BioLogic

Applications of scanning probe electrochemistry– Biology

SCAN-Lab

May 2021

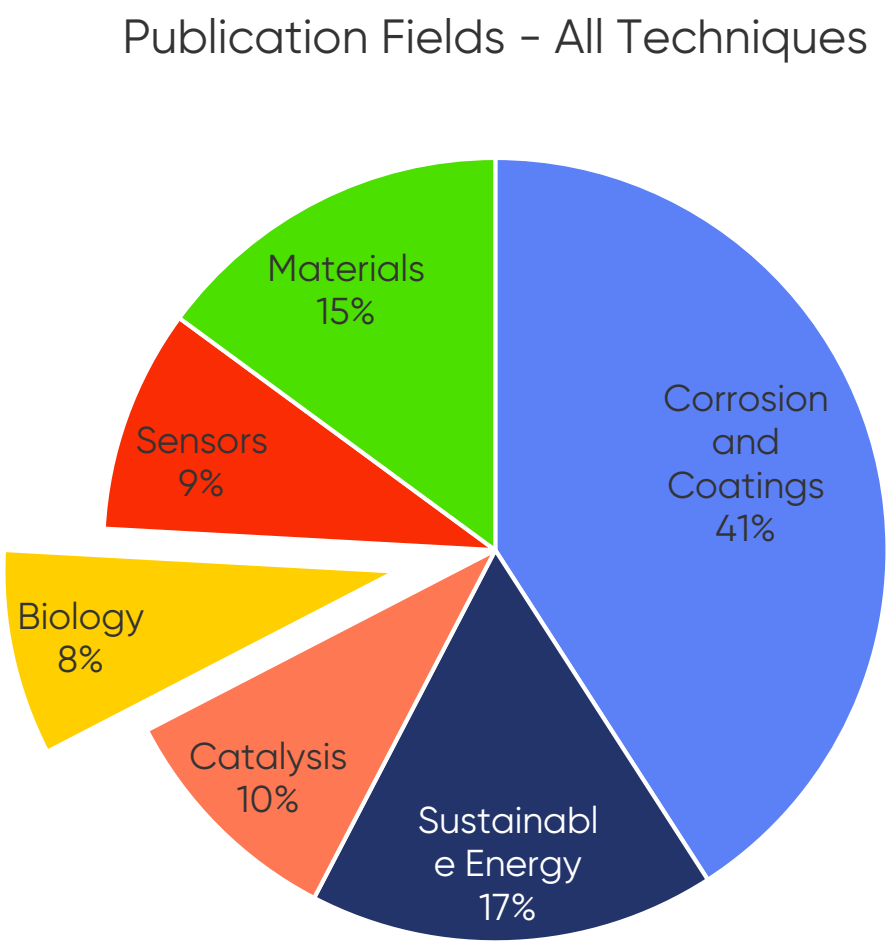
Version 1.0

Background

Background

8% of commercial scanning probe electrochemistry instruments are used in the field of biology.

This document will further investigate the role of scanning probe electrochemistry in biology.

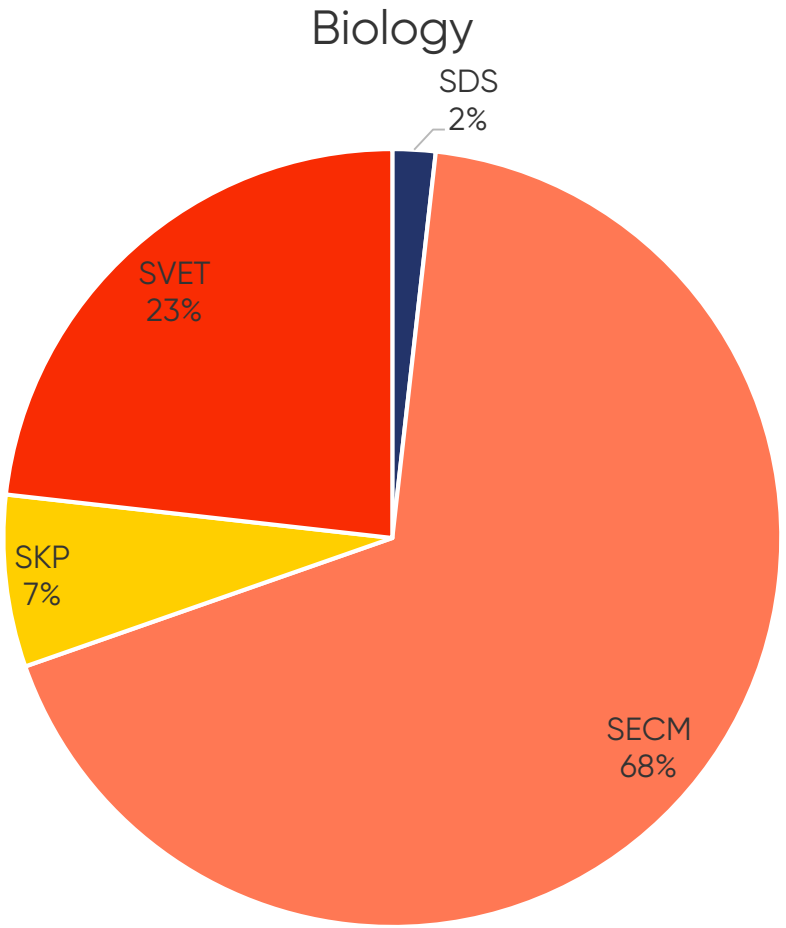


Why is scanning probe electrochemistry applied in biology?

Scanning probe electrochemistry is applied to fundamental R&D studies of biological samples to investigate:

- Study living cells, including their morphology and uptake of metabolites
- Investigate ion flow through biological and biomimetic membranes
- Measure enzymatic activity
- Determine conformation of DNA, and oligomeric nucleic acids

What techniques are used?

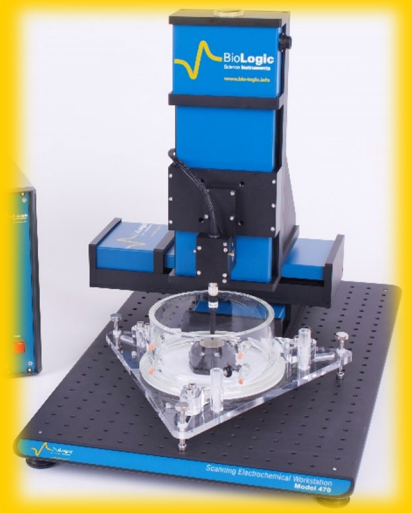


In studies of biological systems all but LEIS has seen use. SECM is by far the most popular technique used, followed by SVET. In the field of biology SVET is also referred to as Vibrating Probe.

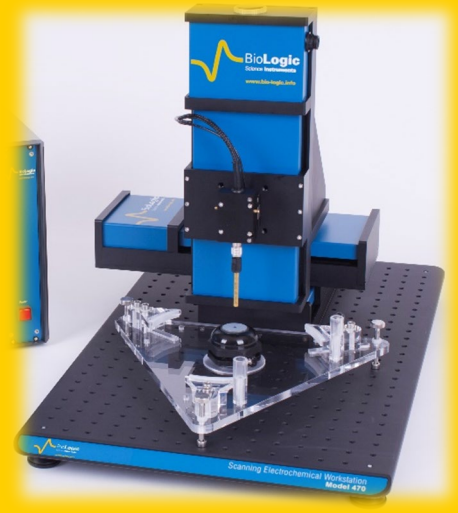
Source: Analysis of scientific publications citing commercial instruments. Each research group was only counted once per technique.

What techniques to propose for biology?

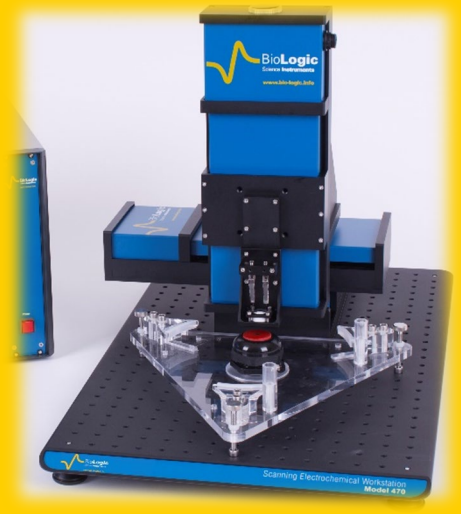
SVET



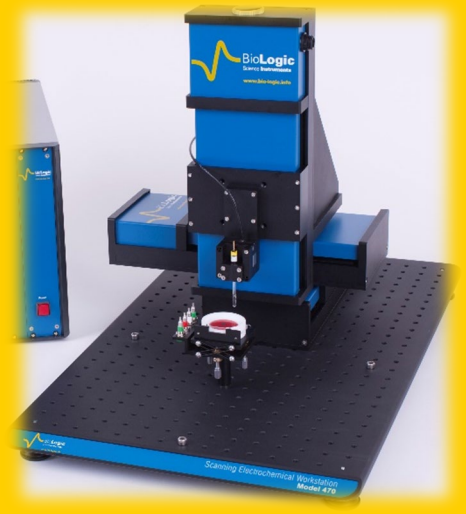
SKP



SDS



SECM



Biology

What are the research problems?

Electrochemical processes of biological samples can be locally confined, measurement by bulk techniques can lose this local data.

- Solution: Electrochemical measurement with spatial resolution

Microscopy measurements of biological samples require the use of tags, dyes, or contact with the sample which interfere with the biological processes.

- Solution: Measurement which does not interfere with the process under study

It is important to understand rapid biological processes over time.

- Solution: Real time measurements

To study the flow of metabolites or ions a means of selectively measuring these is needed.

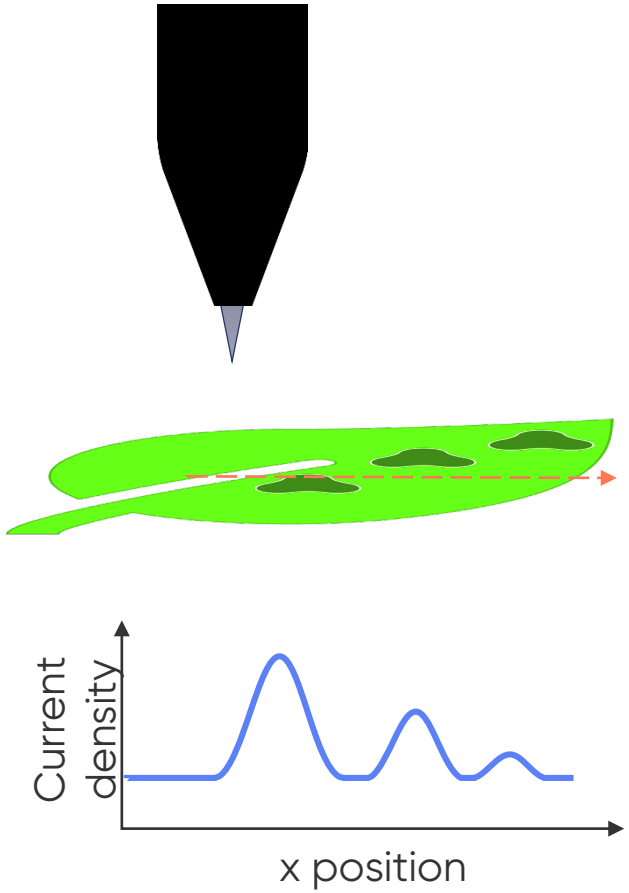
- Solution: Chemical selectivity

Solution: Electrochemical measurement with spatial resolution

How this is met by scanning probe electrochemistry:

When biological 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 activity 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 activity. By raster scanning the probe across the sample an x-y map of activity can be produced.

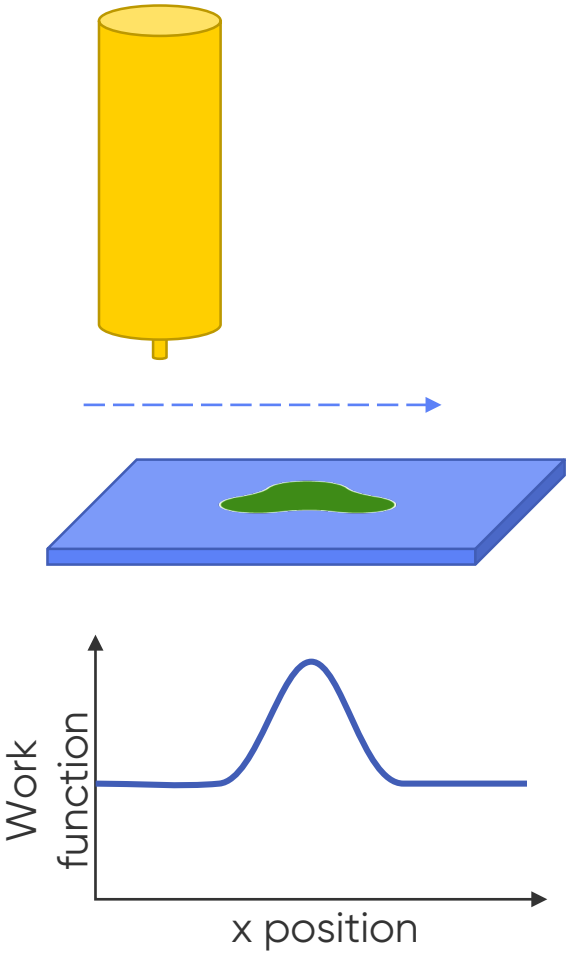


Solution: Measurement which does not interfere with the process under study

How this is met by scanning probe electrochemistry:

Many microscopies require the use of tags, or contact with the sample which can alter the biological process of interest. Scanning probe electrochemistry can be performed without the need for tags or contact because they utilise characteristics inherent to the sample to perform the measurement.

All scanning probe electrochemistry techniques can be performed in constant height mode removing the need for sample contact throughout the measurement.

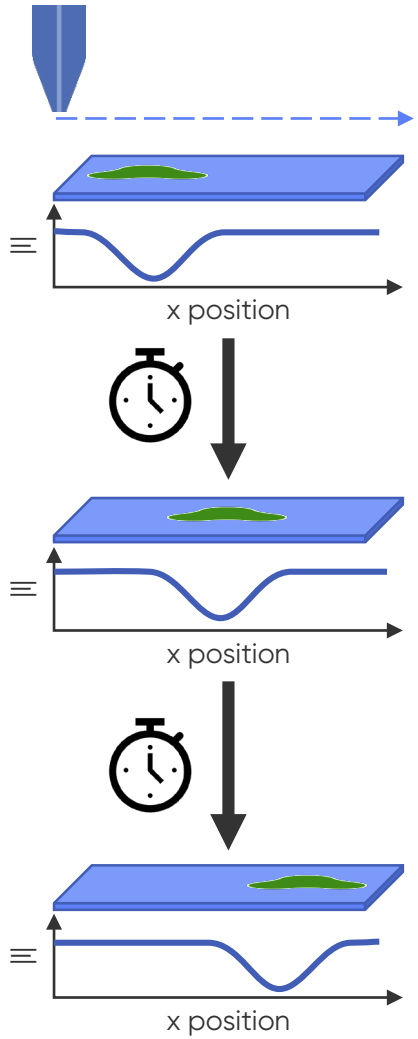


Solution: Real time measurements

How this is met by scanning probe electrochemistry:

Rapid biological processes are followed in real time using scanning probe electrochemistry by utilizing high scan rates, and sweep scan where possible. To follow the evolution of these processes multiple area maps of the same region of a sample are measured at given time intervals. Changes in the magnitude of the probe response can then be compared to follow the process as it occurs.

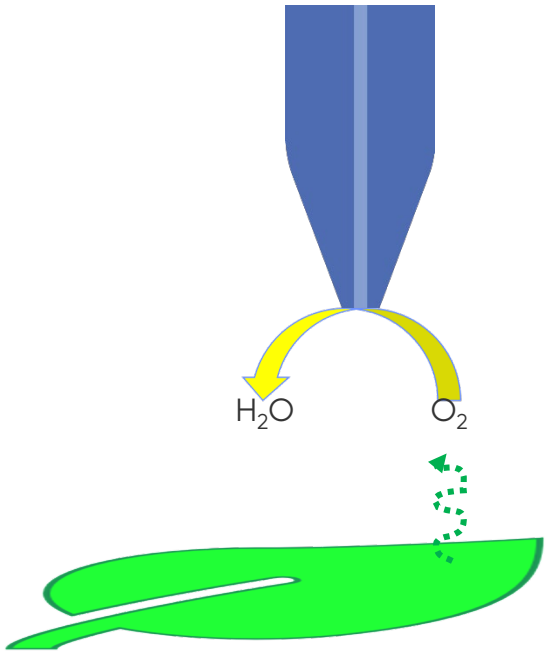
The SCAN-Lab softwares have the option to automatically loop experiments. By looping any scan type the response over hours, days, or more can be followed.



Solution: Chemical selectivity

How this is met by scanning probe electrochemistry:

Chemical selectivity is specifically met by SECM. In SECM the probe can be biased to interact selectively with a given electrochemically active species. The resulting current signal measured by the probe is directly related to the concentration of the species present. Therefore SECM can be used to perform quantitative measurements with chemical selectivity.



Conclusions

Summary

- Scanning probe electrochemistry is used to perform biological measurements with spatial resolution
- Scanning probe electrochemistry achieves local measurements of biological samples without interfering with the process under study
- Real time measurements of rapid biological processes can be performed with scanning probe electrochemistry
- SVET, also known as Vibrating Probe, SKP, SDS and SECM have all be used in studies of biological samples

Why SCAN-Lab?

The scanning probe electrochemistry instruments available through BioLogic allow the mapping of the rapid processes occurring at biological samples, without influencing the process under study. BioLogic offers the most diverse range of techniques on a single platform, allowing a range of characteristics of biological samples to be measured. This expands the current and future research avenues available from a single instrument.

Learning Center Article

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

Scanning Probes & Biology Research

Application Notes

SECM and Vibrating Probe (SVET) have been used to study the leaves of *chlorophytum comosum* in two application notes.

AN#15: Introduction to the USB-PIO: measuring the effect of light on a live leaf

AN#22 The use of the SVP470 for Vibrating Probe measurements of plants

Technical Note

Living samples can require measurement in specific orientations to mimic its real world situation. For example measuring plant roots can require measurement of a vertical sample. This is explored for Vibrating Probe (SVET) in the technical note below:

TN#20: Using SVET to measure Vertical Samples

Acronyms

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