*Engineering and Physical Sciences Research Council Doctoral Landscape Award*

**PROJECT TITLE:** Pushing the frontier of ultrasensitive on-chip sensing - advanced metamaterials for Surface-Enhanced Infrared Absorption (SEIRA) sensing

**Lead Supervisor:** Prof. Isaac Luxmoore

**Co-Supervisors:** Dr. Calum Williams

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**Webpage:** https://experts.exeter.ac.uk/22641-isaac-luxmoore

**Project Partner:** Fraunhofer Centre for Applied Photonics (CAP)

**Project details:**

Project Overview: Surface-Enhanced Infrared Absorption (SEIRA) spectroscopy is a transformative approach for ultrasensitive molecular detection, enabling chemical and biological identification down to trace concentrations. Optical metamaterials—artificial structures engineered at the nanoscale—can trap and enhance infrared fields, amplifying molecular vibrational signals by orders of magnitude and enabling multiplexed trace-level sensing on compact chips.

This PhD project aims to develop next-generation SEIRA metamaterials, combining recent breakthroughs in plasmonic and all-dielectric architectures, perfect absorbers, and AI-driven optimisation. Conducted jointly between the University of Exeter and the Fraunhofer Centre for Applied Photonics (CAP), the project brings together leading expertise in nanofabrication, infrared spectroscopy, and integrated photonic sensing. The goal is to deliver broadband, low-cost, and reconfigurable on-chip SEIRA sensing, suitable for applications in environmental monitoring, healthcare diagnostics, and lab-on-chip technologies.

Research Aims: The successful candidate will: Design and simulate novel multi-material metamaterials for SEIRA enhancement, using electromagnetic modelling including FDTD and coupled-mode approaches. Explore machine learning methods (e.g. genetic algorithms, deep neural networks) for automated design and spectral interpretation. Investigate integration of tunable hybrid materials (e.g. 2D materials, phase-change materials, metal-organic frameworks) to improve sensitivity and selectivity. Nanofabricate and characterise prototype devices using nanolithography, thin-film deposition, and Fourier-transform infrared spectroscopy (FTIR). Integrate SEIRA structures with microfluidic or MEMS platforms for real-time on-chip detection of target gases and biomolecules. Training and Environment: The student will join the Centre for Metamaterial Research and Innovation (CMRI) at the University of Exeter. The CMRI is a community of academic, industrial, and governmental partners that harnesses world-leading research excellence from theory to application, and enables simulation, measurement, and fabrication of metamaterials and metamaterial-based devices.

We are home the UK's biggest ever single investment (£19.6million) in metamaterials – MetaHUB. We provide scientific knowledge as well as transferable and technical skills training to all our students to prepare them for careers within and outside of academia. Our breadth of research is our centre's strength: our PhD students, researchers and academics solve multi-faceted research questions and challenges.

This studentship will be executed in close collaboration with Fraunhofer Centre for Applied Photonics (CAP). The first of the highly regarded Fraunhofer Research Centres to be based in the UK, Fraunhofer CAP specialises in undertaking applied R&D in a range of photonics themes. Based at the University of Strathclyde's Technology and Innovation Centre in Glasgow city centre, Fraunhofer CAP's main remit is to be a key partner to UK companies in the development of state-of-the-art products and processes that will enhance their competitiveness; it is expected that throughout this PhD, the student will spend some time at Fraunhofer CAP implementing the developed metamaterials for sensing applications.

As such, the student will join an interdisciplinary research team combining expertise in nanophotonics, materials science, and chemical sensing. They will gain skills in:

• Nanofabrication and cleanroom micro/nano-device processing • Infrared spectroscopy and metamaterial optical characterisation

• Computational photonics and AI-assisted device design

• Collaborative research with industry and academic partners

**Project Specific requirements:** Applicants should hold (or expect to obtain) a first-class or upper second-class degree (or equivalent) in Physics, Materials Science, Electrical Engineering, Nanotechnology, or a related discipline.

Experience with numerical simulation (e.g. COMSOL, Lumerical, CST) or nanofabrication is desirable but not essential. This project will bridge through the fields of nanophotonics and biochemical sensing, so the candidate must have a strong interest in these fields and desire to set-up experimental systems and put theory into practice.

We hope for candidates who are sociable and professional, have strong oral and written communication skills with the demonstrable ability to work collaboratively and independently. Please see https://www.exeter.ac.uk/research/metamaterials/ and https://www.cap.fraunhofer.co.uk/en/careers.html for further details.

**PhD programme of study:** PhD in Metamaterials

**Location:** Streatham campus, Exeter

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Please ensure you read the entry requirements for the programme you are applying for.

To apply for this project please click on the following link – Apply Here