CENTRE FOR ADVANCED PHOTONICS & PROCESS ANALYSIS

CAPPA

Innovation Through Light

Your Research Partner for Photonics Solutions

- *Pharmaceuticals*
- *Food Technology*
- *Medical Devices*
- *Sensors & Systems*

Optical solutions for Industrial life sciences applications

Sept 23

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Munster Technological University

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CAPPA – A Research Centre of Munster Technological University

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44 PEOPLE
21 RESEARCHERS
23 POSTGRADUATES

€13 MILLION
FUNDING AWARDED
IN LAST 5 YEARS

23 PROJECTS
GREATER THAN €100K
CURRENTLY ACTIVE

COLLABORATING WITH
11 OF THE TOP **100**
UNIVERSITIES WORLDWIDE

ENGAGED WITH
›220 COMPANIES
IRISH AND INTERNATIONAL
IN THE LAST 5 YEARS

90 PAPERS
PUBLISHED IN PEER-REVIEWED
JOURNALS IN LAST 5 YEARS

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CAPPA Location

- **Co-located across 2 sites:**

MTU
Ollscoil Teicneolaíochta na Mumhan
Munster Technological University

Tyndall
National Institute
Institiúid Náisiúnta

CREATE Building

- *Cork Bishopstown Campus*
- *4 Labs, ~200 m²*

Tyndall National Institute

- *Lee Maltings Complex*
- *3 Labs, ~150 m²*

Through a Memorandum of Understanding with University College Cork

What We Do

Photonics – A Key Enabling Technology

The Science of Working with Light

Communications
Powering Fast Internet & Datacentres

Energy
Photovoltaic Solar Cells

Transport
Enabling Self-driving Cars

Manufacturing
Optimising Process Monitoring

Health
Revolutionising Medical Imaging

Environment
Advanced Sensors & Diagnostics

Imaging & Microscopy
Element/ingredient mapping
Medical imaging
Defect analysis

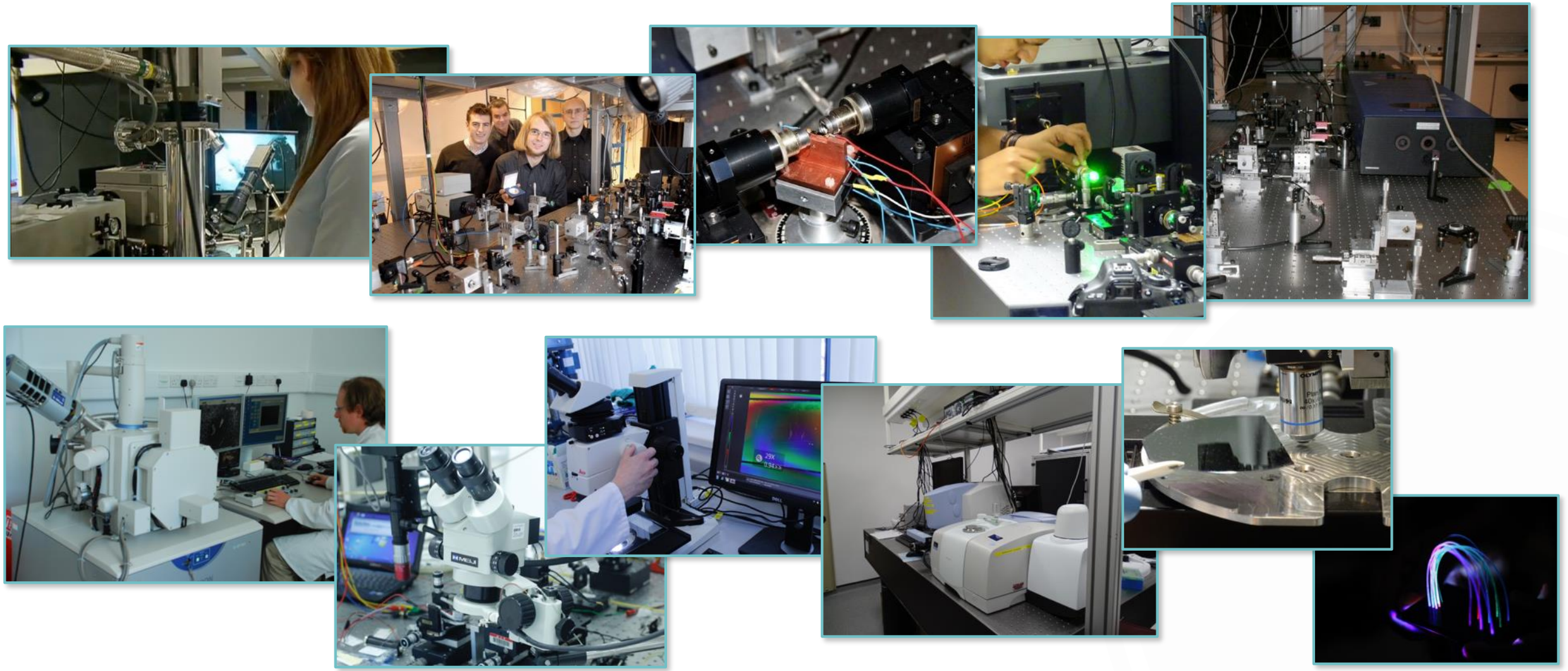
Spectroscopy
Contaminant identification
Cancer screening
Chemometrics

Sensing & Detection
Environmental monitoring
Water & soil analysis
Autonomous cars

Process Monitoring
In-line/on-line sensing
Machine vision
Process analysis & control

Nanophotonics
Photonic crystals
Hybrid lasers
Photonic Integrated Circuits

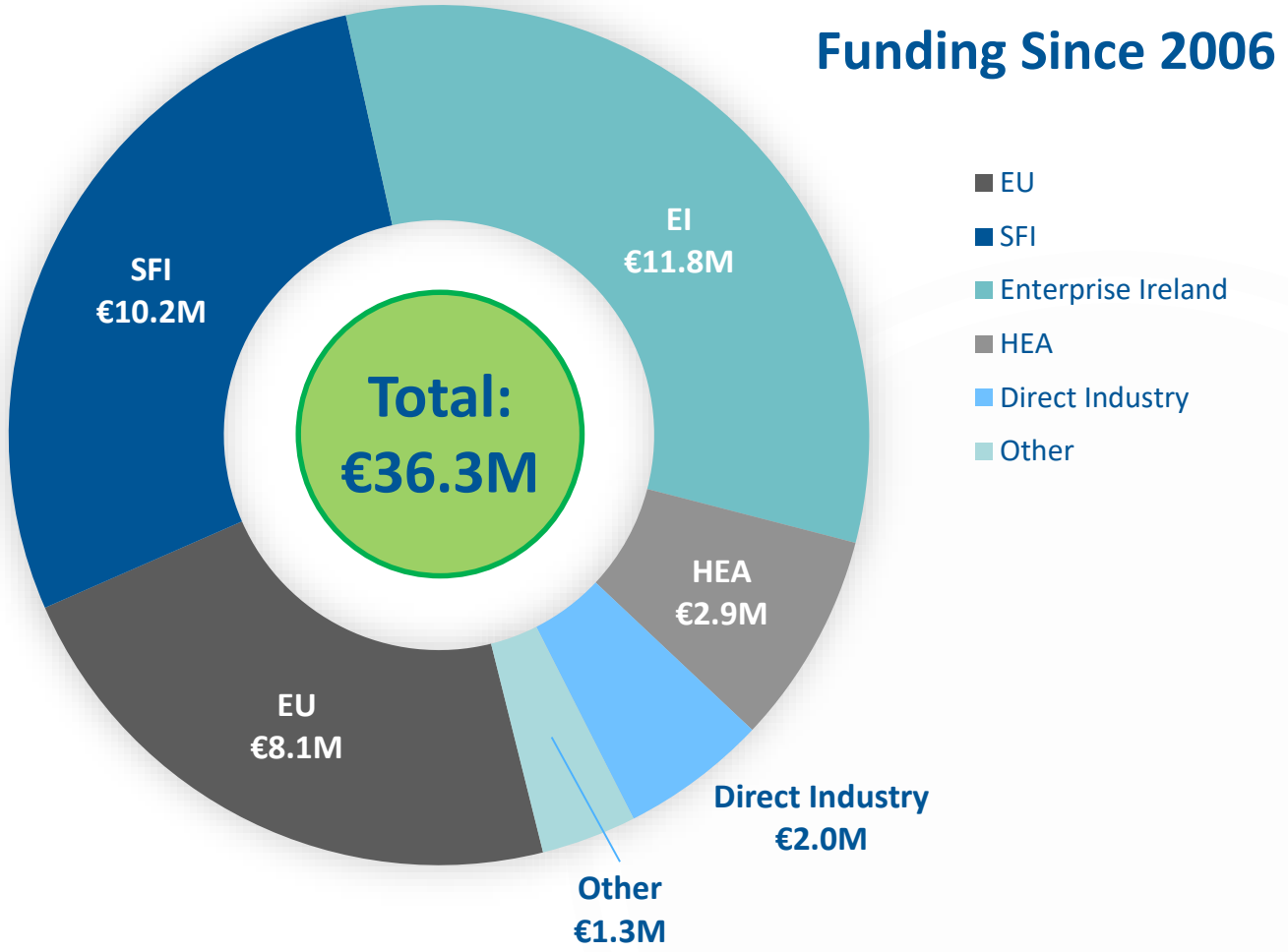
CAPPA Labs



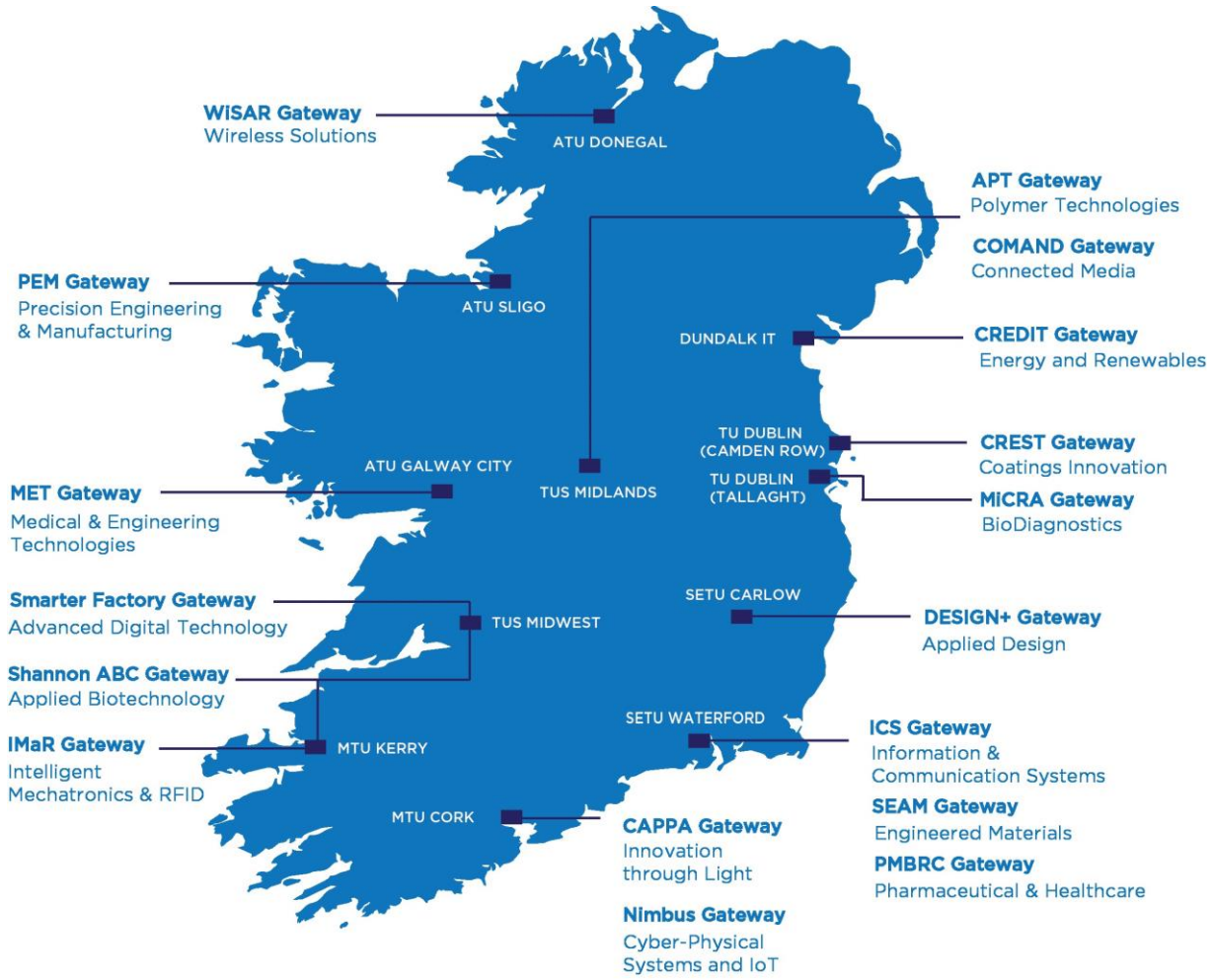
CAPPA Funding Record

Since 2006:

- >250 Proposals Submitted
- ~50% Success Rate
- Coordinator on 10 EU Grants
- 4 phases of ARE/Tech Gateway
- IPIC SFI Centre – 2 phases
- 13 EI Innovation Partnerships
- PRTLI IV & V funding



Working With Industry



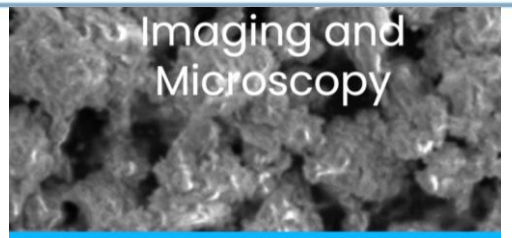
- 17 Gateways
- Funded By Enterprise Ireland
- Deliver R & D Solutions to Industry
- ~ 7,500 completed projects with Irish companies
- Food, Pharma, Design, Process Control, Process monitoring, material testing

- https://www.technologygateway.ie/

- *The Enterprise Ireland Technology Gateway Programme is co-financed by the Government of Ireland and the European Union through the ERDF Southern, Eastern & Midland Regional Programme 2021-27 and the Northern & Western Regional Programme 2021-27.*

Core Competencies

- Fluorescence Detection
- Time – Dependent Change Analysis
- Structural Changes in Materials
- Raw Ingredient Characterization
- Failure Mechanism Exploration
- Polymer Analysis
- Hyperspectral Imaging

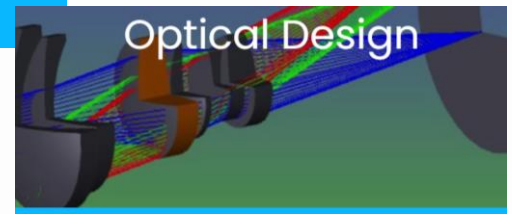


- Inspection
- Scanning Electron Microscopy
- Energy Dispersive Spectroscopy
- Polarized Light Imaging
- Defect Analysis
- Contamination Identification
- Raman Imaging

- Fibre – Based Sensing
- Trace Gas Sensing
- Sensors for Machine Vision and Inspection
- Sensors for Biomedical Applications
- Optical Sensing
- Detection of Concentrations
- Environmental Monitoring

- In – line monitoring of moisture levels
- In – line monitoring of blend uniformity
- Online monitoring of rinse samples for cleaning verification
- Development of process automation to remove manual inspection
- Ingredient tracking in production processes

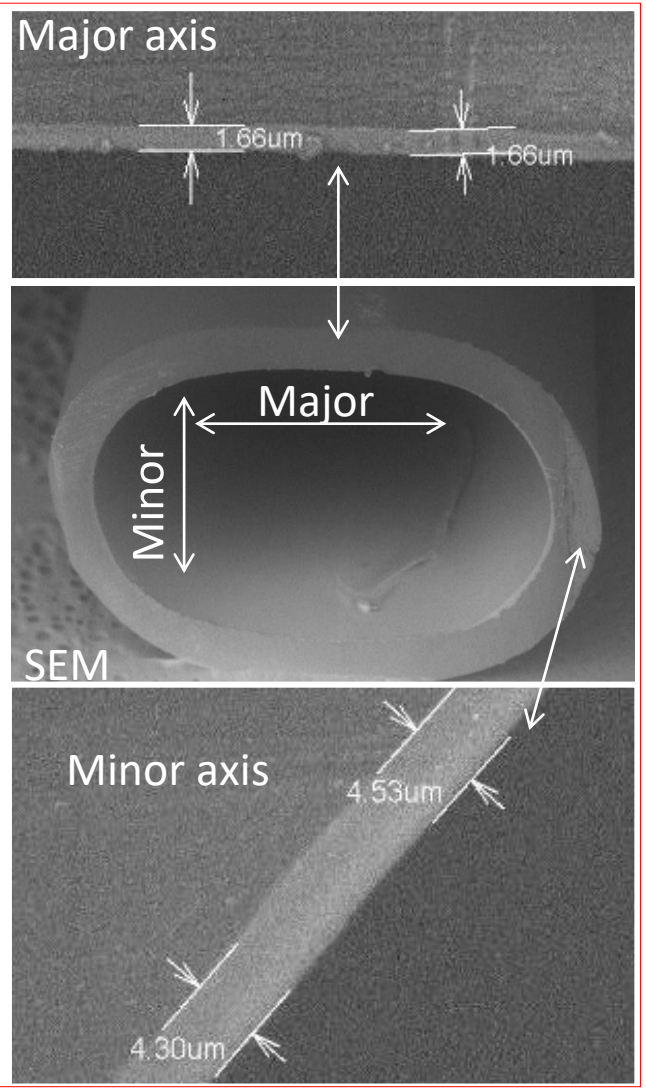
- Contamination Analysis
- Industrial Process Analysis
- Optimisation
- Principal Component Analysis
- Multivariate Curve Resolution



- Lens Design
- Imaging and Detection System design
- Laser optics
- Optical fibre systems
- Physical Phenomena modelling

Coating Inspection

Layer thickness



The Problem

Coatings

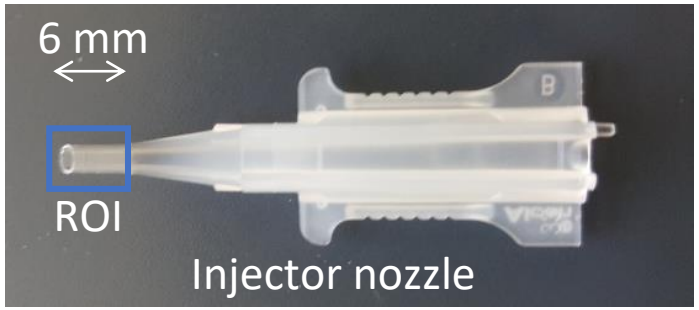
- Lubrication coating (PU and PVP) on the inner wall of the device (PP or PC). The coating consists of a top and base coat layer.

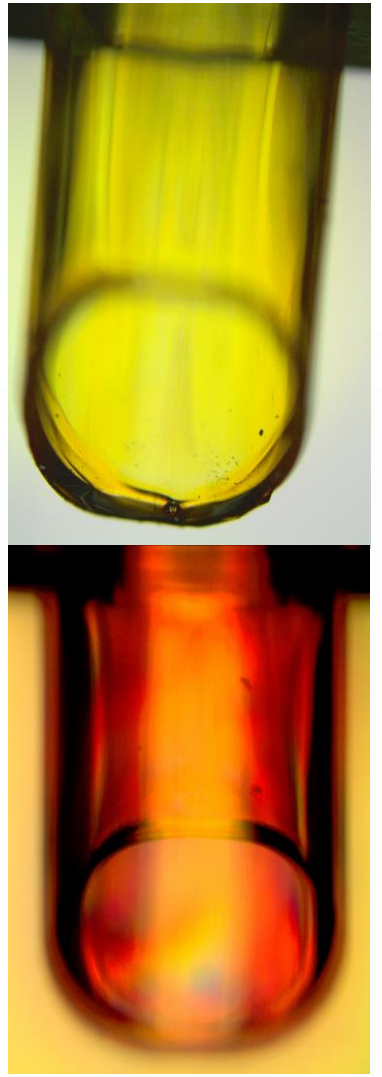
Injector nozzle

- IOL becomes stuck
- Bursts the nozzle tip during use
- Coating can be pushed out during use

Current inspection relied on dye staining and optical imaging

- Labour-intensive and the dyes used are hazardous materials with Carcinogenic properties.
- Destructive testing

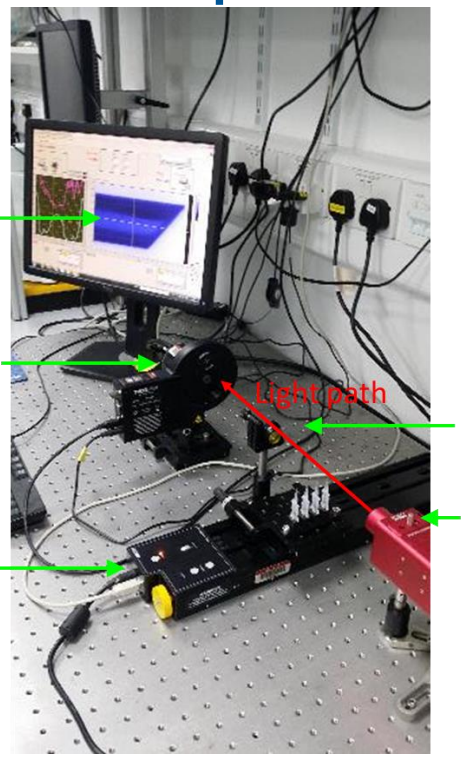




Destructive Dye Testing

Coating Inspection System

Set-up

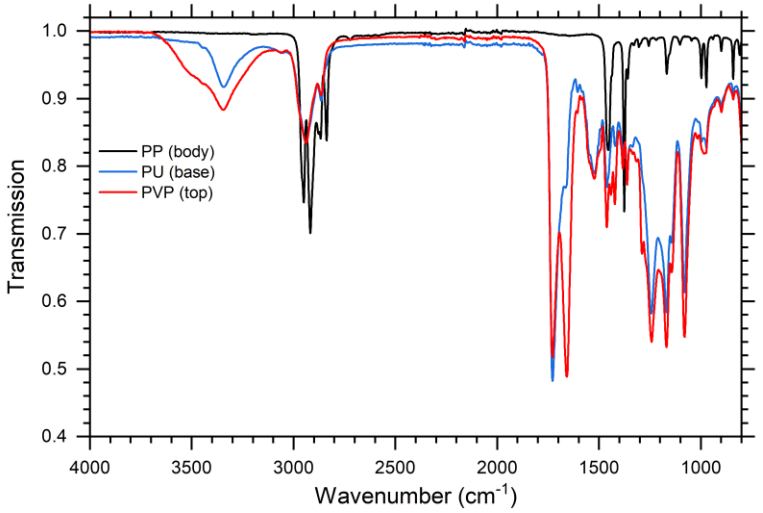


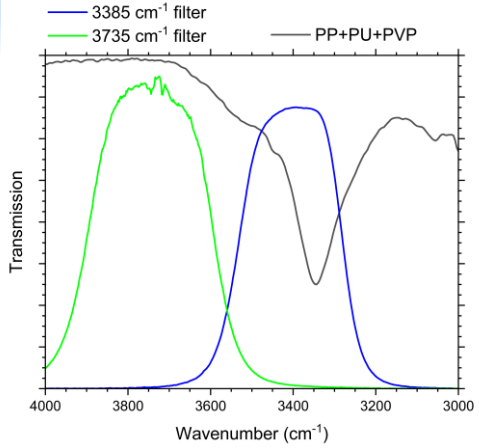
Fully automated with current settings
- 8 nozzles
- 30 seconds per nozzle
- 4.5 minutes for 8 nozzles

Machine vision to analyze samples

Self-calibrating system

Methodology

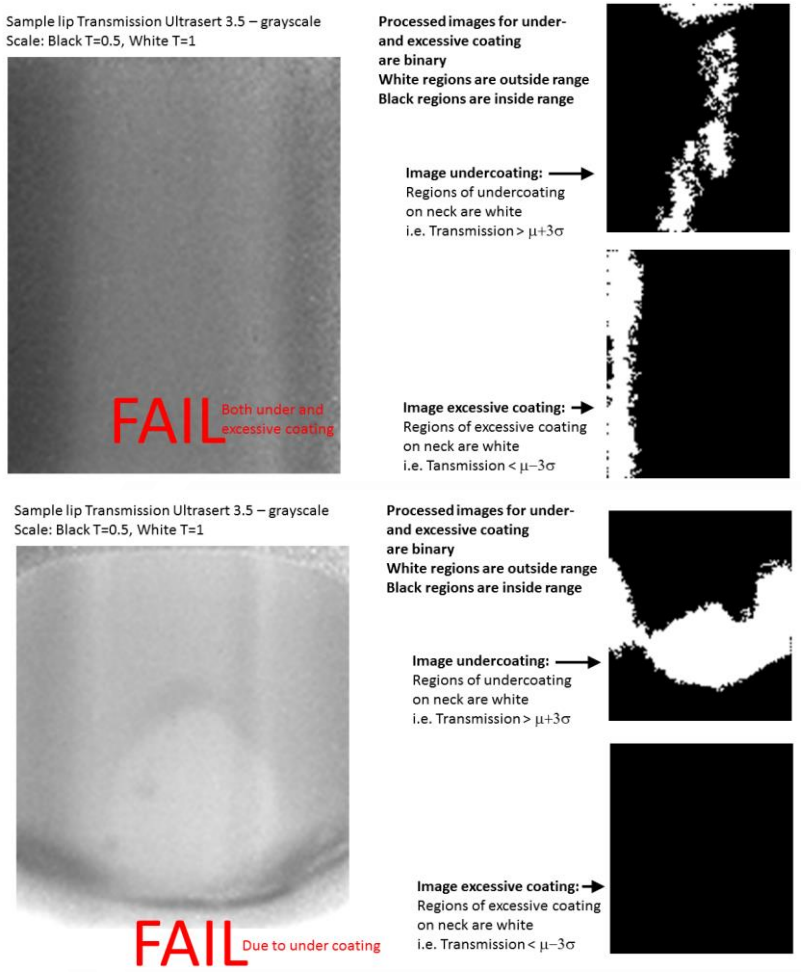




Measure transmission in 2 wavelength ranges

1. ~3735 cm^{-1}
2. ~3385 cm^{-1}

Measurements



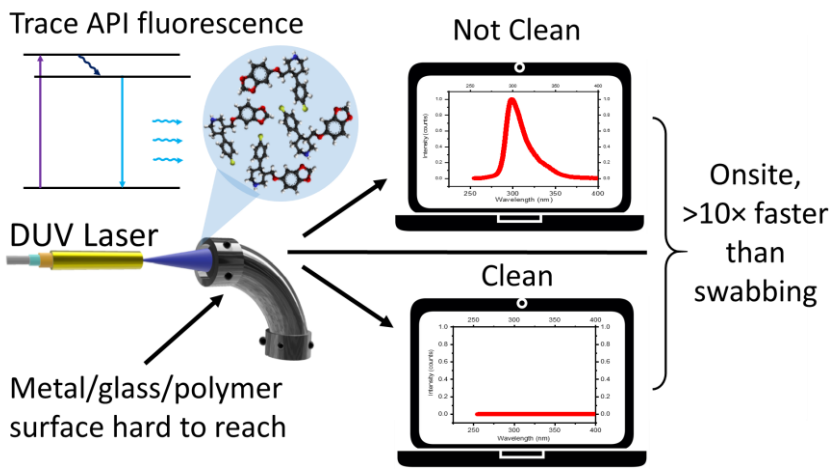
Cleaning cycle in Pharma Industry

Equipment becomes dirty after each batch of product made

Equipment should be clean to a high level: No trace of previous batch allowed:

Up to parts per billion

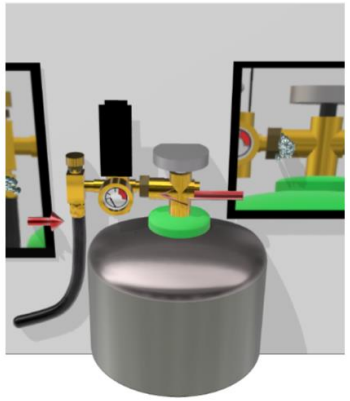
Solution: Portable instrument for onsite validation



Identify product

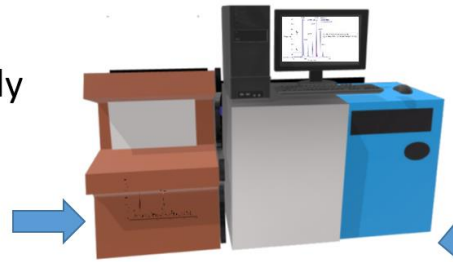
(a)

Identify environment



HPLC/TOC

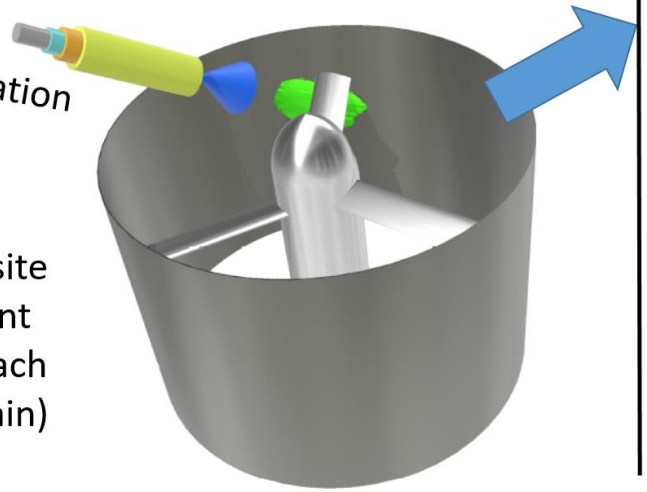
(b) Sampling of accessible area only (≈ 1 hr)



(C) Dedicated lab space (HPLC/TOC) (≈ 5-6 hr)

DUV F

DUV Laser excitation

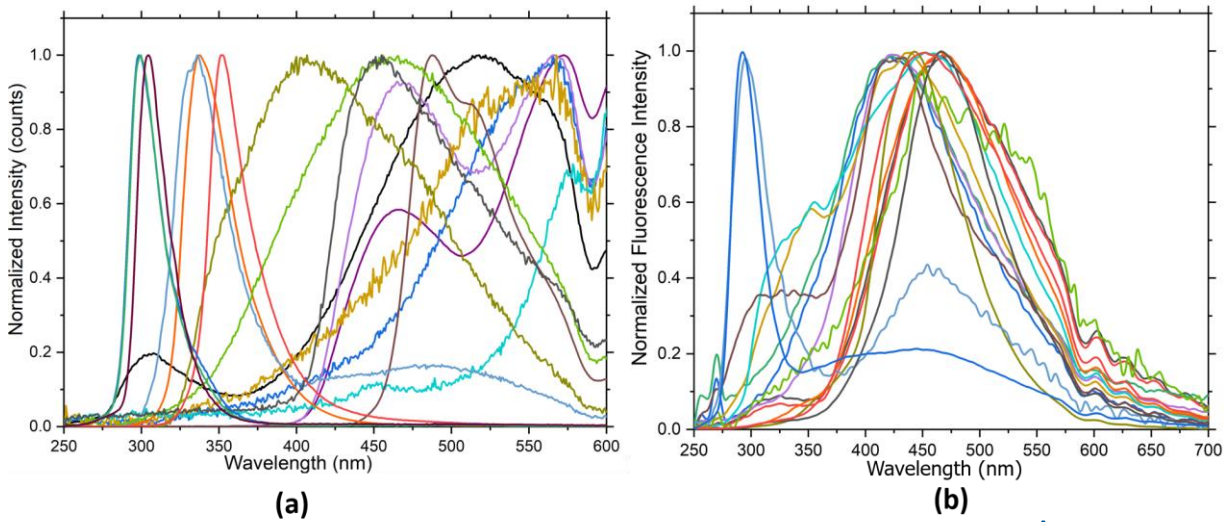


(d) Direct onsite measurement of hard to reach areas (≈ 30 min)

(e) Restart/ Stop cleaning cycle

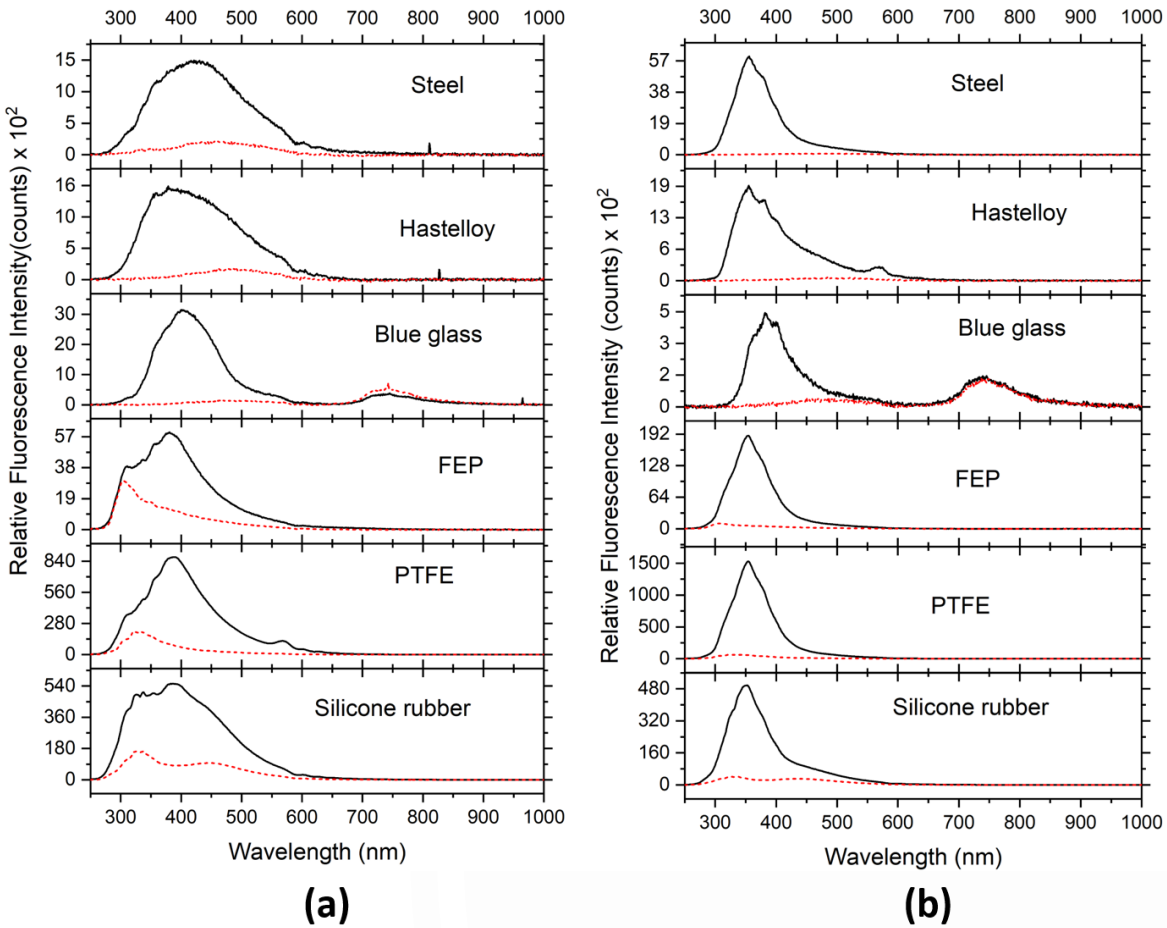
Device performance

Fluorescence of different trace samples from companies



Active Ingredient

Cleaning solution/detergent

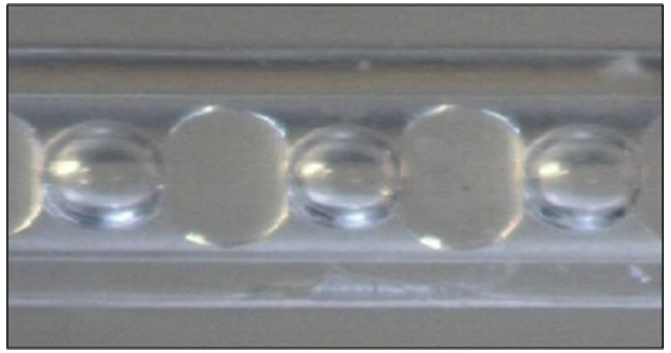


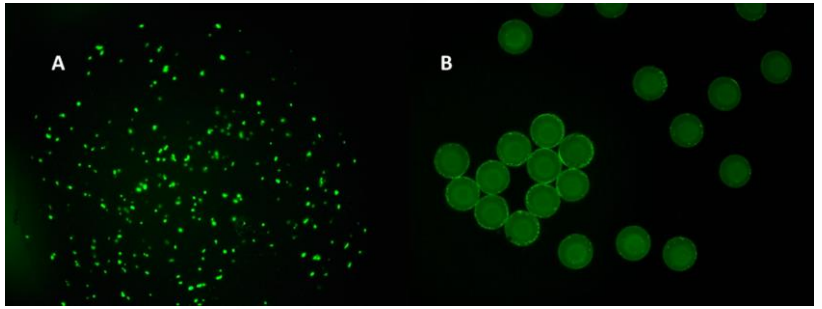
Fluorescence of trace samples on different surfaces

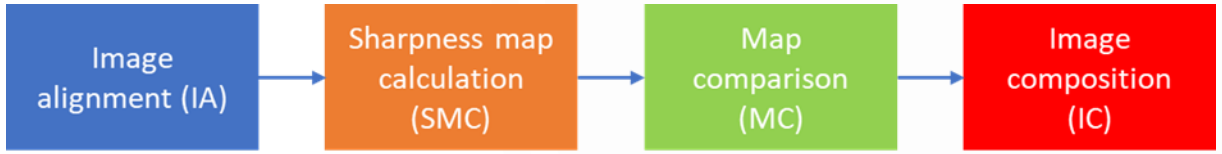
Chullipalliyalil, K., Lewis, L. and McAuliffe, M.A., 2019. Deep UV laser-Induced fluorescence for pharmaceutical cleaning validation. *Analytical chemistry*, *92*(1), pp.1447-1454.v

Drug Testing\Cell counting and viability

- Predicting cell response to new compounds such as drugs etc.
- 2D methods (including both in vitro and in vivo models) often lack predictive power, specificity, sensitivity and speed
- Organoids (clusters of cells) and are much larger (order of hundreds of µm) than single cells (order of several µm).
- 3D cell culture systems (organoids based) represent a more physiologically relevant platform and could provide a high-throughput, automated means for rapid screening



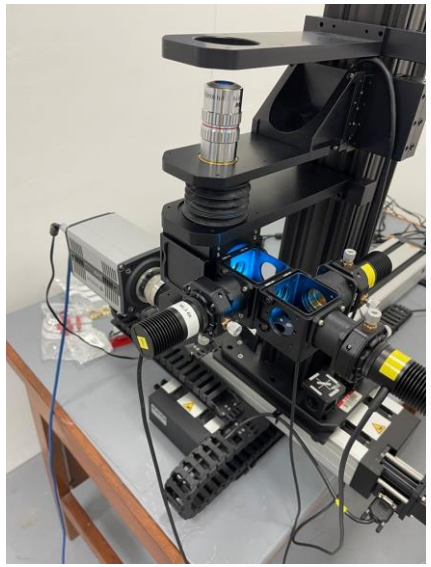


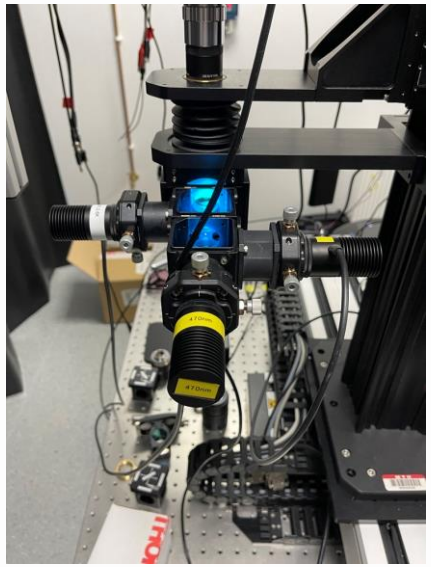


Drug Testing\Cell counting and viability

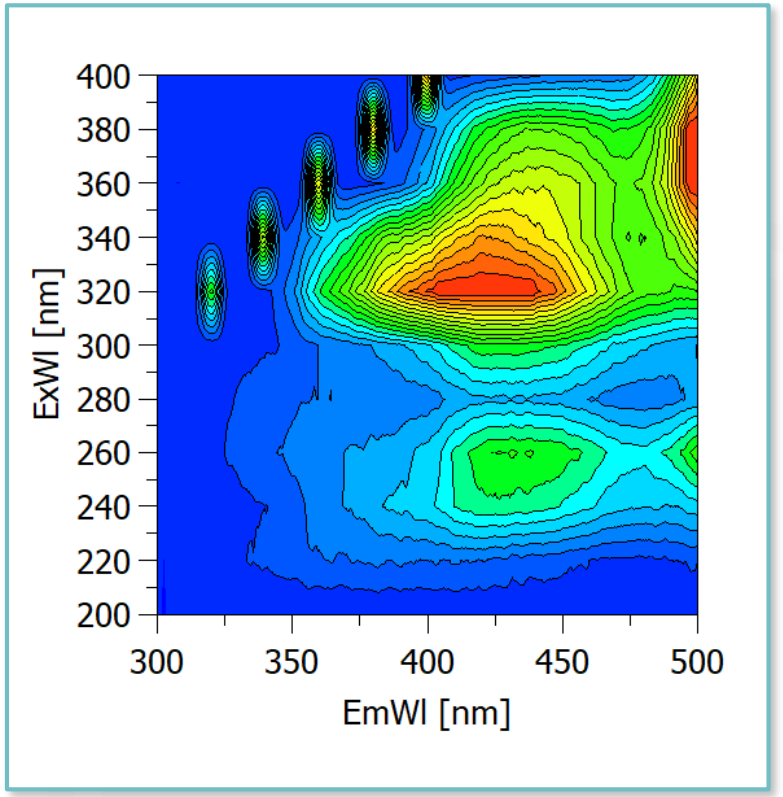
Multimodal, upright microscope based wide field imaging bed capable of:

- Imaging of cells (20-40 µm) and organoids (200-300 µm) in gel matrix/droplets
- White light EPI (reflected light) and transmitted light illumination (LED based)
- EPI/reflected light excitation/detection for steady-state fluorescence at 480nm (FITC) and 525nm (PI) (LED based)
- Transmitted light fluorescence excitation/detection for steady-state fluorescence at 488nm (FITC) and 525nm (PI) (LED based)
- X-Y-Z scanning (mapping and 3D imaging with DOF larger than 500 µm)
- Increased sensitivity for bio-luminescent cells
- Development of hardware control and image acquisition and analysis software layer capable of:
- Image acquisition in X-Y-Z defined points (sample mapping)
- Z-stacking

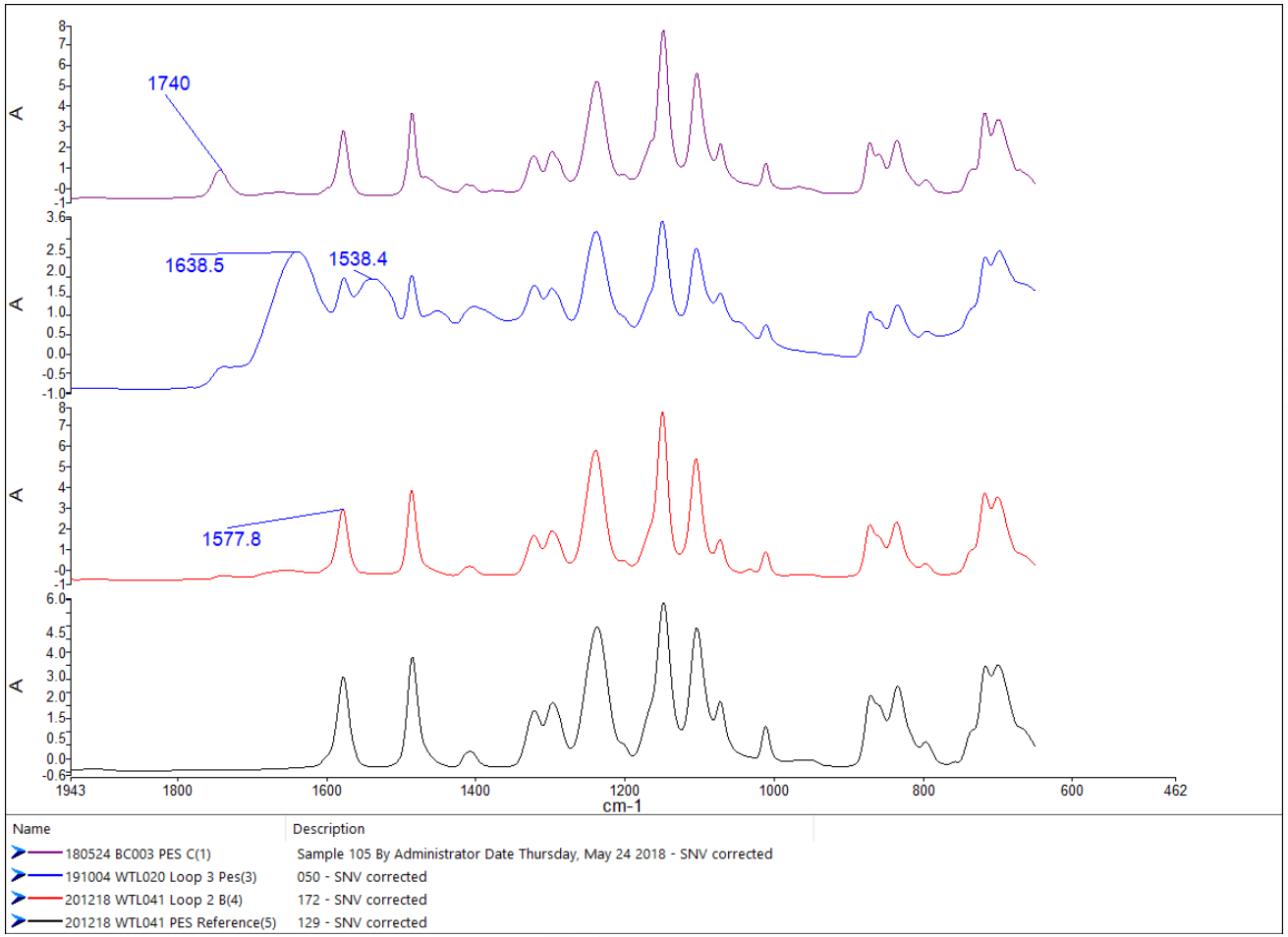




- **Case Study: Ultrafiltration membrane post-mortem**
  - UF membranes applied in whey protein concentration
  - Lifespan and separation efficacy determine efficiency
  - Where membrane blocking has occured, spectroscopic techniques (FTIR/Raman) may:
    - Identify fouling material
    - Identify pore blocking mode
    - Show membrane thermal integrity compromised
    - Show membrane pH limits exceeded
  - Fluorescence spectroscopy can be used to track protein leakage into permeate (inset)

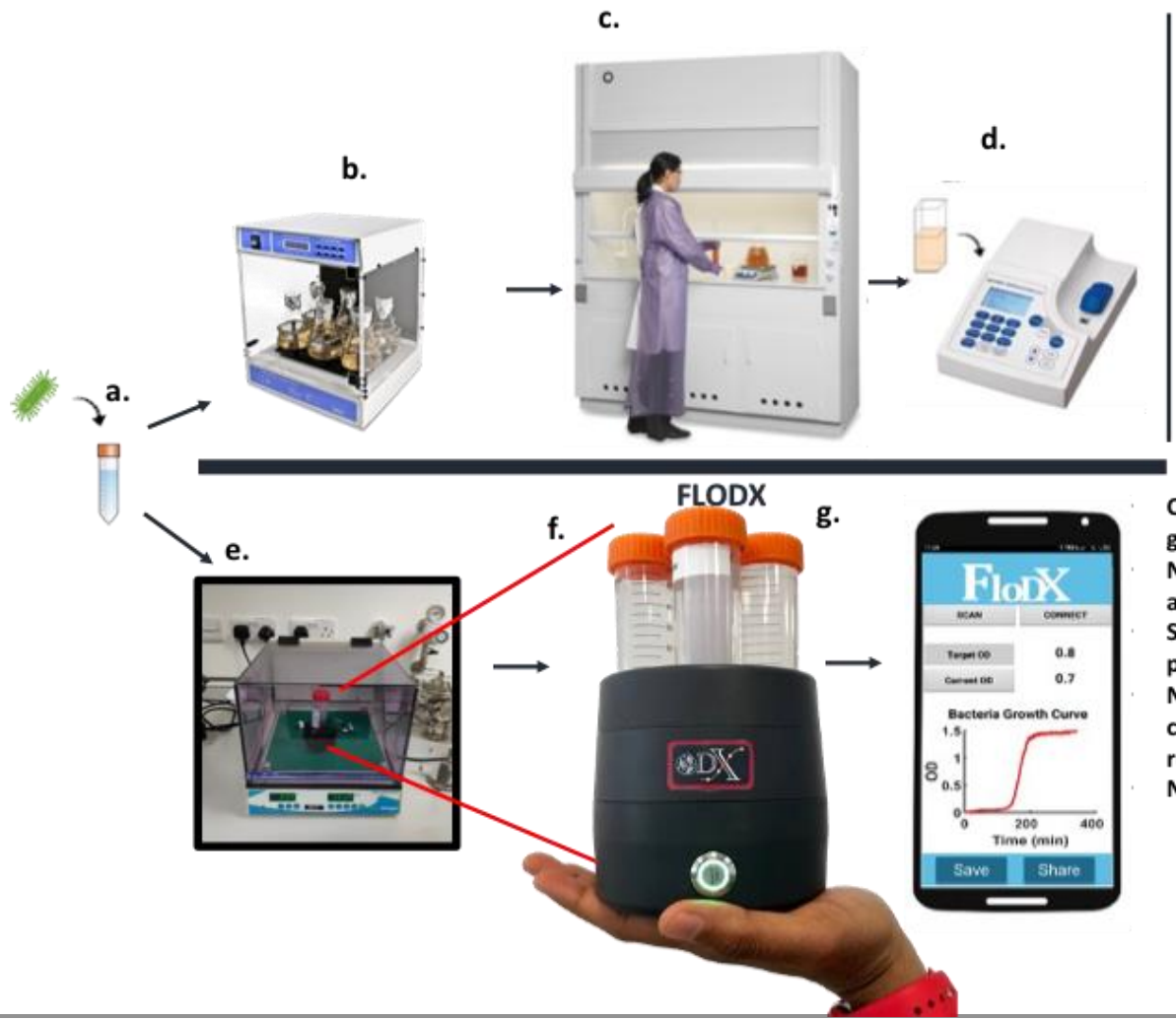


- **Identification of Membrane Failure Mode**
  - Pore blocking by fat
    - Carbonyl peak detected at *ca.* 1740 cm^{-1}
  - Protein layer formation
    - Amide I & II bands found at *ca.* 1650 cm^{-1} & 1550 cm^{-1}
  - Heat damage
    - Aromatic absorption peak shift at *ca.* 1580 cm^{-1}



Continuous Bacterial Growth Monitoring

Traditional way

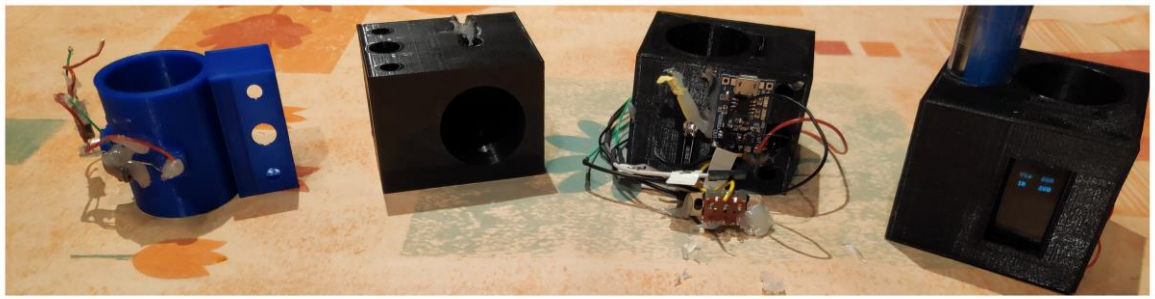


8-10 times

- Risk of contamination
- Sample loss
- Consumable and disposable plastic waste
- Power loss on turning-on hood

Continuous monitoring of growth
No destructive method of analysis
Smart phone aided data processing
No special consumables/plastic required
No risk of contamination

Early design iterations and prototypes



BUZZ Online

RETURN TO ISSUE | < PREV | ARTICLE | NEXT >

ODX: A Fitness Tracker-Based Device for Continuous Bacterial Growth Monitoring

Venkata V. B. Yallapragada, Uday Gowda, David Wong, Liam O'Faolain, Mark Tangney, and Ganga C. R. Devarapu*

Cite this: *Anal. Chem.* 2019, 91, 19, 12329−12335
Publication Date: September 3, 2019
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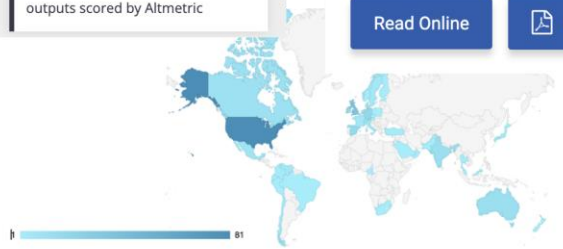
SUBJECTS: 3D printing, Bacteria, Circuits, Diodes, Sensors

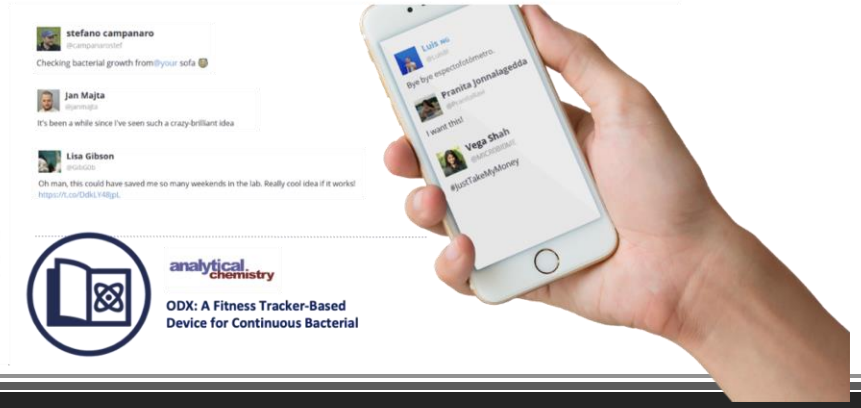


Geographical breakdown

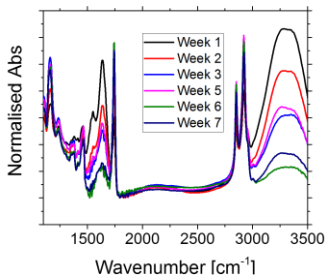
Country	Count	As %
United States	81	20%
United Kingdom	34	8%
Germany	19	5%
Spain	18	4%
Ireland	16	4%
India	13	3%
Australia	13	3%
Canada	11	3%
Netherlands	8	2%
Other	72	18%

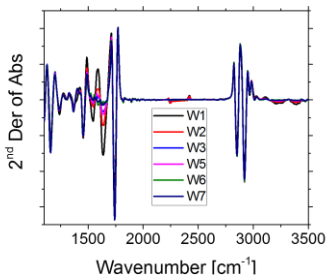
Demographic breakdown

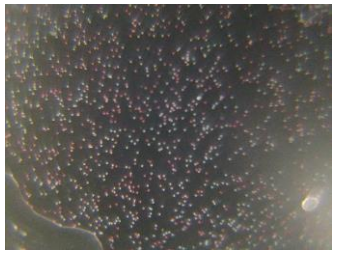
Type	Count	As %
Members of the public	199	49%
Scientists	195	48%
Practitioners (doctors, other healthcare professionals)	8	2%
Science communicators (journalists, bloggers, editors)	1	<1%

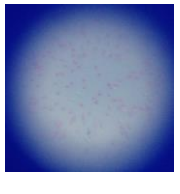


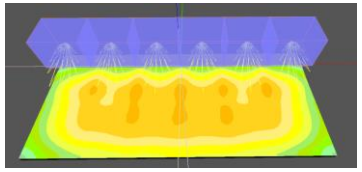
Short Study Examples

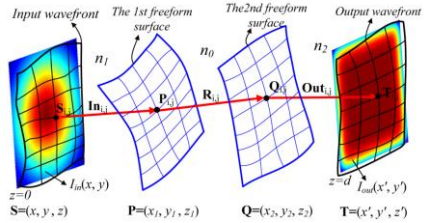


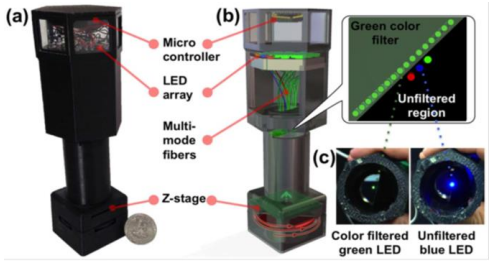


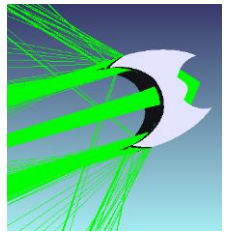


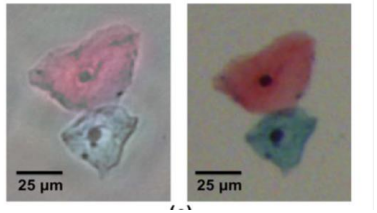












- *Point of care medical device*
- *Beverage quality monitoring device*
- *Optical blood pressure measurement device for heart surgery*
- *Oral bacterial decontamination device*
- *UV Water Purification system for aquaculture*
- *Development of a bacterial contaminant detection unit*
- *Challenge set development for product consistency*
- *Golf aid for shot alignment*
- *Optical design for emergency lighting*
- *UV disinfection unit for food and beverage*
- *Stability testing of cosmetics products*
- *Development of on-site infection detection system (Veterinary)*

CAPPA conducts ~ 50-60 Industry engagements per annum varying from

½ days to long term multi year collaborative projects, 500+ total projects

Contact Info

Thank you for your attention

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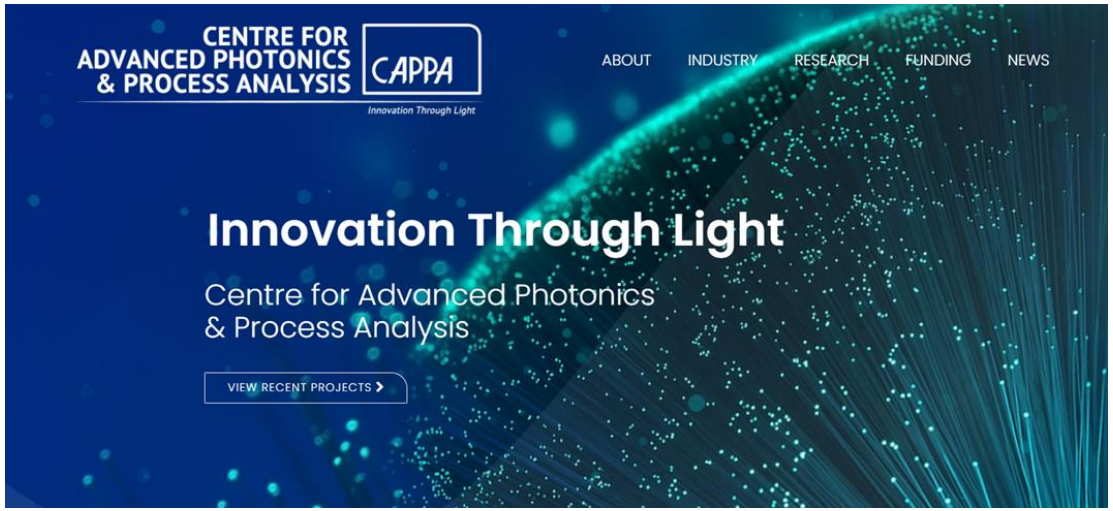

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Tyndall National Institute Institiúid Náisiúnta
IPIC BRINGING PHOTONICS TO LIFE

SFI Science Foundation Ireland
Enterprise Ireland
HEA HIGHER EDUCATION AUTHORITY AN tÚDARÁS um ARD-OIDEACHAS
IRISH RESEARCH COUNCIL An Chomhairle um Thaighde in Éirinn
Ireland's European Structural and Investment Funds Programmes 2014-2020 Co-funded by the Irish Government and the European Union
European Union European Regional Development Fund

CAPPA research areas