Innovate UK

Photonics for …
Environment and Sustainability

11th December 2023

Agenda

10:00 Welcome

10:05

- Photonics Sensing for Sustainability
  David Armstrong - Fraunhofer Centre for Applied Photonics,
- Marine Hydrocarbon Sensing
  Rand Ismaeel - University of Southampton
- Life Cycle Assessment (LCA) for a Resilient Silicon Supply Chain
  Sahin Alacacayir, Minviro,
- Photonics: Critical Raw Materials, LCA and Packaging
  Jeff Kettle - University of Glasgow

11:25 Pitches

11:45 Funding and events

11:55 Final Q&A and wrap up

12:00 Close

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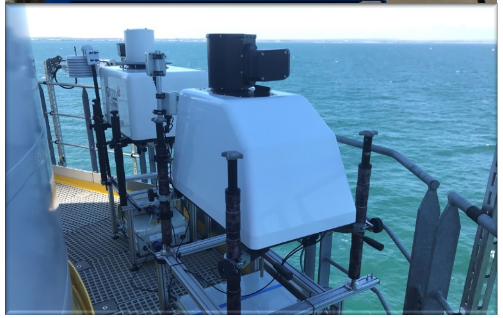
Photonic Sensing for Sustainability

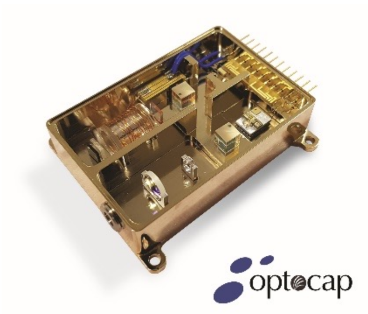
Dr David Armstrong, Fraunhofer CAP
David.armstrong@fraunhofer.co.uk

Fraunhofer UK

Fraunhofer Centre for Applied Photonics: Intro

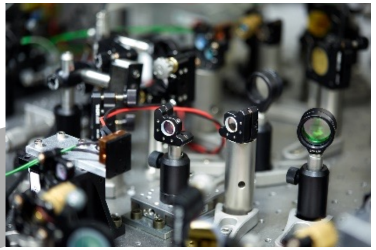
- A UK research and technology organisation, RTO
- UK not for profit Ltd company
- Legally independant affiliate of Fraunhofer Society – Europe‘s leading independent research org.
- Providing professional R&D services
    - Sources (Lasers)
    - Systems (Instrumentation)
- Work with industry to translate technology into products
- >60 professional staff + students



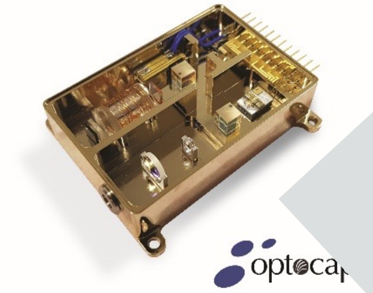


Fraunhofer Centre for Applied Photonics

From this: laboratory bench-top



To this: Product



TRL 1 → TRL 2 → TRL 3 → TRL 4 → TRL 5 → TRL 6 → TRL 7 → TRL 8 → TRL 9

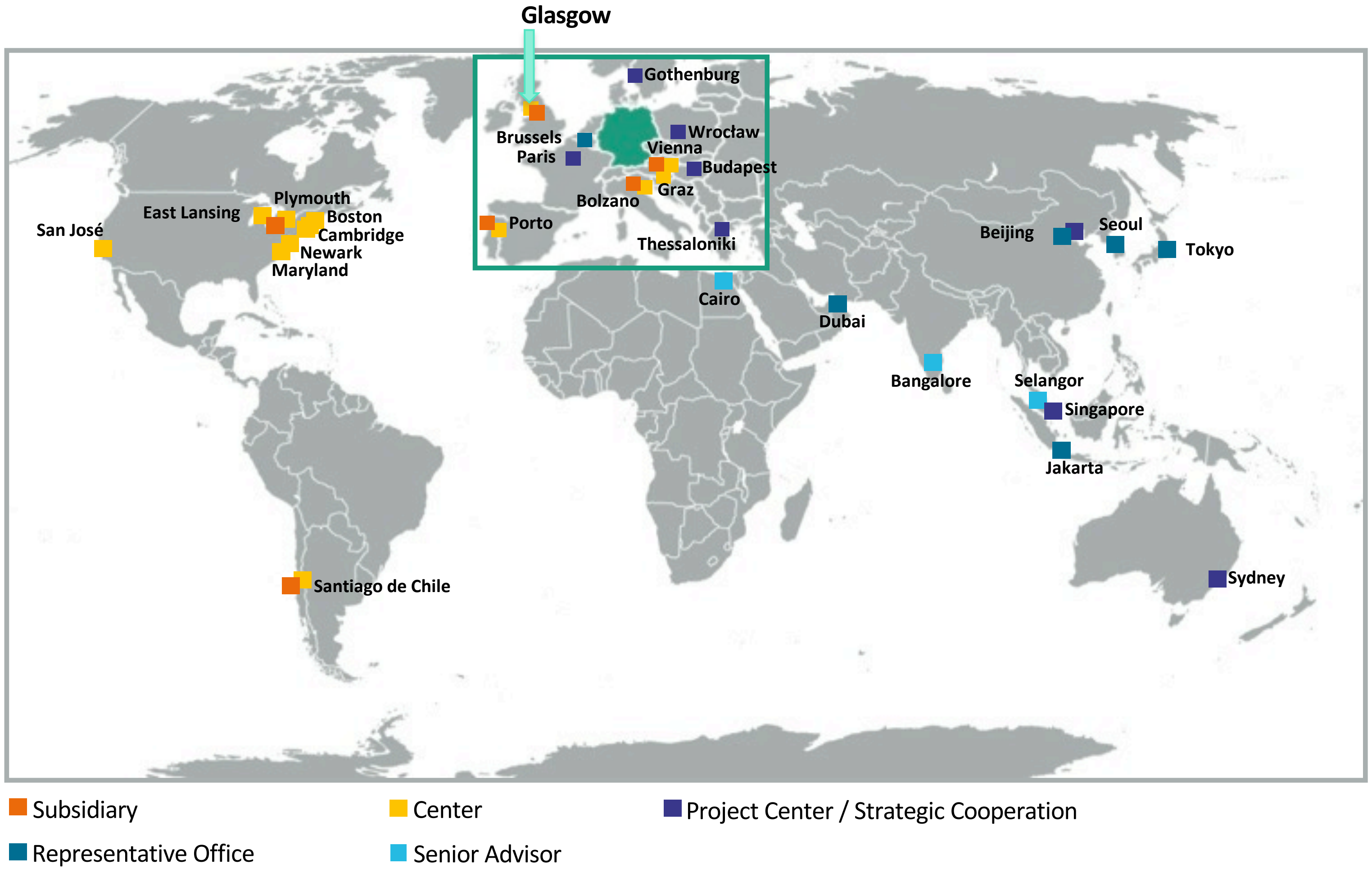
To this: engineered Proof of Concept

Fh-CAP as a delivery partner

*TRL levels indicative only

Fraunhofer - Worldwide Influence and Presence

German in origin – with international presence



Fraunhofer UK

The Fraunhofer-Gesellschaft in Germany

Europe’s leading Applied Research Organisation

- **72 Institutes**
- **More than 26,600 employees**
- **> €2.5 billion budget**

- **7 Groups:**
- **Information and Communication Technology**
- **Life Sciences**
- **Microelectronics**
- **Light & Surfaces**
- **Production**
- **Materials and Components**
- **Defense and Security**

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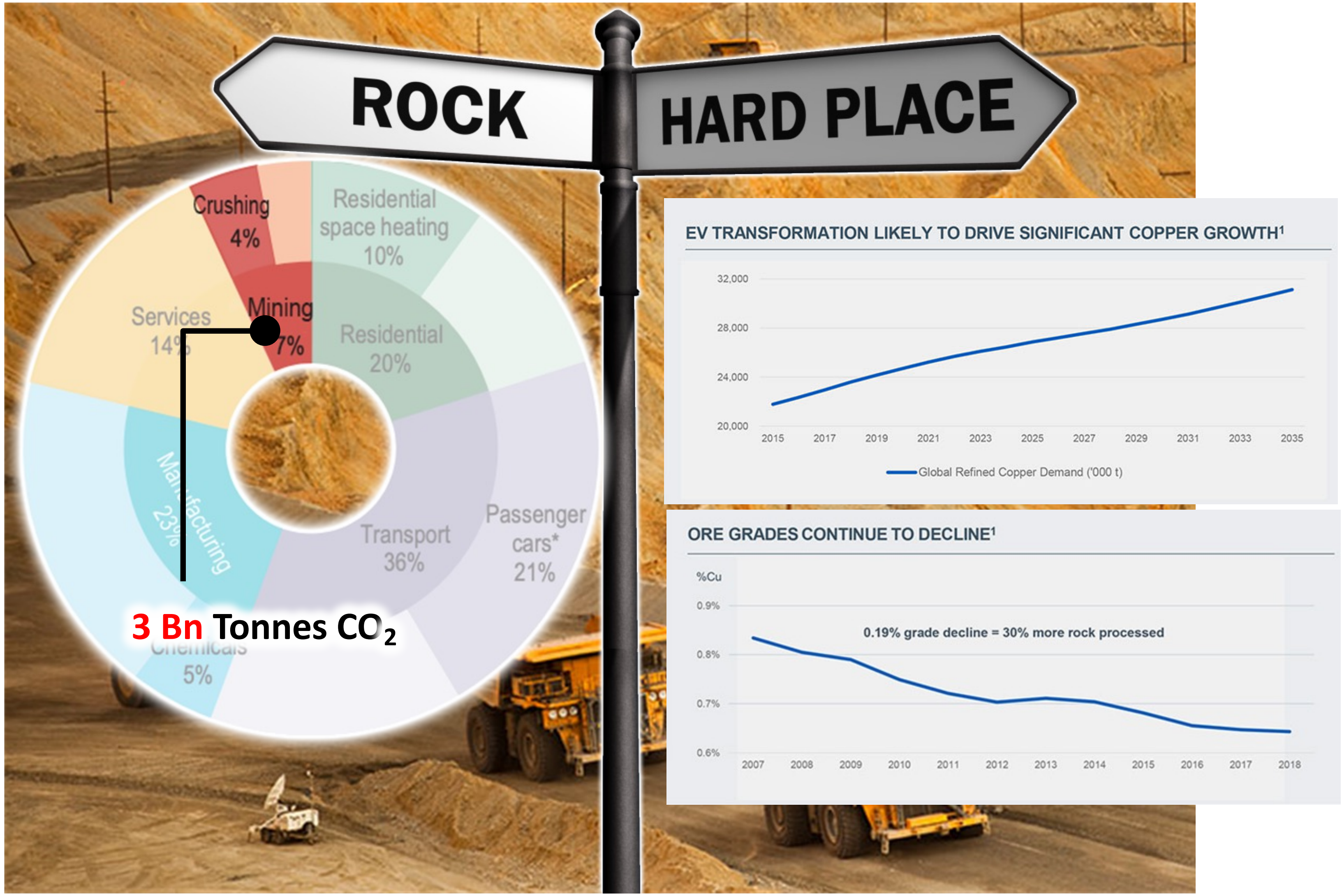
Opportunities: efficient mineral extraction



Opportunities: land remediation

Addressing the Challenge

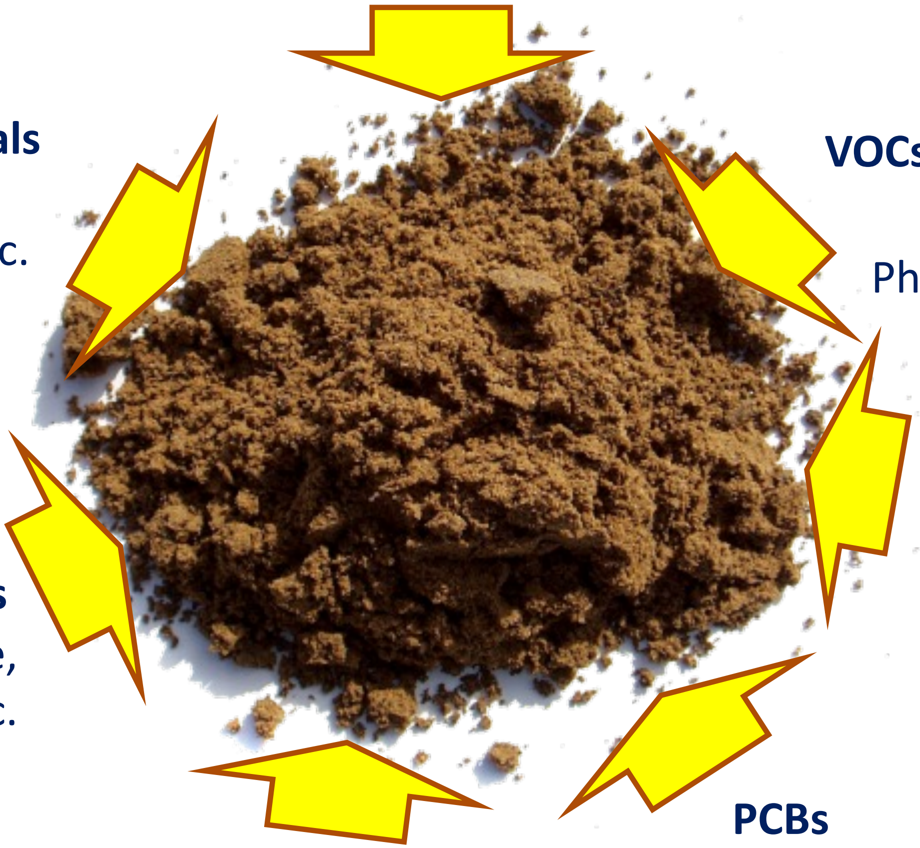
Benign Contamination

Heavy Metals

Pb, Cu, Hg, Cd. Etc.

VOCs / Hydrocarbons

Phenols, Oils, Etc.



TNT

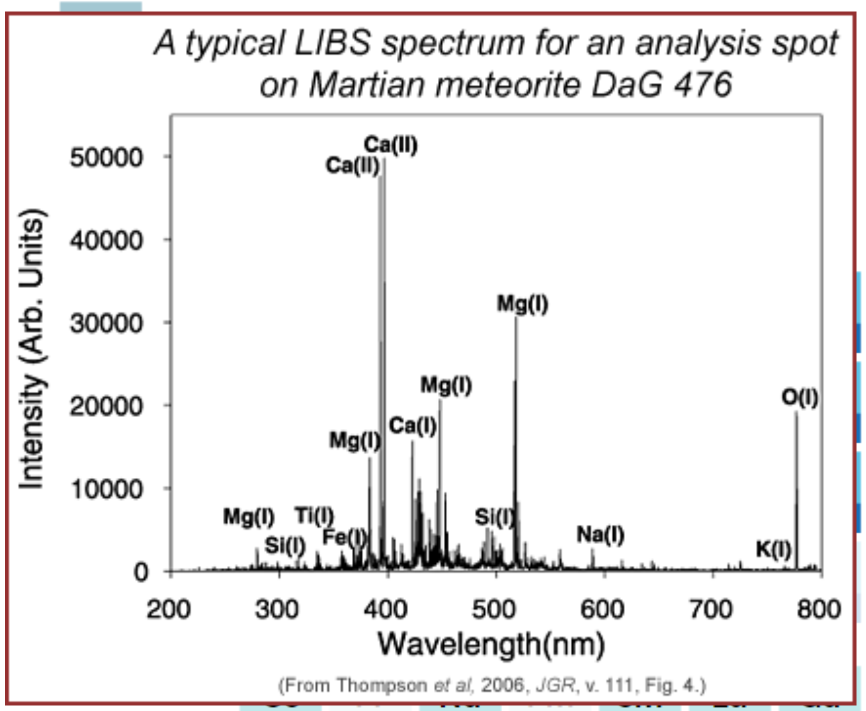
Asbestos

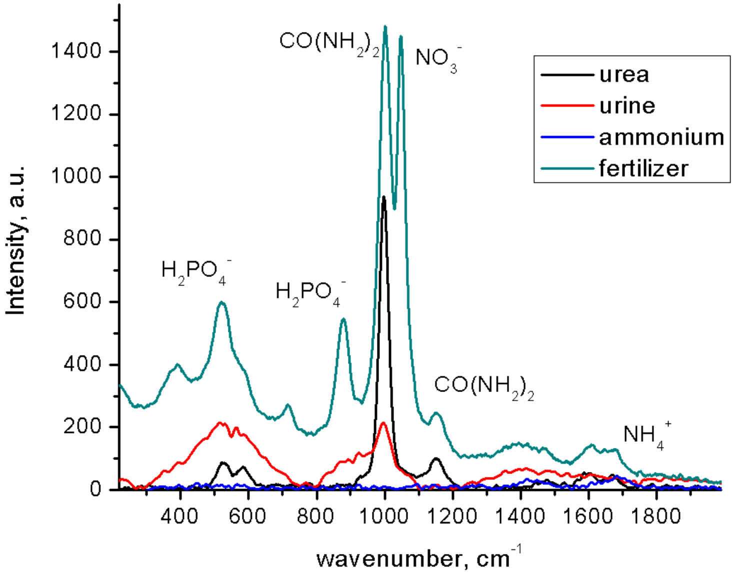
Chrysotile, Lizardite,
Crocidolite, Etc.

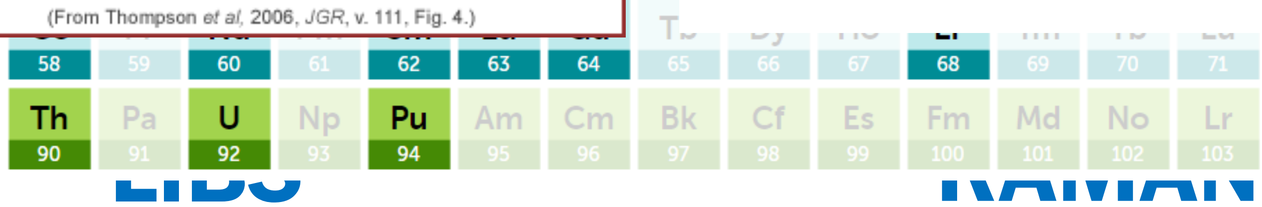
PCBs

Moisture

Laser-based nonlinear Spectroscopy







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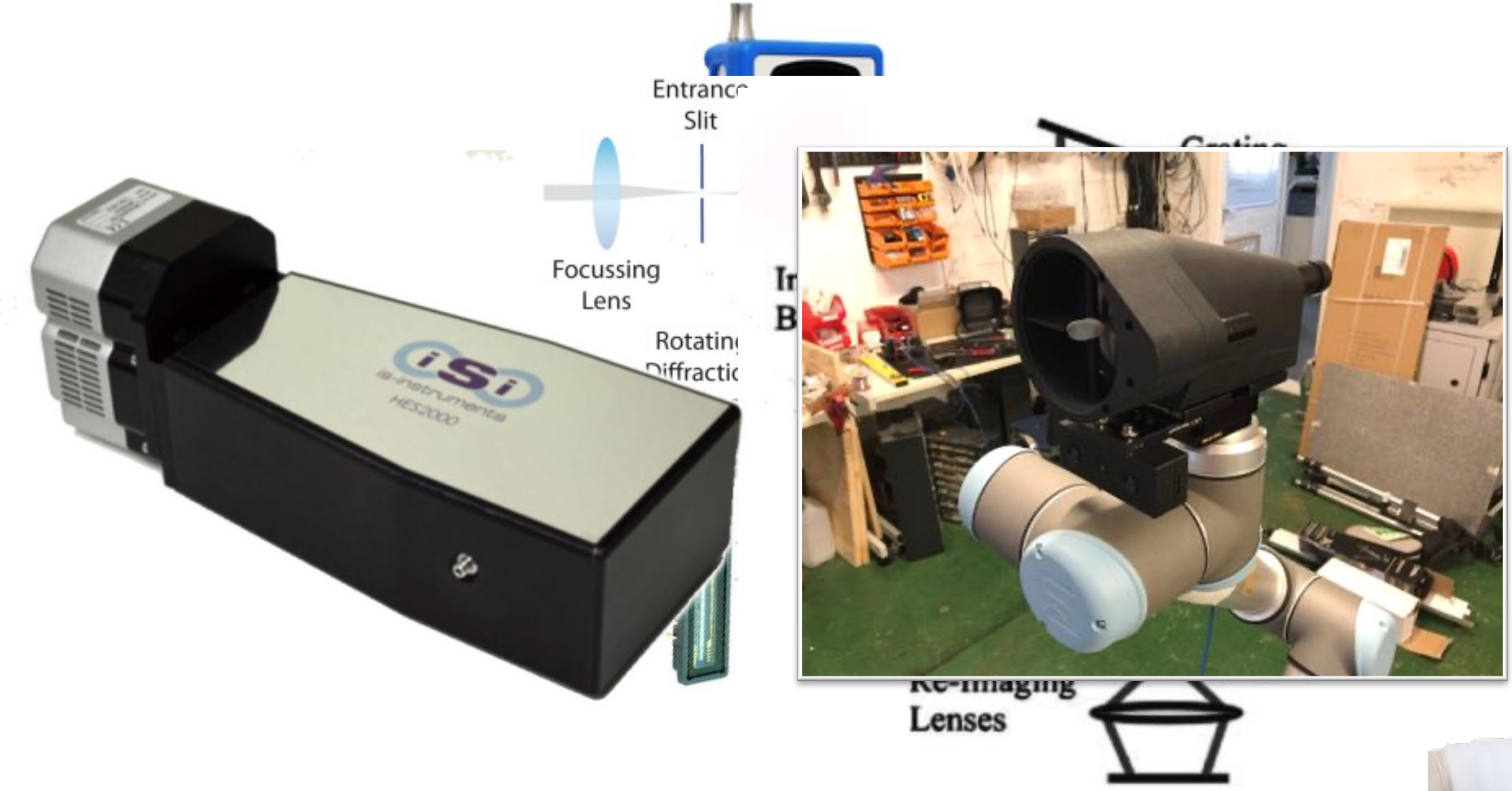
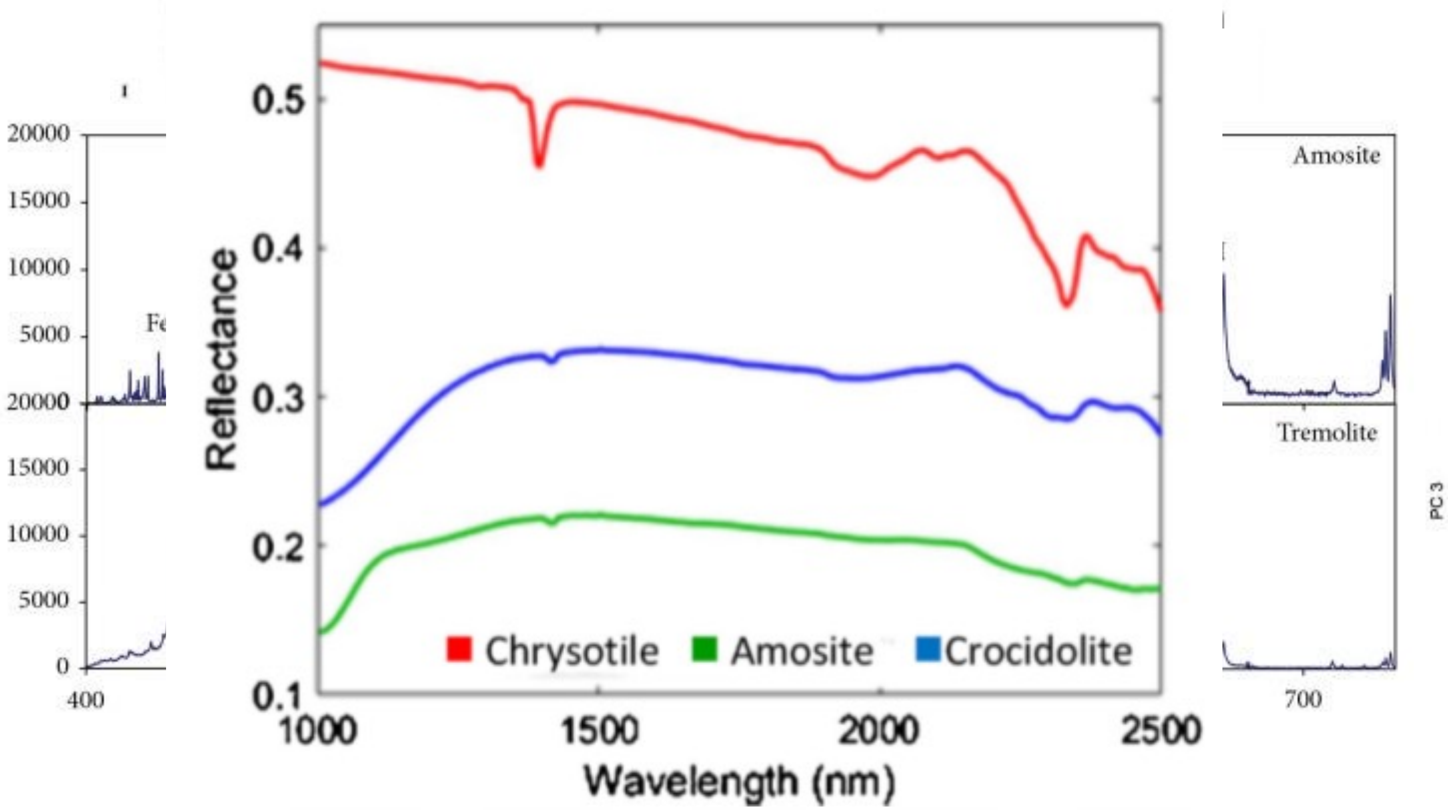
Stand-off Raman Spectroscopy



Examples of SL-relevant substance detection using proposed techniques



& OIL

...oils by laser induced

...applied to plutonium analysis", AIP conference proceedings 532, 305 (2000).

...Article ID 362694 .

...Journal of Raman Spectroscopy, vol. 28, 803-809 (1997).

HYPERSPECTRAL IMAGING

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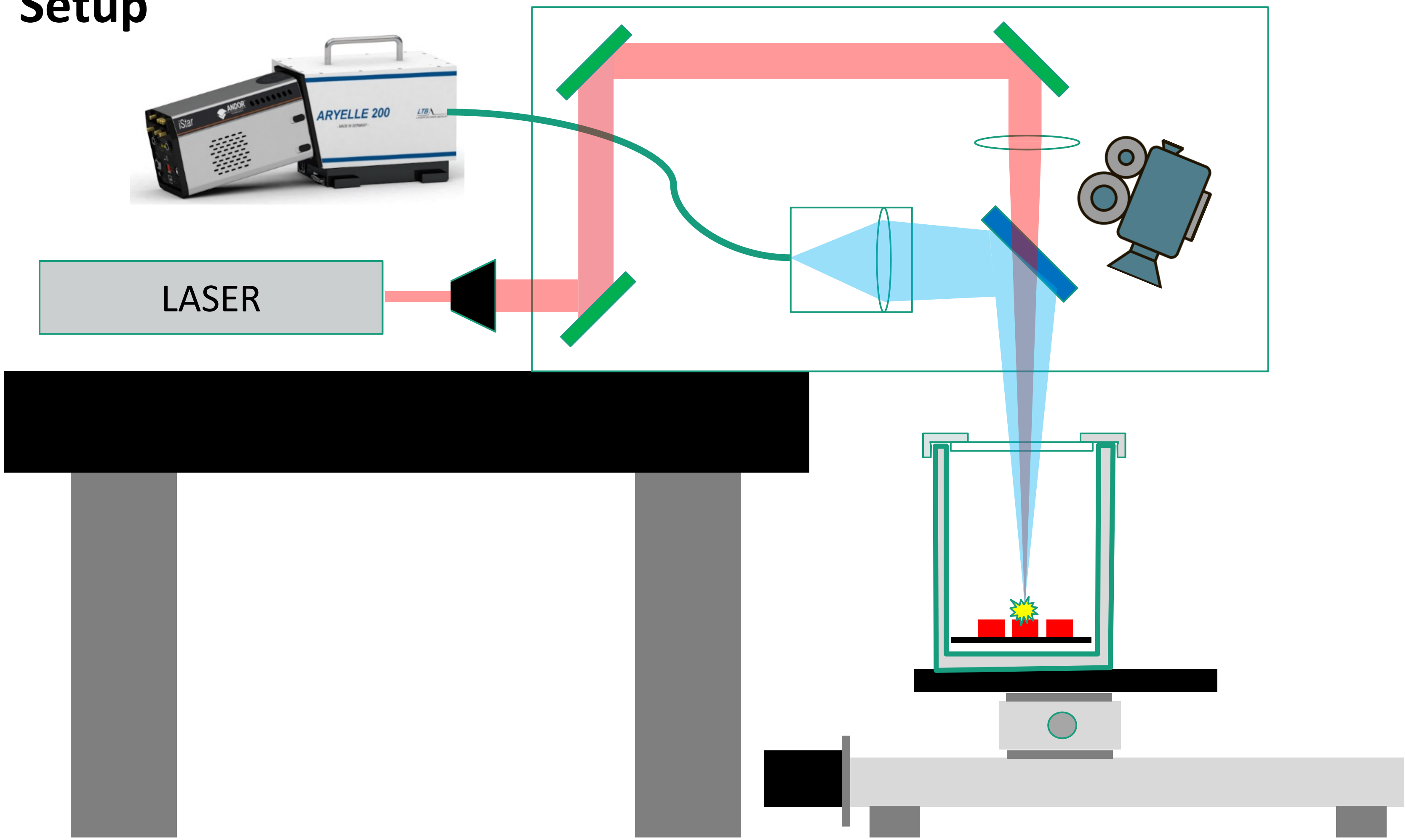
Setup



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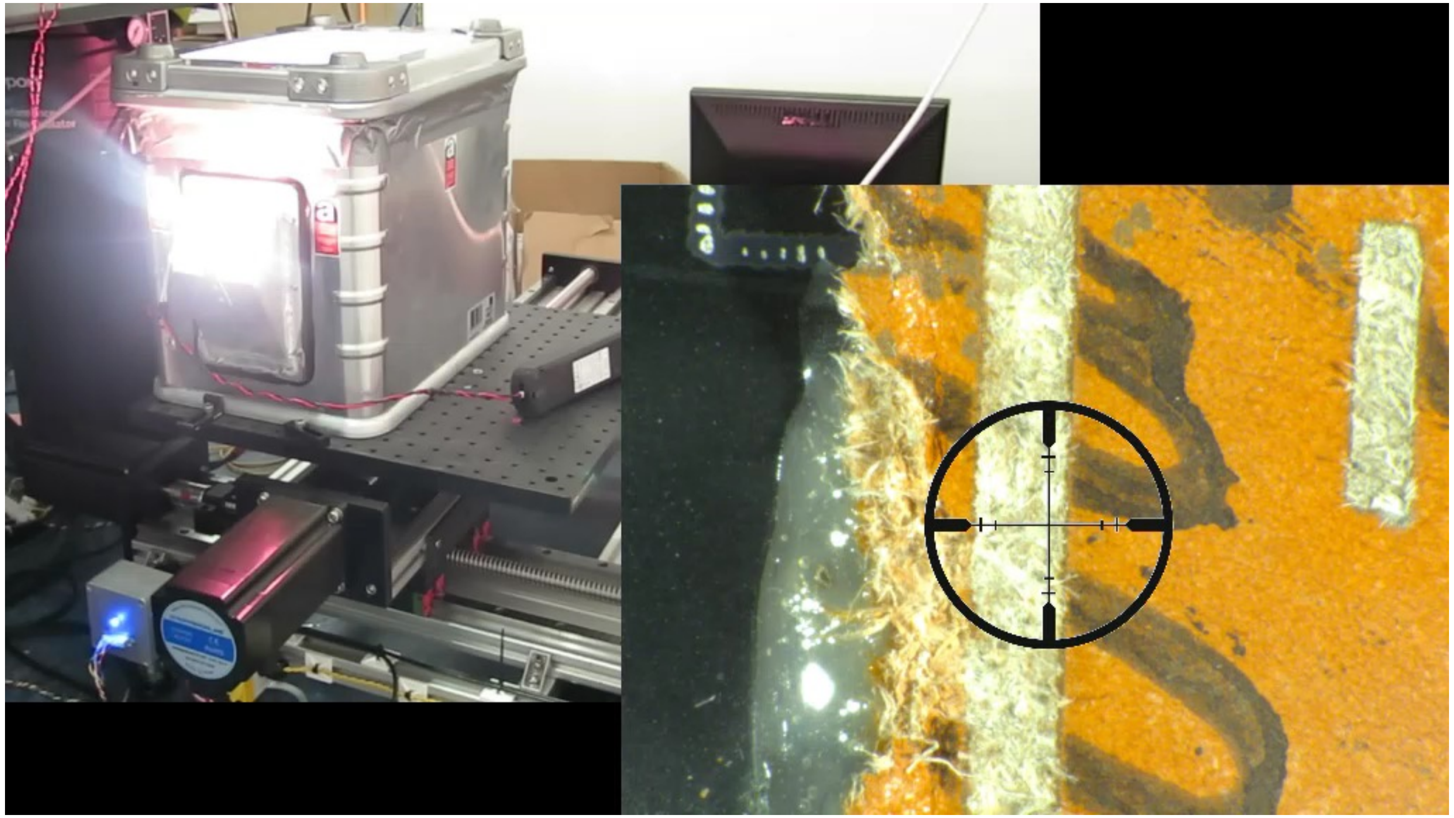
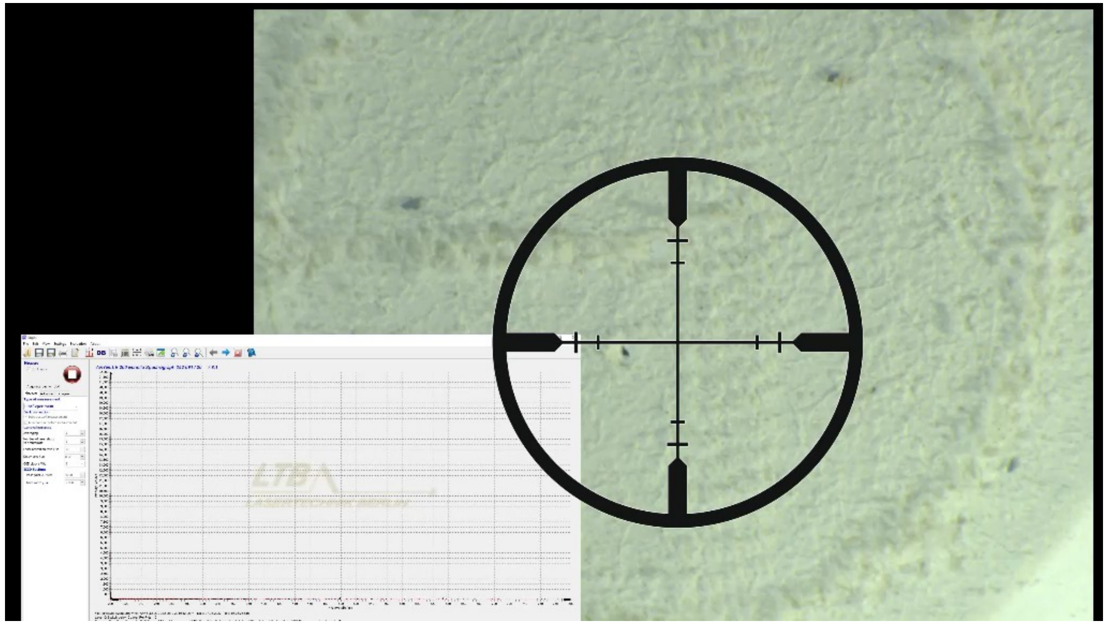
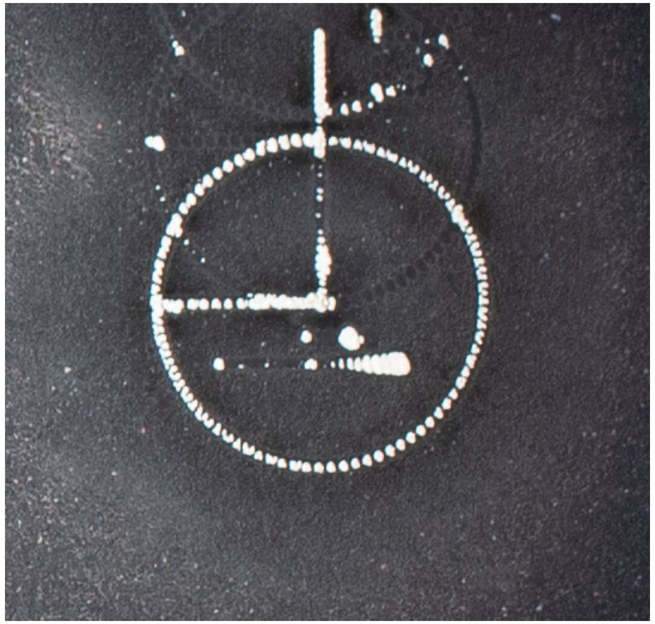
Sample motion with ‘spotting’ camera



Circular multi-point sampling of asbestos disks





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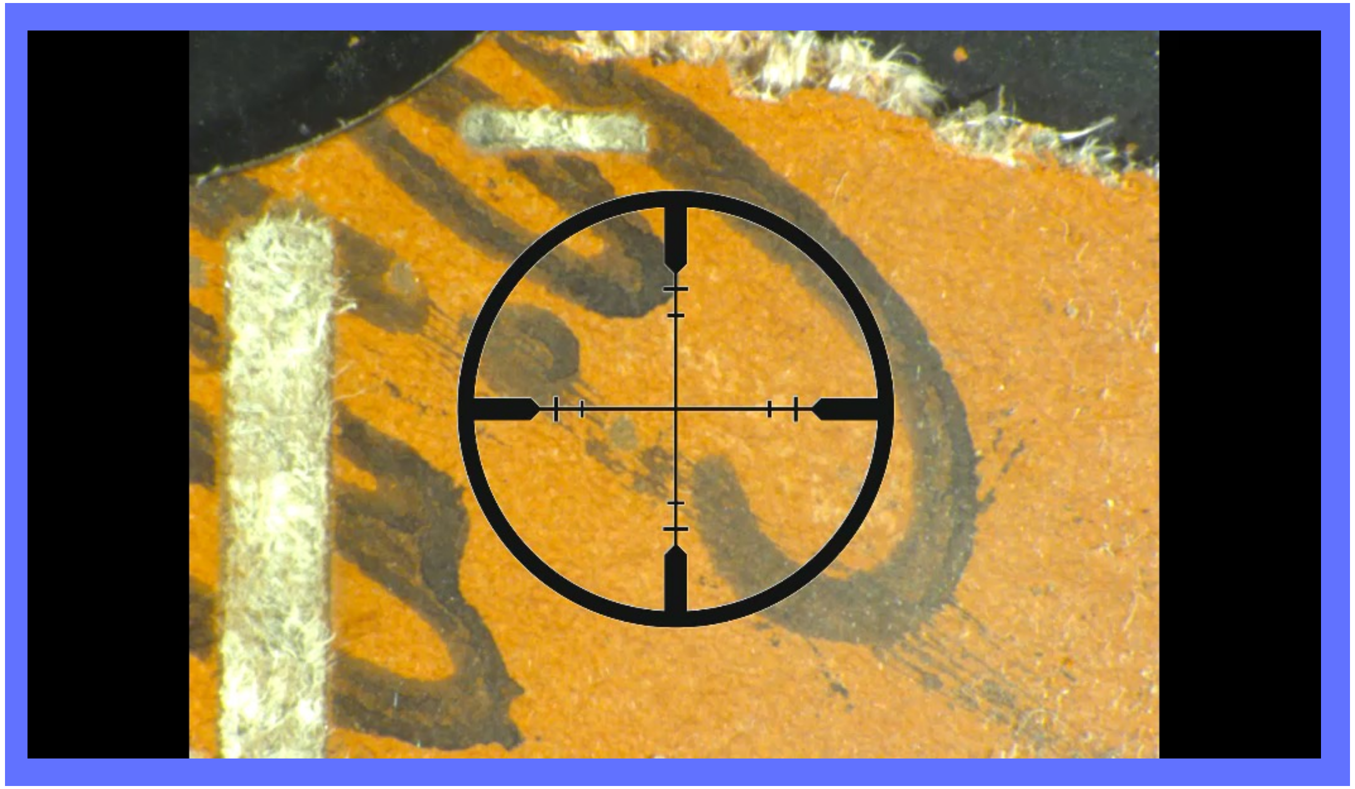
‘Laser cleaning’ of coated materials



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Photonic Sensing for Sustainability

- High energy usage industries and activities e.g.
  - Mining
  - Foundation industries
- Re-use and remediation
  - Contaminated sites
  - Re-use of materials
- Stand-off photonic sensing
  - E.g. Raman and LIBS

Photonic Sensing for Sustainability

Dr David Armstrong, Fraunhofer CAP
David.armstrong@fraunhofer.co.uk

Fraunhofer UK

PHOTONICS FOR THE DETECTION OF HYDROCARBONS IN MARINE ENVIRONMENTS"

Rand Ismaeel
Marine Photonics
(RAEng)

National Oceanography Centre

ONLY IN SOUTHAMPTON

ONLY AT SOUTHAMPTON..

NOC

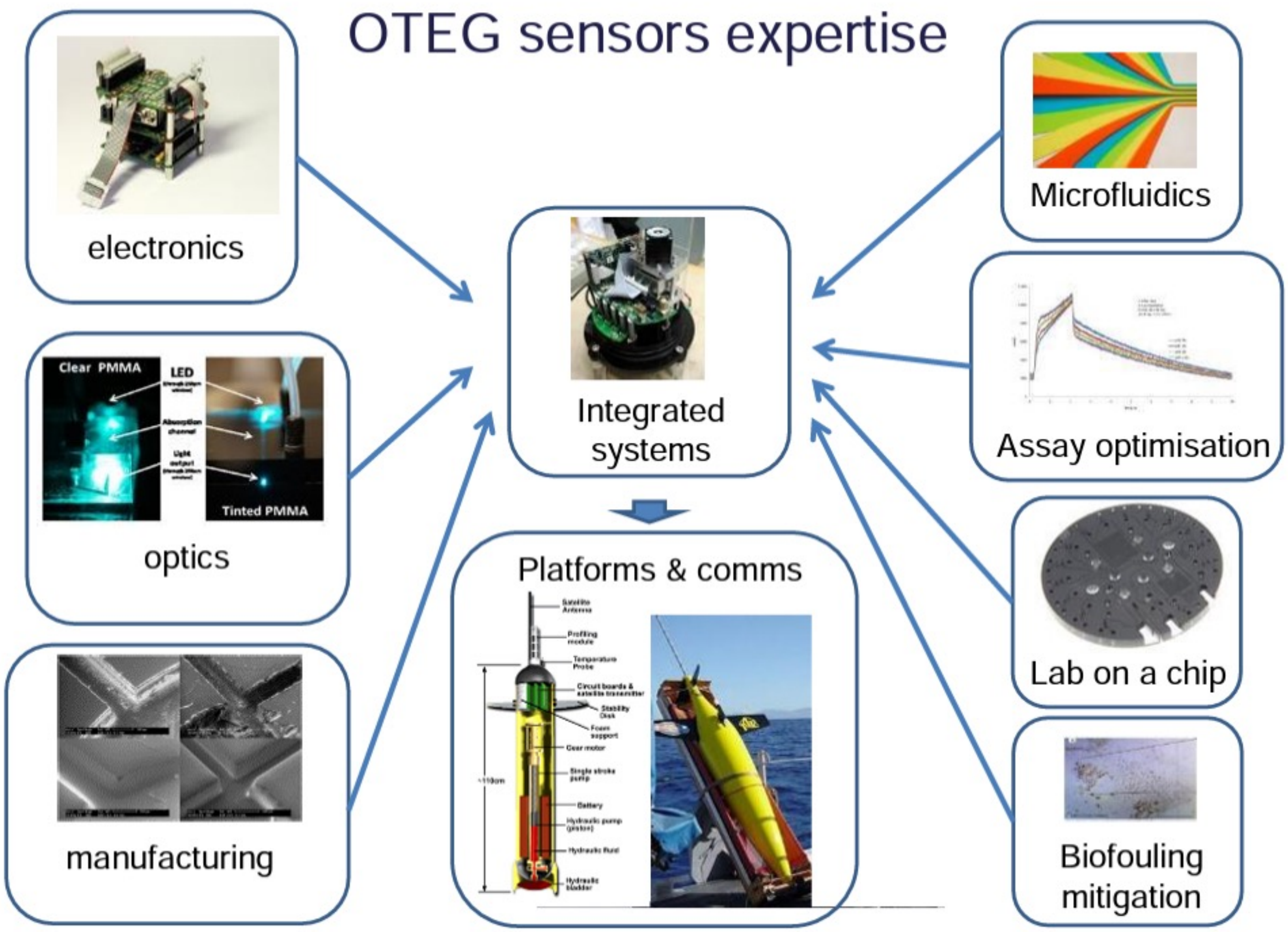
ORC

OTE

NOC: research, technology

Ocean Technology and Engineering Group (OTEG)

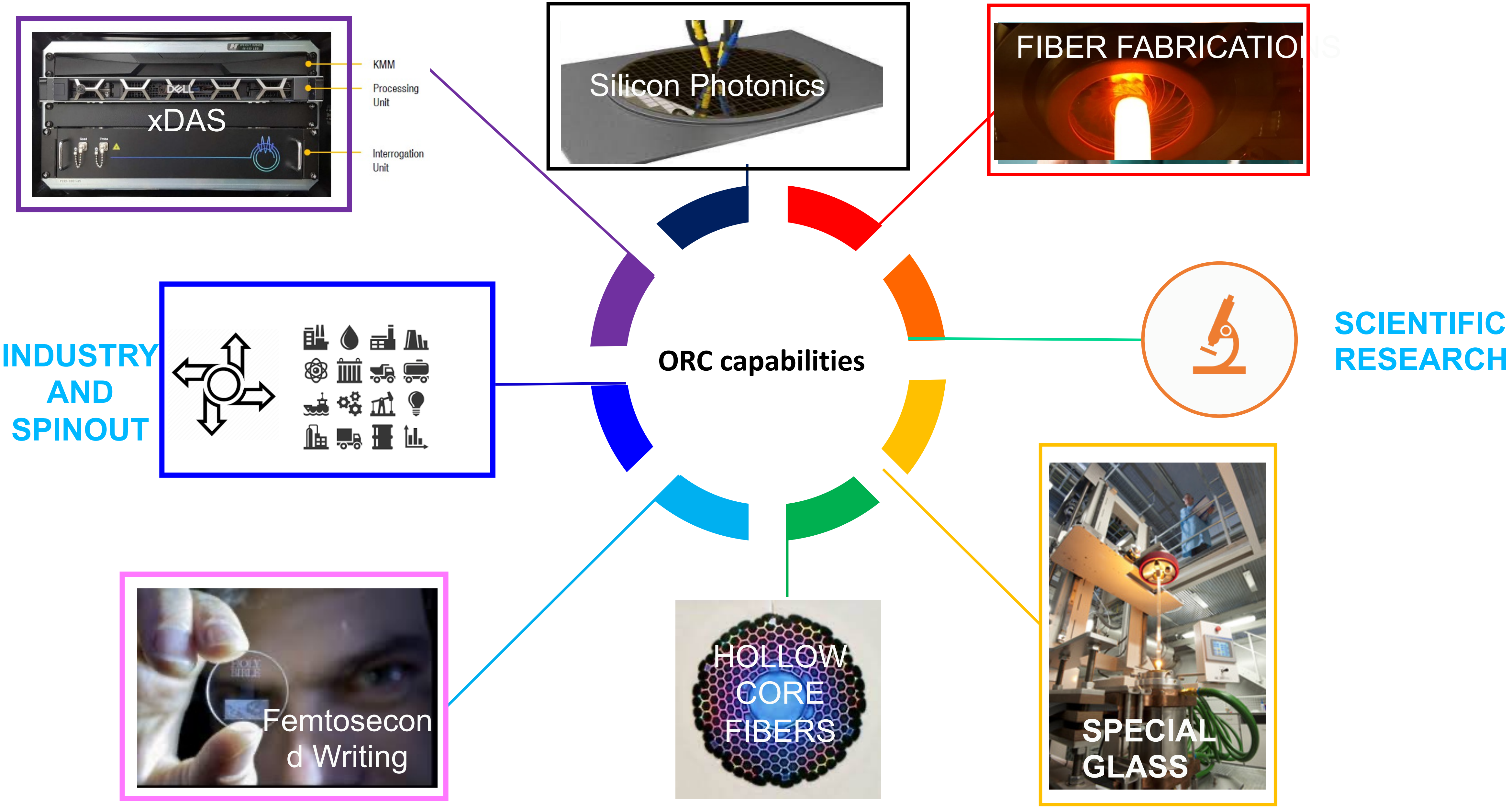
Mission (*"To develop* ***novel technology*** *and engineering resulting in the greatest* ***impact*** *for environmental and marine* ***science****"*)


OTEG sensors expertise
electronics
Clear PMMA
LED
Tinted PMMA
optics
manufacturing
Integrated
systems
Platforms & comms
Microfluidics
Assay optimisation
Lab on a chip
Biofouling
mitigation

ORC

October 2005

Today



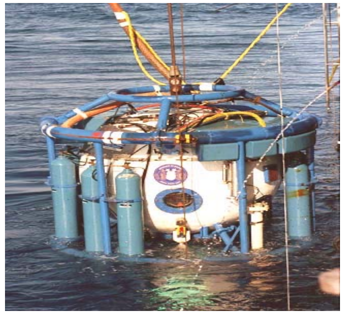
ORC capabilities
xDAS
KMM
Processing Unit
Interrogation Unit
Silicon Photonics
FIBER FABRICATIO
SCIENTIFIC RESEARCH
INDUSTRY AND SPINOUT
Femtosecon d Writing
HOLLOW CORE FIBERS
SPECIAL GLASS

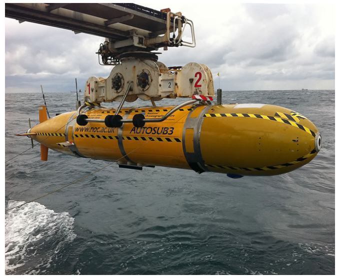
Transform ocean HYDROCARBONS sensing methodology <u>to the next generation</u>

UNIVERSITY OF Southampton Optoelectronics Research Centre

National Oceanography Centre

Current methods





UNIVERSITY OF Southampton Optoelectronics Research Centre

National Oceanography Centre

Royal Academy of Engineering

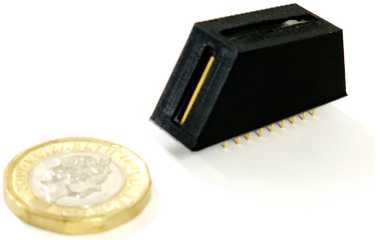
BlueOcean MONITORING

Planet Ocean Ltd

universidad de león

THE ARCTIC UNIVERSITY OF NORWAY • UIT •

The Future



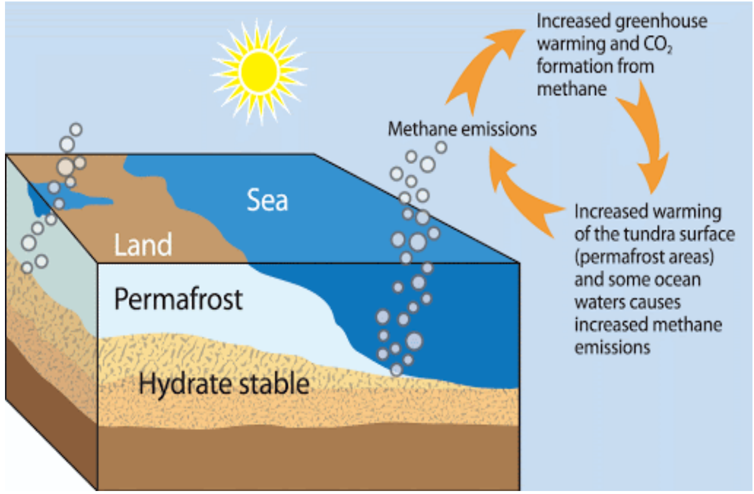
Expand the technology to monitor other unexplored organic and inorganic analytes in the marine environment.

Why the need for in situ Dissolved methane sensor?

- ***Methane is a potent greenhouse gas pollutant, its ability to absorb energy is 81 times greater than the same mass of carbon dioxide. (Methane 20-years Global Warming Potential 'GWP' is 81-83[1]).***
- ***Pipeline leakage***: cost £1,000,000,000s in repair and loss of product.
- ***Understanding of ocean's methane contribution to the global warming***: the methane bomb, unquantified threat to the marine biota.
- ***Assessments:*** before construction or decommissioning of offshore infrastructure.

Pipeline Leak

Methane Hydrate

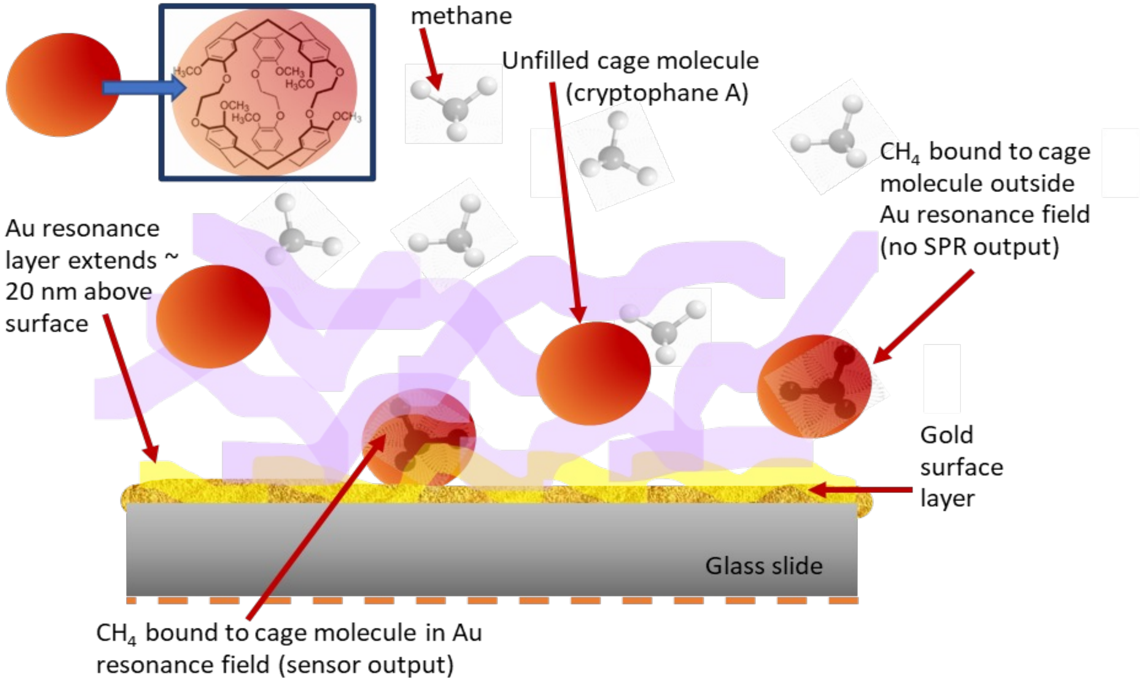


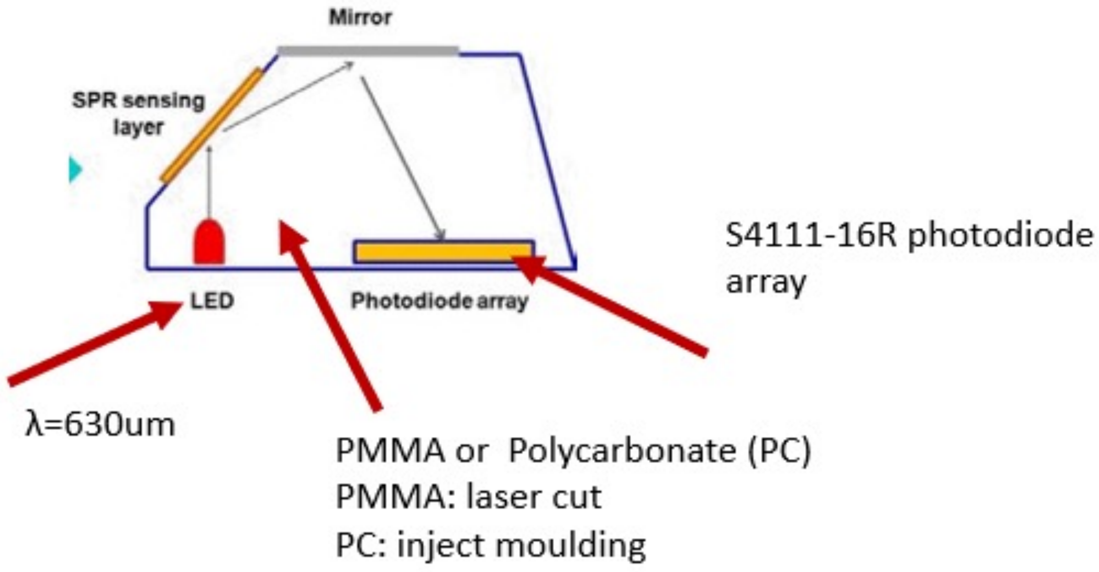
The Big Problem

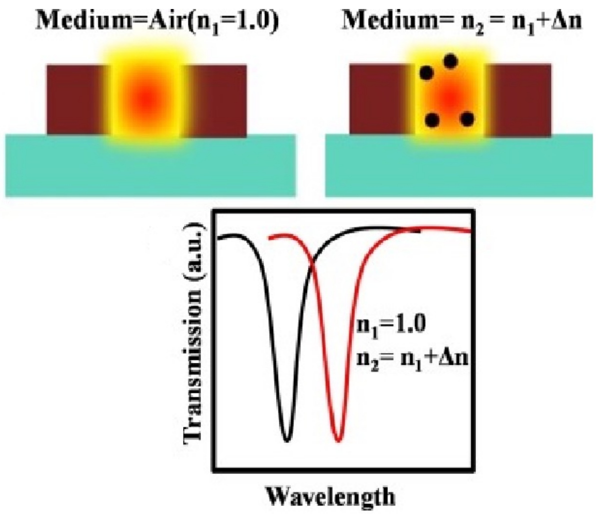
An urgent need for 3D mapping ocean methane and methane isotopes

[1] From EPA, U.S. Environmental Protection Agency

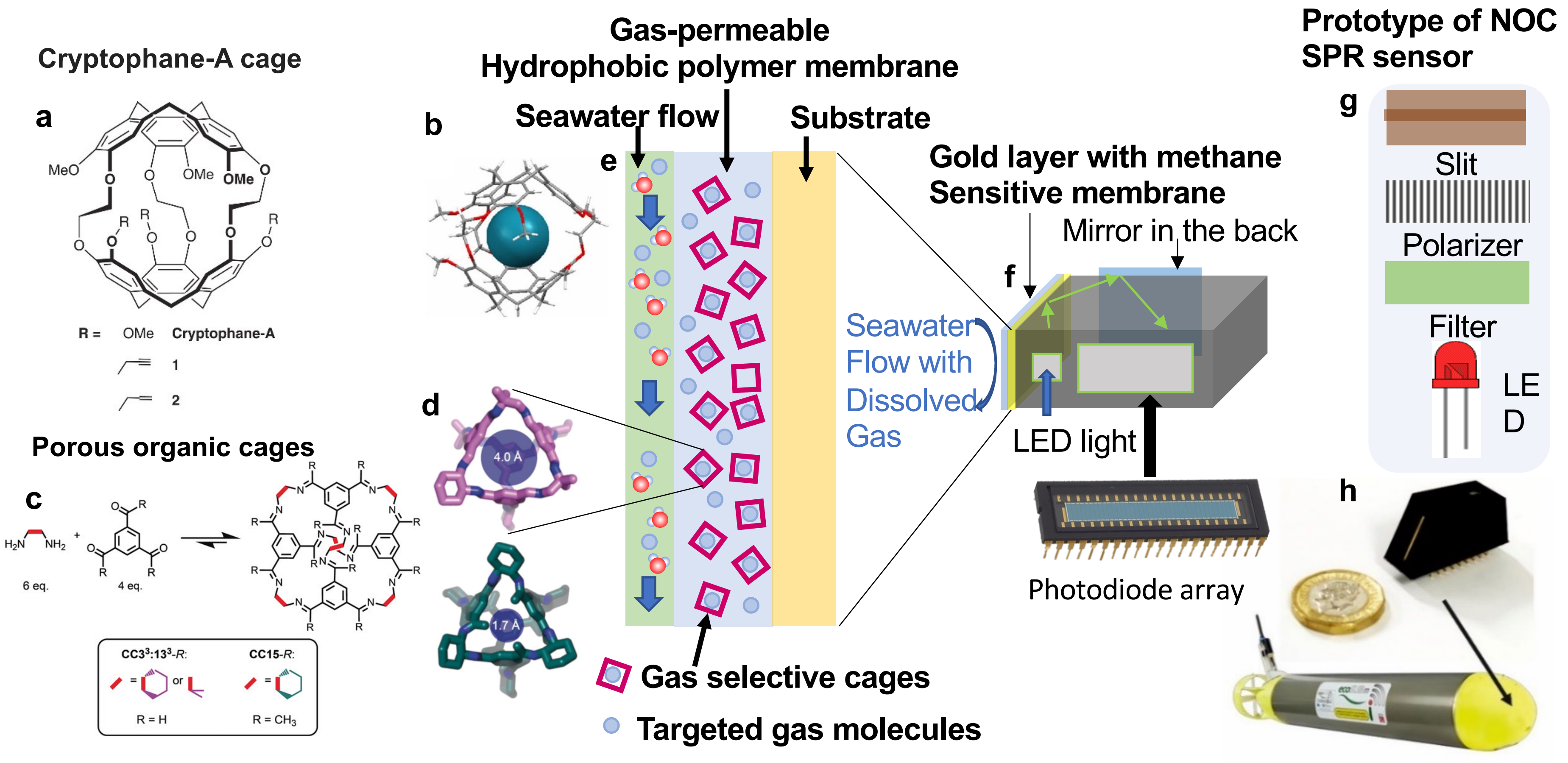
SPR METHANE SENSOR: DESIGN





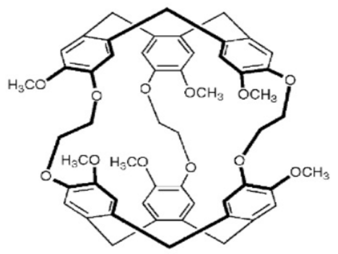


SPR Methane sensor



SPR SENSOR: FLUIDS DELIVERY

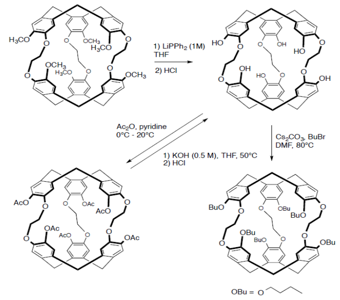
cryptophane-A+PDMS

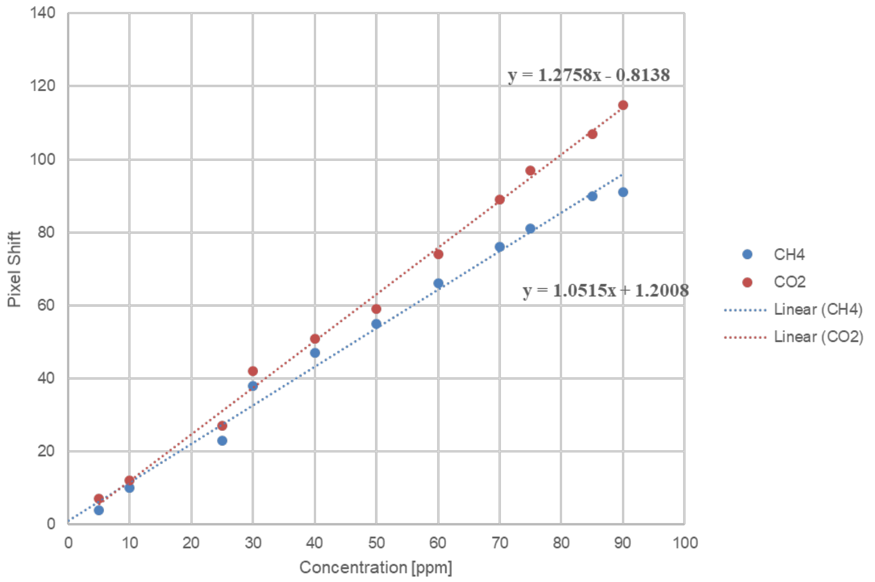


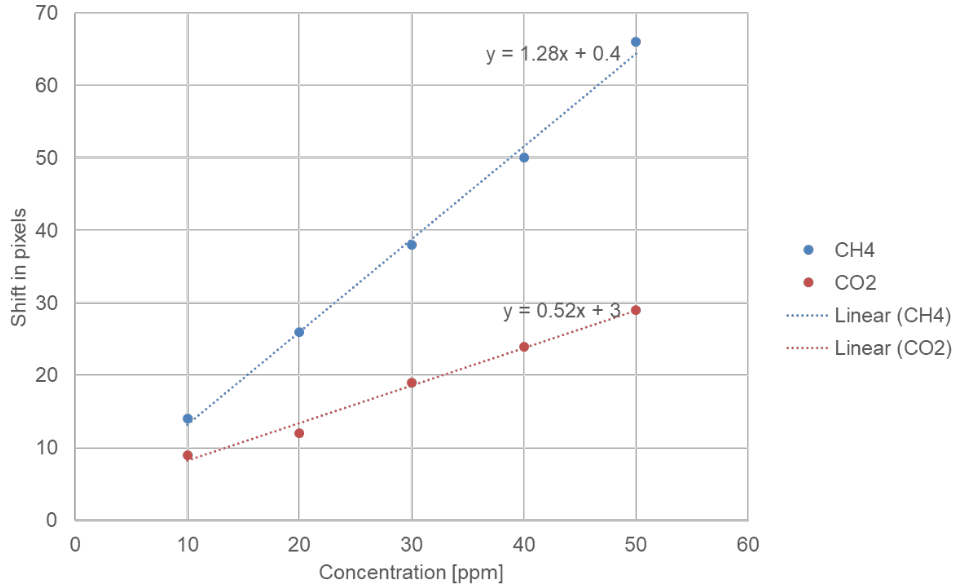
Cryptophane-A

Interference effects Enhanced ~%30

cryptophane(OBu)6 +TEFLON AF

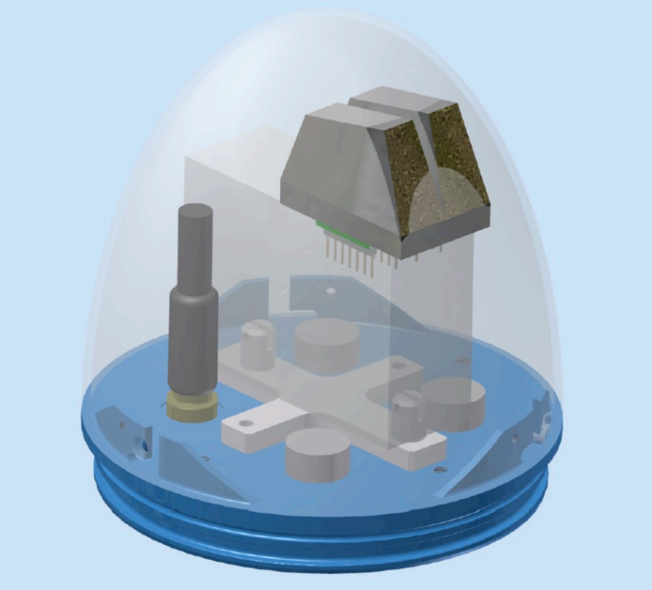


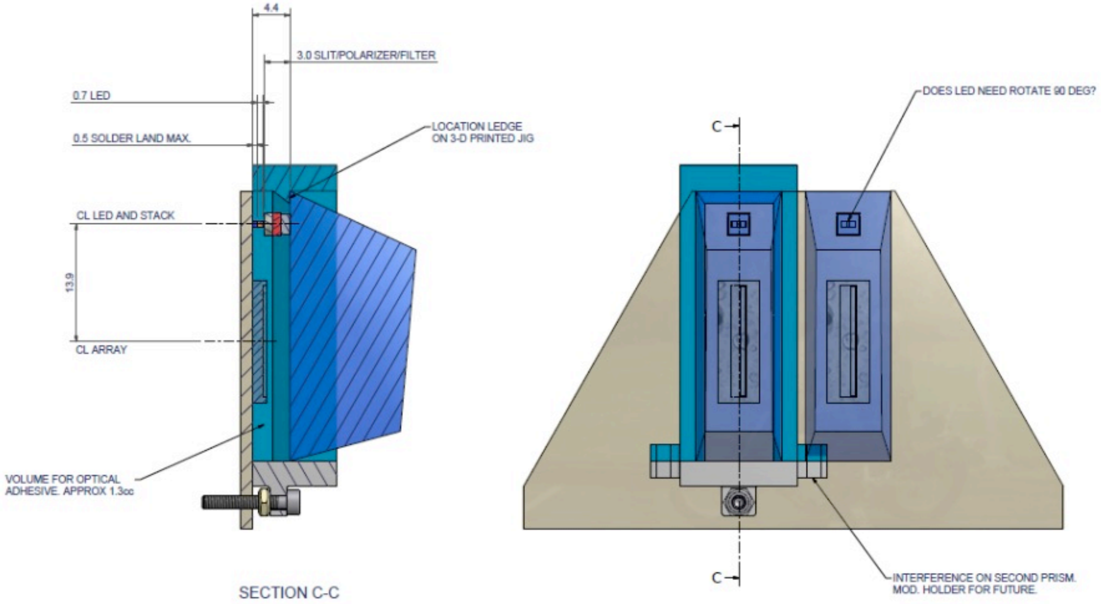




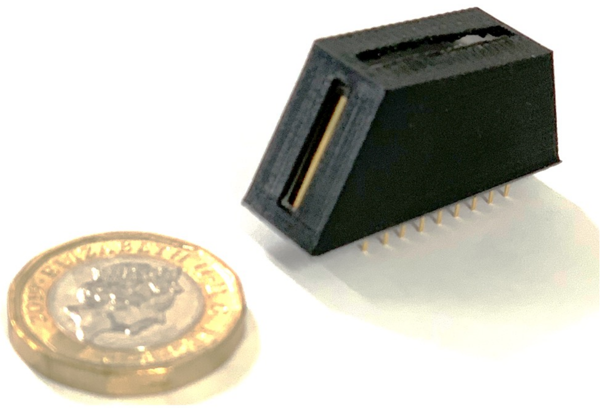
SPR METHANE SENSOR

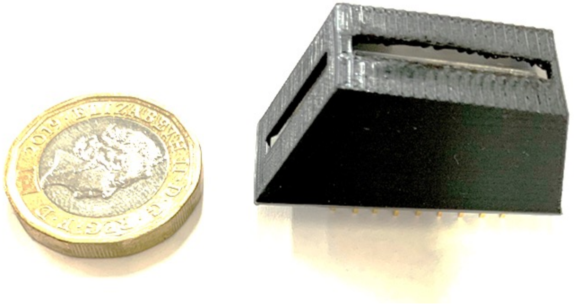
- Integration to the nose Kone of the Ecosub.





SPR METHANE SENSOR

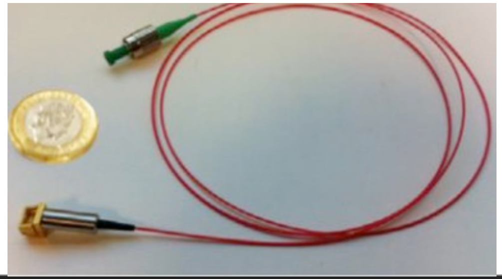


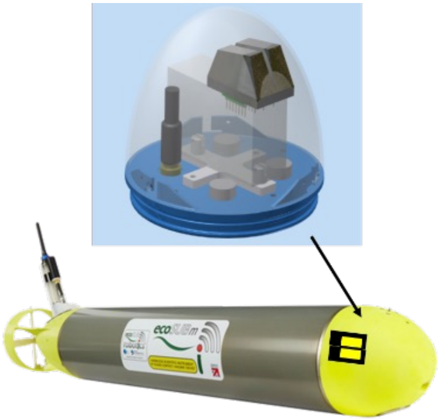


- Supply voltage, 5.0V
- LED current 270mA
- Sensitive surface size 15x1mm
- Operating temperature range 0-70C
- Refractive Index Measurement 1.320-1.468
- Resolution (refractive index) 5x10 ^(-6)

High resolution (0.1nM) ,dynamic range from 0.1nM to 200nM
Response time of 1s.

2nM resolution and dynamic range from 2nM to 830nM.
Response time of 1s





National Oceanography Centre

UNIVERSITY OF Southampton

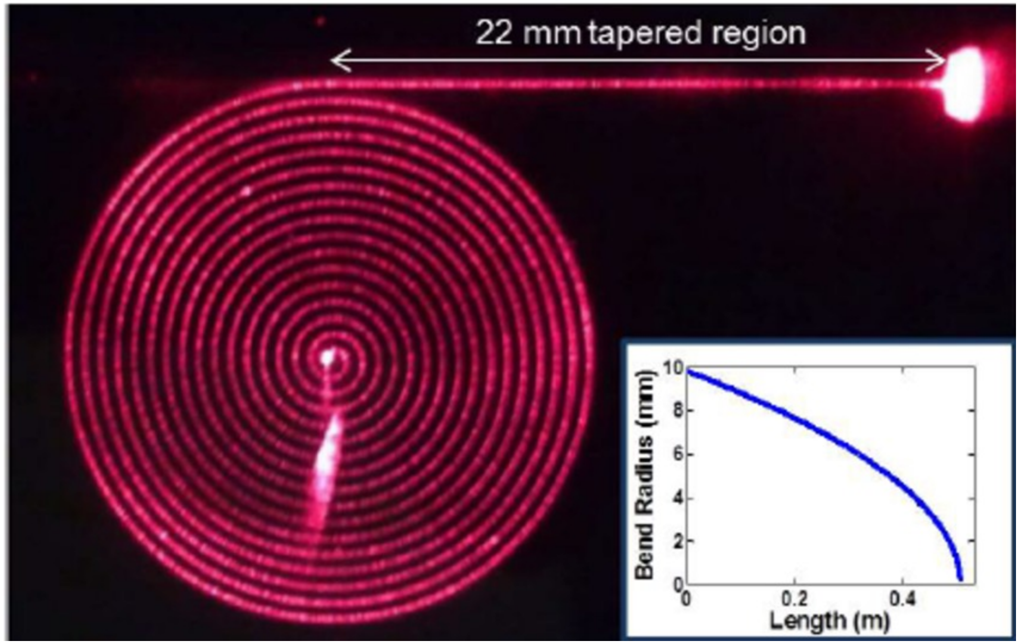
National Oceanography Centre

Spectroscopy sensor

EPSRC Programme Grant investigates using Silicon photonics for ocean monitoring

Highly repeatable and optimized manufacturing.

- Surface uniform in atomic level scale.



Spectroscopy Sensors:

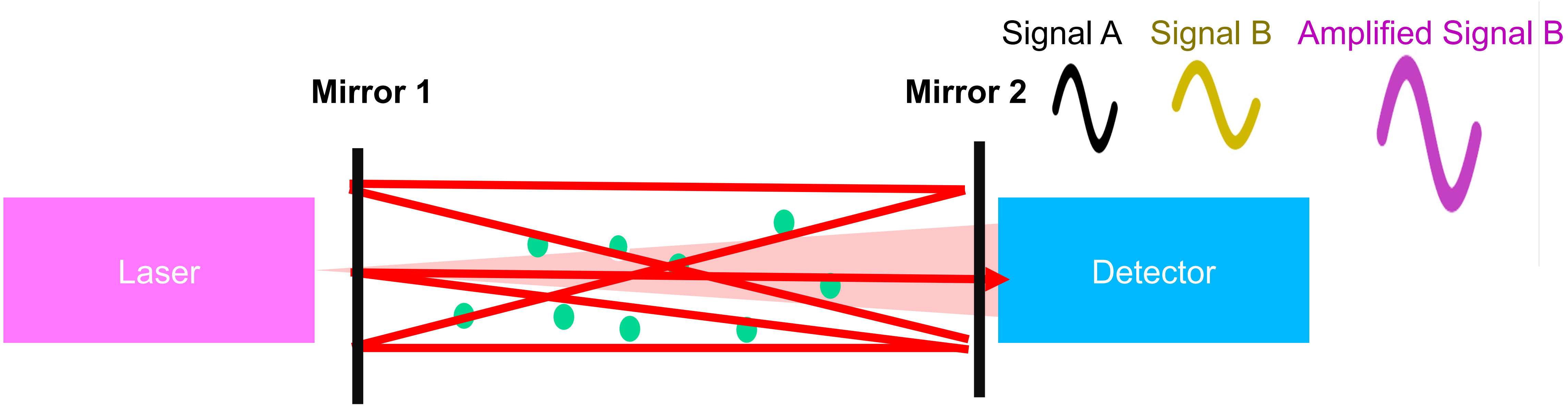
Methods: Beer-Lamber law

- light of intensity I_0 , propagates through a solution with concentration c and length l, output light will reduce to I because of some light get absorbed by the solute molecules.

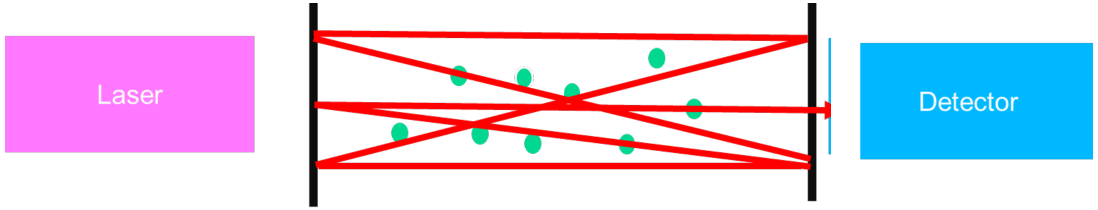
$$I = I_0^{-\alpha l} = I_0^{-c\varepsilon l} = I_0^{-c\sigma l}$$

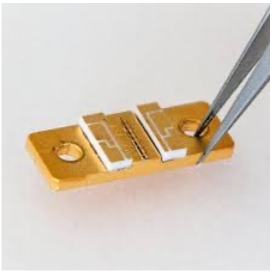
- The concentration of the target molecules can be obtained by detecting the intensity change between the input and output .

STATE OF ART TECH FOR HYDROCARBON DETECTION

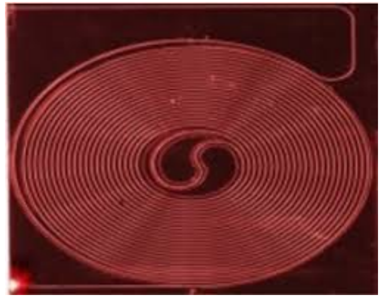


WHAT A PHOTONICS SENSOR LOOK LIKE?



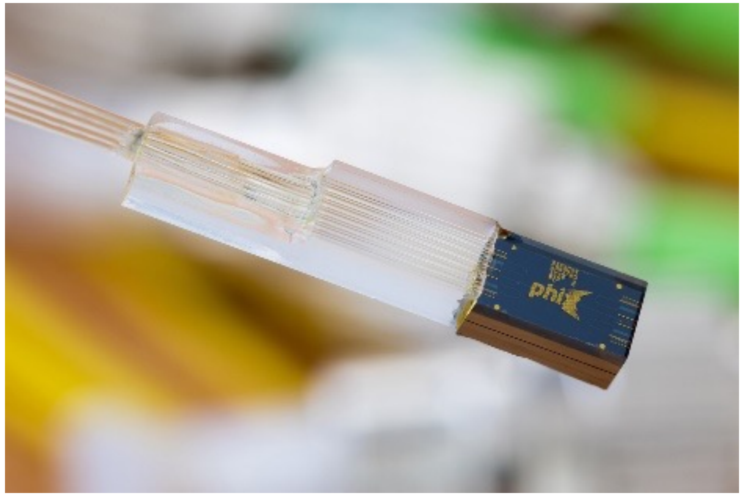


QCL



Optical waveguide

MCT detector



https://www.phix.com/

Optical **dissolved** Gases Sensors

Which Band is more suitable?

Near IR	Mid IR
Weaker absorption for green house molecules 👎	High absorption for green house molecules (1000 times better than NIR 👍
Low water absorption Measurement can be in liquid phase 👍	High water absorption Needs Gas separation (slow response) 👎
Mature Technology Low loss, can be tailored to cavity 👍	100 times lower TRL than NIR Progressing rapidly 👉

Which to Choose?

Optical **dissolved** Gases Sensors

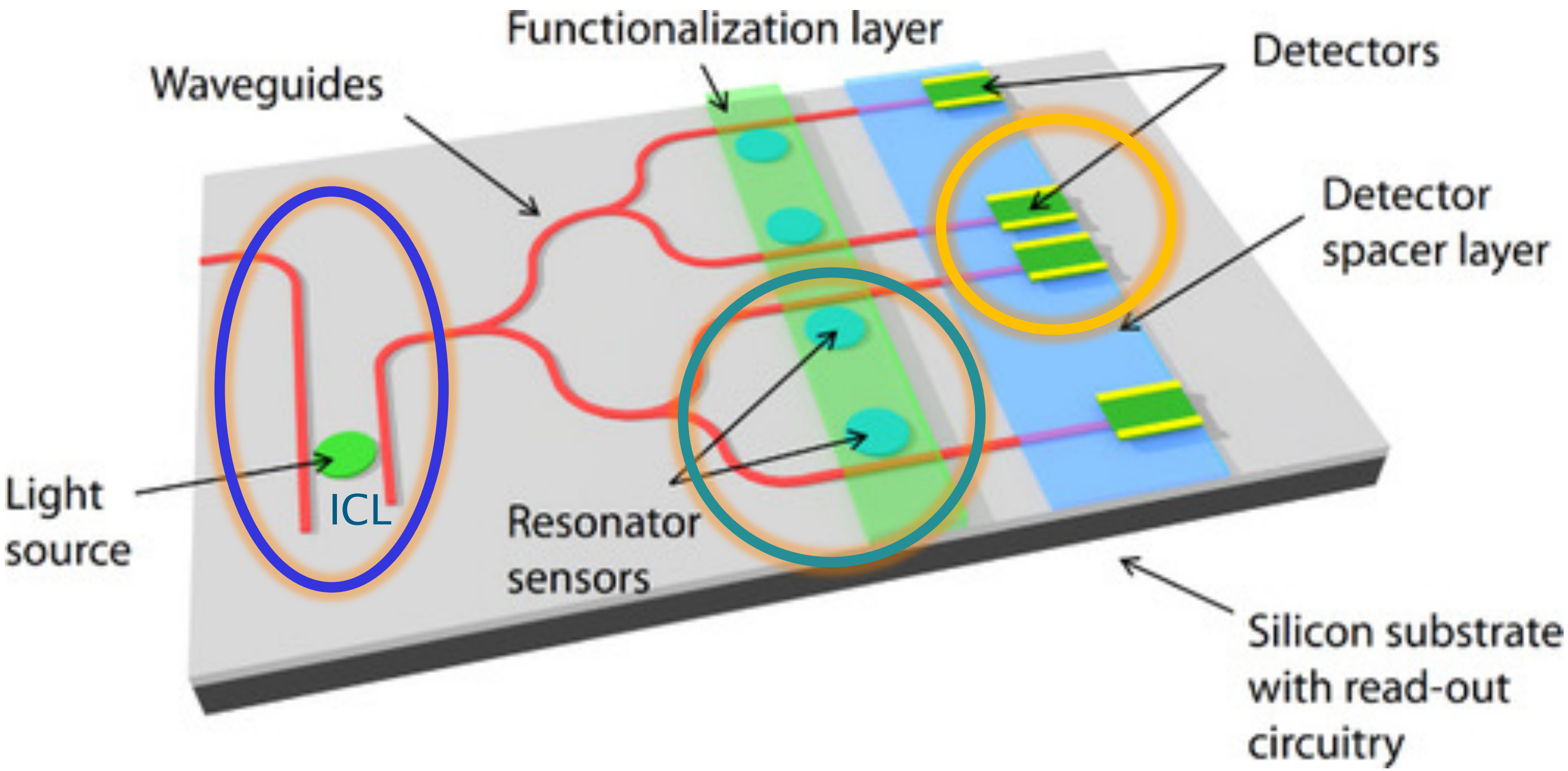
Both! **For now…**

Near IR	Mid IR
Refractive Index change sensors	Compact waveguide sensors With
Resonance spectroscopy	
Spectroscopy-Long waveguides with pre-concentrators	

Future dominant technology

10-20 years span

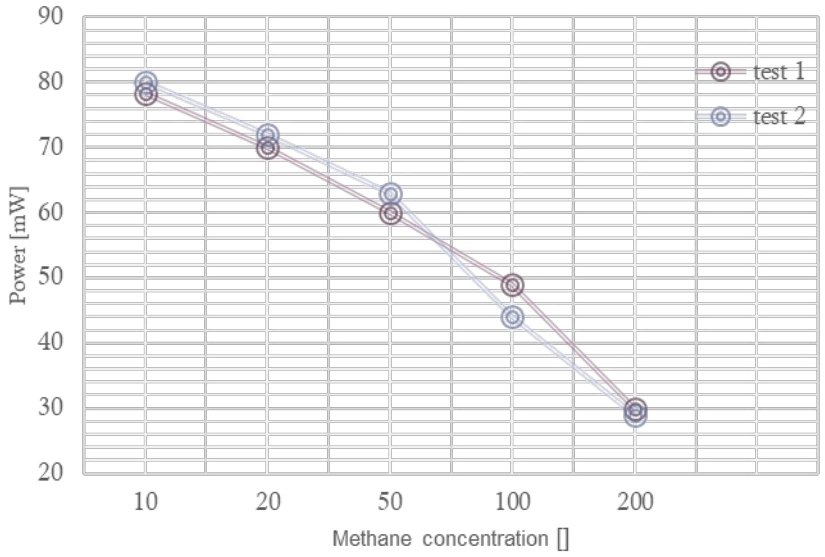
What's on the chip?

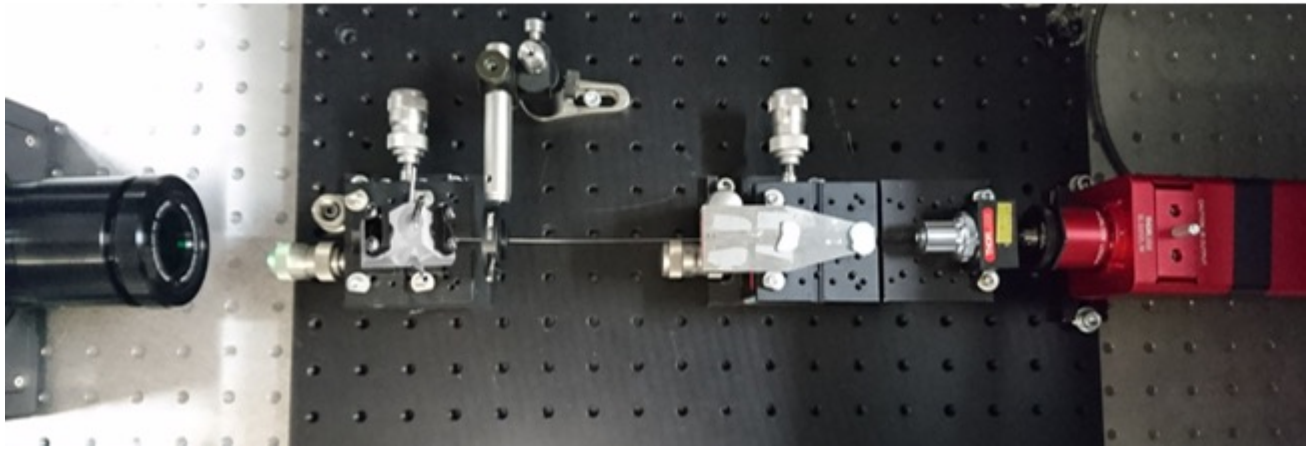


V. Singh, et al (2014) Science and Technology of Advanced Materials

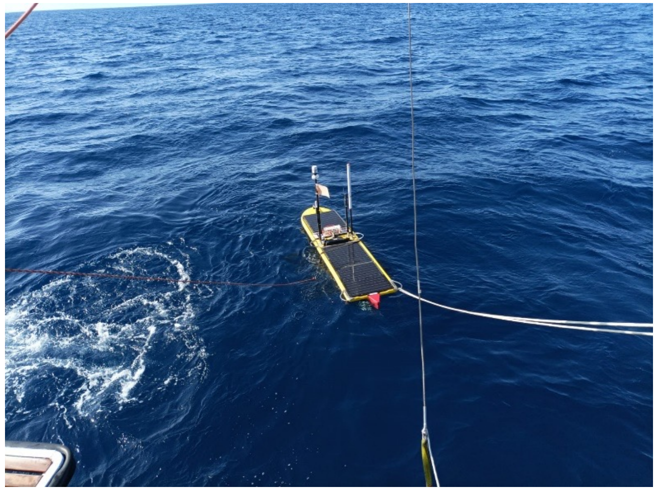
MID-IR setup: Sea-air gas exchange measurements.

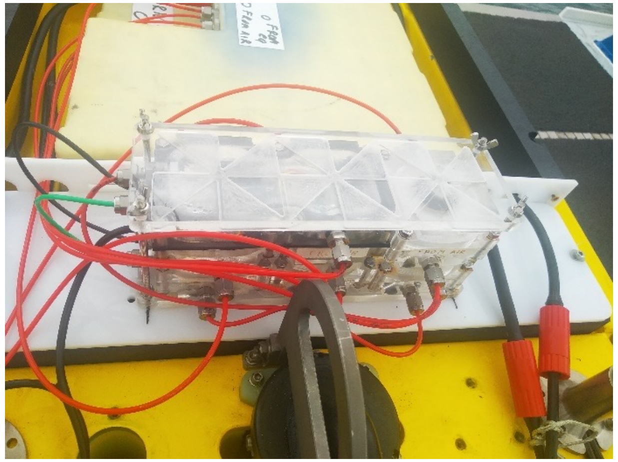
- **Light Source:** SLS202L - Stabilized Fiber-Coupled IR Light Source w/ Universal Power Adapter, 450 - 5500 nm
- **To be** replaced with: LEUKOS MidIR supercontinuum.
- Achromatic fibre coupling module
- Chalcogenide fibre (input/output).
- Germanium waveguide (5mm length).
- **Detector**: ARCOptic FTIR Spectrometer

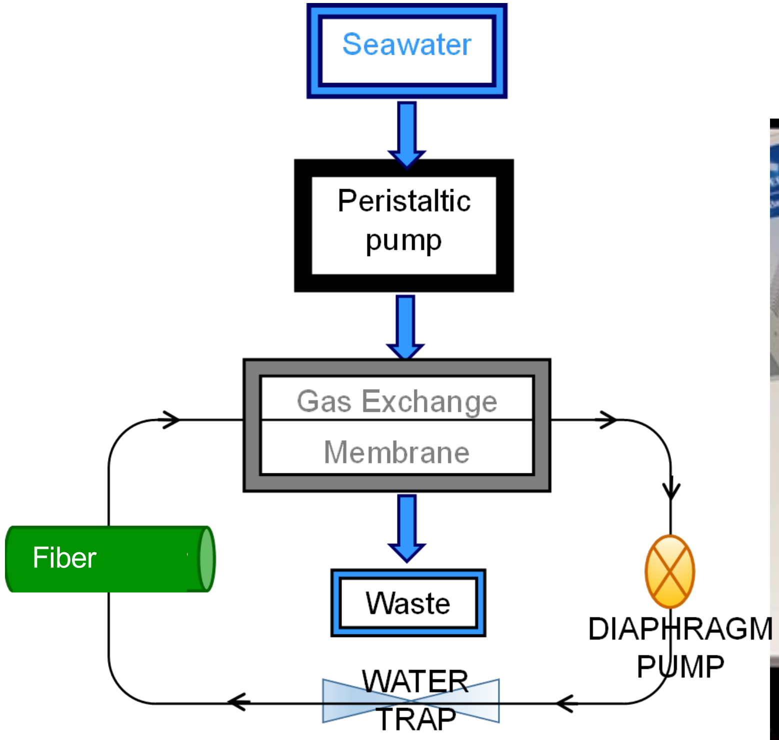


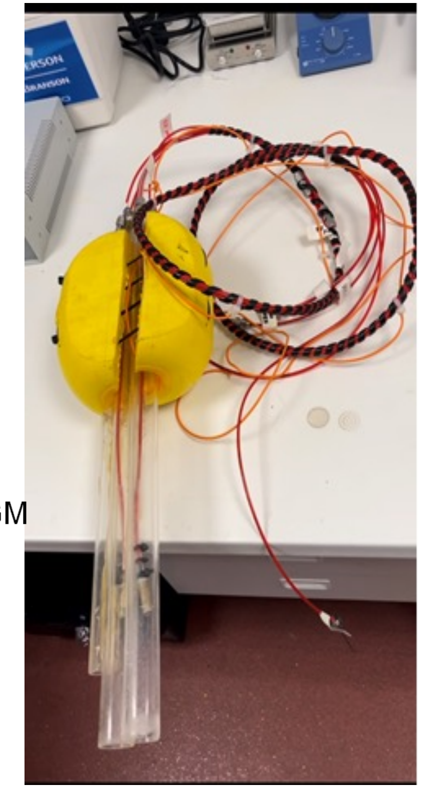


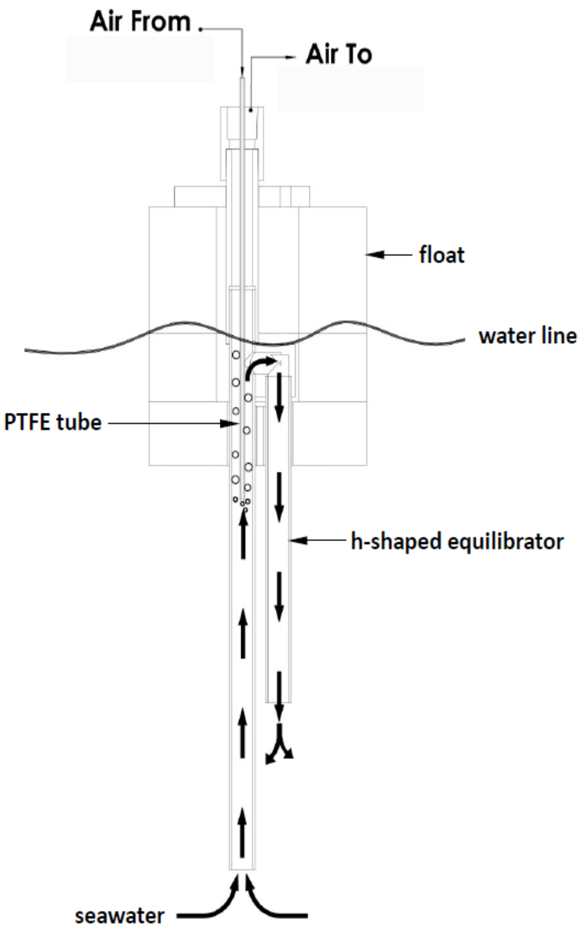
1: Surface flux



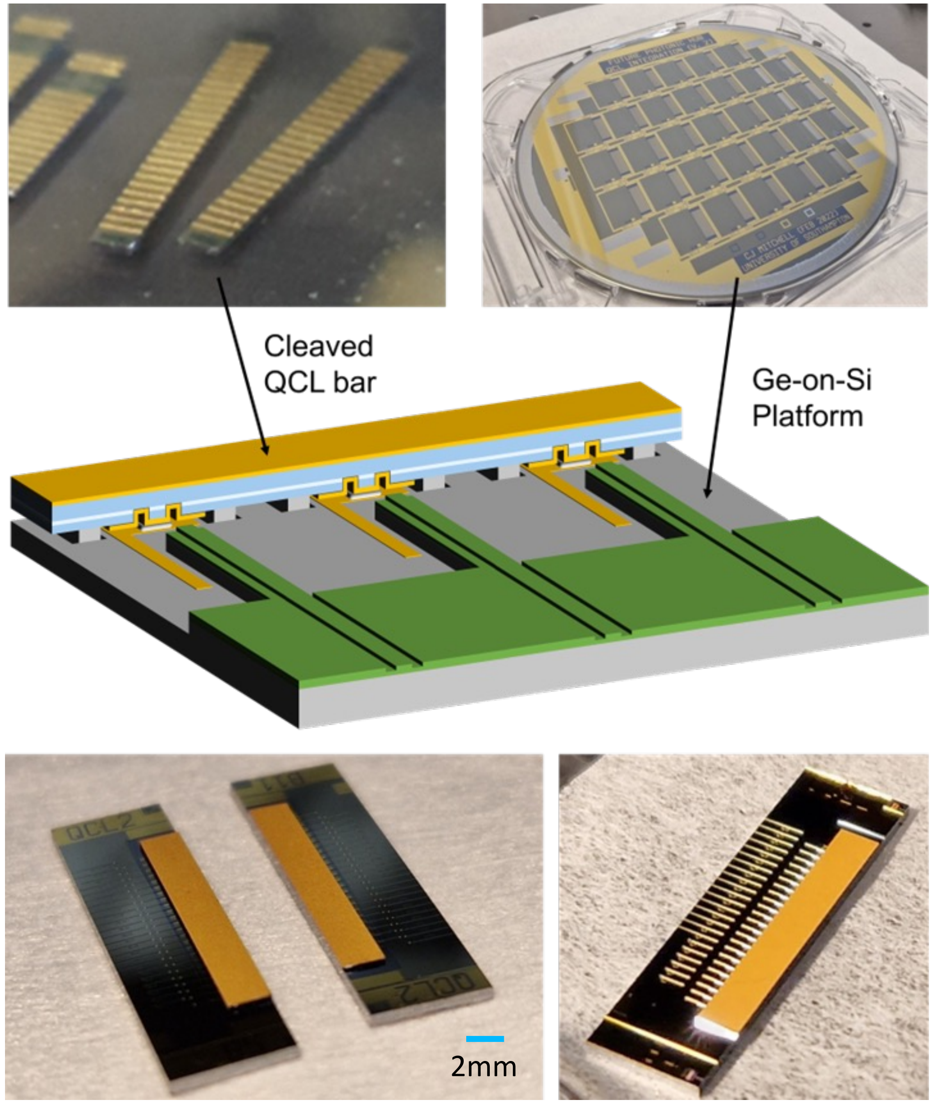


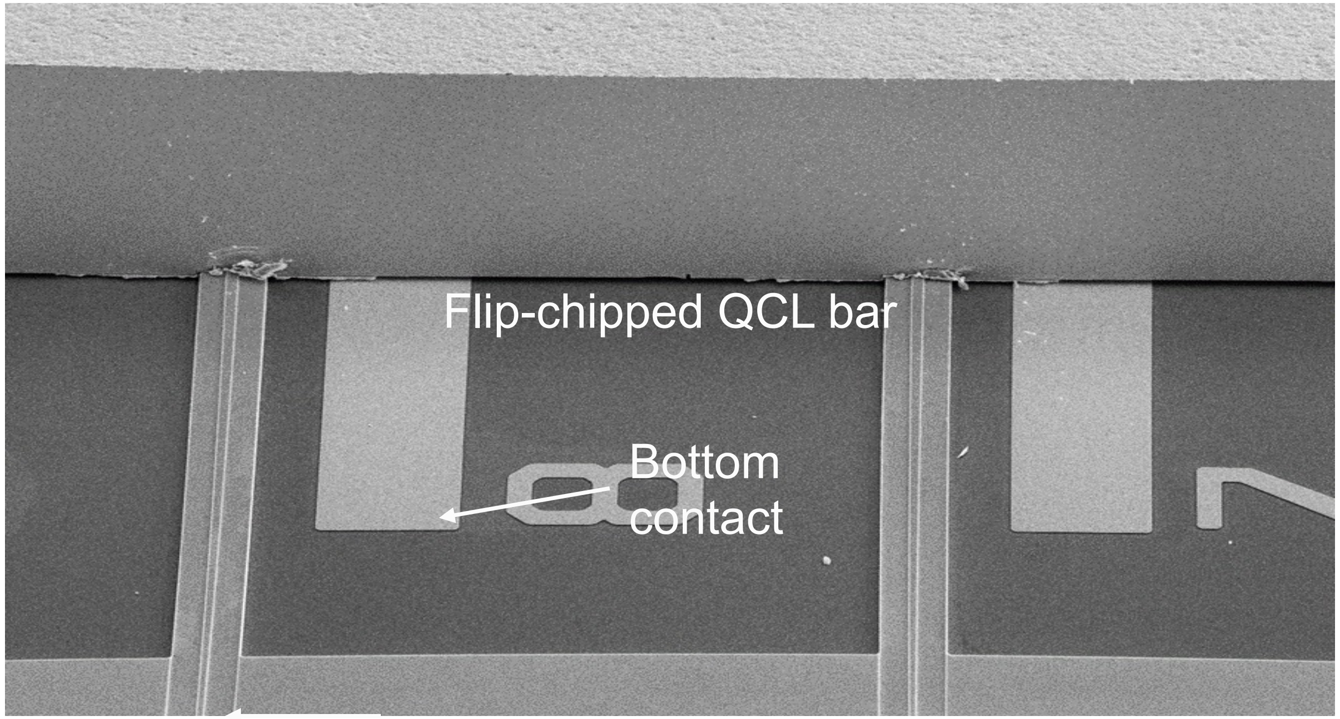






Integration Overview





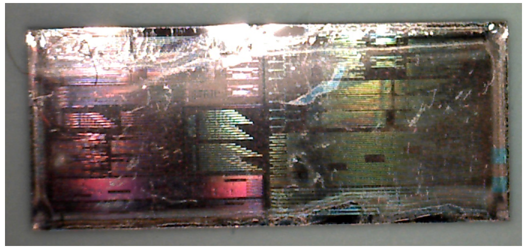
Ge Waveguide

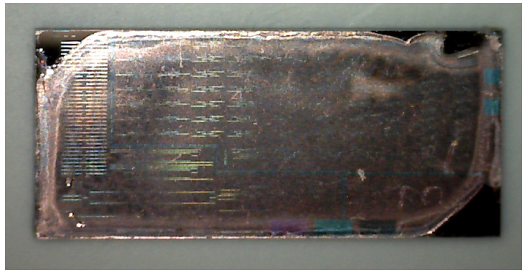
- A laser bar consisting of 24x QCLs is flip-chip bonded on silicon
- Integrated QCLs are coupled with Ge-on-Si waveguides
- Two types of waveguide are processed on the Ge-on-Si platform, i.e., edge-emitting waveguide and grating out coupler waveguide

DEEP SEA DISSOLVED GAS SENSOR

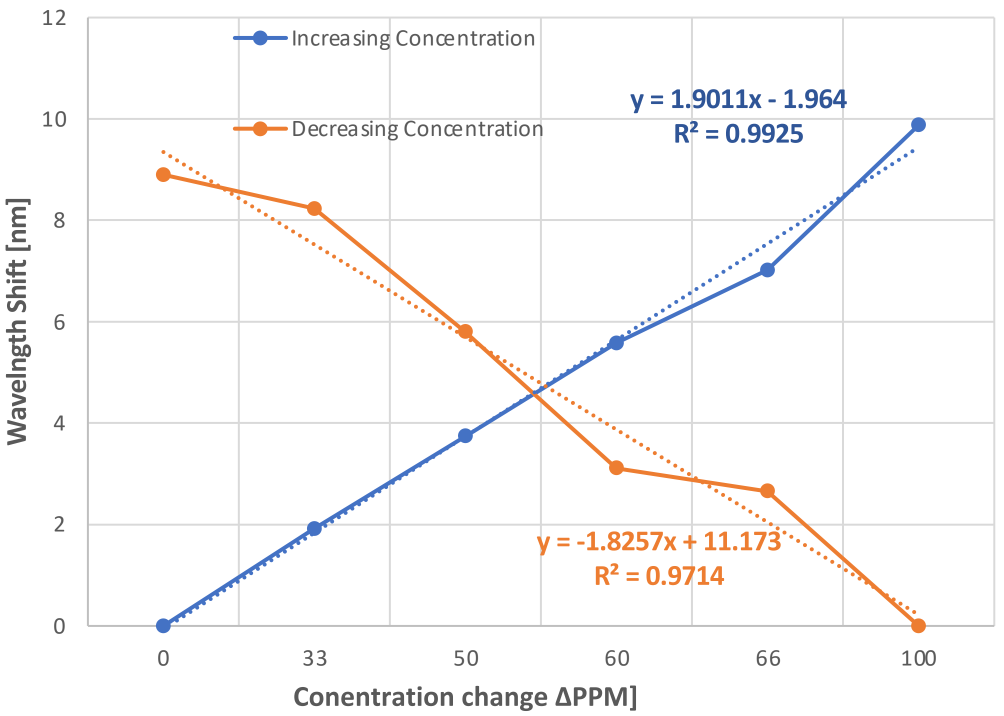
Pressure testing:

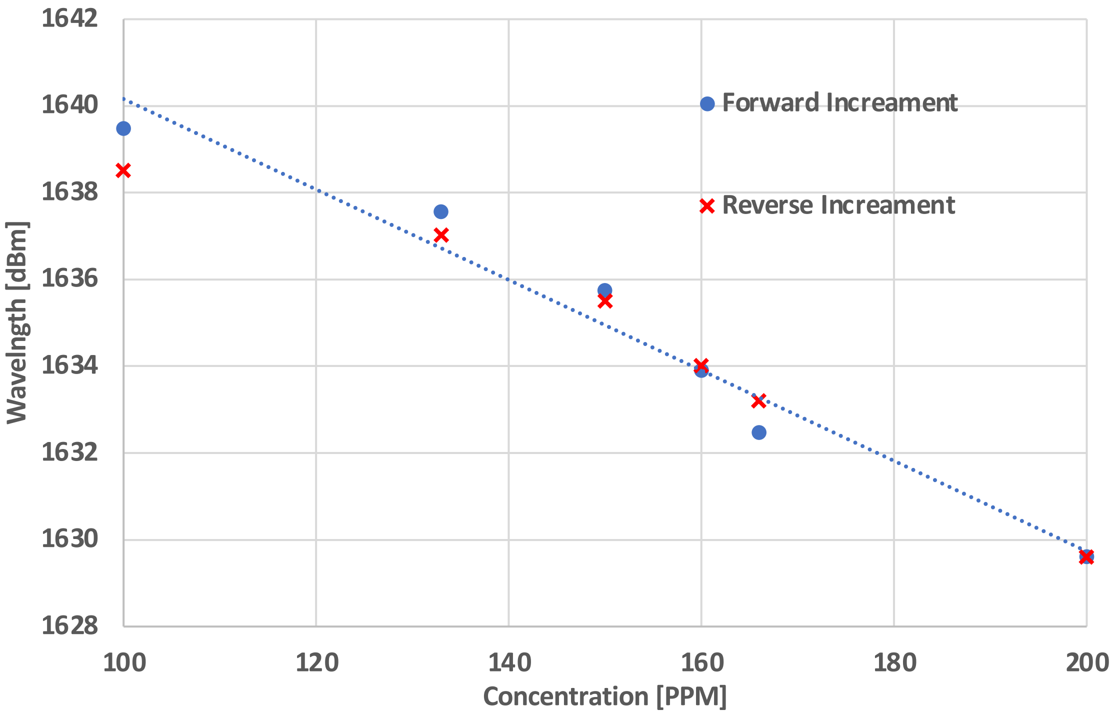
successful trial with pressure testing upto 600BAR!





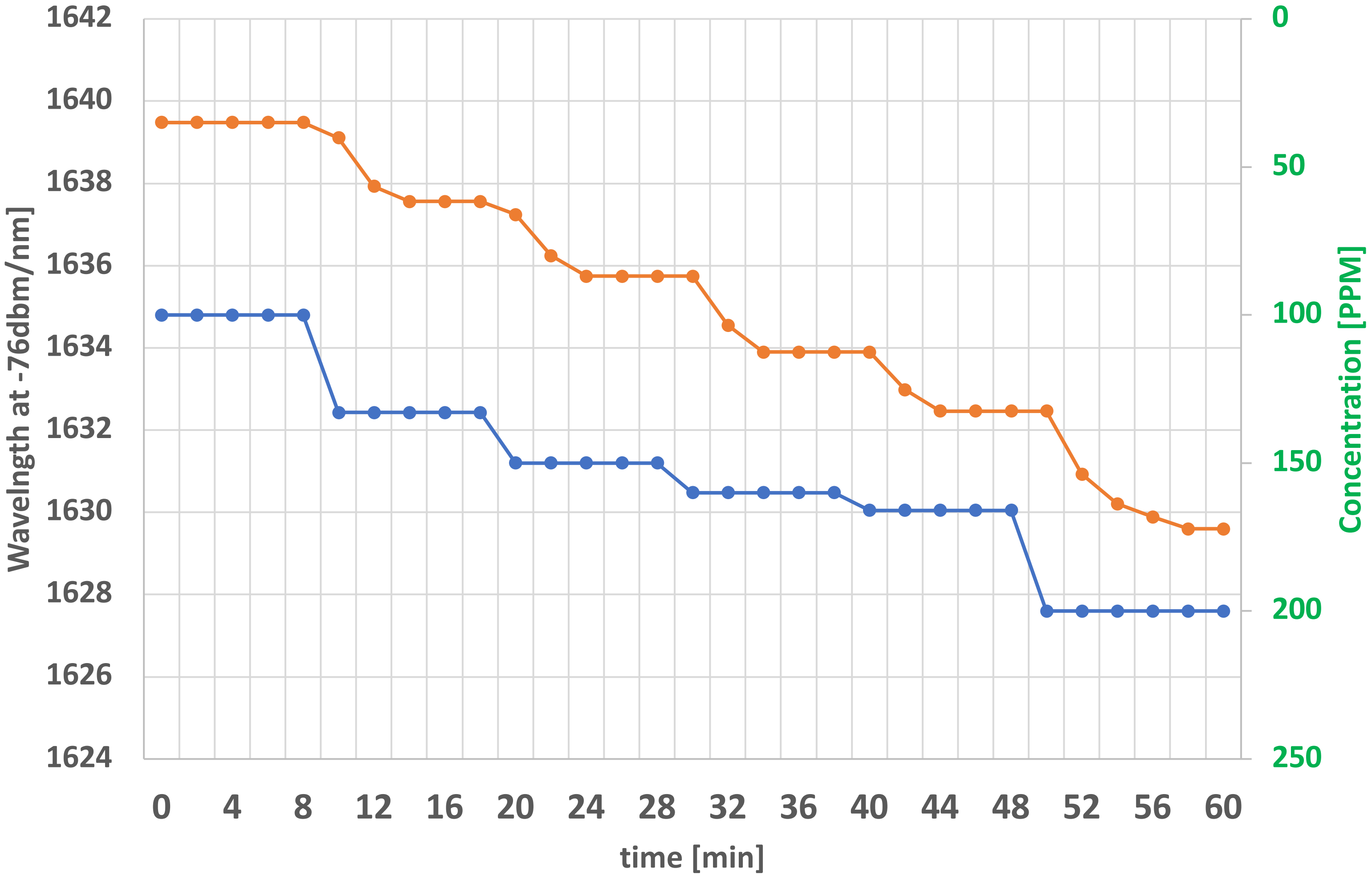
Methane sensor response





Methane sensor response

- **Sensitivity of 0.1ppm/nm**
- **Detection limit of 5PPB**
- **Response time of 3S**

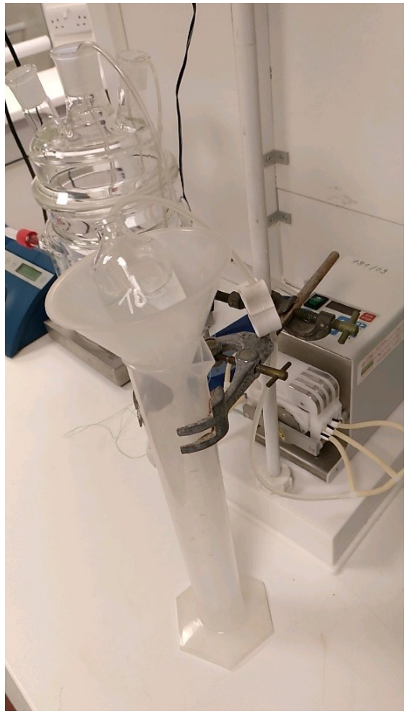


CALIBRATION

Dissolved greenhouse gas measurements via headspace (HS) generation and sampling

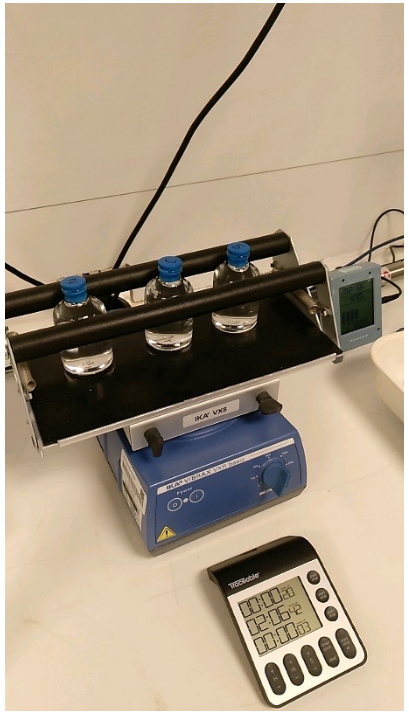
Standard preparation by bubbling a set gas mix through water

Known sample volume sealed in crimped glass vials with rubber bung



HS injection of defined volume (N_2)

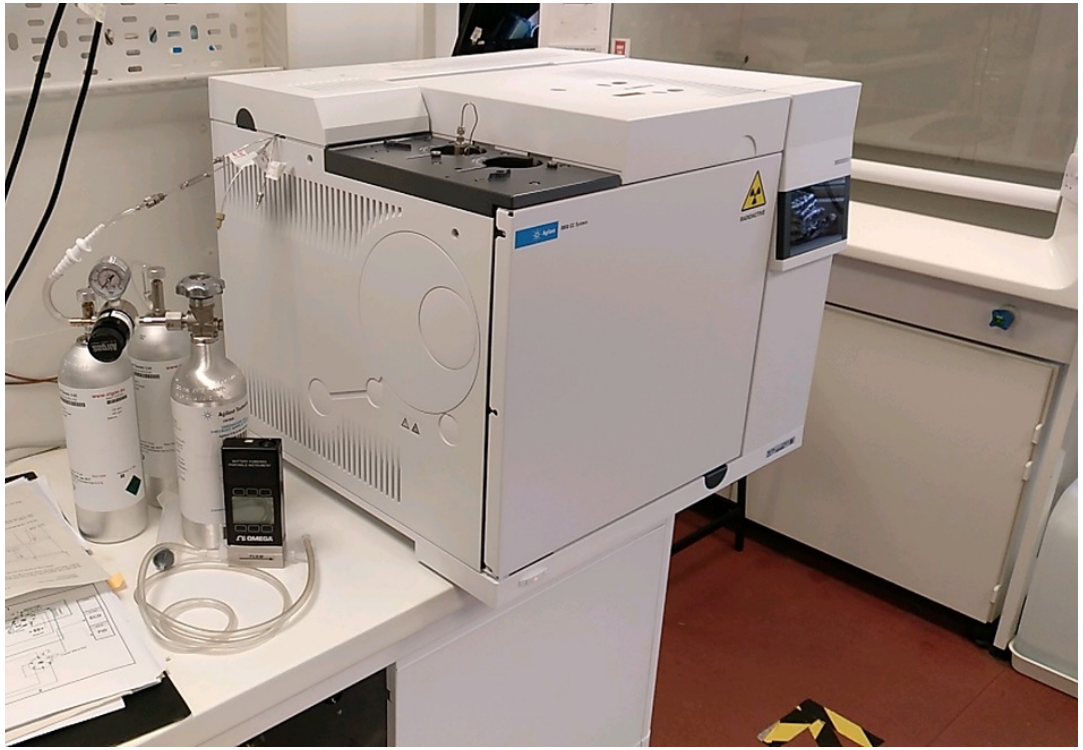
HS equilibration with a water sample



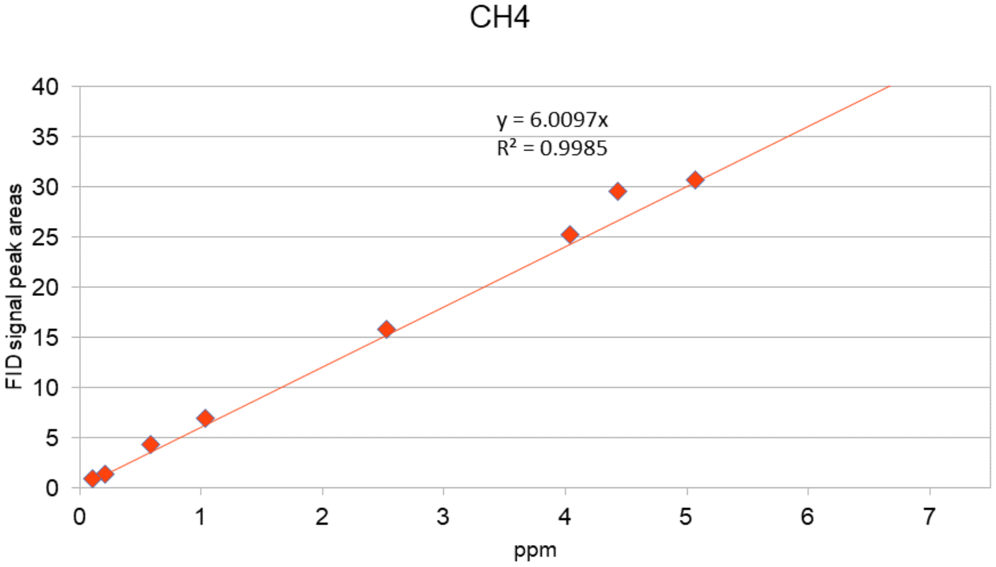
Sampling of HS with gas-tight syringe for injection into GC

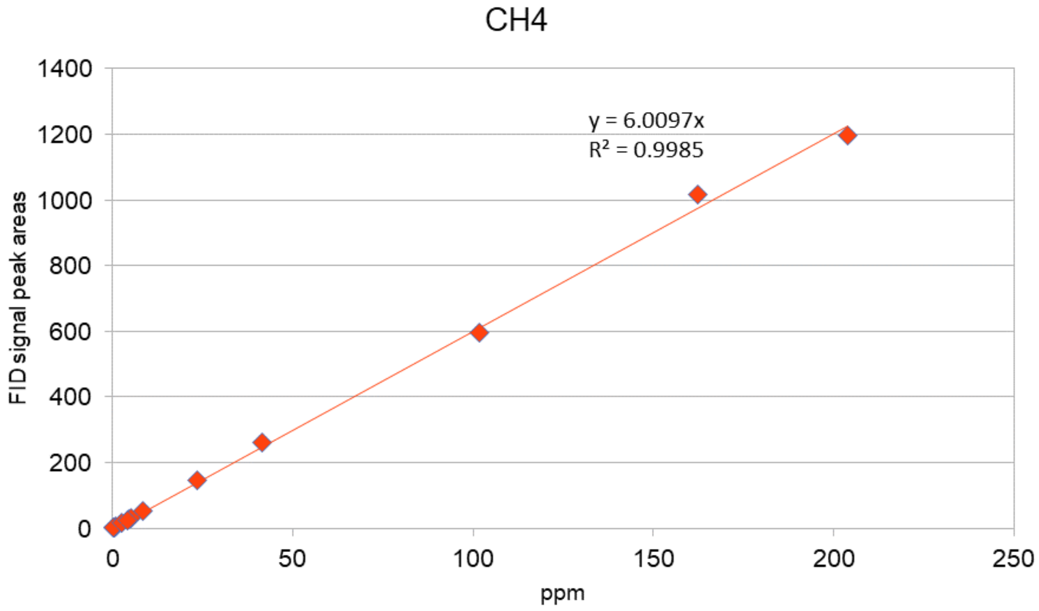
This procedure needs many (tricky) handling steps for each sample and many parameters monitored (time, T, p, V,)

MEASURING METHANE, NITROUS OXIDE, AND CO_2 IN THE GAS PHASE

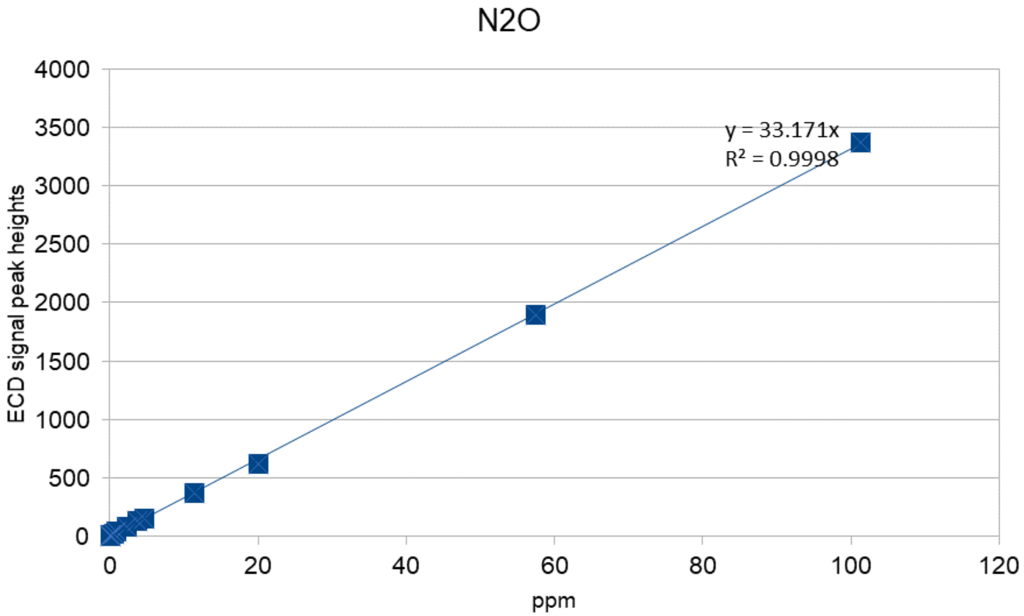


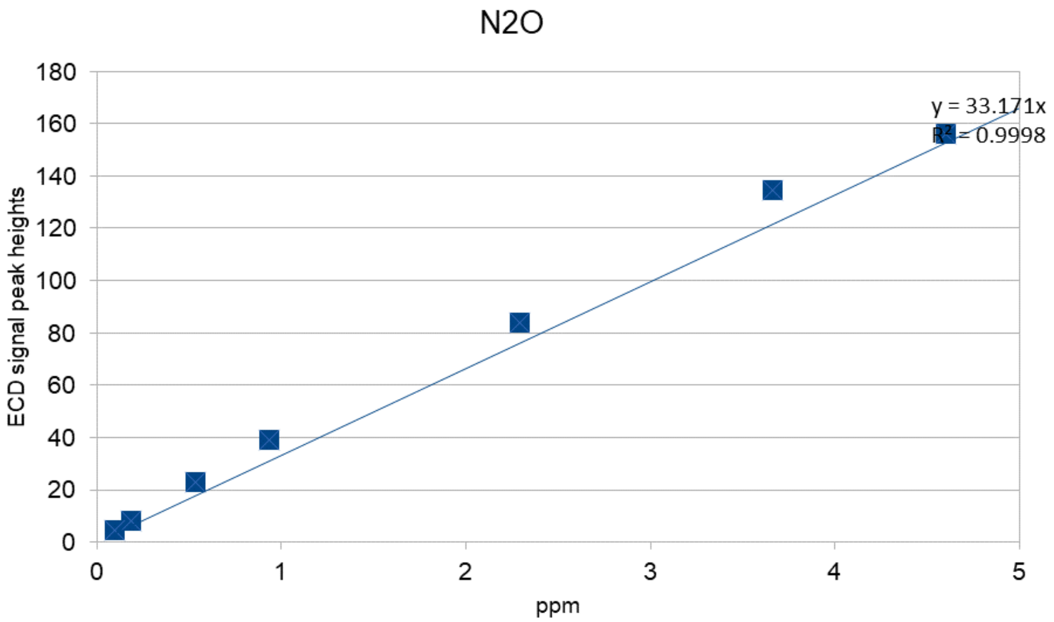
Greenhouse gas analyser (Agilent 8860 GC)





CALIBRATION OF GC FOR N_2O (ATMOSPHERIC ~0.3 PPM)

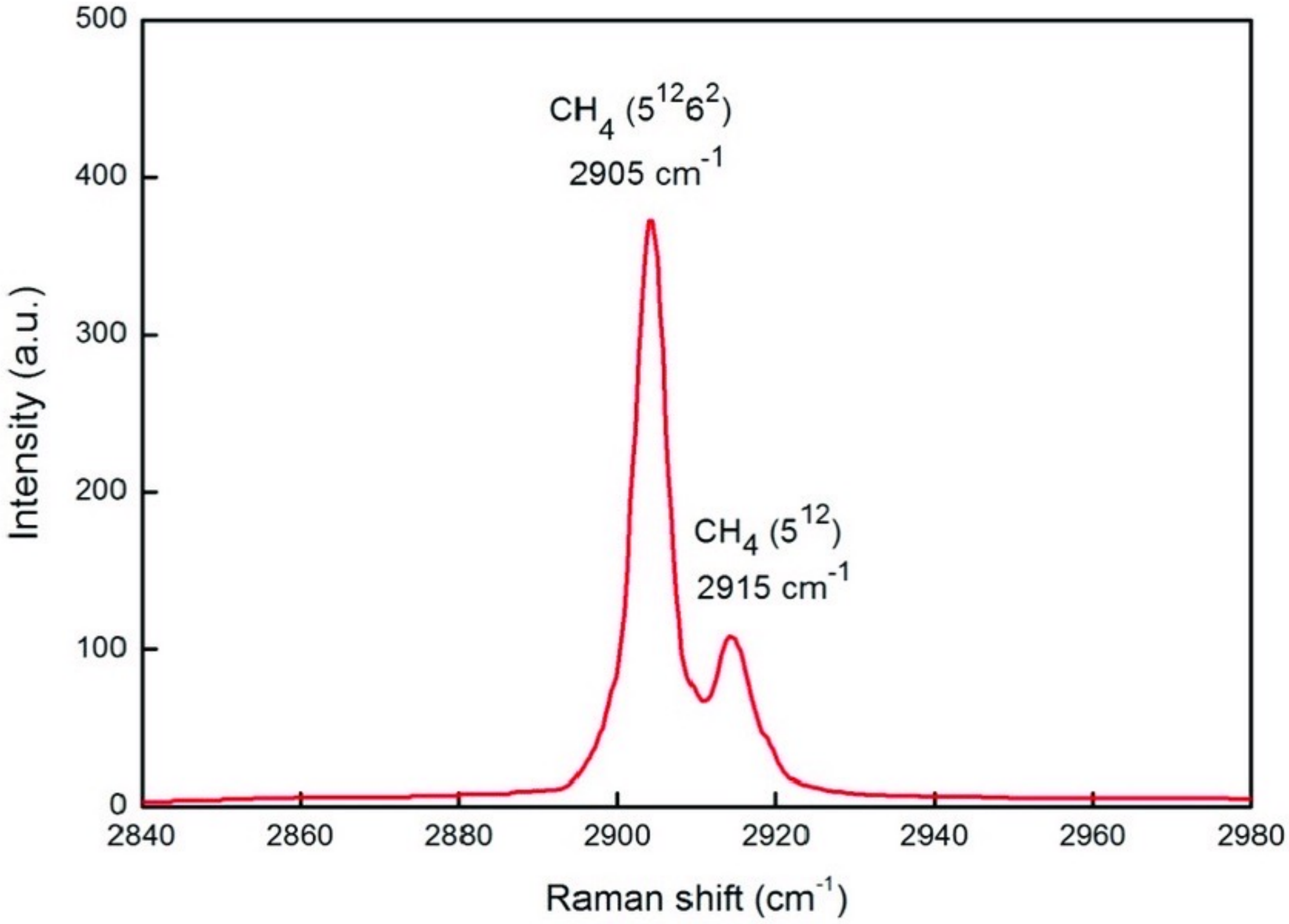




complete range of N_2O concentrations using 5ppm and 500ppm N_2O cylinder and the gas mixing rig.
LOD <0.1ppm

NEXT.. RAMAN SPECTROSCOPY FOR ISOTOPES (ON CHIP)

- Raman is another type of spectroscopy.
- Does not see water
- Weaker than IR
- Can confirm identity
- Single illumination wavelength.



National Oceanography Centre

CONCLUSIONS

Photonics WILL play a vital role in ocean sensing soon.

Proof of concept demo for photonics rigidity.

Focus the fabrication on the application

What can we do to accelerate this revolution?

NERC funded technologies?

FROM TWO WORLDS


OTE NOC


Fibres and sensors ORC

Life Cycle Assessment for a Resilient Silicon Supply Chain

Prepared for Photonics for Environment and Sustainability Webinar

11th December 2023

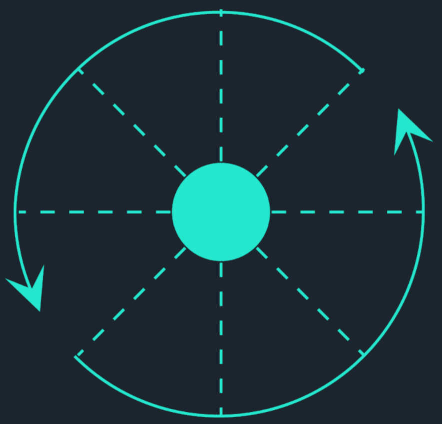
Prepared by: Alacacayir, S., Lindsay, J.

Agenda

Photonics Webinar

About us

Science-based solutions for long term value, risk reduction and a more sustainable planet.



Internationally recognised framework & best practise

Expert consultancy & LCA software

Global reach & business support

Who are Minviro

Minviro is a specialised service and technology company that applies life cycle assessment approaches in evaluating and mitigating the environmental impacts for mining and metals projects.

2023

SECURED INVESTMENT

In 2023, we secured financial investment securing our future

3

GLOBAL REACH

Located in Australia, China and London with over 40+ employees

125m

EXTENSIVE EXPERIENCE

We have measured more than 125 million tonnes of carbon

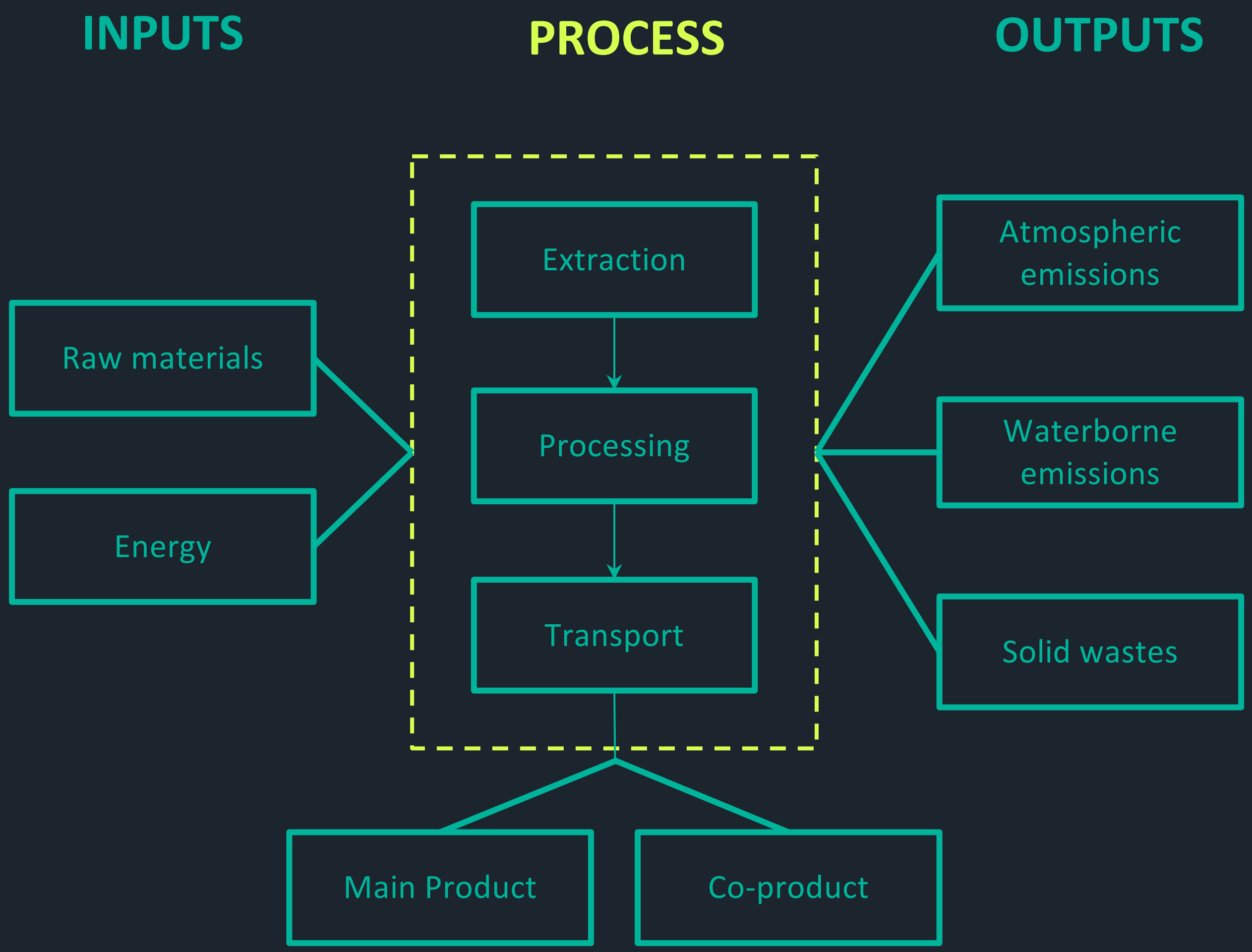
200+

SUCCESSFUL PROJECTS

Our experience includes collaborating with elite and upscale clients

Environmentally informed decisions

- Inventory of environmental impacts tailored for mining processes from extraction to final production.
- ISO-Compliant → ISO 14040-14044 and ISO 14067 standards.
- Impact hotspot identification and mitigation.
- This is the only way to ensure that the raw materials for the low-carbon economy are sourced at minimum environmental impact.



Measure what matters

Climate Change

Ozone Depletion

Human Toxicity

Particulate Matter, Respiratory

Ionising Radiation, Human Health

Photochemical Ozone Formation

Acidification

Eutrophication

Ecotoxicity Freshwater

Land Use

Water Scarcity Footprint

Resource Use Minerals & Metals

Resource Use, Energy carriers

MINVIRO

We Measure

Photonic materials are critica

Criticality

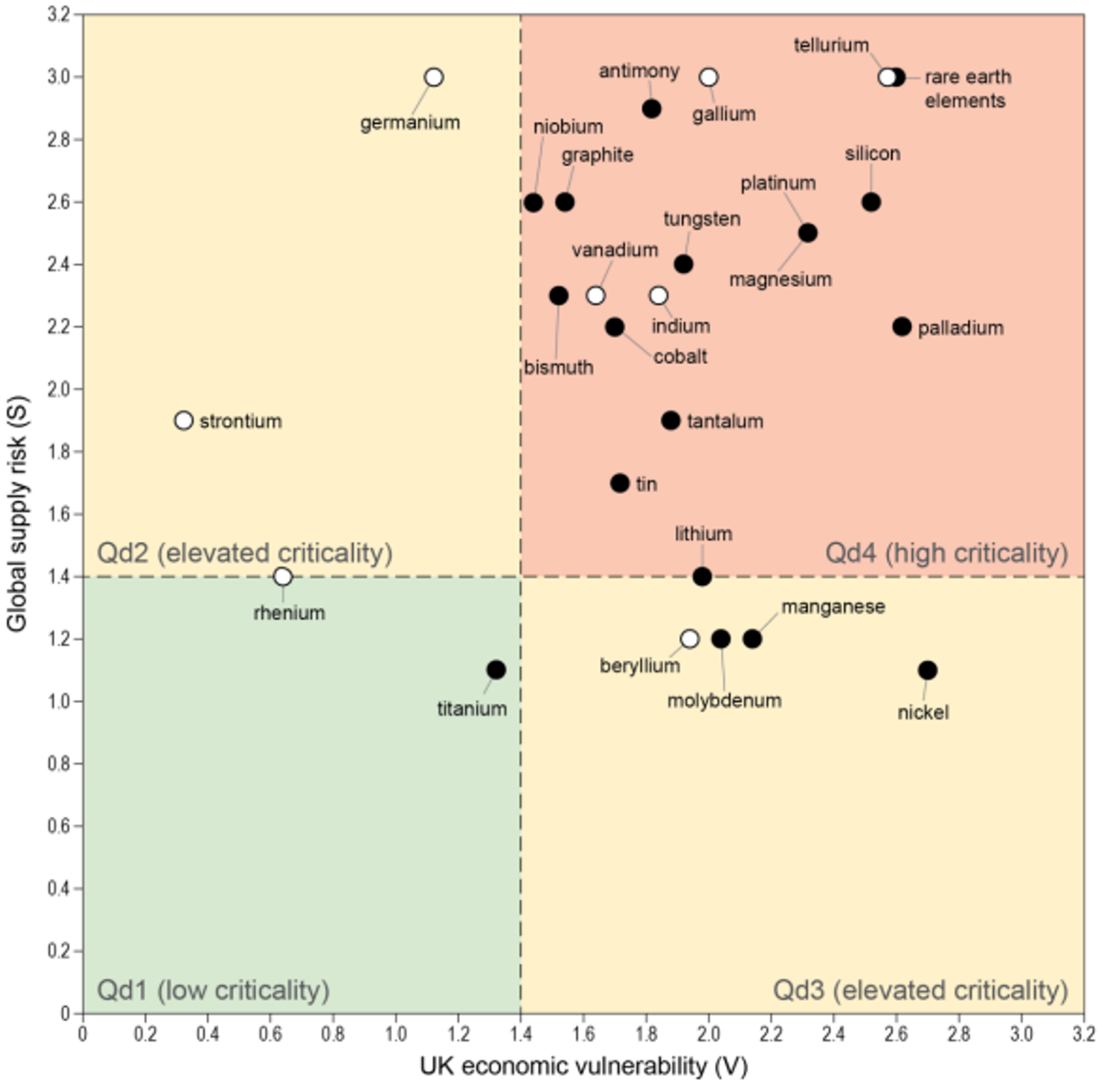
Horizontal axis of the matrix reflects the economic vulnerability of the UK and the vertical axis reflects the likelihood of supply disruption.

Photonic materials

Silicon, gallium, graphite are some other materials that have applications in different photonic technologies are among the most critical metals.

Dynamic systems

This is **not a static matrix**, emerging technologies and global politics will add new materials in this list and some of them might be dropped from 'criticality' in the future.



The case of silicon

Electronics

Integrated circuits, printed circuit boards, semiconductors and other electronic devices are produced by high-purity silicon crystals.

Silicon-Anode Batteries

Replacing Graphite with Silicon for battery anodes boosts the capacity, charging rate and reduces the overall costs.

Solar Energy

Silicon wafers are used to manufacture solar cells & panels due to their semiconducting properties.

Silicone Manufacturing

Silicon is used to manufacture silicone, applied in rubber sector, casings, and medical industry.

Some issues

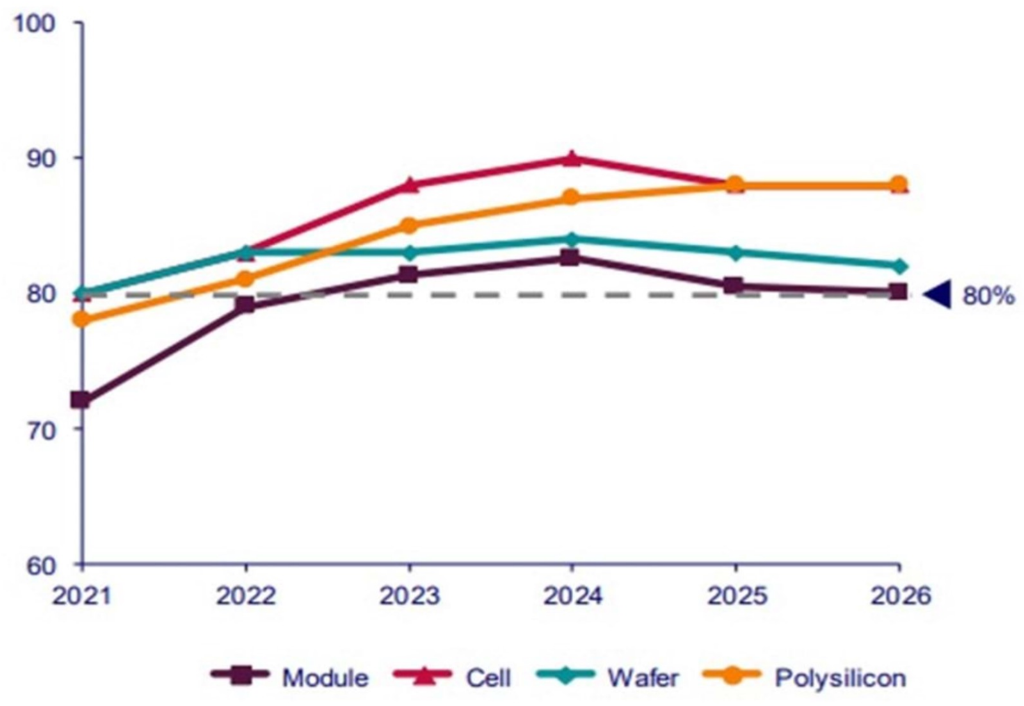
The demand growth is exponential and is expected to increase more in the future, meaning more pressure on the environment and businesses to deliver sustainable resources.

Europe and the UK currently rely on imports of polysilicon and wafers from China, highlighting the urgency to develop a more resilient supply chain through increased recycling efforts and alternative routes. However, none of these routes are cost competitive to matured Chinese manufacturing industry.

Unfortunately, this particular supply chain is not only concerning in terms of environmental pressure, there are also significant human rights issues through certain geopolitical conflicts in different regions around China, making the upstream value chain more vulnerable.

The World's Most Vulnerable Supply Chain Impacts All Supply Chains

China production capacity share by component, 2021-2026



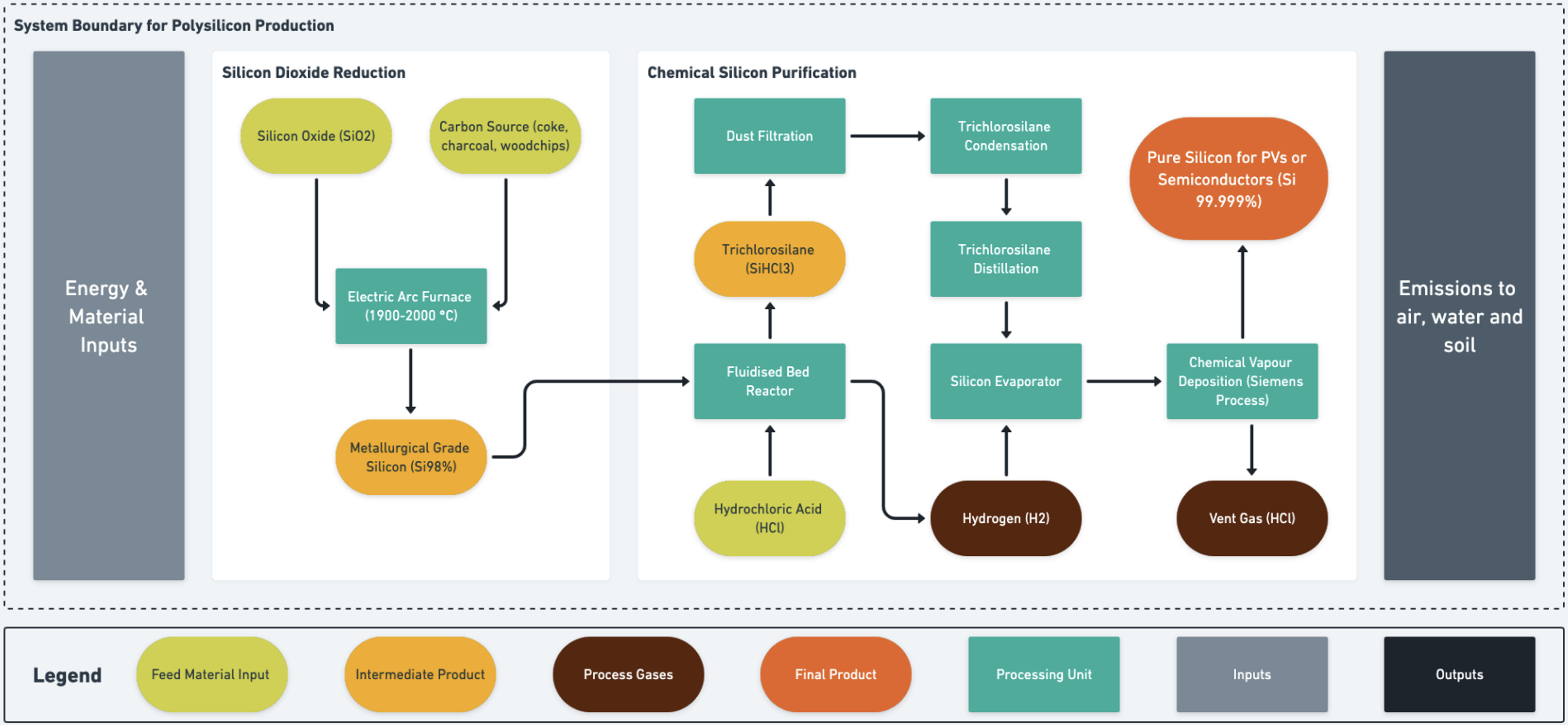
Source: Wood Mackenzie

MORE THAN

80%

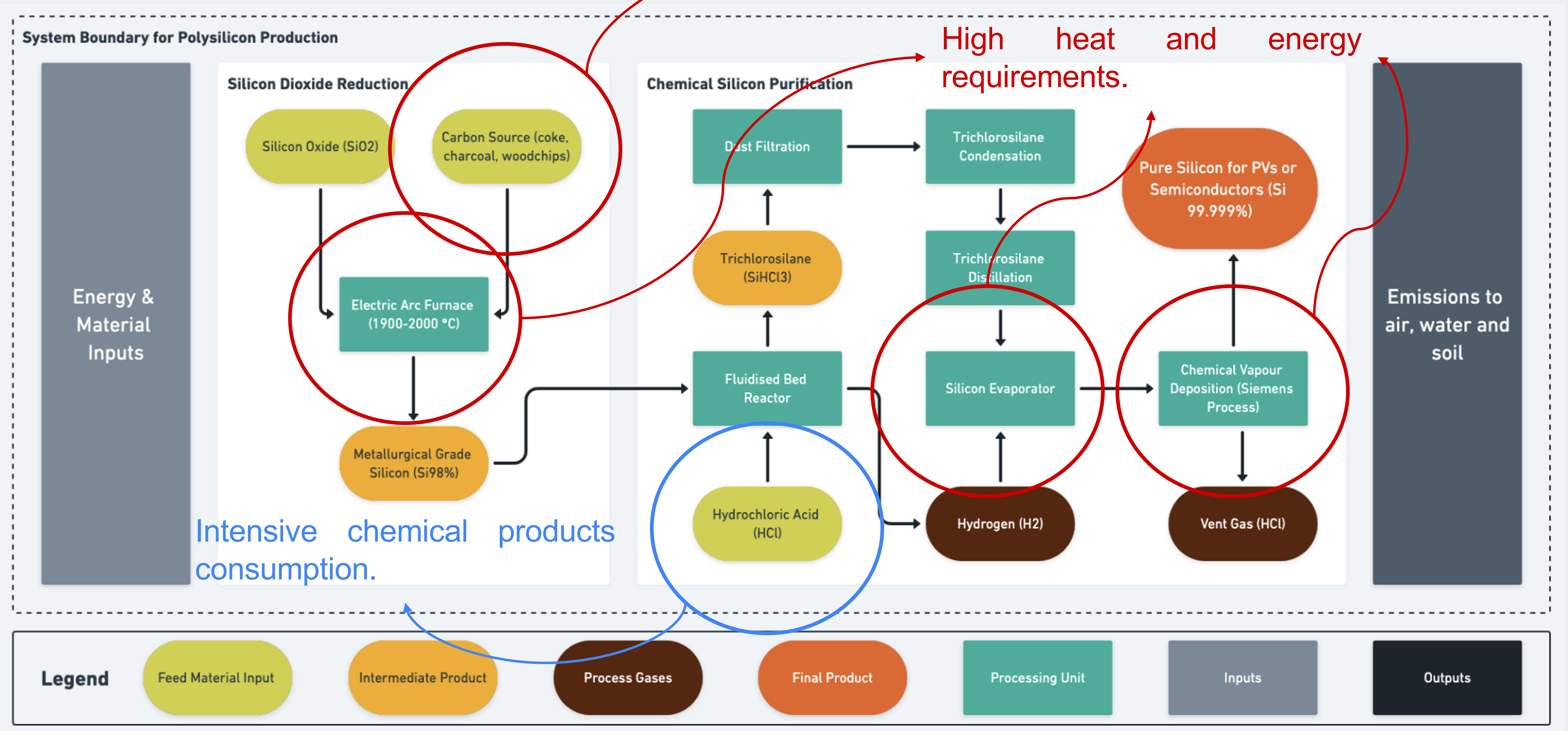
OF THE ALL MANUFACTURING STAGES OF POLYSILICON ARE DOMINATED BY **CHINA**

Polysilicon Production Route



Let’s zoom in

Direct CO_2 emissions from combustion of petroleum coke, and other carbon sources.



Raw material production matters

Production origin can double or halve the overall impact

Impact drivers

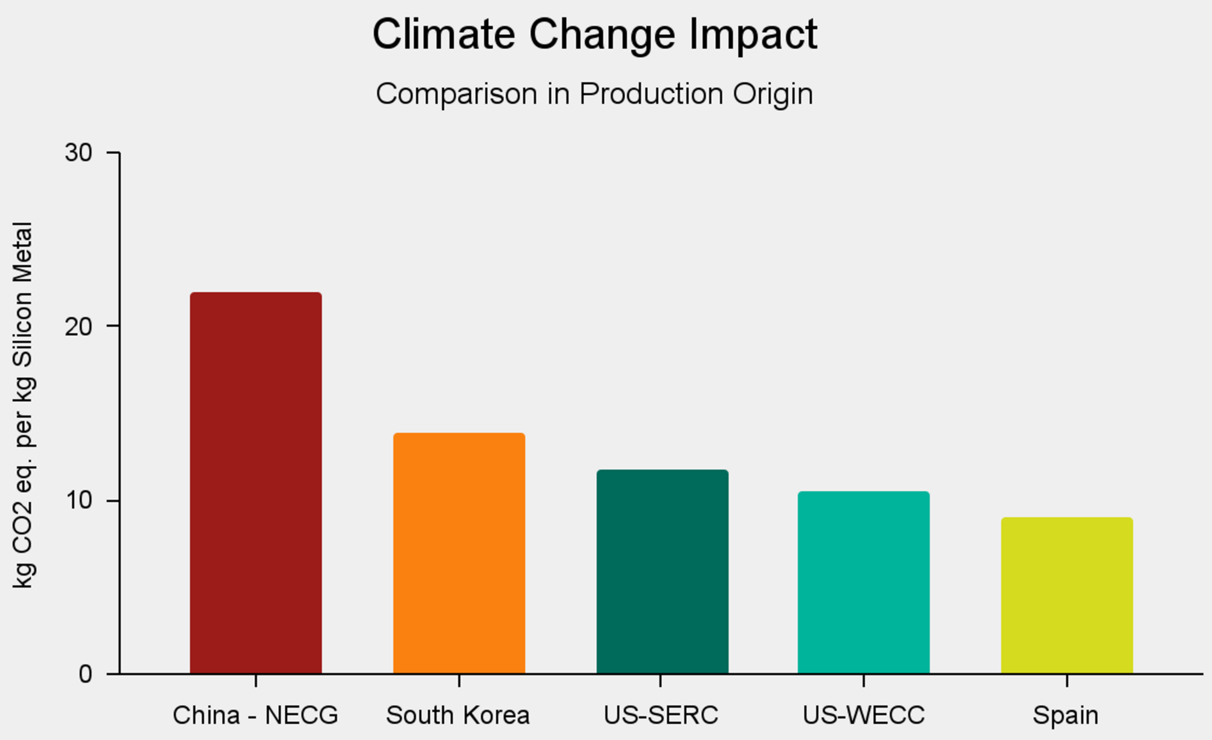
As discussed, the impact of the production is mainly driven by the direct carbon emissions and energy consumption of the process. That is why, the **carbon intensity of the electricity source** has a significant impact on the overall climate change impact. Integrating renewable, low-intensity energy sources into the production process is the main impact reduction tool that we can implement now.

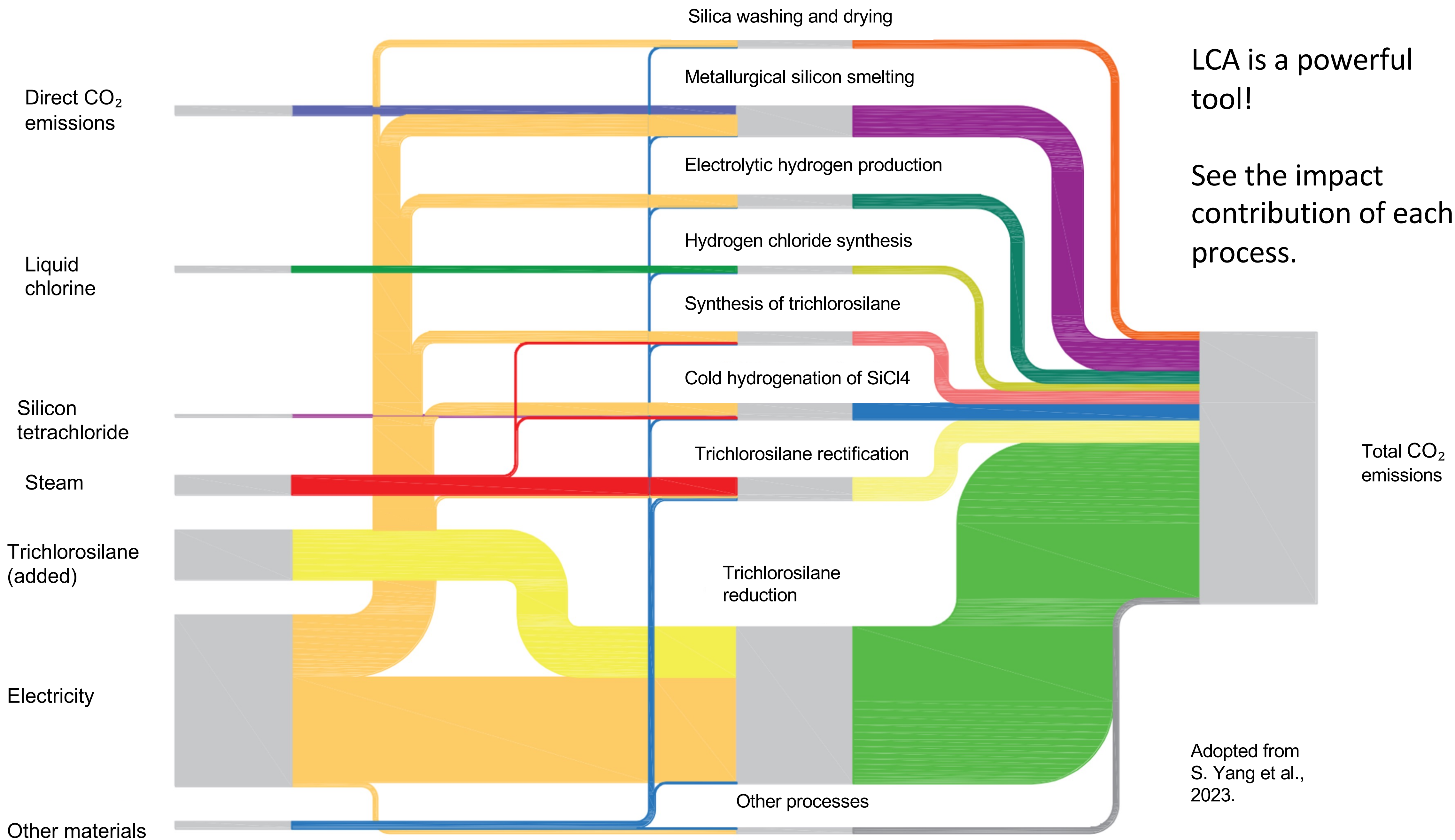
Functional unit

1 kg silicon metal produced via carbothermal reduction of quartz and fossil-based materials

System boundary (cradle-to-gate)

Starting from raw material production to final product recovery.





LCA is a powerful tool!

See the impact contribution of each process.

Adopted from S. Yang et al., 2023.

Different Applications of LCAs

What can you do with the LCA data?

Concepts → Sustainability Applications → Outputs → Value Generation

Concepts

- Life Cycle Thinking
- Sustainability Literacy

Sustainability Applications

- Sustainable Business Models
- Circular Economy
- Eco-Design & Product
- Digital Twins

Outputs

- Process Efficiency
- Impact Reduction (Scenario analysis)
- Impact Reports and Claims (Communication)
- Production Routes (Comparison Scenarios)

Value Generation

- License to operate
- Investment
- Stakeholder engagement
- Marketing
- Sustainable reporting
- Sustainable action plan

Raw material data unlocks downstream sectors

The earlier the better

80% of a project's impact are fixed in the design phase

DESK STUDY → EXPLORATION & FIELD STUDY → PRE-FEASIBILITY STUDY → FEASIBILITY → CONSTRUCTION → OPERATION → CLOSURE

Impact the decision before significant capital expenditure

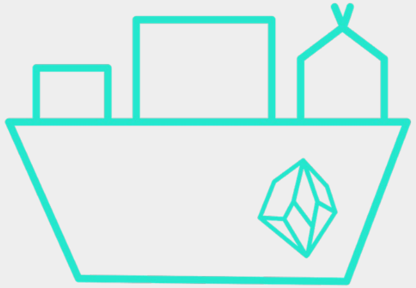
Greater certainty about the benefits of choices

Some of Minviro's projects

Objectives:

Here at Minviro, we believe in diving deep into the ***raw material production*** *processes of energy transition technologies and providing valuable insights into suitable environmental* ***impact mitigation*** *strategies. That is why, providing data and solutions for* ***a sustainable silicon supply chain*** *ecosystem is one of our focus areas.*

Key focus areas



Enabling scaling up of secondary resources supply through **industrial symbiosis**.

Integrating different pillars of sustainability through **Life Cycle Sustainability Assessments**.

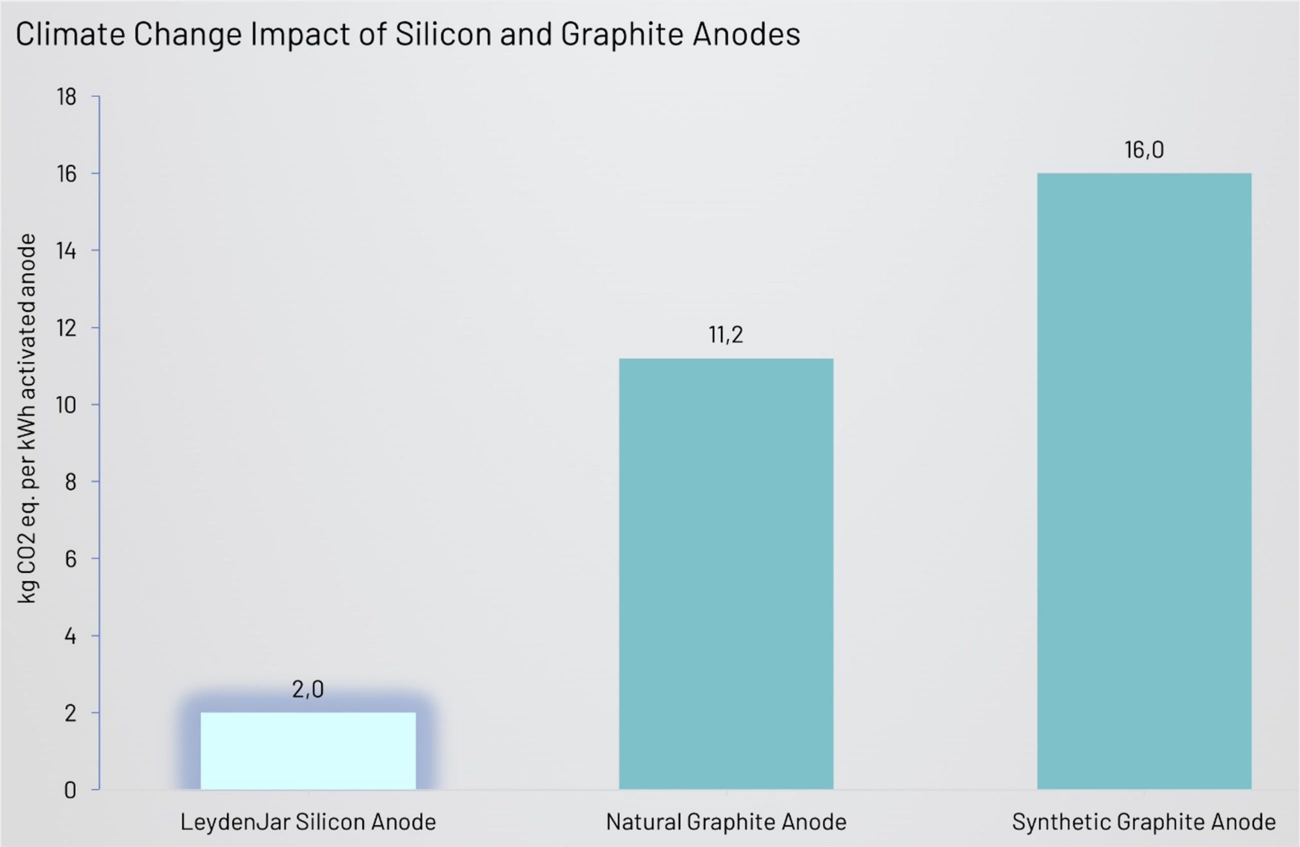
Providing state-of-art, **reliable LCA data** to the industry and decision-makers.

Silicon Anode Case Study

Silicon anodes can reduce the battery impact up to 85%

The key outcome of the study is that LeydenJar's **pure silicon anode** achieves a lower climate change impact than existing graphite anodes, emitting only **2.0 kg of CO2-e per kWh** of activated anode.

In contrast, synthetic graphite anodes emit up to 16.0 kg CO2-e per kWh; natural graphite anodes up to 11.2 kg CO2-e per kWh. The **reduction of up to 85%** pitches LeydenJar's silicon anode as an essential building block for a low-emission battery ecosystem.



LeydenJar Technologies 2023 Press Release

Conclusion

01 Photonics material supply chains have high environmental impacts and are vulnerable to geopolitical risks

02 Silicon is a critical material, enabling key technologies to develop and its production is dominated by China

03 LCA provides valuable insights into the whole value chain, letting us quantify the whole range of impacts transparently

04 Recycling and industrial symbiosis will play a crucial role in securing the decarbonisation of energy and transport sectors

05 Integrating the environmental decision-making early into the project development is incredibly useful

Future Perspectives

01 Sustainability does not start with LCAs and does not end with them. Trade-offs between different sustainability decisions need to be investigated

02 LCA is a useful tool, but having high quality data is more important. More research and collaboration are needed to make the data available

03 We have so many solutions to implement, from digitalisation to developing new business models. Understanding life cycle thinking is a key solution for innovation

MINVIRO

Thank you!

Let’s get in touch

sahin@minviro.com

SCAN THE QR CODE TO FIND OUT MORE

University of Glasgow

THE AWARDS 2020 | UNIVERSITY OF THE YEAR

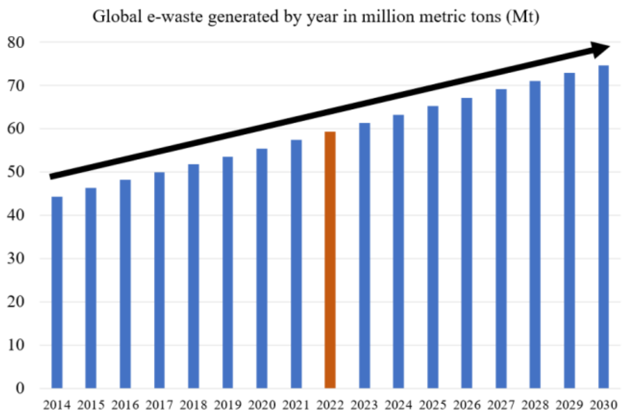
Evaluation of the environmental Impact within photonic devices

Prof Jeff Kettle,

James Watt School of Engineering

WORLD CHANGING GLASGOW

Why sustainable electronics & photonics?



Source: Global e-Waste monitor, ITO, 2020

- **Waste;**

- 53.6m tonnes globally in 2020, <20% collected and recycled
- 66 countries covered by e-waste legislation in 2021
- 41 countries have official e-waste statistics
- WEEE is the fastest growing waste sources in the world

- **CRMs Critical Raw Materials**

- are required in eg batteries, power electronics, photonics, and the UK is almost 100% reliable on imports (national security!)

- Materials such as Au, Ag, Pt, Pd, Ga, Sb

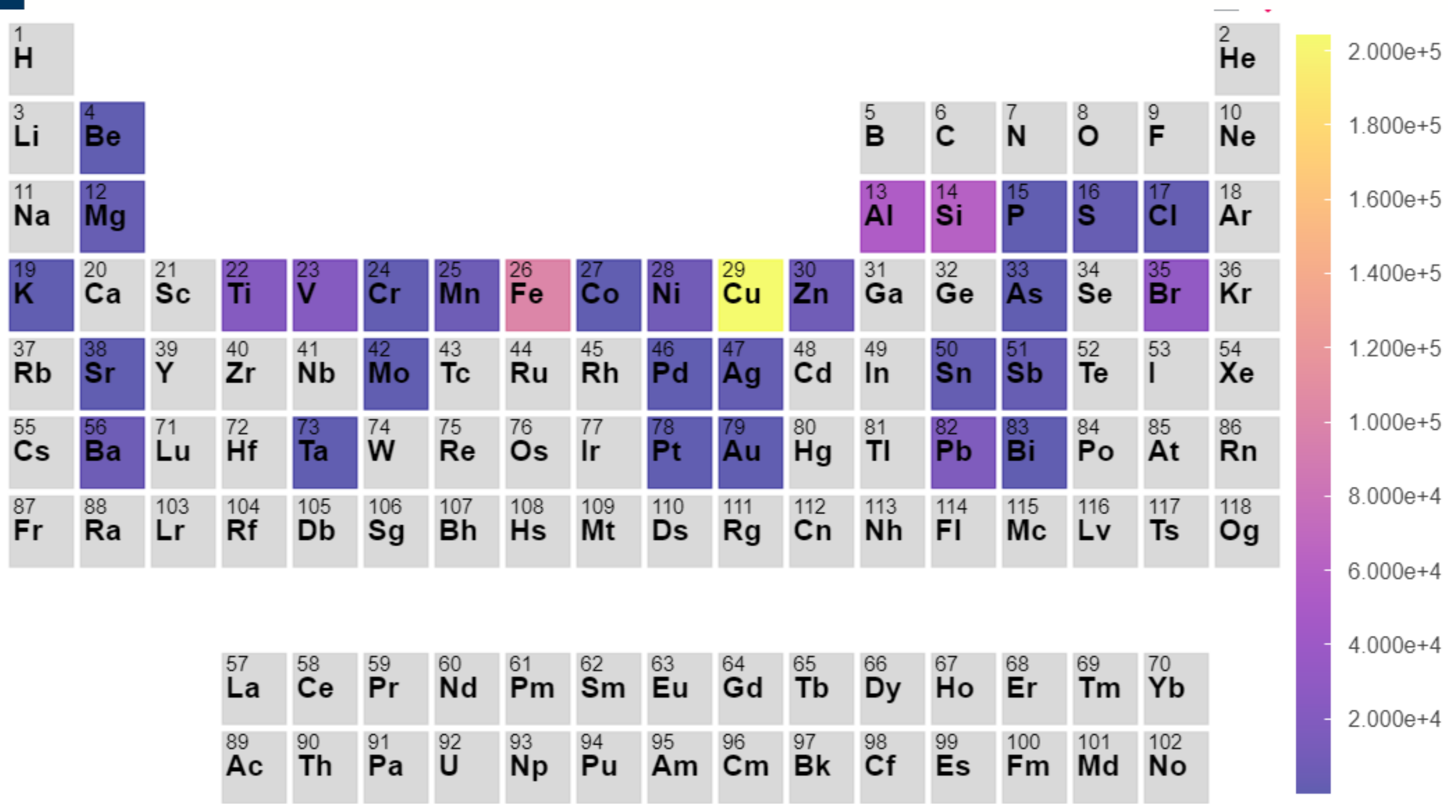
Export of e-waste

- **Emissions**

- Electronics one of the top 8 sectors that account for more than 50% of global carbon emissions, mostly attributed to the supply chain (77%) including production, manufacture, assembly, and transportation + circular economy, reuse, repair, redesign

University of Glasgow

E-waste = WEEE = photonic waste



Others by weight

Ferrous metals – 40%
Aluminium – 5%
Copper – 5%
Plastic -20%
Glass – 10%
Others – 5%

Automation?

ournal on *Flexible Electronics*, *1*(1), 4-23, 2022

- cooling and freezing equipment - refrigerators, air conditioners, heat pumps, *photovoltaics*

- Screens, monitors televisions, laptops, notebooks, tablets

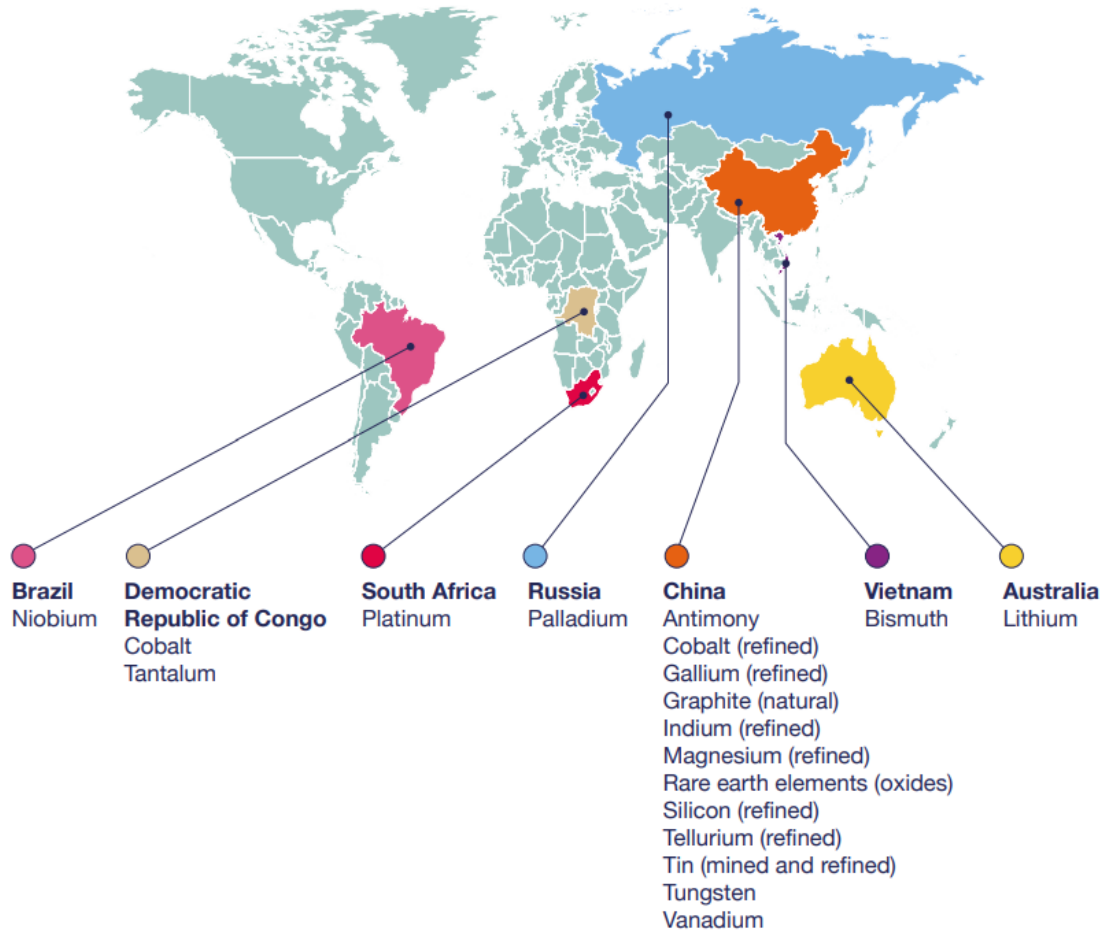
- fluorescent lamps, high intensity discharge lamps, LED lamps

- washing machines, dryers, large copy machines,

- vacuum cleaners, microwaves, toasters, electrical and electronic tools, medical devices

- Phones, printer, laptop, tablet, ICT equipments

The United Kingdom's Critical Minerals Strategy

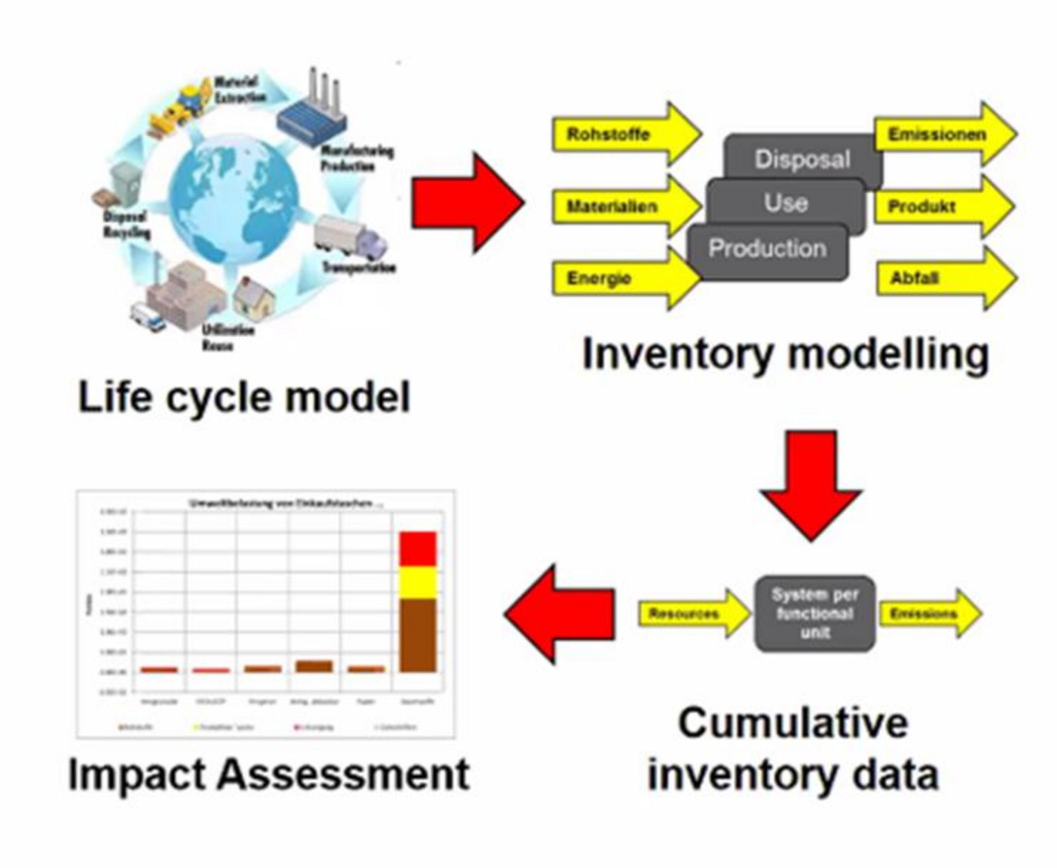


Source: Data from the UK Critical Minerals Intelligence Centre, 2022

Critical **Photonics** metals (from a UK perspective)

Antimony	**Bismuth**	Cobalt
Gallium	**Graphite**	**Indium**
Lithium	Magnesium	Niobium
Palladium	**Platinum**	**Silicon**
Tantalum	**Tellurium**	
Tin	**Tungsten**	**Vanadium**

How can we measure environmental impact

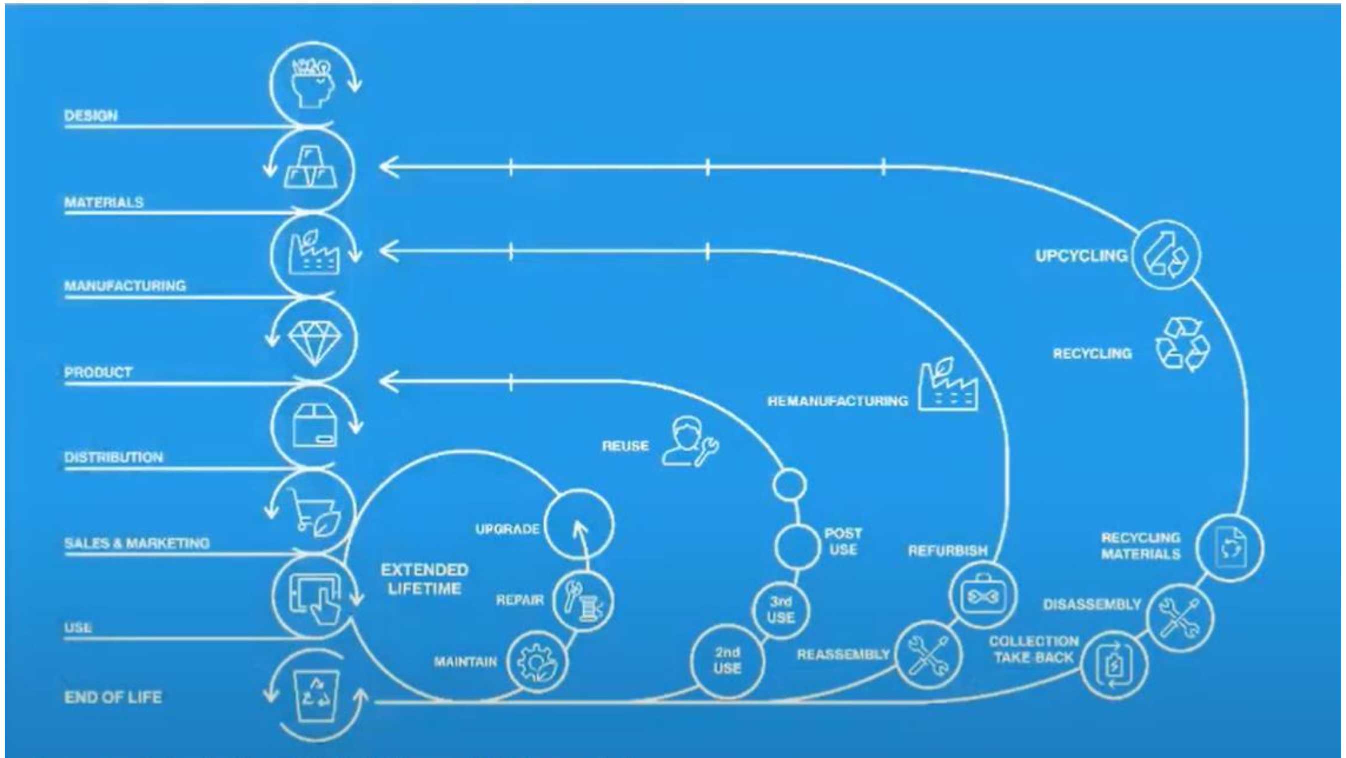


Source: Roland Hischier, EMPA

- **LCA is a Comprehensive approach** that quantifies ecological and human health impacts of a product or service over its complete life cycle
- **LCA uses credible scientific methods** using specialist software which contains databases with environmental impact information for standard procedures
- **LCA helps decision makers** to understand the scale of the many environmental and human health impacts of competing products, services, policies etc
- Gabi – rare metals and electronic components

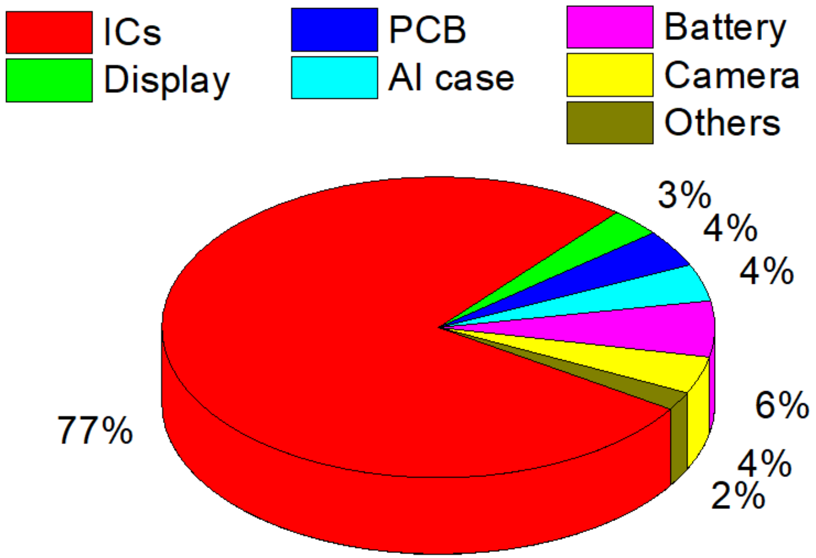
Circular design of electronics & photonics?

• Specifically characteristic for EEE with increasing consumption, short life spans and not energy efficient
• Most WEEE today designed without considering recycling and even less to be eco-efficient, repaired, reused, remanufactured or refurbished



Source: Fraunhofer IZM (T Jokinen, M Marwede)

LCA of a google watch



-Division of LCI results show the manufacturing phase in baseline scenario in GWP ~80-90% in most impact categories
-Highest proportion of consumption in the Ics (around 80%)
-Nanofabrication processing has the most significant impact
-Uncertainty on displays, ICs, materials, processes etc
Usage becomes more important for 24/7 kit

Reducing the Impact of Photonic devices and systems

- **Design for repair**: spare parts availability and time frames
- **Design for upgradability**: being able to upgrade a product as customer's needs or technology changes
- **Design for reliability**: create products that last longer, clear product level reliability targets, e.g. resistance to accidental drops for mobile devices
- **Design for dematerialization**: reducing the overall size, weight and number of materials involved in a design - additive manufacturing
- **Design for disassembly**: a product is designed so that it can be easily and cost effectively taken apart at the end of life, including marking on materials
- **Design for recyclability**: using materials in the design which can be recycled and recycling processes exist, marking of materials to facilitate manageable waste streams

Particular challenges in Photonics

Very little data on photonics components (LEDs, lasers, sensors, fibre oprics) – semiconductor processes, epi growth, packaging – product footprint, fate

Still developing infrastructure and technologies for WEEE recycling

- Wide variety of photonics devices - LED lamps/LCDs – different materials, sizes..
- Photonic waste is very diffusely spread
- WEEE quality is reducing – less Au and Pd. Economics has driven material changes in electronics
- Three materials in PCBs are economically viable to recover (Au, Pd, Cu and Ni) – Au In photonics
- Few metallic recovery facilities in the UK

Poor recycling of many critical elements e.g. Ga, Ge, Nb, In, Sb, rare earth elements

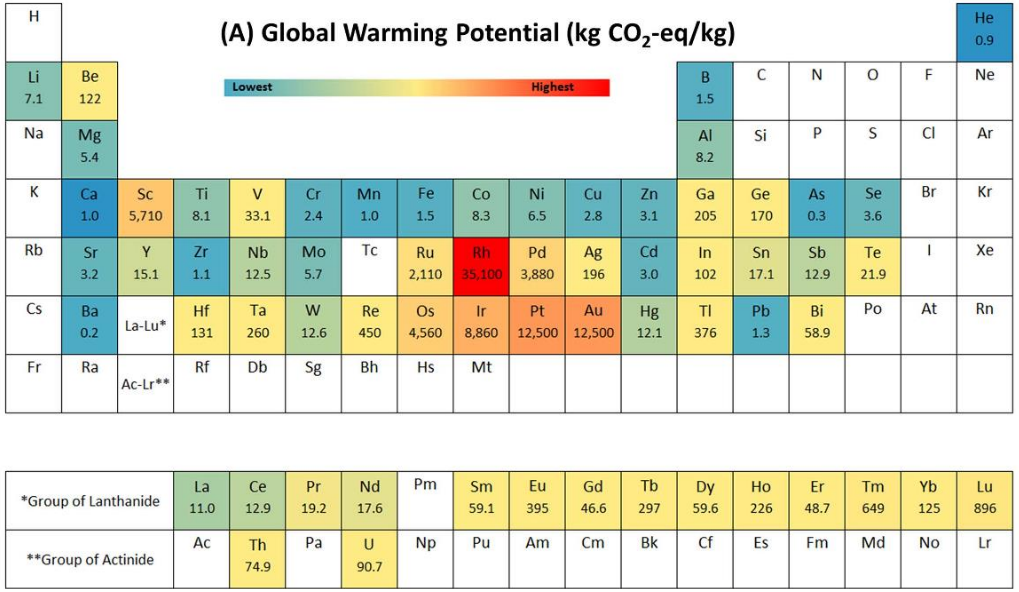
- low concentrates of some critical raw materials in WEEE and undeveloped recycling processes

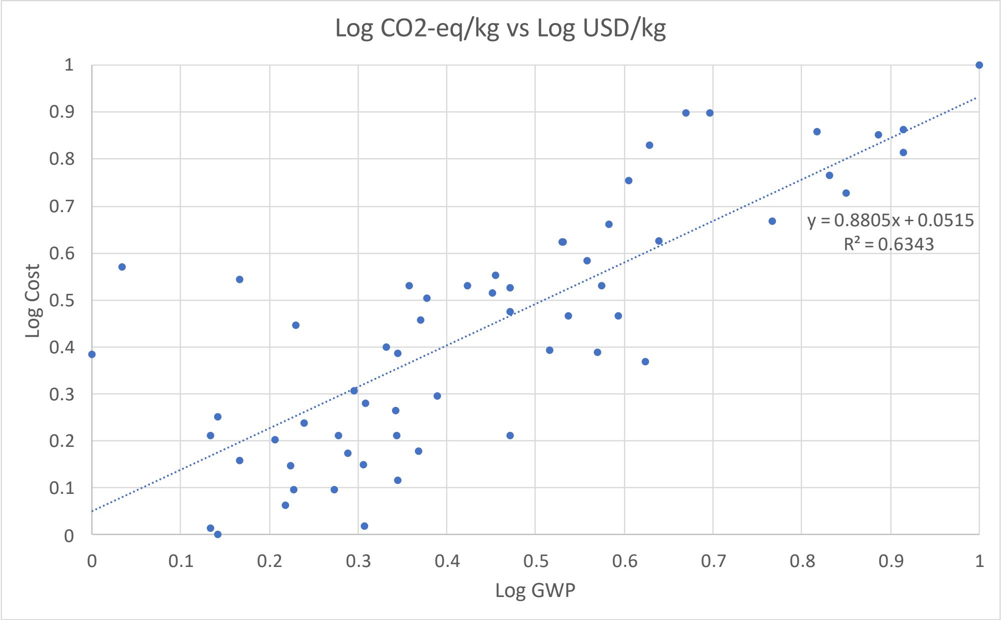
Lower impact vs lower reliability/performance

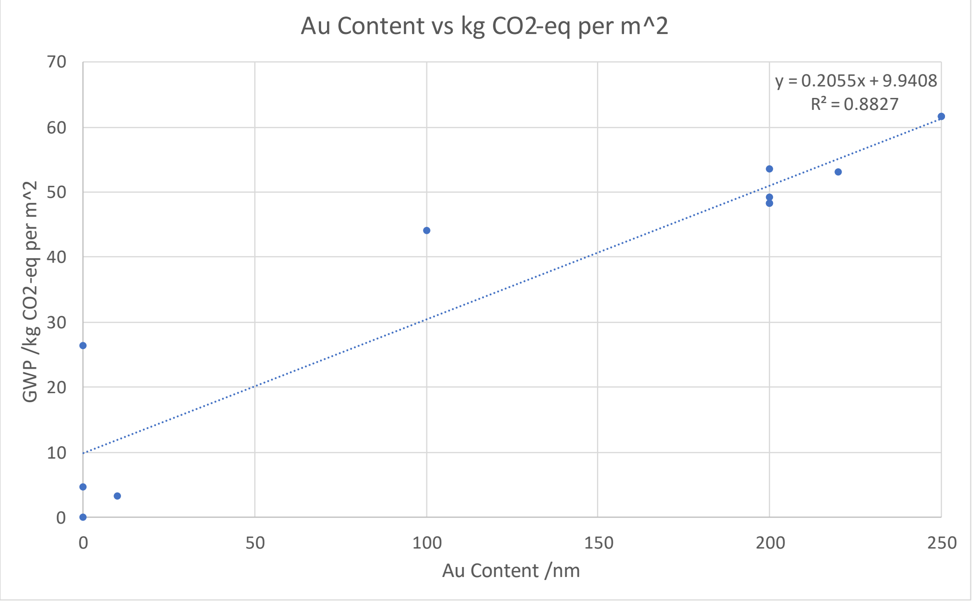
ICT power consumption

Metals in electronic & photonics

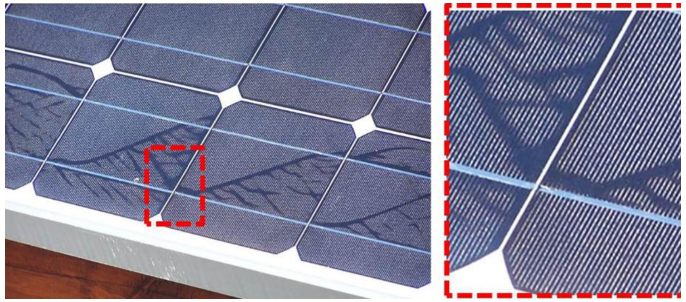
- 63 metallic elements + He
- Considered cradle-to-gate environmental burden
- Five output parameters (GWP, CED, TA, FWE, HT)
- TA, FWE, HT less well investigated due to limited LCI data relating to tailings
- Where metals are co-produced, impact allocated based on economic value







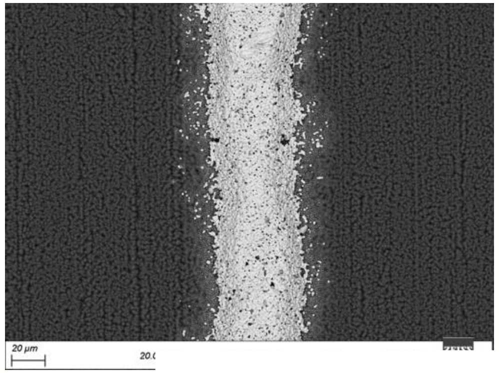
Metals recovery

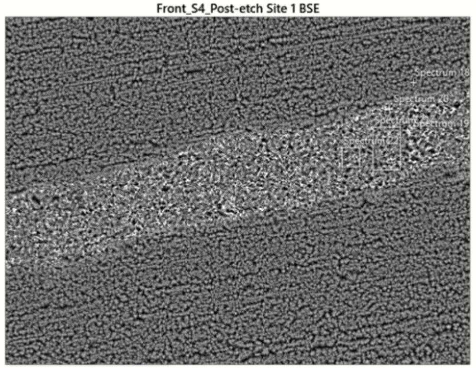


Ultrasonic Frequency : 40 kHz
Power Supply :70 W
Power Density : 0.035 W·cm− 3

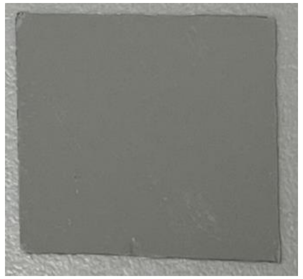
Project PI - *Prof Andy Abbott*, K Ryder, Univ of Leicester, *A. Feeney*, P Prentice, Je Kettle, University of Glasgow

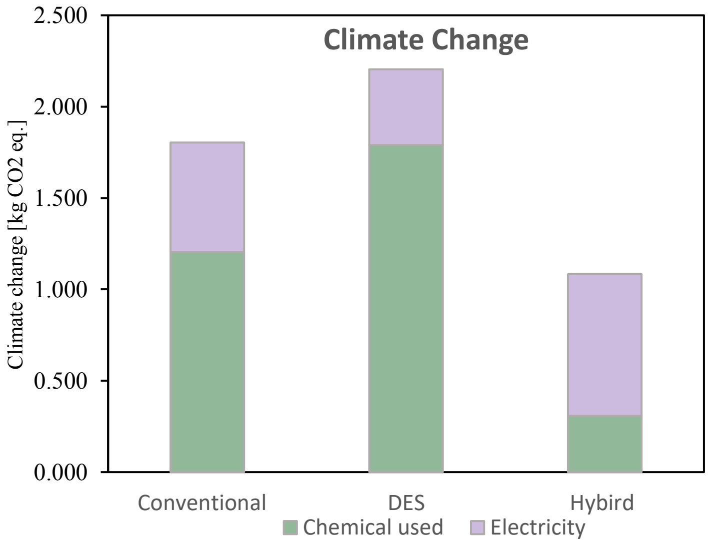
Before & After



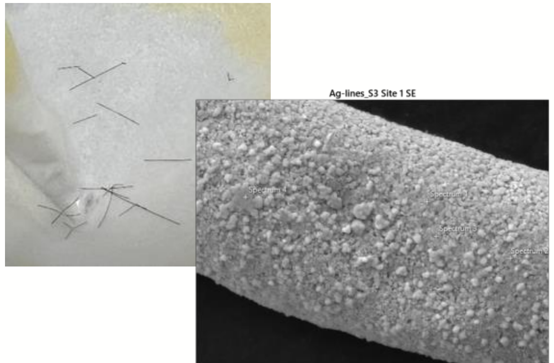


First leaching step : Using **2M** NaOH :70°C



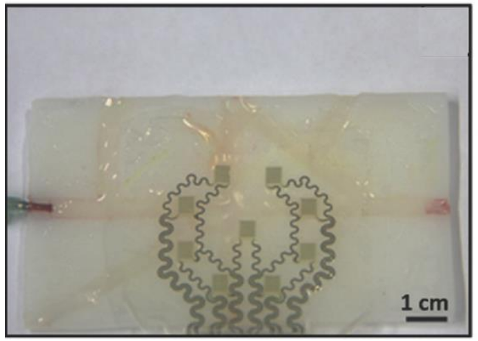


Second leaching step : Using **0.8 M** $FeCl_3$ + ChCl :70°C and 200

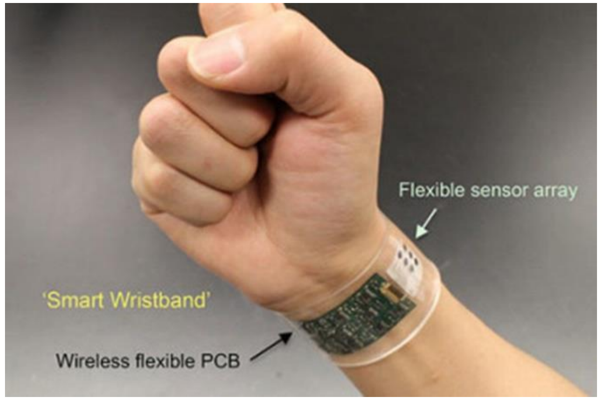


Zero-waste electronics and photonics

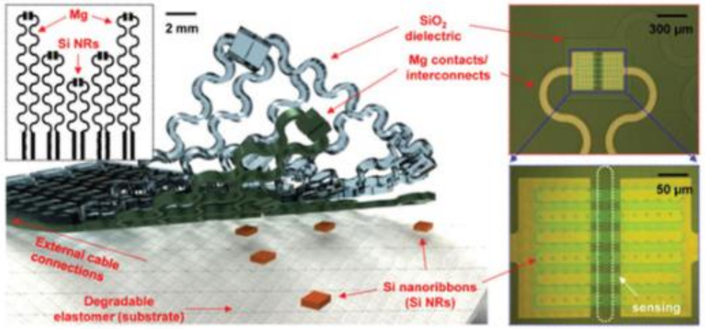
Temperature sensor



Wearable Electronics

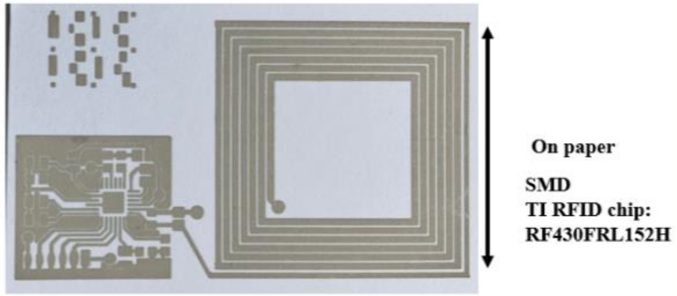


pH sensor



Smart Packaging

RF antenna



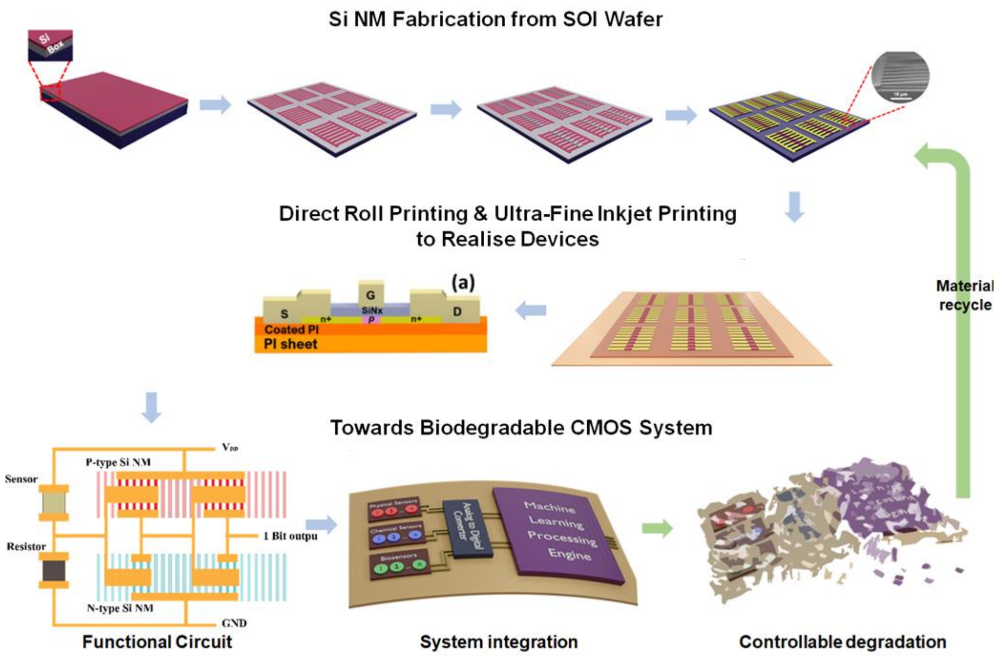
Agriculture applications

University of Glasgow

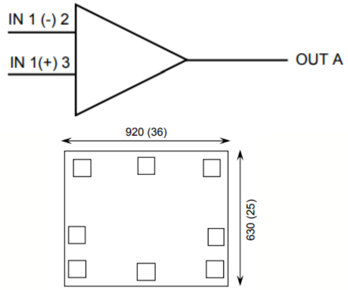
Zero Waste Electronics

GEOPIC - Green Energy-Optimised Printed Transient ICs

UKRI Engineering and Physical Sciences Research Council



Functionality in devices	Biodegradable and Natural Materials	Manufacturing techniques
Dielectric materials	***Inorganics:*** MgO, SiO_2, Si_3N_4, ***Synthetic polymers:*** *PLA, PVA,* ***Naturally derived polymers:*** glucose, cellulose, *silk, shellac, gelatin, amino acids, peptides*	Conventional methods, Wet deposition techniques, Printing, Electrospinning
Semiconductor materials	***Inorganics:*** *ZnO,* SiNM, SiGe, Si_3N_4, ***Synthetic polymers:*** P3HT, DPP, PEDOT, PANI, Ppy ***Naturally derived polymers:*** Indigo, melanin, β-carotene	Conventional methods, Wet deposition techniques, Printing,
Electrode/conductor/antenna materials	***Metals:*** Mg, Zn, W, Fe, Mo, Cu ***Inorganic:*** CNT, MWCNT, Graphene, Graphite, Carbon black, Carbon-metal composites **Polymer-based:** PEDOT:PSS	Metal deposition, Printing
Substrates	***Naturally derived polymers:*** silk, cellulose, chitosan, collagen ***Synthetic polymers:*** PLA, PLGA, PU, PVA,	Spin coating, drop casting, electrospinning
Encapsulants and adhesives	***Naturally derived polymers:*** *Starch, sucrose* ***Synthetic polymers:*** PLGA, PVA, POC, PCL, Ecoflex	Spin coating, drop casting



PEL Printed Electronics Ltd

PragmatIC

ZERO WASTE SCOTLAND

SEPA Scottish Environment Protection Agency

NPL National Physical Laboratory

IQE

ARM

Conclusions –

Looking to change manufacturing – zero waste solutions are possible

LCA very important to understand hotspots in processing – very under researched in photonics

Most sustainable materials/design is largely dependent on end –product

For long term/high value electronics, reliability is key

Increase the recovery of materials including critical raw materials (CRMs). Also be aware of legacy chemicals that are have now been reclassified as hazardous

University of Glasgow

Thank you for listening

jeff.kettle@glasgow.ac.uk

#UofGWorldChangers

@UofGlasgow

Pitches

Aston University – Aisha Bibi

Nuron - Paul Dickenson

QLM Technology - Murray Reed

Quantum Science Ltd – Stuart Stubbs

Seneye LTD – Matthew Stevenson

UKRI Innovate UK

Pitch Deck
Photonics

Contact Details

Aisha Bibi
a.bibi33@aston.ac.uk
+447587311682

Institute

AIPT, Aston University

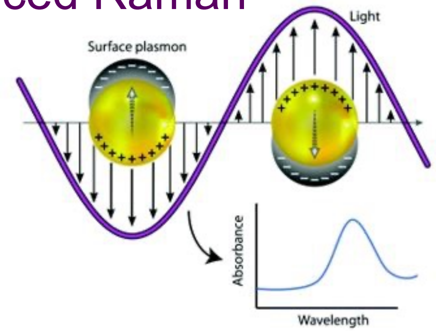
1. Project: Detection of nanoplastics

Bottle-fed babies swallow millions of microplastics a day, study finds
Microplastics revealed in the placentas of unborn babies
Car tyres are major source of ocean
Airborne plastic pollution 'spiralling around the globe', study finds

Rising levels of microplastic pollution raise questions about the impact on human health, experts say

2. Work done

- Multiwavelength Raman micro-spectrometer
- Substrates suitable for detection of nanoplastics through the use of surface enhanced Raman spectroscopy (SERS)



3. Seeking

- Collaborations……
  - MNP
  - Biological
  - Microfluidic

Grow your startup with Ansys

Optics & Photonics Bundle

- Ansys Lumerical
- Ansys Zemax OpticStudio
- Ansys SPEOS
- And more!

Electromagnetics Bundle

- Ansys Electronics
- Ansys Discovery
- Ansys Motor-CAD Enterprise
- And more!

Structures & Fluids Bundle

- Ansys Mechanical
- Ansys CFD
- Ansys Discovery
- And more!

Use Industry-Leading Software
Eligible startups get access to the same software used by industry leaders at deep discounts

Reduce Your Costs
Reduce manufacturing, materials, warranty and prototype costs

Reduce Your Time to Market
Impact your design, testing and prototype timeline

Validate Your Technology
Prove real-world functionality and gain further funding

Join the Ecosystem
Ansys is largest simulation company in the world
- Gain the opportunity to collaborate on mutually beneficial marketing to gain exposure

Reach out to Denis Purackal, Ansys Startup Program Manager- EDR Medeso UK (Ansys Elite Channel Partner)
Email: denis.purackal@edrmedeso.com Mob: 07399043659

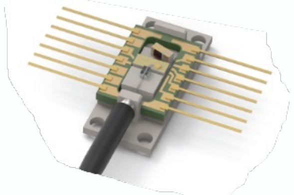
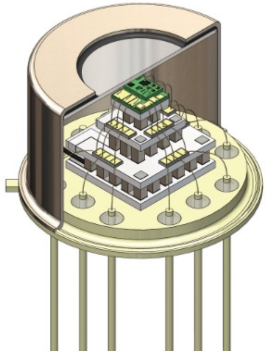
Photonic for Environment and Sustainability webinar, Dec'23

- **About your Company**
  - Bay Photonics
  - Experts in photonic & semiconductor packaging
  - Chip attach to module build & test
  - SME, 31 people, facility in Torbay
- **Your Contact Details**

  - Andrew Robertson, CTO
  - andrew.robertson@bayphotonics.com
  - 0776 988 2657

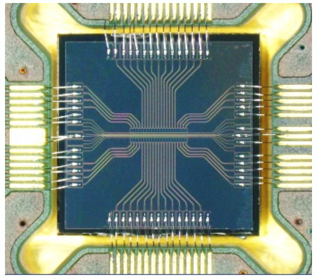
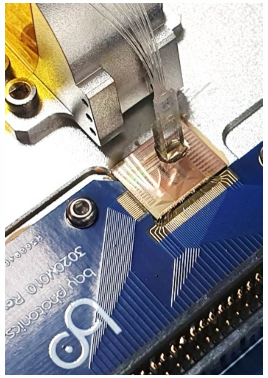
1. Project Idea - What is the solution you are proposing / What is the Challenge you wish to address

- Providing innovators with low volume advanced semiconductor and silicon photonics packaging solutions
- Advanced packaging solutions designed for volume manufacture

2. The services or solutions you can offer

- Electrical, optical, thermal and mechanical bonding, interconnectivity, hermetic sealing
- Free Space alignment
- Single Fibre or Fibre array attach

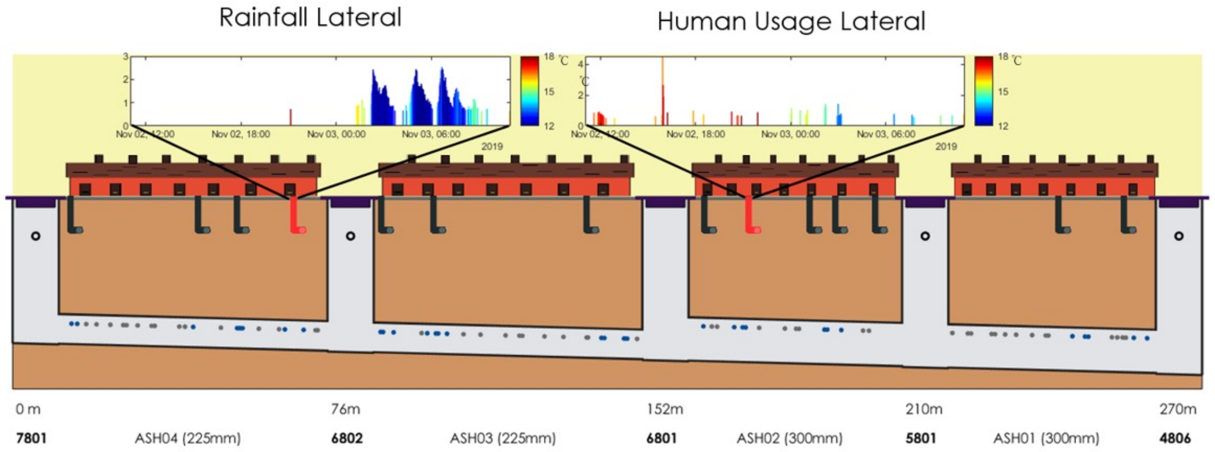




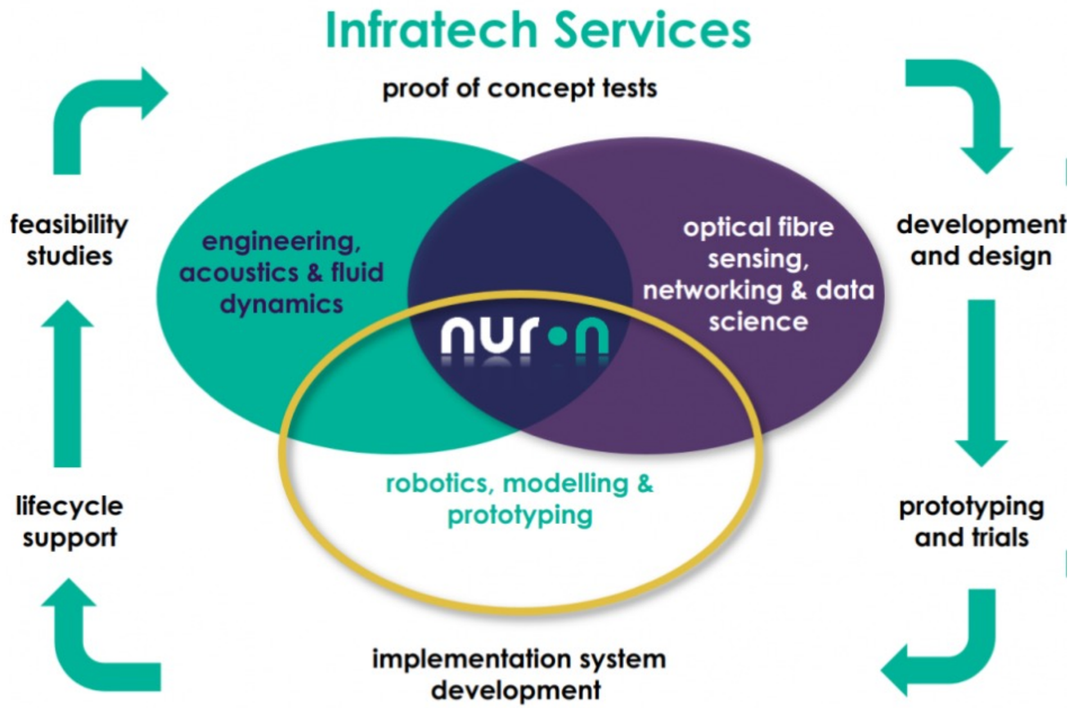
3. The partners/services you are seeking

- Bay Photonics has history of providing packaging for photonic integrated circuits and advanced silicon photonics, application areas include;
- Quantum & AI
- Telecoms/datacoms
- Wearable devices & lab on a chip
- LIDAR
- Remote sensing

Application agnostic but typically photon friendly!

Infrastructure technology to cut carbon, stop pollution and boost prosperity





Poseidon Digital Holdings Ltd

Pitch Deck

Photonics

Guidance : Please follow this standard 1 slide format if you wish to present a project idea or offer services to others

About your Company

- Mr John Milne starting a new Business
- To Develop Custom Robots & Automation
- An SME Startup in Robotic Automation

Your Contact Details

- Name: John Milne
- Email: johnm@poseidon-digital-holdings.co.uk
- Phone: +447456631430

1. Project Idea - What is the solution you are proposing / What is the Challenge you wish to address

- It is to design and build a fully Autonomous vehicle with Remote Control capability to locate Land Mines or other unexploded ordnance using Photonic Sensors incorporating Laser technology picking up the scent of explosive chemicals, also with GPR capability.

2. The services or solutions you can offer

- The company will provide design and build services for customers that have ideas for design development of custom Robotic Technology.
- Advice from 30+ years of experience in IT profession designing and building Global Bank Infrastructure, that will be developed as part of Industry 4.0/5.0 infrastructure.Extensive experience also in CNC CAD/CAM software.

3. The partners/services you are seeking

- Photonics research services developing the use of Laser technology for measurement of molecules that are in the part per million from chemicals in explosive devices within a captured air stream in real time.
- Also scientific research groups working on greater detail and depth of soil penetration in GPR systems for detection of NON-metal encased explosives.

Pitch Deck
Photonics

About QLM

- QLM is a Bristol start-up working to help limit climate change by developing continuous, autonomous, long-range and low-cost greenhouse gas monitoring systems using tuneable-diode-laser single-photon lidar.

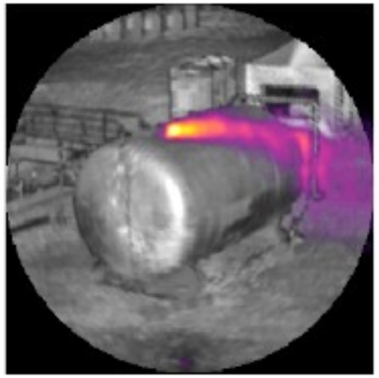
- **Murray Reed CEO**
- **murray.reed@qlmtec.com**
- **7525 813892**

1. The Challenge QLM is addressing

The growing requirement to measure, report, verify and stop methane and other GHG emissions energy and waste sectors. Continuous widespread monitoring by companies of their equipment to detect leaks, identify repair needs and prove they have been completed.

2. QLM Solutions and Services

- Methane Lidar for autonomous leak monitoring
- Cloud control, reporting and compliance service


3. The Partners & Services QLM are seeking

- Integrated rapidly tuneable SWIR diode lasers
- Advanced SWIR single-photon detectors
- Large volume contract manufacturing
- Industry specific channels to market
- Global field support services
- Drone deployment expertise
- Anyone interested in stopping greenhouse gas emissions

Pitch Deck

Photonics

Guidance : Please follow this standard 1 slide format if you wish to present a project idea or offer services to others

About your Company

- Quantum Science Ltd.
- Quantum dot sensor technology
- SME

Your Contact Details

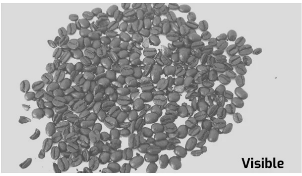
- Name: Stuart Stubbs
- Email: sstubbs@qscis.com
- Phone: 01925 807980

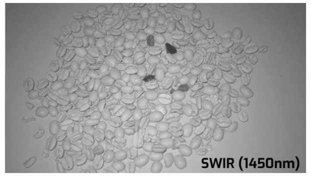
SWIR

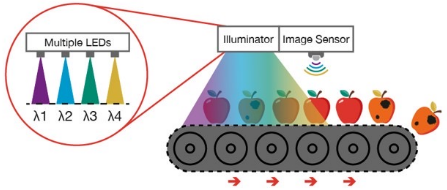
1. Project Idea - What is the solution you are proposing / What is the Challenge you wish to address

Solution

- Novel SWIR quantum dot sensor technology for machine vision applications
- Capable of detecting light from visible (400 nm) to SWIR (2400 nm)

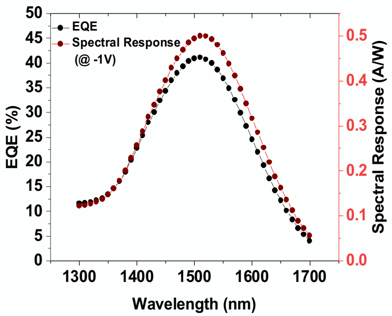


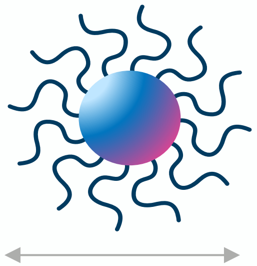




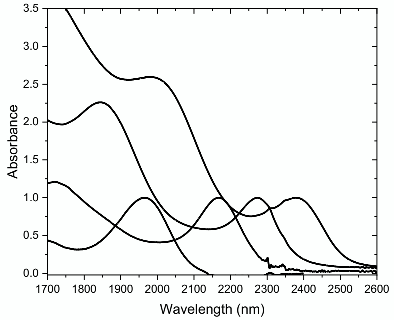
2. The services or solutions you can offer

- Short wave infrared sensitive nanomaterials supply
- Quantum dot photodiode stack development
- Custom wavelength development for specific applications





3-10 nm



3. The partners/services you are seeking

- Semiconductor design and process expertise
- Photodetector and image sensor design and fabrication expertise
- Image sensor supply chain partners – Semicon makers, end users etc.
- Hyperspectral filter technology (narrowband or variable filter technology, wafer level optics etc.)
- High value SWIR end users

seneye

Seneye Ltd

https://sensors.seneye.com/

Pitch Deck

Photonics

About your Company

- **Seneye** has been manufactured IoT, Cloud sensors for over 12 years.
- **Seneye** HQ where design and manufacture takes place is in Norwich, Norfolk.
- **Seneye** is a growing SME with a £1m+ turnover

Your Contact Details

- Name: Matthew Stevenson
- Email: matt.s@seneye.com
- Phone: 0783(seven) 90(six) 70(eight)

1. Project Idea - What is the solution you are proposing / What is the Challenge you wish to address

- The UK has more 1500 river systems, comprising over 200,000km of water. The UK has more than 393,460kms of sewers with over 140,000 pipes licenced to release sewerage.
- Seneye has the best technology to fulfil Section 82 of the Environment with sensors at the lowest environmental impact and lowest cost to taxpayer / bill payer.

2. The services or solutions you can offer

- Optical Water Sensing.

- Our patented technology is based on three pillars:

1. **Photonics**, especially in low-cost spectrometry
2. **Chemistry** concentrated in gas sensing
3. Mathematics techniques for low-cost sensing.

- Our in-house team combines the three pillars with electronics, optical / product design and software development to provide full solutions.

3. The partners/services you are seeking

- Help with independently testing our solution.
- Help with developing new chemical sensor dots for our patented multiplexing sensor. NO_3, PO_4, Coliforms.
- Help with access to funding.

Funding and events

Innovate UK

Funding opportunities – open now

- **SEMIconductors Manufacture Scaleup CR&D £12m Competition**
  https://apply-for-innovation-funding.service.gov.uk/competition/1811/overview/f30a8999-d44e-4912-bce3-05136b66e8aa
  - Up to £2.5m per project. Closes 31st Jan
- **Canada-UK Critical Minerals: Sustainability and Circularity**
  https://apply-for-innovation-funding.service.gov.uk/competition/1757/overview/736a153e-70a4-41d4-8be4-cfff091566a8
  - UK partners up to £400k, Closes 3/4/24
- **Xecs: Electronic Components and Systems Call 3**
  https://eureka-xecs.com/calls/
  - Semiconductors is a theme. Eureka programme. Outline deadline 18th Jan
- **Eureka GlobalStars Japan Round 2**
  https://apply-for-innovation-funding.service.gov.uk/competition/1752/overview/fc1fc0f6-bb40-4dce-98e9-72a2eaff95b0
  - Broad scope. Closes 31/12/24

UKRI Innovate UK

Funding opportunities – Horizon Europe

- Smart photonics for joint communication & sensing and access everywhere (RIA)
  - HORIZON-CL4-2024-DIGITAL-EMERGING-01-54
  - Expected 4 projects @ €4-5m. Deadline date: 19 March 2024
  - Sensors/probes to monitor the quality of the communication network
  - Methods to use the network as large-scale distributed sensor
  - Development of foundational optical technologies for future access infrastructure
- Photonics Innovation Factory for Europe (IA)
  - HORIZON-CL4-2024-DIGITAL-EMERGING-01-55
  - 1 project @ €15m. Deadline date: 19 March 2024
  - Substantially improved penetration of core photonics technologies into multiple end-user application domains and industry sectors
  - Creation of a sustainable streamlined ecosystem for photonics innovation in Europe.

Innovate UK

Funding opportunities – any area

- Innovation Hub https://ukinnovationhub.ukri.org/
- Innovate UK …

  Analysis for Innovators (A4I)

  https://iuk.ktn-uk.org/programme/analysis-for-innovators/

  Knowledge Transfer Partnerships (KTP)

  https://iuk.ktn-uk.org/programme/knowledge-transfer-partnerships/

  Innovate UK Innovation Exchange (iX)

  https://iuk.ktn-uk.org/programme/innovation-exchange/

  Innovate UK Innovation loans future economy

  https://iuk.ktn-uk.org/programme/innovation-loans-future-economy/

Forthcoming events …

- ISP53 – Emerging Sensing Technologies for Net Zero
  - https://iuk.ktn-uk.org/events/53rd-intelligent-sensing-program-isp53-emerging-sensing-technologies-for-net-zero/
  - 16 January, Birmingham
- Photonics for Space
  - 12 March, Leicester
- ISP54 – Sensing Technologies for Emerging Blue Economy
  https://iuk.ktn-uk.org/events/isp54-sensing-technologies-for-emerging-blue-economy/
  - 13 March, Liverpool
- Materials for Future Economy Workshop Series
  https://iuk.ktn-uk.org/events/materials-for-future-economy-workshop-series/
  - January – March, various online sessions inc circularity, photonics and sensors

UKRI Innovate UK