Overview of Printable Sensors

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Application of Sensors in Precision Aquaculture

25 May 2021

Sensors for Aquatic Monitoring

Several commercial systems available to measure key parameters:

1. Temperature (5 - 25°C)
2. pH (6-10)
3. Salinity (0-50pss)
4. Dissolved oxygen (0-20mg/l)
5. Total dissolved solids (0-60g/l)
6. Dissolved organic matter
7. Chlorophyl (0-200µg/l)
8. Turbidity (0-3000NTU)
9. Ionic salts (Nitrates etc)
10. …….

EXO2 Sonde – courtesy Xylem Analytics

Values in brackets are typical, generally commercial sensors have a wider working range

Data Capture, Retrieval and Management

Several options available

- Hand held from the sonde
- Wireless transmission to a receiving portal
- Very large data volumes can be generated

Management

- Time trend displays
- Space variation displays
- …….
- Big data analytics

The Need for Printable Sensors and Challenges

Commercial systems are accurate, but high cost

- Sonde + sensors – typically £20k
- Prevents widespread monitoring of aquatic environments

Printable sensors

- Offer potential for lower cost solutions
- Sensors to measure a range of parameters may be fabricated as an integrated system

Challenges

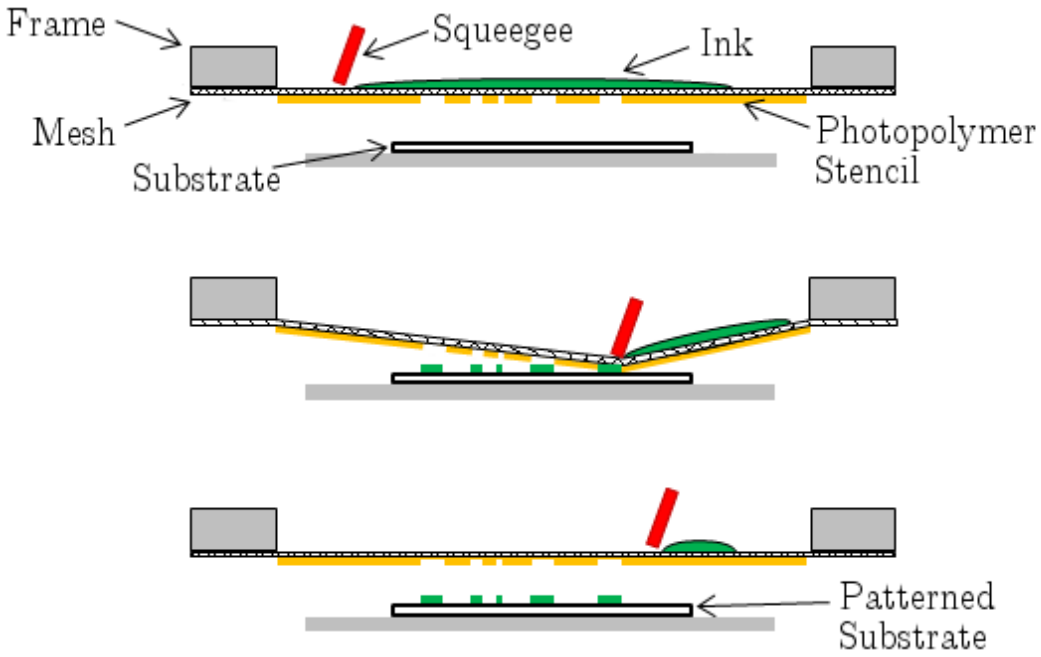
- Measurement accuracy – calibration against laboratory and commercial devices
- Survival in a harsh environment
- Working duration

Potential Printed Sensors

1. Temperature (5 - 25°C)
2. pH (6-10)
3. Salinity (0-50pss) – via conductivity
4. Dissolved oxygen (0-20mg/l)
5. Total dissolved solids (0-60g/l) – via conductivity and temperature

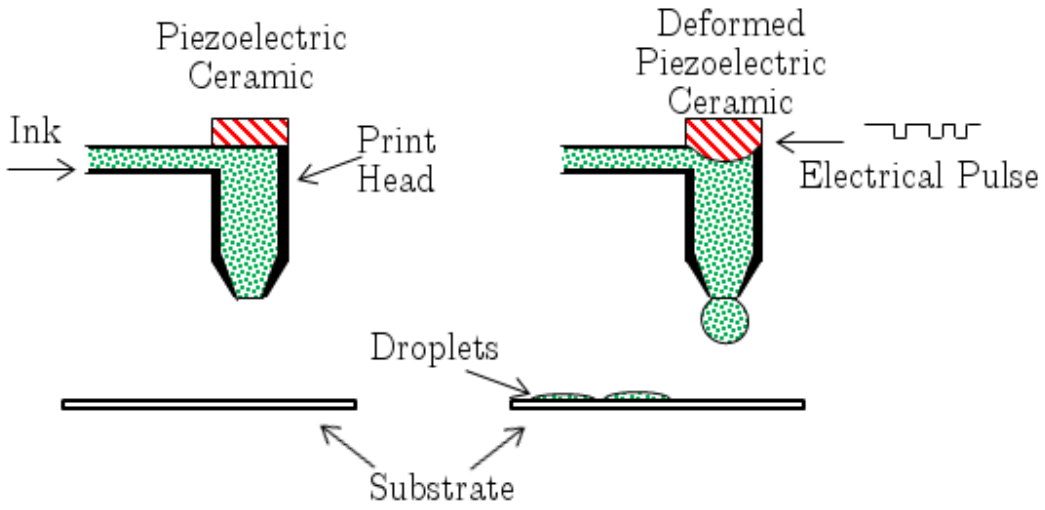
Remaining parameters may be measured by optical methods (being developed by Waterford)

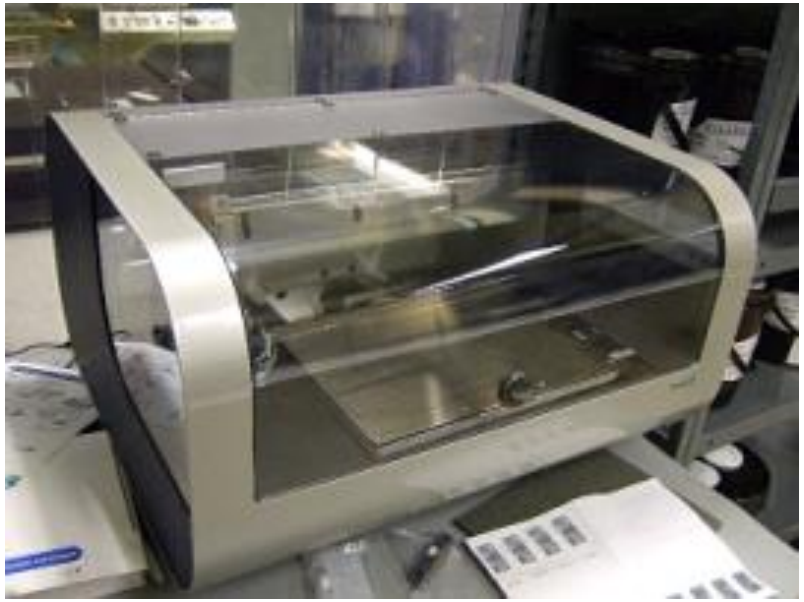
Potential Printing Methods - Screen



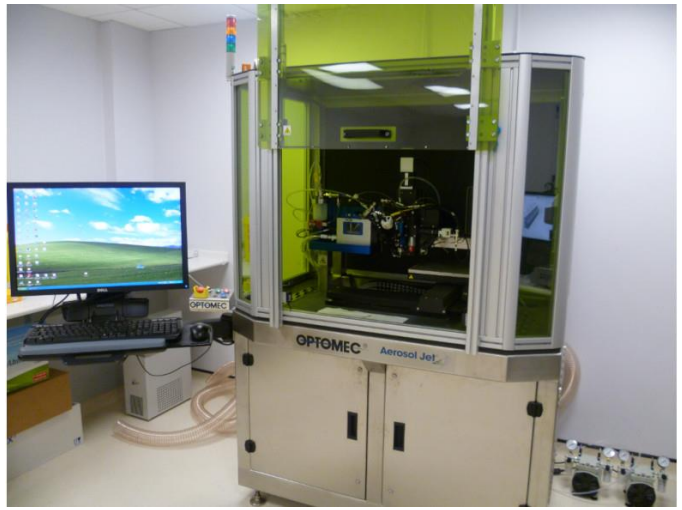
Screen is the principal process for sensor printing

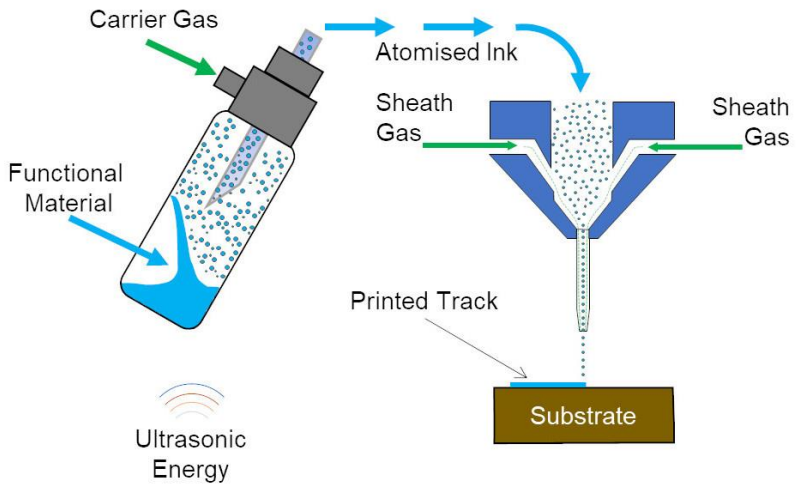
Potential Printing Methods - Inkjet

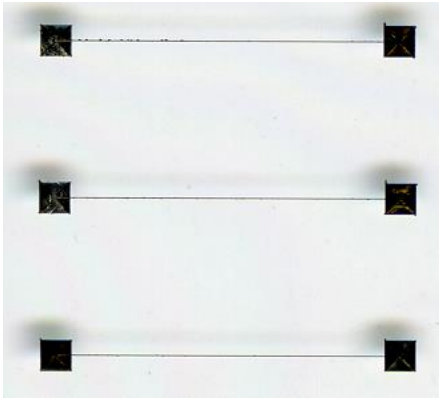


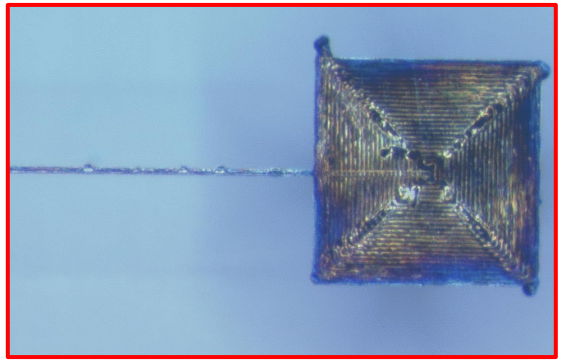


Potential Printing Methods – Aerosol Jet

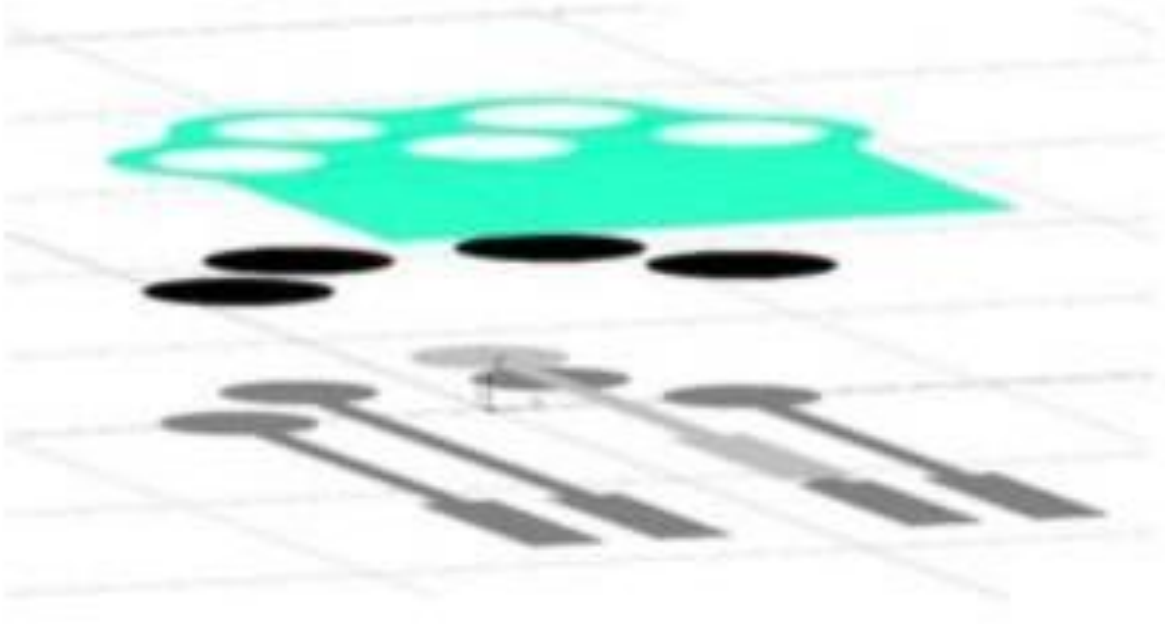


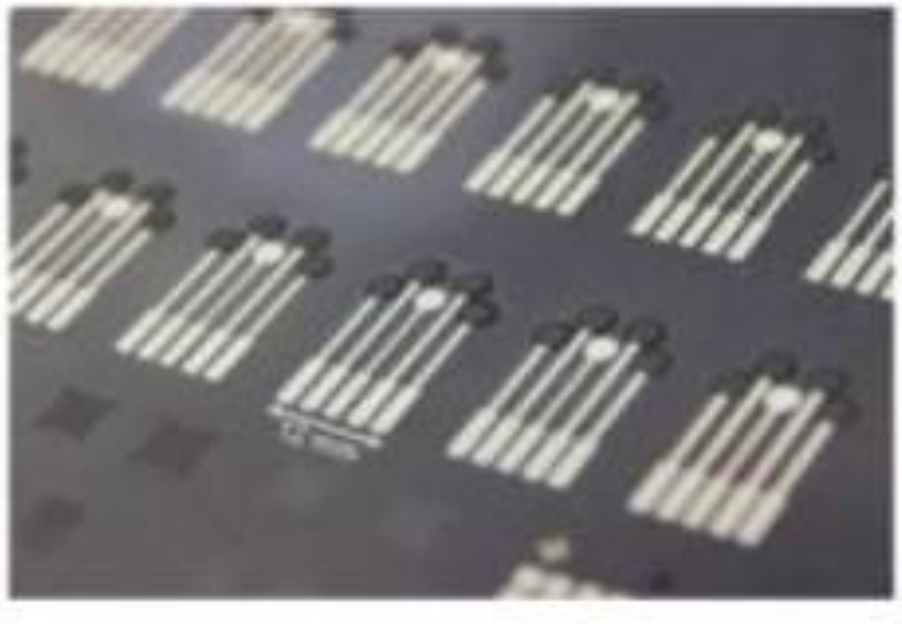




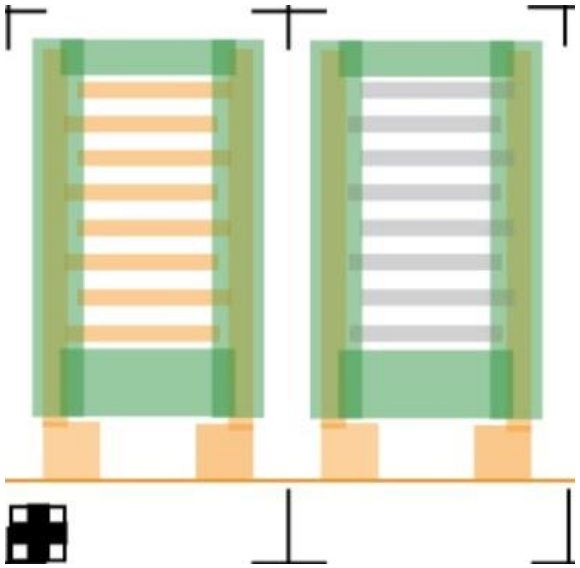


Fabricating a Sensor – multiple layers

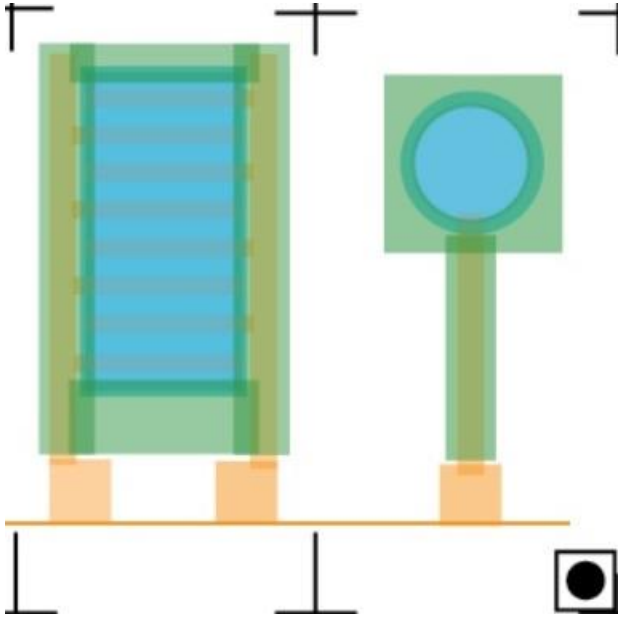




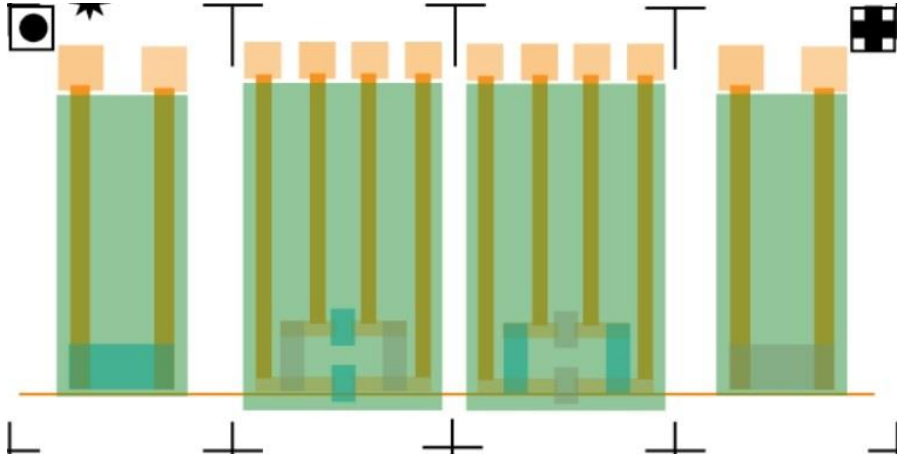
STREAM Sensors – Initial Study



Conductivity



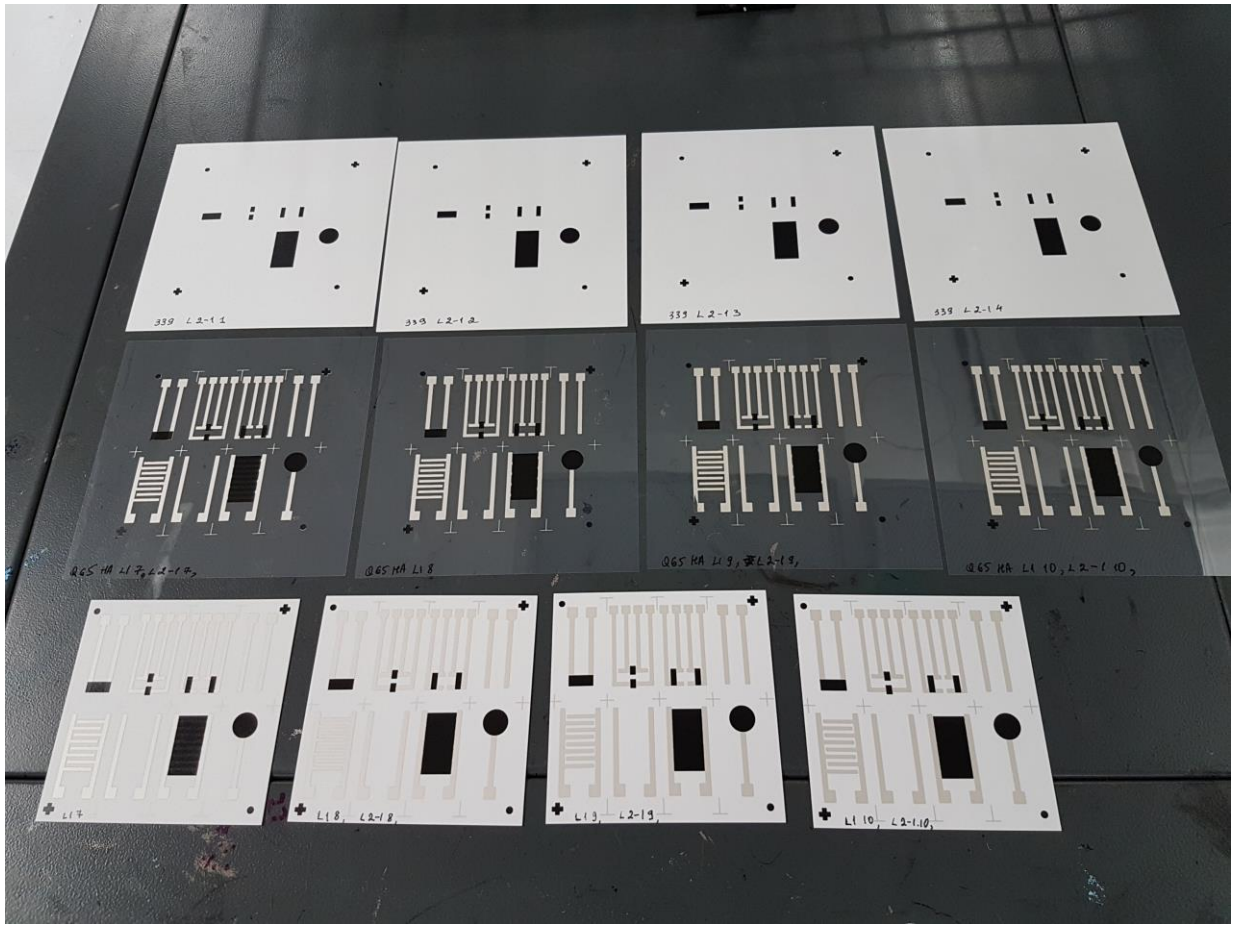
pH



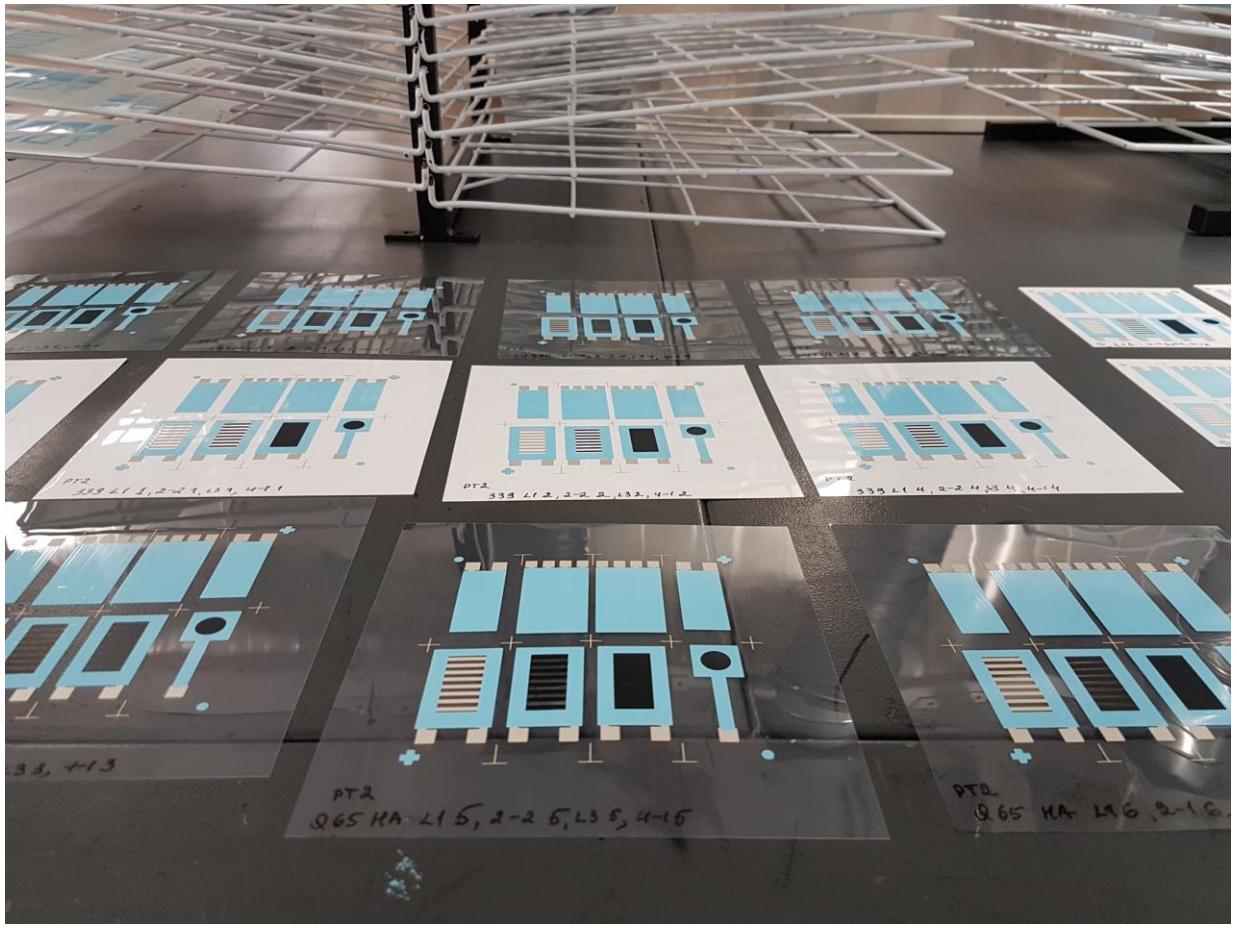
Temperature

Silver Conducting Track Layer

Carbon PEDOT:PSS Sensing Layer



Dielectric/Protecting Layer



Next Steps

Testing, calibration and development

Design for deployment

COVID has impeded progress

Example Printed Potassium Sensor

Screen printed

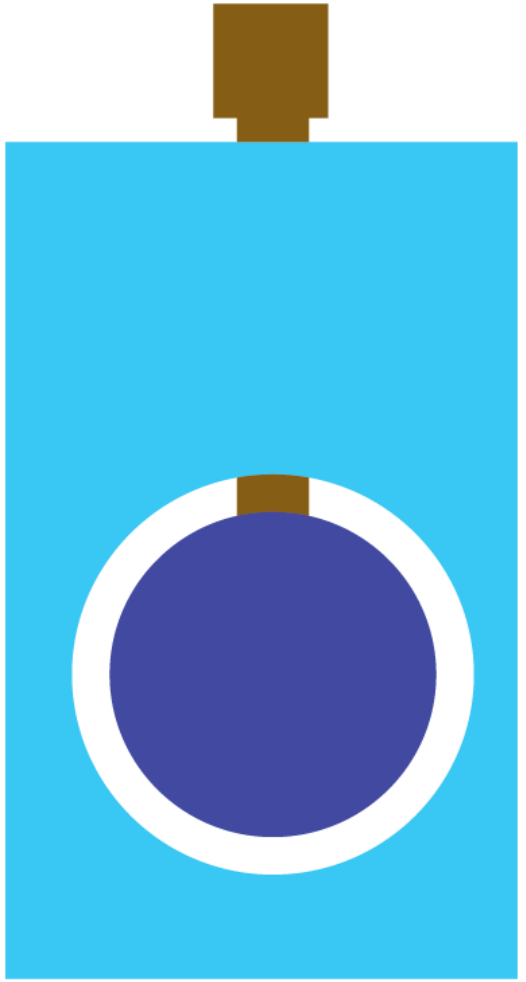
Conductor: 1 layer

Transducer: 1-2 layers

Insulator: 1-2 layers

Applied manually using a pipette

ISM: 1-2 layers

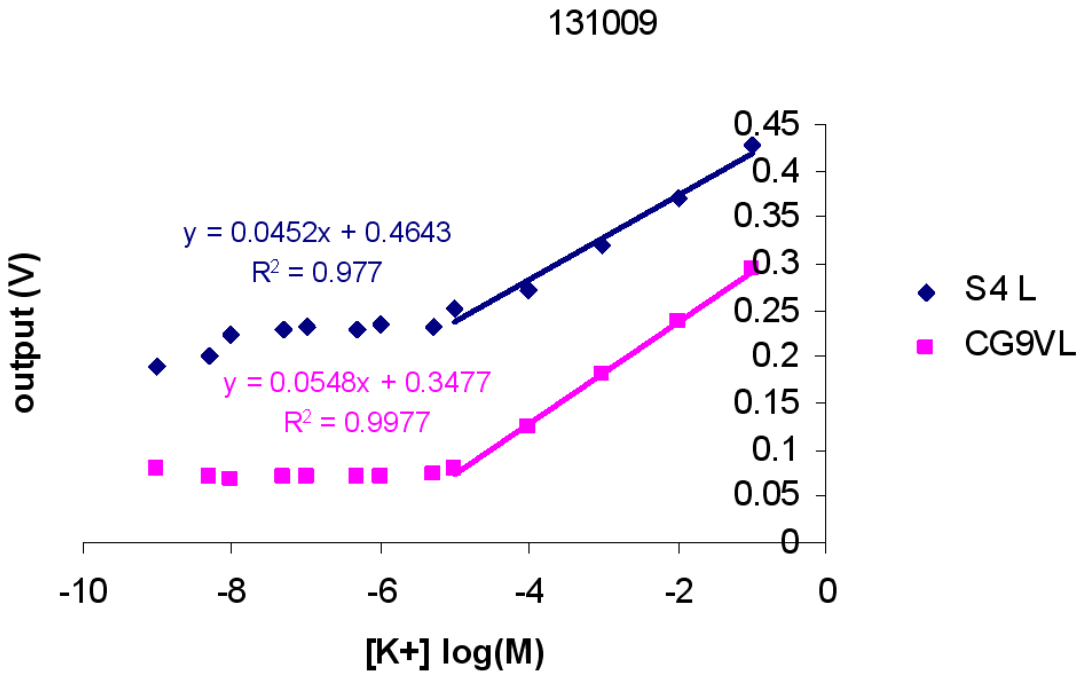


Example Printed Potassium Sensor

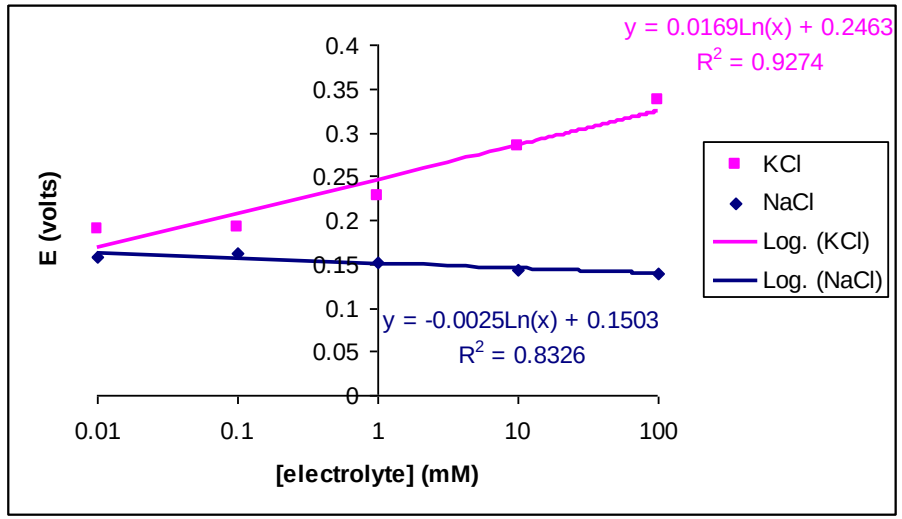
Sensitivity to K+: 55 and 45 (mV dec-1)

The lower limit of detection for both sensors is around 10 µM

Exhibit a near Nernstian response over a given and practical range of activity



Example Printed Potassium Sensor



Responds Potassium Ions only – does not respond to Sodium