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CENTRE FOR SENSOR WEB TECHNOLOGIES

Probing the functionality of ion-selective membranes using electrochemical impedance spectroscopy: Towards "calibrationless" sensors

Pittcon 2009

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This work is supported by Science Foundation Ireland under grant 07/CE/I1147

Outline

- Why “calibrationless” - Concept of Wireless Sensing Network
- How to make chemical sensors (ISEs) applicable in WSNs
  - Mass production
  - Data acquisition system with wireless data transmission capability
  - Calibration
    - Electrical signal as a tool for diagnostic of the functionality of ISEs (to exclude underperforming and/or non-functional ISEs from calibration) – evaluation of conditions likely to occur in deployed devices
      - Physical damage
      - Biofouling
      - Leaching of membrane components

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Wireless Chemical Sensing Network

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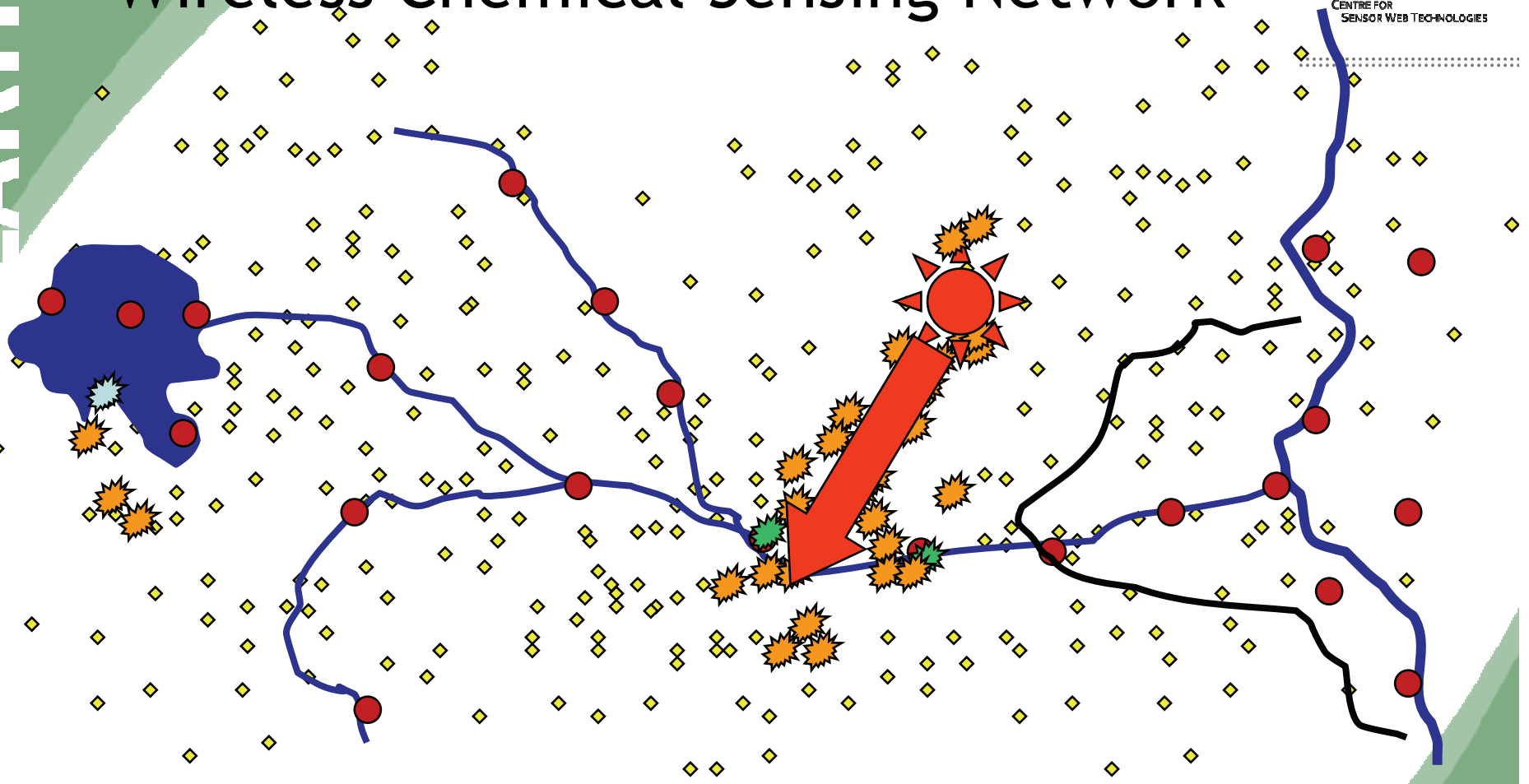

- **Each device does not need sophisticated comms capabilities**
- **Messages 'hop' to neighbours until accepted by basestation**
- **Complex information can be extracted from considering the behaviour of the sensor community rather than single devices – minimise FPs/FNs**
  - **Origin (time, location); speed, direction, spread…….**

Sophisticated devices – calibrated, reliable, less densely distributed

Dumb devices – uncalibrated, less reliable, more densely distributed

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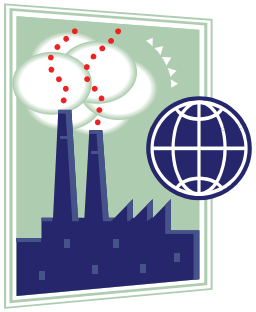
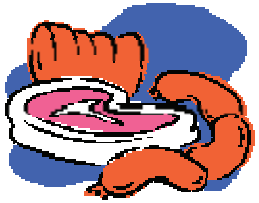
Why WCSNs?



- Safety and security
- Environment
- Food



Pale, soft and exudative (PSE) pig meat

- Health

- ISEs in WCSNs – new application fields, collaboration with scientist and engineers of different expertise; <u>expansion of the field</u>

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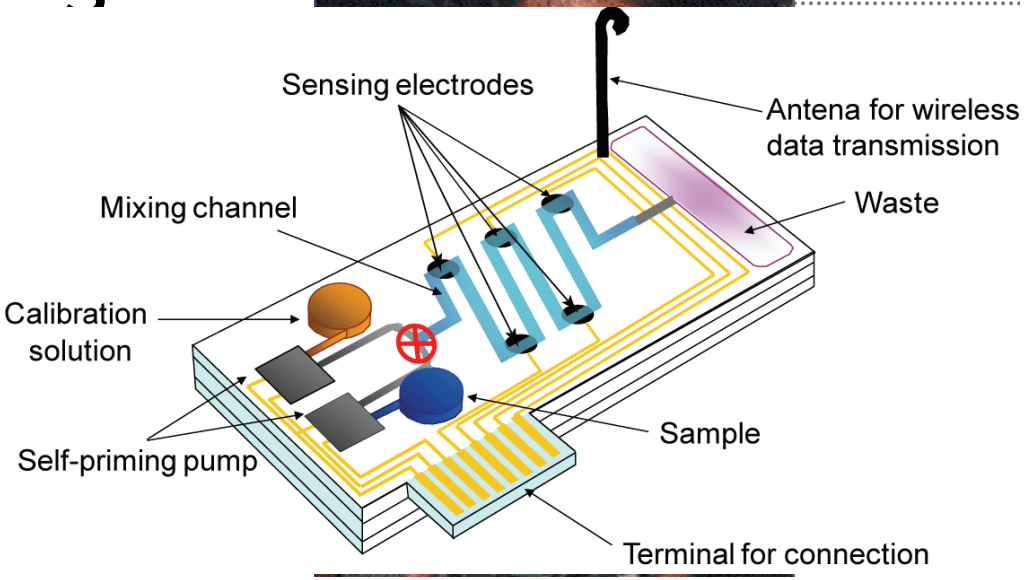
Challenges

- Electronics
  - Hardware
  - Software
- Platforms
- Adequate sensors
  - Inexpensive
  - Sensitive
  - Exiguous and requi
  - simple



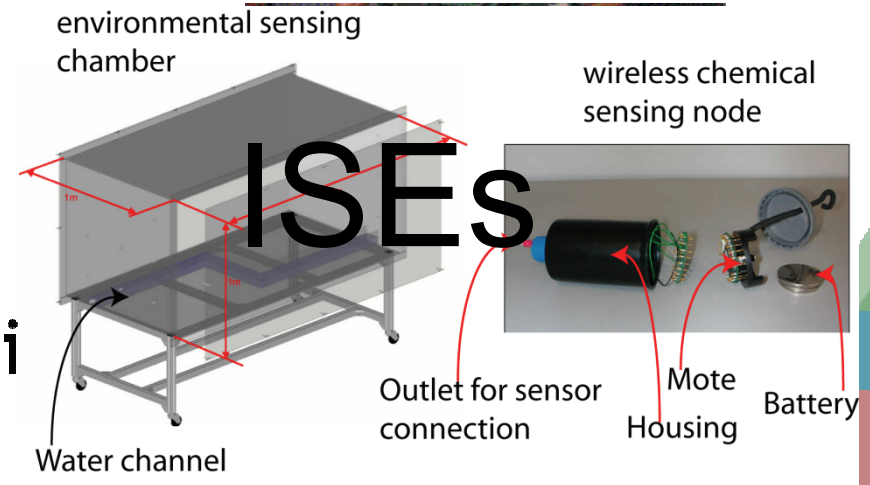


Figure 1. Environmental sensing chamber and wireless chemical sensing node

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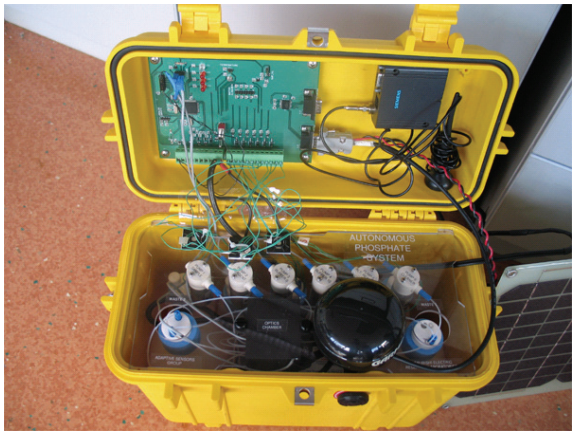
How cheap are ISEs?

Z655481 Aldrich

Hanna combination ISE electrodes
Chloride, Solid-state

€495.18 ($621.96)



- Mass production
- Calibrationless

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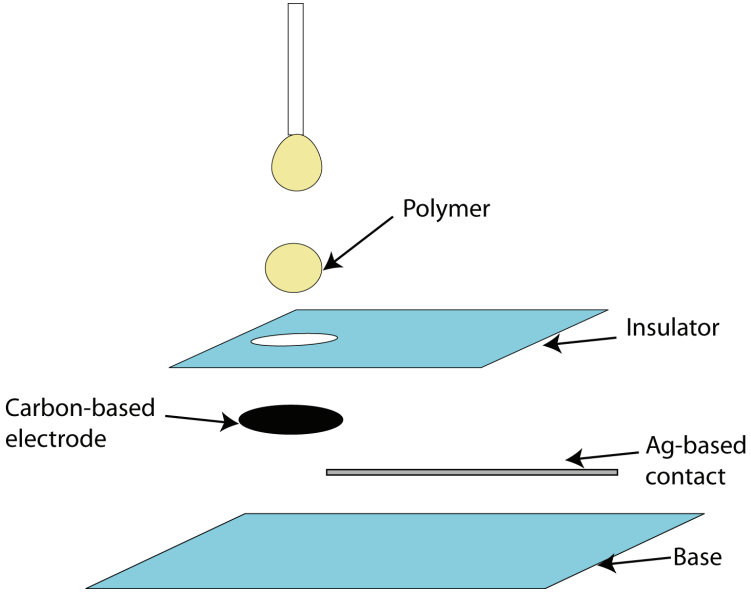
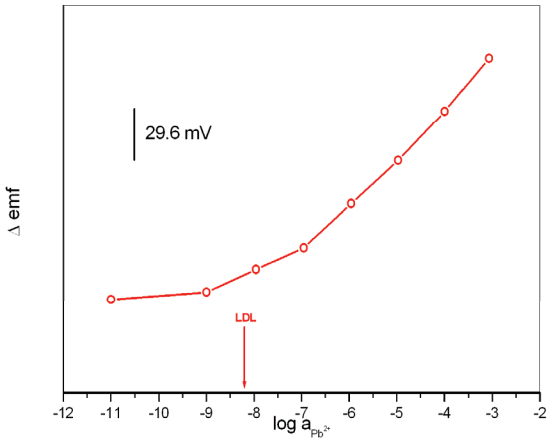
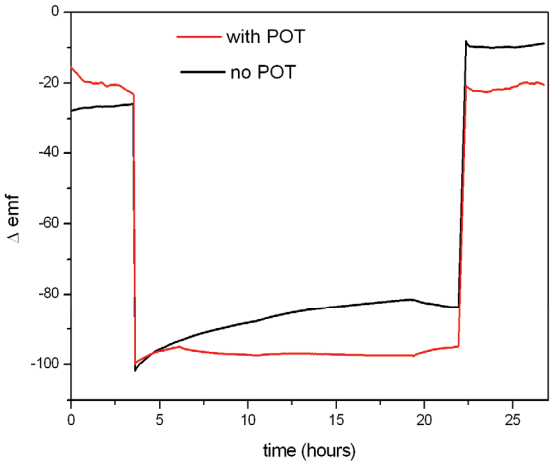
Mass production



Pb IV
NaTFPB
PVC
DOS





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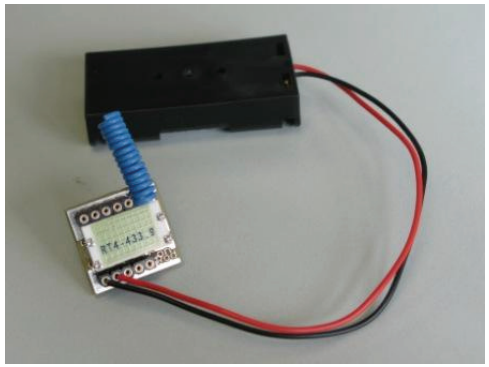
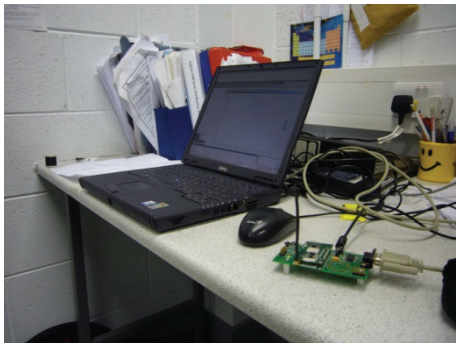
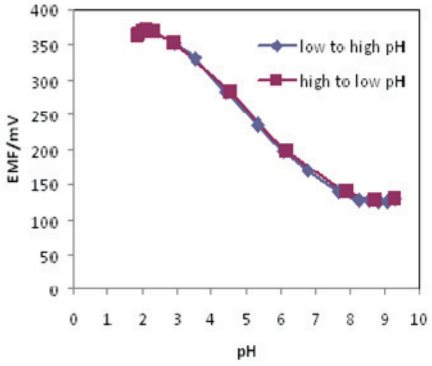
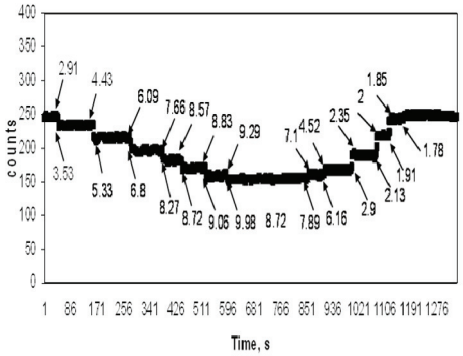
Integration with motes

- Mote (electronic circuitry for data acquisition and wireless transmission)









H II (ETH 1907)
KTpClPB
PVC
NPOE

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Reducing the need for calibration

- Can we use electric signal instead of solutions?
  - Evaluate the functionality – exclude under-performing ISEs from calibration
    - Physical damage
    - Biofouling
    - Leaching of the components

Dr. Salzitsa Anastasova – poster on Tuesday morning slot #2

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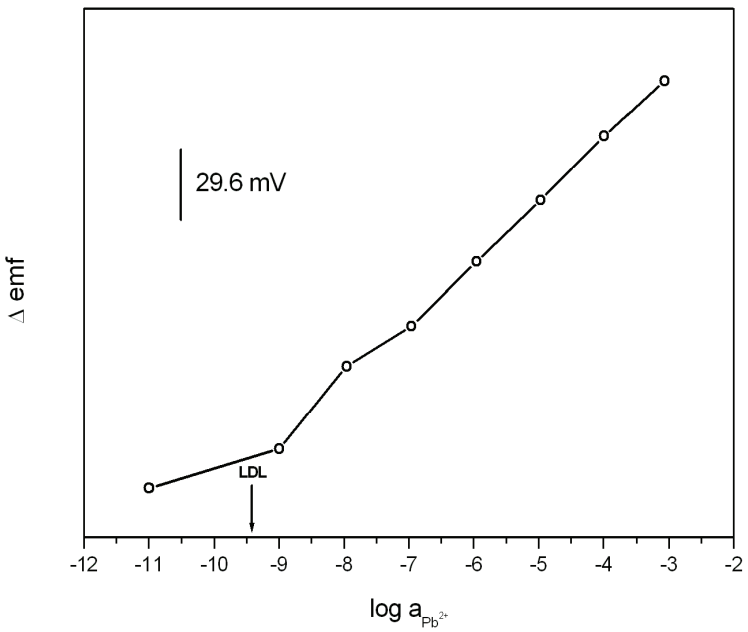
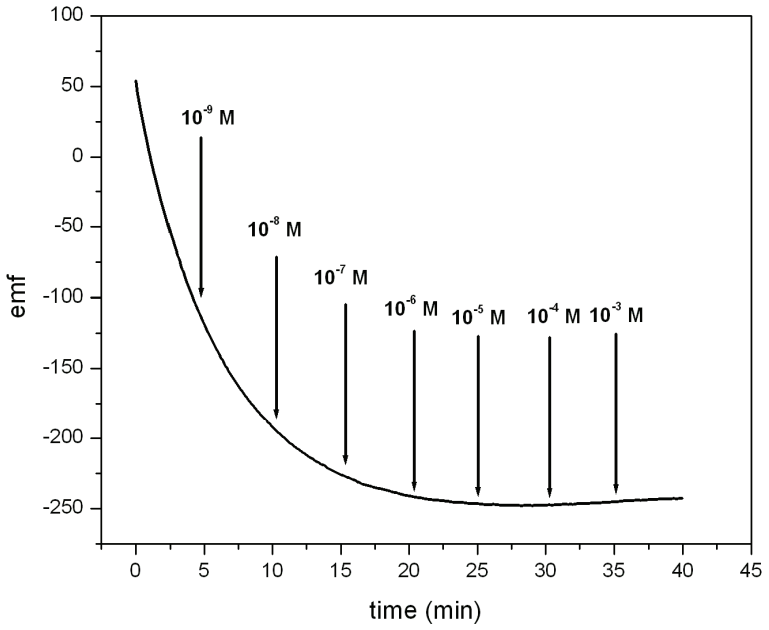
Physical damage (LC ISEs)





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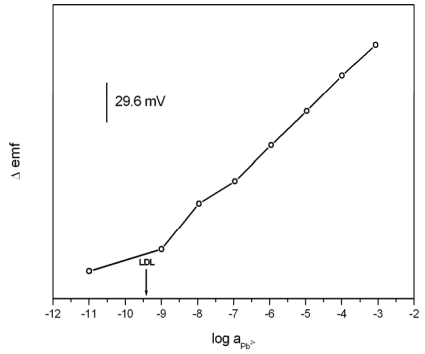

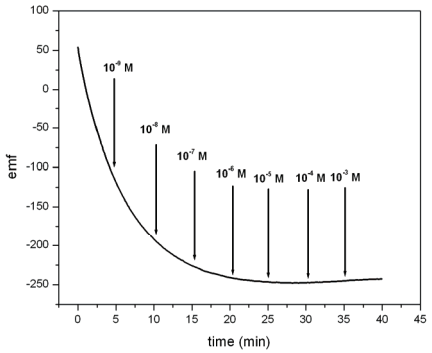

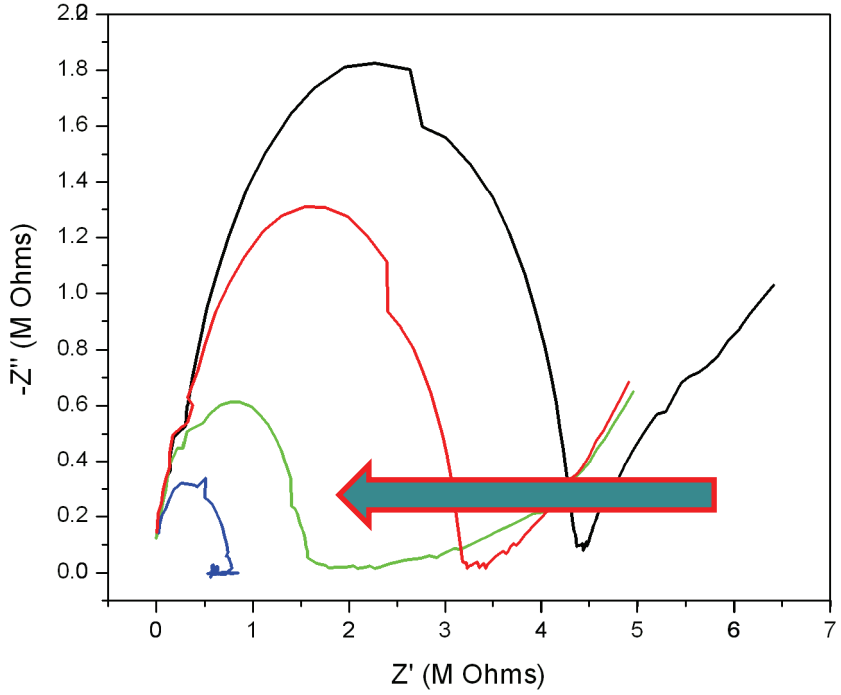

- Excitation potential: 100 mV
- ω range 100 kHz to 0.01 Hz
- 3 electrode setup
- 10^{-3} M $Pb(NO_3)_2$

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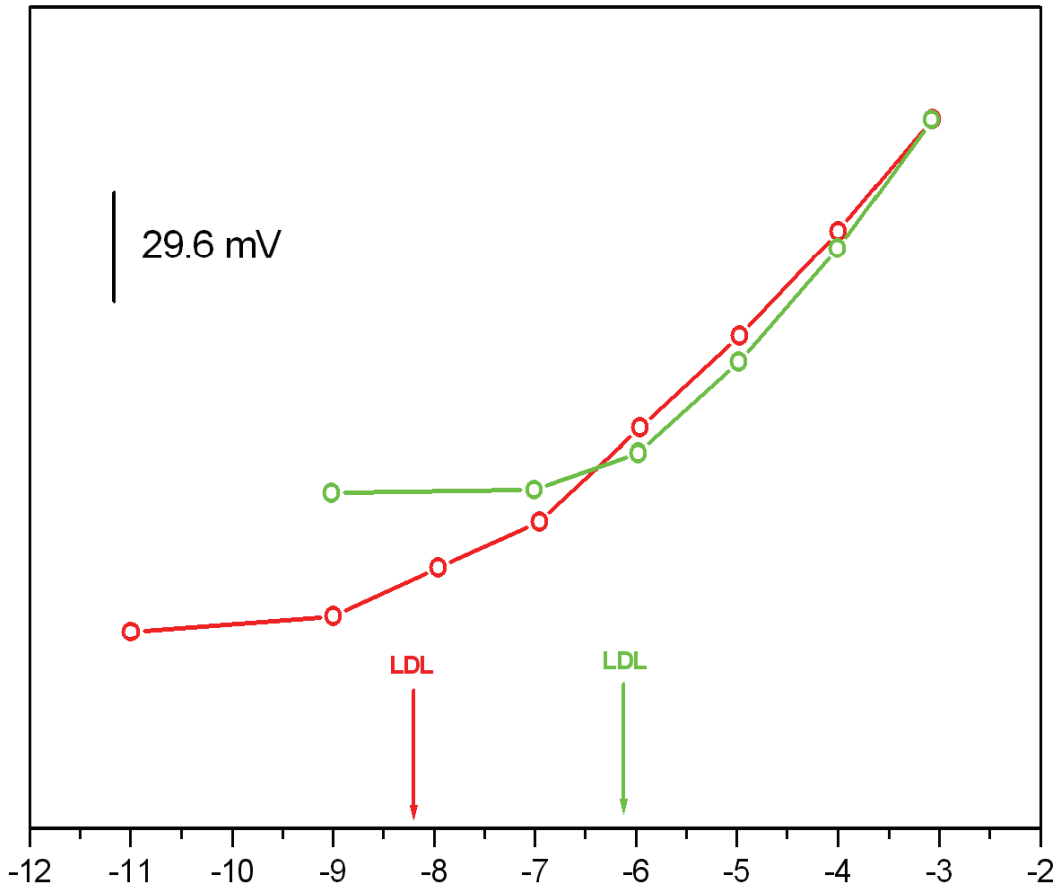
Physical damage (SC ISEs)



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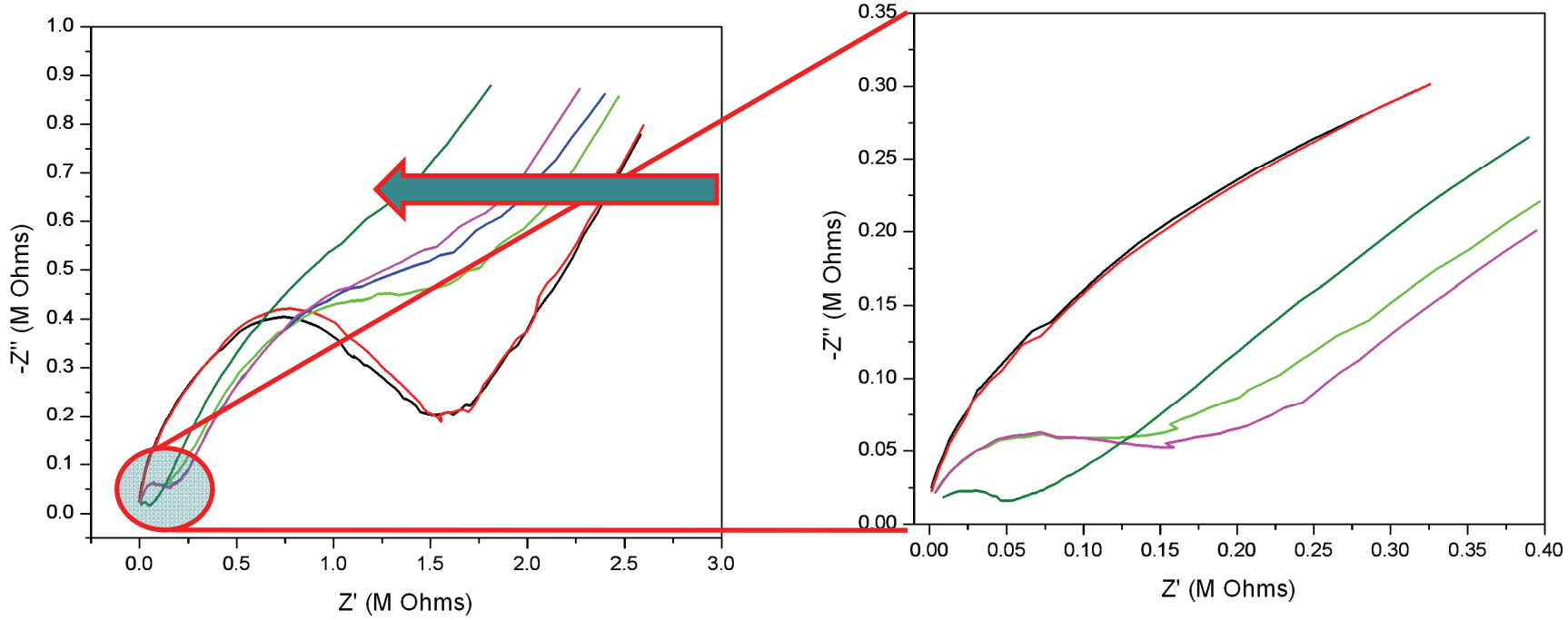

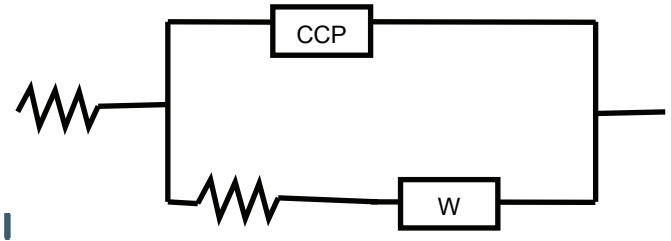

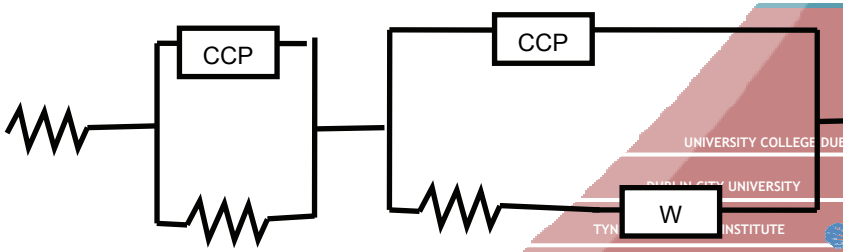

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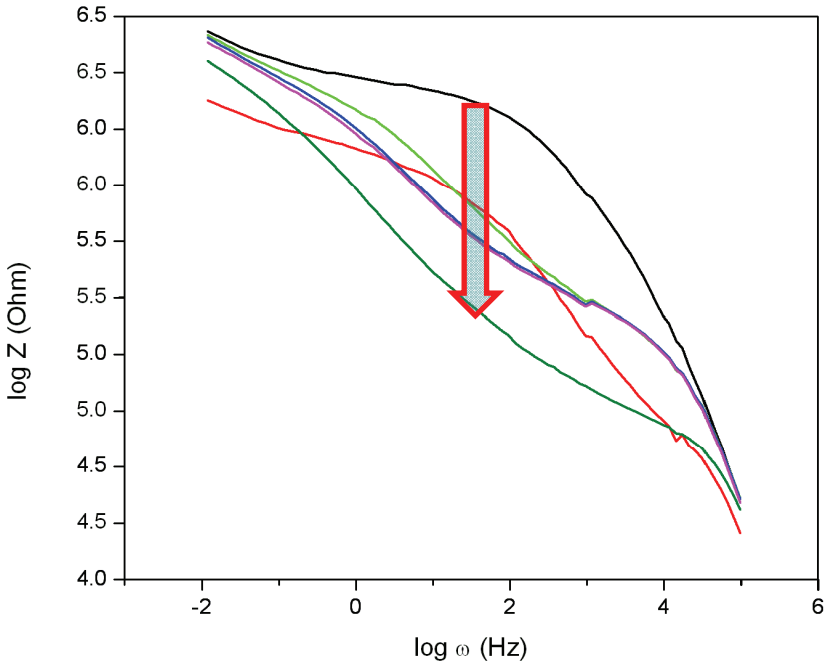

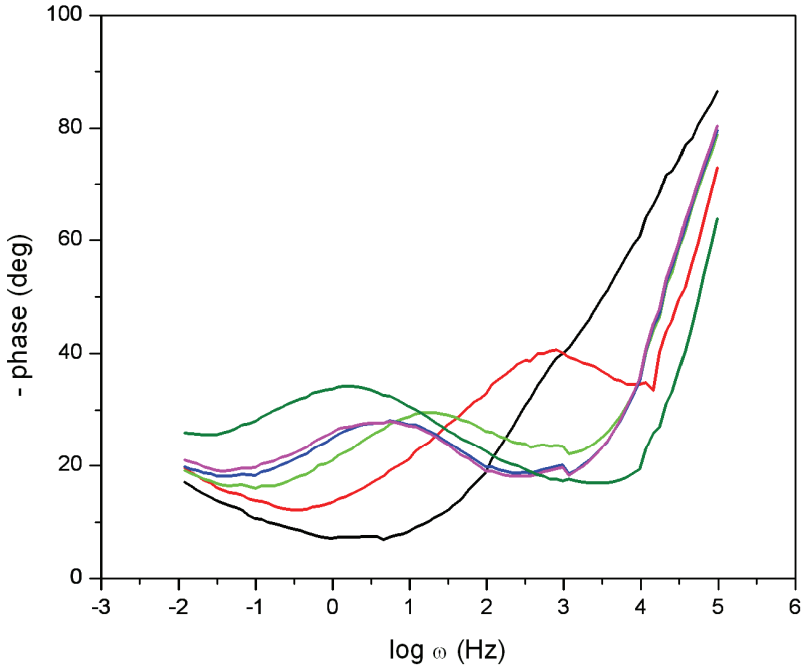

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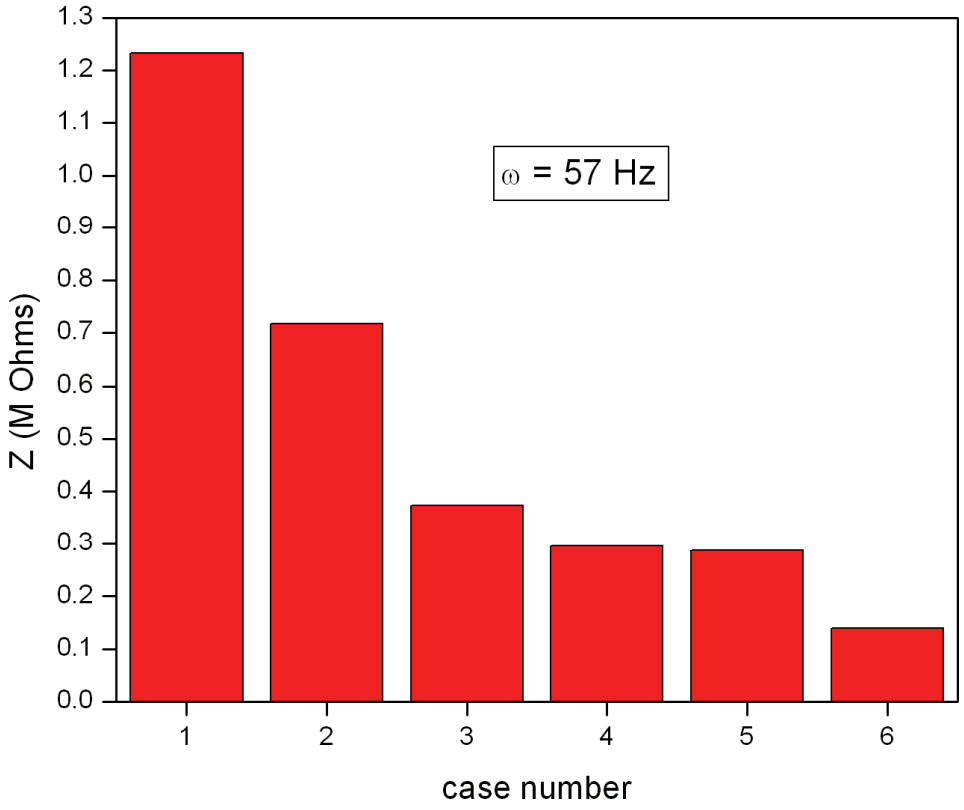

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Conclusions

- Reducing the need for sensor calibration will open up many new application areas
- Screen-printed ISEs perform similarly to classically prepared ones
- *In-house* prepared motes allow wireless data transmission and are compatible with screen-printed ISEs
- Using EIS enabled two important conclusions:
  - AC current can be used as a diagnostic tool for estimate functionality of ISEs (cases when physical damage, biofouling, leaching of components render ISEs non-functional)
  - Optimal current parameters (ω, amplitude) can be identified in order to design simple circuitry for evaluation of functionality of ISEs

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