



EU - SOUTH KOREA – Joint Researchers Forum
on Semiconductors



1.4 Digital Technologies for Agri 4.0 Applications

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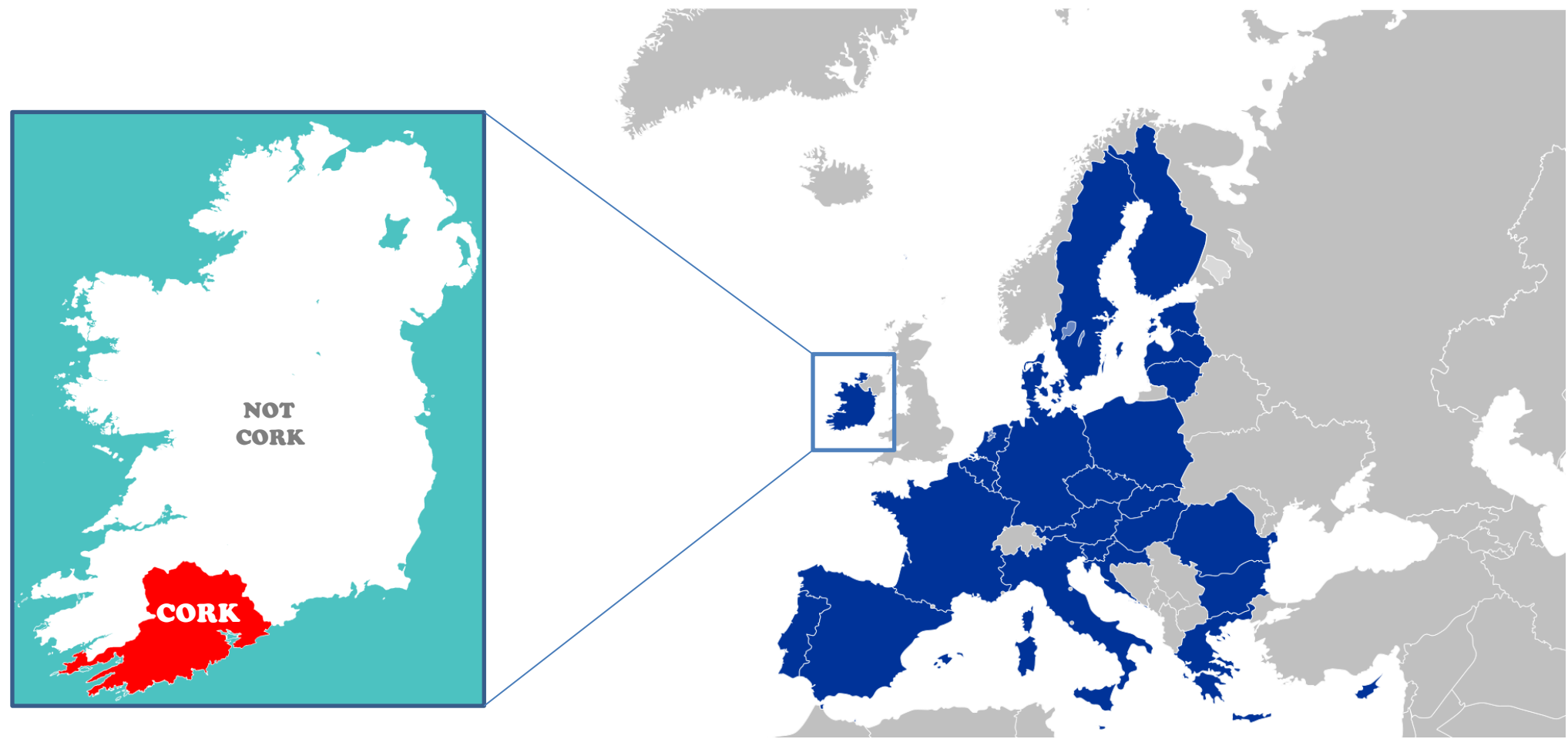


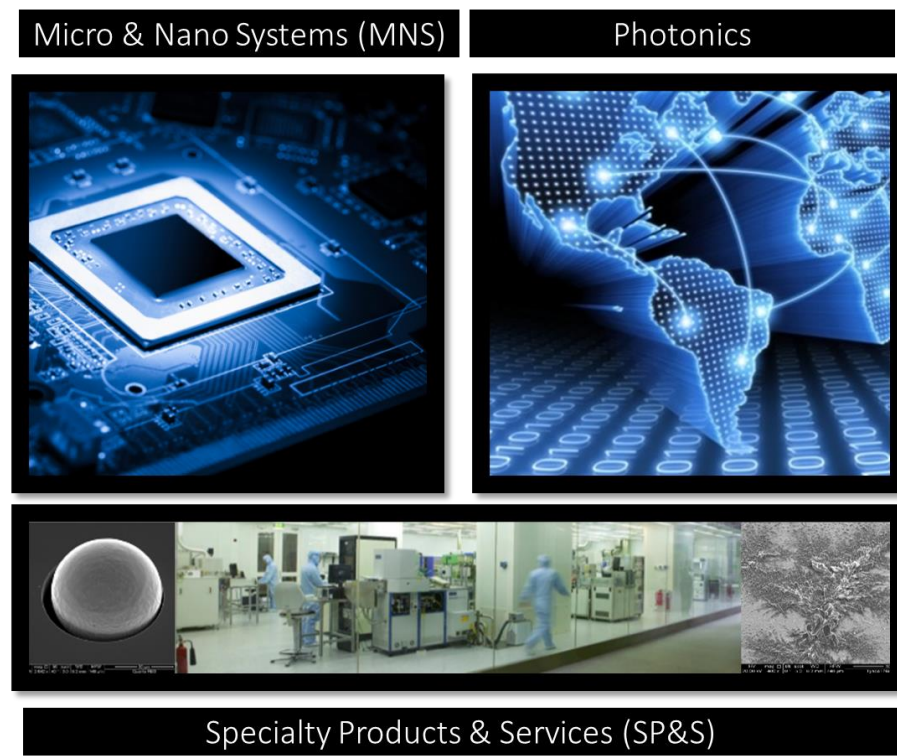
Brussels (Belgium)

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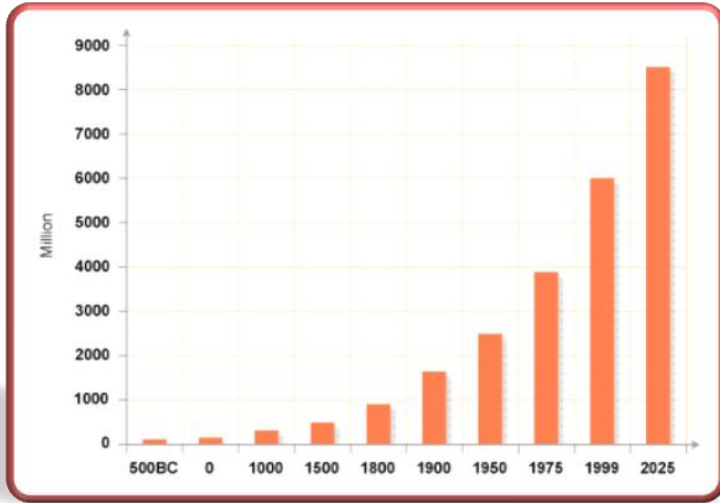


Nanotechnology, electronics, photonics, quantum engineering, wireless & energy

Application Areas



Why AgriFoods? Societal Impact



Climate Change



Competition for land




Loss of Biodiversity



Agriculture Analytics

PEN Group - Research Focus



On-Farm Diagnostics

- Diseases
- Animal Health
- Stress & Welfare

Water Quality

- Sterilisation products
- Priority pollutants
- Anthropogenic contamination

Food Security

- Bacterial spores
- Residues

Processing

- Milk Stability
- Allergens

Plant Pathology

- Real time Virus detection

Soil Chemistry

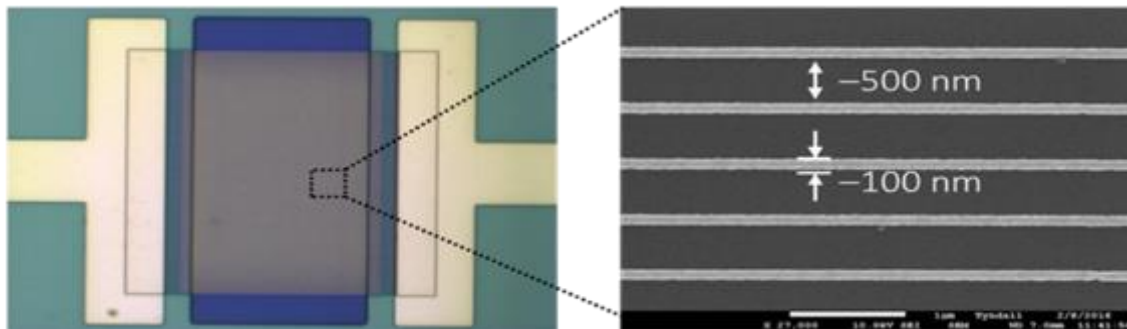
- Micro & Macro nutrients
- Manure & Dirty Water

- Developing new advanced nanosensing platforms to digitalize the agri-food sector to enhance food security, reduce losses, increase sustainable production & economic return while also protecting biodiversity.
- Digital technologies will transform the traditional based agriculture industry to a knowledge based one.

Electrochemical Nanosensor

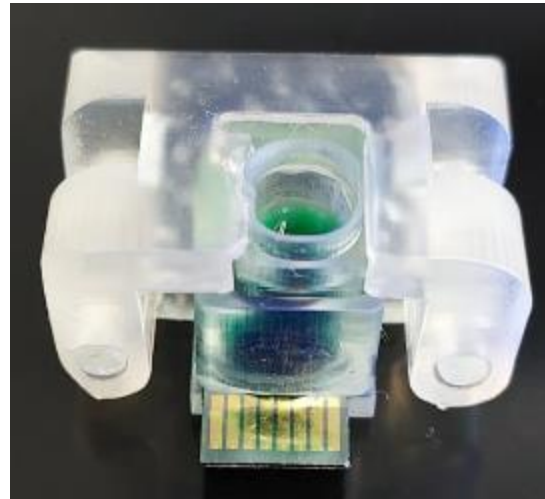


- ✓ Demonstrated increased sensitivity arising from enhanced analyte mass transport
- ✓ Significantly reduced signal noise (background noise)
- ✓ Enable direct electrical signal readout
- ✓ Very low analyte depletion
- ✓ Rapid Sensing
- ✓ Bi-potentiostat (2 Working electrodes)
- ✓ Multiplexed detection



Key Challenges

- Reference electrode drift
- Need to add chemical reagents
- Specificity, selectivity and sensitivity
- Need to calibrate every sensor
- Temperature Sensitivity

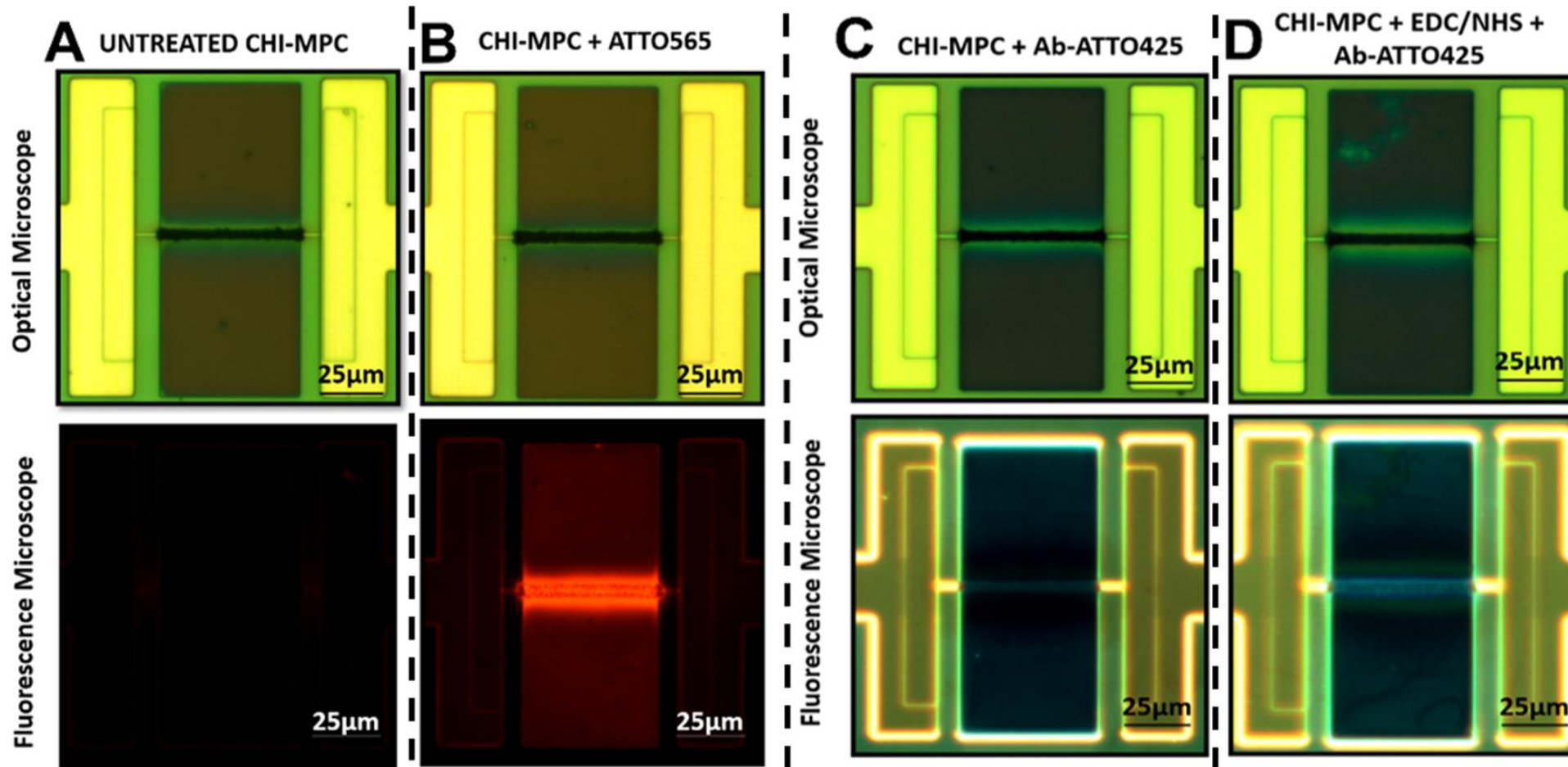




- A key challenge to producing high-grade potato seed is the continued prevalence of Potato Virus Y (PVY)
- A surveillance strategy requires rapid and pre-symptomatic diagnosis in the field
- Absence of a field-based test that both detects and provides real-time information on the incidence of PVY within a potato crop.

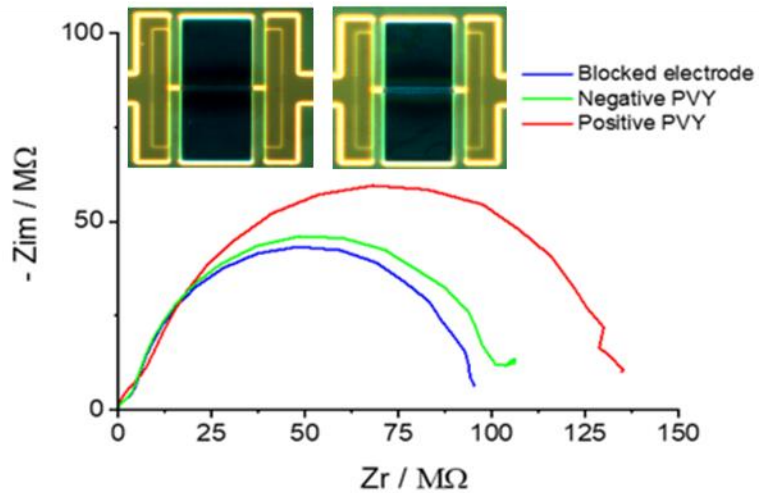
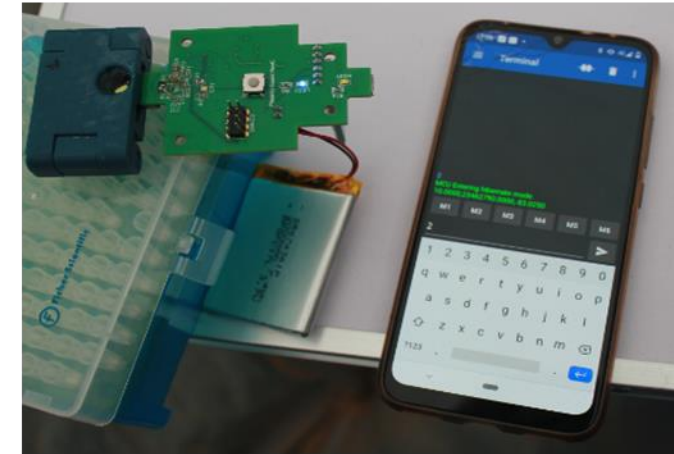
➔ Solution - Digital Technology-based Portable Biosensor

Surface functionality – Spectral characterisation

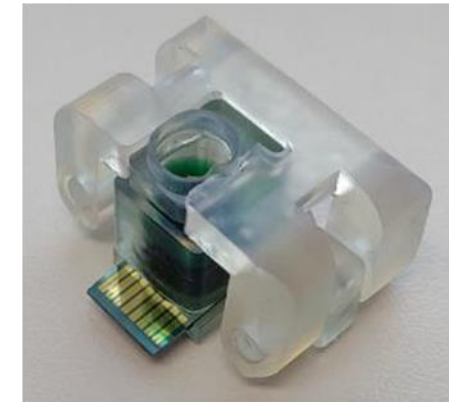




Minimum Viable Product



Positive Negative

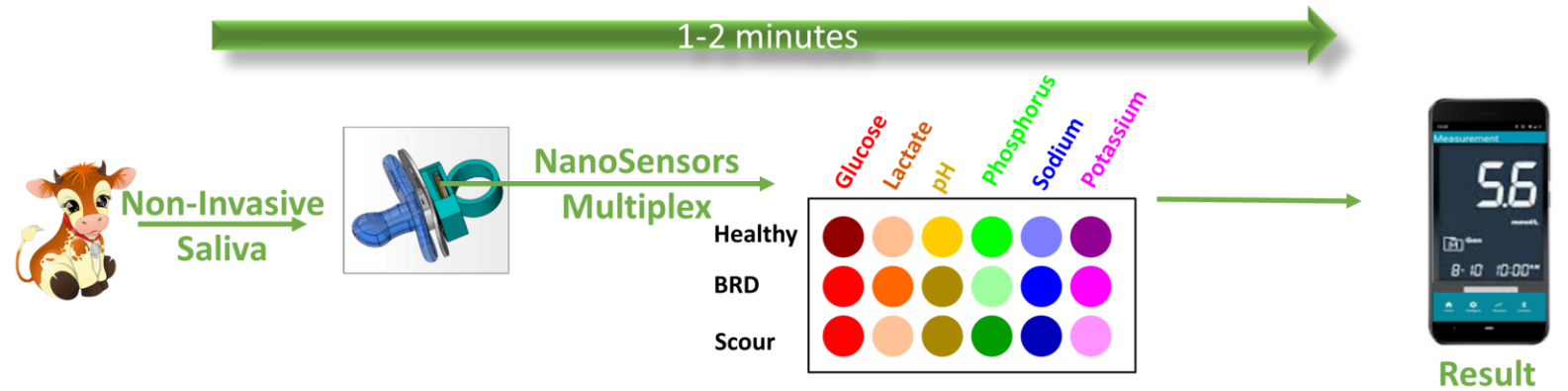
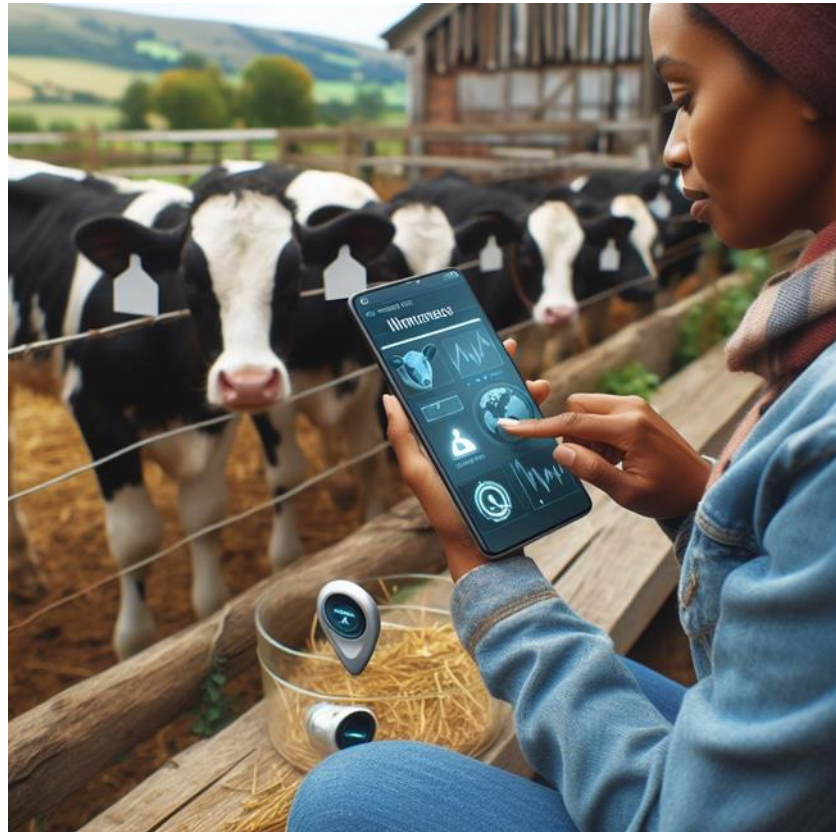


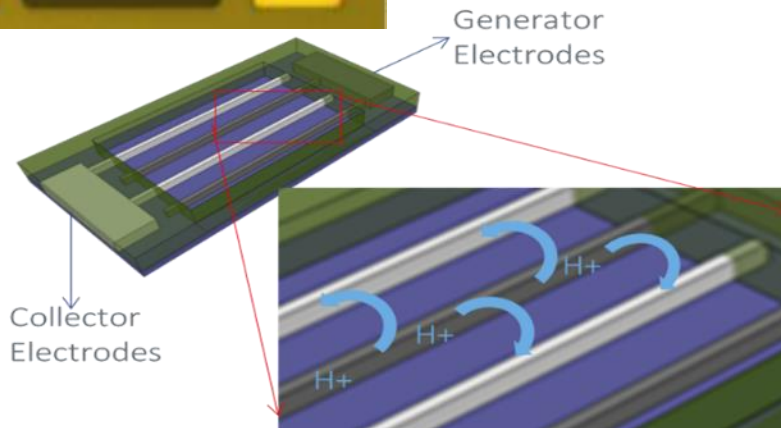
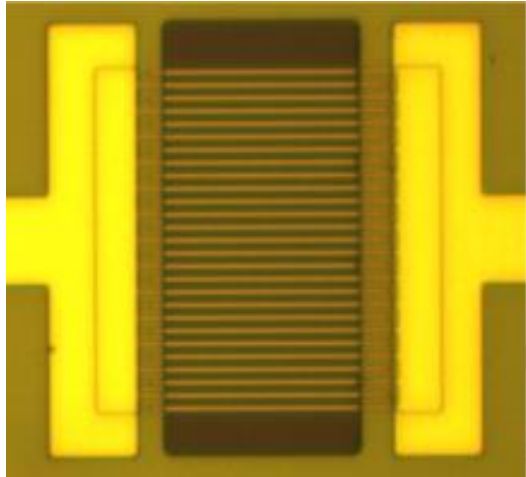
Technology Benchmarking

SAMPLE		ELISA (Absorbance)			PCR		Impedance (MΩ)	
ID	Variety	PVY	PVS	PVA	PVY	Ct RT-PCR	rRct (MΩ)	PVY Presence
155A	T8247/04	0,326 (P)	0,231(P)	0,2 (N)	P	14,515	32	LP
155B	T8247/04	0,114 (N)	1,72 (P)	0,189 (N)	N	29,505	27	N
156A	T8304/08	1,232 (P)	0,125 (N)	0,154 (N)	P	14,875	70	MP
156B	T8304/08	0,114 (N)	1,817 (P)	0,303 (P)	N	30,715	23	N
157A	T8310/03	1,897 (P)	0,191 (N)	0,144 (N)	P	14,755	100	MHP
160A	T8472/05	0,102 (N)	0,141 (N)	0,415 (P)	N	29,42	25	N
161B	T8486/02	2,538 (P)	0,108 (N)	0,2 (N)	P	14,505	250	HP
161A	T8486/02	0,232 (P)	0,19 (N)	0,208 (N)	P	15,63	35	LP
164A	T8560/07	0,977 (P)	0,111 (N)	0,166 (N)	P	14,995	57	MLP
165A	T8561/01	1,593 (P)	0,262 (P)	0,312 (P)	P	13,895	77	MP
166A	T8597/02	0,101 (N)	0,146 (N)	0,133 (N)	N	30,95	20	N

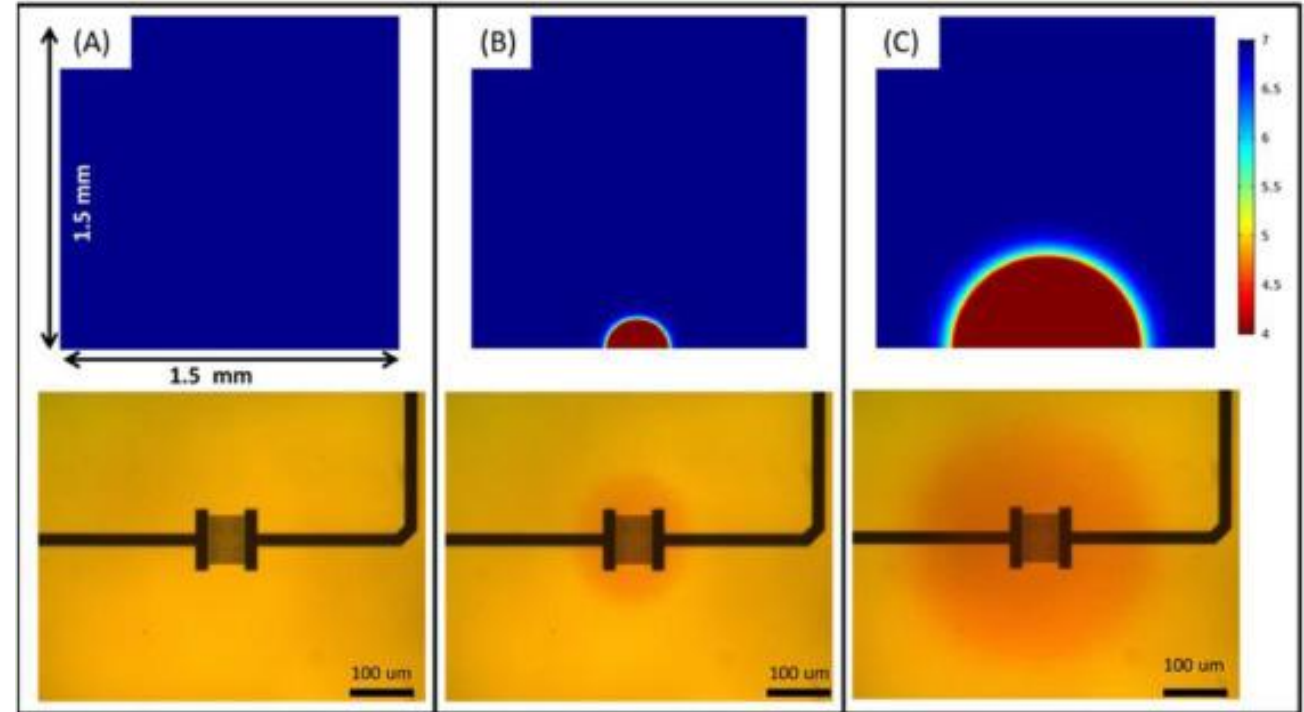
Abbreviations: P (Positive), N (Negative); LP (Low Positive) , MLP (Medium-low Positive); MP (Medium positive), MHP (Medium-High Positive); HP (High Positive); PVY (Potyvirus Y) PVS (Potyvirus S); PVA (Potyvirus A) Ct-PCR (cycle threshold PCR), Rct (Charge transfer resistance)

Calf wellbeing – animal welfare

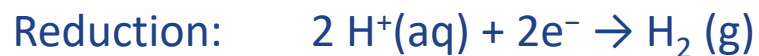


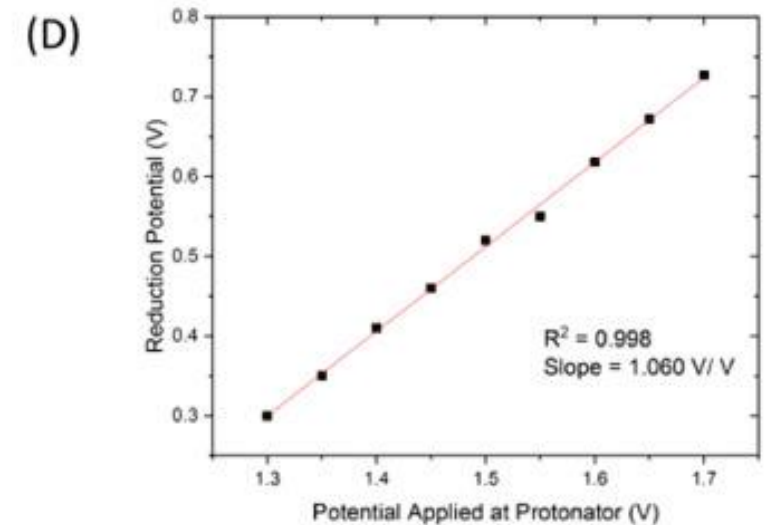
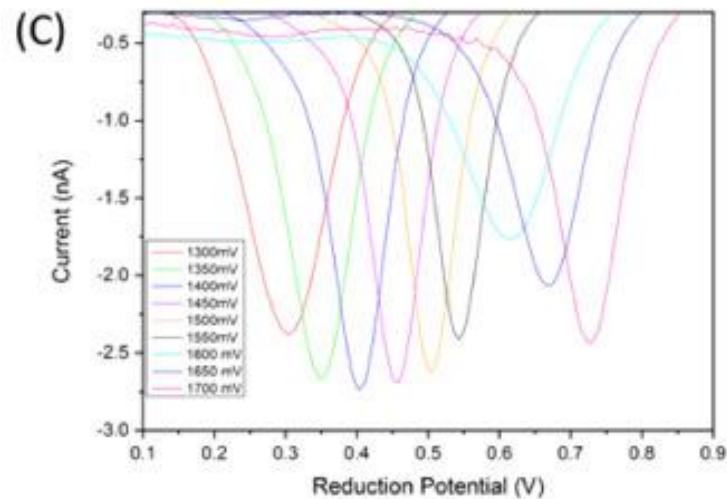
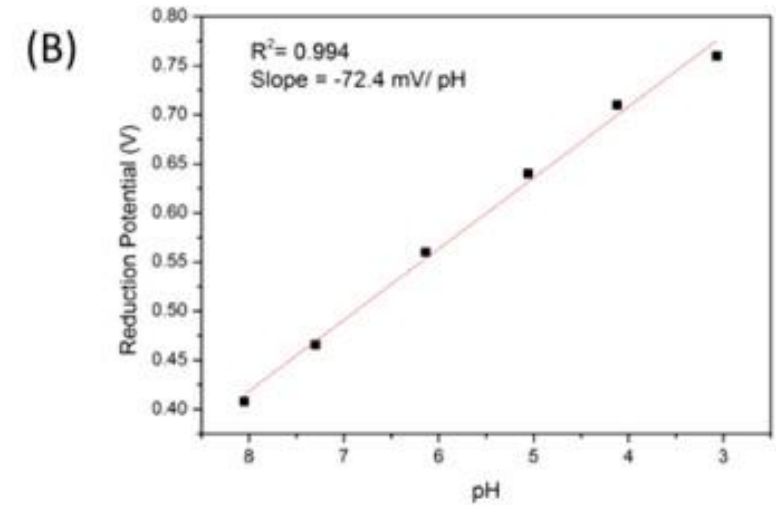
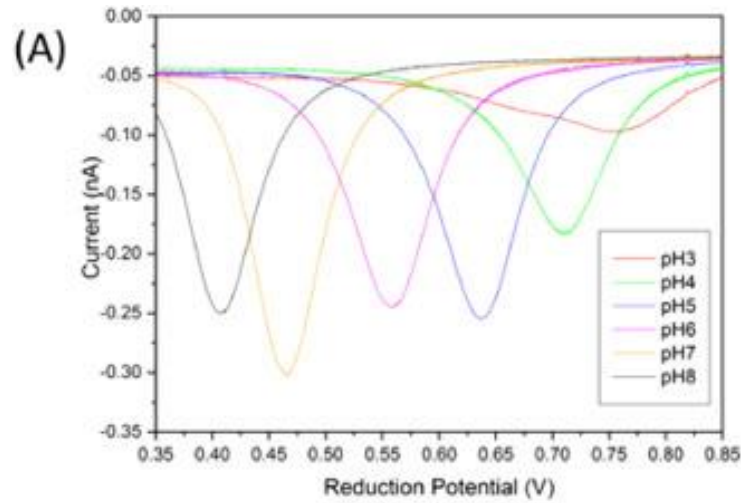
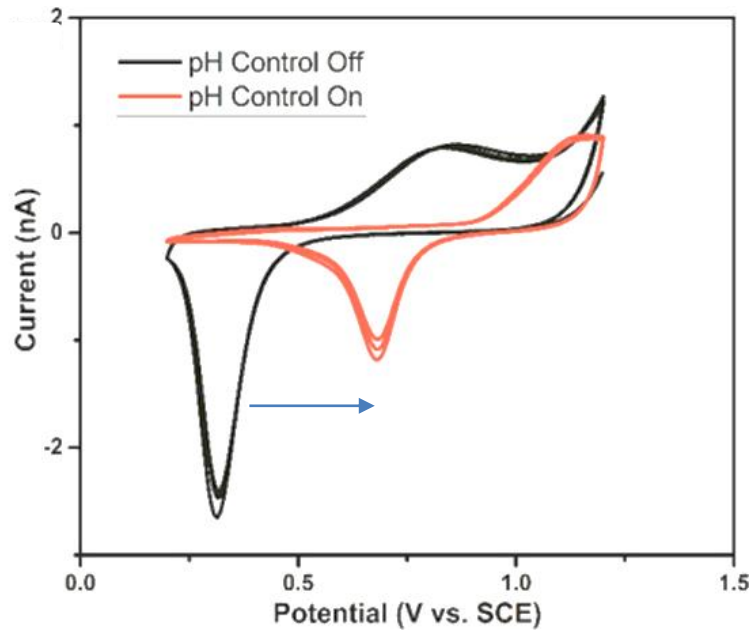


Simulation of proton diffusion of protons from protonator electrode:
 t=0 s t= 1s t=10 s

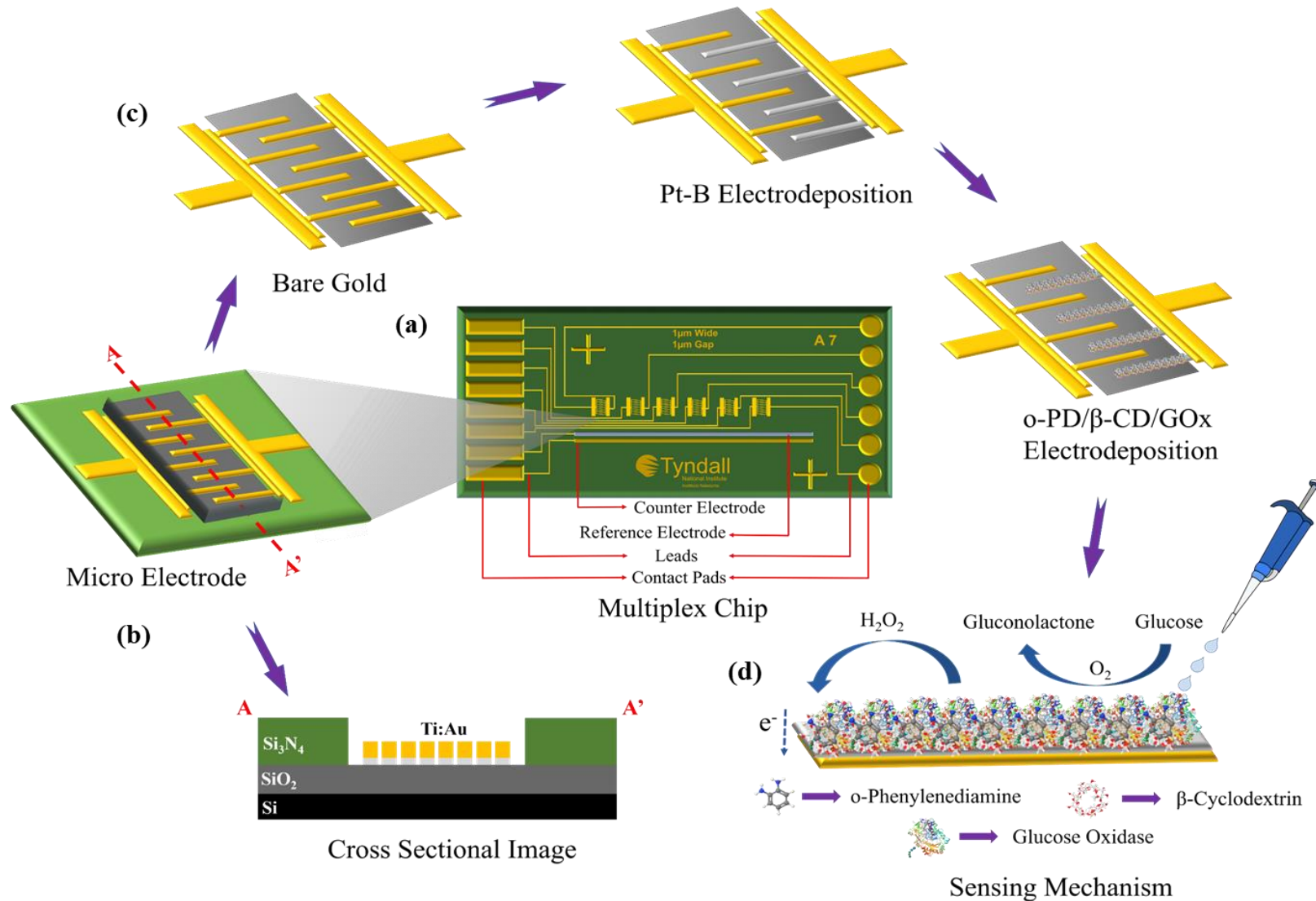


Visualisation of pH change using methyl red pH indicator dye.





Saliva Sensor - approach



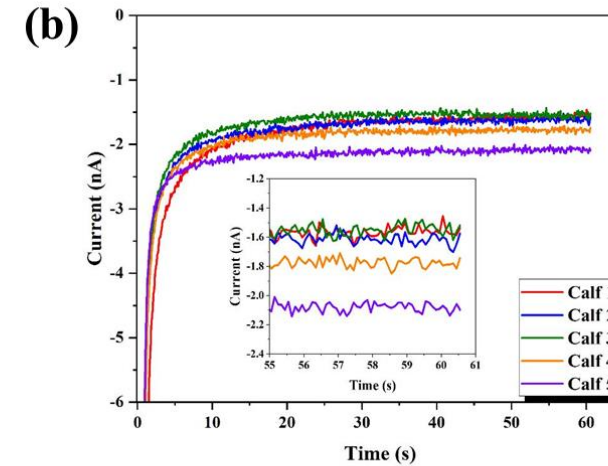
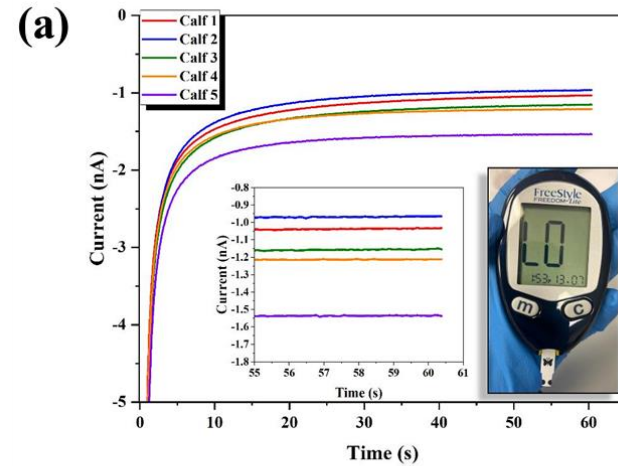


Table 2. pH and glucose concentrations found in real saliva samples.

Samples	pH	Glucose Concentration (μM)	
		(pH control off)	(pH control on)
Calf-1	8.2	1.7 ± 0.1	120 ± 6
Calf-2	8.6	0.8 ± 0.1	110 ± 6
Calf-3	7.6	6.5 ± 0.3	100 ± 5
Calf-4	7.3	14 ± 1	190 ± 9
Calf-5	5.3	460 ± 23	1420 ± 71

Conclusion



- Global Population has surpassed 8 Bn people, urgent need to produce more food sustainably and/or reduce food losses.
- 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 sector
- Biosensor were developed for detection in saliva and both plant and animal sera
- Time to result of Between 2 – 30 minutes → real-time decision-making capacity to stakeholders



THANK YOU

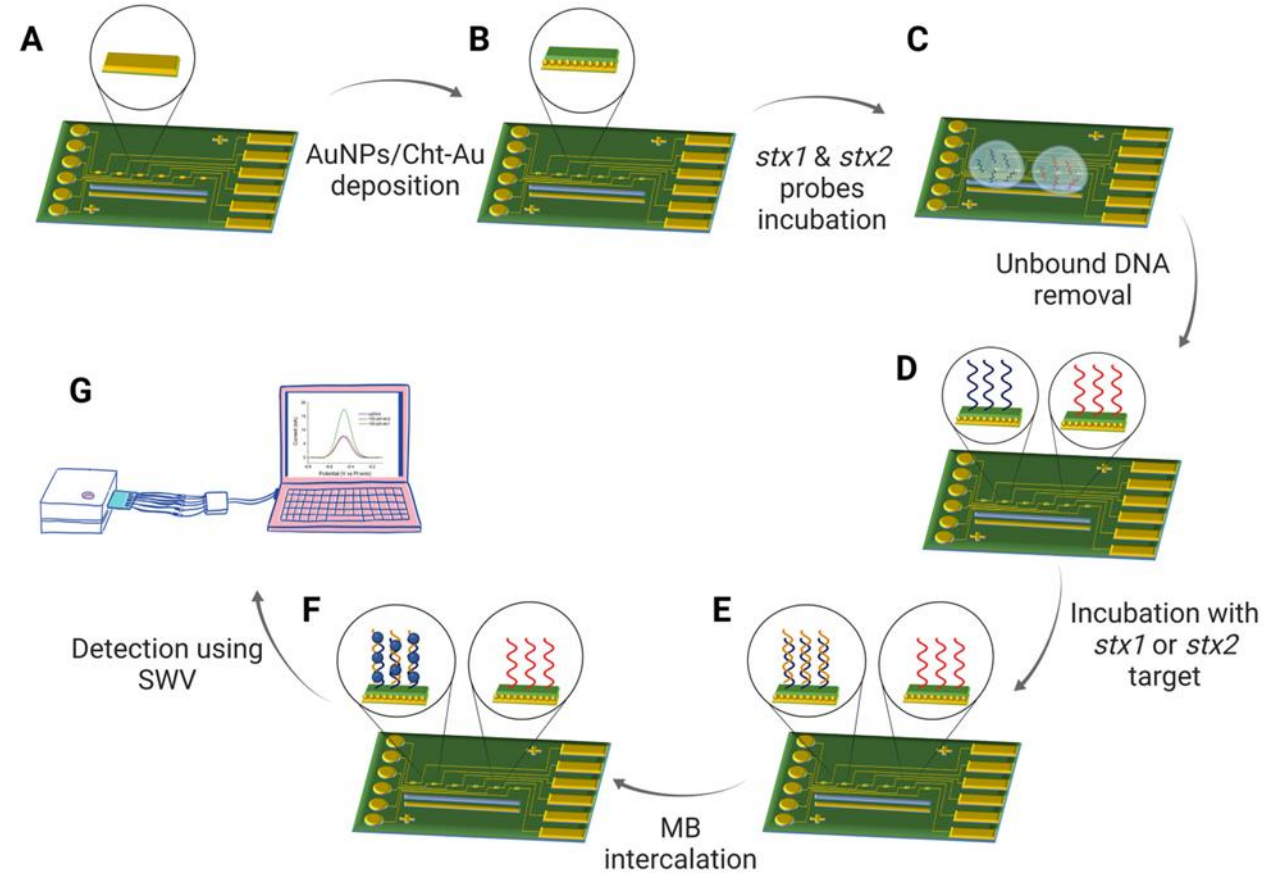


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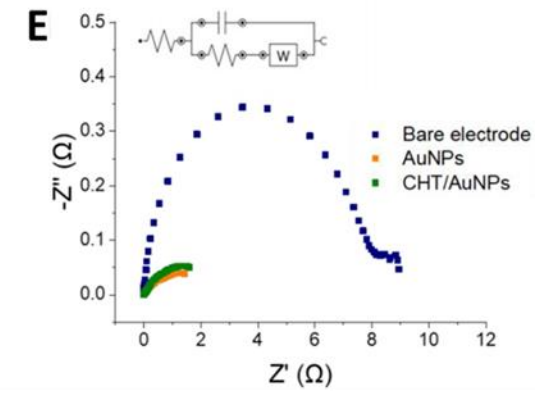
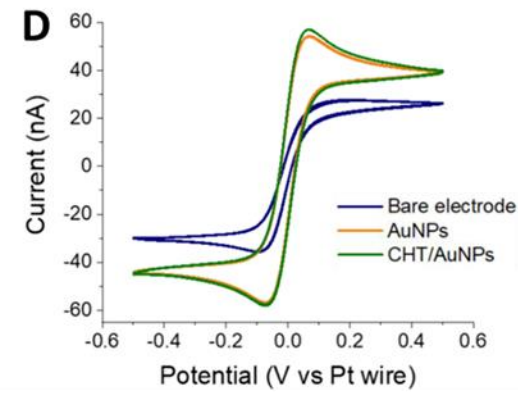
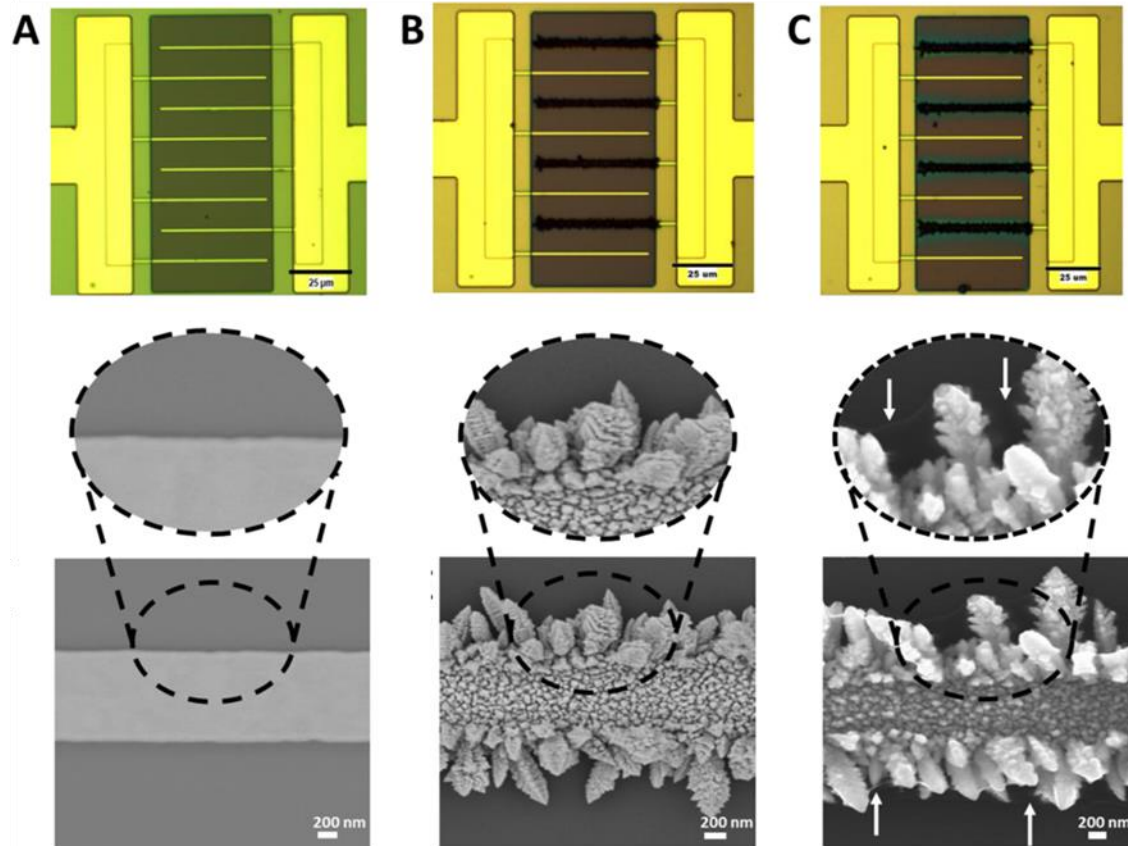
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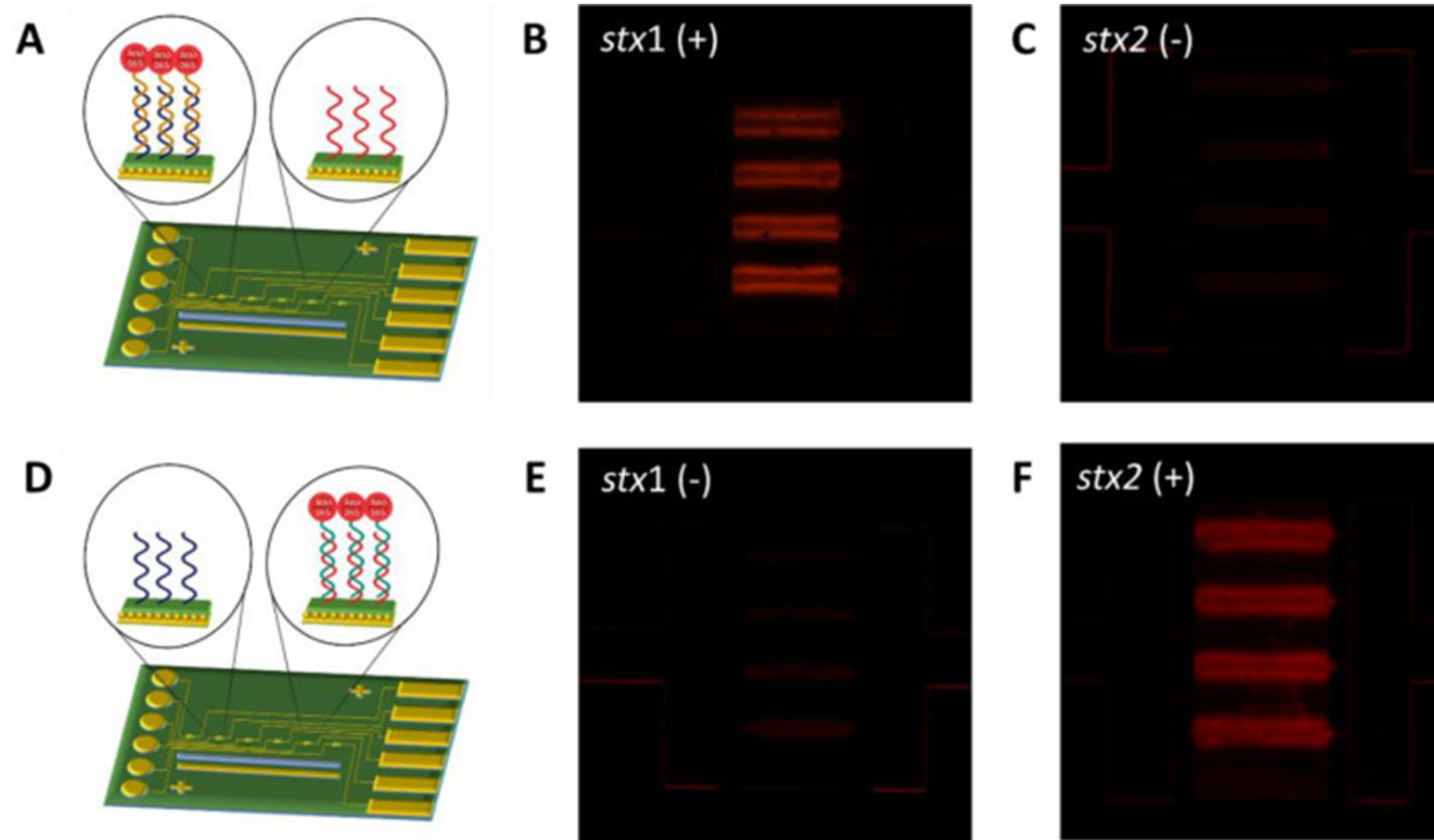
Shiga toxin-producing E. coli



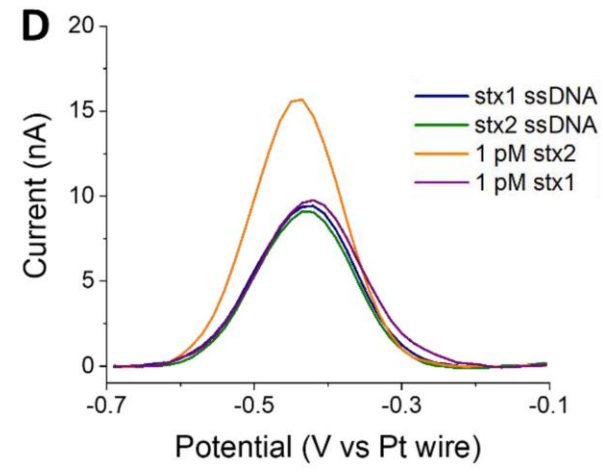
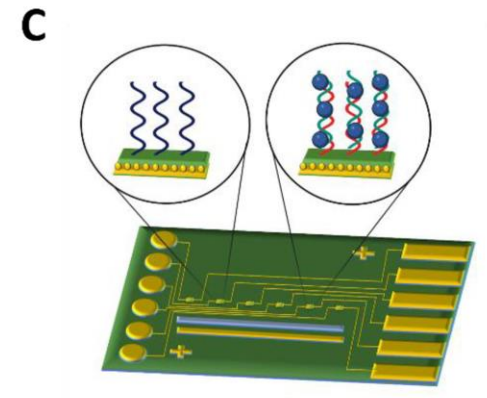
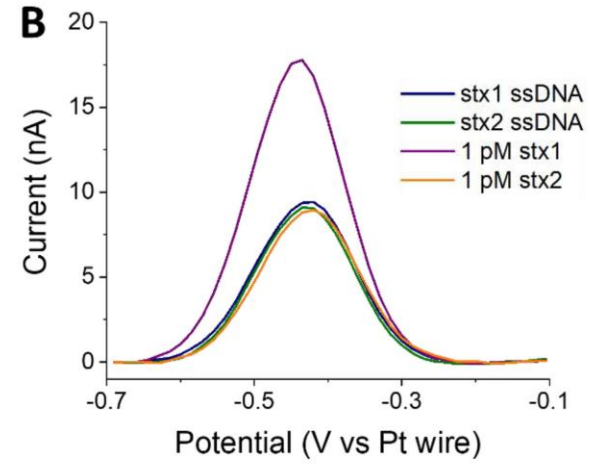
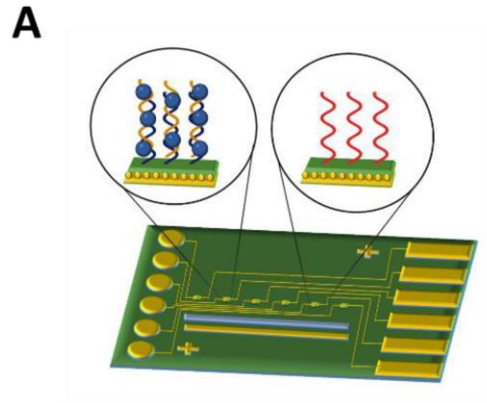
Chitosan Gold Deposition



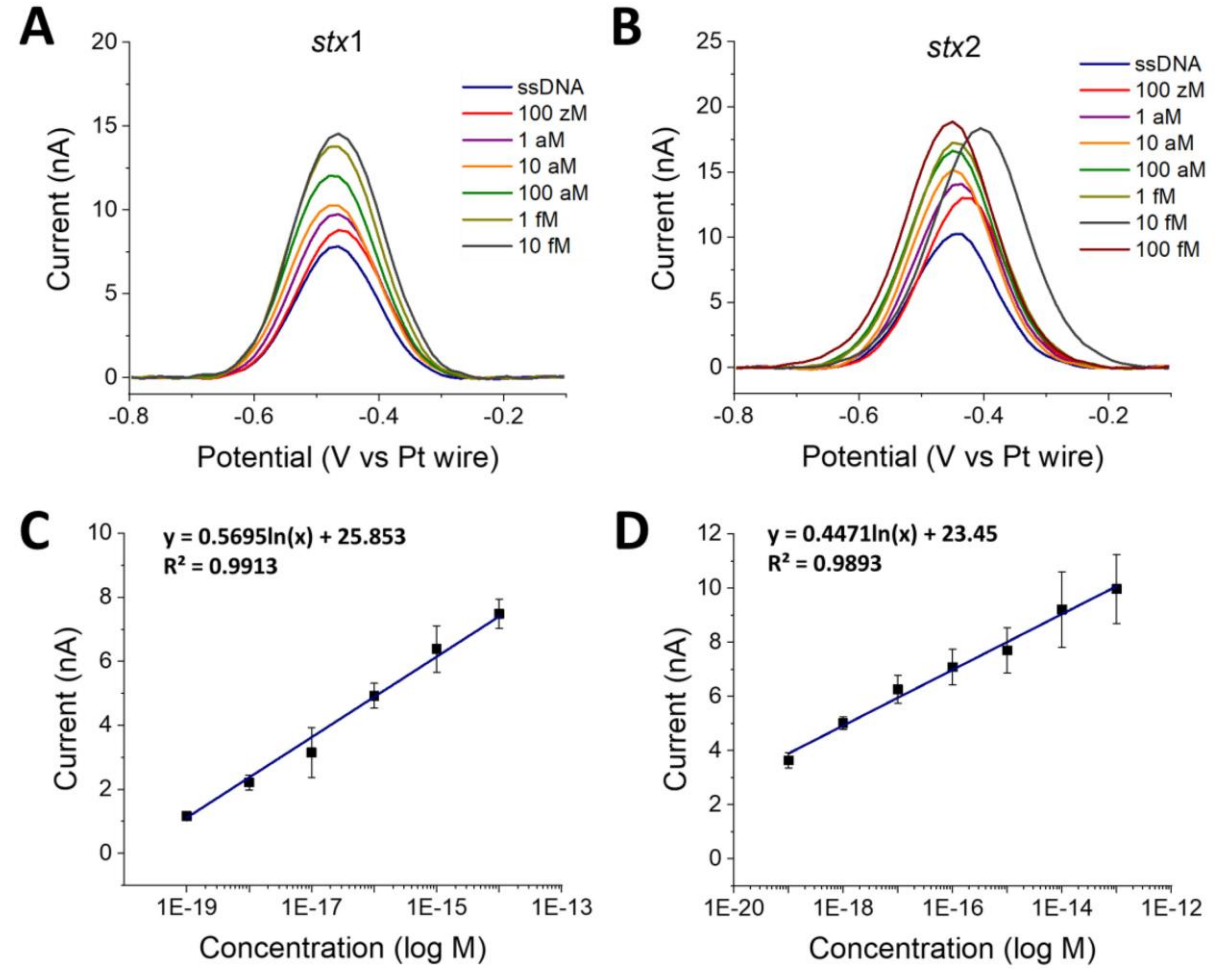
Fluorescence Characterisation



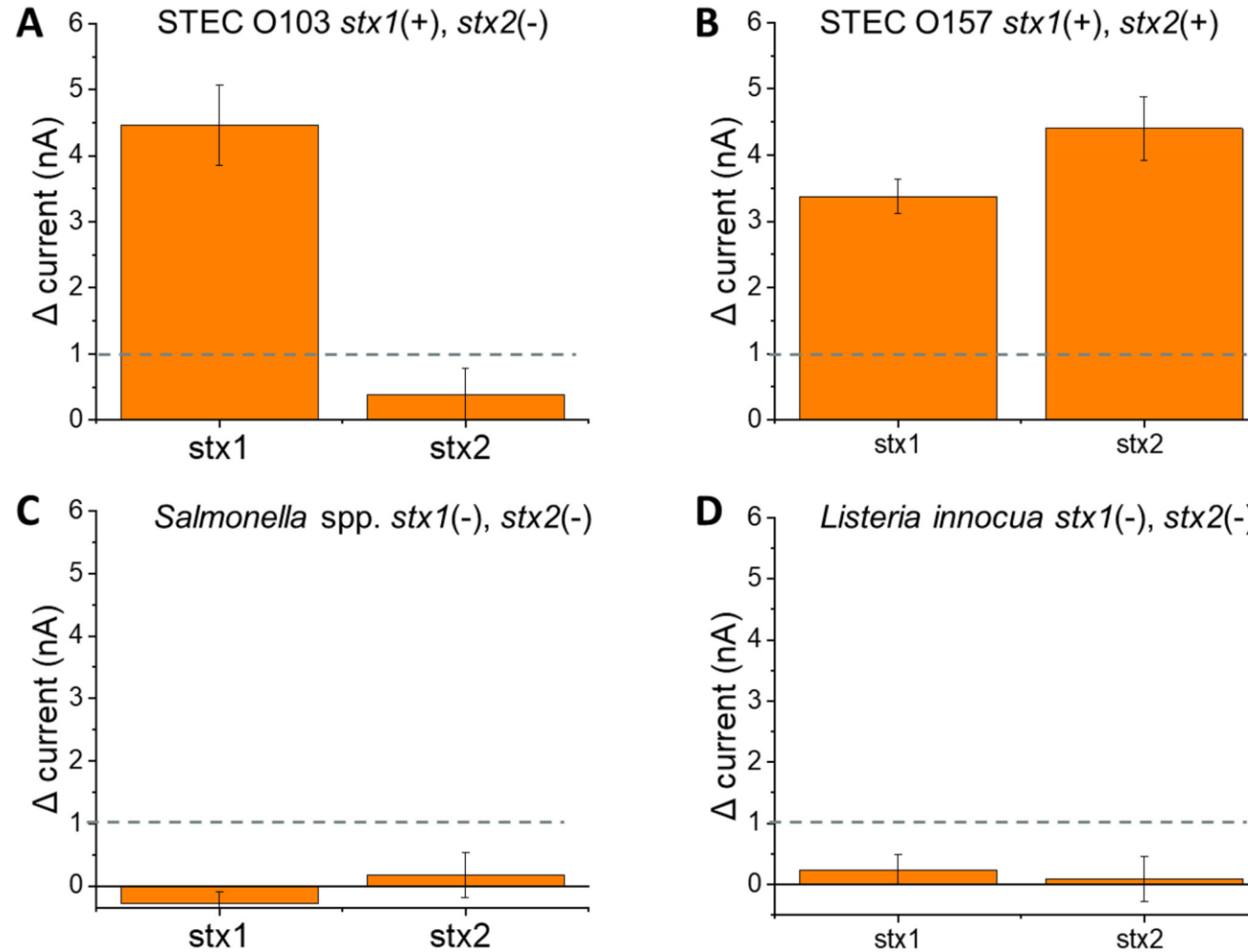
DNA - Electrochemical Detection



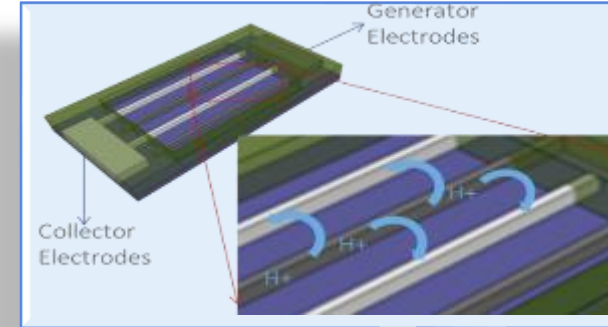
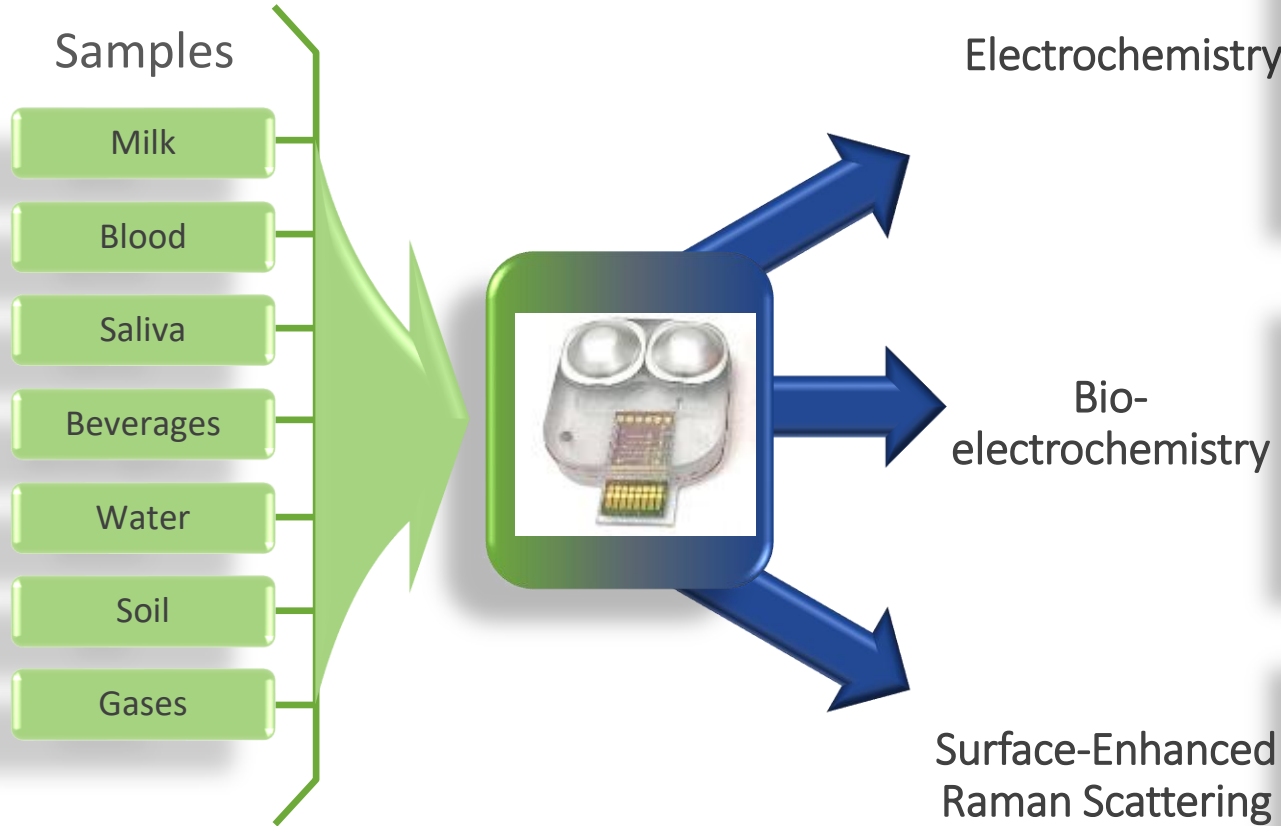
Quantitative Detection



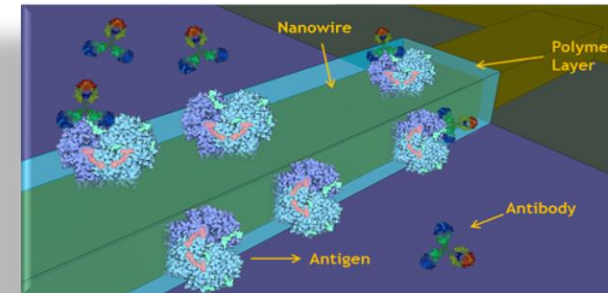
Cell Lysate - Selectivity



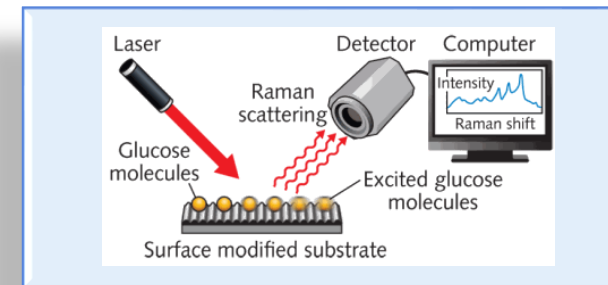
Nanosensor Platform



- Generator-Collector
- pH Control
- (Soil) Nutrients
- Electrolytes
- Heavy metals



- Parasites
- Viruses
- Proteins
- Enzymes
- DNA



- Food Adulterants
- Flavourings, sweeteners
- Antibiotics
- Pesticides