
2nd
EU-JAPAN DIGITAL WEEK 2026
23 March - 30 March 2026
Tokyo, Japan
The EU-Japan Digital Week is organised as part of the EU-Japan Digital Partnership

Tyndall National Institute
Institiúid Náisiúnta

Smart Sensors for Sustainable Agriculture, Food & Environmental applications

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PI, VistaMilk SFI Centre

Rialtas na hÉireann Government of Ireland
Tionscadal Éireann Project Ireland 2040
Ireland's European Structural and Investment Funds Programmes 2014-2020
European Union
European Structural and Investment Funds

UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

Global Leadership in Deep-Tech Semiconductor R&I

Deep tech, atoms-to-systems research in micro & nano-technology, photonics, quantum engineering and materials involving chemists, physicists, engineers and manufacturing

>650
researcher, engineer & support staff

€60m+
total annual income

>150
MSc & PhD student

100
industry researchers-in-residence

80%
from competitive funding

€500m
Infrastructure investment

Ireland’s Semiconductor Infrastructure

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18,000m^2 of buildings
incl. 1,200m^2 of cleanrooms

New research building opening in 2028

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Current site as viewed from the new facility

New €100M government investment to expand (17,000m^2) research infrastructure, industry suites and dedicated Spin-out & New Ventures facilities

Controlling electrode – molecular interactions

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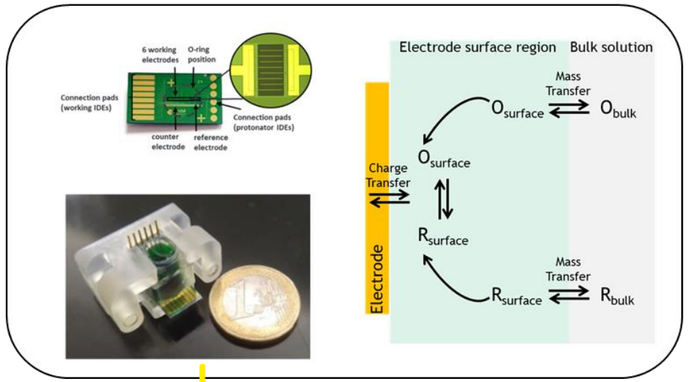
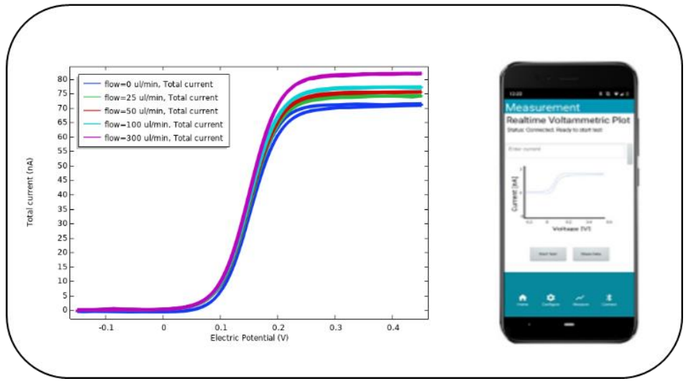
Chemical Interactions



Digital Output



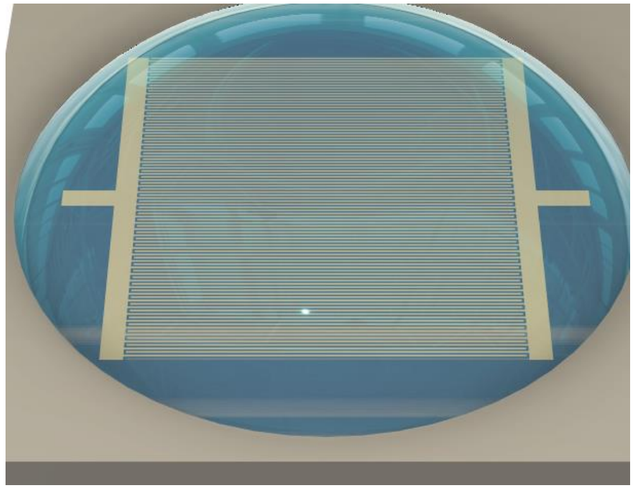
Advantages

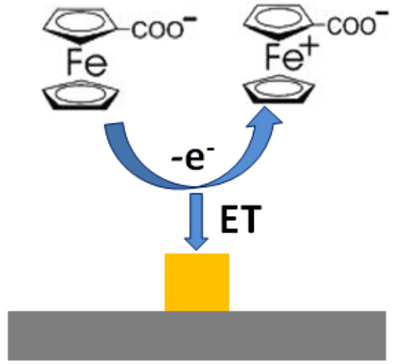
- ✓ Cost-effective
- ✓ Reasonable sensitivity
- ✓ Rapid time to results (secs to mins)
- ✓ Digital output
- ✓ Can be fabricated at high density

Why aren't electrochemical sensors used everywhere?

Challenges = Opportunities

- ➢ Reference electrode drift
- ➢ Requirement for electrolyte
- ➢ Sample preparation (e.g., pH)
- ➢ Interferant ions
- ➢ Lack of Specificity
- ➢ Individual Sensor Calibration





$k_{OX} = k_{ET}$

Four Electrode Configuration Platform

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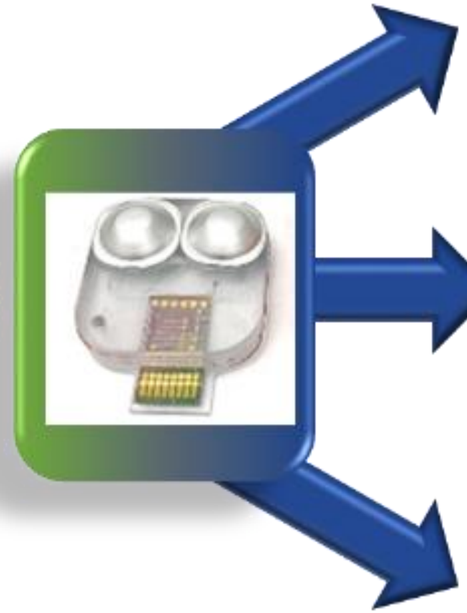
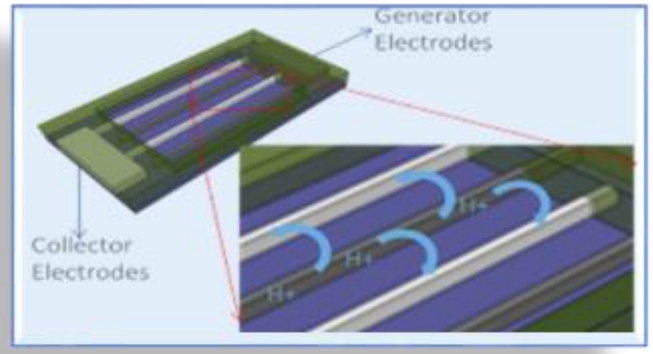
Samples

- Milk
- Blood
- Saliva
- Beverages
- Water
- Soil
- Gases

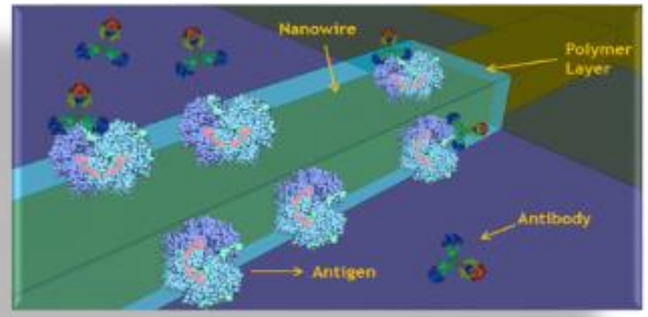


Electrochemistry



- Generator - Collector
- pH Control
- Materials Chemistry
- CECs
- System Integration

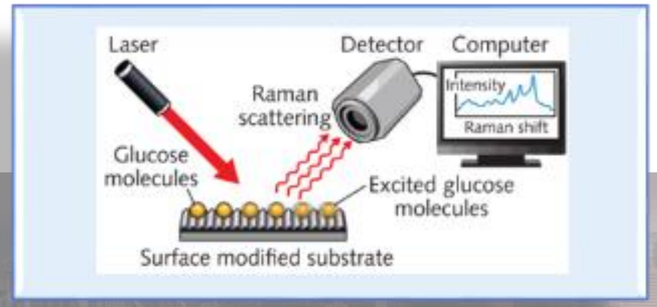
Bio-electrochemistry



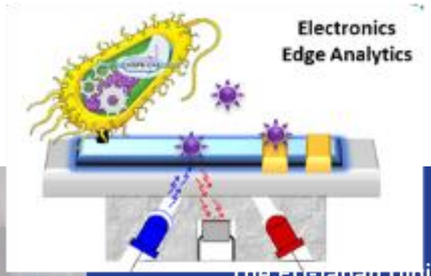
- Parasites
- Viruses
- Proteins
- Enzymatic substrates
- DNA

Detection Platforms under Development

Surface-Enhanced Raman Scattering



Cell-Based Biosensors



- Food safety
- Flavourings, sweeteners
- Antibiotics/residues
- Pesticides
- CECs

Four Electrode Configuration

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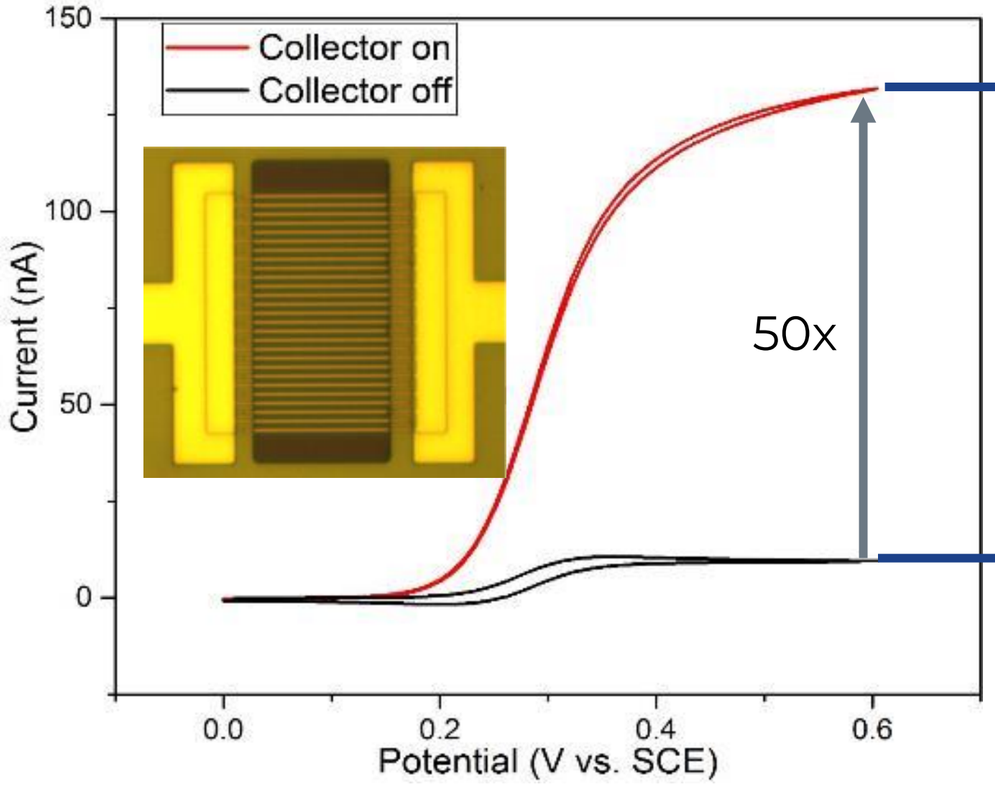
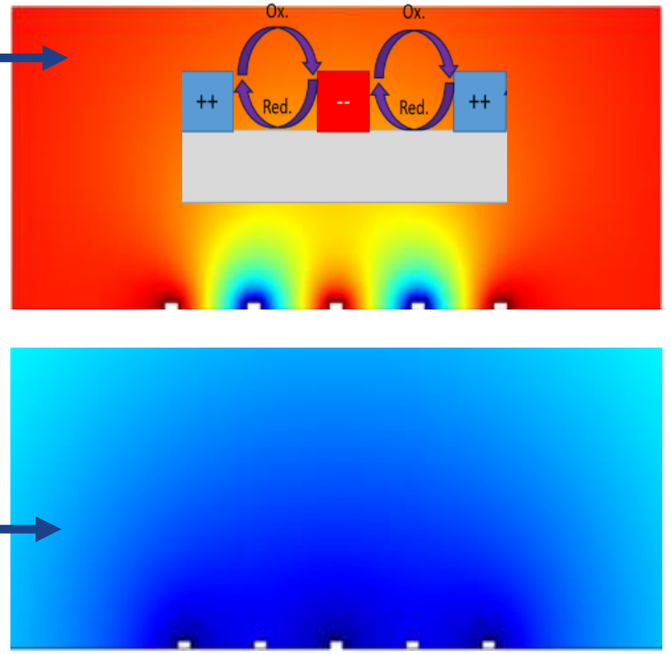
Advantages

- Generator Collector much higher sensitivity
- Remove Interference effects
- Temporal and spatial control of chemistry in the region of the electrode – pH control

Addition of a collector bias

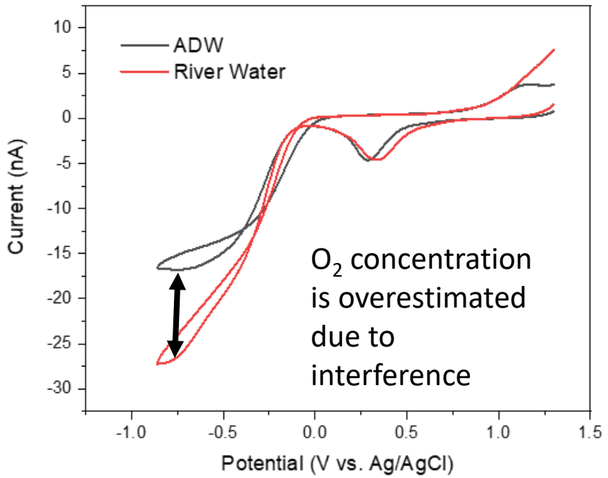


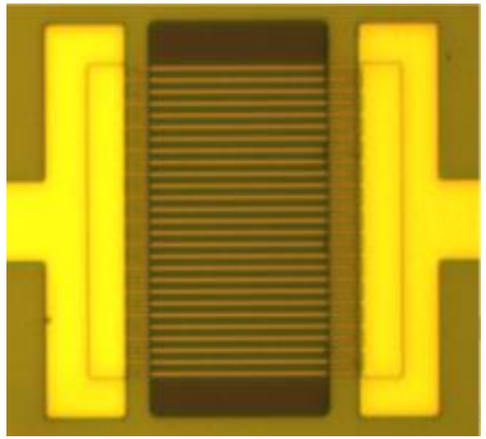
Redox cycling occurs

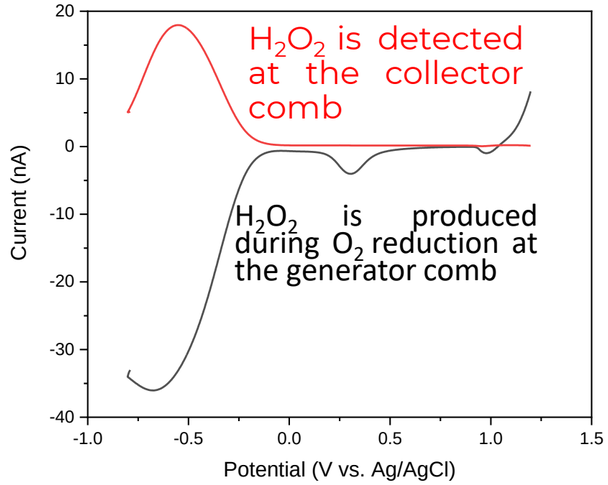


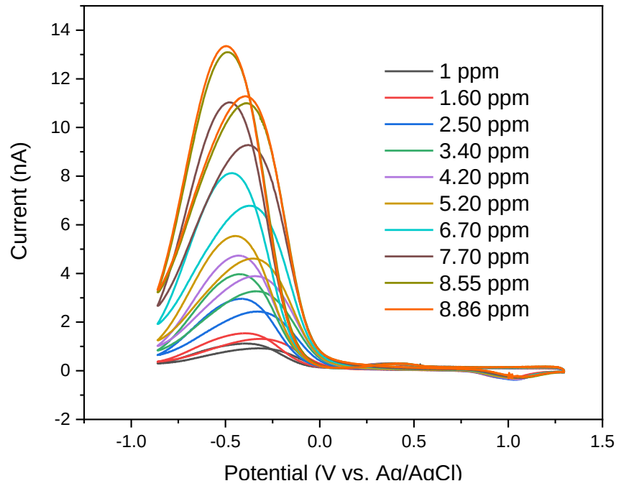
Analyte Depletion

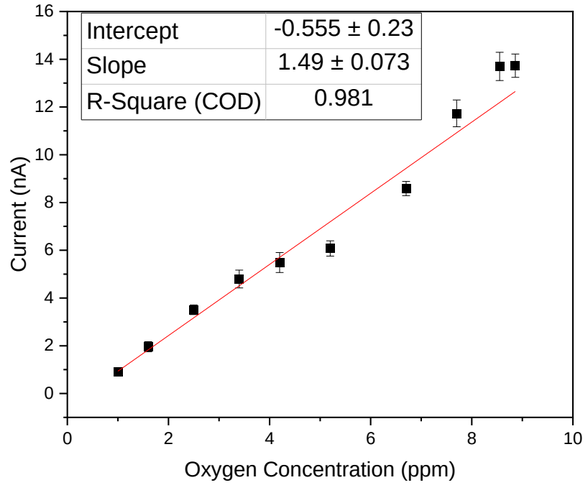
Generator Collector – Removing Interference

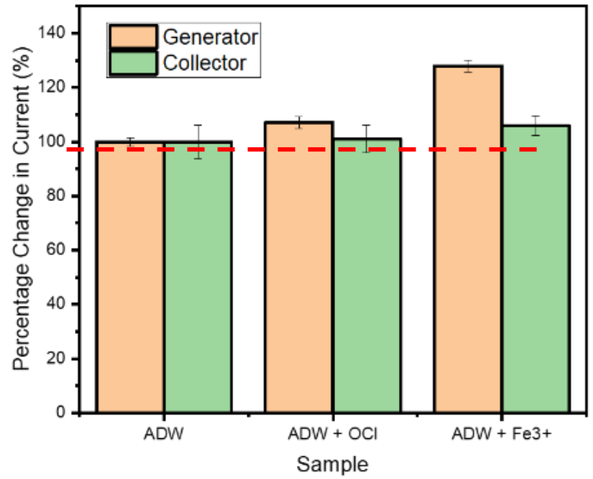




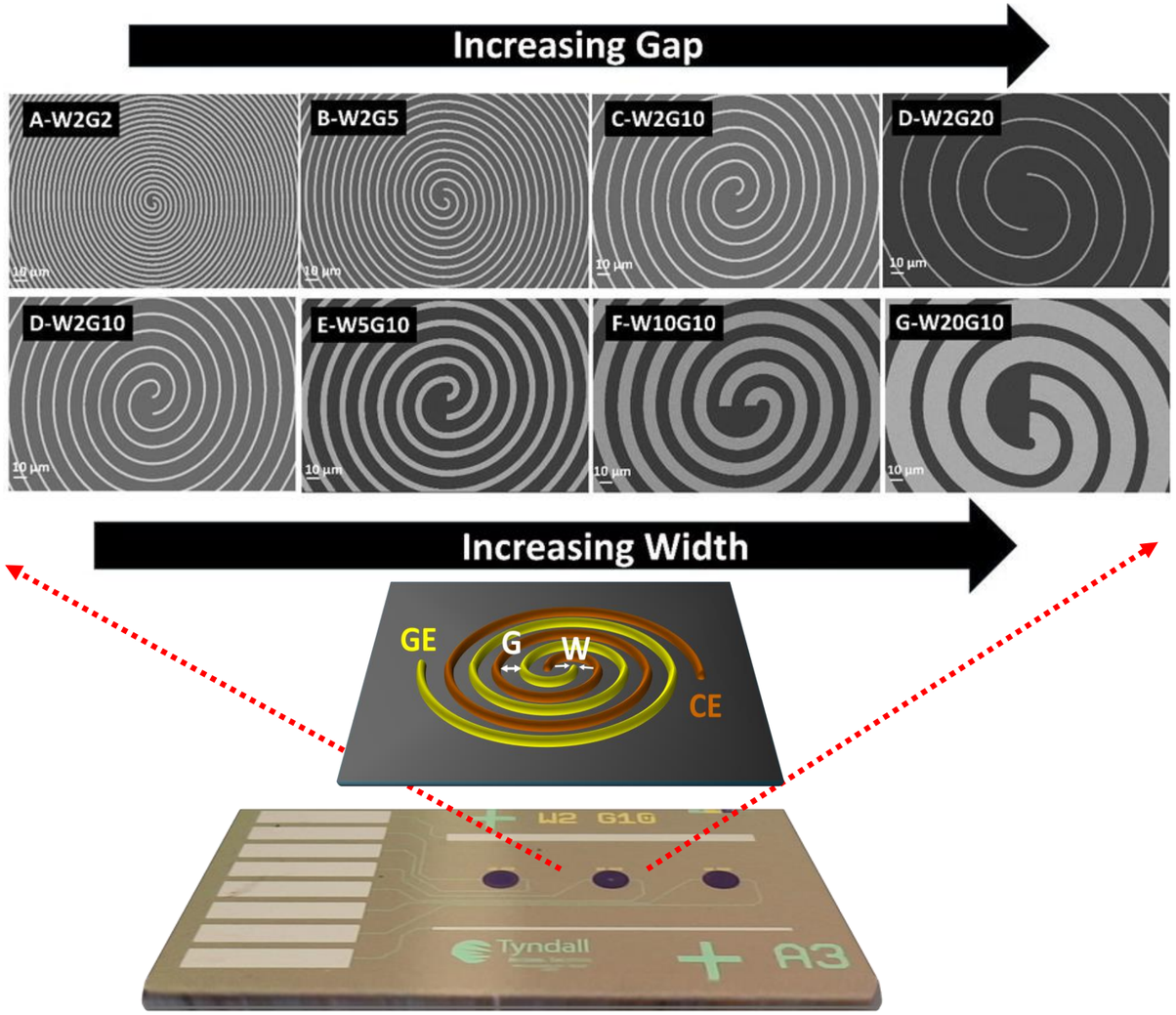


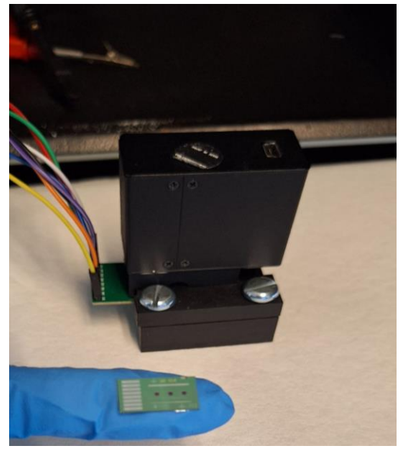




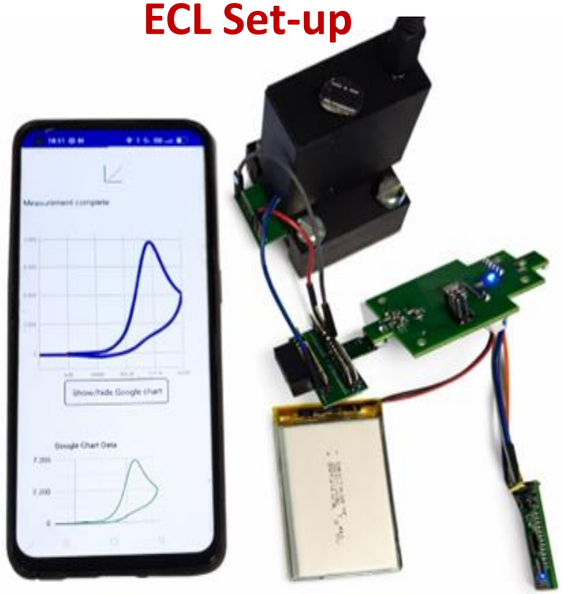


ECL Sensing Platform: Entwined Spiral

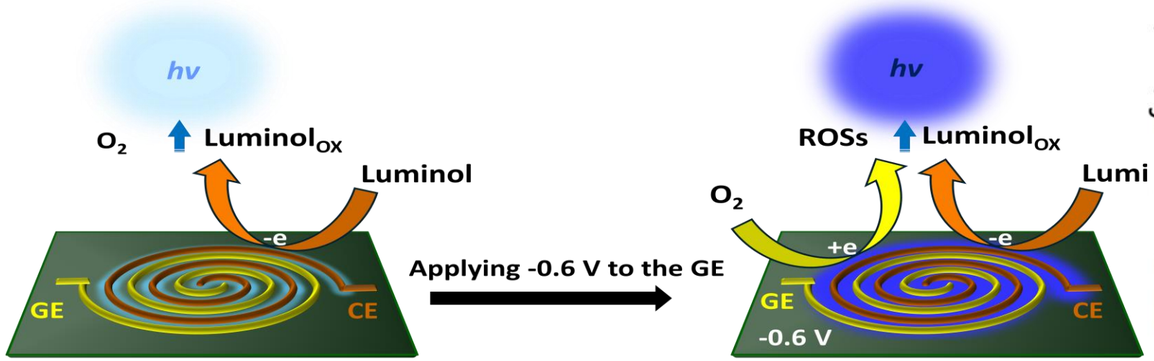


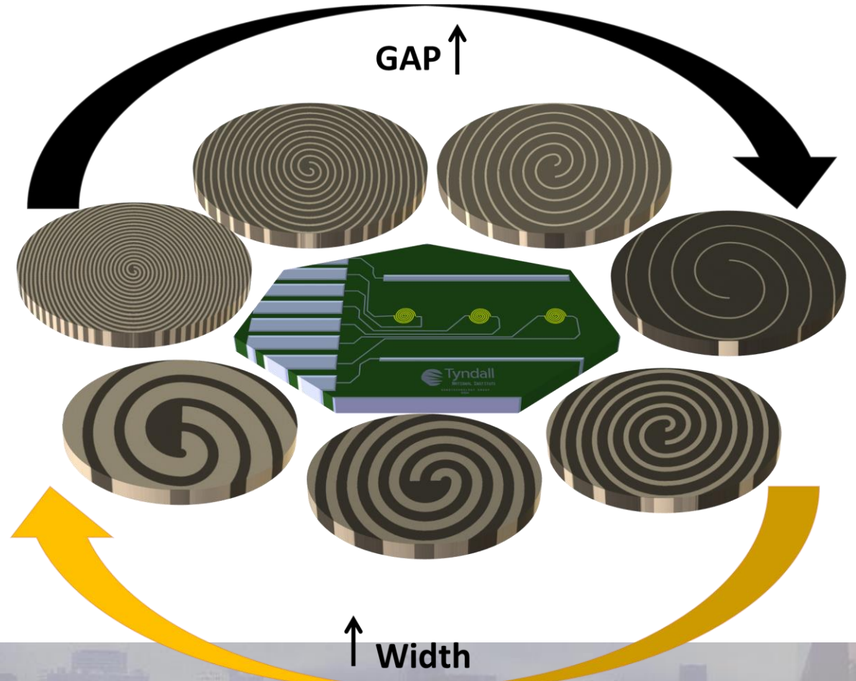


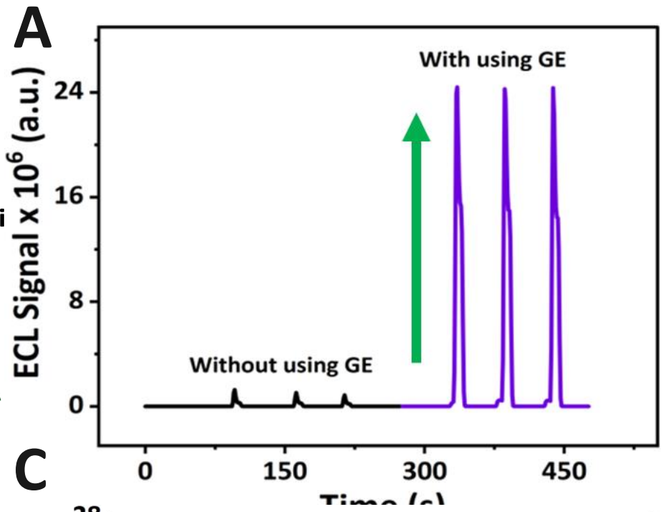
ECL Set-up

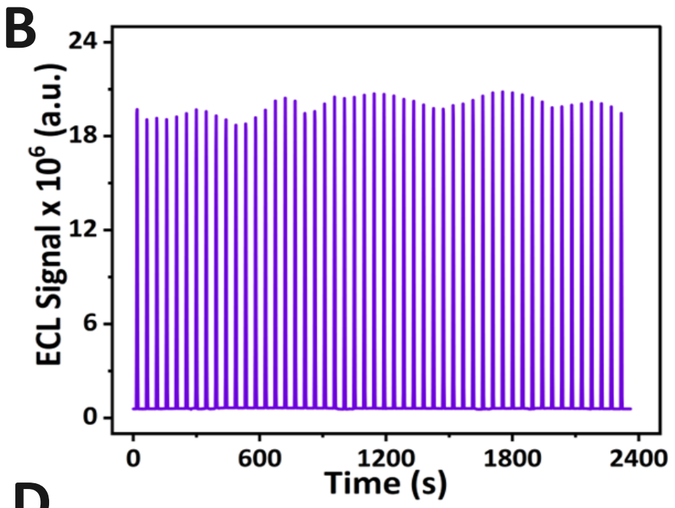


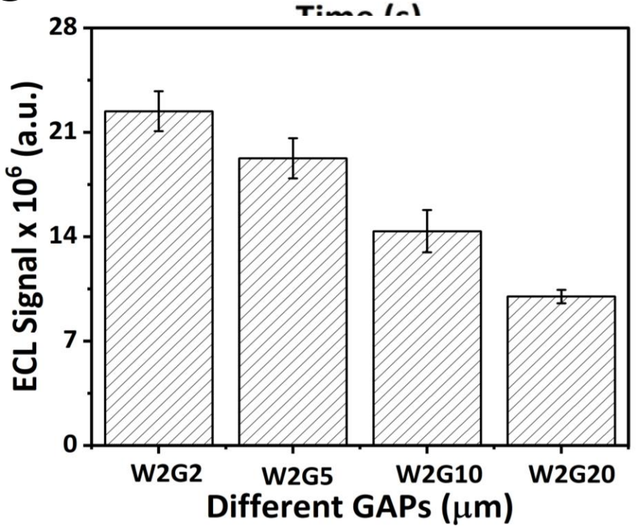
Coreactant-Free ECL Performance

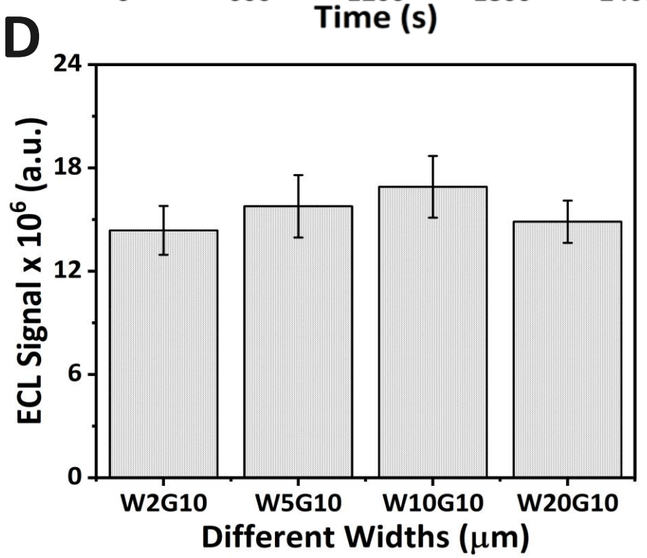




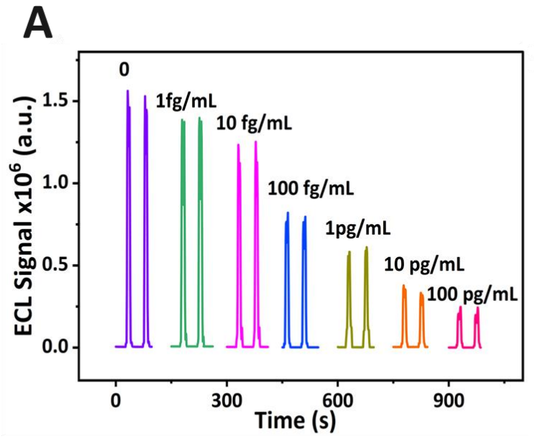


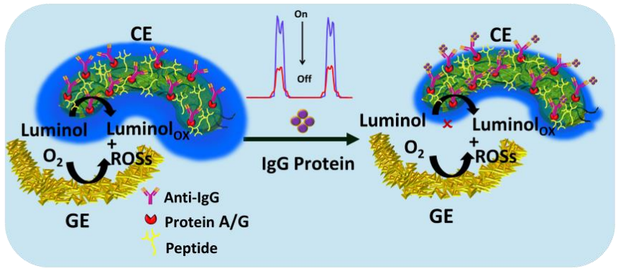


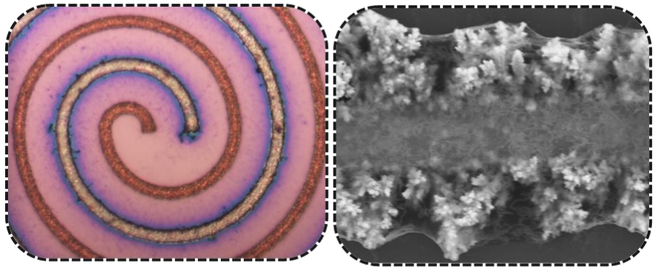


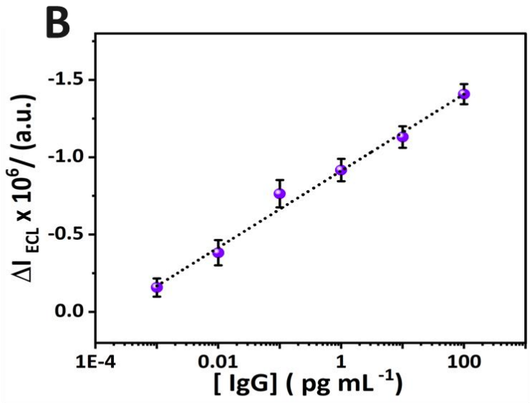


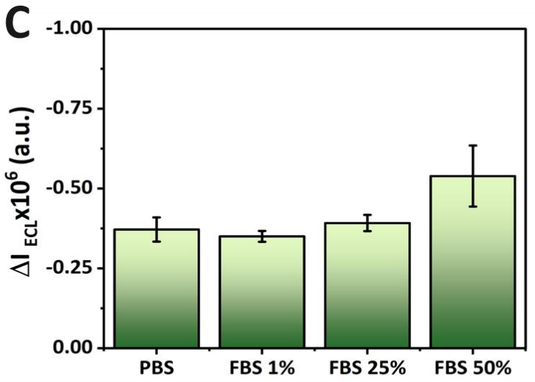
Coreactant-Free ECL Immunosensors

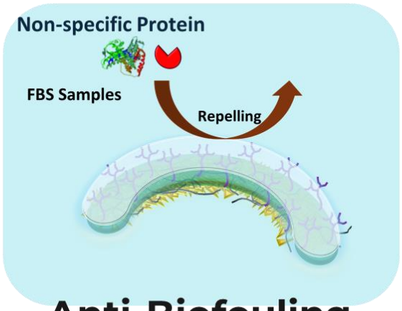




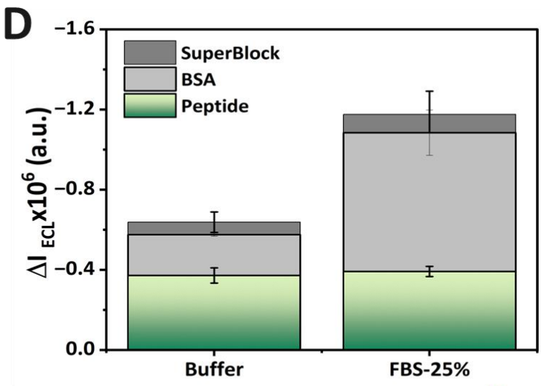




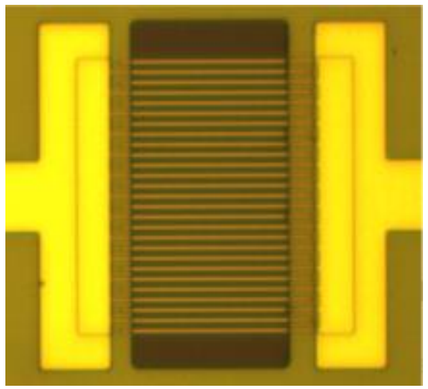


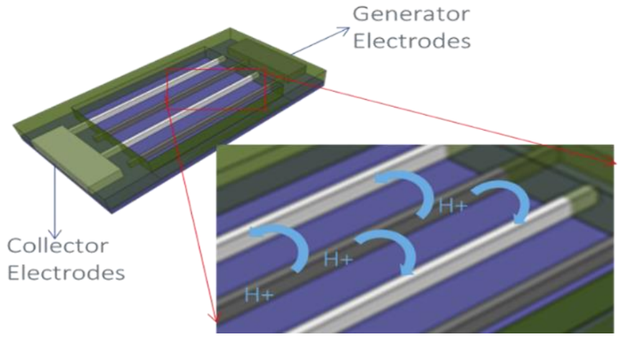


Anti-Biofouling Layer



Interdigitated electrodes for local pH control



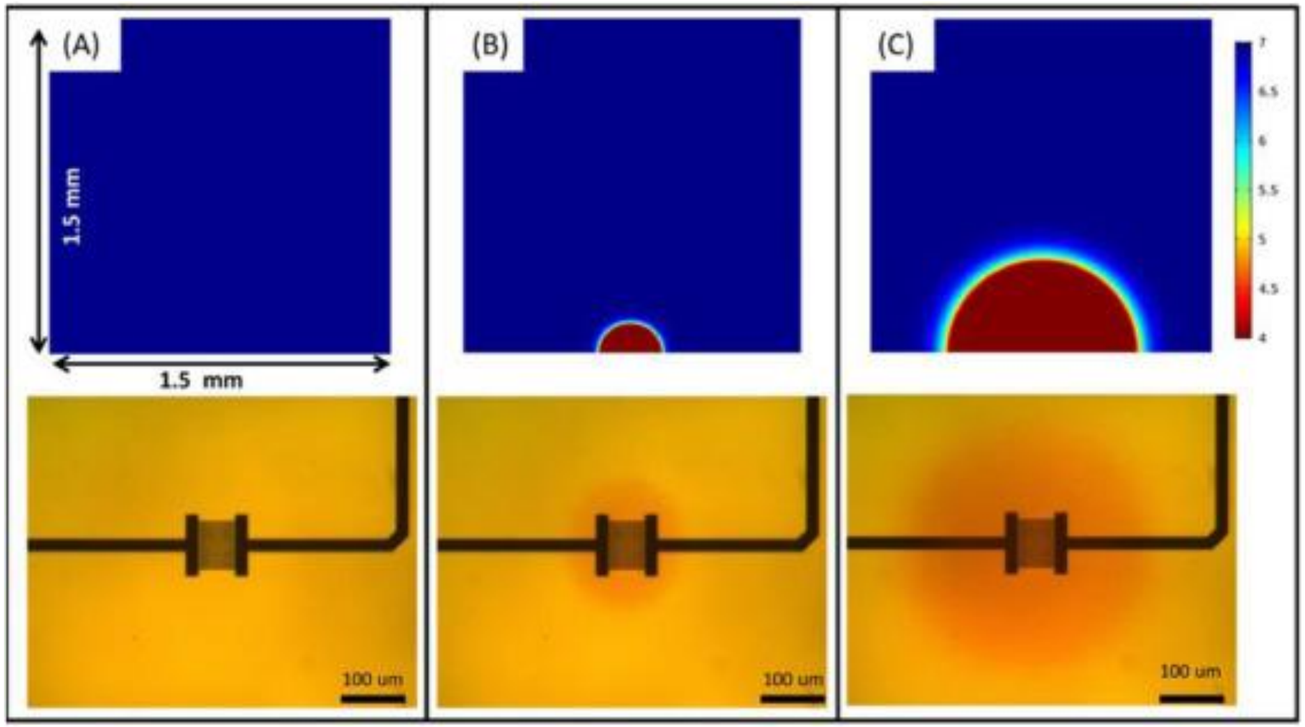


Oxidation: $2\ H_2O(l) \rightarrow O_2\ (g) + 4\ H^+(aq) + 4e^-$

Reduction: $2\ H^+(aq) + 2e^- \rightarrow H_2\ (g)$

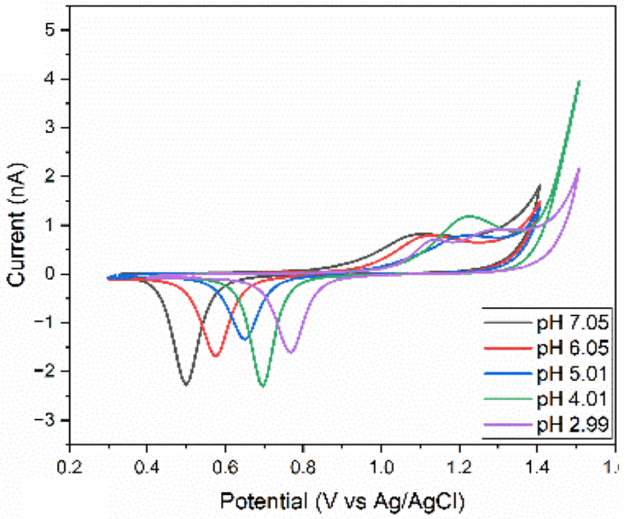
Simulation of proton diffusion of protons from protonator electrode:

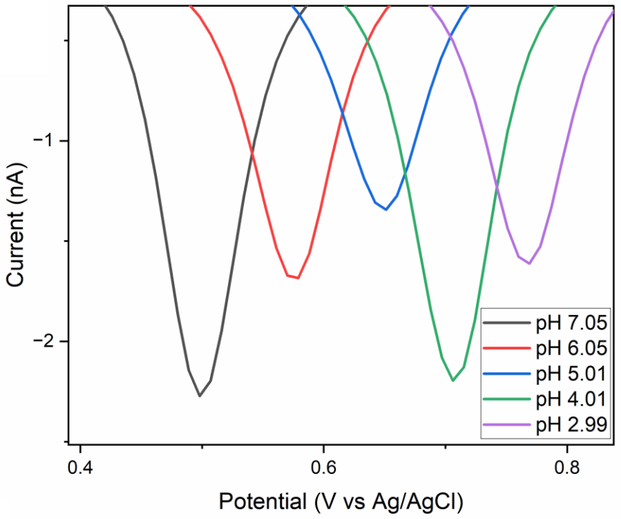
t=0 s t= 1s t=10 s

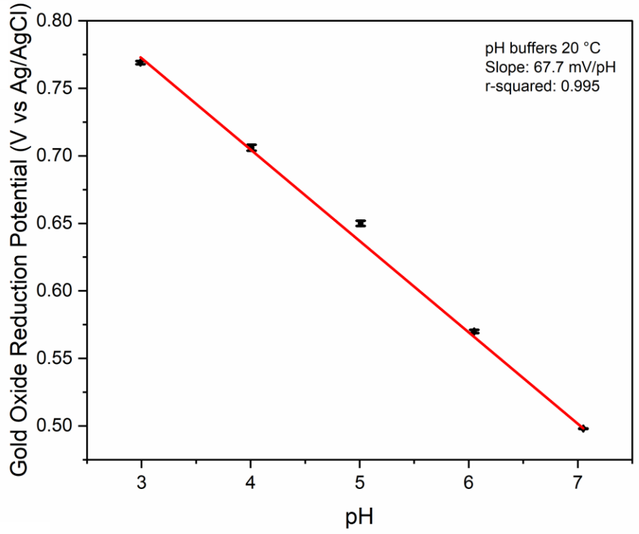


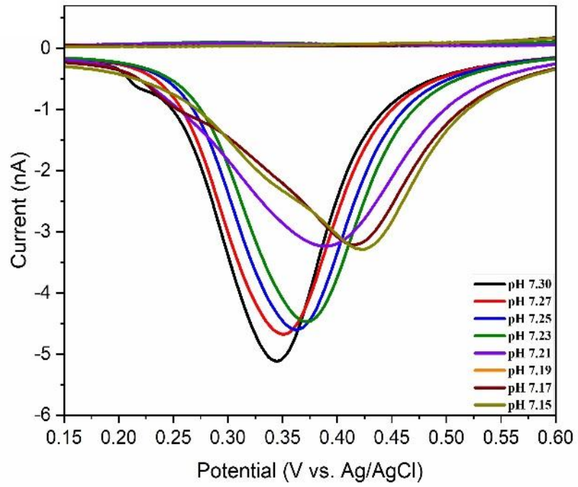
Visualisation of pH change using methyl red pH indicator dye.

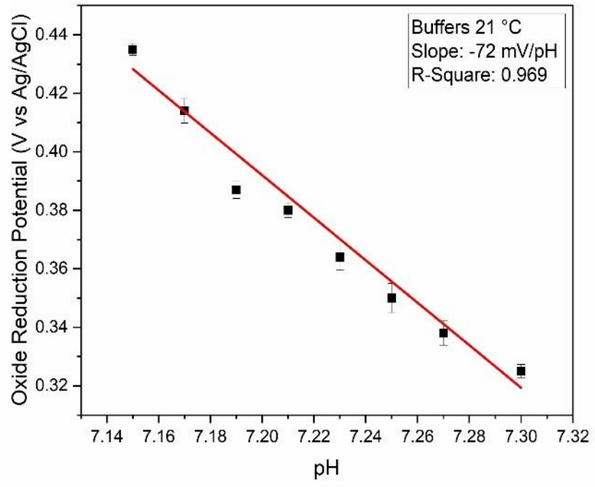
Gold Oxide Reduction as pH Probe

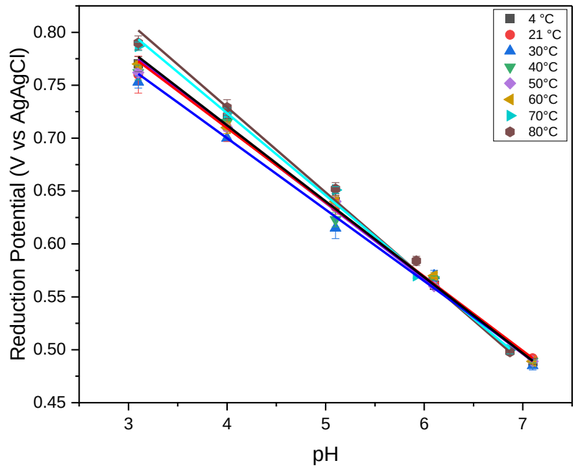




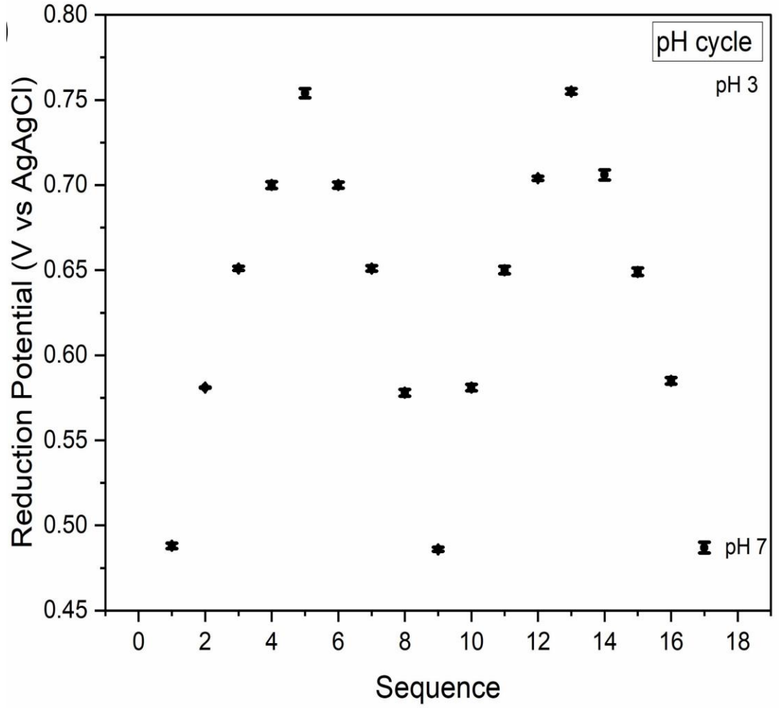


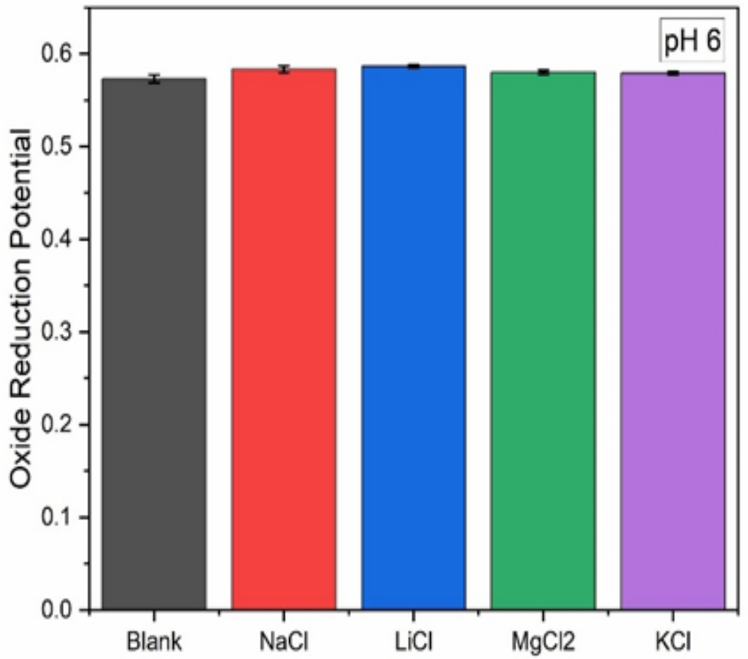


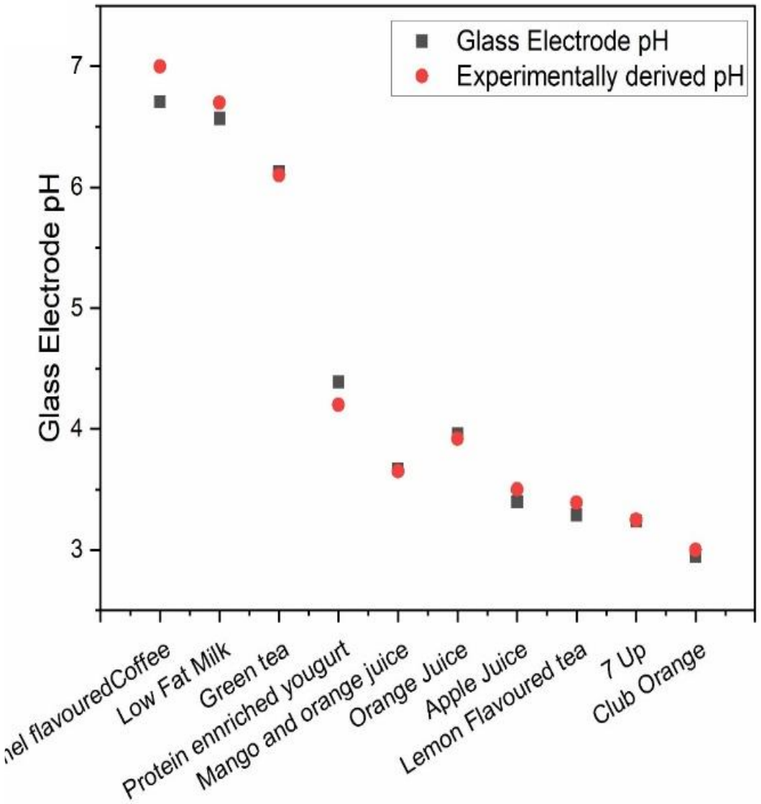




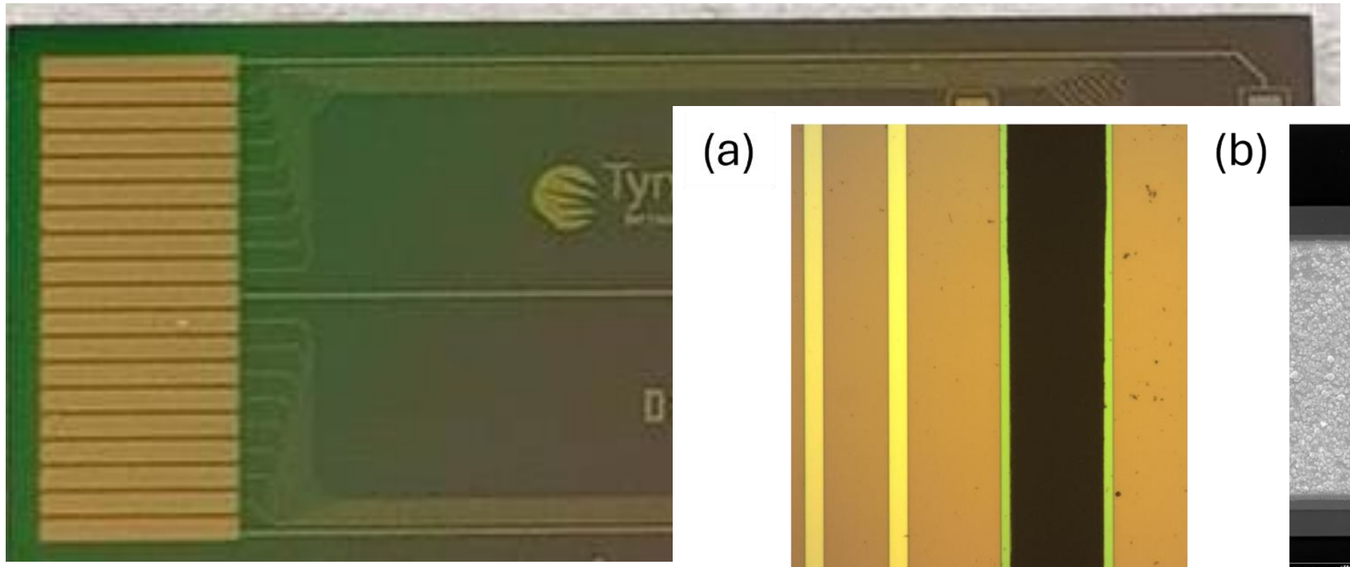
Gold Oxide Reduction as pH Probe





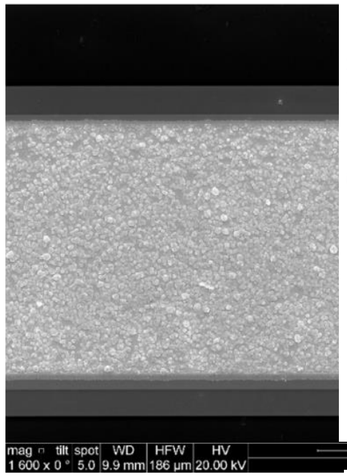


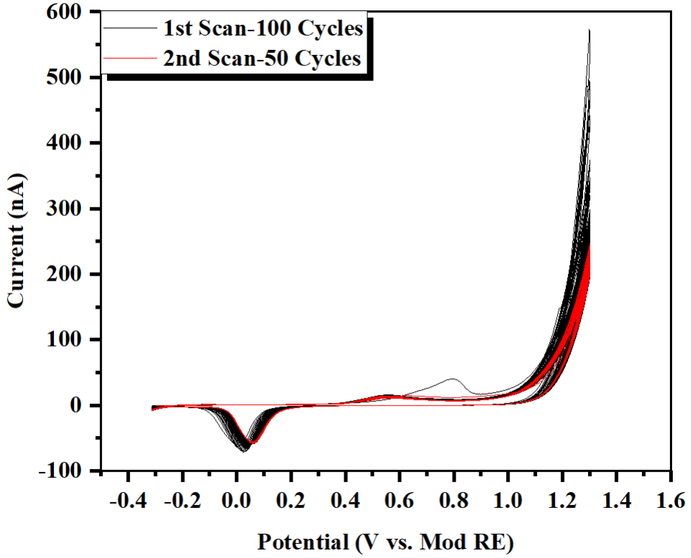
Reference Electrode Stabalisation



(a)

(b)





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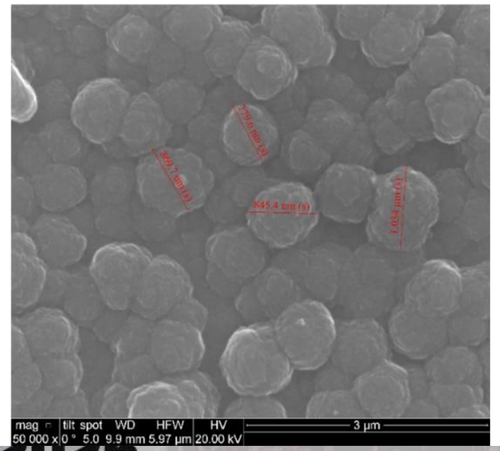

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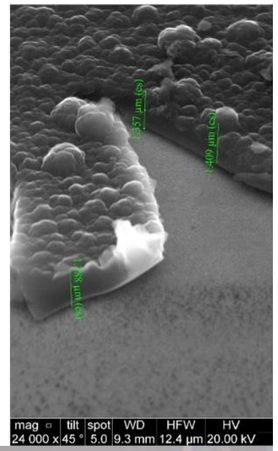
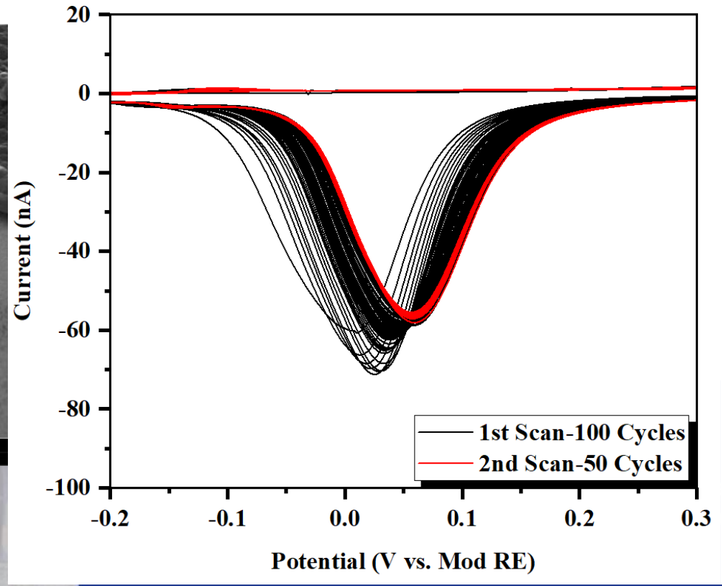
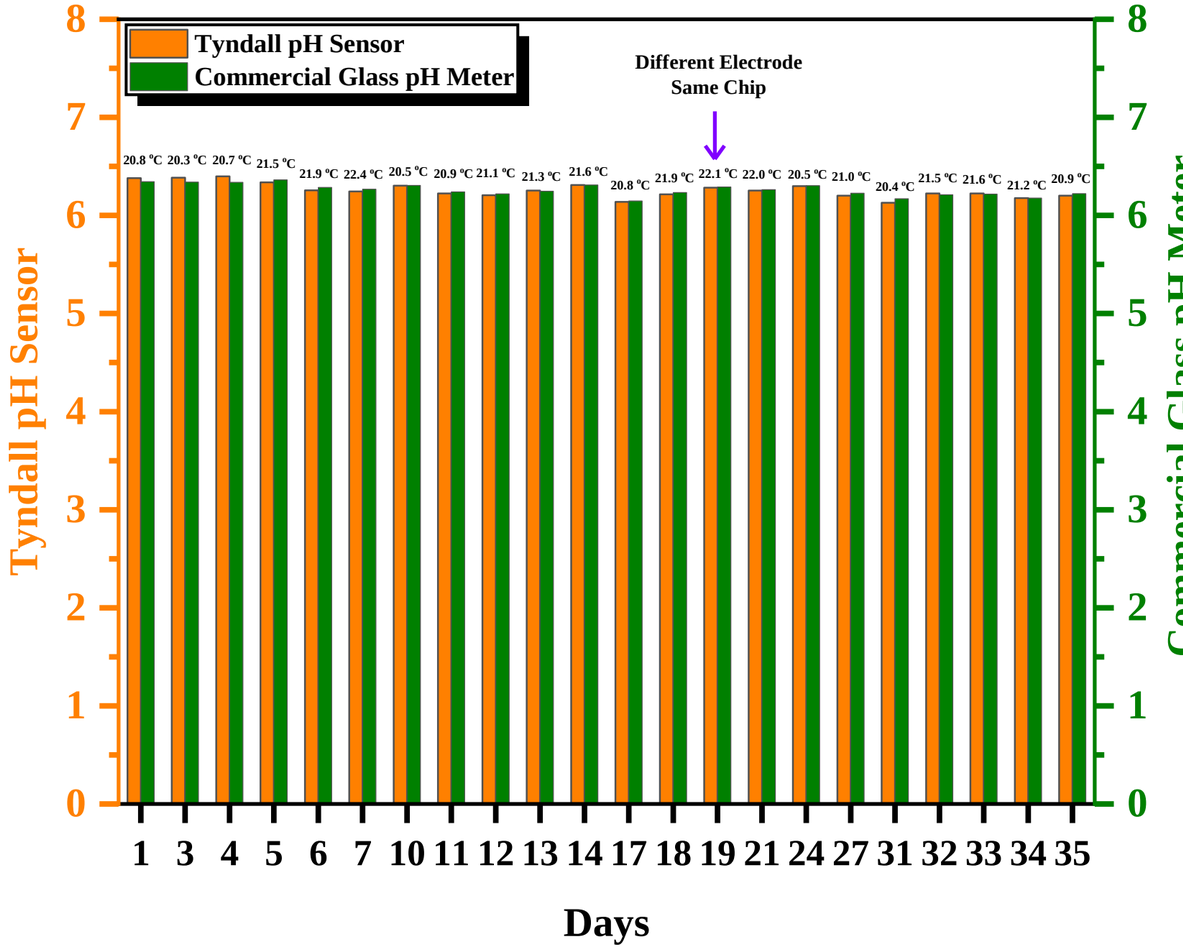




pH sensing in rumen fluid

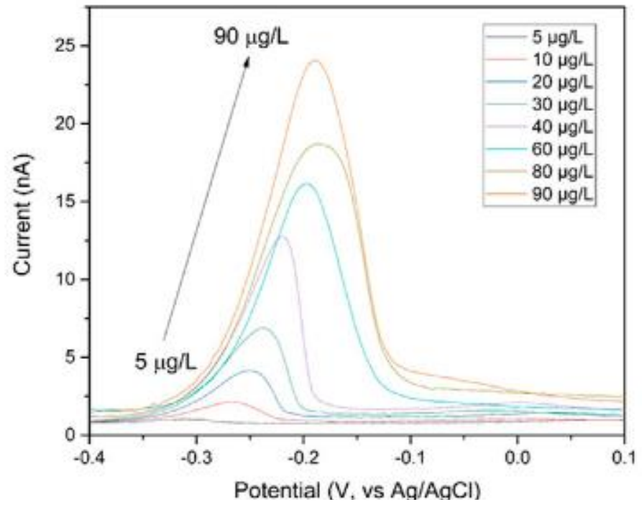


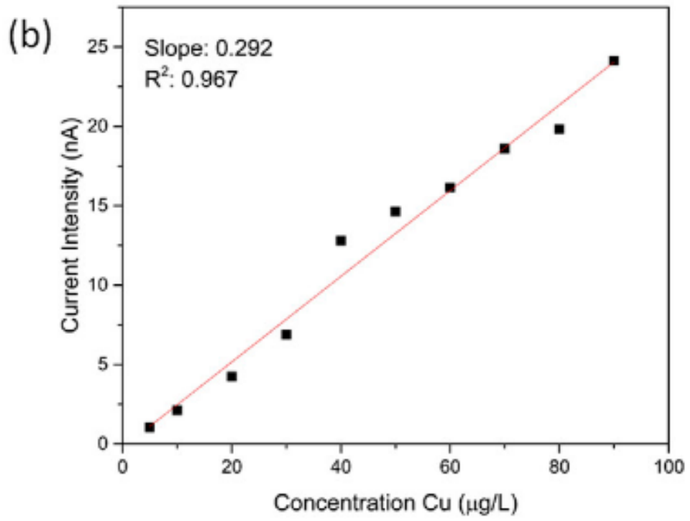
- Early Detection of Illness
- Nutrition, Digestion, and Production Optimization
- Reproductive Efficiency and Calving Management

Challenge Glass pH sensor ➔ Tyndall Gold pH sensor

Metals: *In-situ* pH control

Sites	ICP-MS (µg/L)	Pt IDA Sensor (µg/L)
Avoca	22	17
Ross Mines	27	20
Bunmahon	<3	1





Same approach successfully applied to silver, lead, mercury, cadmium and mixed metals

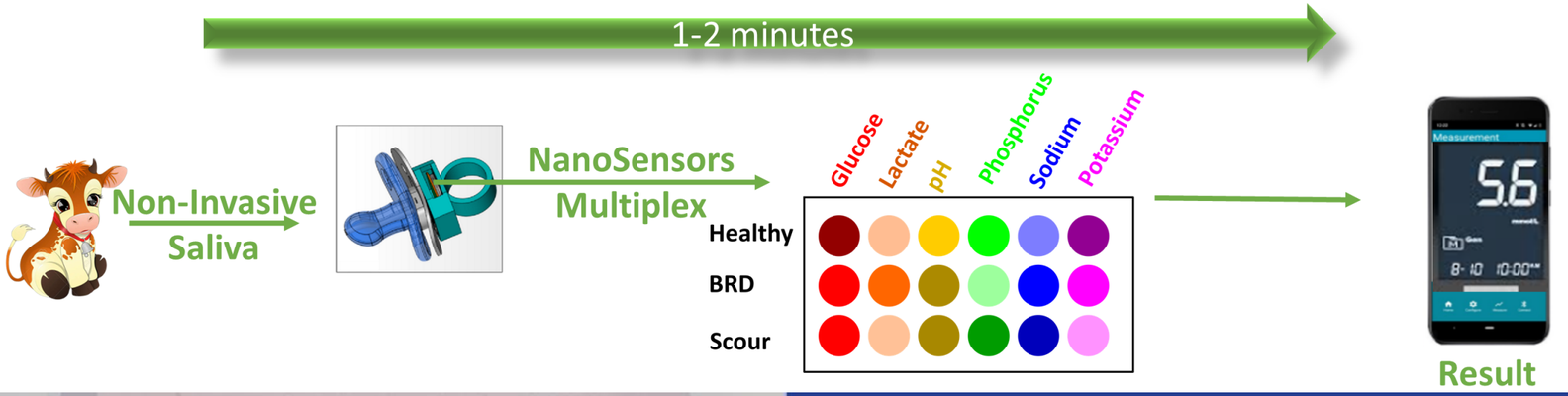
Calf wellbeing – animal welfare

Bovine Respiratory Disease

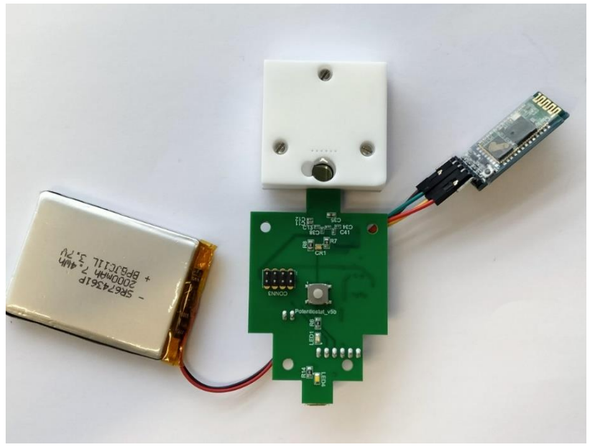
A complex, **bacterial** infection that causes **pneumonia** in calves.
IMPACT: **65%** of feedlot morbidity, **€800** to **€900 million economic loss**

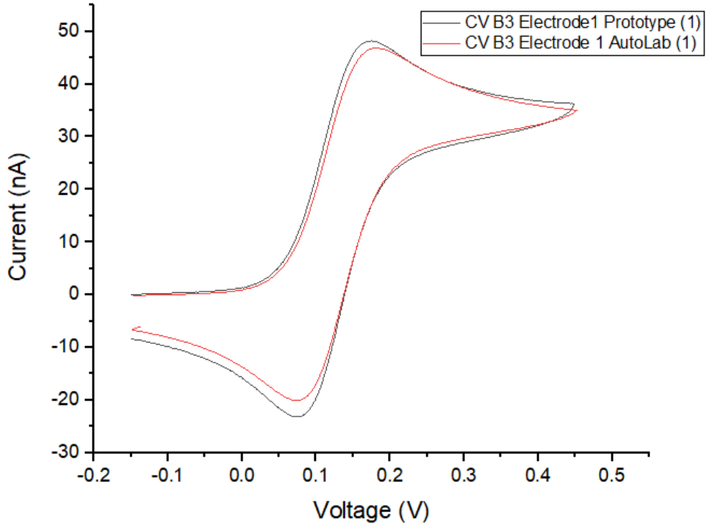
Scour Disease

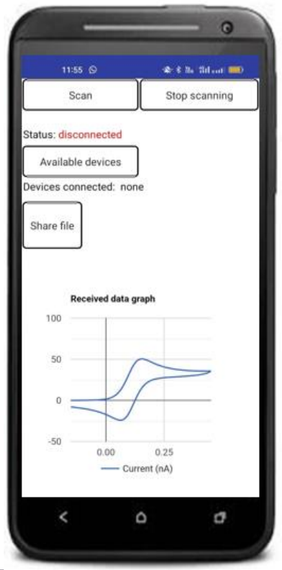
Bacterial, viral or parasitic infection which causes **diarrhea** in calves.
IMPACT: **48%** calves death, **€90** to **€102 million economic loss**



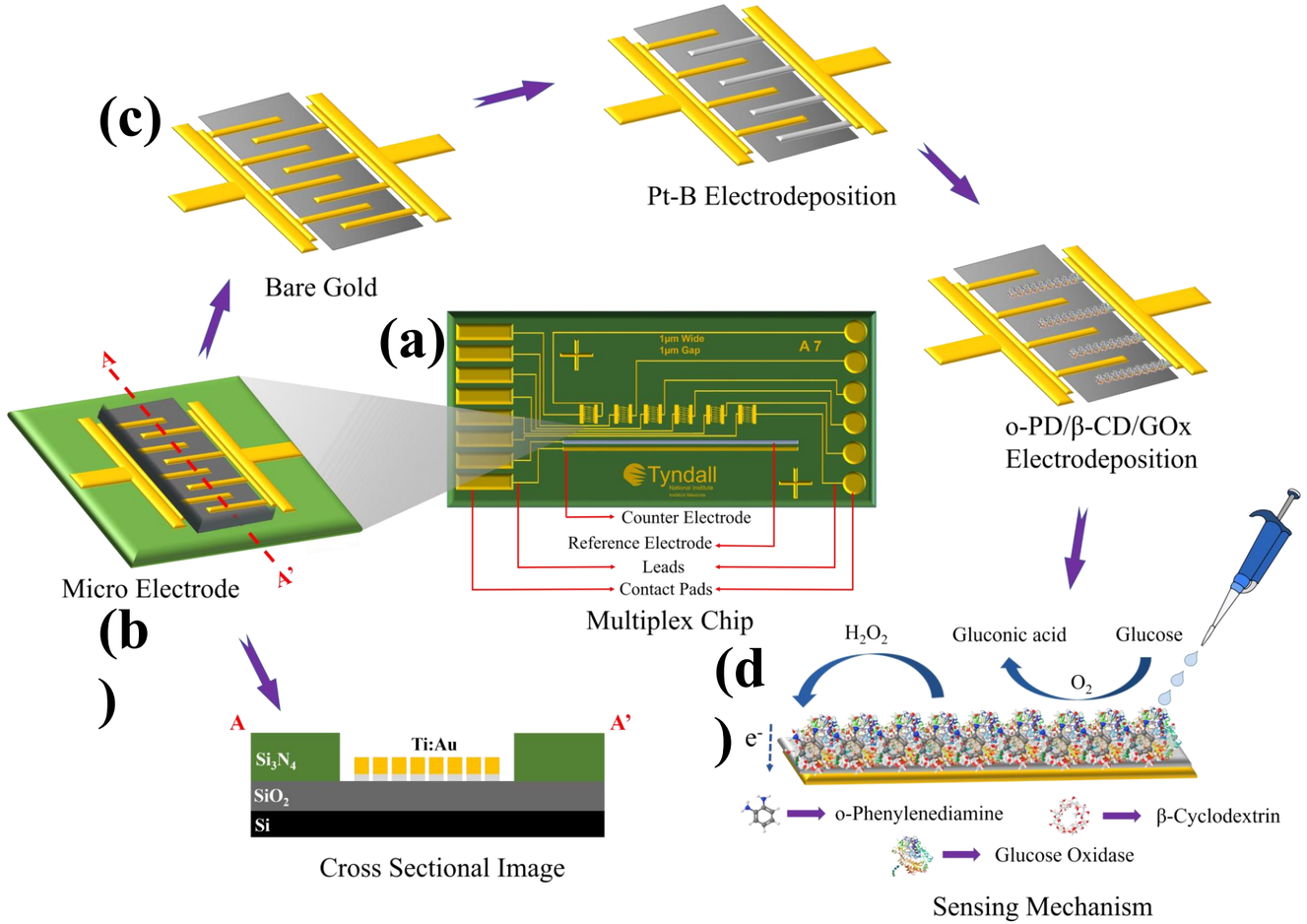
System Development







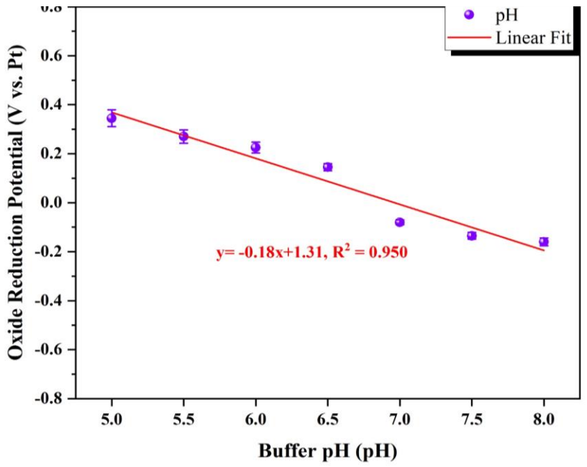
Specificity – Bio-modification

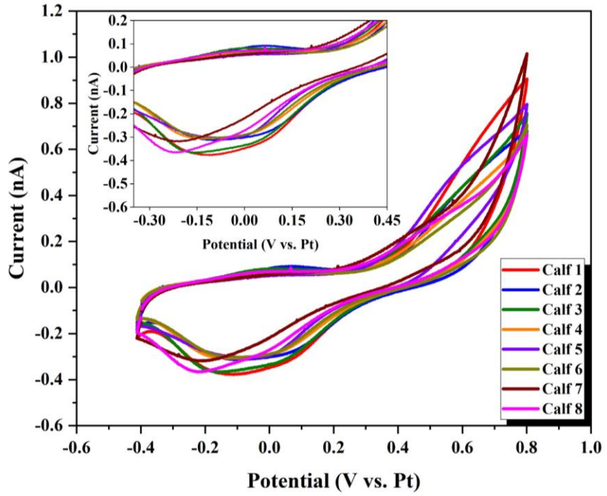


Schematic image of the multiplexed chip

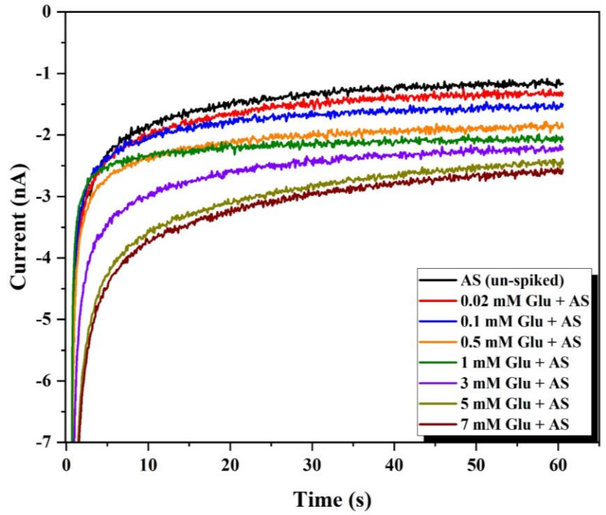
Saliva Biosensor – pH, Glucose and Lactate

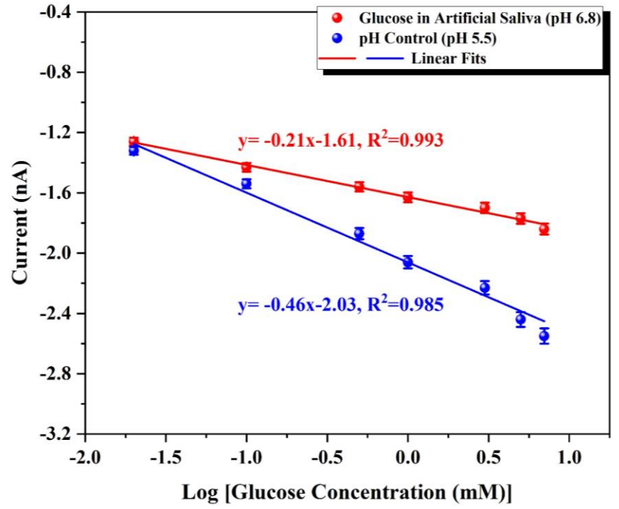
pH calibrated in saliva



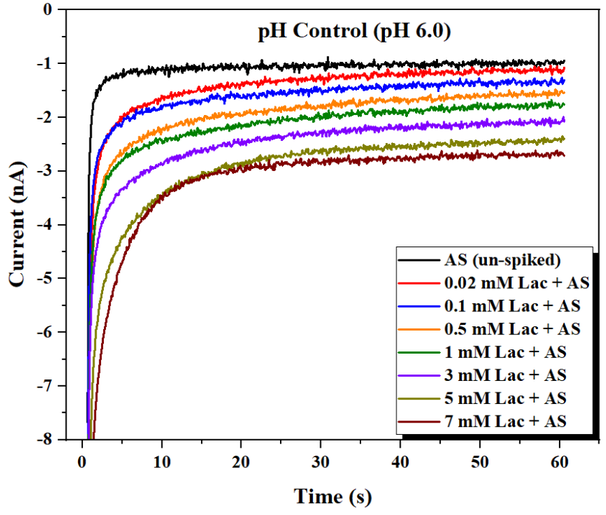


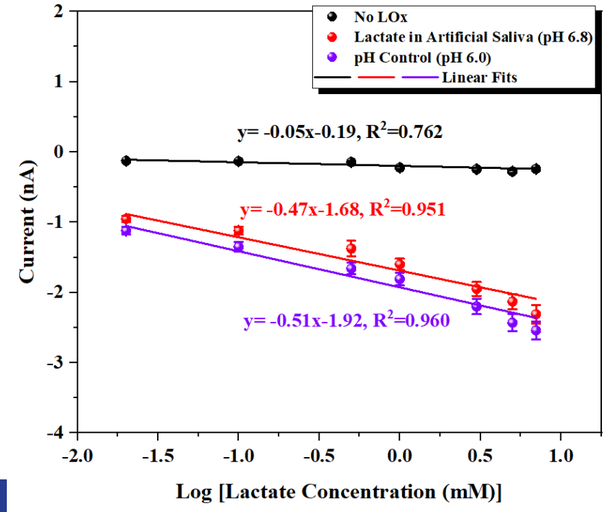
Glucose (pH control)





lactate (pH control)





Multiplexed Biosensor (pH, Glucose, Lactate)

Sample	Sample ID	pH	Glucose Concentration (µM)	Lactate Concentration (µM)
Calf-1	1887	8.0	120 ± 6	583 ± 10
Calf-2	1889	8.1	110 ± 6	613 ± 8
Calf-3	1893	7.8	105 ± 5	643 ± 9
Calf-4	1910	7.9	300 ± 9	680 ± 10
Calf-5	1900	7.7	272 ± 9	709 ± 9
Calf-13	**2218**	**8.3**	**16.5 ± 0.12**	**952 ± 8**
Calf-14	**2202**	**8.4**	**6.1 ± 0.07**	**1004 ± 10**

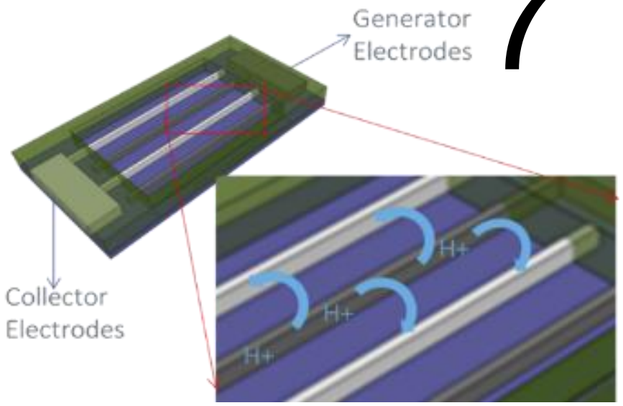
Healthy saliva pH range	**7.7 - 8.2**
Healthy saliva glucose range	**110 - 1350 µmol/L**
Healthy saliva lactate range	**110 - 780 µmol/L**

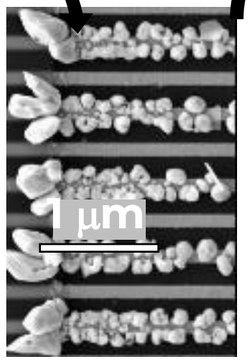
Precision Electrochemical Nanosensors

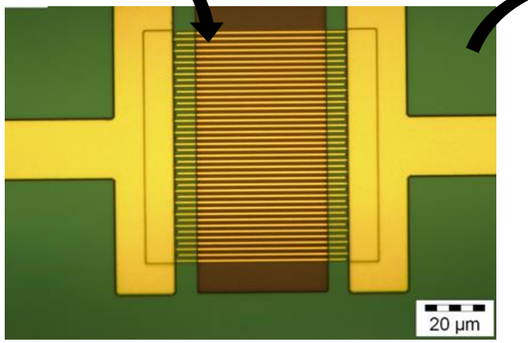
Taighde Éireann Research Ireland

VistaMilk

SARMENTI

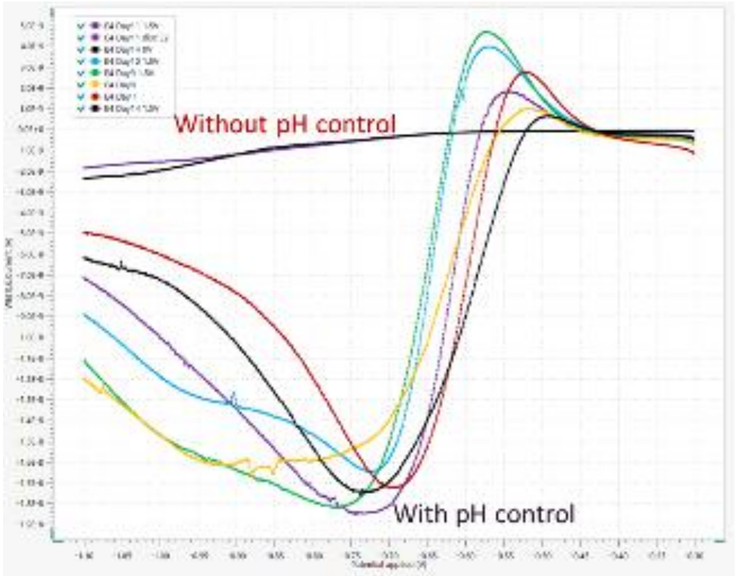


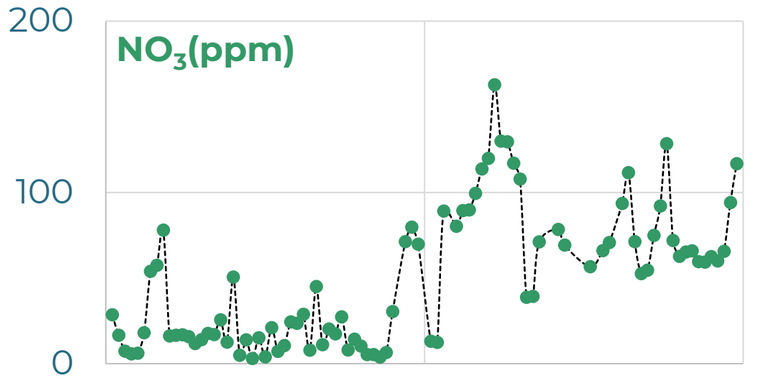




Packaged nanosensor chip on farm

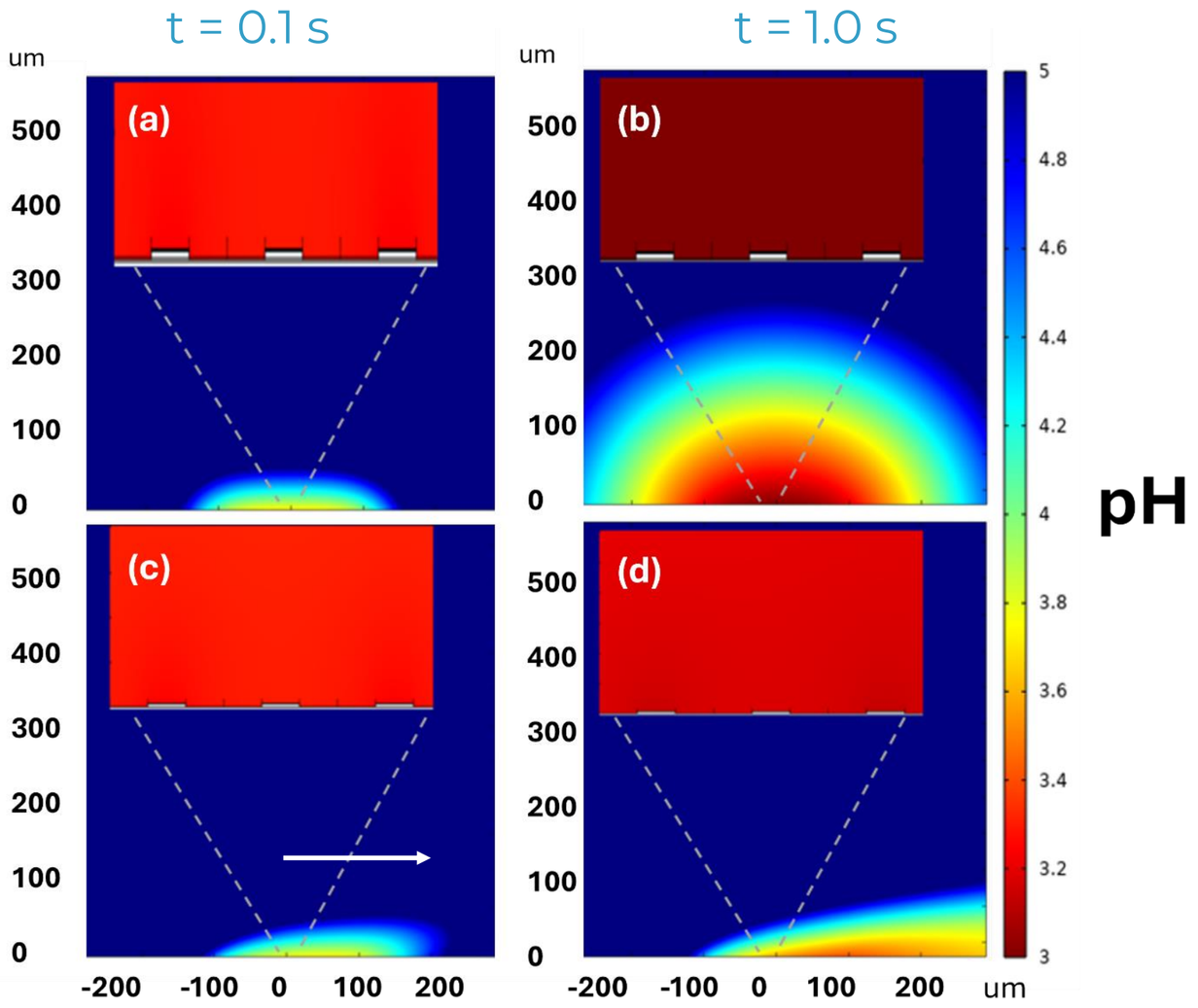
Enabling Real-time Decision Making:
Developed new sensor materials and in-situ pH control which enable selective detection of nitrates (NO_3), pH and dissolved oxygen in soil.
PCT Granted: [WO2024261348A1]



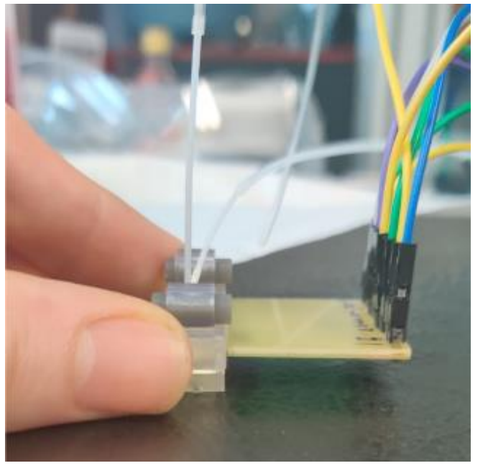


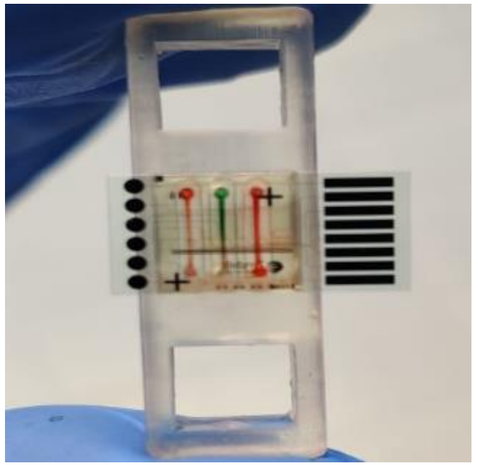
Continuous NO_3, pH, oxygen monitoring

Finite Element Simulations - Hydrodynamic



pH

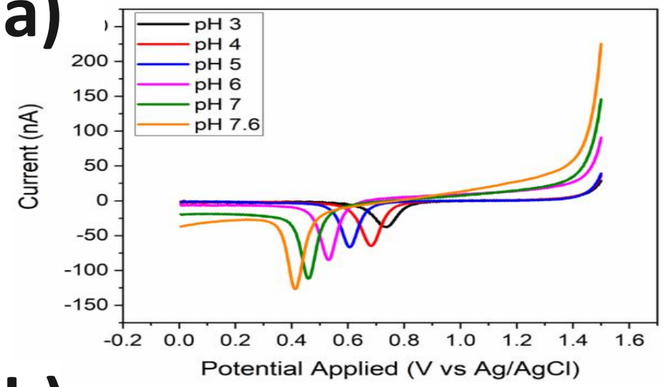




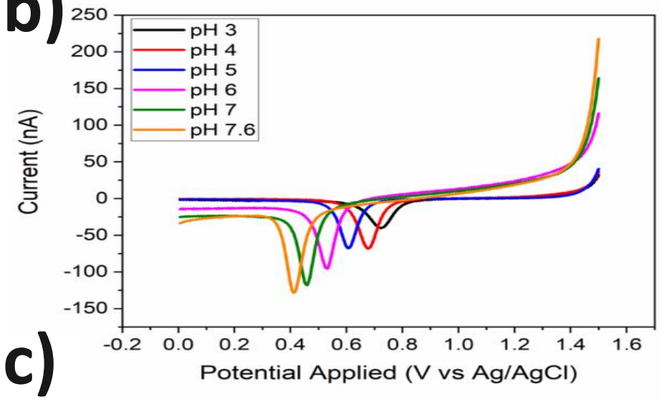
Gold oxide Static & Flow

Chemically

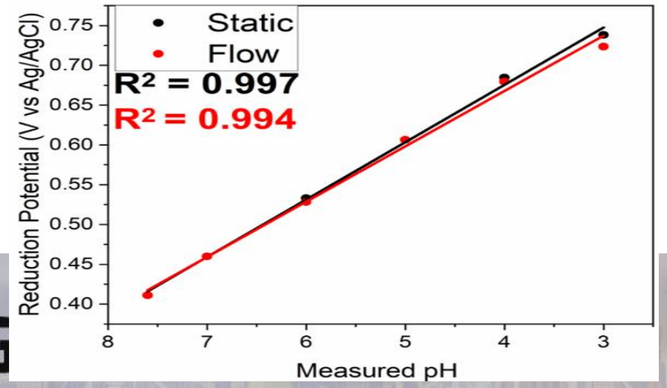
(a)



(b)

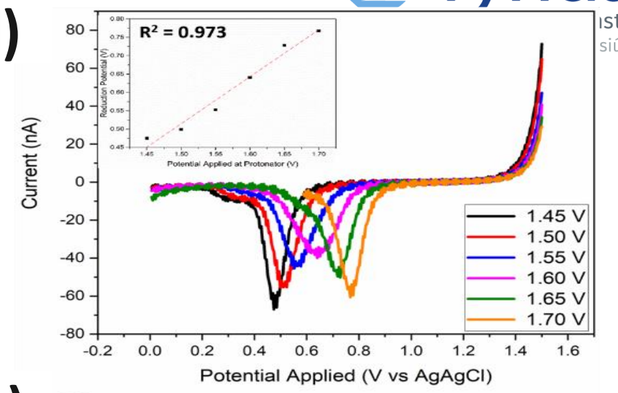


(c)

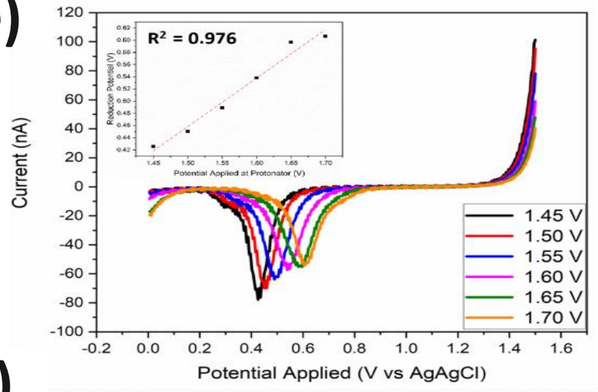


Electrochemically

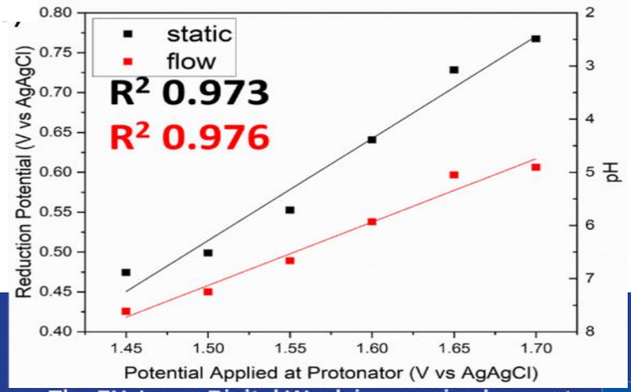
(d)



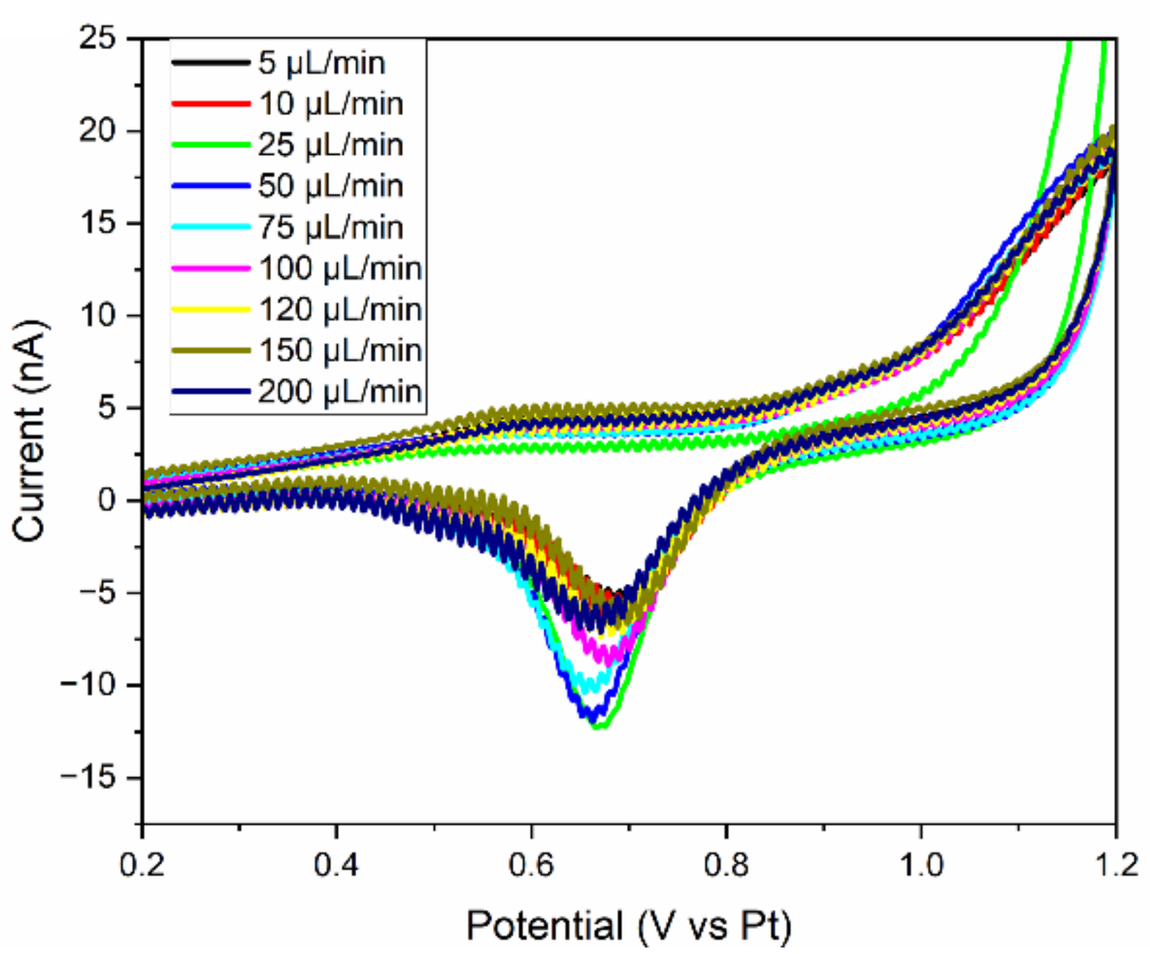
(e)



(f)

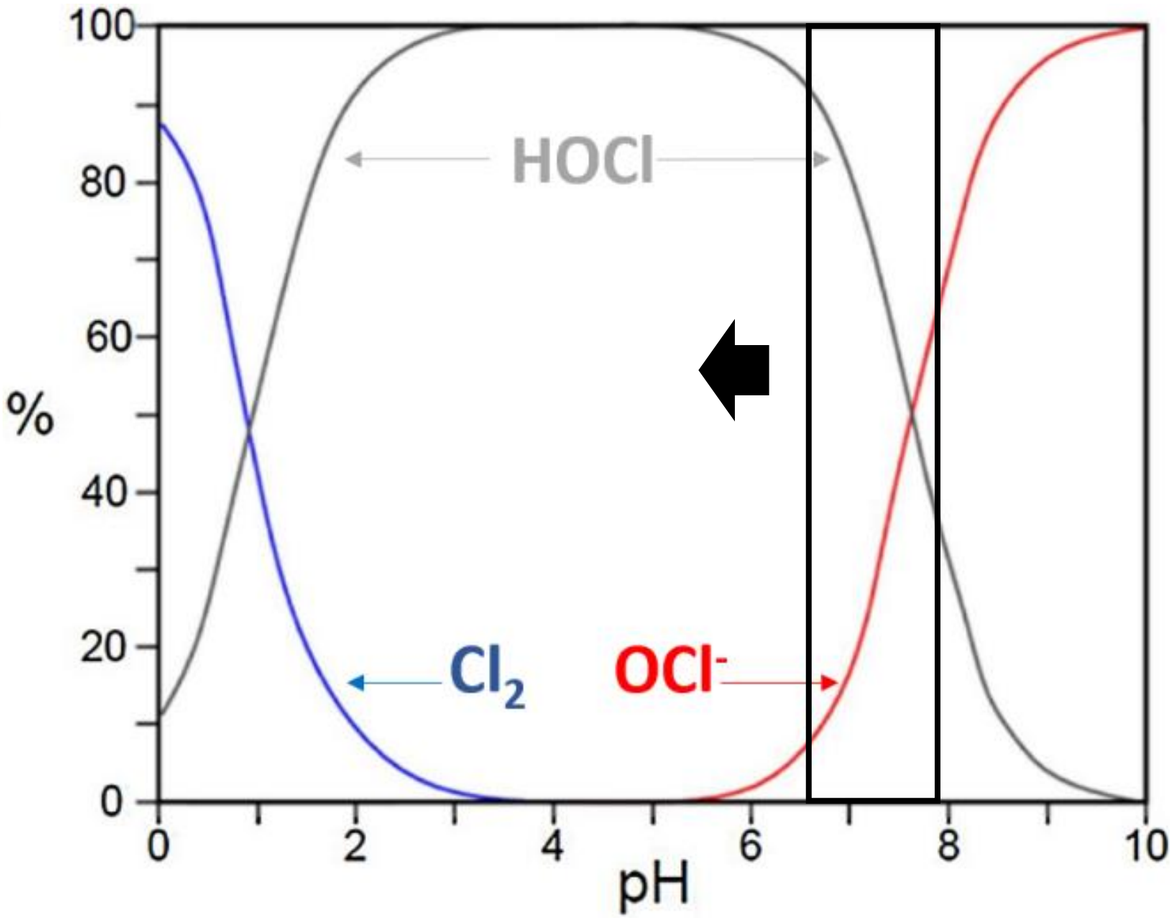


Gold oxide Static & Flow



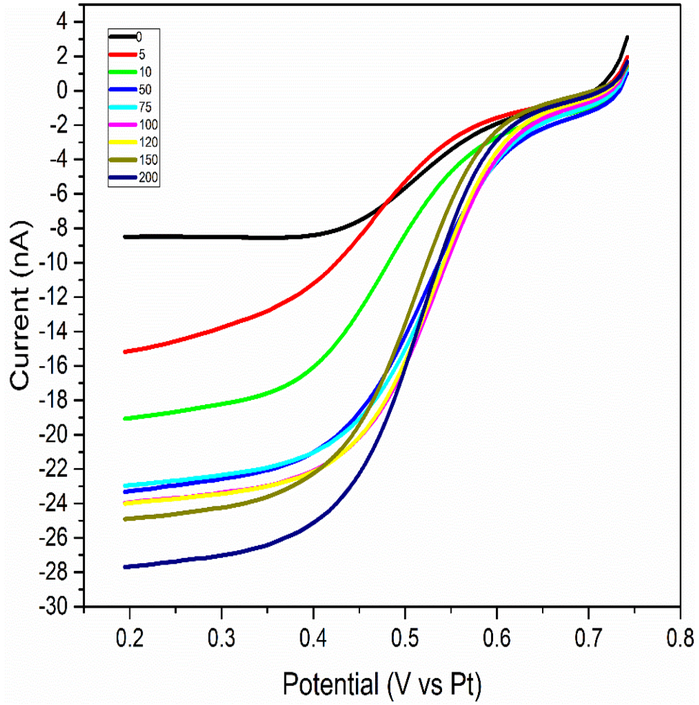
Chlorine Sensing

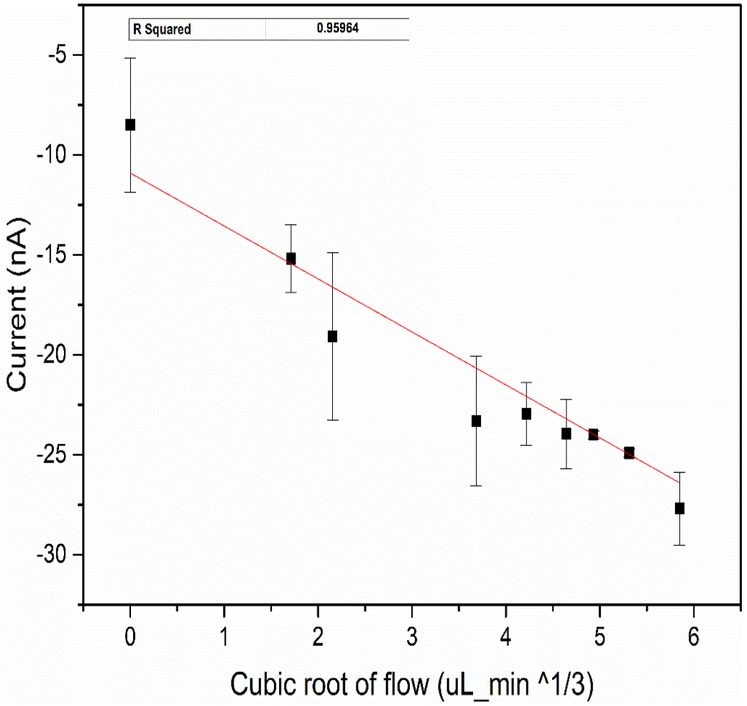
- Chlorine used to sterilise water
- Insufficient chlorine – Biological species in water
- Excess chlorine – toxicity/death
- Typical method – colorimetry
- Electrochemical pH control method – Hypochlorous Acid (HOCl)
- Ideal sensor would operate under flow (in-line)

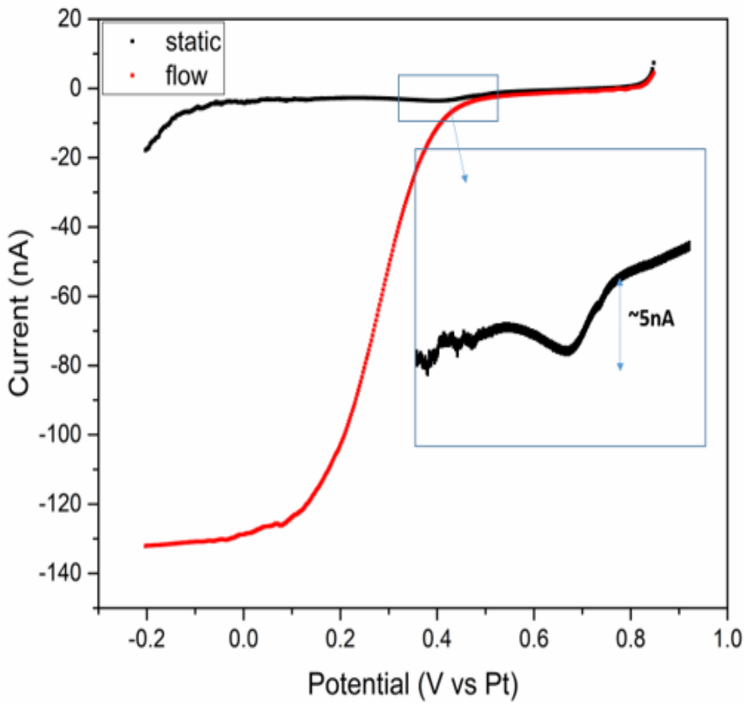


Detection of Chlorine under flow

5.3 ppm Chlorine in water sample





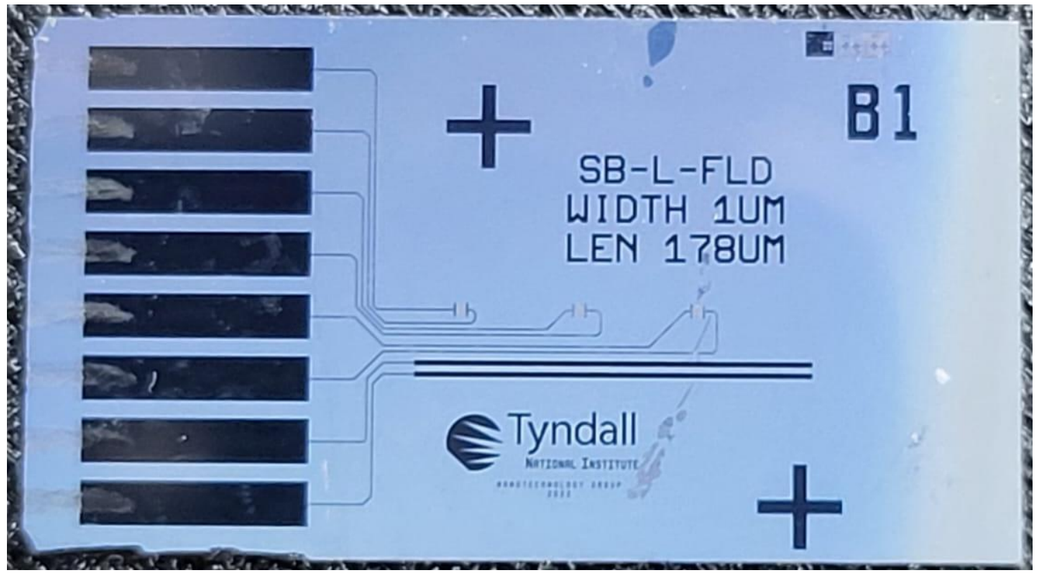


4th Water Framework Directive – chemcial watchlist

Tyndall National Institute
Institiúid Náisiúnta

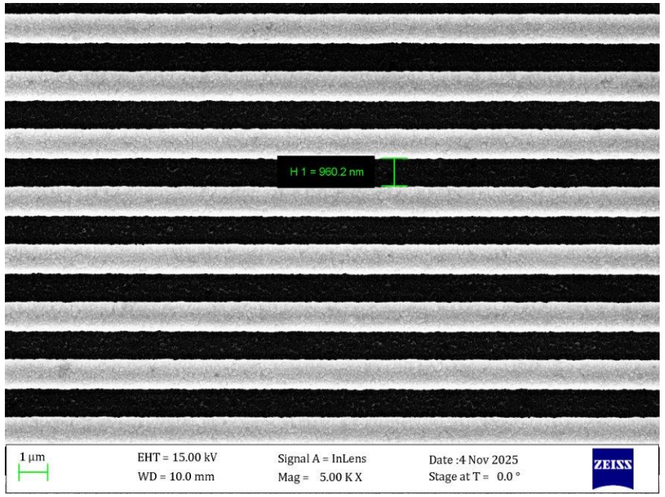
4th WL proposed substances

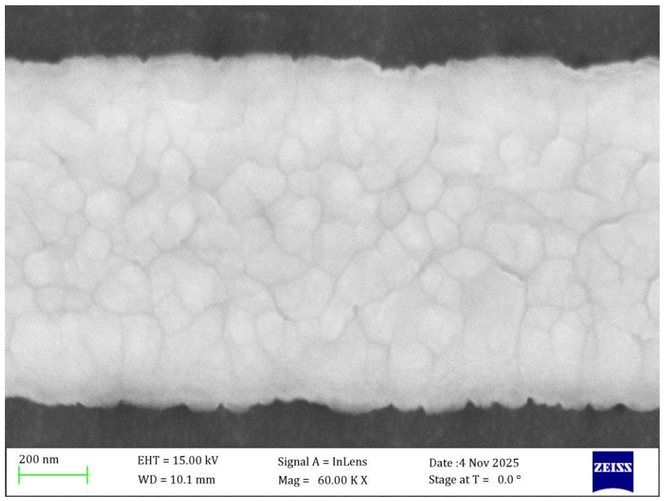
Industrial products	PPP and biocides	Pharmaceuticals and illicit drugs
Alkylphenols	Azoxystrobin	Metformin and its transformation product (guanylurea)
Chloroanilines	Diflufenican	Antibiotics
Siloxanes	Fipronil	Illicit drugs
Sunscreen agents	Metazachlor	Synthetic hormones
UV filters	Pyrethroids	
	Rodenticides	

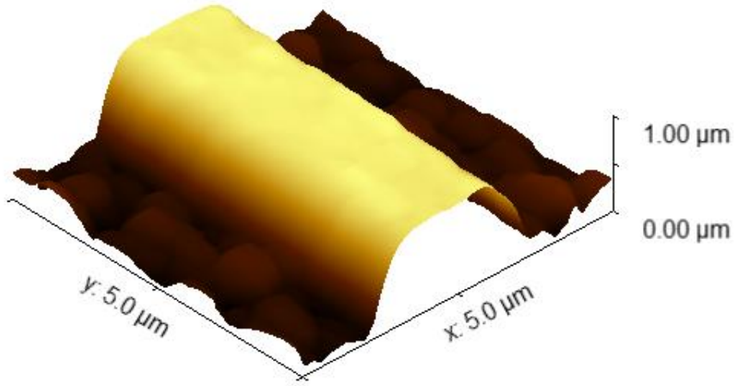


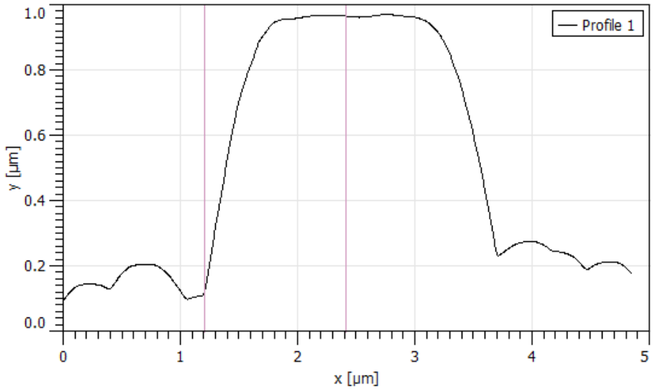
Limits of detection required are low to sub ng/L

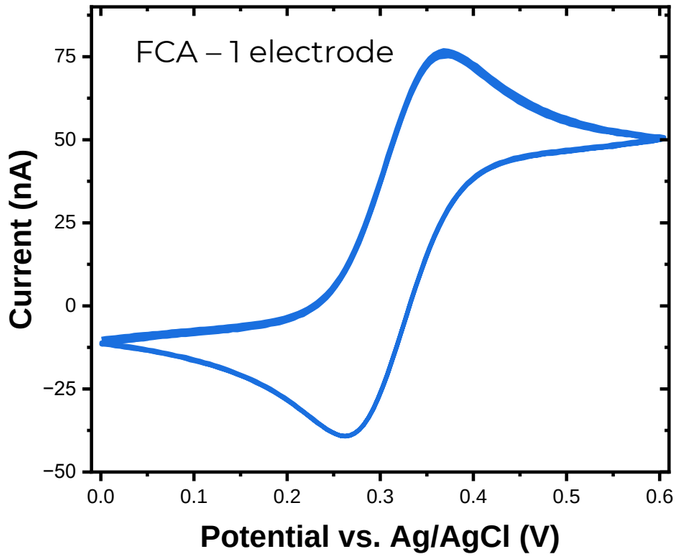
BDD Ultra-Micro IDE

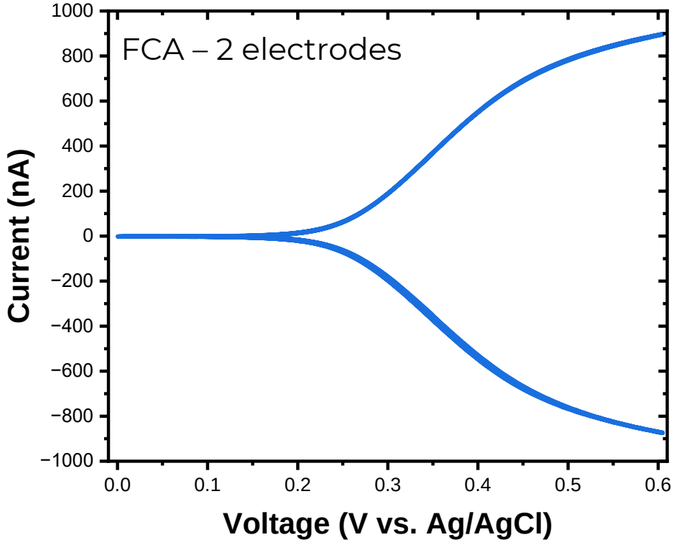












Detection of Granisetron

Wide Potential Window: widest of any material

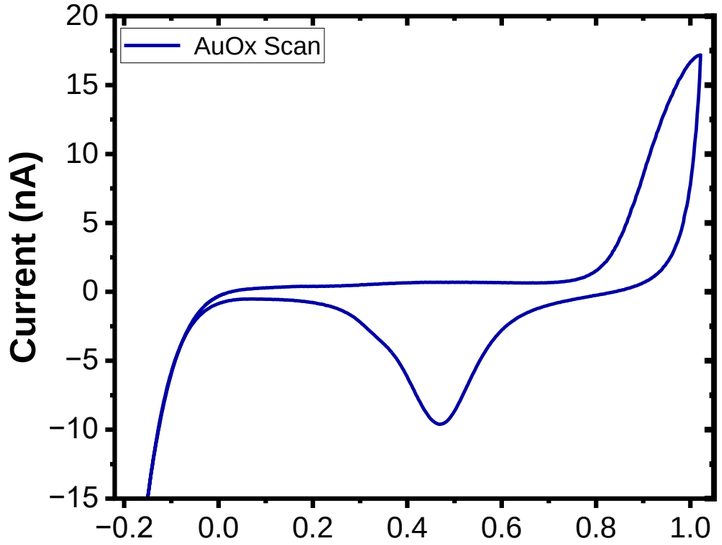
Low Background/Capacitive Current: high signal-to-noise ratios and exceptional sensitivity

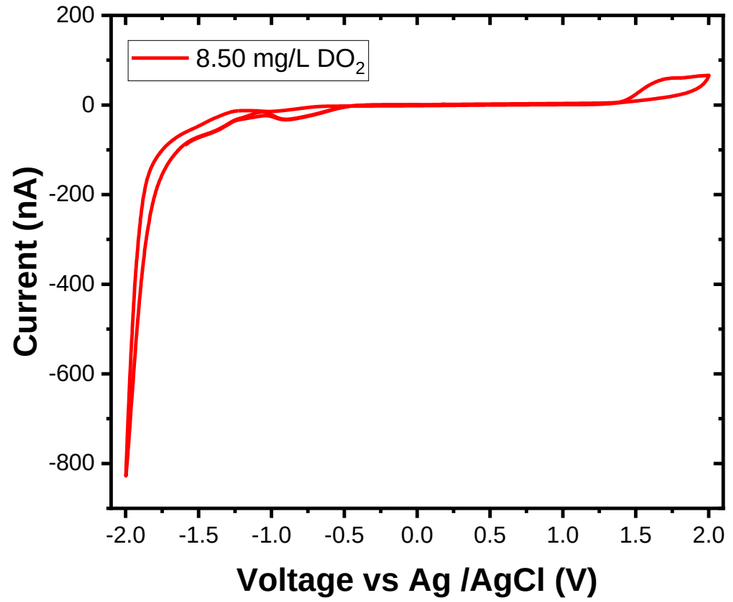
Exceptional Stability and Durability: High corrosion resistance

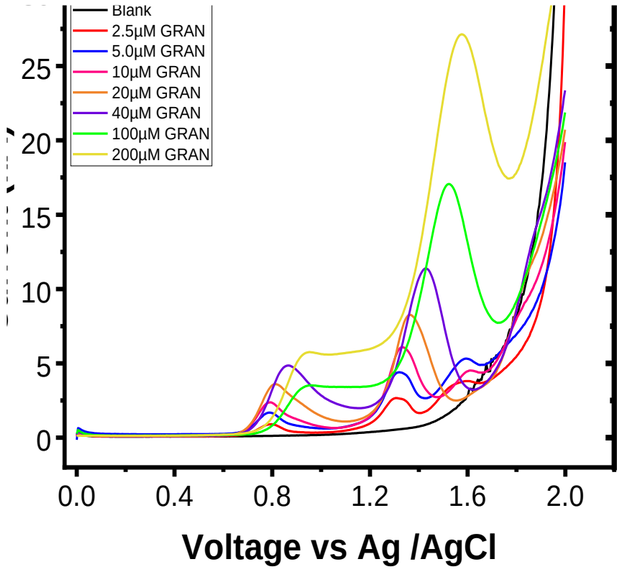
Reduced Fouling: Inert, sp^3 surface

Surface Tunability: modified via surface termination (cathodic/H-terminated or anodic/O-terminated) to suit specific applications.

Biocompatibility: Suitable for use in medical and biological sensor applications







Conclusion & Acknowledgements

- Silicon chip-based chemical and biochemical sensors are being developed that can provide input into digital support systems.
- Significant commercial opportunities exist for new and disruptive technologies in the Agri-Food / Environmental sector
- In-situ pH control is opening the door to otherwise difficult to measure problem statements
- PEN group: Students, Post Docs and Staff
- Ridwan Adib, Shane O'Sullivan, Sana Muzaffar Richard Murray, Han Shao, Tarun Narayan, Kathleen Kennedy, Ian Seymour

VistaMilk
Department of Agriculture, Food and the Marine
An Roinn Talmhaíochta, Bia agus Mara
ENTERPRISE IRELAND
HORIZON EUROPE
The New EU Framework Programme for Research and Innovation
2021-2027
Taighde Éireann Research Ireland

THANK YOU FOR YOUR ATTENTION!

The EU-Japan Digital Week is an initiative under the EU-Japan Digital Partnership and is supported by the following projects and organisations

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地経学研究所
Institute of Geoeconomics

東京大学
THE UNIVERSITY OF TOKYO

SiNANO Institute

BioSensei: Cell Based Sensors Project

Underlying Sensing Principle