Booth 1718

Electrochemical sensors for atmospheric corrosion monitoring and materials testing

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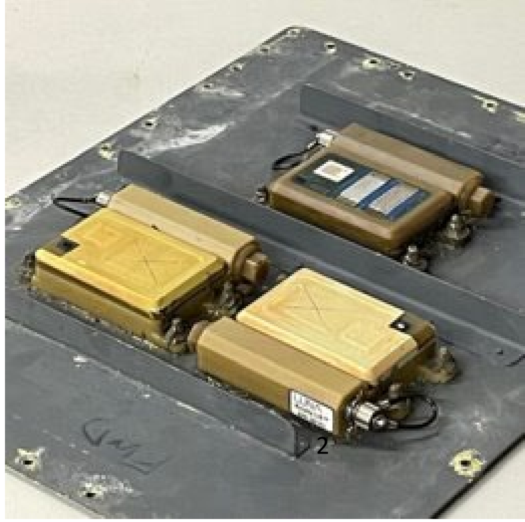
Issue and Objective

Atmospheric corrosion is a significant issue for transportation, infrastructure, and energy applications

There is a need to provide continuous environment and corrosion measurements for materials characterization and asset management

Electrochemical sensors and monitoring systems have been developed and standardized for atmospheric corrosion

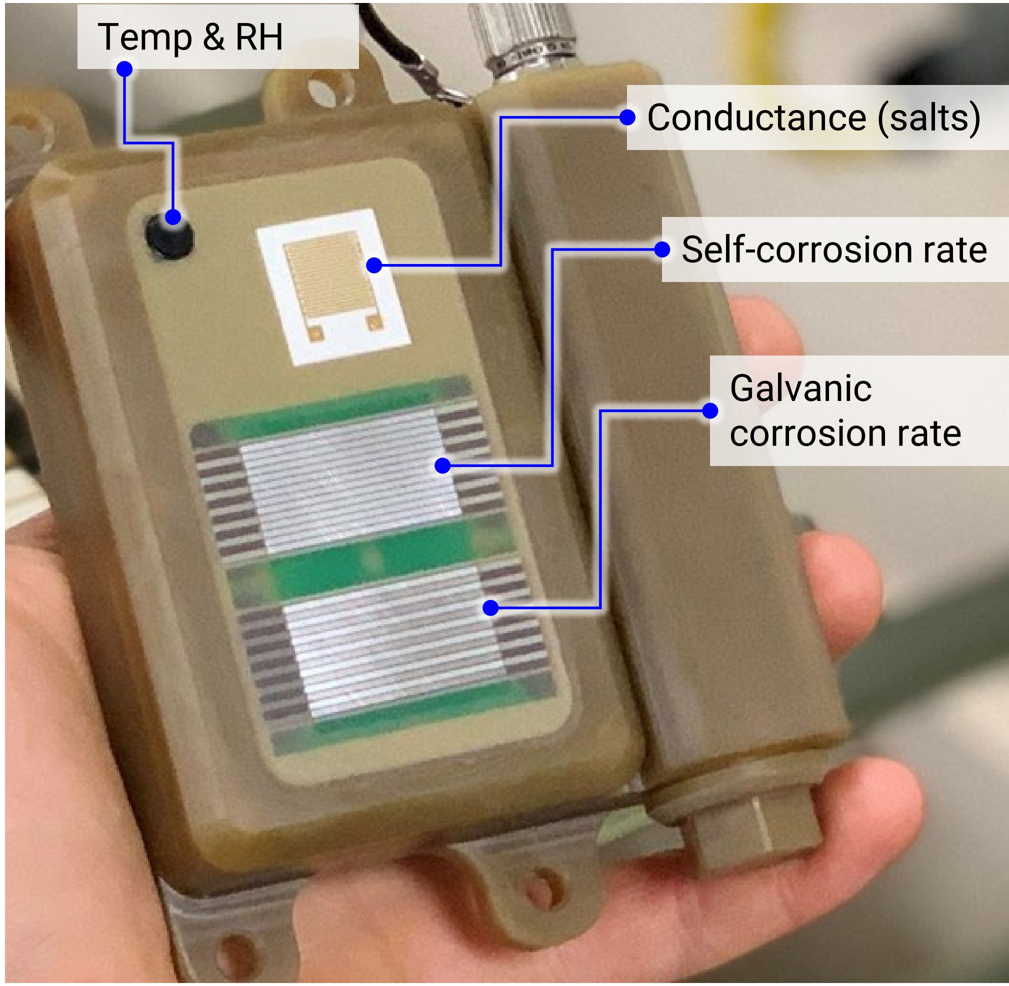


Measurement Parameters for Atmospheric Corrosion



- Humidity
- Temperature
- Contaminant or salt loading
- Corrosion rates

Small and lightweight
Periodic measurements and data storage
Autonomous, battery powered operation



Atmospheric Corrosion Measurements

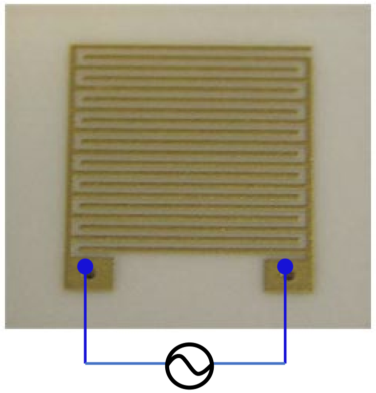
Measurements of conductance, self-corrosion, and galvanic corrosion are made using interdigitated electrodes (IDE)

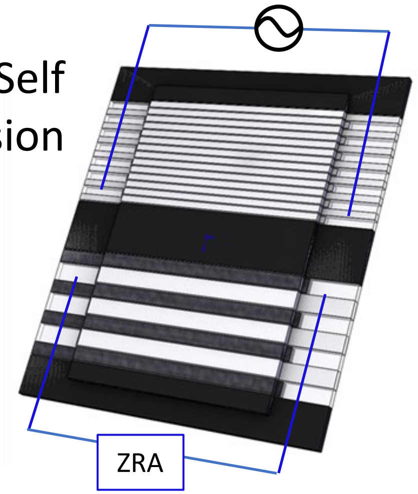
Two electrode measurements

- Conductance and self corrosion – impedance measurements using the same alloy or metal for each electrode
- Galvanic corrosion – zero resistance ammeter (ZRA) measurements using dissimilar materials using

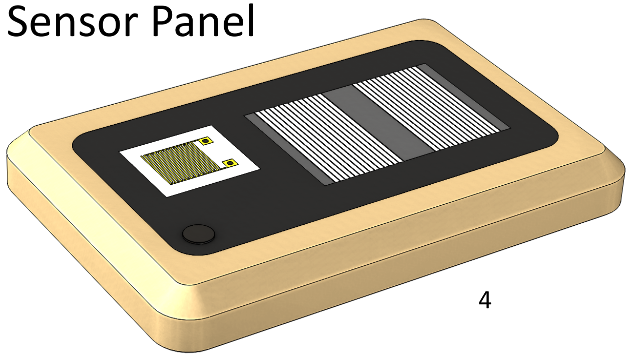
Measurement	Symbol	Range Min	Range Max	Units	Sensor Excitation
Air Temperature	T_a	-40	+85	°C	-
Relative Humidity	RH	0	100	%	-
Conductance (Low Freq)	G_L	0.005	1	µS	20 mV_{pp}, 10 Hz
Conductance (High Freq)	G_H	5	10,000	µS	20 mV_{pp}, 25 kHz
Galvanic Corrosion	I_g	0.01	100	µA	ZRA
Free Corrosion	I_c	0.005	100	µA	20 mV_{pp}, 0.5 Hz

Gold Conductance





Sensor Panel



Atmospheric Corrosion Measurements

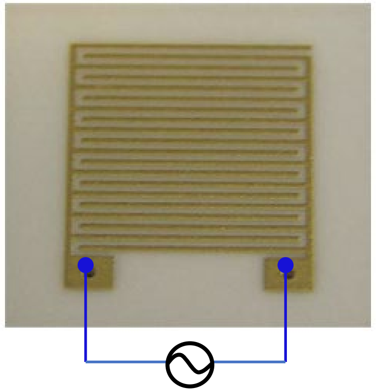
- High frequency gold IDE two electrode measurement used to determine solution resistance (conductance)

$$Z_{\omega \to \infty} = R_s$$

- Low frequency two electrode self corrosion measurement for polarization resistance

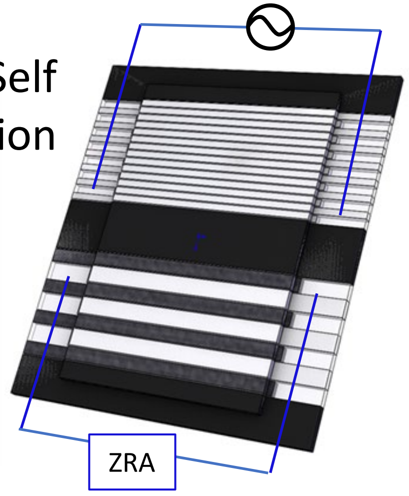
$$Z_{\omega \to 0} = 2R_p + R_s$$

Gold Conductance

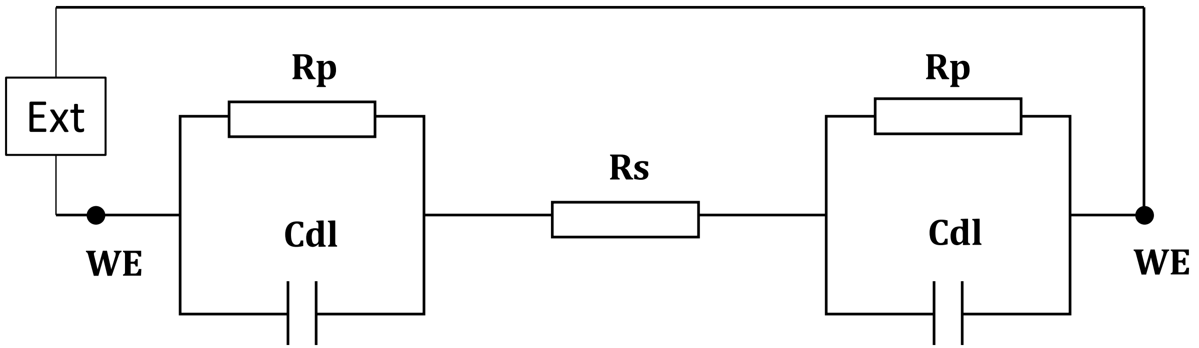


Self Corrosion

Galvanic Corrosion



Two electrode equivalent circuit



Corrosion Rate

The self corrosion current can be convert to a corrosion rate using the Stern-Geary Equation

$$R_{\mathrm{p}} = \frac{(\Delta E)}{(\Delta I)_{\Delta E \to 0}} = \frac{\beta_a \beta_c}{2{,}3 I_{\mathrm{corr}} (\beta_a + \beta_c)} \quad \text{or} \quad \frac{\beta}{I_{\mathrm{corr}}} \quad \text{therefore} \quad I_{\mathrm{corr}} \propto \frac{1}{R_{\mathrm{p}}}$$

- Requires either Tafel slopes or empirically derived constants for the sensor alloy

The ZRA current measurement is a direct measure of galvanic corrosion rate

Mass loss and thickness loss can be determined using Faraday's Law and the corrosion rate

* Application of Stern-Geary and thickness loss calculations depend on mechanism of attack, and are not appropriate for localized corrosion

Example Data – Outdoor Exposure

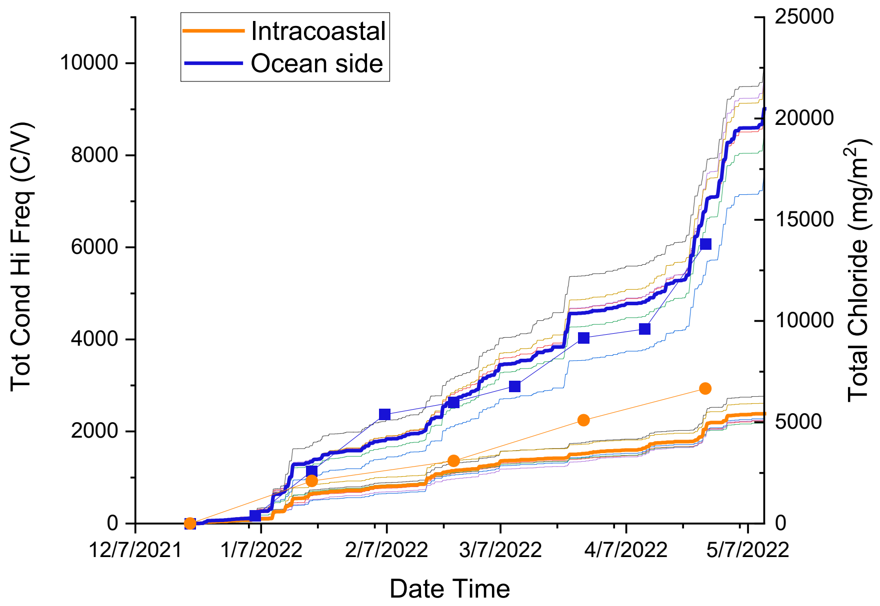
Electrochemical measurements can be used to determine site severity

- Conductance and wet candle measurements at two marine sites 800 m apart

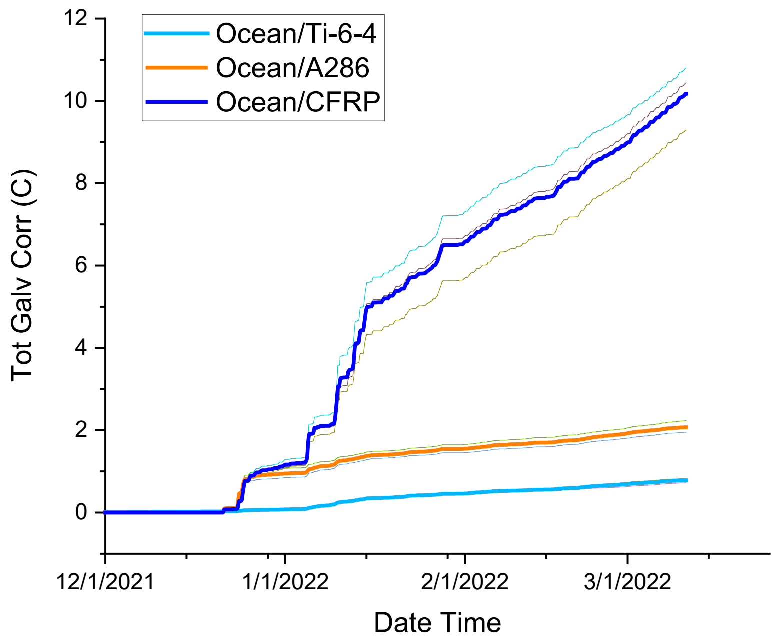
Alloy corrosion rates can be compared under the same environmental conditions

- Aluminum alloy galvanic compatibility at a single test site

Chloride Deposition



Corrosion of AA7075-T6

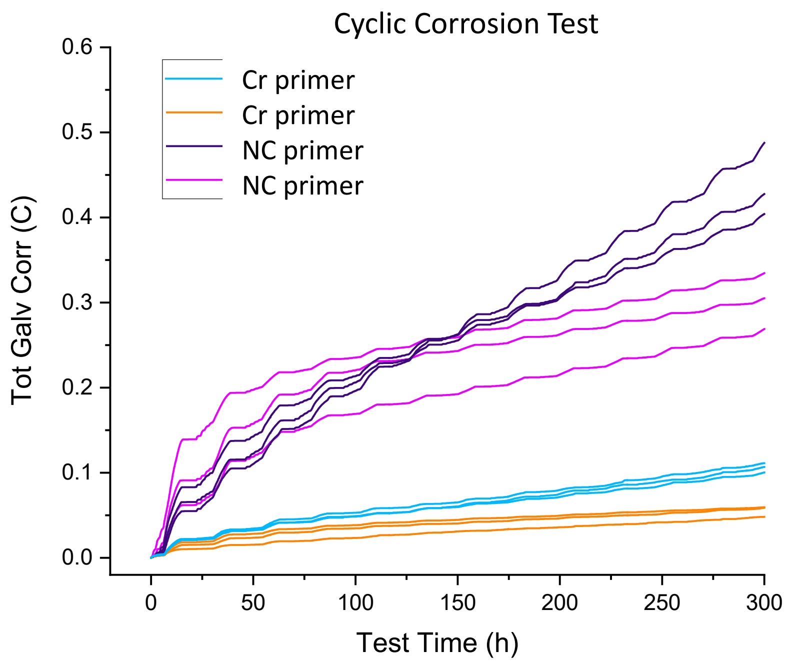


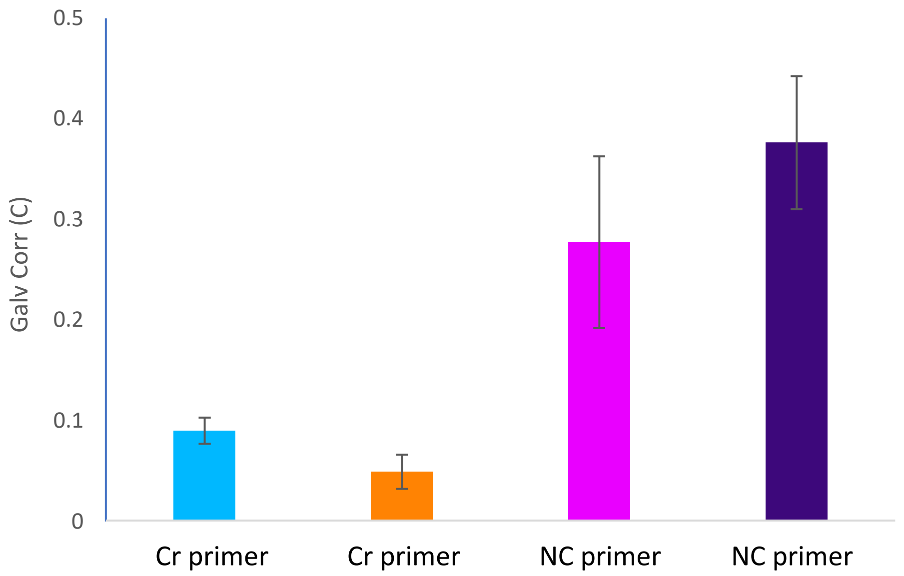
AA7075-T6 Galvanic Couple

Alloys	Corr Ratio
CFRP/A286	5
CFRP/Ti64	13
A286/Ti64	3

Example Data – Laboratory Coating Test

Coating performance can be quantified throughout an exposure test





Summary

- Electrochemical sensors and measurement systems can be used for continuous monitoring of environment conditions and corrosion in laboratory tests, outdoor exposures, and on assets
- Site severity can be assessed with multiple environment and corrosion parameters
- Alloy and coating performance can be quantified continuously throughout a test or exposure

ANSI NACE INTERNATIONAL

ANSI/NACE TM0416-2016

Test Method For Monitoring Atmospheric Corrosion Rate

AMPP™

TM21449 Continuous Measurements for Determination of Coating Protective Properties

AMPP™

AD HOC I-SC 07 Environment Spectra and Severity Classification

Standards About us News Taking part Store EN ☰ MENU

ISO

ICS › 77 › 77.060

ISO 22858:2020

Corrosion of metals and alloys — Electrochemical measurements — Test method for monitoring atmospheric corrosion

SAE INTERNATIONAL

WIP 2012-01-17

Atmospheric Corrosion Monitoring Informational Report

AIR6970

Sensors

Coatings Performance

Asset Tracking Systems

Environment Spectra

ACUITY corrosion technology

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