BioLogic

Who are the worldwide customers? – Biology

SCAN-Lab

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Version 1.0

Background

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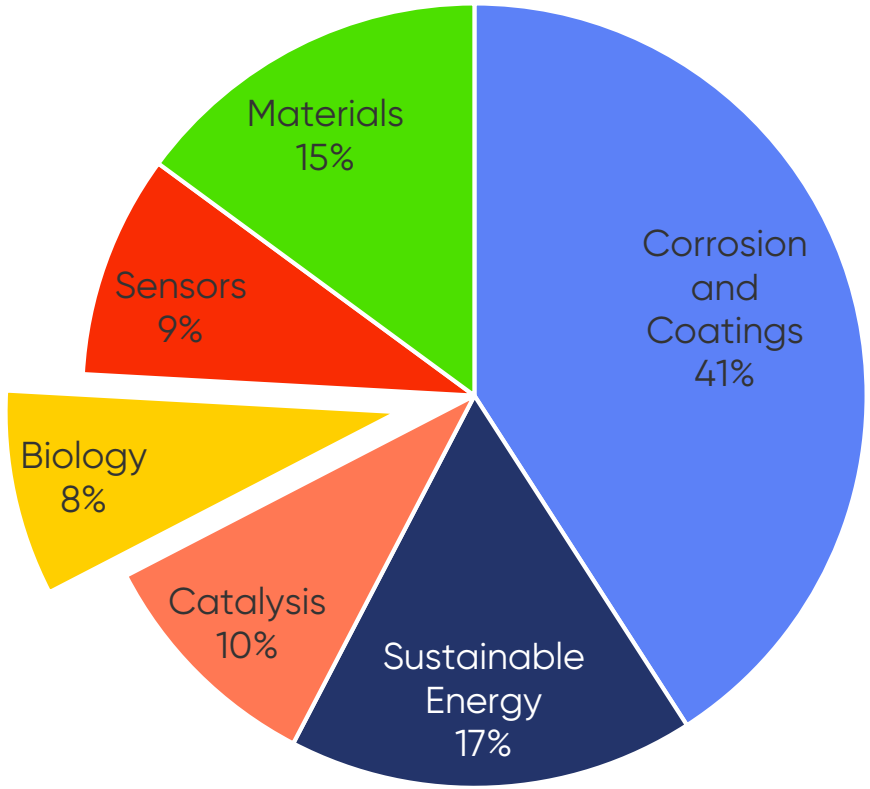
8% of commercial scanning probe electrochemistry instruments are used in the field of biology.

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

Publication Fields - All Techniques



Who is interested in biology?

Users interested in the study of biological samples using scanning probe electrochemistry are typically performing fundamental R&D. Researchers typically come from academia. Scanning probe electrochemistry is used in biological research to:

- 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 fields?

Researchers interested in scanning probe electrochemistry in biology may come from the following fields:

- **Medical industry**
- **Pharmaceutical industry**
- **Biosensors**
- **Agriculture**
- **Biotechnology**

Keywords

Keywords relevant to biology include:

Bilayer membrane

Bioelectronics

Cell membrane

Cell metabolism

Cell morphology

Enzyme activity

Extracellular current

Ion channels

Living cells

Membrane permeability

Photosynthesis

Respiratory activity

Wound healing

Biology

What are the customer 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

Researchers want 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.

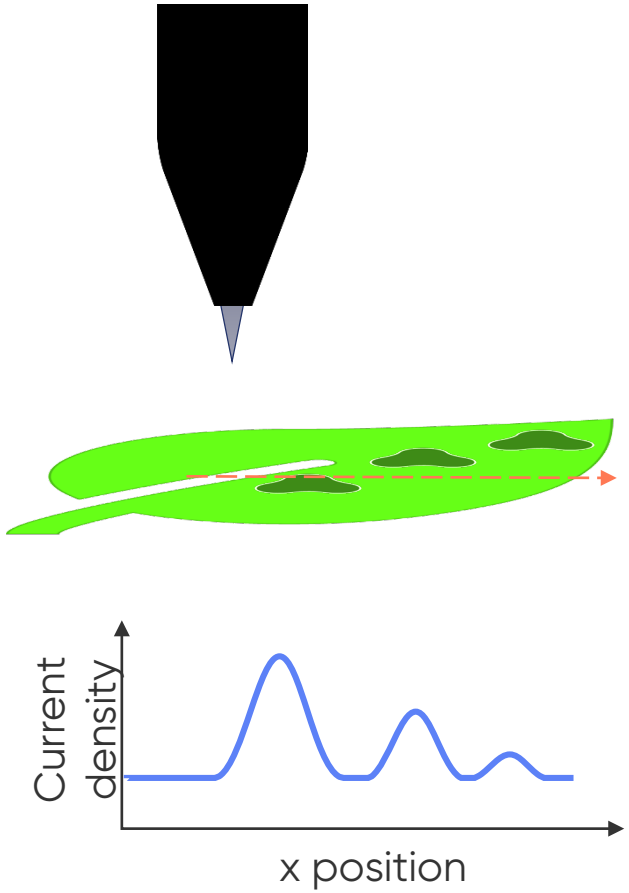
- Solution: Chemical selectivity

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 impedance 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.

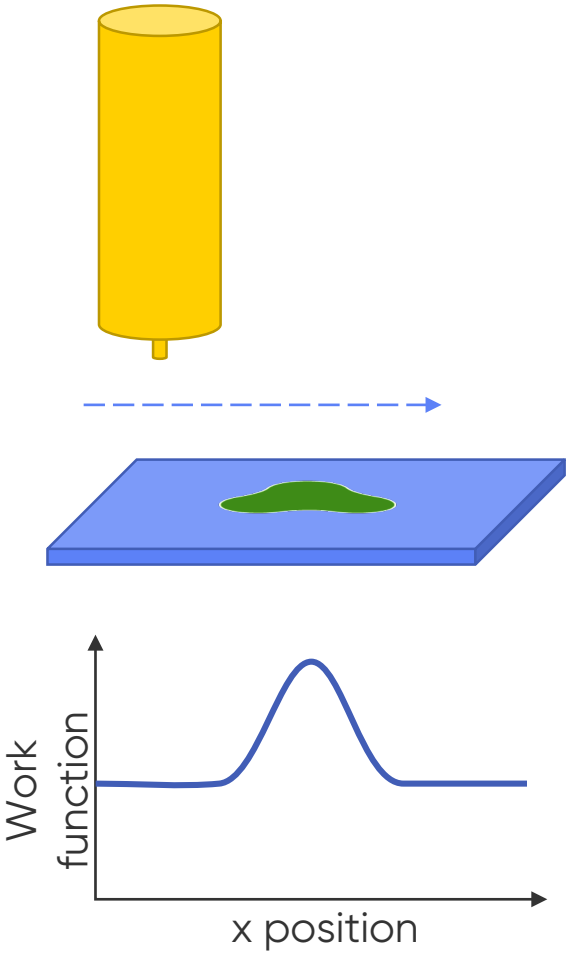


Solution: Measurement which does not interfere with the process under study

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.

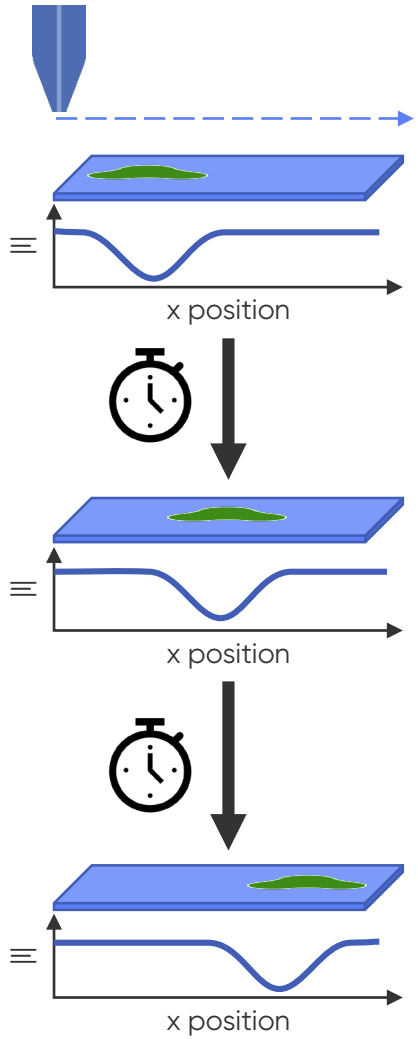


Solution: Real time measurements

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, 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 process as it occurs.

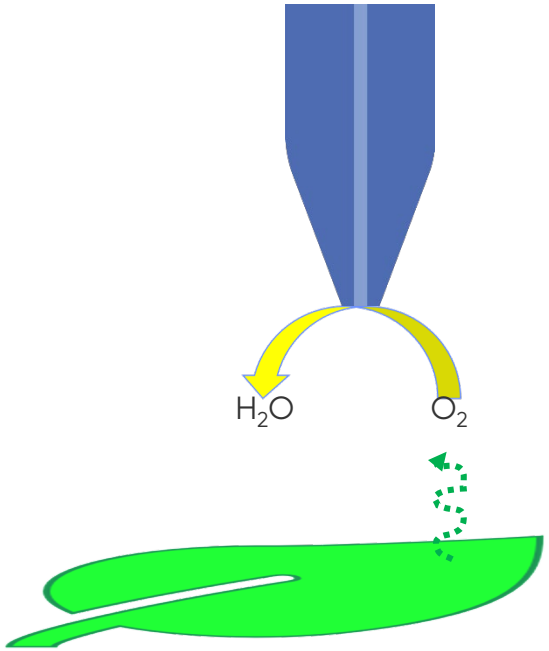
The SCAN-Lab softwares have the option to automatically loop experiments. By looping any scan type the response over hours, or days can be followed.



Solution: Chemical selectivity

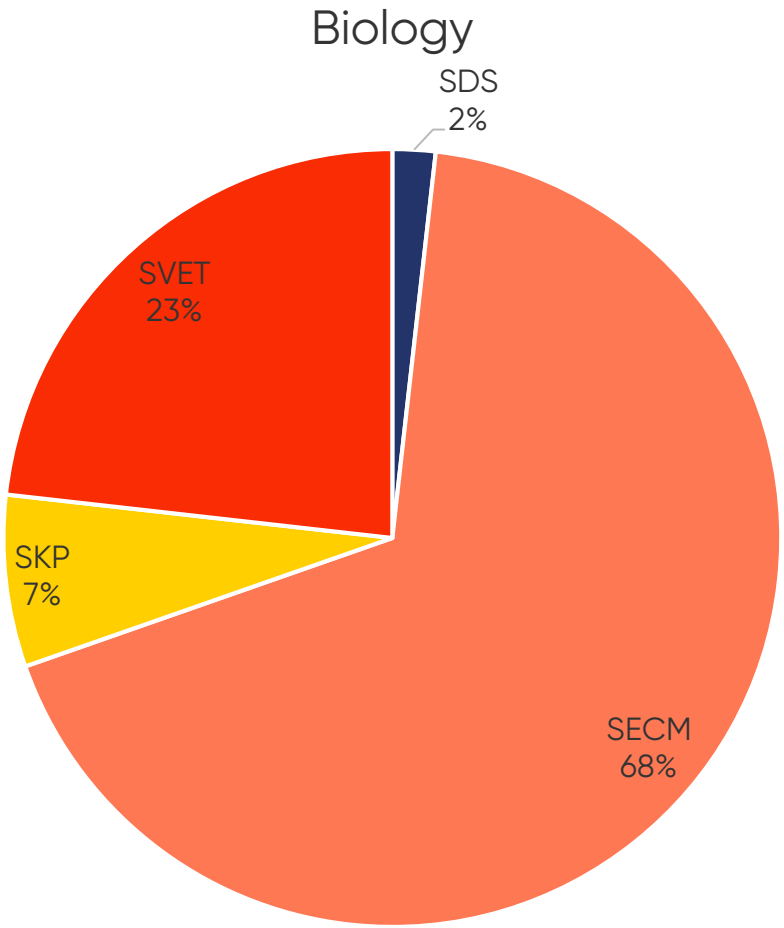
How this is met by scanning probe electrochemistry:

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.



Scanning Techniques for Biology

What techniques are used?

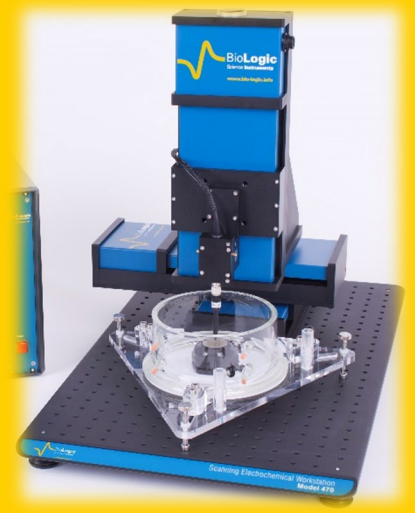


In studies of biological systems all but LEIS has seen use. SECM is by far the most popular technique used, followed by SVET. In biology SVET is often referred to as Vibrating Probe.

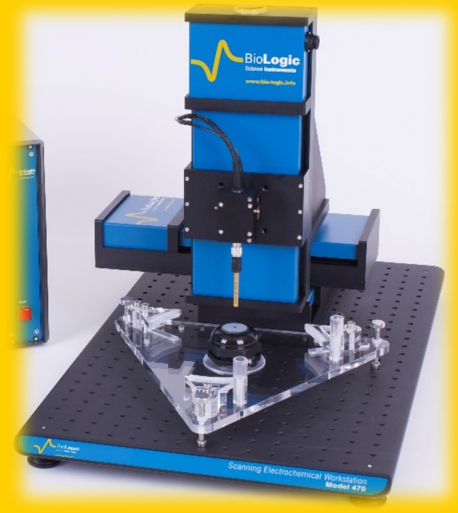
Source: Analysis of scientific publications citing commercial instruments. Each research group was only counted once per technique.

What techniques to propose for biology?

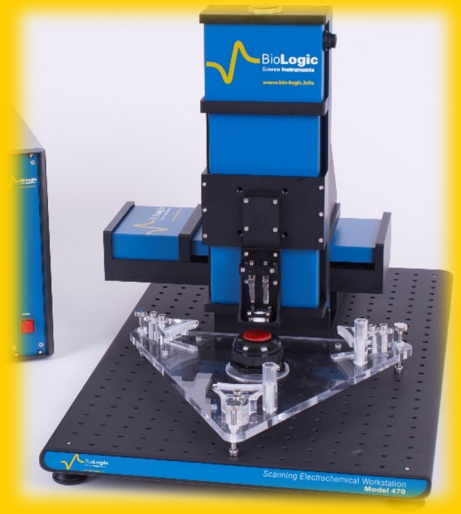
SVET



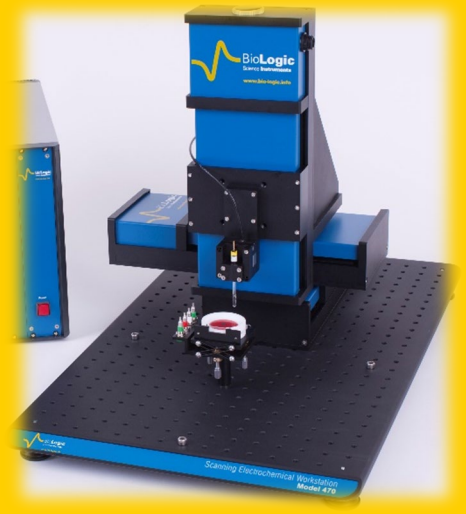
SKP



SDS



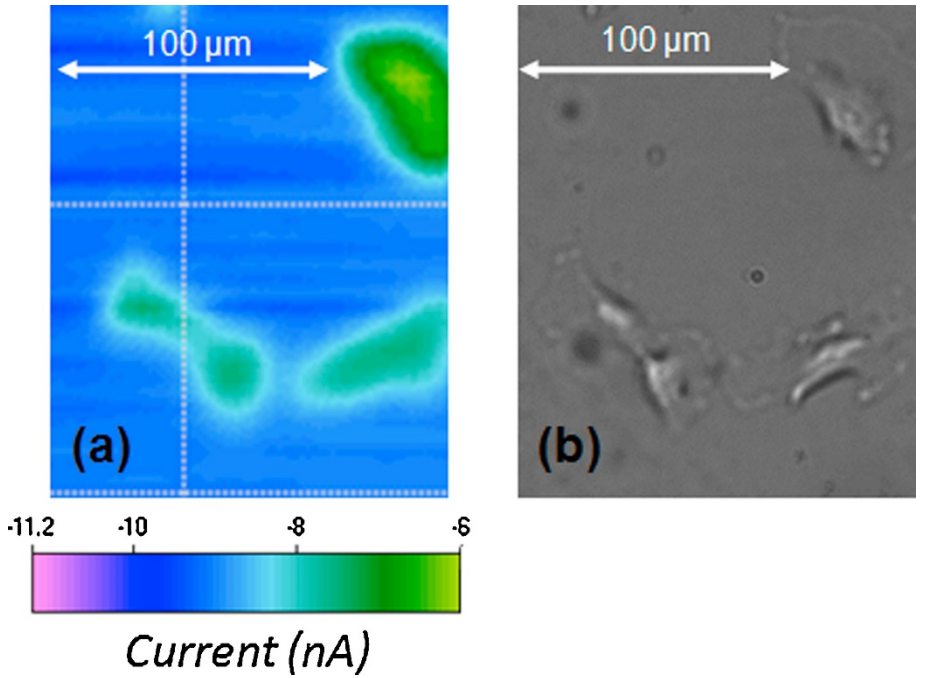
SECM



Example application of dc-SECM to biology

Can cell morphology be detected?

The probe current in dc-SECM depends on sample activity and topography. When the cell is inactive to the redox mediator and on a conductive substrate it appears as a low current region with defined morphology. Unlike optical measurements of cells, the morphology is 3D with the lowest current regions reflecting highest regions of the cell.



(a) SECM imagery above fixed EA.hy926 cells using 10 µm Pt tip (5 mM $[Ru(NH_3)_6]Cl_3$ in 0.1 M KCl, E_{tip} = −0.5 V vs Ag/AgCl). Acquisition time: 18 minutes (tip scan rate: 5 µm/s) (b) Optical microscopy image of the cells studied by SECM (magnification 20X).

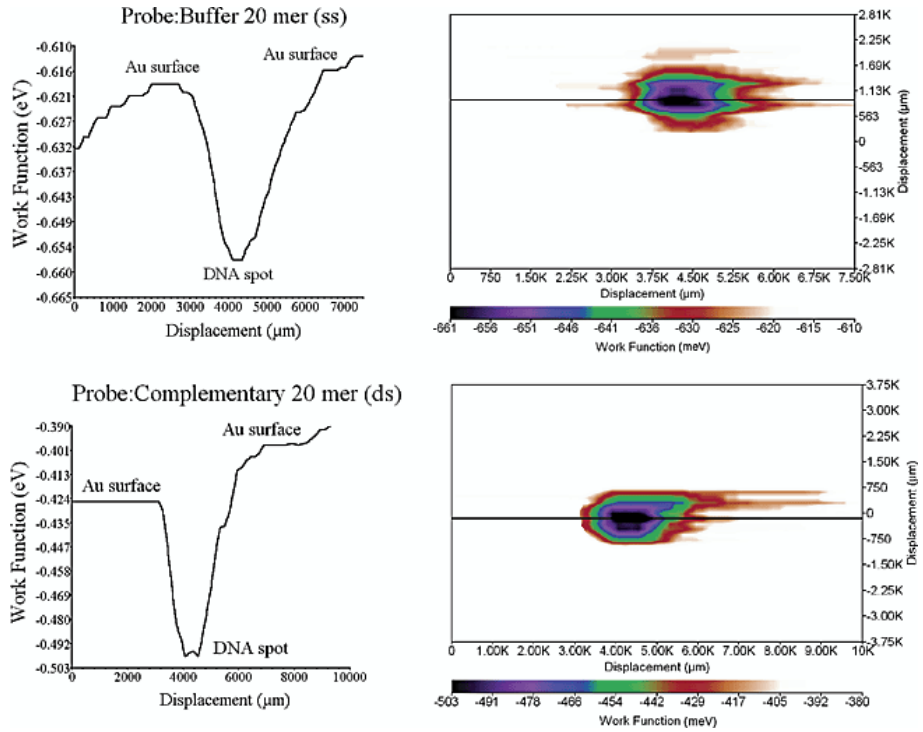
Example using SCAN-Lab Instruments:

[1] F. Razzaghi, *et al.*, Electrochim. Acta 157 (2015) 95–100

Example applications of SKP to biology

Is it possible to distinguish between different biomolecules?

Changes in conformation, hybridization, polarization, etc. of immobilized biomolecules cause changes in surface potential detected in SKP as a change in contact potential difference. The contact potential difference can distinguish between the biomolecules.



Representative Kelvin probe scans of ssDNA and dsDNA spots. Right images are area scan maps; left images are plots of the line scan data as indicated by the horizontal line in the right image.

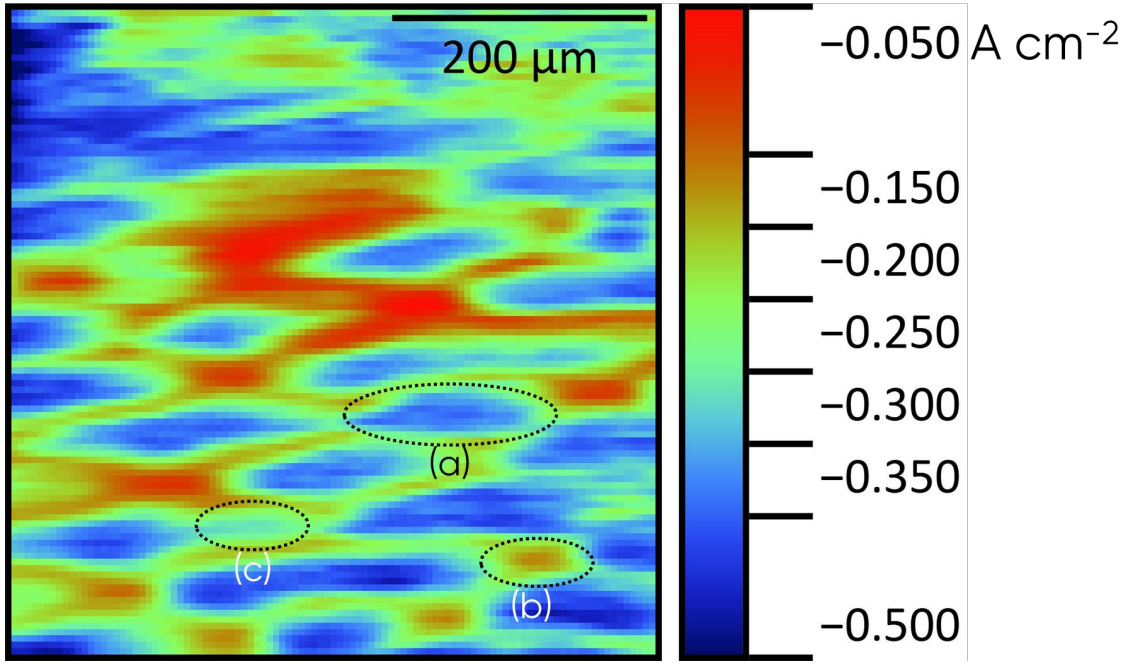
Example using SCAN-Lab Instruments:

[1] D. C. Hansen, *et al.*, Langmuir 19 (2003) 7514-7520

Example applications of Vibrating Probe (SVET) to biology

Can photosynthetic processes be followed?

Photosynthetic processes, like the opening of guard cells at the stomata are linked to local changes in current density as measured by vibrating probe. Changes in current density over time, can reflect the influence of different light and dark conditions.



Vibrating probe measurement of the underside of spider plant leaf. Epithelial cell (a), stomata (b), and undifferentiated plain cell (c) are circled.

Example using SCAN-Lab Instruments:
[1] Vibrating Probe measurements of plants – Scanning Probes. Application Note 22

Indirect alternatives

Indirect alternatives to scanning probe electrochemistry in biology studies include bulk characterization techniques and local microscopies.

Bulk Characterization
This includes bulk electrochemical measurements such as cyclic voltammetry. These bulk techniques provide valuable information on a material, however they do not provide local information.

Local microscopies

- Atomic Force Microscopy (AFM)
  - Offers a local view of the material under study but does not provide information on the electrochemical nature of the sample.
  - AFM can be difficult to perform in liquids.
  - Typically has a scan range of 10s of microns. This can be too small for some studies.

Optical microscopy

- Often requires fluorescent tags which can interfere with the process understudy
- Does not provide 3D topographic information as can be obtained with SECM for example
- Does not provide information on the electrochemical characteristics.

Direct alternatives – SDS

Direct alternatives to SDS from BioLogic include the Versascan from Ametek, and the SDS from Sensolytics. For performance comparison refer to the separate *SCAN-LAB: How to defeat the competition* document.

Versascan
A modular instrument with a range of techniques. It has not been designed to optimize scanning functionality or user experience. Customer support is low in many regions.

SDS Sensolytics
Instruments produced on license from Wolfgang Schuhmann. They offer only a limited number of techniques which require the use of a 3rd party potentiostat. The SDS instrument is based on a reservoir head, and has little use in the literature.

Direct alternatives – SECM

Direct alternatives to SECM from BioLogic include the Versascan from Ametek, the CHI920D from CH Instruments, the ElProScan from HEKA, and the SECM from Sensolytics. For performance comparison refer to the separate *SCAN-LAB: How to defeat the competition* document.

Versascan
A modular instrument with a range of techniques. It has not been designed to optimize scanning functionality or user experience. Customer support is low in most regions.

ElProScan
A range of SECM instruments similar to those a researcher might build. The software is notoriously difficult to learn and use.

CHI920D
A constant height SECM only instrument. It is a lower quality instrument than those from BioLogic. Support quality varies widely based on the user region.

Sensolytics
SECM instruments produced on license from Wolfgang Schuhmann. They offer only a limited number of techniques which require the use of a 3rd party potentiostat.

Direct alternatives – SKP

Direct alternatives to SKP from BioLogic include the Versascan from Ametek, and a range of SKP instruments from KP Technology. HEKA recently introduced SKP to the ElProScan. For performance comparison refer to the separate *SCAN-LAB: How to defeat the competition* document.

Versascan
A modular instrument with a range of techniques. It has not been designed to optimize scanning functionality or user experience. Customer support is low in most regions.

KP Technology
A range of instruments capable of SKP and closely related techniques. The technology used to achieve SKP measurements can introduce difficulties to the experiments.

ElProScan
SKP was recently introduced, there is no evidence of its use in the literature. Glass shielded SKP probes are used which fail faster than other designs.

Direct alternatives – SVET

Direct alternatives to SVET from BioLogic include the Versascan from Ametek, and the SVET from Applicable Electronics. For performance comparison refer to the separate *SCAN-LAB: How to defeat the competition* document.

Versascan
A modular instrument with a range of techniques. It has not been designed to optimize scanning functionality or user experience. Customer support is low in most regions.

Applicable Electronics SVET
Available with the AE SLEIS option. AE instruments lack usability requiring users to do some work before starting their own measurements. AE is the most popular SVET manufacturer.

Conclusions

Global value proposition

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.

Summary

- Researchers interested in scanning probe electrochemistry for biology will be performing fundamental R&D
- Researchers require biological measurements with spatial resolution
- Local measurements of biological samples should not interfere with the process under study
- Real time measurements of rapid biological processes are of interest
- SVET, also known as Vibrating Probe, SKP, SDS and SECM have all be used in studies of biological samples

A final point…

Where users would like to see what scanning probe electrochemistry can do for their samples we can offer to test a limited number

Learning Center Article

A series of Learning Center articles has been created to help direct prospects and end users to the most appropriate technique for the research problem they have. 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.