Applications of scanning probe electrochemistry– Corrosion & Coatings

SCAN-Lab

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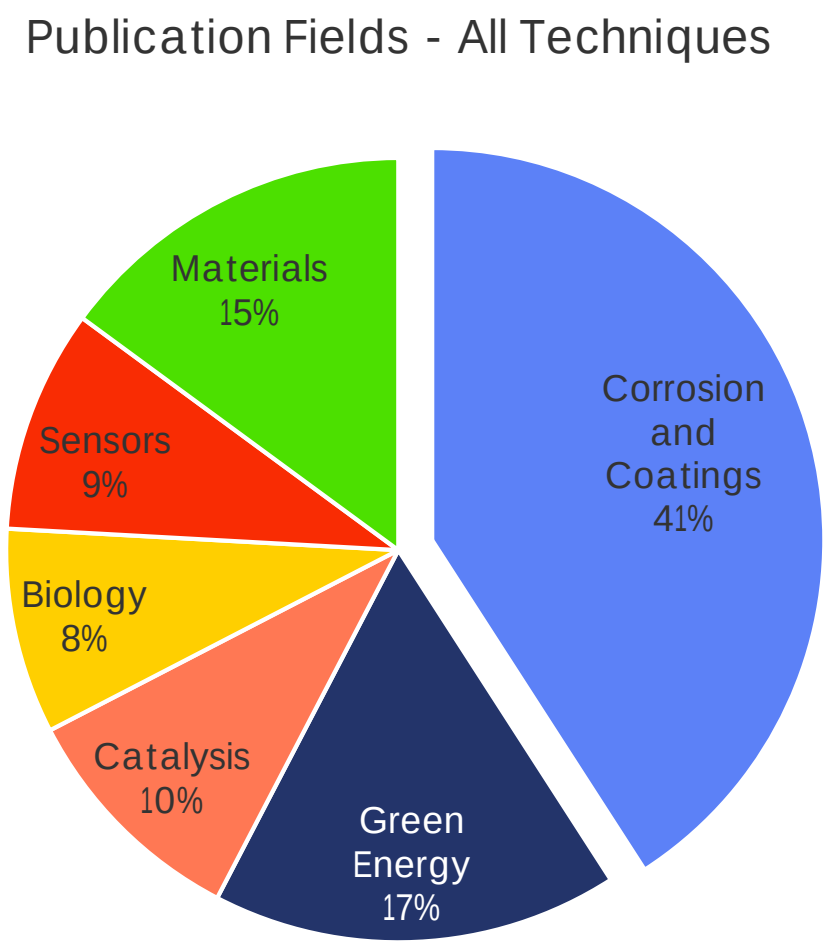
Background

Background

41% of commercial scanning probe electrochemistry instruments are used in the related fields of corrosion and coatings. The global cost of corrosion is estimated at $2.5 trillion, with corrosion control having the potential to save $375-875 billion annually [1].

This document will further investigate the role of scanning probe electrochemistry in the fields of corrosion and coatings.

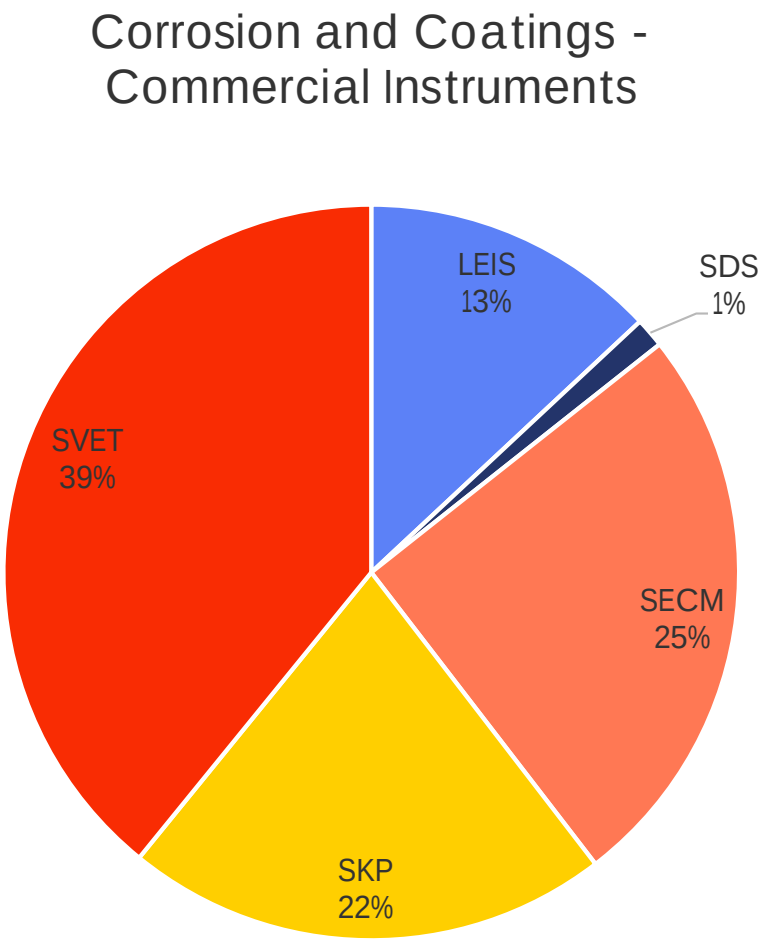


Why is scanning probe electrochemistry applied in corrosion and coatings?

Scanning probe electrochemistry is applied to the study of corrosion and coatings to perform fundamental R&D studies into corrosion prevention, and corrosion mechanisms.
Scanning probe electrochemistry is used in corrosion and coatings research to:

- Understand the causes of coating failure
- Investigate the effectiveness of novel coatings
- Study the self-healing properties of smart coatings
- Examine localized corrosion of pure and alloyed metals
- Determine the initiation of corrosion and follow its evolution
- Investigate the effect of material features on corrosion

What techniques are used?



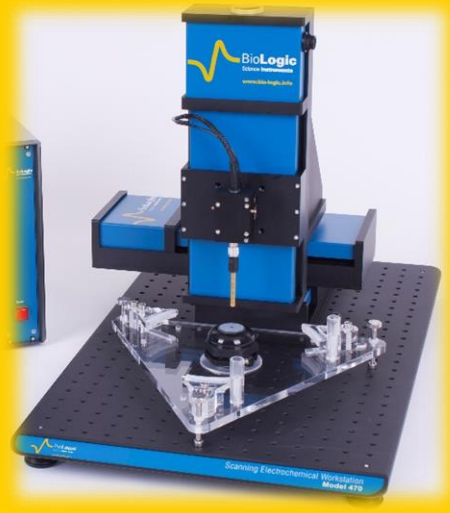
All SCAN-Lab scanning probe electrochemistry techniques have been applied to corrosion and coatings research. The most popular technique for corrosion and coatings research is SVET, followed by SECM and then SKP.

Source: Analysis of all scientific publications retrieved through Google Scholar citing commercial instruments (all known manufacturers). Each research group was only counted once per technique.

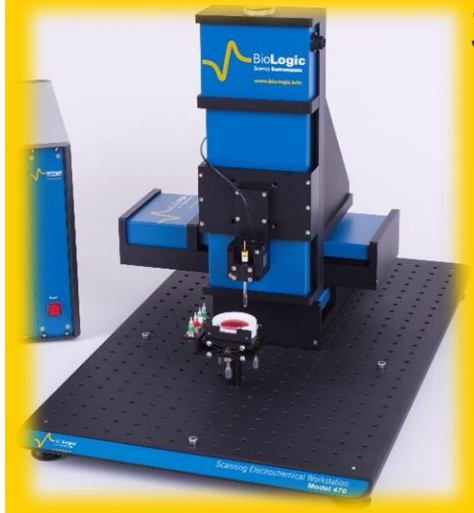
What techniques to consider for corrosion and coatings?

SVET

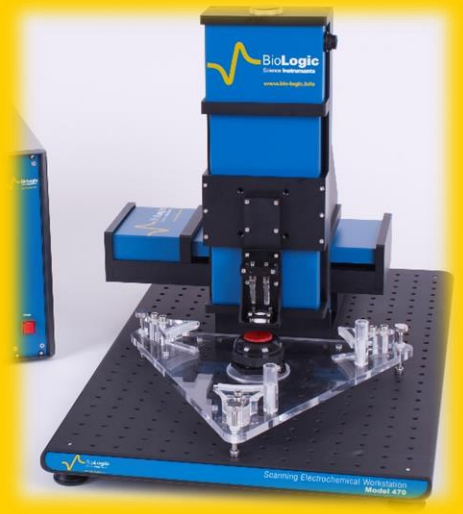
SKP



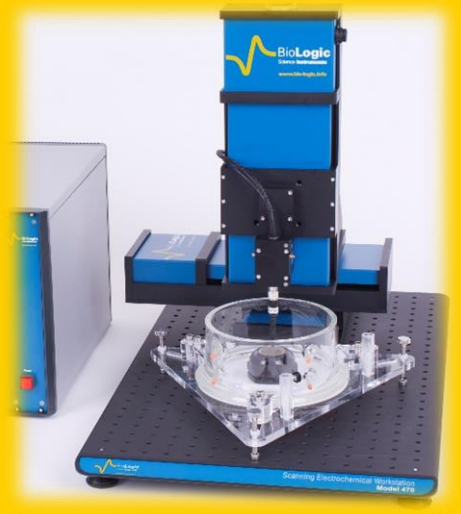
SECM



SDS



LEIS



Corrosion and Coatings

What are the research problems? - Corrosion

Corrosion initiates and proceeds locally at surface irregularities, for example defect sites, weld zones, and grain boundaries. It is often not uniform. Studies of corrosion through bulk techniques do not pinpoint where corrosion is occurring. Furthermore, for more detailed information bulk studies require complex data interpretation.

In studies of corrosion inhibitors the resulting inhibitor film is of interest. Bulk studies cannot be used to determine whether an inhibitor film has formed, and if this film has formed uniformly.

- Solution: Visualize local corrosion activity at a point in time

During real world use corrosion of materials will naturally occur over time. Without the ability to investigate samples under real world conditions over extended periods it is not possible to understand the corrosion mechanisms of the material.

- Solution: *In situ* investigations of freely corroding samples
- Solution: Visualize changes in corrosion activity with time

What are the research problems? - Coatings

Failure of coatings systems occur locally at natural and artificial defect sites. Using bulk measurements provides an average of the sample properties, without the local specificity to fully understand these processes, and truly assess the ability of a novel coating to protect a surface from corrosion.

- Solution: Visualize local corrosion activity at a specific point in time

When working with self healing coatings the healing process is time dependent. The comparison of different coating compositions requires knowledge of self-healing time and efficiency.

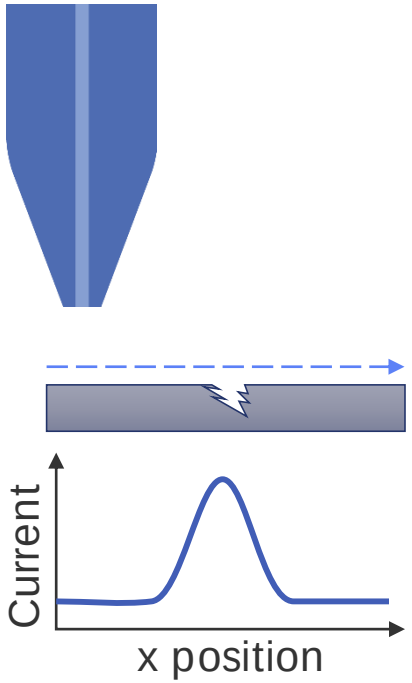
- Solution: Visualize changes in corrosion activity over time

Solution: Visualize local corrosion activity

How this is met by scanning probe electrochemistry:

When corrosion and coatings investigations are performed using bulk techniques the result is an average of the bulk sample. This can be difficult or impossible to interpret to obtain information on the local corrosion of the sample.

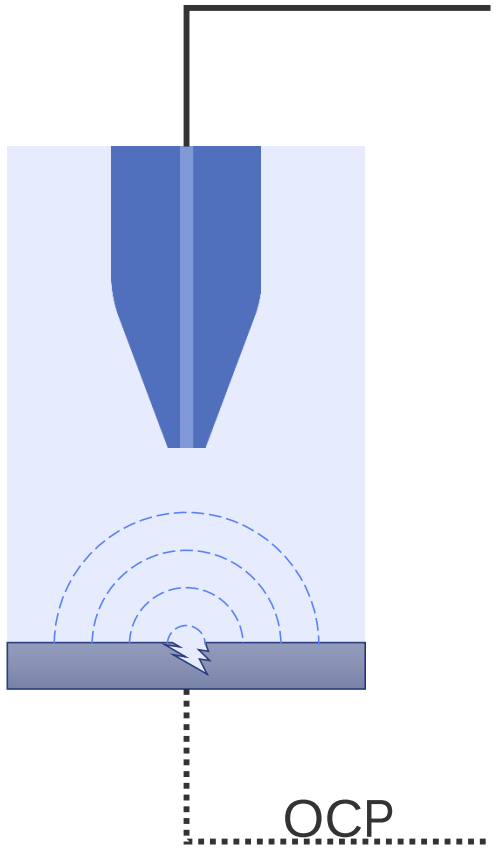
In scanning probe electrochemistry only the area under the probe is measured, providing local data. The electrochemical characteristics measured by scanning probe electrochemistry, for example work function or current density, **relate to a sample's corrosion activity. By raster** scanning the probe across the sample an x-y map of corrosion activity can be produced.



Solution: *In situ* investigations of freely corroding samples

How this is met by scanning probe electrochemistry:

A key requirement of many scanning probe electrochemistry techniques is that they are performed in electrolyte. This means the ability to perform *in situ* measurements is built into the technique. In all cases the measurement can be performed with the sample at OCP allowing the sample to be freely corroding throughout the technique. The stronger the corrosion activity at this freely corroding sample, the stronger the measured signal will be.

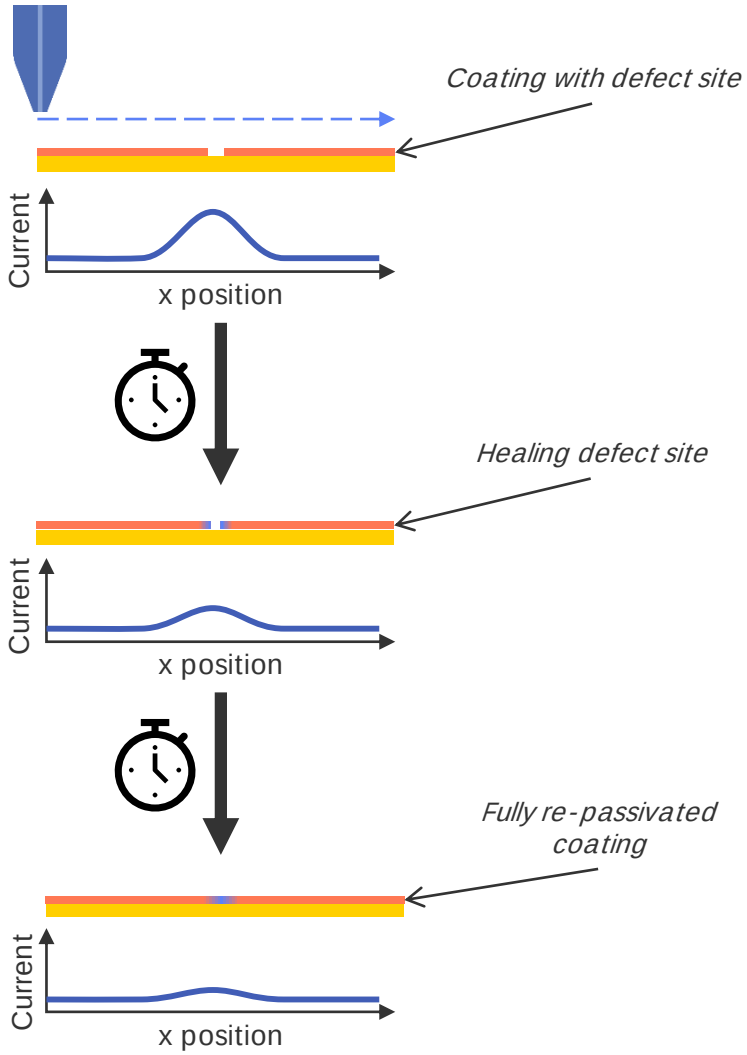


Solution: Follow processes over time

How this is met by scanning probe electrochemistry:

Most scanning probe electrochemistry experiments can be performed *in situ*. To follow corrosion and re-passivation processes over time, therefore, researchers measure multiple area maps of the same region of a sample at given time intervals. Changes in the magnitude of the probe response can then be compared to follow the re-passivation.

The SCAN-Lab softwares have the option to automatically loop experiments. By looping any area scan type the response over hours, days, or more can be followed.



Conclusions

Summary

- Scanning probe electrochemistry is used to obtain data on local corrosion which is difficult through bulk techniques
- Scanning probe electrochemistry can be used to follow the evolution of corrosion over time
- In scanning probe electrochemistry experiments can be performed *in situ* to allow comparison to real world applications

Why SCAN-Lab?

The scanning probe electrochemistry instruments available through SCAN-Lab allow the visualization of local corrosion processes *in situ* at coated and uncoated samples as they occur. SCAN-Lab products offer the widest range of scanning probe electrochemistry techniques relevant to corrosion research.

Learning Center Articles

A series of Learning Center articles has been created to help determine the most appropriate technique for a given research problem. This includes articles dedicated to corrosion and coatings research:

Scanning Probes & Coatings Research

Scanning Probes & Corrosion Research

References

1. http://impact.nace.org/documents/Nace-International-Report.pdf
2. https://www.coatingsworld.com/heaps/view/6014/1/

Acronyms

- LEIS: Local Electrochemical Impedance Spectroscopy. Localized Electrochemical Impedance Spectroscopy also used
- SDC: Scanning Droplet Cell. Scanning Droplet System (SDS) also used.
- SECM: Scanning ElectroChemical Microscopy
- SKP: Scanning Kelvin Probe
- SVET: Scanning Vibrating Electrode Technique. Vibrating Probe and Scanning Vibrating Probe (SVP) also used.