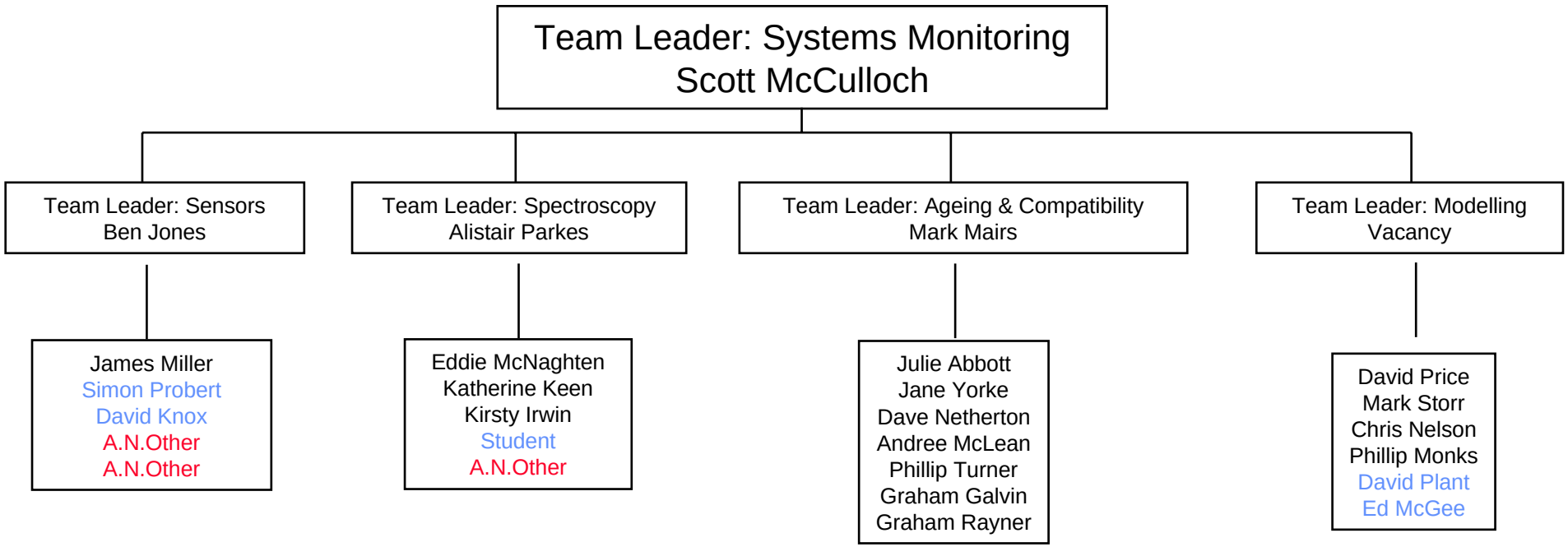
Nitrocellulose – Supply, Ageing and Characterisation

Multidiagnostic Materials Ageing Capability

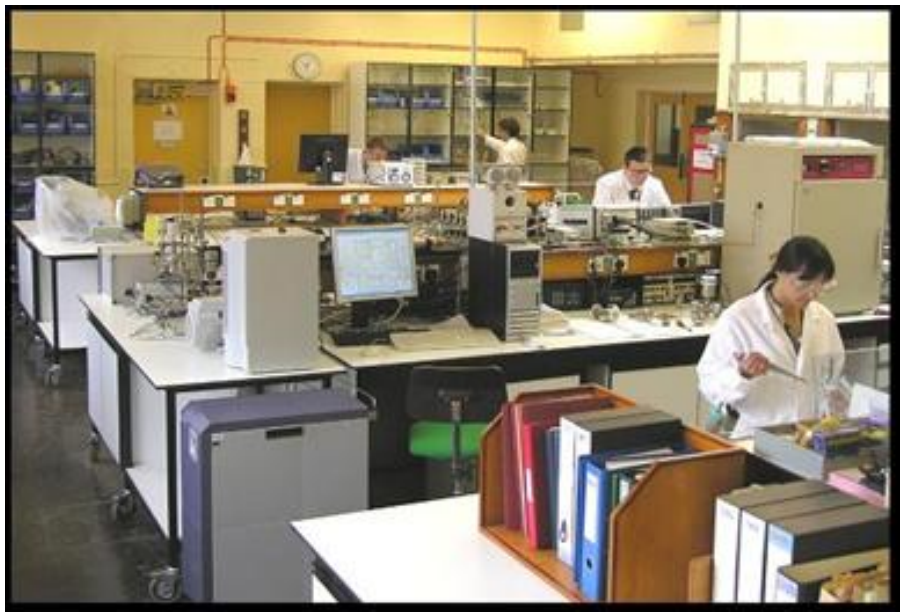
Introduction



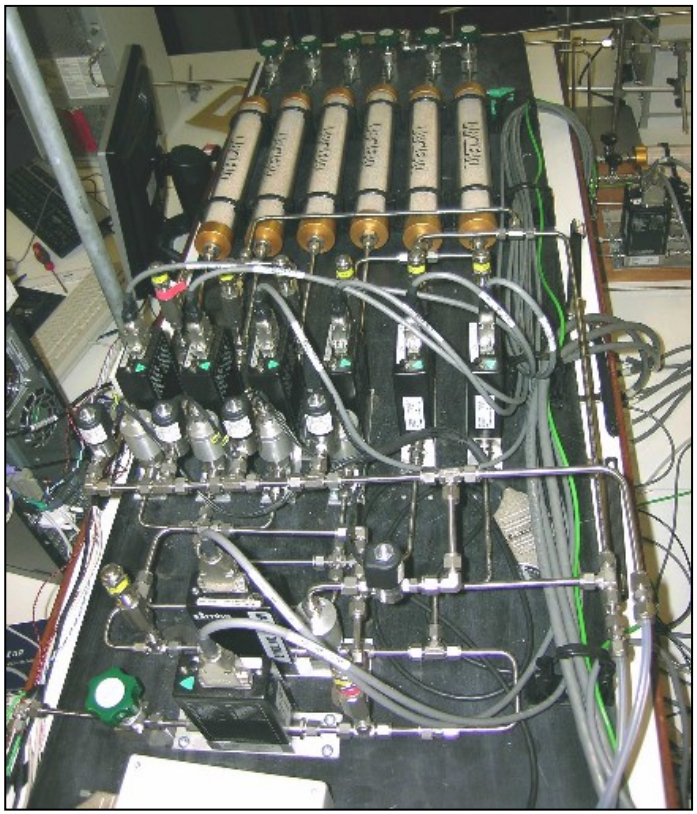
Introduction

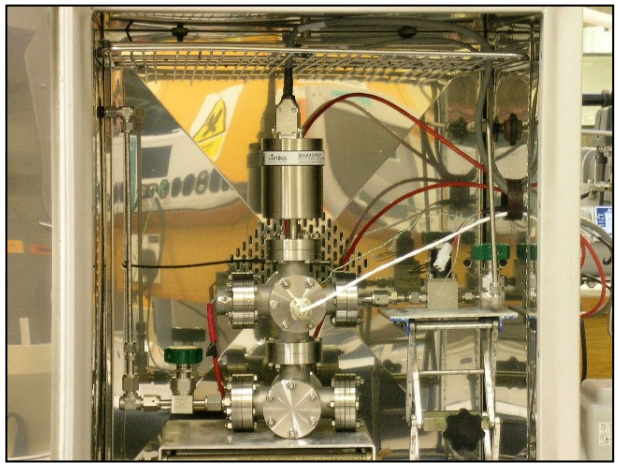
- Provide diagnostics to aid ageing and compatibility materials trials
  - Provide sensors capability to enable monitoring of:
    - Temperature and pressure
    - Gas composition
    - (Shape change)
- Characterise diagnostics
- Demonstrate deployment of diagnostics

Introduction



Diagnostic Characterisation



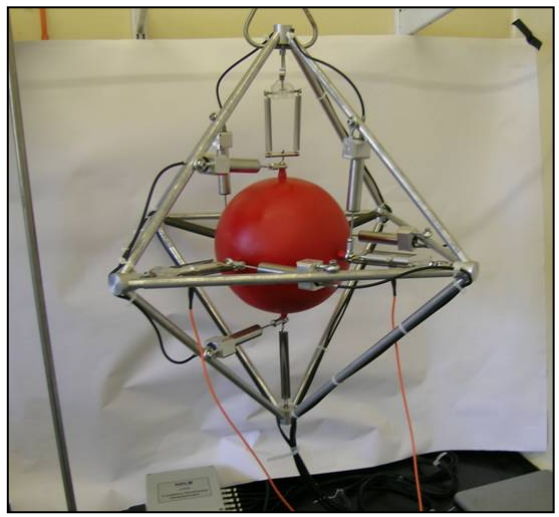


2 stage gas blending apparatus

- ppm to 100 %
- LabVIEW controlled

Position monitoring

- LVDTs



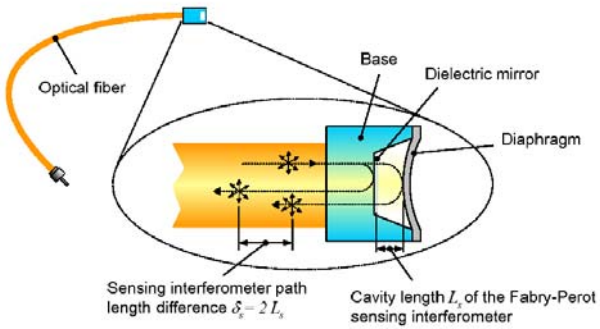
Diagnostic Characterisation

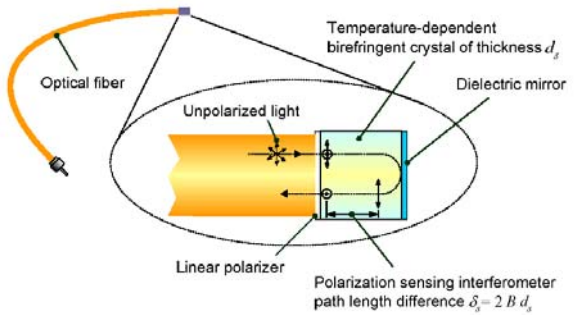
- Procedure for diagnostic characterisation
  - Baseline response
    - Response towards the vessel matrix (carrier gas)
    - Look for stability
  - Response towards the analyte
    - Does it respond to the analyte?
    - Response times, LOD and sensitivity
  - Recovery
    - One-hit or multiple response
    - Response times
  - Repeatability
    - Repeated exposure to a given concentration of the analyte
    - Precision of response
  - Stability
    - Long term signal drift

Diagnostic Characterisation

- Proving through experimental trials programmes
  - Inclusion in ageing and compatibility experiments alongside conventional detection methods
  - Mimic conditions
    - Pressure
    - Gases
    - Radiation
    - Electromagnetic noise
    - Interfering species

Temperature and pressure



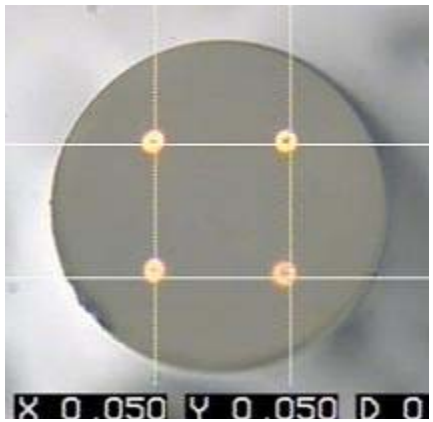


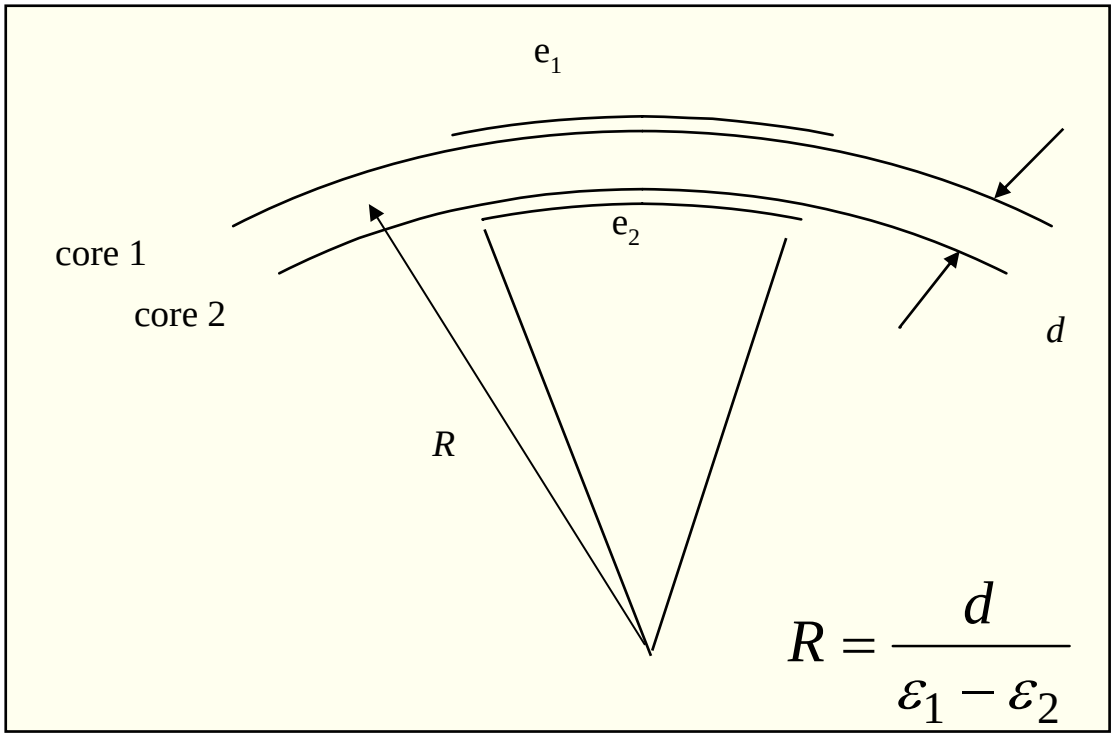
opSens Ltd.

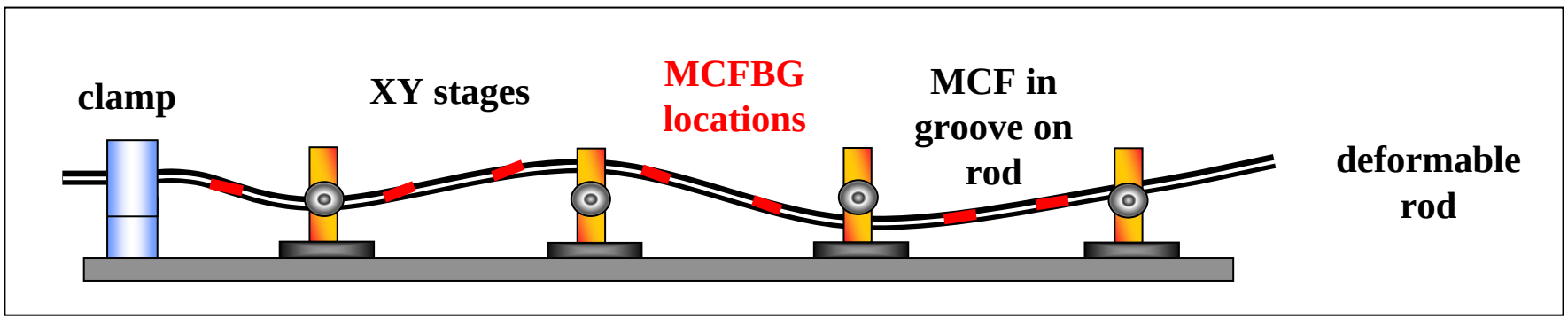
- Temperature
  - Interferometric temperature sensor
  - Utilising birefringent crystal
  - Range : -40 to 250 ^{o}C, accuracy : 1.0 ^{o}C (<100 ^{o}C), resolution : 0.1 ^{o}C
- Pressure
  - Range : 0 to 1000 mbar, accuracy : 1.0 mbar, resolution : 0.5 mbar

Shape Change

Shape sensing using multicore FBGs



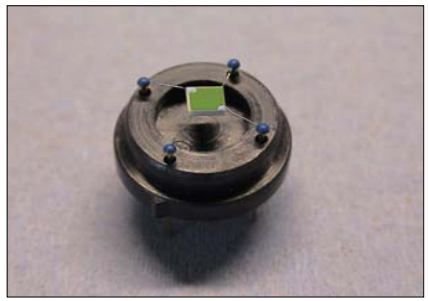


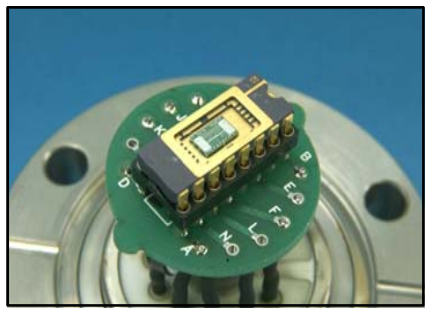


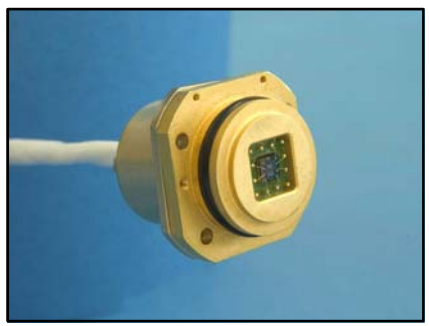
Hydrogen Sensing

Sensors tested at AWE

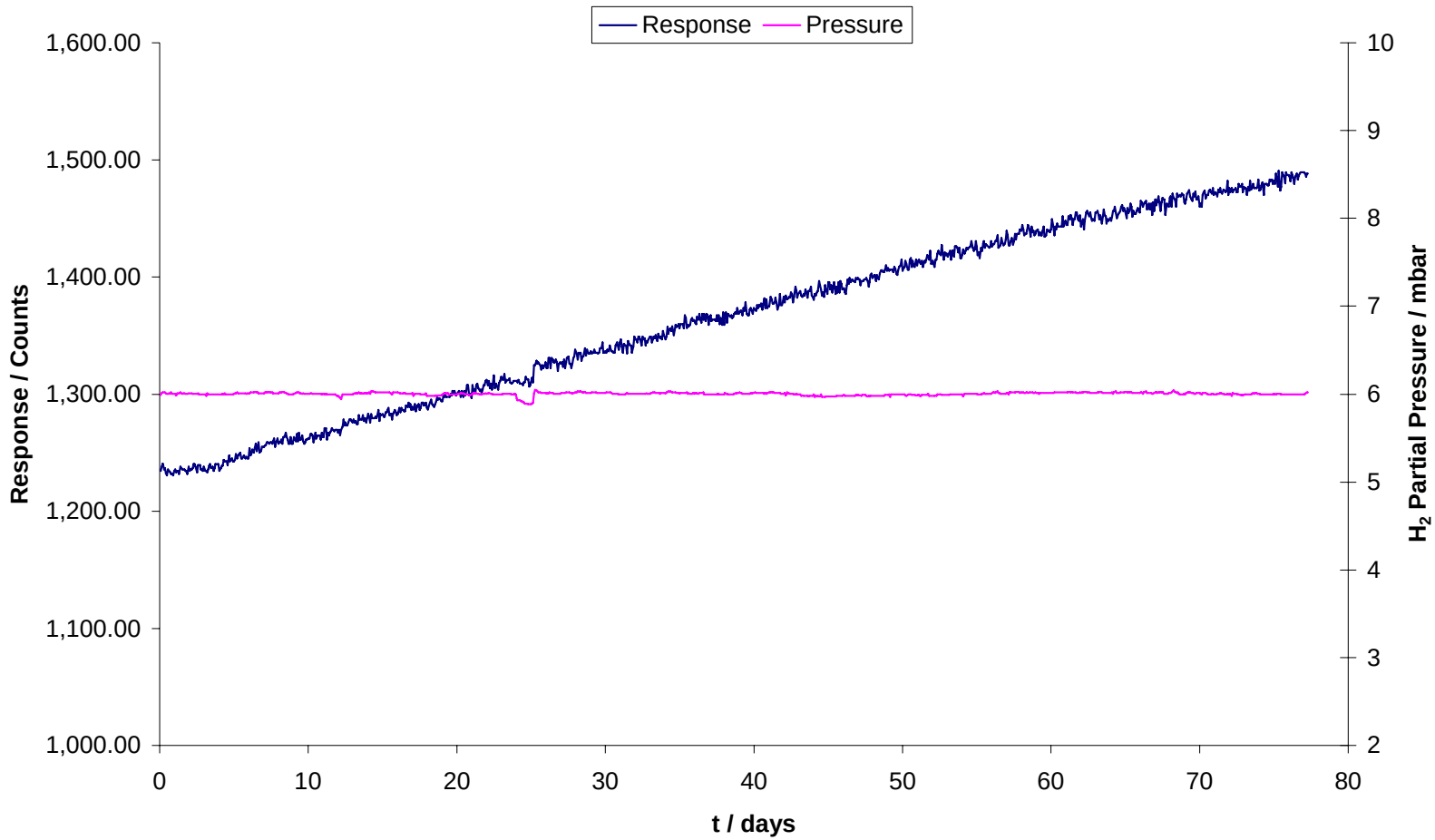
- City Technology Ltd.
  - Metal oxide chemiresistors
- DCH Technology Inc.
  - H_2SCAN
- Makel Engineering Inc.
  - Hydrogen Detection System





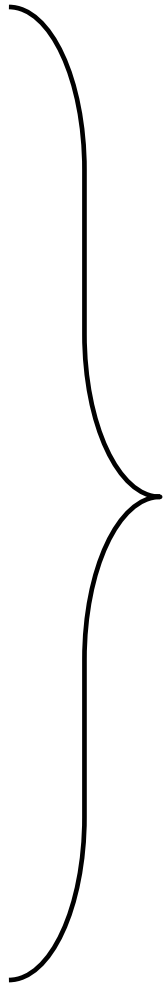


Hydrogen Sensing



In-house Spectroscopic Techniques

- Fourier Transform Infra-Red
  - Heated Cells
  - Hollow Waveguide Cells
- Raman
- Fibre optic UV-Vis
- Tunable Diode Laser Based:
  - TDLAS / WMS
  - CRDS / CEAS
  - PAS



Fibre Optics / Waveguide

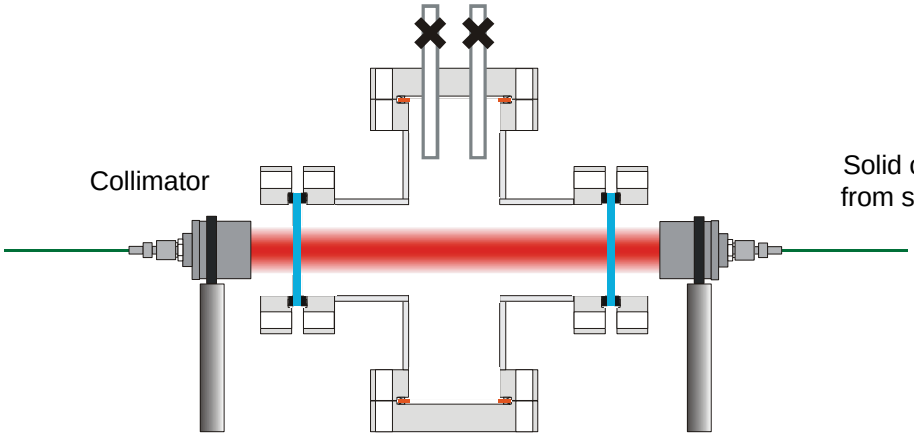
Target Analytes

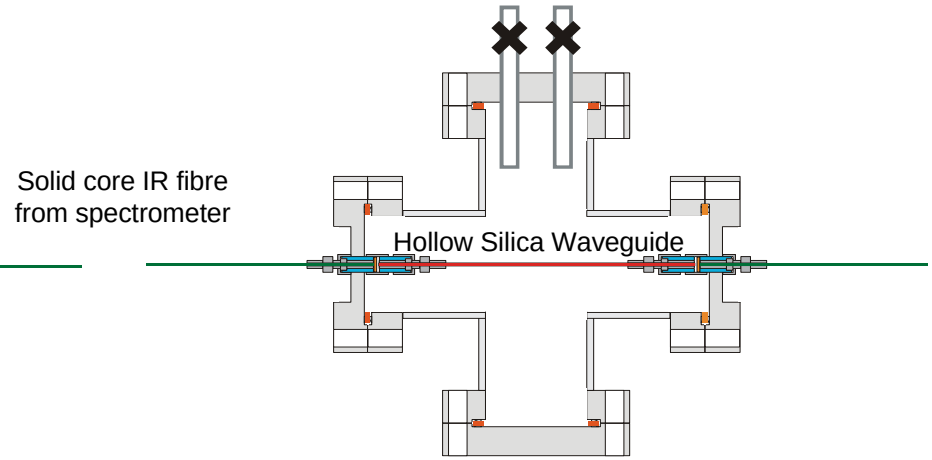
- We aim to detect gases from a variety of sources:
  - Release of volatiles during ageing of polymeric materials:

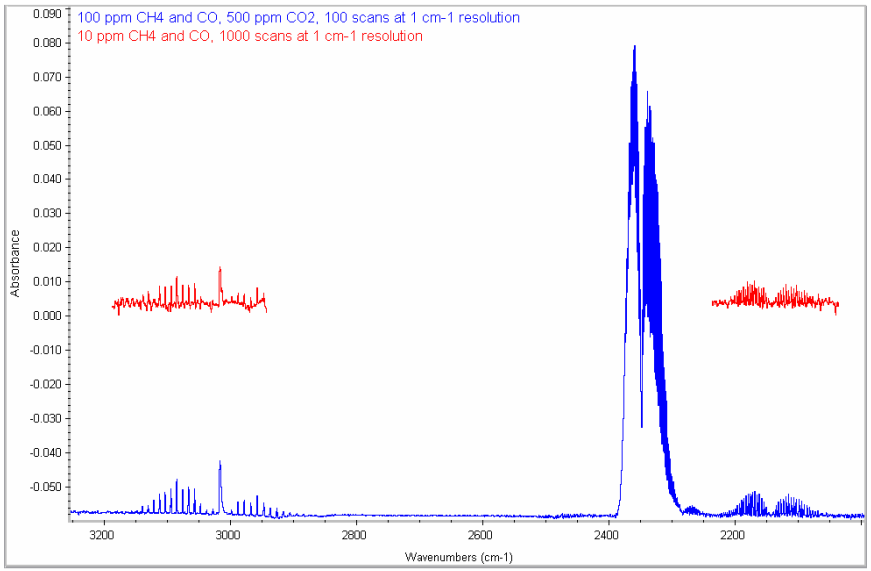
    CO, CO_2, H_2CO, H_2O, CH_4 , VOCs
  - Energetic materials decomposition products – materials such as nitrocellulose and PETN can produce NOx and other gases:

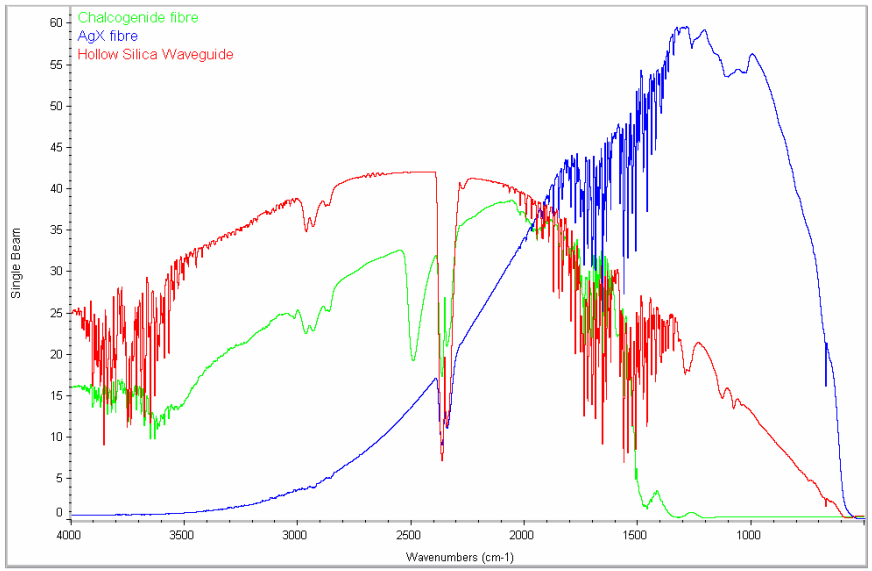
    NO, NO_2, N_2O, CO_2 , CO
  - Hydrogen, oxygen and water vapour (corrosion)
- We need to detect these gases at ppm levels

FTIR analysis









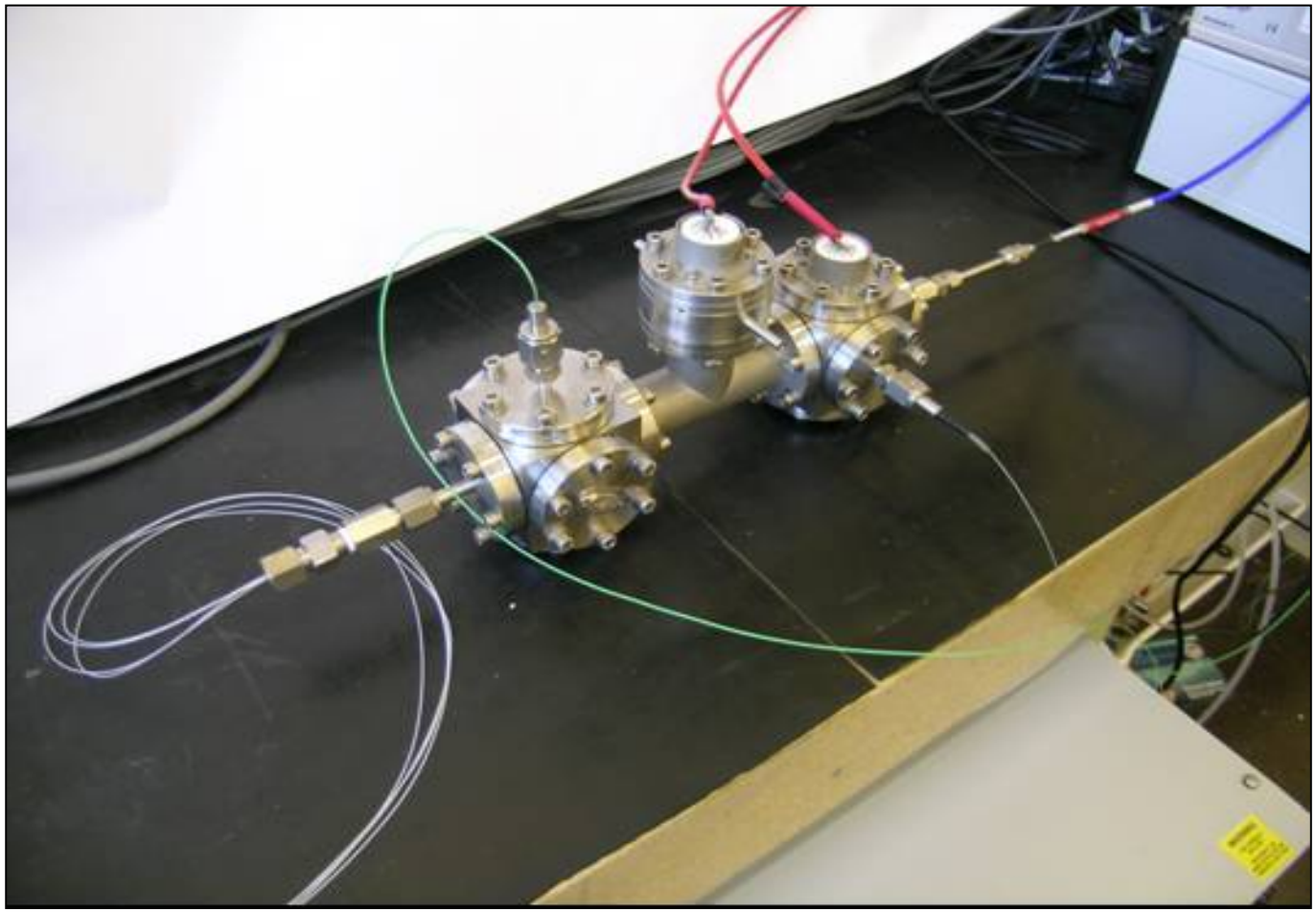
AWE Generic Trials Vessel

- Development of hardware for in-situ monitoring of trials
- Proving ground for future weapons integrated diagnostics
  - Small gaseous molecules
  - Generic ‘crud’ sensor
  - ‘Unknown unknowns’
  - Temperature & pressure

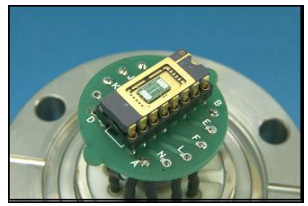
AWE Generic Trials Vessel

- Current version includes:
  - Optical and electrical diagnostics
  - H_2 sensors
  - Photoacoustic IR sensor (CO, CO_2, H_2O, NO, N_2O, NO_2 etc.)
  - TDLAS IR Open path sensor (cross check)
  - Fibre optic O_2 probe (Fluorescence – commercial)
  - Interferometric and FBG temperature and pressure
  - Metal Oxide total VOC sensor

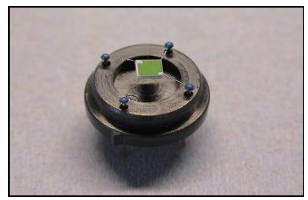
AWE Generic trials vessel



White, Green and Blue = Fibre Optics
Red = Electrical Cable

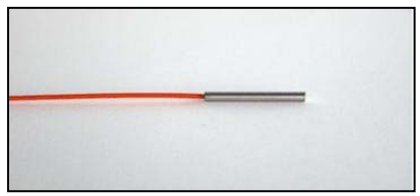


DCH H_2SCAN

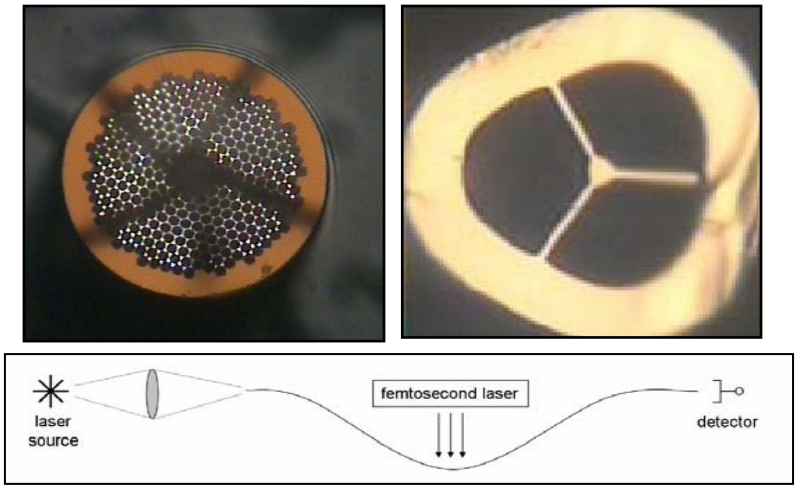


City Technology Ltd metal oxide chemiresistor

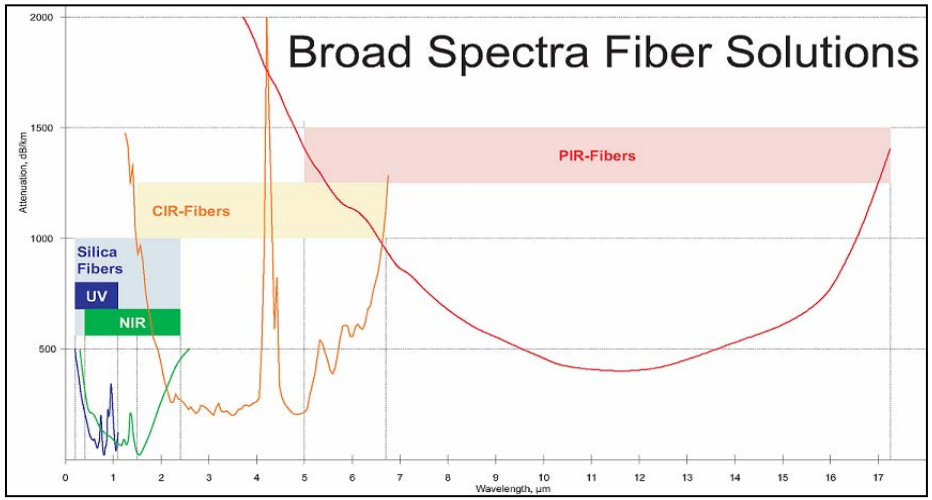
Accurate Controls Ltd temperature & pressure sensor



Generation 2 (2007)



Fibre acts as gas cell for TDLAS or FTIR



ART Photonics

- Fewer electrical sensors
- Hollow core fibre gas cells
- Fibre FTIR (Chalcogenide/Polycrystalline fibres)
- Fibre based H_2 sensor?
- Raman Probe?

Summary

- Diagnostic development
- Diagnostic characterisation
  - Stability/sensitivity
- Diagnostic demonstration

- Future
  - Fully characterised in-situ materials analysis
  - No user intervention