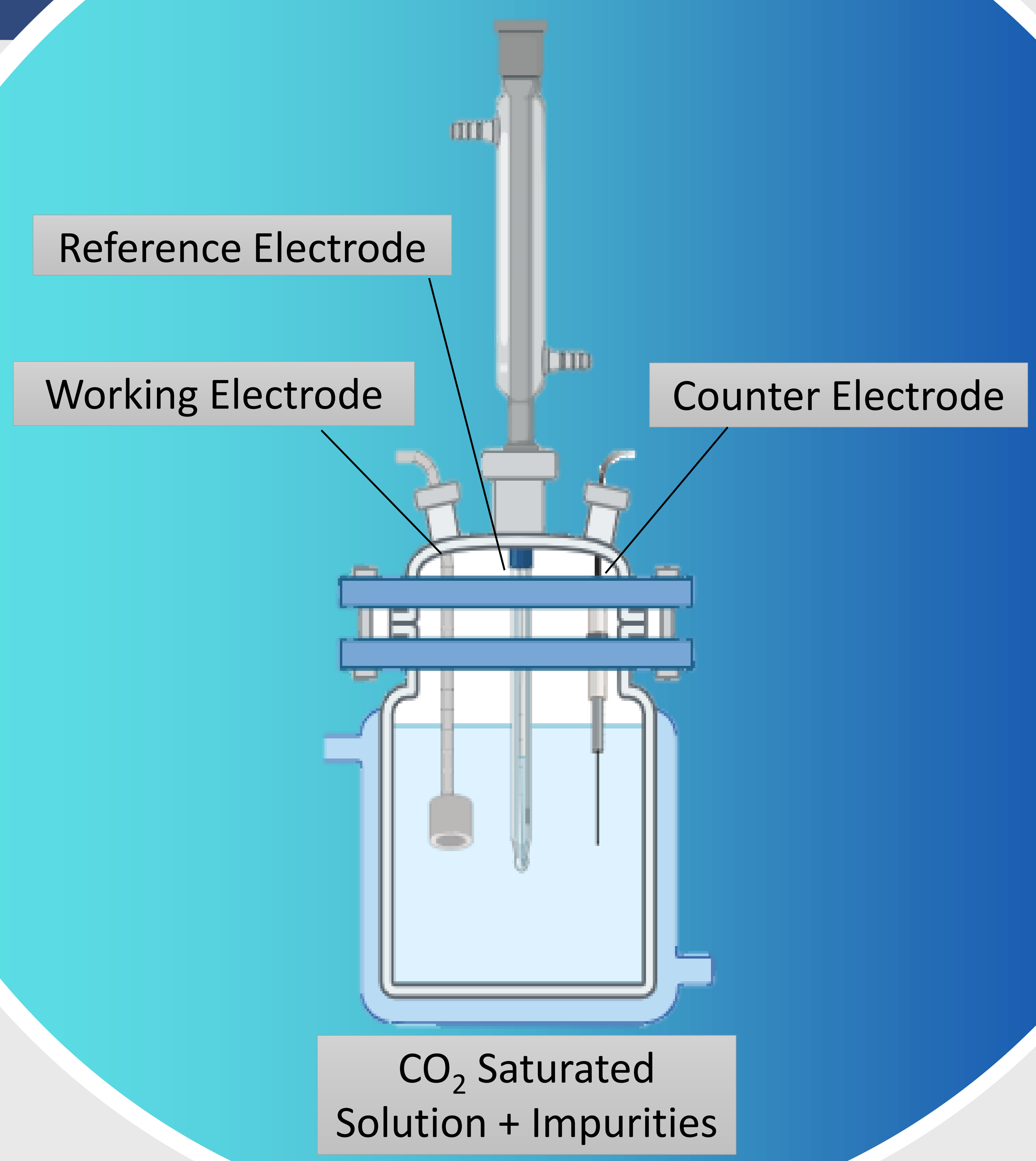
Lack of comprehensive studies on CRA's **& limited understanding of long-term durability** under real CCS conditions

AIMS & OBJECTIVES

Assess the **corrosion performance** of **AM corrosion-resistant alloys (CRAs)** in **CO_2-rich conditions** and evaluate if AM alloys can match or exceed conventional CRAs

- Develop corrosion testing methods simulating supercritical CO_2 with impurities (O_2, chlorides, acids, water).
- Establish baseline corrosion behaviour in simplified aqueous CO_2 environments.
- Compare corrosion performance of AM vs conventional CRAs in identical autoclave conditions.
- Investigate how AM process parameters and post-treatments affect corrosion mechanisms and microstructure.

Experimental Setup



METHODOLOGY

Electrochemical Test Method:
Cyclic Potentiodynamic Polarisation

- Breakdown potential
- Re-passivation potential

Materials :

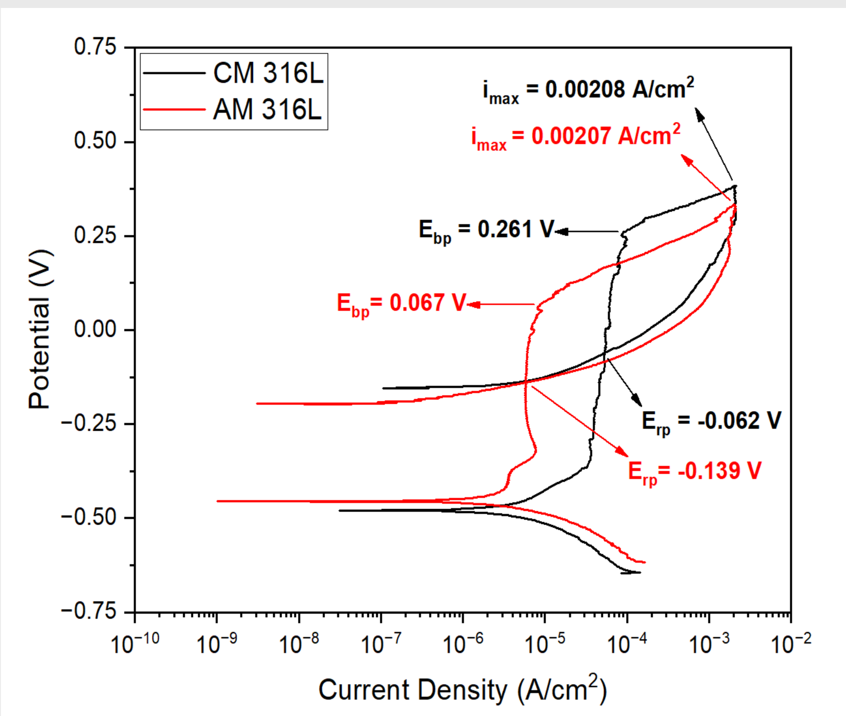
- Conventionally manufactured Stainless Steel, CM 316L
- Additively Manufactured Stainless Steel, AM 316L, produced by laser-powder bed fusion (LPBF)

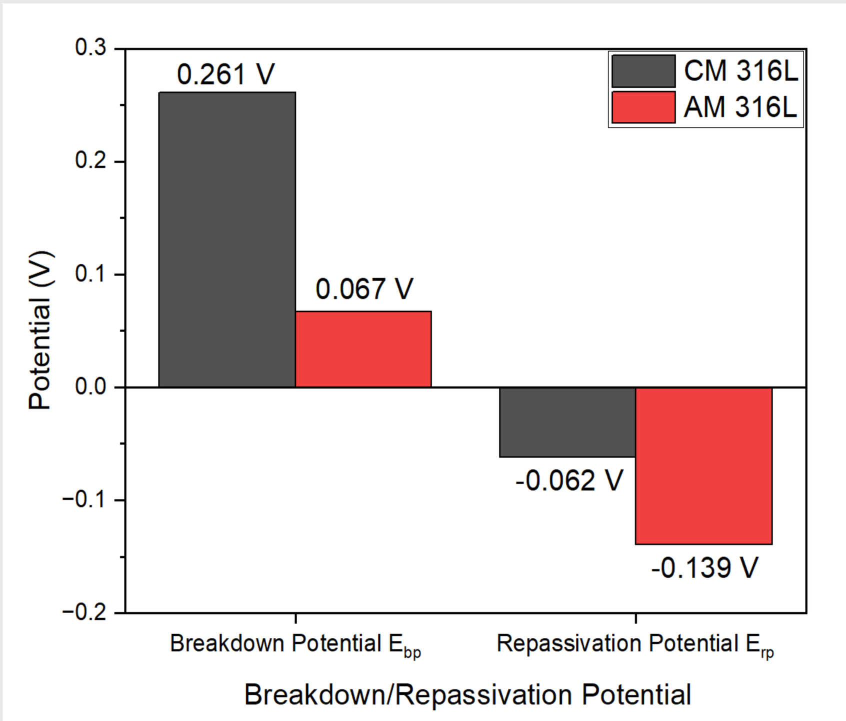
TEST CONDITIONS

- 3.5 wt% sodium chloride (NaCl)
- CO_2 saturated
- Pressure = atmospheric
- Temperature 30 ºC

PRELIMINARY RESULTS

Cyclic polarisation results CM 316L vs AM 316L





CONCLUSIONS & FUTURE WORK

- CM 316L shows **greater resistance** to pitting but a **higher passive current**, indicating a **less stable passive film**.
- AM 316L **repassivates more readily** and exhibits **lower passive current**, indicating a more **stable film** under general corrosion.
- AM alloys show **potential for corrosion performance comparable to conventional CRAs,** with further process optimization
- Further testing will be conducted to validate and develop **corrosion testing protocols in autoclaves** supported by **thermodynamic modelling**

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MSCA

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