Zimmer & Peacock

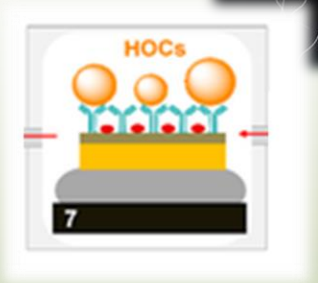
eSensor Manufacturing and Technology

Welcome - Sensors - Red Hot Chillies to Patients

2018

What do sensors mean for ZP

- We like measuring things and sensing things?



Zimmer & Peacock

Workshop content

1. Introductions
2. Cyclic voltammetry through Chilli Sensing
   - Break at 10:30 AM – 11:00 AM
3. Biosensor Market
4. Amperometry through oxygen sensing
   - Break for lunch 12 to 1 PM
5. Amperometry through glucose and lactate sensing
6. Potentiometry through pH and potassium sensing
   - Break at 2:30 PM – 3:00 PM
7. Develop a quick test for coffee
8. Summary

Zimmer & Peacock

Quick resume

- Martin Peacock
- First degree chemistry
- Second degree electrochemistry
- Industrial roles:
  - GSK – Medicinal Chemist
  - Abbot Diabetes – Electrochemist
- Companies founded in the last 4-years:
  - Zimmer and Peacock Ltd
  - Zimmer and Peacock AS
  - Zimmer and Peacock Inc
  - CeeLab
  - Aliksir

https://www.linkedin.com/in/martinpeacock/

martinpeacock@zimmerpeacock.com

Zimmer & Peacock

ZP Background

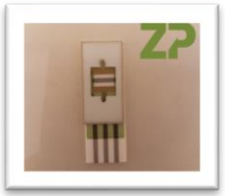
- Formed in 2014.
- Locations: USA, UK and Norway
- Products: Standard Products for Sensor Developers
- Services:
  - Contract Development
  - Contract Troubleshooting
  - Contract Manufacturing
  - Contract Commercialization: Packaging, Logistics, Sales Channels Etc.
  - IP development

Zimmer & Peacock

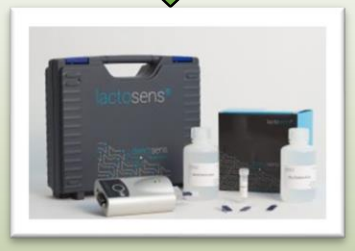
Product

The sensor technology development roadmap

Ideas



Are there products and services that you can offer along the way



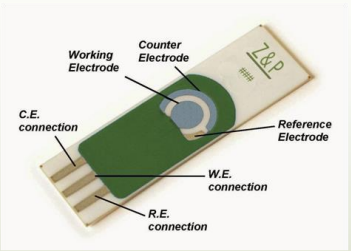
Zimmer & Peacock

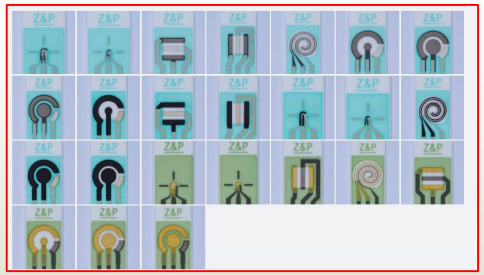
ZP - Services and Products

24 people

Engineering services
and manufacturing

Application specific products





Development products

Zimmer & Peacock

Business model

https://www.zimmerpeacocktech.com/store/

Zimmer & Peacock

Sensors

O_2

K^+

Lac

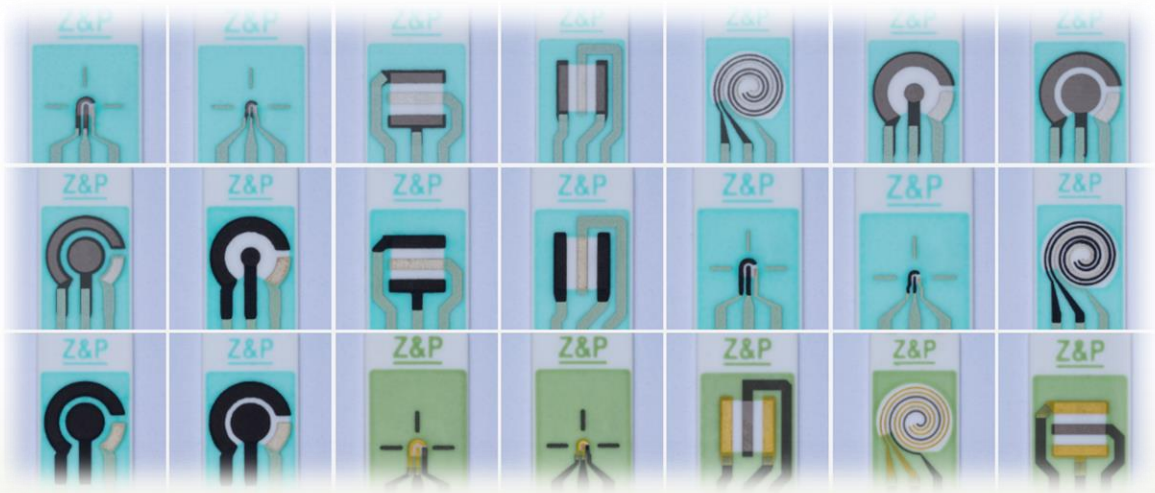
H_2O_2

Glu

Chilli

pH

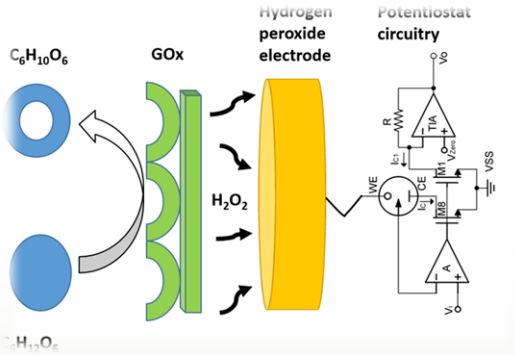
Na^+



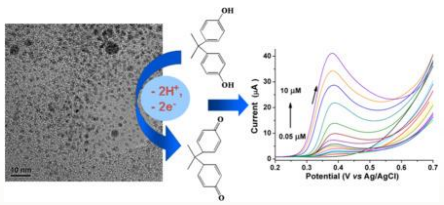
Zimmer & Peacock

Electrochemistry How does our science work?

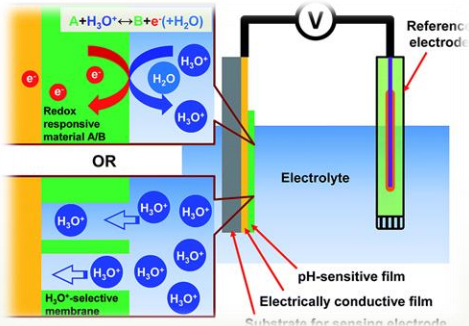
Amperometric



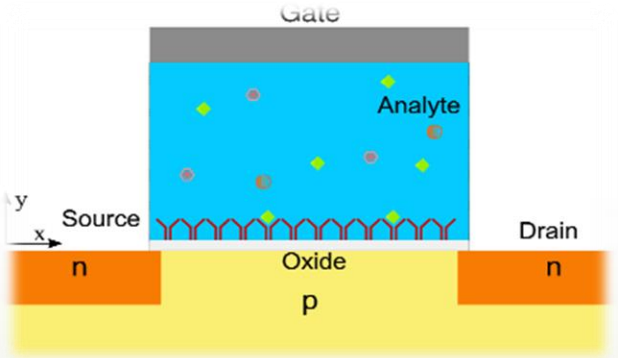
Voltametric



Potentiometric

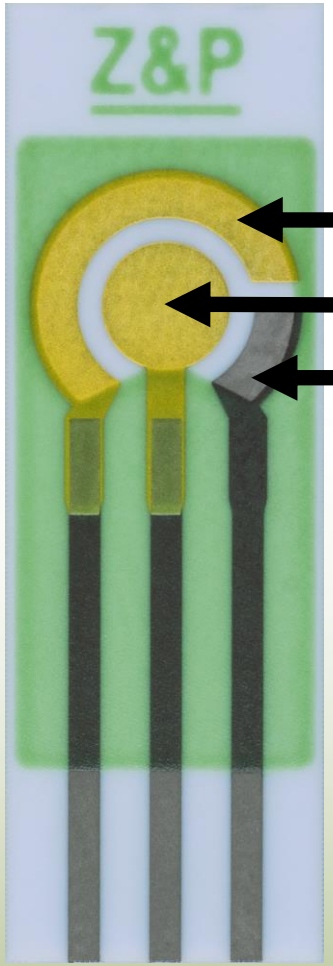


Bio-FET



Zimmer & Peacock

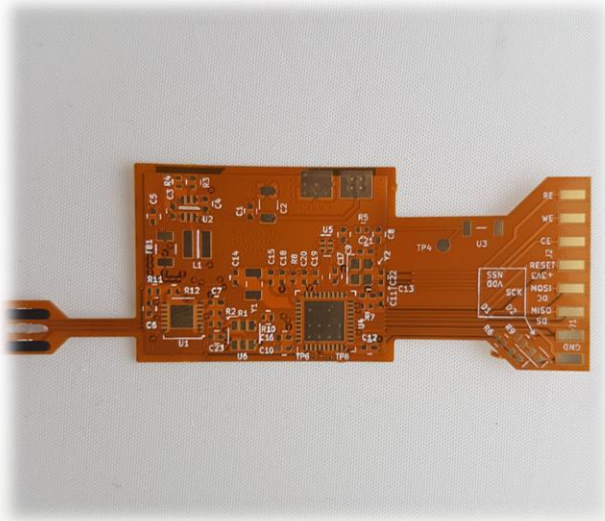
An anatomy lesson

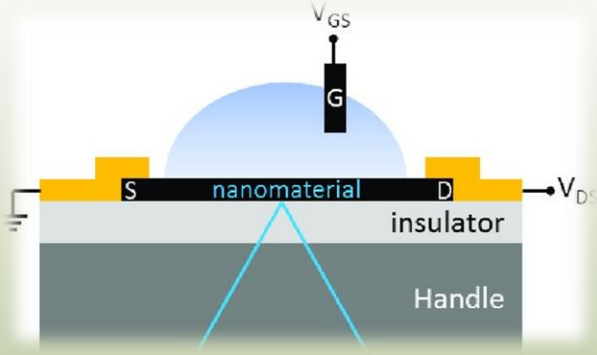


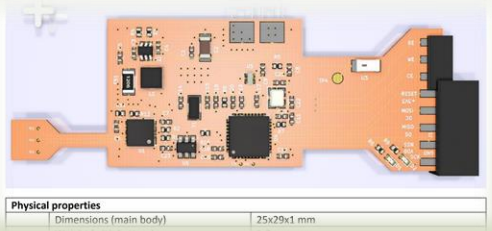
Counter electrode

Working electrode

Reference electrode



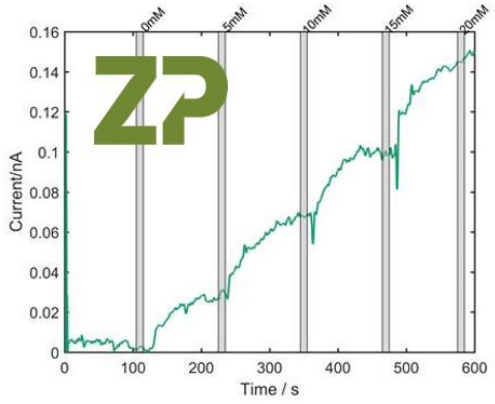


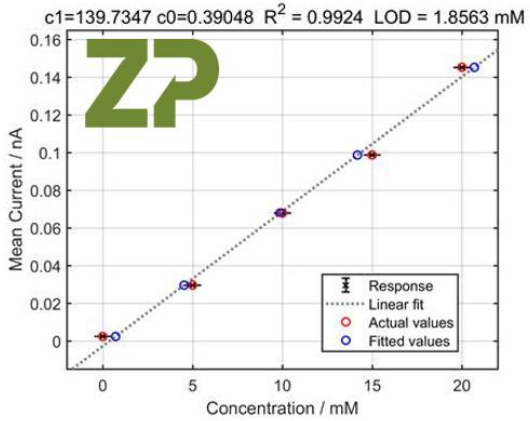


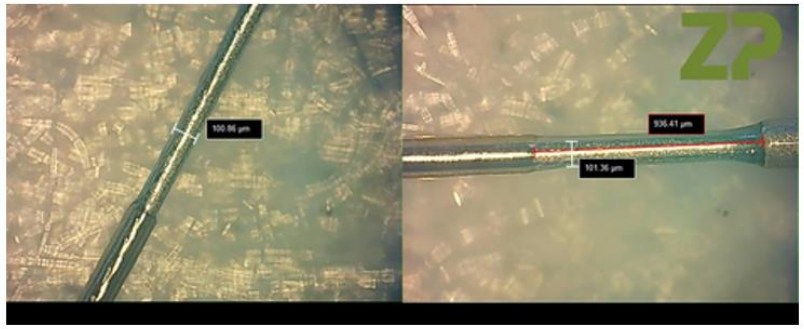
Zimmer & Peacock

What does a signal look like?

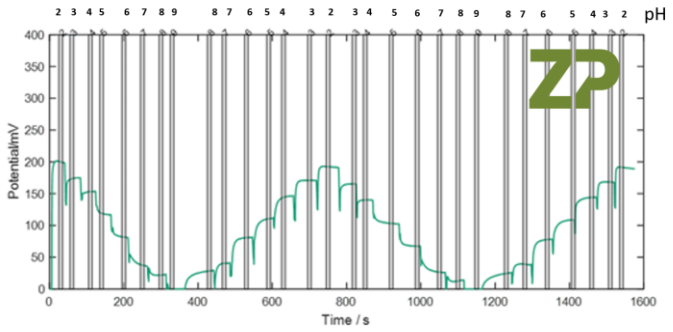
Amperometric Glucose Sensor

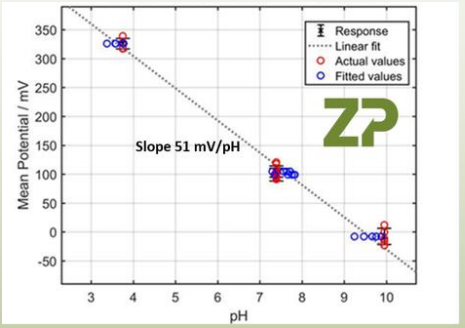






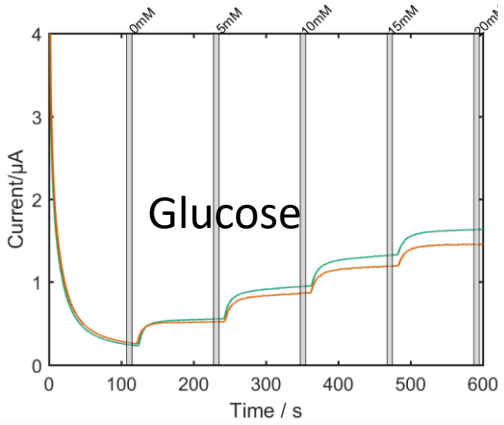
Potentiometric pH Sensor

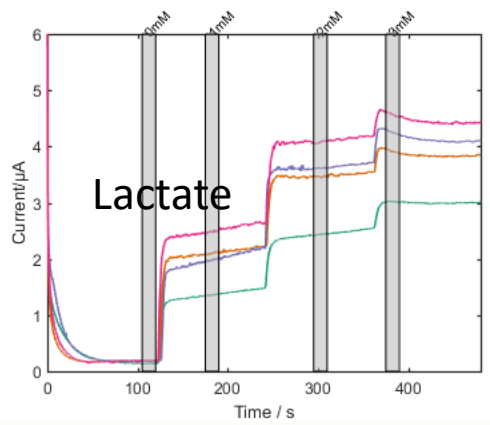


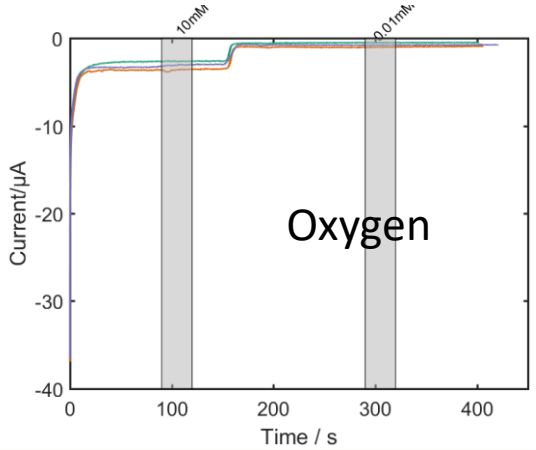


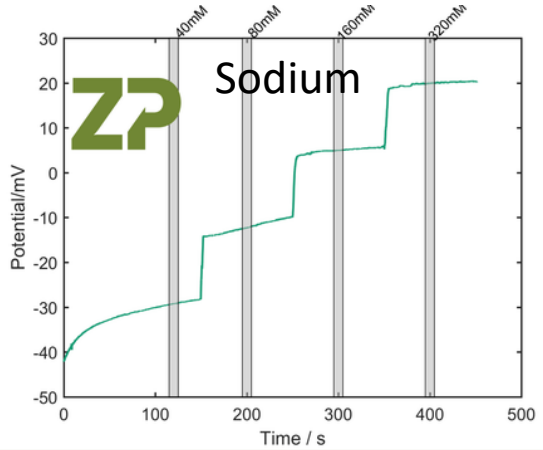
Zimmer & Peacock

Sensors



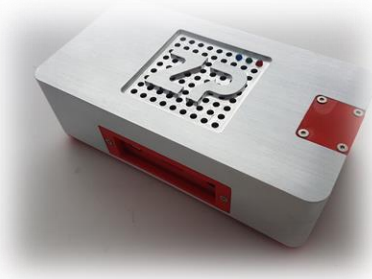






Zimmer & Peacock

Online supermarket of potentiostats

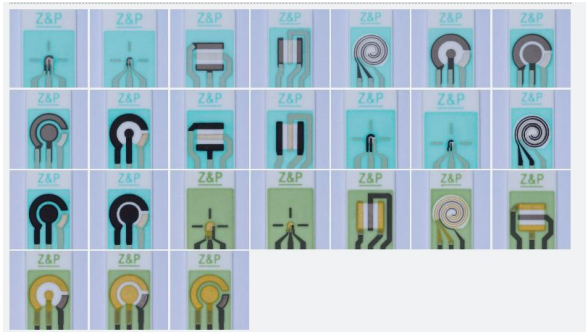


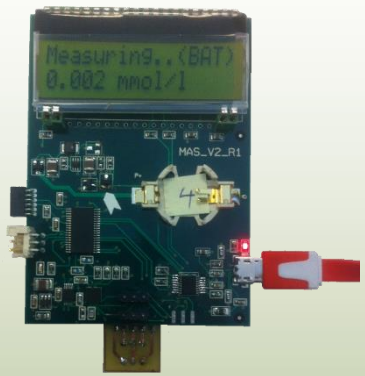
https://www.zimmerpeacocktech.com/store/

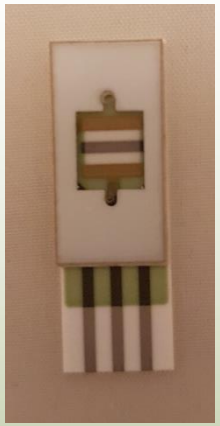
Zimmer & Peacock

Tools and workflow – Zimmer and Peacock

- **Jump start the sensor development phase.**
- **Jump start the cartridge/disposable development.**
- **Jump start the electronics effort.**



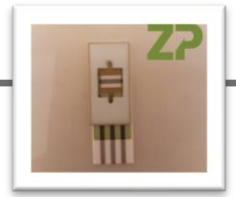


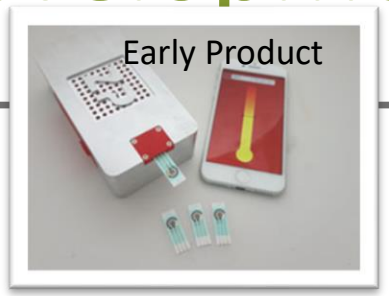


Zimmer & Peacock

The technology development roadmap

Idea

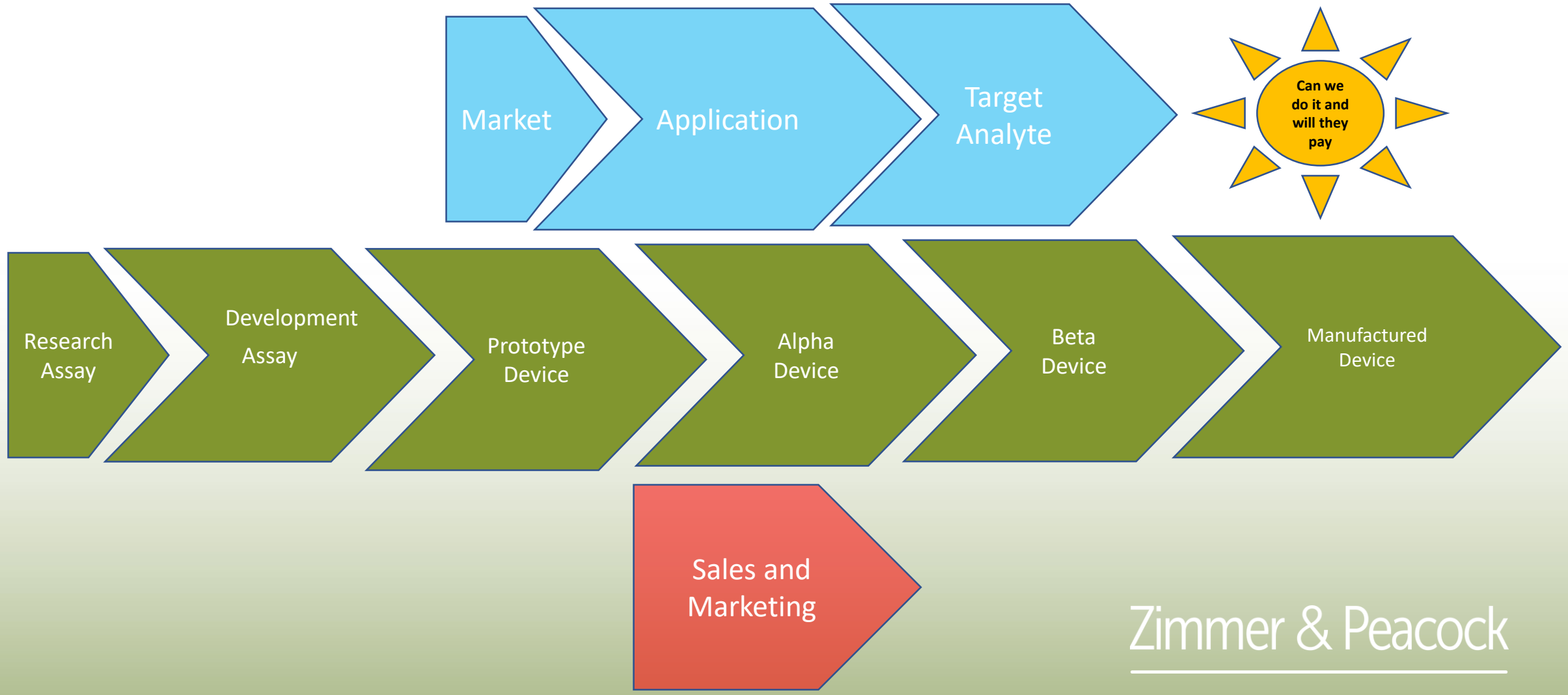




Are there products and services that you can offer along the way

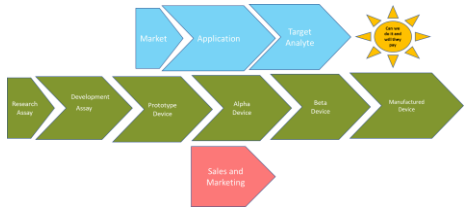
Zimmer & Peacock

Steps on the way to get to market?

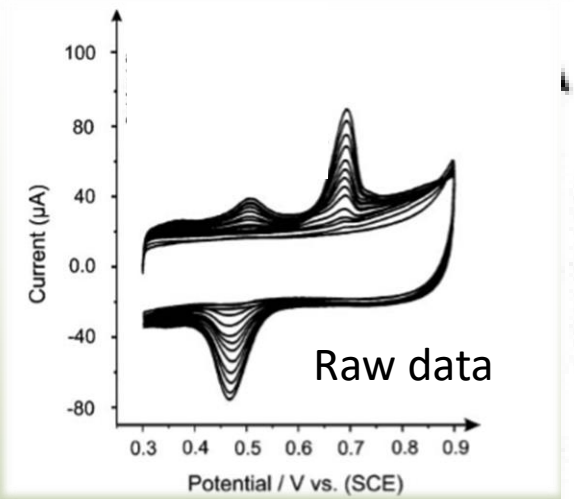


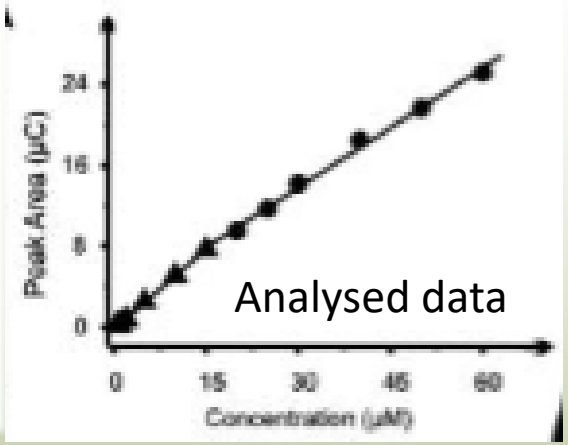
Zimmer & Peacock

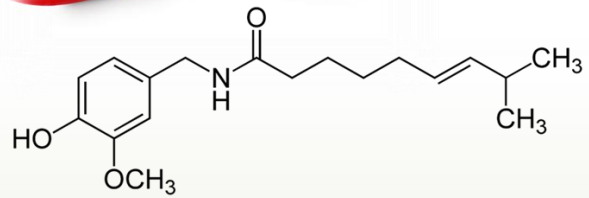
Research Assay - Proof of Principle



Carbon nanotube-based electrochemical sensors for quantifying the 'heat' of chilli peppers: the adsorptive stripping voltammetric determination of capsaicin







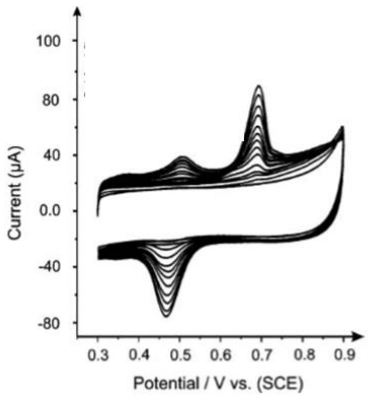
Zimmer & Peacock

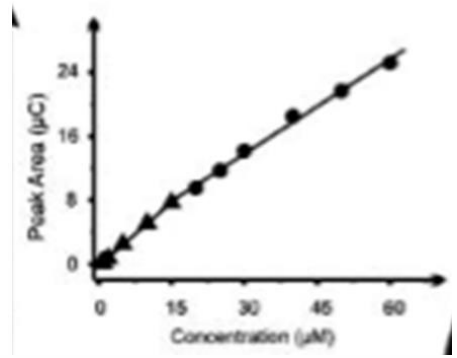
How hard is it to do a proof-of-principle?

Scenario One

EASY

The sensor is unaffected which means you can re-use the sensor

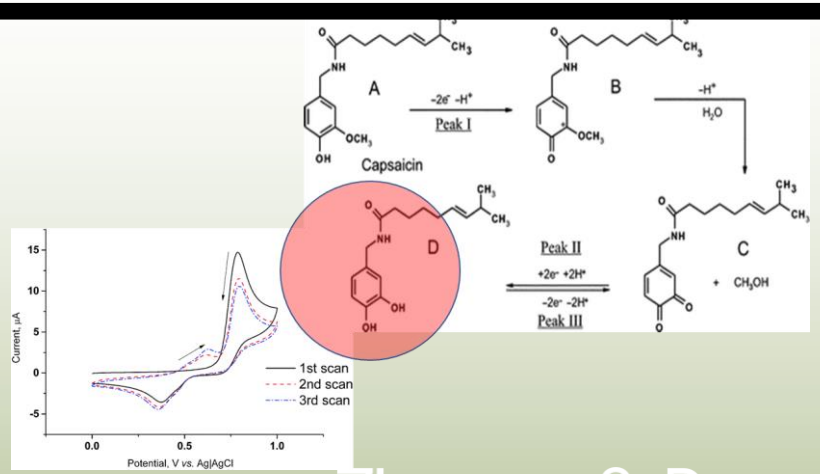




HARD

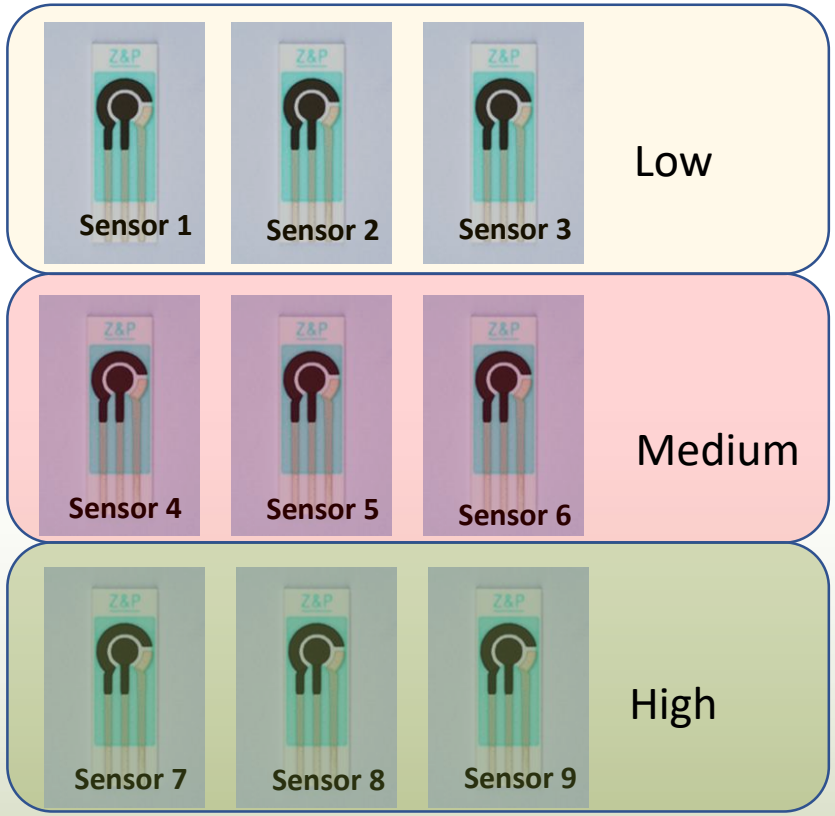
Scenario Two

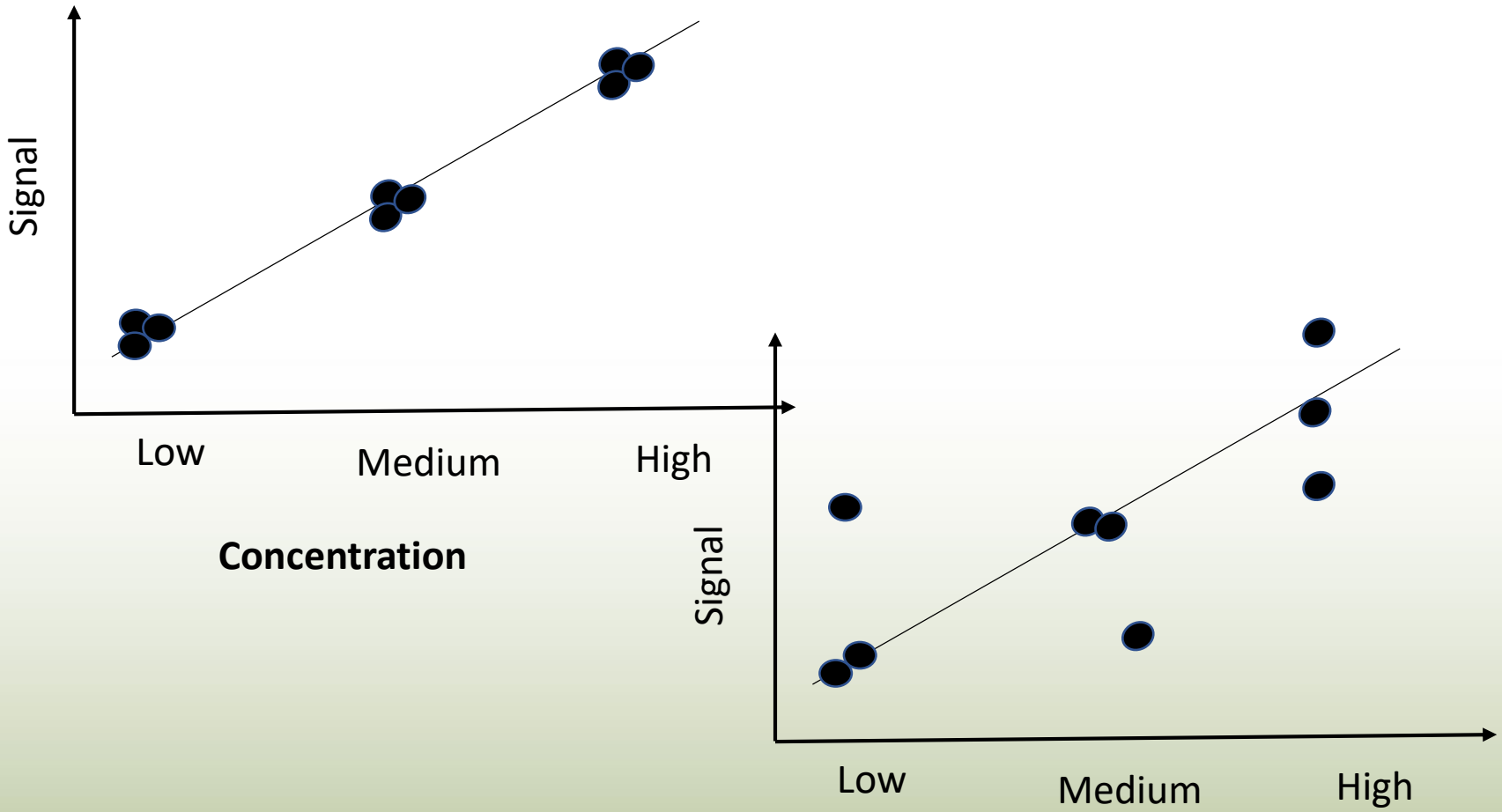
The sensor is changed during the assay which means you can't re-use the sensor



Zimmer & Peacock

What really happens – HARD Scenario



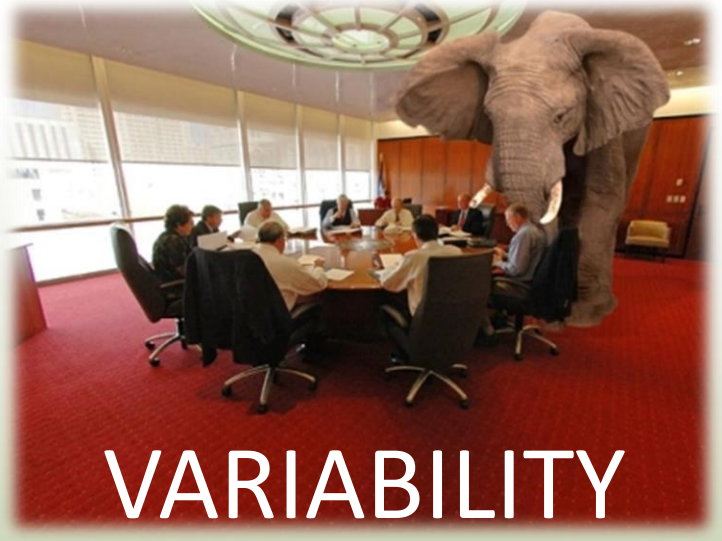


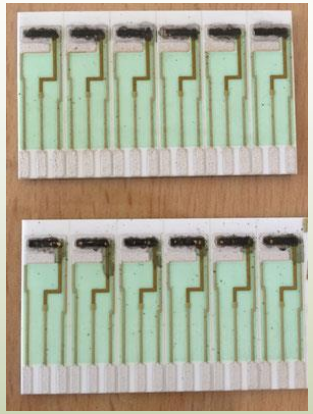
Zimmer & Peacock

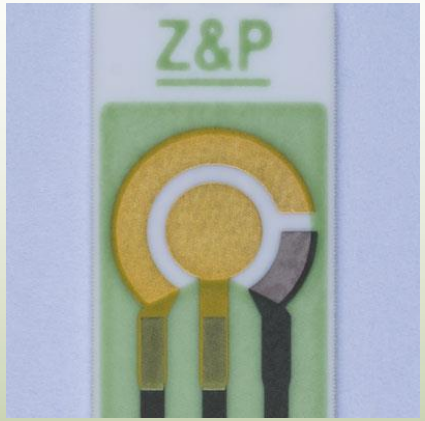
What is going on the?

The experiment is irreproducible, and it is in part due to the electrodes

When every you make things you have variation.

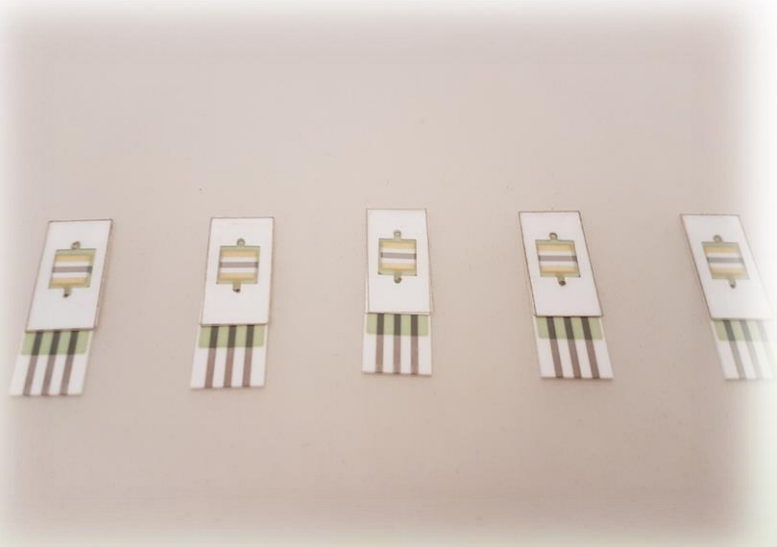


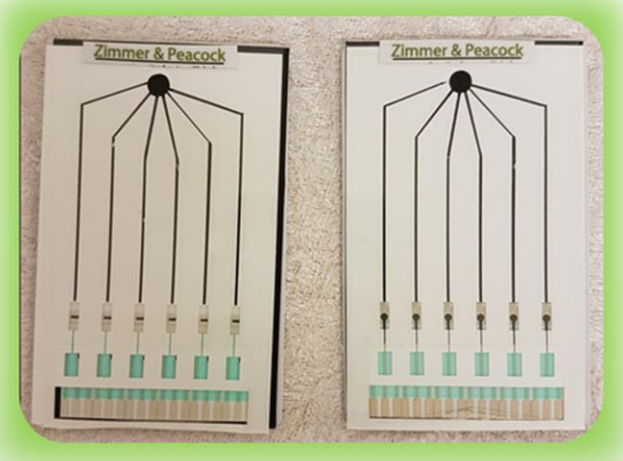




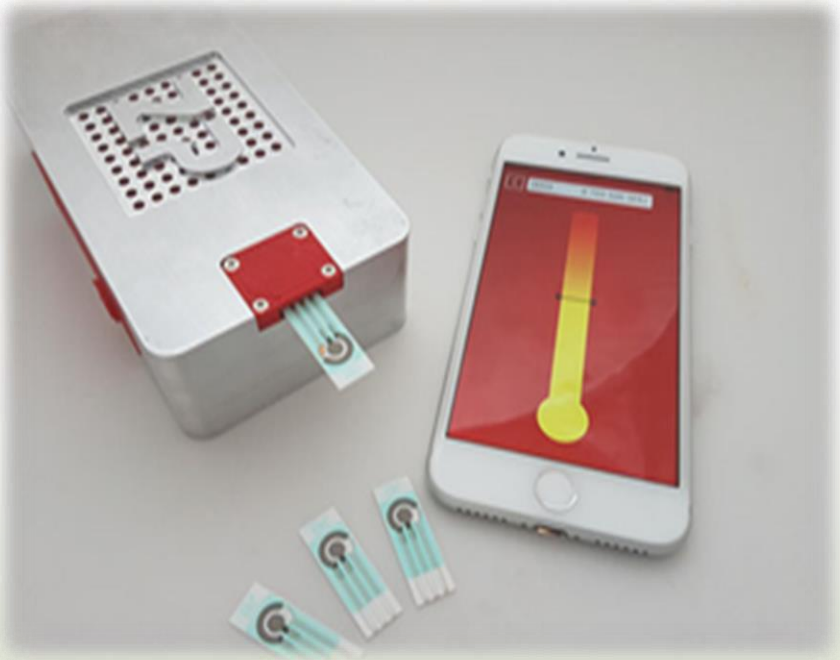
Zimmer & Peacock

Microfluidics/Packaging



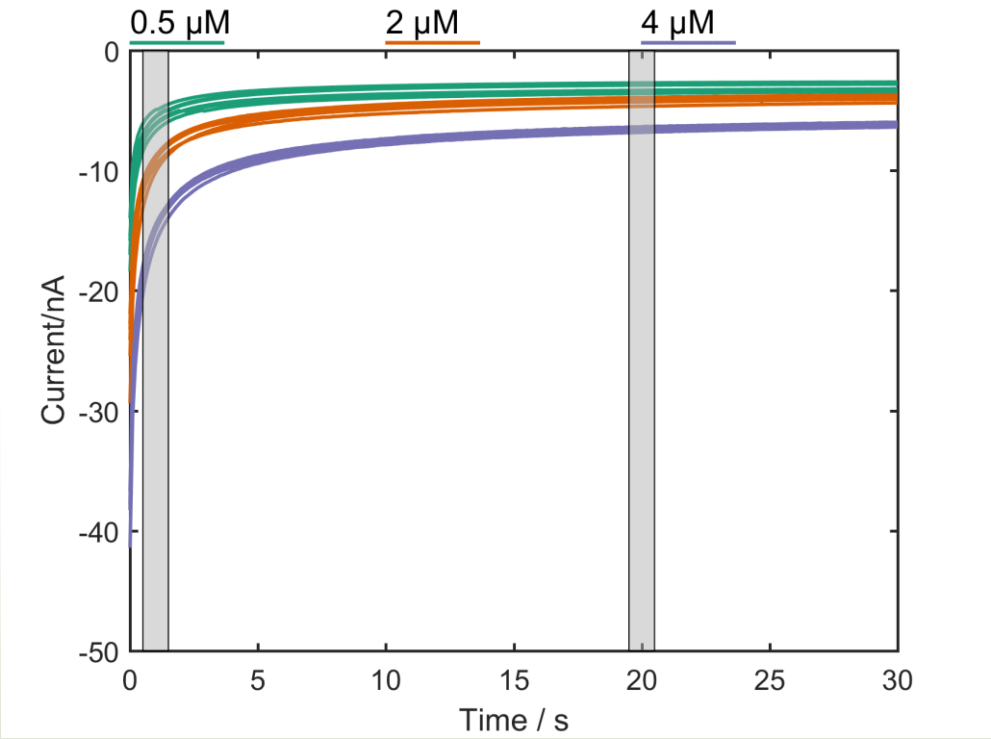


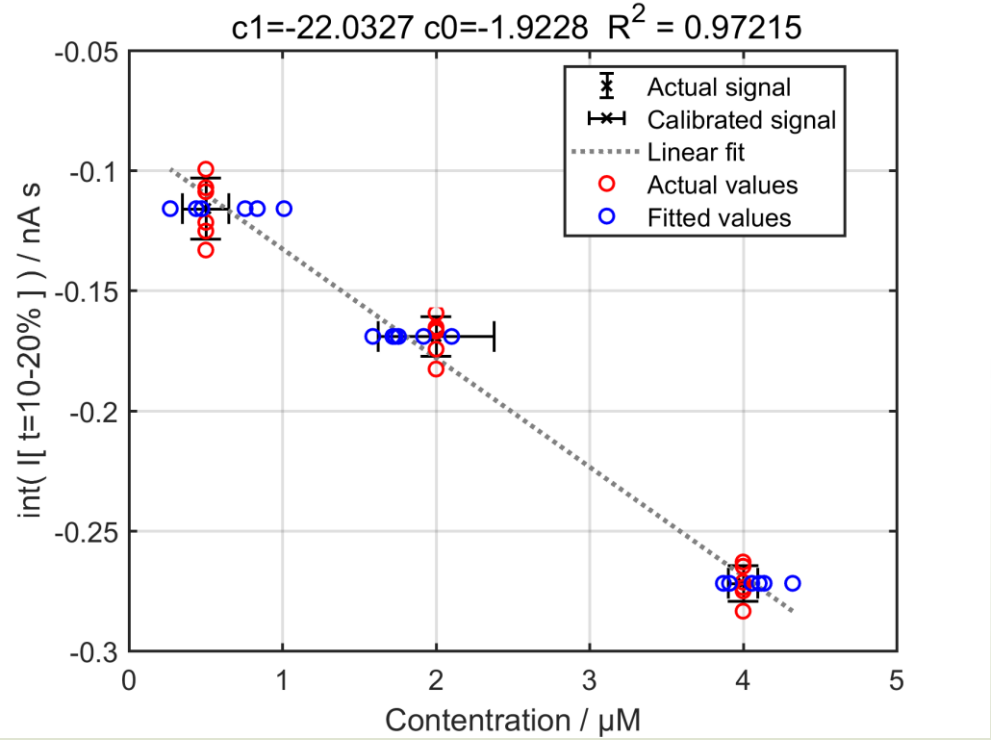
The necessary level of robustness/accuracy depends on what you are trying to do



Zimmer & Peacock

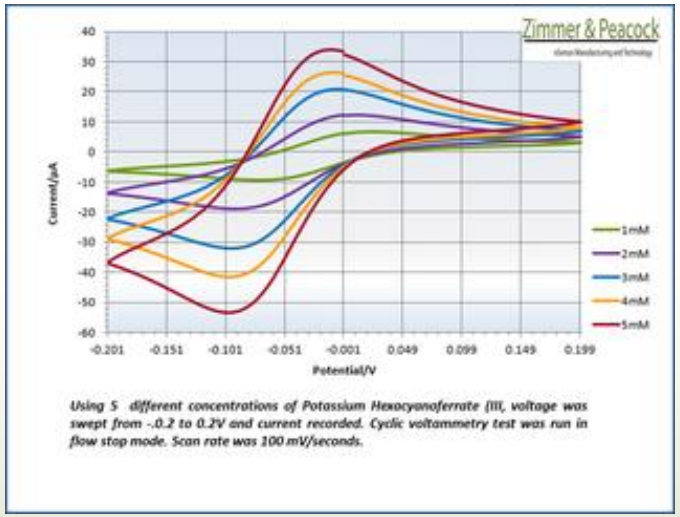
Variation in biosensors?





Zimmer & Peacock

How do you know your variation?



Across a wafer we have a variation of 7 %

Sensor 01	right	left	right	left
	5.503	6.17	5.474	5.775
	6.421	5.52	6.486	5.972
	6.509	5.697	5.93	6.671
	5.796		5.364	5.345
	6.132	6.932	6.932	6.134
	5.549	6.544	5.107	5.271
	6.223	5.074	5.704	5.56
	5.805	4.63	5.697	5.909
	5.572	6.352	5.814	6.491
	6.077	6.272	6.247	5.711
	5.182	5.973		6.214
	5.467	5.928	6.685	6.079
	5.842	6.284	5.625	6.48

AVG	5.852154	5.948	5.922083	5.970154	5.92262
STD	0.399651	0.639748	0.55599	0.435642	0.498941
STD%	0.068291	0.107557	0.093884	0.07297	8.424324

Zimmer & Peacock

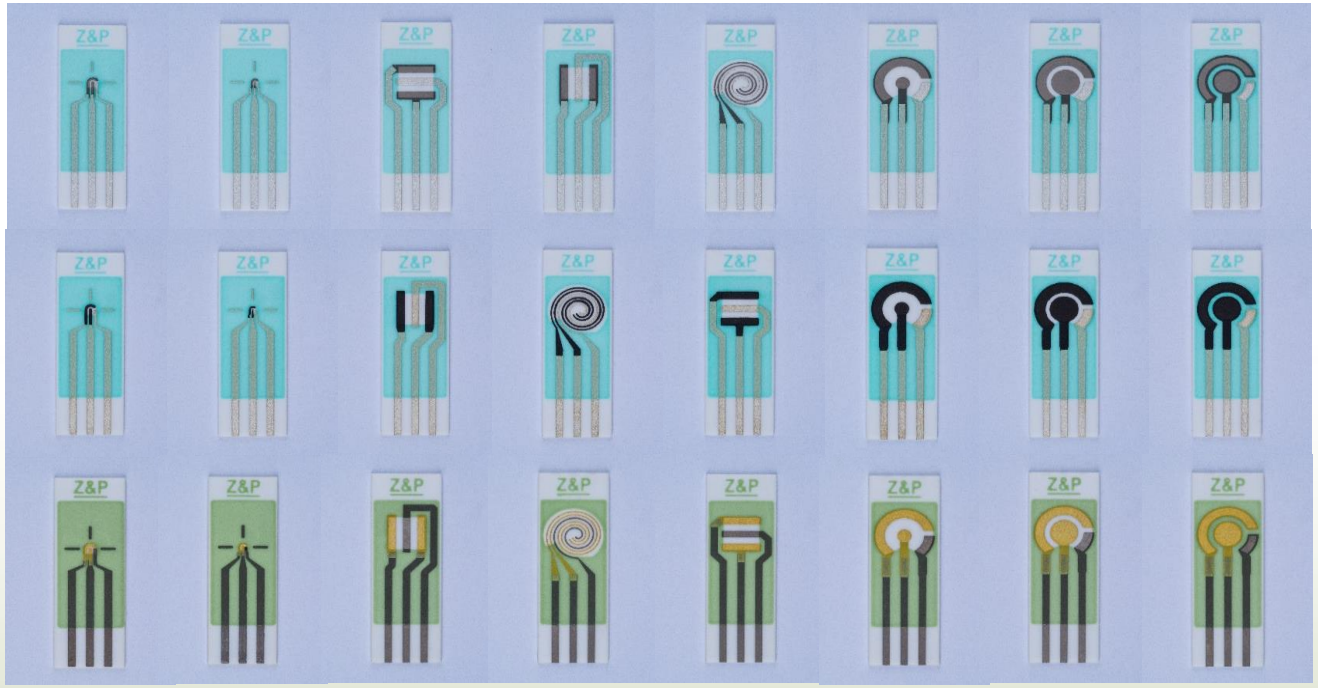
Zimmer & Peacock

eSensor Manufacturing and Technology

Zimmer and Peacock tool kit for biosensor development

Screening sensor configuration

- Graphene
- Gold
- Platinum
- Carbon
- Biosensor Ideal
- Harsh Environment Compatible
- Ceramic
- Flex substrate



Zimmer & Peacock

Sensors

O_2

K

Lac

H_2O_2

Glu

Chilli

pH

Na^+

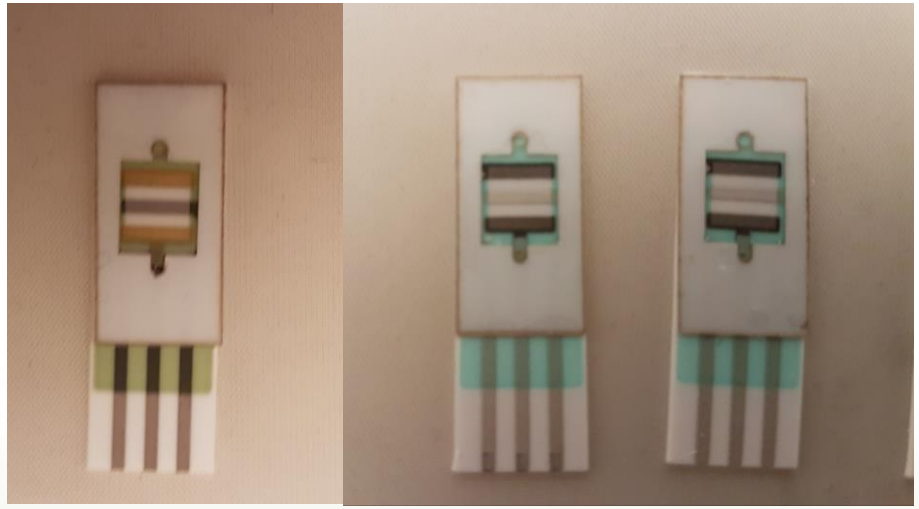
Zimmer & Peacock

Applicability

- **Very small molecule detection** – hydrogen peroxide, nitric oxide, carbon monoxide, CO_2, etc.
- **Ion detection** – sodium, potassium, calcium, trace heavy metals, pH etc.
- **Small molecule detection** – glucose, alcohol, lactate etc.
- **Macromolecule detection** – proteins, enzymes, antibodies, DNA, RNA detection.
- **Whole cell** – E Coli. Staphylococcus. Legionella

Packaging/Capillary fill sensors

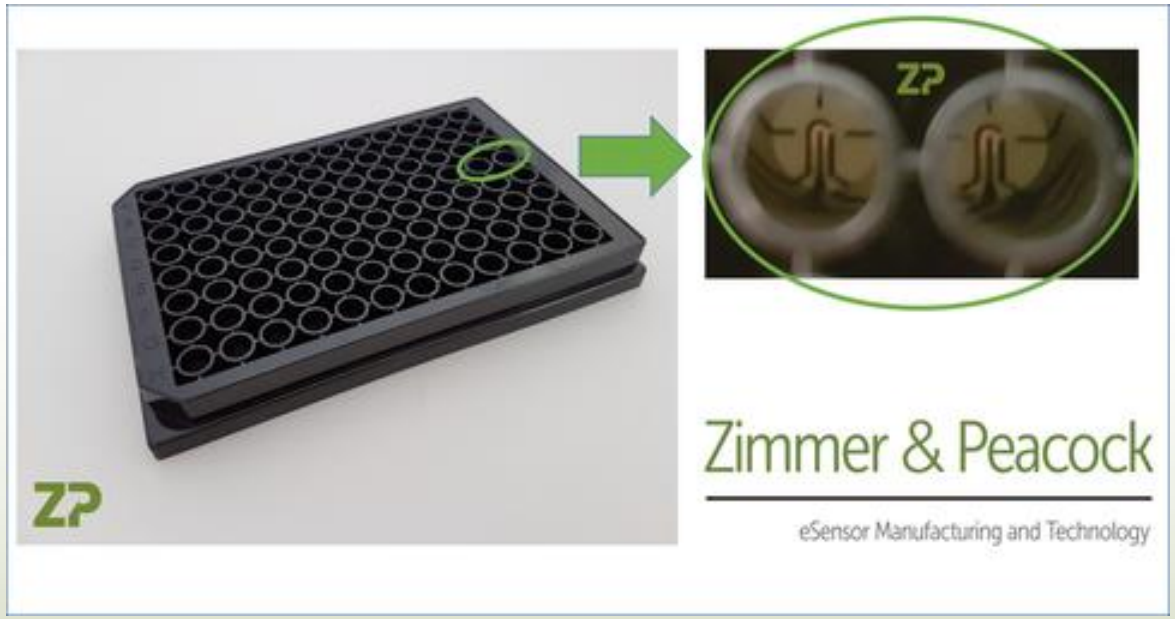
- Gold electrode capillary fill
- Carbon electrode capillary fill
- Platinum electrode capillary fill



Zimmer & Peacock

Microplate format

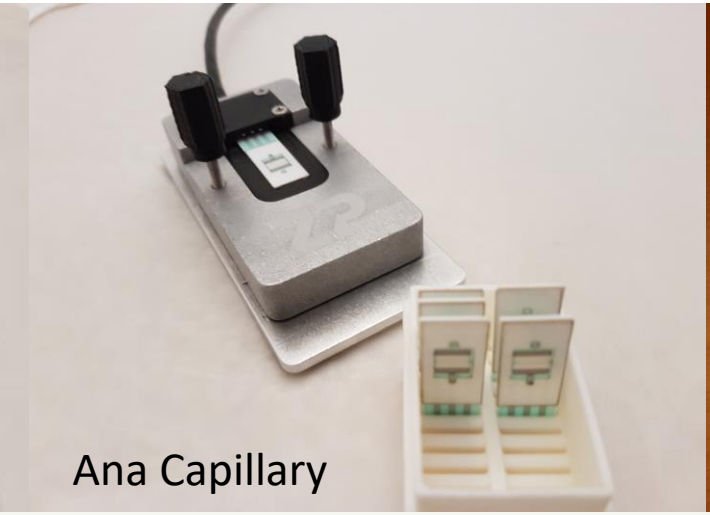
- 96 well – 3 electrode cells



Test Rig

Ana Drop

For those who want to pipette onto their sensors

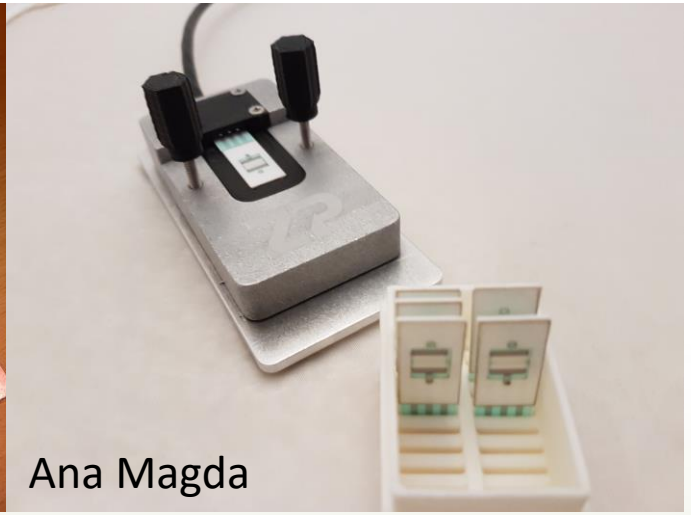


Ana Capillary

For those capillary filling their sensors

Ana Flow

For those pumping samples over their sensor



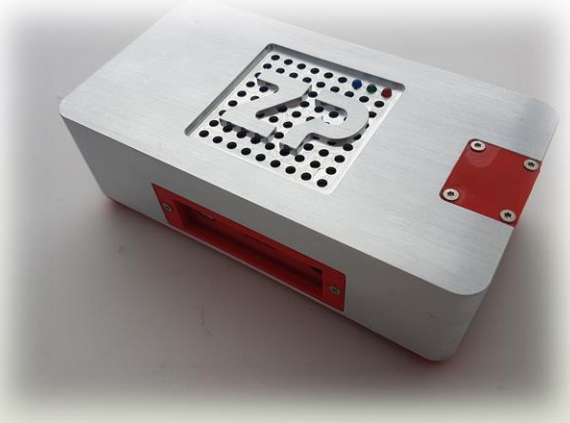
Ana Magda

For those wishing to use magnetic beads. Note we have a permanent magnet and an electromagnet version and this can be used with any of the other base types.

Zimmer & Peacock

Single Application Ana Pot Extra (ZP Application)

We are able to offer this set up with an
iPhone 7 Application



Zimmer & Peacock

Single Application Ana Pot Extra (ZP Application)

- In this image we have:
  - Sensor
  - A test rig
  - A Ana Pot
  - An app
- We are iOS developers so an iPhone App talking to the Ana Pot Extra, about 2-weeks
- We can put a QR reader so we can send out calibration factors.

Zimmer & Peacock

The Result

Zimmer & Peacock