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To Whom It May Concern

Date: 08 March 2017

Dear Sir/Madam

NAME: DR. WAN WARDATUL AMANI WAN SALIM
INSTITUTE: INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA
COUNTRY: MALAYSIA

CONFIRMATION OF INVITATION TO CONTRIBUTE TO A SHORT COURSE ON "CONTAMINATED LAND AND WATER" AT THE UNIVERSITY OF MANCHESTER IN MARCH 2017

We are delighted to confirm that Dr. Wan Wardatul Amani Wan Salim has been invited to contribute to the short course on "Contaminated Land and Water" being organized by the School of Earth and Environmental Sciences at the University of Manchester on 20 – 21st March 2017. We separately welcome discussions regarding building potential collaborative UK-Malaysia research links during her visit. We are able to offer to cover reasonable expenses for travel (economy class) and subsistence, upon submission of a claim form and original receipts.

If you have any queries, please do not hesitate to contact me as the lead short course organizer at laura.richards@manchester.ac.uk.

Yours sincerely

Laura Richards

Dr. Laura Richards
Research Fellow, University of Manchester

Design and Fabrication of Biochemical Sensors for Environmental Monitoring: Innovative Materials that Enhance Electrochemical Transduction

Wan Wardatul Amani Wan Salim, Ph.D

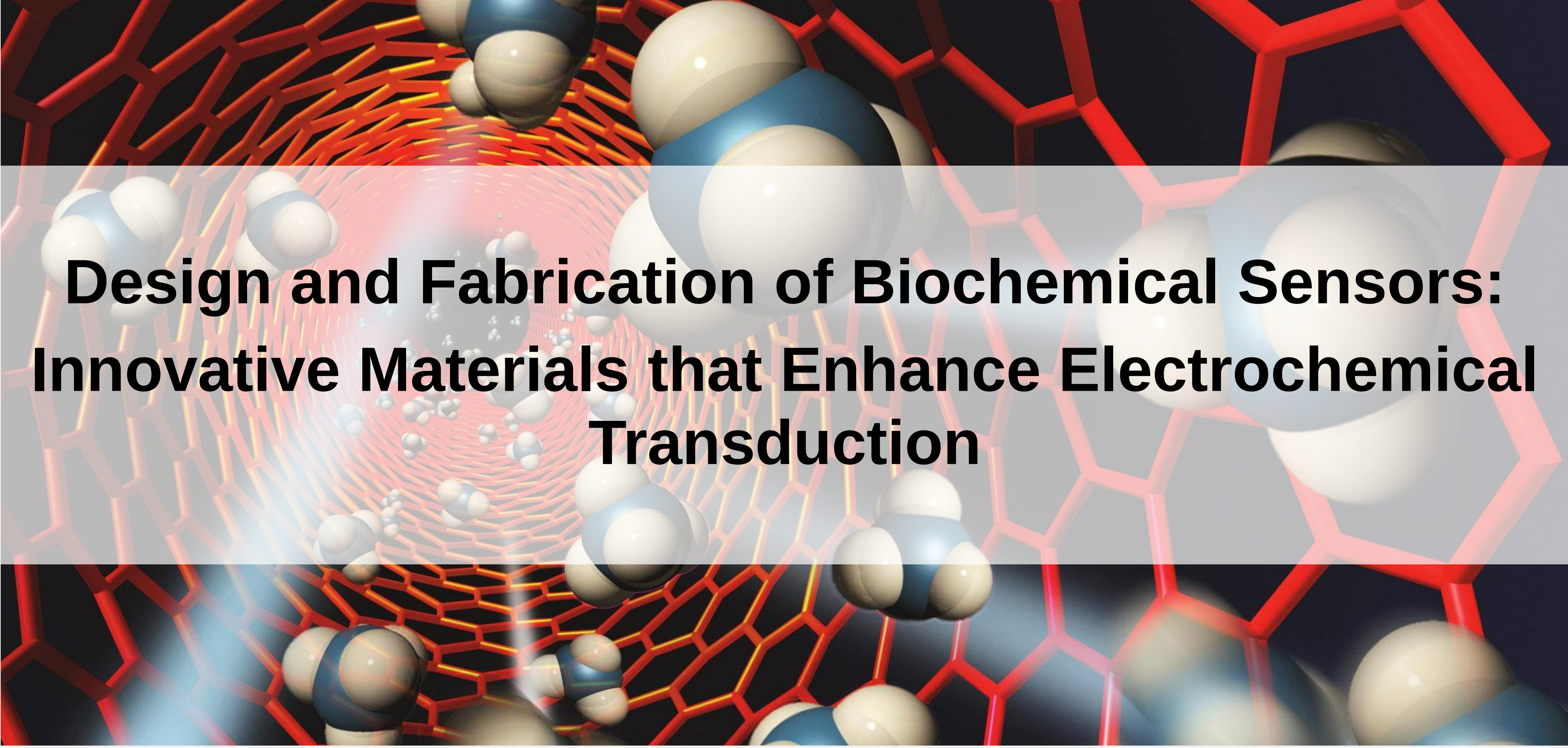
Projected increases in pollutants and waste products warrants the need for biochemical sensor–based monitoring technologies for efficient protection, remediation, and restoration of the environment, and also addresses the issue of homeland security. Efforts to develop biochemical sensors for environmental monitoring in projects funded by the Malaysia Ministry of Education (MOE) under the fundamental/basic grants and by private awards such as the L'Oréal-UNESCO award for applied research will be presented. Work has been done to optimize the electrochemical transducer layer of biochemical sensors in terms of stability, sensitivity, detection limit, and mechanical properties utilizing conductive polymers and/or graphene-based nanomaterial composites. Results show that electrochemical deposition of ethylene dioxythiophene (EDOT) and its conjugates as transducer layers can retain redox capability over multiple sensor use and provide stable current measurements in a water-flow test. Furthermore, Fourier transform infrared spectroscopy (FTIR) results reveal that methods of graphene oxide reduction affect sensor performance in terms of sensitivity and detection limit owing to the availability of surface functional groups. Biochemical sensors have been developed to successfully detect and quantify *E. coli* O157:H7 and ions involved in water-quality monitoring; the sensors are currently being integrated with portable platforms such as open-source microprocessors intended for field-work use.

WAN WARDATUL AMANI WAN SALIM, Ph.D. Assistant Professor in the Biotechnology Department at International Islamic University of Malaysia (IIUM), received her B.Sc. and M.Sc. in Electrical Engineering from the University of Minnesota Twin Cities in 2001 and 2003 respectively, and her Ph.D. in BioMEMS and Microelectronics from the Weldon School of Biomedical Engineering at Purdue University in 2009.

Prior to her position at IIUM, she was an academician at Purdue University, USA, and was appointed as the Principal Investigator to a NASA Small Satellite project (www.sporesat.org); the satellite was launched on April 2014. Her research focuses on multidisciplinary approaches for the development of advanced sensor technologies and the application of these technologies towards answering important questions in agriculture, biology, environmental science, medicine, and space biology. She has done extensive work with biological-micro-electro-mechanical systems (bio-MEMS).

Dr. Amani has published numerous research articles in journals such as *Lab-on-a-chip*, *Langmuir*, and *Nanotechnology*. She also received the Thora W. Halstead Young Investigator's Award in 2012 from the American Society for Gravitational and Space Research (ASGSR), and was recipient of the 2015 Malaysia National L'Oréal – UNESCO Fellowship for Women in Science. Recently, she was chosen to represent Malaysia to attend the Commonwealth Conference organized by the Royal Society and the National Research Foundation under the office of the Singapore Prime Minister. Dr. Amani was also a TedX KL speaker; her talk focused on the subject of frugal innovative technologies in developing countries.

Amani may be reached at asalim@iium.edu.my



Design and Fabrication of Biochemical Sensors: Innovative Materials that Enhance Electrochemical Transduction

INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA

ARG DR. AMANI RESEARCH GROUP

Wan Wardatul Amani Salim, Ph.D

International Islamic University Malaysia
Kuala Lumpur

The Needs

Over the last decade we have witnessed a rise in patients with diabetics diseases and an alarmingly increasing frequency of water-borne related disease outbreaks – both outcomes has worldwide consequences on public health and commerce.

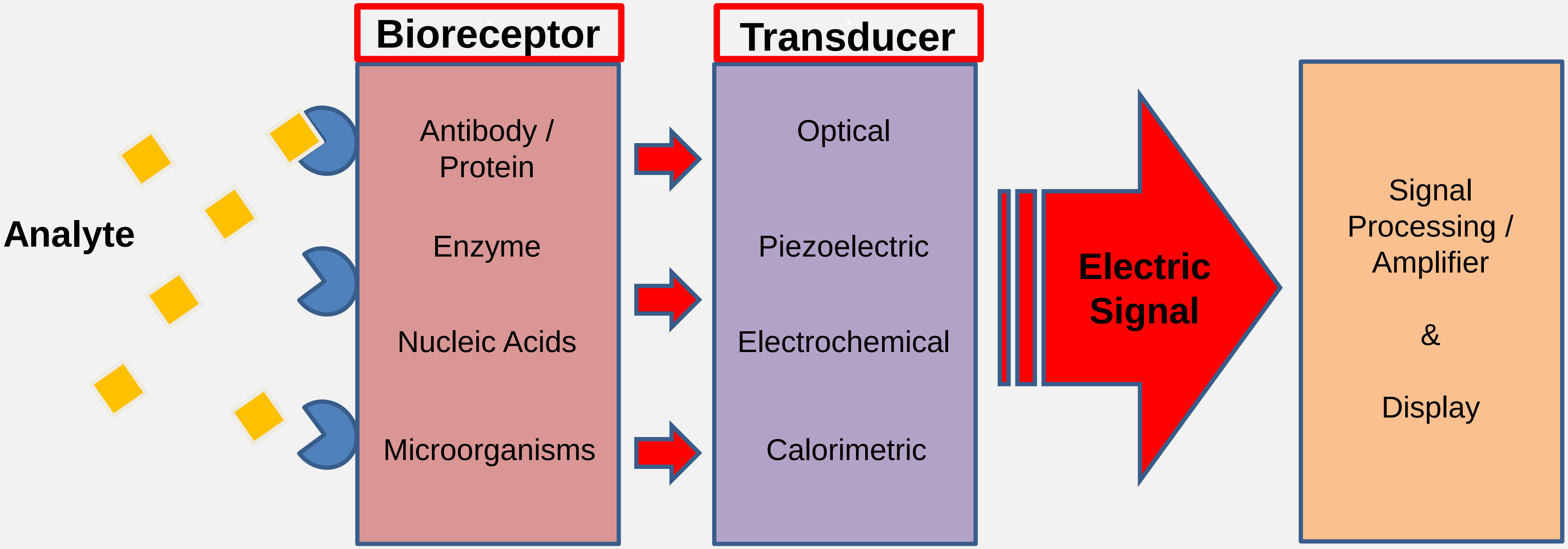
There is a need for preventive technology that can detect and quantify glucose levels in various bodily fluids/ monitor water quality, hazardous chemicals, and deadly pathogens in water

A device that is capable of providing measurements in liquid media, signals produced not easily perturbed, simple to use, and inexpensive

The purpose of such device is to provide rapid, real-time, accurate, and reliable information about a targeted analyte

Biosensor

"A self-contained integrated device which [sic] is capable of providing specific quantitative or semi-quantitative analytical information ***using a biological recognition element*** which is in direct spatial contact with a transducer element."



Application

Application of Biosensors

Quality assurance in agriculture, food, water quality, and pharmaceutical industries

- ➢ *E. Coli, Salmonella, Campylobacter*

Monitoring environmental pollutants & biological warfare agents

- ➢ *Bacillus anthracis* (anthrax) spores

Medical diagnostics

- ➢ Glucose, other biomarkers

Biological assays

- ➢ DNA microarrays

World-market for Biosensors

World Market Revenue for **biosensors** is expected to reach

$22.68 billion

by **2020** – Marketsandmarkets(2015)

In **2009**,

31.55% of total world market sensing goes to **glucose sensing**

Biosensors Application

Application of Biosensors (early diagnosis)

Sensing of biomolecules at low concentrations is critically important to the early diagnosis and successful treatment of diseases and fundamental physiological research.

- Diabetes (Glucose)
- Neurological Diseases (Glutamate)
- Cellular Metabolism (Ethanol)

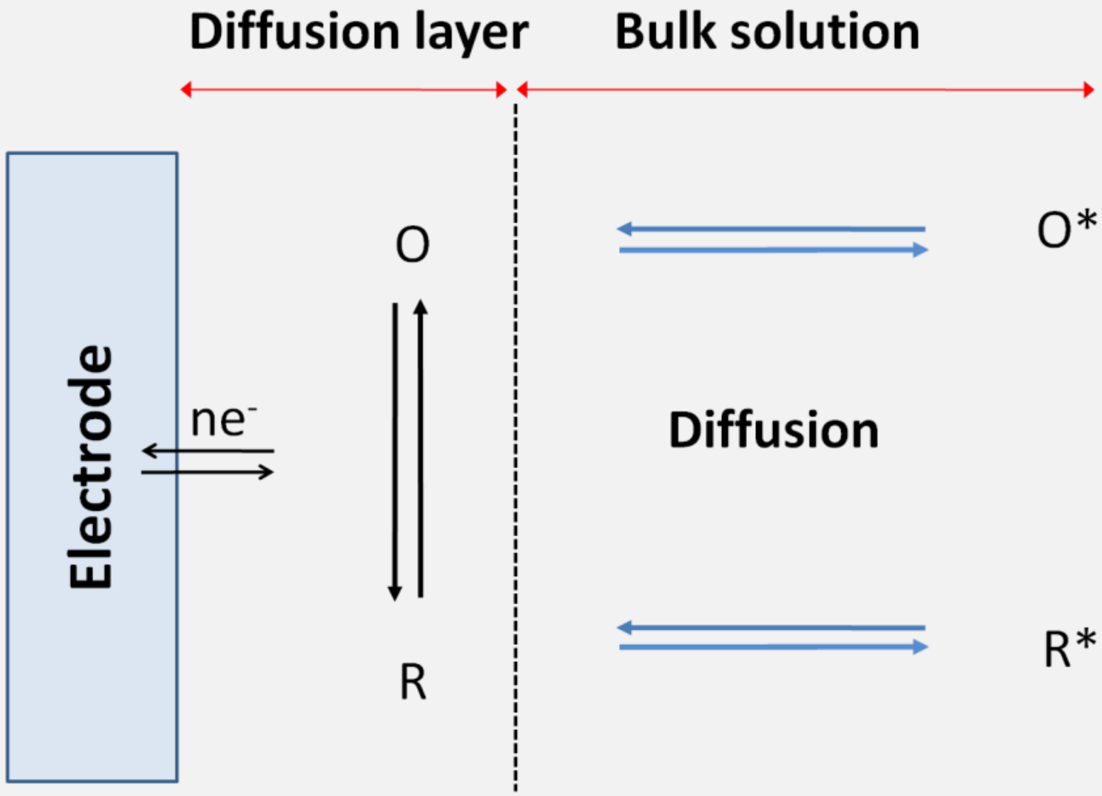
Electrochemical Principles

Involves oxidation-reduction reaction related to charge transfer process occurring at the electrode-solution interface.

$O + ne^- \longleftrightarrow R$

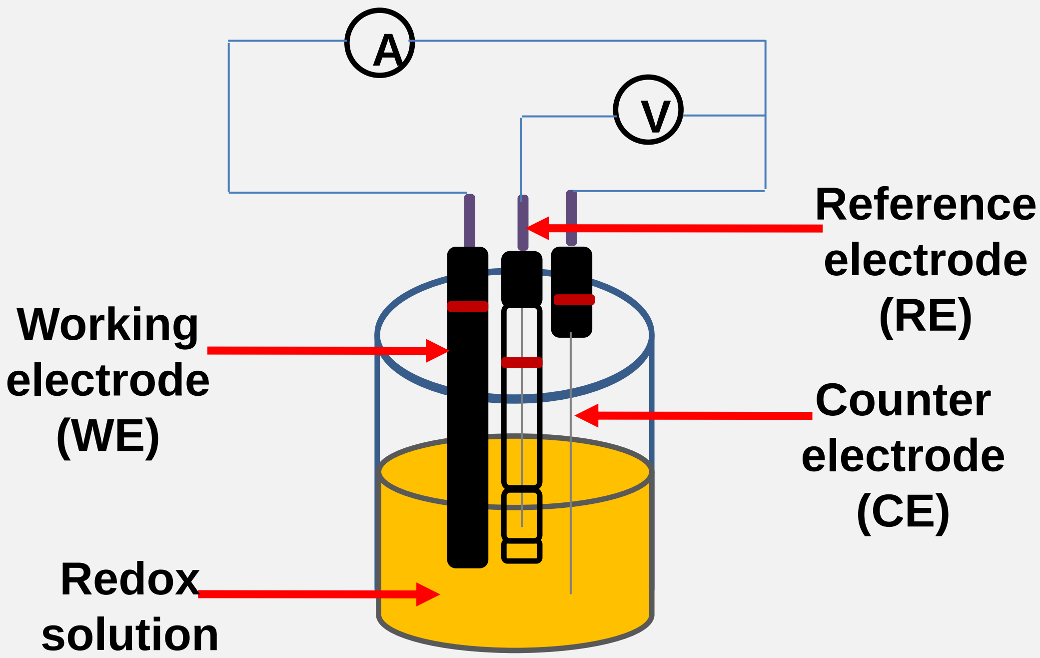
where
O is the oxidized species
R is the reduced species
n is the amount of electron transferred

Current at the electrode surface is generated when the electron is transferred to redox species.



Electrochemical Cell

- 3-electrode point setup connected to a potentiostat/galvanostat
- Current is determined according to the rate of redox reaction occurring at WE, in reference to RE, and the circuit is completed with CE.

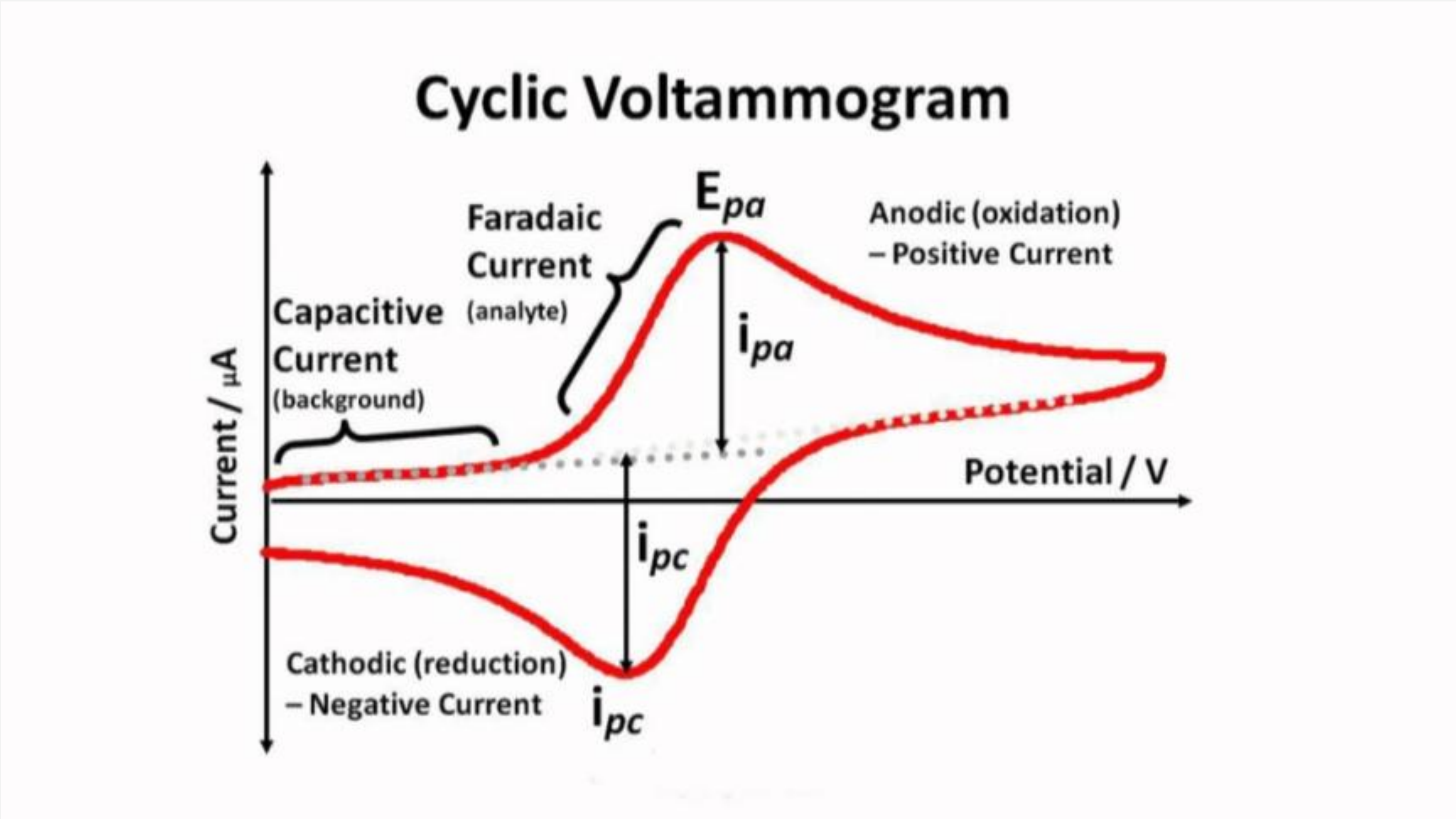


A portable potentiostat/galvanostat

Electrochemical Technique

Cyclic voltammetry (CV)

- Most frequently used diagnostic and electroanalytical tool to elucidate capability of an electrode to perform electrochemical reaction.



Source: www.youtube.com/watch?v=1f92vGOridg

Electrochemical Technique

Chronoamperometry (CA)

- Another commonly used electroanalytical tool in determining diffusion coefficients and investigating mechanism kinetics.

- It is performed by applying an applied potential pulse and the resulting current is measured against time.

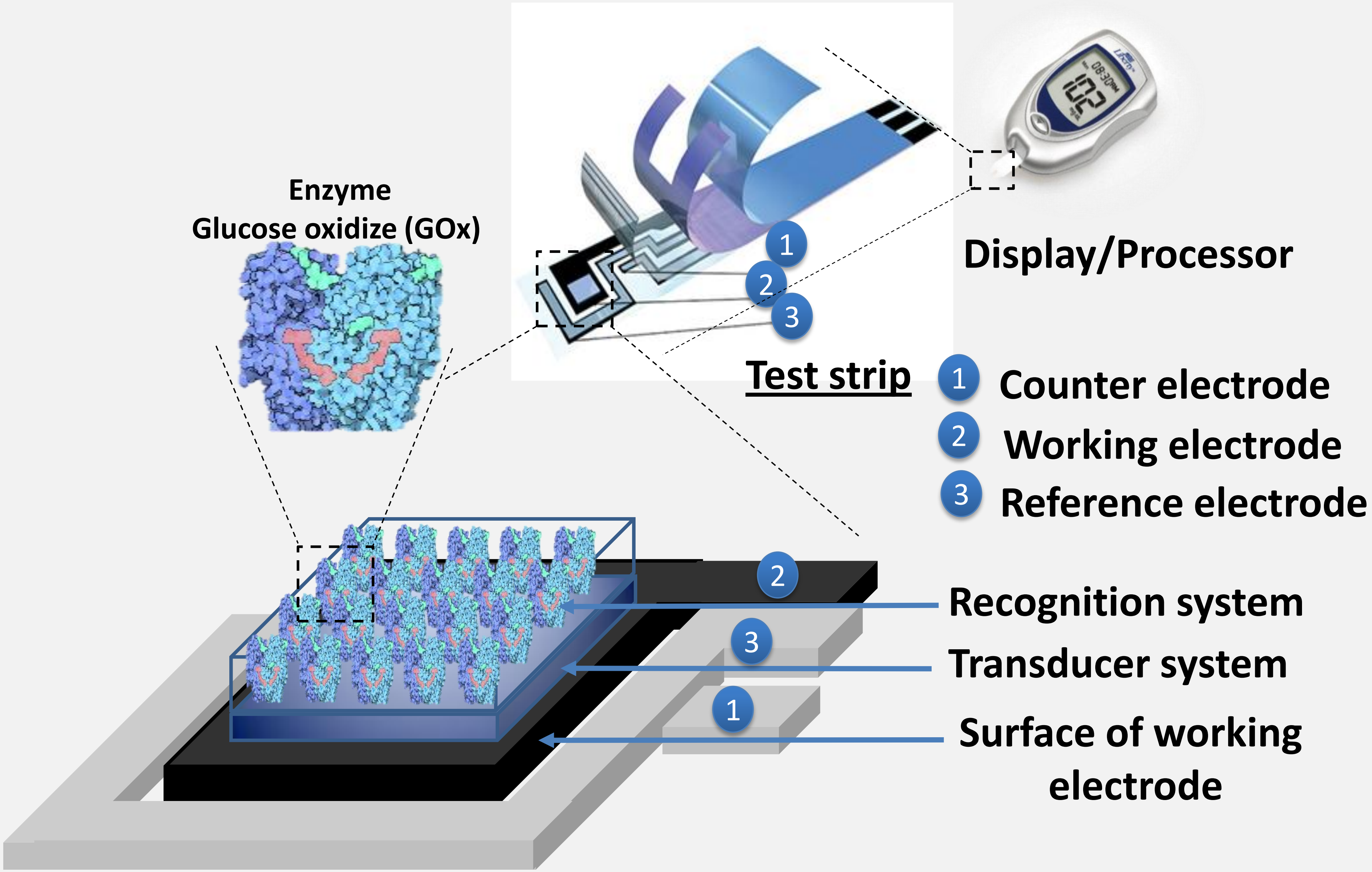
- To test the performance of glucose biosensor, CA will be employed by applying voltage of +400 mV to +500 mV and the resulting current is proportional to the glucose concentration.

Performance Parameters

- Calibration
- Background signal
- Sensitivity
- Detection Limit
- Selectivity
- Dynamic range
- Stability
- Response time
- Spatial resolution (if applicable)
- Accuracy
- Precision/ Repeatability

DEVICE DESIGN AND FABRICATION

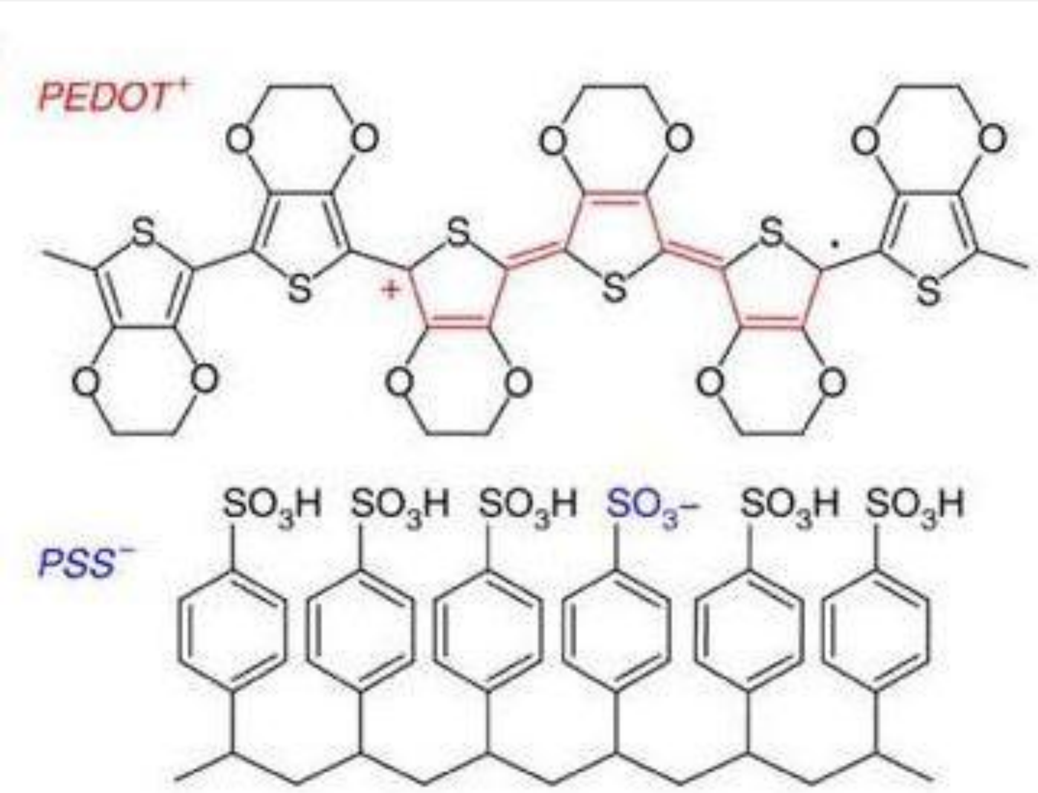
GENERIC GLUCOSE SENSOR DESIGN

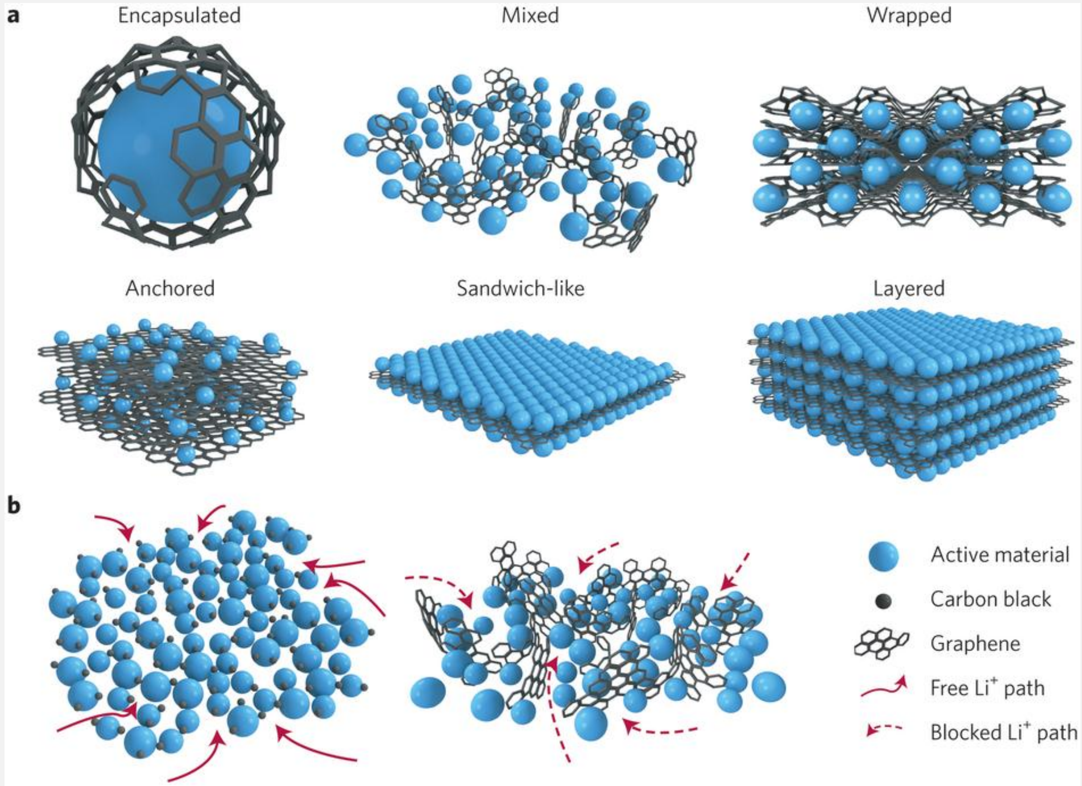


Components of Electrochemical Sensors

- **Analyte:** chemical/biological target
- **Semipermeable Membrane (1):** allows preferential passage of analyte (limits fouling)
- **Detection Element (Biological):** provides specific recognition/detection of analyte
- **Semipermeable Membrane (2):** (some designs) preferential passage of by-product of recognition event
- **Electrolyte:** (electrochemical-based) ion conduction medium between electrodes
- **Transducer:** converts detection event into a measurable signal

Different materials are widely used in electrochemical biosensor transducer fabrication to improve sensitivity, detection limit, and response time





Conductive polymers – PEDOT:PSS

PEDOT charge transporting species

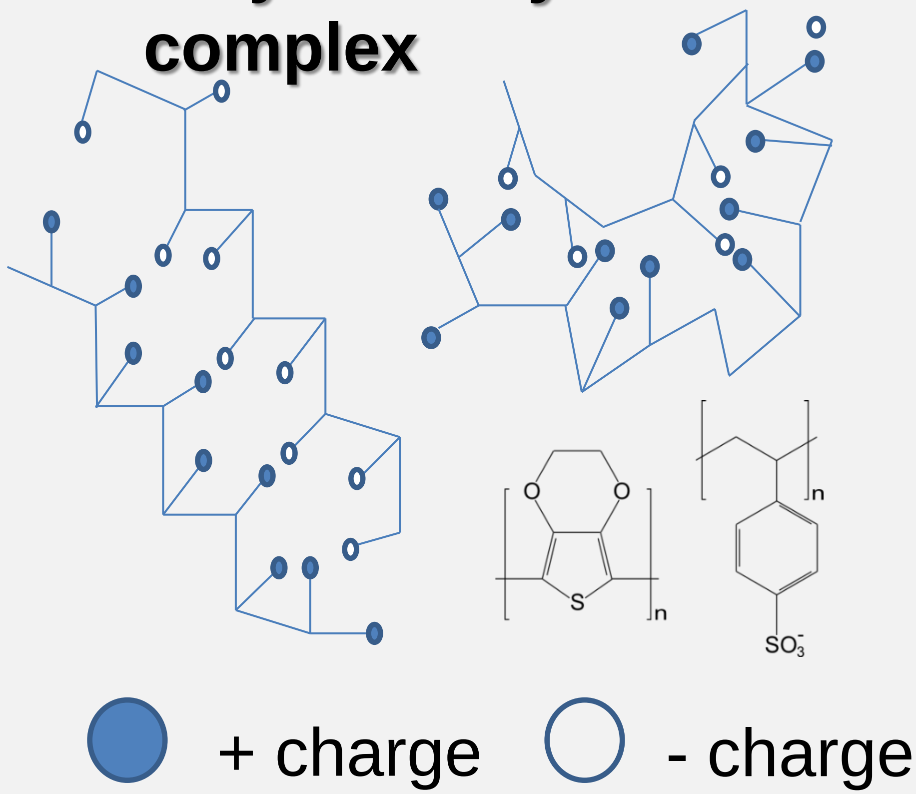
PSS charge balancing dopant, counter polyanion

Graphene

Why conducting polymers?

- Comparable conductivity as gold and platinum
- Rapid prototyping through electrochemical or chemical deposition
- Can be deposited from solution
- An electro-active material
- Tailored electrochemical properties
- Robust – fouling resistant

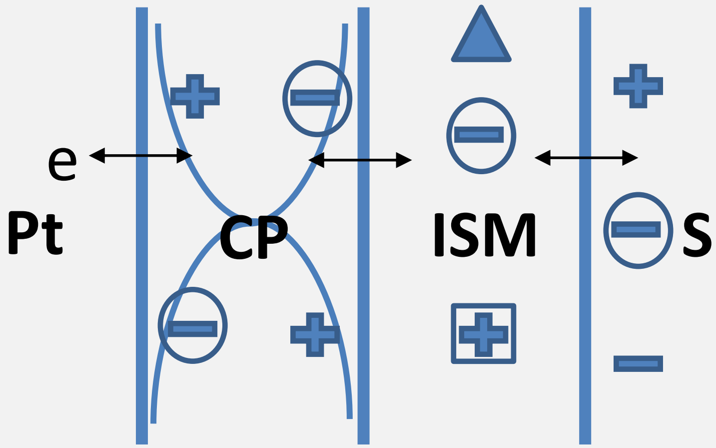
Polyelectrolyte complex



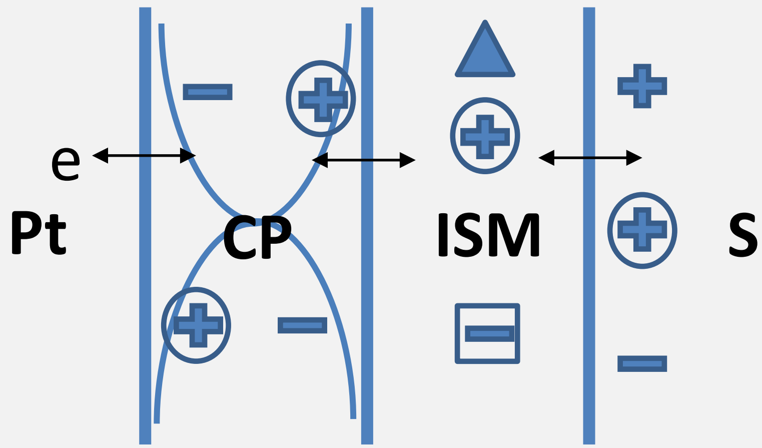
Adapted from Philipp, W. Dawydoff et al., (2001) Makromoleküle Physikalische Srukturen und Eigenschaftenm Vol 2, 6th ed., Wiley-VCH

We use PEDOT:PSS conducting polymer conjugates as it meets all the required criteria for our new generation biosensor

Anion-selective-all-solid-state-electrode

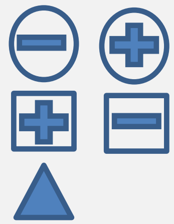


Cation-selective-all-solid-state-electrode

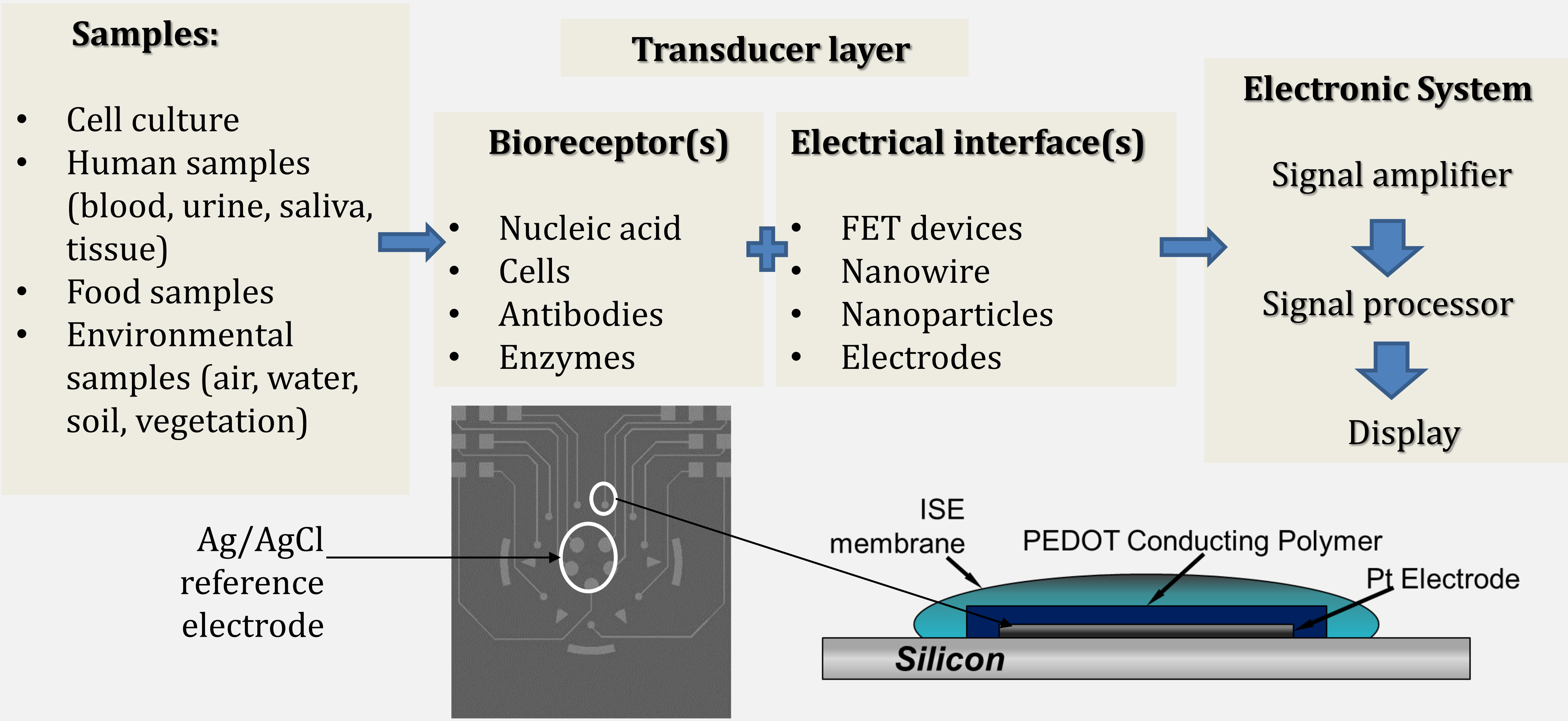


Pt: Platinum electrodes
CP: Conductive polymer
ISM: Ion-selective-membrane
S: Solution

Primary ions
Counter ions
Ion-recognition site

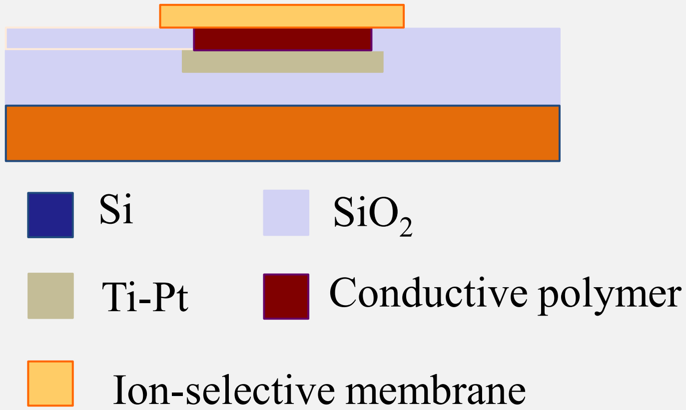


Adapted from Bobacka et al., (2006). Electroanalysis 18, No. 1, 7 – 18

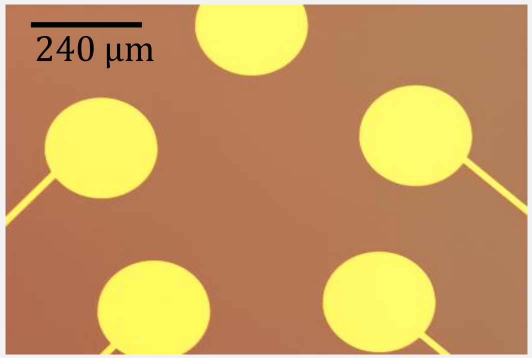

Samples:
Cell culture
Human samples (blood, urine, saliva, tissue)
Food samples
Environmental samples (air, water, soil, vegetation)
Transducer layer
Bioreceptor(s)
Nucleic acid
Cells
Antibodies
Enzymes
Electrical interface(s)
FET devices
Nanowire
Nanoparticles
Electrodes
Electronic System
Signal amplifier
Signal processor
Display
Ag/AgCl reference electrode
ISE membrane
PEDOT Conducting Polymer
Pt Electrode
Silicon

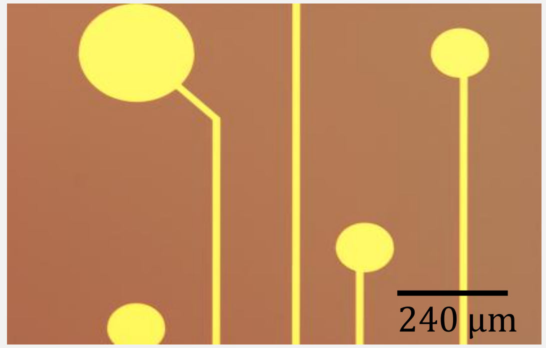
All-solid State Sensor Development

ISE cross-section

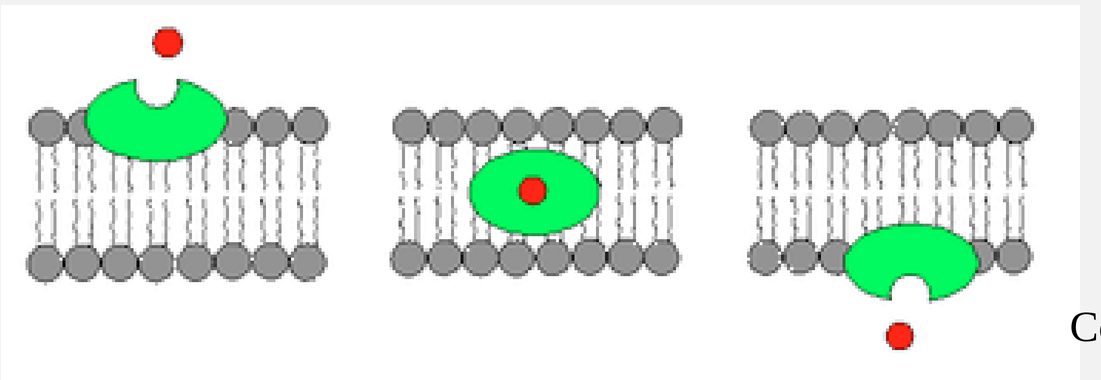


Microscope images of microfabricated electrodes

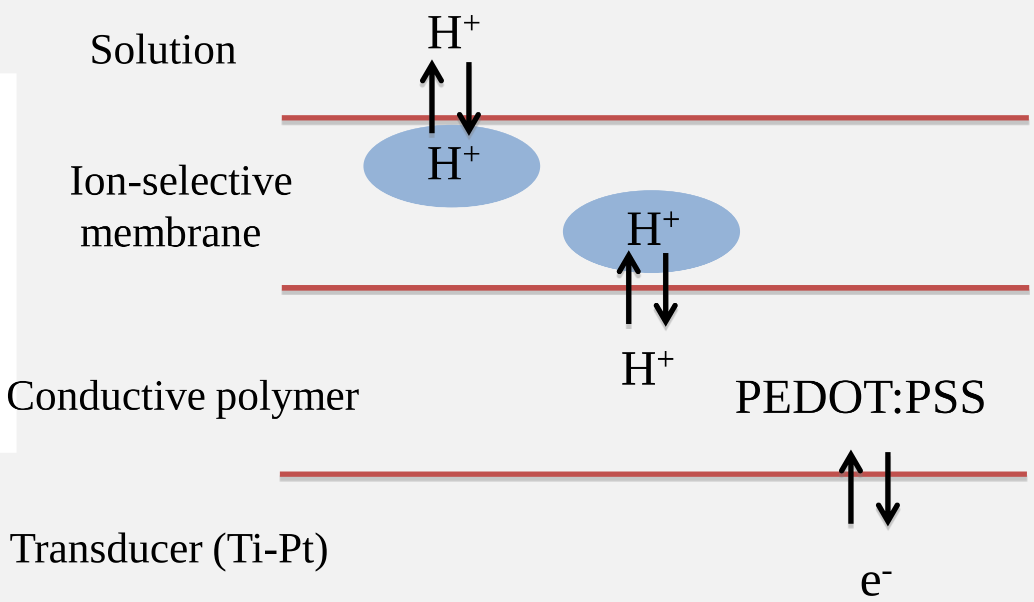




Ion-selective membrane



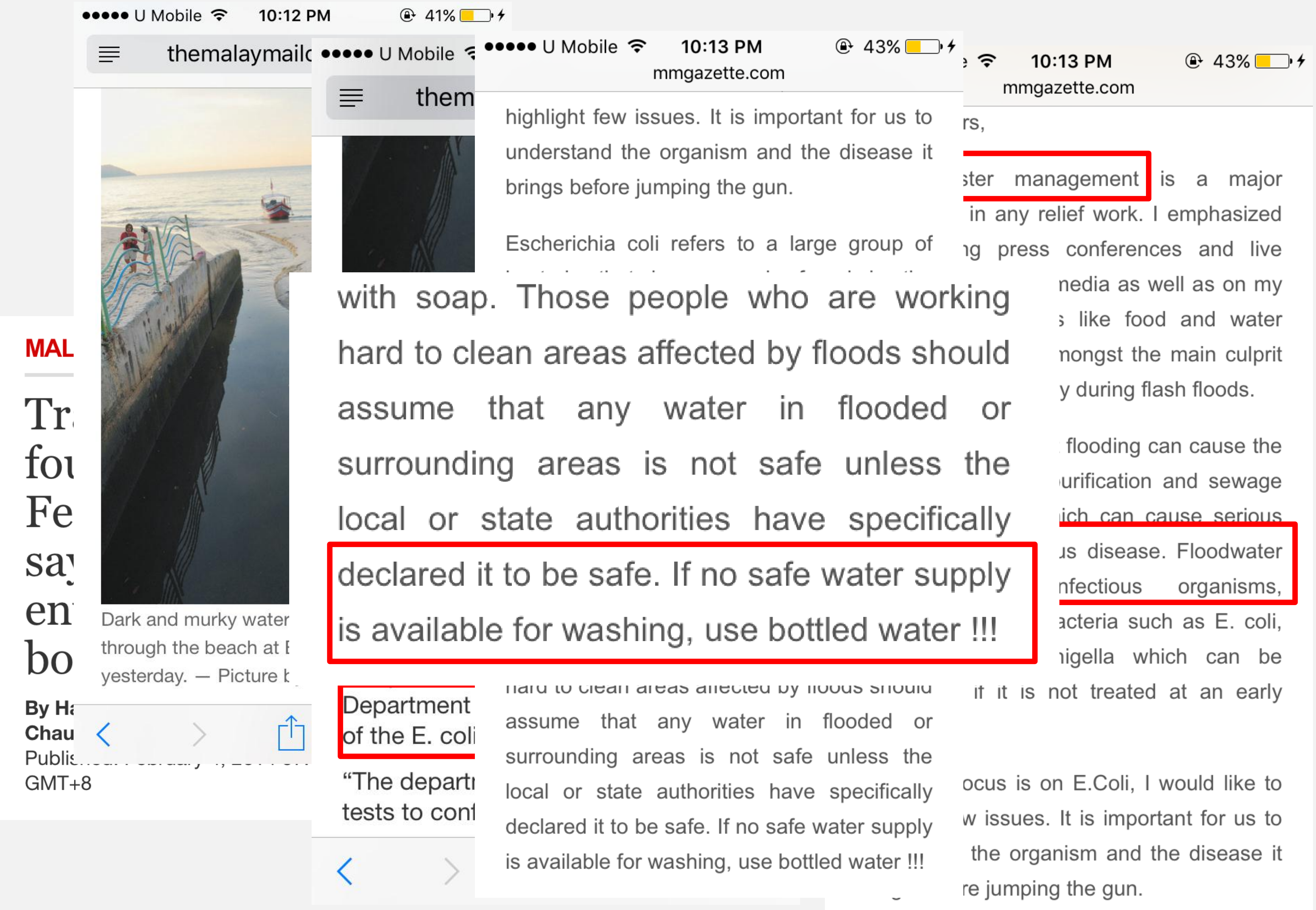
Conductive polymer transducer



Sensor Calibration

		Tap Water Range*	MAB Lower Detection Limit	Response Time
pH	H^+	pH 6.0-8.5	pH 4.0-9.0	45 s
Disinfectant	Cl^-	20-80 ppm	11.2 ppm	60 s
	NH_4^+	0-0.2 ppm	0.18 ppm	15 s
Hardness	Ca^{2+}	128-176 ppm	0.4 ppm	> 5 min
	Mg^{2+}	20-30 ppm	3.6 ppm	> 5 min
	HCO_3^- /CO_3^{2-}	N/A	6 ppm	120 s

***Potable water quality for West Lafayette, IN (reported May - December, 2011)**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Dark and murky water through the beach at
yesterday. — Picture
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highlight few issues. It is important for us to understand the organism and the disease it brings before jumping the gun.
Escherichia coli refers to a large group of
with soap. Those people who are working hard to clean areas affected by floods should assume that any water in flooded or surrounding areas is not safe unless the local or state authorities have specifically declared it to be safe. If no safe water supply is available for washing, use bottled water !!!
Department
of the E. coli
"The depart
tests to con
assume that any water in flooded or surrounding areas is not safe unless the local or state authorities have specifically declared it to be safe. If no safe water supply is available for washing, use bottled water !!!
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mmgazette.com
management is a major
in any relief work. I emphasized
press conferences and live
media as well as on my
like food and water
mongst the main culprit
during flash floods.
flooding can cause the
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nfectious organisms,
acteria such as E. coli,
which can be
if it is not treated at an early
ocus is on E.Coli, I would like to
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the organism and the disease it
re jumping the gun.

Drinking Water QS

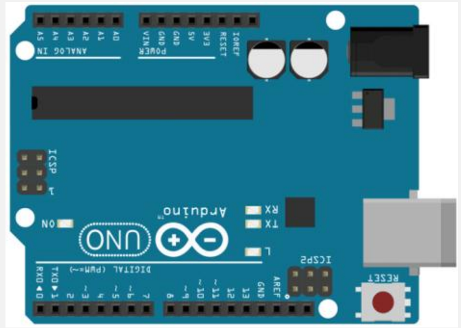
Drinking Water Quality Standard

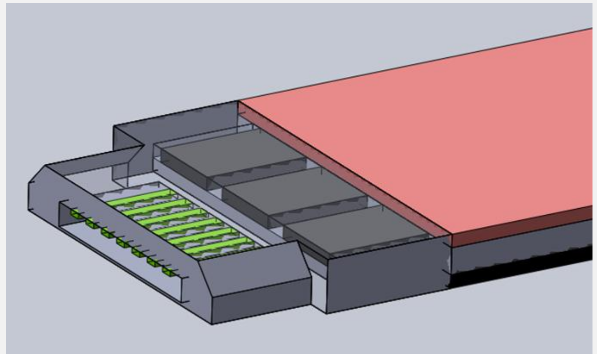
Drinking water quality standard

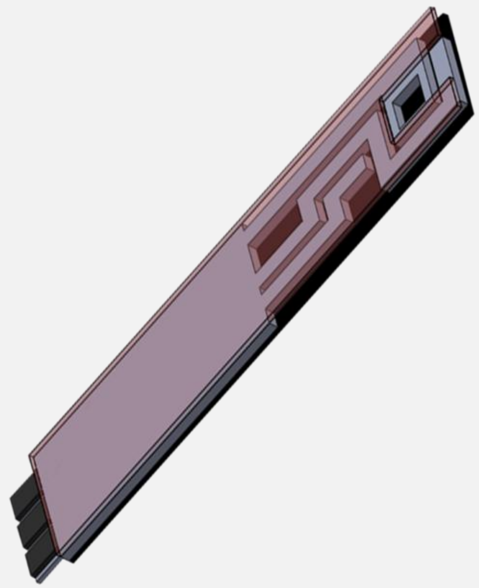
Parameter	Group	RECOMMENDED RAW WATER QUALITY	DRINKING WATER QUALITY STANDARDS
		Acceptable Value (mg/litre (unless otherwise stated))	Maximum Acceptable Value (mg/litre (unless otherwise stated))
Total Coliform	1	5000 MPN / 100 ml	0 in 100 ml
E.coli	1	5000 MPN / 100 m	0 in 100 m

http://kmam.moh.gov.my/public-user/drinking-water-quality-standard.html

Portable Sensor Design & Development







CHEAPSTAT

- Open source potentiostat.
- Capable to perform electrochemistry-based analytical techniques.
- Cheap in cost compared to laboratory grade potentiostat.
- Application: Pathogen detection

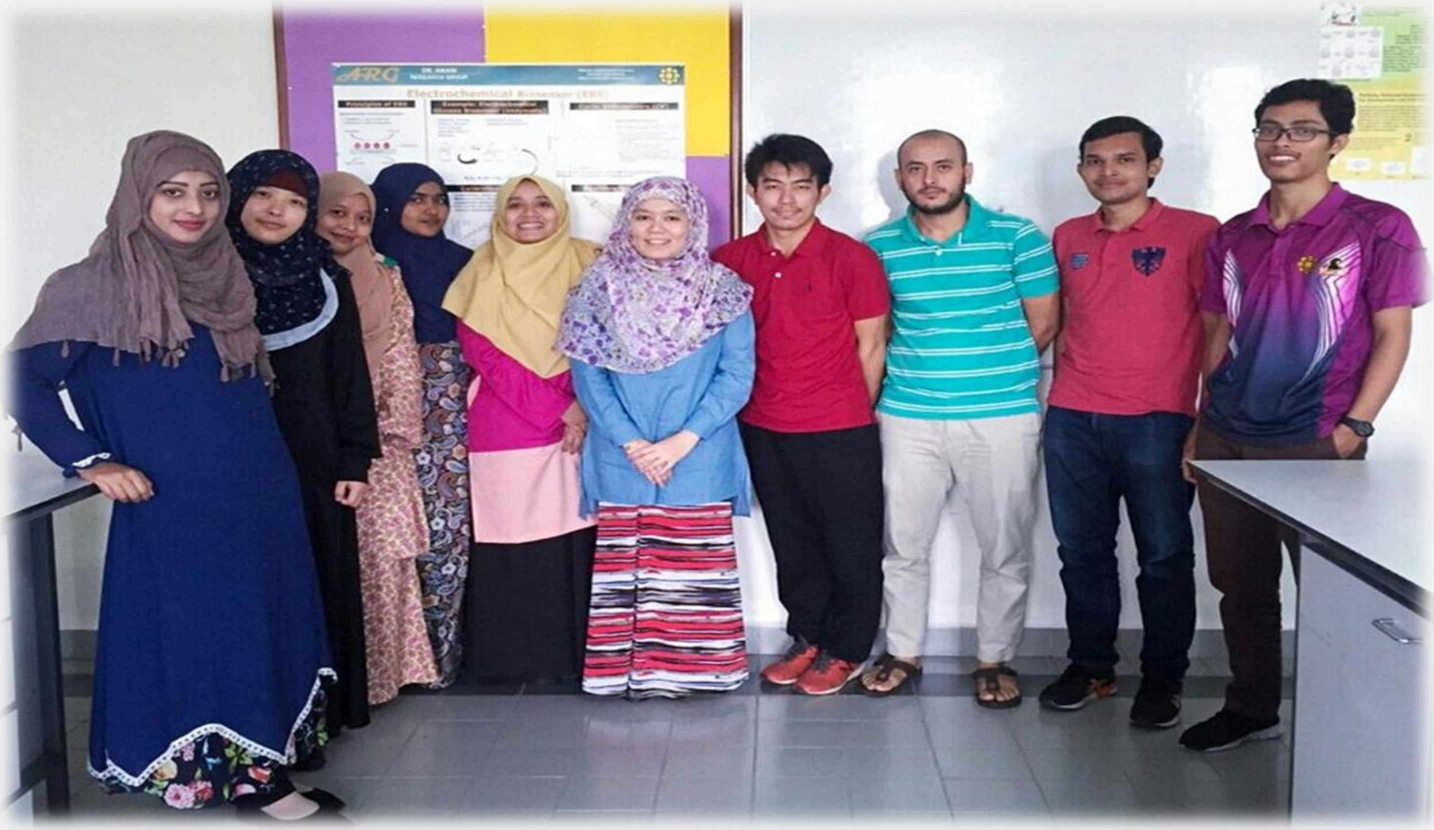
ARDUINO

- Open source electronic hardware.
- Consist of microcontroller that able to read input signal (sensor, etc.) and also displaying it as an output.
- Application; Water quality (pH, DO, etc.)

ARG

DR. AMANI

RESEARCH GROUP



THANK YOU