CALL 2 PROSPECTUS

PROTEMIC

An EU MSCA Joint Doctoral Training Network on

INTEGRATED PHOTONICS SPECTROSCOPY FOR PROTEINS

Using Metasurfaces and Interband/Quantum Cascade Devices

LASER SOURCES

IN-SITU SPECTROSCOPY

REACTION MONITORING

WWW.PROTEMIC.EU

MTU Ollscoil Teicneolaíochta na Mumhan Munster Technological University

Nanosystems and Technologies GmbH nanoplus

Tyndall National Institute Institiúid Náisiúnta

Fraunhofer IAF

Julius-Maximilians-Universität Würzburg

TU WIEN Technische Universität Wien

INSUCAPS LTD

IIS La Fe

Universitat de València

Paul Scherrer Institut PSI

Funded by the European Union

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PROTEMIC

DOUBLE DEGREE PH.D. POSITIONS

4 AVAILABLE (OF 12 TOTAL)

*Are you a **physicist**, **photonics expert,** or **laser enthusiast** eager to tackle real-world problems? Join a cutting-edge European PhD network using **mid-IR lasers**, **photonic integrated circuits**, and **advanced spectroscopy** to unlock the secrets of proteins. With world-class labs, industry partners, and dual degrees, PROTEMIC is your gateway to scientific impact and career acceleration.*

- STUDY IN 2 EUROPEAN COUNTRIES (IRELAND/GERMANY/AUSTRIA/SPAIN)
- BE AWARDED A PH.D. DEGREE FROM 2 UNIVERSITIES (DOUBLE DEGREE/COTUTELLE)
- BECOME A MARIE SKŁODOWSKA-CURIE FELLOW WITH FULL SALARY AND BENEFITS
- GAIN INDUSTRY EXPERIENCE EITHER PART-BASED IN INDUSTRY OR THROUGH A SECONDMENT
- UNDERTAKE MULTI-DISCIPLINARY RESEARCH & TRAINING IN INTEGRATED PHOTONICS, SPECTROSCOPY AND PROTEIN SCIENCE
- BE PART OF AN INTERLINKED TEAM OF 12 FELLOWS WORKING TOWARDS COMMON GOALS

4 DOCTORAL CANDIDATE (Ph.D.) POSITIONS ARE AVAILABLE IN CALL 2

The projects involve real-world application of physical principles such as:

- *Semiconductor band engineering*
- *Photonic device miniaturization and integration*
- *Laser absorption, photothermal, and dispersion spectroscopy*
- *Mid-IR light-matter interaction and detector physics*

AVAILABLE PROJECTS ARE: DC1, DC2, DC4 and DC7

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PROTEMIC

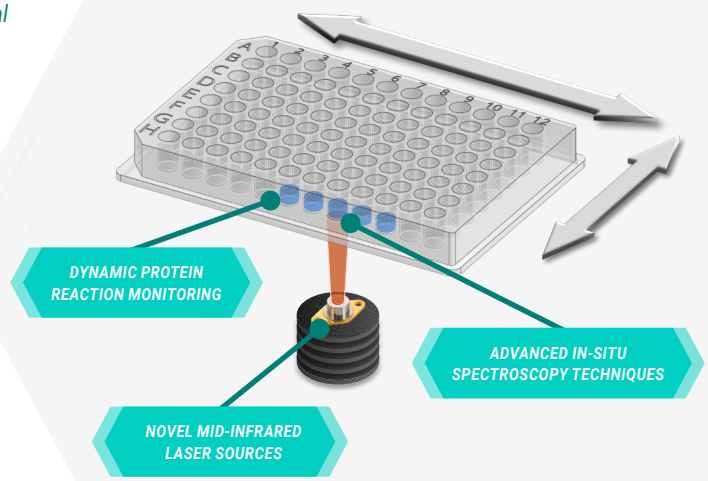
RESEARCH OVERVIEW

TODAY'S TECHNOLOGY GAP: THE LACK OF DYNAMIC MONITORING OF PROTEIN STRUCTURAL CHANGES

Proteins are complex biopolymers that form the fundamental building blocks of life. The structure of proteins is crucial in determining how they behave, and this structure can change under different conditions; e.g. proteins may incorrectly fold during the expression process, or denature in response to changes in temperature, pH, etc. These deviations lead to loss of function, loss of therapeutic effectiveness, increased immunogenicity or reduced product shelf life. Hence, medicine and pharmaceutical industries have an unmet need for dynamic, in-situ monitoring of proteins, for quality control and accelerated drug discovery.

***PROTEMIC** brings together the disciplines of Physics, Analytical Chemistry and Biotechnology to address this critical issue. The protein structure will be determined using the sample's mid-infrared absorption spectrum without the use of labels or reagents, building on recent technological breakthroughs and the consortium's wealth of experience.*

*The network combines **photonic integration** and **advanced spectroscopy** to demonstrate a new paradigm of **in-situ measurements of protein denaturation**, by embedding the photonic chip into the reaction vessel. It will enable the mapping of structural changes during dynamic reactions in realtime, improving the manufacturing efficiency of protein-based pharmaceuticals and allowing scalable screening of proteins for drug discovery.*



ADVANCED SPECTROSCOPY SYSTEMS

*Going beyond the limits of established absorption spectroscopy, PROTEMIC will investigate novel technologies such as **integrated photothermal spectroscopy**, **on-chip dispersion spectroscopy** and imaging techniques such as **AFM-IR** and **Fluorescence-Photothermal Induced Resonance**.*

MID-INFRARED LASERS & DETECTORS

*PROTEMIC will expand the accessible wavelength range of **Interband Cascade Lasers** far beyond 6 µm at room temperature, and explore the platform's use as **mid-IR detectors**. The performance of **External Cavity Quantum Cascade Lasers** will be improved for wavelength tuning applications.*

PHOTONICS INTEGRATION

*The on-chip integration of photonics capabilities will be employed to **add in-situ functionality to microtitre plates**. **Photonics packaging** and **Photonic Integrated Circuits** (PICs) will be used to implement pluggable optical interconnects for disposable reaction vessels.*

PROTEIN ENCAPSULATION

***Encapsulation** is a process in which tiny droplets are surrounded by a coating to give small capsules, and provide for the controlled release of the contents (e.g. a vaccine). PROTEMIC will seek to vastly improve the options to **study encapsulation in real time**, improving the understanding of the release process.*

PROTEIN QUALITY CONTROL

*The protein content of **human milk**, in particular **Extracellular Vesicles** (EVs), is important for promoting infant growth. PROTEMIC will develop a compact prototype to enable fast and direct **quantification of diet-related parameters in HM samples** at point-of-care, and a novel **analyzer for EVs.***

PROTEMIC

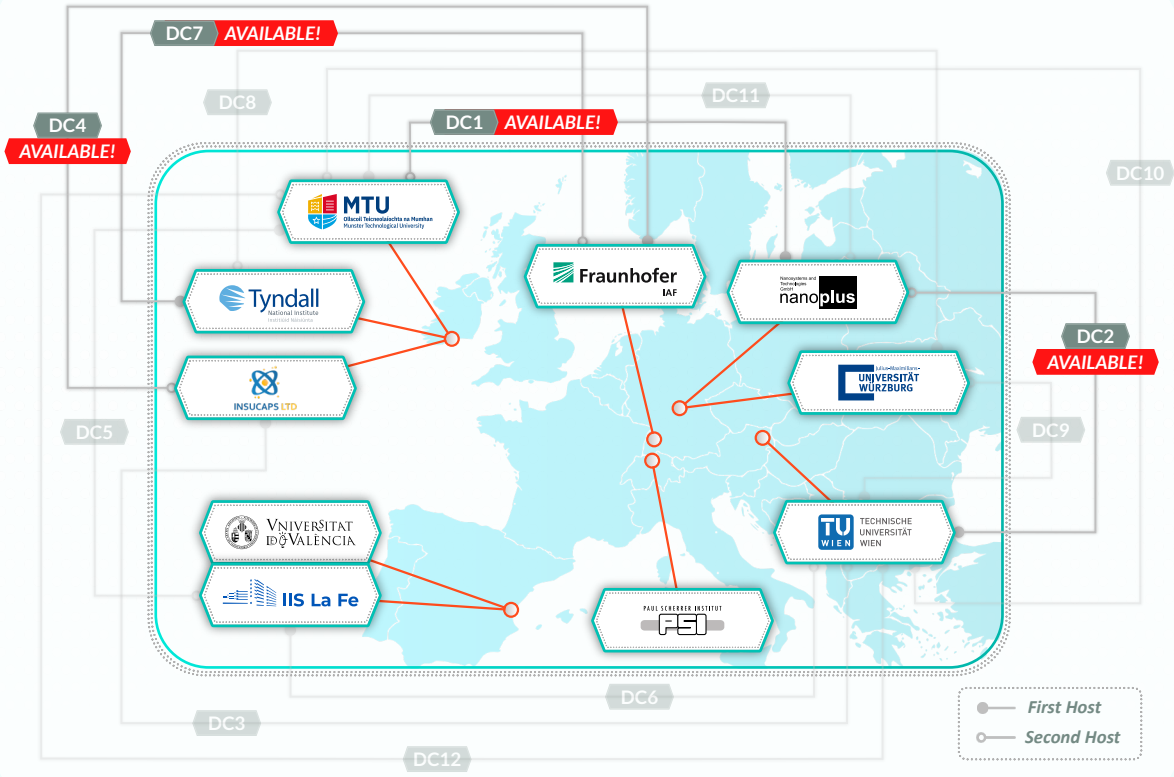
TRAINING IN THE PROTEMIC NETWORK

12 INDIVIDUAL DOCTORAL CANDIDATE (DC) RESEARCH PROJECTS
4 AVAILABLE IN CALL 2: DC1, DC2, DC4, DC7

FELLOWSHIPS ARE 45 MONTHS DURATION

EACH FELLOW IS RECRUITED BY 2 PARTNERS, SPENDING APPROX 50% AT EACH CO-HOST

PROJECTS ARE GROUPED INTO 3 THEMES (WORK PACKAGES)



NETWORK-WIDE TRAINING EVENTS

- **WORKSHOP 1** Würzburg, Germany
- **SUMMER SCHOOL** Cork, Ireland
- **WORKSHOP 2** Valencia, Spain
- **WORKSHOP 3** Cork, Ireland
- **FINAL CONFERENCE** Vienna, Austria

WWW.PROTEMIC.EU

PROTEMIC PARTNERS

MUNSTER TECHNOLOGICAL UNIVERSITY

Cork, Ireland
www.mtu.ie / www.cappa.ie

*The **Centre for Advanced Photonics & Process Analysis** (CAPPA) spearheads photonics research at MTU. Nano-photonics uses nanoscale devices to control and manipulate light, primarily through nanostructuring high refractive index silicon based materials with techniques such as electron beam lithography. The group is one of the leading authorities on disorder and loss in Photonic Crystals, and works extensively on metasurfaces and integrated sensors.*

TECHNISCHE UNIVERSITÄT WIEN

Vienna, Austria
www.tuwien.at / www.cavs.at

***Technische Universität Wien** was founded in 1815 and is Austria's leading research and higher education establishment on natural sciences and engineering. TU Wien's mission is "Technology for People". The research division on environmental and process analytical chemistry, headed by Prof. Dr. Bernhard Lendl, focuses on advanced analytical sciences through the development of novel analytical techniques and instrumentation. The research division on optoelectronic devices, headed by Prof. Dr. Benedikt Schwarz, focuses on semiconductor technology for mid-infrared applications.*

NANOPLUS GMBH

Gerbrunn, Germany
www.nanoplus.de

***nanoplus Advanced Photonics Gerbrunn GmbH** is a privately owned German limited liability company (GmbH) and as main manufacturing and RnD enterprise forms part of the nanoplus Group. Over the last years, the nanoplus Group has become the leading manufacturer of DFB laser diodes for gas sensing applications. This position was achieved by a steady and constant growth rather than by a quick expansion.*

INSUCAPS LTD

Cork, Ireland
www.insucaps.ie / www.anabio.ie

***InsuCaps Limited**, a sister company of AnaBio Technologies Ltd, is a specialist micro encapsulation company based in Ireland, focussed on improving health and performance through micro-encapsulation of sensitive functional ingredients including macronutrients and active pharmaceutical ingredients. The patent technologies create a protective coating around probiotics and/or bioactives to protect them against heat and moisture, mask unpleasant tastes and control the release kinetics.*

TYNDALL NATIONAL INSTITUTE

Cork, Ireland
www.tyndall.ie / www.ucc.ie

*The **Tyndall National Institute**, part of University College Cork, is Ireland's largest research centre. Tyndall has a very strong track record in both coordinating and partnering in European projects over many years, as well as very strong links with industry. The Photonics Packaging and Integration Group is led by Prof. Peter O'Brien and is recognized for its ability to convert research results generated in the laboratory to commercialization.*

PROTEMIC

PROTEMIC PARTNERS

HEALTH RESEARCH INSTITUTE LA FE

Valencia, Spain
www.iislafe.es/en

*The **Fundación para la Investigación del Hospital Universitario La Fe dela Comunidad Valenciana** (IISLAFE) is a Spanish non-profit organization that carries out the scientific and research policy of the La Fe Health Department, and was accredited as a "Health Research Institute" in 2009. IISLAFE comprises multidisciplinary and complementary research groups with consolidated expertise in cellular and molecular biology, cell culture, functional analysis imaging, "omics", biostatistics and clinical research.*

FRAUNHOFER INSTITUTE FOR APPLIED SOLID STATE PHYSICS

Freiburg, Germany
www.iaf.fraunhofer.de/en

*The **Fraunhofer Institute for Applied Solid State Physics** IAF is one of at present 76 research institutes run by the Fraunhofer Society, Europe's largest organization for applied research. Fraunhofer IAF is one of the world's leading research institutions in the fields of III-V semiconductors and synthetic diamond. Fraunhofer IAF develops components for future-oriented technologies, covering the entire value chain from materials research, design and processing to modules, systems and demonstrators.*

JULIUS-MAXIMILIANS-UNIVERSITÄT WÜRZBURG

Würzburg, Germany
www.uni-wuerzburg.de

***Julius-Maximilians-Universität Würzburg** (JMU) is a full-spectrum, research-intensive university that strives towards the highest standards in cutting- edge research and interdisciplinary training, within and across its ten faculties. The department of Technical Physics of JMU is a technology center for advanced lithography and processing for nanoelectronic and nanophotonic materials and devices, and includes a 550 m² cleanroom facility.*

PAUL SCHERRER INSTITUT

Villigen, Switzerland
www.psi.ch

*The **Paul Scherrer Institut** (PSI) is the largest research institute in Switzerland for natural and engineering sciences. At PSI cutting-edge research is conducted in the areas of future technologies, energy and climate, photonics and quantum mechanics, health innovation and the foundations of nature. The Laboratory of Nano and Quantum technologies (LNQ) focuses on the synergies of nanotechnology and quantum science, photonics and electronics.*

UNIVERSITAT DE VALÈNCIA

Valencia, Spain
www.uv.es

*The **University of Valencia** (UV) is one of the oldest universities in Spain, and, according to University Ranking by Academic Performance, UV is the third best university in Spain in scientific production. UV currently consists of 18 Faculties, with more than 50.000 students. In the PROTEMIC project, UV will award the Ph.D. degrees of the Fellows hosted at IISLAFE.*

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PROTEMIC Ph.D. PROJECTS SUMMARY

nanoplus	DC1	AVAILABLE! Development of ICL arrays and application in protein sensing	MTU Ollscoil Teicneolaíochta na Mumhan Munster Technological University
TU WIEN TECHNISCHE UNIVERSITÄT WIEN	DC2	AVAILABLE! ICD arrays for absorbance sensing using variable pathlengths	nanoplus
INSUCAPS LTD	DC3	Dynamic in-situ studies of drug release by mid-IR laser spectroscopy	TU WIEN TECHNISCHE UNIVERSITÄT WIEN
Fraunhofer IAF	DC4	AVAILABLE! Tunable EC-QCLs for PTS based protein sensing	INSUCAPS LTD
MTU Ollscoil Teicneolaíochta na Mumhan Munster Technological University	DC5	Multiprotein analysis in human milk using photothermal spectroscopy	IIS La Fe
IIS La Fe	DC6	Mid-IR near-field imaging (AFM-IR) of human milk Extracellular Vesicles	TU WIEN TECHNISCHE UNIVERSITÄT WIEN
Tyndall National Institute Institiúid Náisiúnta	DC7	AVAILABLE! Compact modular photothermal spectroscopy	Fraunhofer IAF
Julius-Maximilians-UNIVERSITÄT WÜRZBURG	DC8	Scalable integrated photonics assisted PTS on microtitre plates	Tyndall National Institute Institiúid Náisiúnta
TU WIEN TECHNISCHE UNIVERSITÄT WIEN	DC9	Advancing mid-IR dispersion spectroscopy toward chip-based passive MZIs	Julius-Maximilians-UNIVERSITÄT WÜRZBURG
TU WIEN TECHNISCHE UNIVERSITÄT WIEN	DC10	Optimising PTS for use in scalable and connectable microreactors	MTU Ollscoil Teicneolaíochta na Mumhan Munster Technological University
MTU Ollscoil Teicneolaíochta na Mumhan Munster Technological University	DC11	EC-CL with high speed wide tunability for PTS and LAS	nanoplus
TU WIEN TECHNISCHE UNIVERSITÄT WIEN	DC12	Free space optics based metasurfaces for enhanced PTS in microtitre well plates	MTU Ollscoil Teicneolaíochta na Mumhan Munster Technological University

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WORK PACKAGES & RESEARCH SKILLS

TRAINING IN PHOTONICS — TRAINING IN PROTEIN SCIENCE

WP1: INTEGRATED SPECTROSCOPY FOR PROTEIN-ASSISTED DRUG DISCOVERY & DELIVERY

	DC3	INSCL/TU-WIEN	Dynamic in-situ studies of drug release by mid-IR laser spectroscopy	
AVAILABLE!	DC4	IAF/INSCL	Tunable EC-QCLs for PTS based protein sensing	AVAILABLE!
AVAILABLE!	DC7	TNI/IAF	Compact modular photothermal spectroscopy	AVAILABLE!
	DC10	TU-WIEN/MTU	Optimising PTS for use in scalable and connectable microreactors	

WP2: INTEGRATED SPECTROSCOPY FOR PROTEIN QUALITY CONTROL

DC5	MTU/IISLAFE	Multiprotein analysis in human milk using photothermal spectroscopy	
DC6	IISLAFE/TU-WIEN	Mid-IR near-field imaging (AFM-IR) of human milk Extracellular Vesicles	
DC8	JMU/TNI	Scalable integrated photonics assisted PTS on microtitre plates	
DC12	TU-WIEN/MTU	Free space optics based metasurfaces for enhanced PTS in microtitre well plates	

WP3: INTEGRATED SPECTROSCOPY FOR ADVANCED PROTEIN SENSING SCHEMES

AVAILABLE!	DC1	NP/MTU	Development of ICL arrays and application in protein sensing	AVAILABLE!
AVAILABLE!	DC2	TU-WIEN/NP	ICD arrays for absorbance sensing using variable pathlengths	AVAILABLE!
	DC9	TU-WIEN/JMU	Advancing mid-IR dispersion spectroscopy toward chip-based passive MZIs	
	DC11	MTU/NP	EC-CL with high speed wide tunability for PTS and LAS	

	WP1: INTEGRATED SPECTROSCOPY FOR PROTEIN-ASSISTED DRUG DISCOVERY & DELIVERY				WP2: INTEGRATED SPECTROSCOPY FOR PROTEIN QUALITY CONTROL				WP3: INTEGRATED SPECTROSCOPY FOR ADVANCED PROTEIN SENSING SCHEMES			
Doctoral Candidate No.:	DC3	DC4	DC7	DC10	DC5	DC6	DC8	DC12	DC1	DC2	DC9	DC11
Lead Host (Recruits for 22.5 months):	INSCL	IAF	TNI	TU-WIEN	MTU	IISLAFE	JMU	TU-WIEN	NP	TU-WIEN	TU-WIEN	MTU
Co-Host (Recruits for 22.5 months):	TU-WIEN	INSCL	IAF	MTU	IISLAFE	TU-WIEN	TNI	MTU	MTU	NP	JMU	NP
PhD Awarding Entities:	MTU	TU-WIEN	MTU	TU-WIEN	MTU	UV	JMU	TU-WIEN	JMU	TU-WIEN	TU-WIEN	MTU
	TU-WIEN	MTU	TU-WIEN	MTU	UV	TU-WIEN	MTU	MTU	MTU	JMU	JMU	JMU
For All Projects:	Planned Start: July/August 2025				Duration: 45 months				Total Researcher-Months in PROTEMIC: 540 months			
COMPONENTS: III-V Based Mid-IR Active Devices:		●	●			●	●		●	●	●	●
COMPONENTS: Passive Devices (Metasurfaces, Passive Chips):			●	●		●	●	●	●	●	●	●
COMPONENTS: Photonic Integration & Packaging:	●		●	●	●		●	●			●	
SPECTROSCOPY: Photothermal Spectroscopy:	●	●	●	●	●		●	●	●			●
SPECTROSCOPY: Dispersion & Multi-pathlength Spectroscopy:		●		●					●	●	●	●
SPECTROSCOPY: AFM-IR Spectroscopy:		●				●						
PROTEINS: Downstream Protein Processing:		●	●				●	●		●		●
PROTEINS: Quality Control of Clinical Proteins:				●	●	●	●	●				●
PROTEINS: Protein Encapsulation & Release:	●	●	●						●		●	
PROTEINS: Data Processing & Chemometrics:	●			●	●	●		●			●	

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WORK PACKAGE 1

INTEGRATED SPECTROSCOPY FOR PROTEIN-ASSISTED DRUG DISCOVERY & DELIVERY

WP1 is dedicated to developing an innovative on-chip Mid-IR photonics device and generating data analysis algorithms for drug release kinetics, towards comprehending protein-based drug delivery dynamics

InsuCaps leads WP1, their expertise in protein encapsulation and delivery forms the backbone of the work package. TU-WIEN and MTU lead critical tasks related to instrument development and successful monitoring of the drug release process and data analysis.

Task 1.1 [Lead: InsuCaps]: Understanding protein denaturation and protein-based encapsulation methods

This task centres on gaining a comprehensive understanding of industrial protein-based encapsulation methods, protein denaturation, and the dynamic changes that occur during drug delivery. PhD candidates will delve into the factors contributing to protein denaturation, including environmental conditions and formulation. The insights gained will provide a foundation for the development of advanced drug delivery systems.

Task 1.2 [Lead: TU-WIEN]: Spectroscopy for understanding protein denaturation and temporal resolution of dynamic changes

Task 1.2 aims to develop an on-chip metasurface-based mid-IR photonics device for monitoring protein structure dynamics. Candidates will design and fabricate this innovative device to provide high-resolution spectroscopy, enabling a deep understanding of protein kinetics during denaturation. This task bridges photonics and molecular biology, advancing drug discovery and delivery systems in WP1.

Task 1.3 [Lead: MTU]: Data analysis and algorithms for protein denaturation kinetics

Task 1.3 is dedicated to the systematic analysis of data obtained from spectroscopic monitoring of protein denaturation and drug release processes. Candidates will employ advanced data analysis techniques to extract meaningful insights from the complex spectroscopic data sets. These algorithms will enable the quantification of key parameters governing the release processes, such as release rates, reaction kinetics, and stability profiles.

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WORK PACKAGE 2

INTEGRATED SPECTROSCOPY FOR PROTEIN QUALITY CONTROL

WP2 aims to develop real-time monitoring of protein structural changes during downstream processing and analysing the structural changes observed in donated human milk to enhance infant nutrition

This WP is led by IISLAFE and involves partners MTU (human milk testing prototype assembling), IISLAFE (prototype benchmarking; collection of HM samples), TU-WIEN (balanced detection), and IAF (EC-QCL source).

Task 2.1 [Lead: TU-WIEN]: Integrated photonics PTS system for real-time monitoring of structural integrity during manufacturing and quality control

This task focuses on developing an integrated photonics-based mid-IR and photothermal spectroscopy hardware, capable of monitoring proteins for subtle changes in their secondary structure, primarily for downstream processing chromatography columns.

Task 2.2 [Lead: IISLAFE]: Advanced spectroscopic monitoring for downstream processing of industrial proteins and quality control of human milk proteins

This involves the testing of human milk samples using the developed prototypes for the rapid and direct quantification of the three main proteins in human milk: casein, α-lactalbumin, and lactoferrin. The prototype, equipped with an EC-QCL source, will operate in the flow-through mode and be evaluated against difference absorbance spectroscopy using a balanced detector. Clinical benchmarking will be conducted by analysing human milk samples across different postnatal and gestational ages.

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WORK PACKAGE 3

INTEGRATED SPECTROSCOPY FOR ADVANCED PROTEIN SENSING SCHEMES

WP3 aims to develop novel sensing schemes for in-situ reaction monitoring. The combination of the developed active and passive building blocks including packaging will produce competitive analysis systems

WP3 is led by TU-WIEN, and will provide designs & test platforms for use by the DCs.

Task 3.1 [Lead: MTU]: PIC-assisted Photothermal Spectroscopy

This task will include systematic studies on the time resolved effects in photothermal spectroscopy including photoacoustic (ns - µs time scale) using dedicated sources (EC-QCL). Based on the gained understanding, an optimal sensing configuration based on integrated and fibre coupled PICs for monitoring of a reaction vessel (SpectroModule) as well free-space coupled sensing PICs for monitoring the wells of a 96-well plate (SpectroPlate) will be realized. Increased wavelength coverage and rapid tuning through metalenses will amplify the possibilities of PTS. Metasurfaces will also support efficient focussing and lead to relaxed alignment requirements in the assembled systems.

Task 3.2 [Lead: TU-WIEN]: Multi-pathlength Waveguides and Dispersion Spectroscopy

*Planar Mid-IR waveguides offer an additional degree of freedom for evanescent wave spectroscopy. Coupled to ICD arrays multi-waveguide sensors will be realized first. This work shall lead to passive 3*3 chip-integrated Mach Zehnder Interferometers employing waveguide structures. Chips will be created for absorption spectroscopy versions of SpectroModule and SpectroPlate.*

Task 3.3 [Lead: TU-WIEN]: AFM-IR Imaging

AFM-IR will allow for label-free imaging with 10 ns resolution, whereas F-PTIR achieves contactless readout of temperature modulated fluorescence. Metasurfaces and dedicated pulsed sources will allow improvements in terms of speed and sensitivity for both modalities leading, enabling also the study of dynamic samples.

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PROTEMIC

DOCTORAL CANDIDATE 1

AVAILABLE!

Development of ICL arrays and application in protein sensing

Nanosystems and Technologies GmbH nanoplus

MTU Ollscoil Teicneolaíochta na Mumhan Munster Technological University

nanoplus GmbH
Location: *Gerbrunn, Germany*
Supervisor: *Dr. Robert Weih*

Munster Technological University
Location: *Cork, Ireland*
Supervisor: *Dr. Maria Kotlyar*

OBJECTIVES

In this project, the DC will receive hands on training on the design and fabrication of active and passive photonic components. These shall be used in a range of different sensing modalities for measuring protein denaturation. At the start of the PhD development, fabrication of active components, i.e. light sources, will be carried out at NP, going from single DFB-ICLs to ICL arrays with a minimum of 5 laser lines on a single chip which shall target the α-helical (for BSA e.g. 1655 cm^{-1}) as well as β-sheet (1617 cm^{-1}, 1692 cm^{-1}) secondary structure elements. The DC will learn to operate the laser individually, enabling multi-wavelengths spectroscopy and determine the most relevant wavelengths for monitoring protein structure. Special attention will be laid on the operation mode in order to minimize thermal crosstalk and evaluate suitable driving schemes. The research will focus on passive devices for evanescent wave spectroscopy at MTU. DC1 will simulate and fabricate planar waveguides using Si on CaF_2 material system as well as several multimode interference couplers (1:2, 2:2, 3:3) which will be used as building blocks in realising complex sensing schemes such as an integrated passive MZIs (designs provided by DC2 and DC9). Protein sensing experiments will be conducted at MTU building on the set-ups developed within PROTEMIC.

EXPECTED RESULTS

The optimized design will lead to ICLs and ICL arrays with low power consumption, cw and pulsed operation at room temperature. Average power will be > 10 mW and sufficient for measuring proteins in aqueous solutions. Measurement protocols based on the produced ICL array will allow a high time resolution as required for fast protein denaturations, which will be induced either through temperature or rapid changes in the chemical environment, like pH changes. Pulsed operation using different pulse frequencies for each laser of the array and the use of demodulation techniques will enable simultaneous measurements at all wavelengths using a single detector. The gained advantages in terms of speed and gained time resolution will be documented. These lasers can be used for real-time monitoring of protein denaturation (folding) in various physiochemical conditions. The DC will study pH induced protein denaturation on the example poly-L-lysin prior to testing samples from the industrial partners. The acquired data will be evaluated by chemometric approaches and the obtained insights will be used for the ***development of functional models on protein denaturation****. These models will enhance our understanding of protein denaturation dynamics, offering insights with broad applications in drug discovery and biopharmaceutical development.*

Planned Secondment:
Paul Scherrer Institut

PAUL SCHERRER INSTITUT PSI

N.B. Secondments are indicative and may be subject to change

Ph.D. Awards From:
Julius-Maximilians-Universität Würzburg
Munster Technological University

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DOCTORAL CANDIDATE 2

AVAILABLE!

ICD arrays for absorbance sensing using variable pathlengths

TECHNISCHE UNIVERSITÄT WIEN

Nanosystems and Technologies GmbH nanoplus

Technische Universität Wien
Location: *Vienna, Austria*
Supervisor: *Prof. Dr. Benedikt Schwarz*

nanoplus GmbH
Location: *Gerbrunn, Germany*
Supervisor: *Dr. Jordan Fordyce*

OBJECTIVES

The problem of uneven water background absorption in the "protein range" from 1700-1500 cm^{-1} will be tackled by DC2. Most sensitive mid-infrared photodetectors suffer from saturation effects at large laser powers, which strongly limits their usable dynamic rage. This prevents a precise measurement of small and large signals with the same waveguide and detector. In the first step of this project, the DC will develop high-speed carrier transport optimized interband cascade detectors, which provide both high sensitivity and high saturation power levels to improve the dynamic range. In a second step, an array of these detectors will be used for simultaneous absorption measurements using varying optical path lengths to gain a higher SNR in spectral regions with very strong or very low background water absorption. Mid-IR planar waveguide with multiple channels will be fabricated in cooperation with DC1 and DC9. Advanced coupling strategies will be investigated for parallel beam coupling to the photodetector array, including metamaterial couplers and on-chip hybrid integration. DC2 would perform protein sensing experiments using different solvents, protein concentrations, and temperatures to validate the on-chip device. BSA and Whey proteins would be used as standard examples.

EXPECTED RESULTS

The approach to combine individual spectra measured at different path-lengths into one single spectrum holds the promise for improved S/N across the whole covered spectral region despite of strongly varying background (solvent)absorption. Through careful comparison with the classical approach of constant pathlength measurements the anticipated advantages will be documented on the example of protein analysis in aqueous solutions. Furthermore, by combining absorbance measurements at different effective path lengths the dynamic range in terms of concentration coverage will be significantly enlarged compared to single pathlength measurements. Finally we also expect comparison of the analytical figures of merit (LOD, linearity, dynamic range) of this approach when absorbance measurements at varying pathlengths with dispersion spectroscopy measurements.

Planned Secondment:
Paul Scherrer Institut

PAUL SCHERRER INSTITUT PSI

N.B. Secondments are indicative and may be subject to change

Ph.D. Awards From:
Technische Universität Wien
Julius-Maximilians-Universität Würzburg

PROTEMIC

DOCTORAL CANDIDATE 4

AVAILABLE!

Tuneable EC-QCLs for PTS based protein sensing

Fraunhofer IAF

INSUCAPS LTD

Fraunhofer IAF
Location: *Freiburg, Germany*
Supervisor: *Dr. Stefan Hugger*

InsuCaps Ltd
Location: *Cork, Ireland*
Supervisor: *Dr. Sinéad Bleiel*

OBJECTIVES

The DC 4 project is multidisciplinary: The work at IAF focuses on assembly, in-depth characterization and optimization of External Cavity Quantum Cascade Lasers (EC-QCLs) regarding the requirements of different measurement techniques to be developed in PROTEMIC. During the second stage at INSCL, the EC-QCL will be applied to study protein denaturation processes. The project is therefore best suited for candidates with a solid background in physics / photonics, who are also eager to cross the bridge to analytical chemistry and develop a good understanding of protein denaturation and its relation to mid-IR spectroscopy.

At IAF a flexible EC-QCL technology platform has been developed resulting in miniaturized and rugged EC-QCL modules. During the first stage of the project, dedicated EC-QCL modules for application in protein sensing will be realised. These EC-QCL sources will be optimized for direct (absorption, dispersion) and indirect (photothermal and photoacoustic) spectroscopy, respectively. In each case low noise operation, spectral repeatability and wavelength-dependent beam pointing instability will be investigated, and measures for improvement will be implemented. An EC-QCL unit dedicated to time resolved studies of indirect spectroscopies will be developed to provide maximum power in short pulses and at low repetition rates (~ 10-100Hz). DC4 will work with DC7 to adapt SpectroPlate for the EC-QCL. This laser will be used also by DC10 for microreactor measurements. DC4 will further assemble an EC-QCL(1500-1700 cm^{-1}) for use in PT imaging (coop. with DC5) and on the study of protein denaturation processes when working at the co-host INSCL during the second state of the project. For the latter application small changes in the protein spectra need to be detected requiring utmost stability of the planned measurements. Difference spectra will be utilized for analysis, effectively eliminating drifts and matrix effects. ***A key objective is to engineer a versatile platform that continuously probes protein denaturation processes within a digestion reactor/chamber****.*

EXPECTED RESULTS

The project will deliver miniaturized EC QCLs, emitting in the 1500-1700 cm^{-1} range, optimized towards: a) high peak power / short pulse, low duty cycle operation; b) high average power, highly stable low noise operation. It will also provide an improved understanding of critical factors for EC-QCL performance such as wavelength dependent beam pointing instabilities. Using the optimized EC-QCLs in a double micro-reactor PTS set-up we expect that minute changes in the amide I and II bands can be detected when performing protein denaturation studies. The developed sources will also support research in imaging of HM EVs using AFM-IR (DC6).

Planned Secondment:
Munster Technological University

MTU Ollscoil Teicneolaíochta na Mumhan Munster Technological University

N.B. Secondments are indicative and may be subject to change

Ph.D. Awards From:
Technische Universität Wien
Munster Technological University

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DOCTORAL CANDIDATE 7

AVAILABLE!

Compact modular photothermal spectroscopy

Tyndall National Institute
Institiúid Náisiúnta

Fraunhofer IAF

Tyndall National Institute
Location: *Cork, Ireland*
Supervisor: *Dr. Padraic Morrissey*

Fraunhofer IAF
Location: *Freiburg, Germany*
Supervisor: *Dr. Stefan Hugger*

OBJECTIVES

To render PIC (Photonic Integrated Circuit) based sensor systems truly applicable for sensing applications - particularly in biopharma and medical diagnostics - robust integration of light sources and detectors is essential. These systems must maintain high analytical performance while supporting sterility, sample integrity, and the use of disposable microfluidic cartridges. A modular design, enabling reusability and interchangeability of components, is critical for real-world deployment.

DC7 will focus on the laser physics and photonic integration required to support such a system. A major aspect of the project will involve the characterisation and optimisation of near- and mid-infrared lasers, including their beam properties, thermal stability, modulation behaviour, and free-space coupling efficiency. This will be paired with work on the optical and mechanical packaging of these sources into a robust, compact platform compatible with photonic integrated circuits (PICs) and disposable sensing cartridges. The NIR laser will be integrated through a modular optical interface using 3D-printed lenses on fibre arrays and PICs - designed to preserve beam quality and alignment across repeated connections. The mid-IR excitation laser (developed in DC1 and DC4) will be free-space coupled into the system, and DC7 will work with IAF and DC11 on the evaluation and integration of metasurface-tuned EC-QCLs, including strategies for temperature-controlled wavelength tuning.

This project is particularly suited to candidates with a background in physics, especially laser physics, optics, or photonics, who are interested in applying fundamental optical principles to system-level challenges. The work will combine laser system design and characterisation, beam propagation modelling, and precision opto-mechanical integration, offering a unique opportunity to contribute to the development of cutting-edge sensing technology with direct industrial relevance.

EXPECTED RESULTS

Compact and modular photothermal spectroscopy system based on a user-friendly pluggable optical interface using 3D printed lenses on fiber arrays and PICs. Based on iterative improvements all noise sources like interference fringes will have been identified and eliminated. ***The developed design will contain a functional mechanism for deploying disposable bio-cartridges for sample sterility and integrity****. Furthermore, metasurface based EC-QCLs will be realized and evaluated for lineshape, wavelength precision and tunability. Integration into a PTS system will allow comparison of their performance to established EC-QCLs.*

Planned Secondment:
InsuCaps Ltd

INSUCAPS LTD

N.B. Secondments are indicative and may be subject to change

Ph.D. Awards From:
Munster Technological University
Technische Universität Wien

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APPLICATION PROCESS

Applications will only be accepted through the website

WWW.PROTEMIC.EU

MSCA ELIGIBILITY RULES

*Researchers may be of any nationality. However, they **must** undertake physical, **trans-national mobility** (i.e. move from one country to another) when taking up their appointment. Mobility is defined as: the researcher must not have resided or carried out his/her main activity (work, studies, etc.) in the country of the recruiting organisation for more than 12 months in the 3 years immediately prior to his/her recruitment*. This applies to the first recruiting host for each position.*

*Candidates **must not** already have a doctoral degree (whether awarded, or defended and awaiting award).*

- **Compulsory national service, short stays such as holidays, or time spent as part of a procedure for obtaining refugee status under the Geneva Convention, are not taken into account.*

BEFORE APPLYING

- *Check you meet the **MSCA Eligibility Requirements** regarding Early Career Stage and Mobility.*
- ***Rank the 4 available projects** in your order of preference, from first preference to fourth preference.*
- ***Prepare your CV and Cover Letter**; these should be combined into a **single pdf** document. Your Curriculum Vitae should include details of the country(ies) where you have lived/worked within the past 3 years, and the dates of award of your qualifications, in order to verify your eligibility under the MSCA rules. Documentary evidence will be required at recruitment stage. The Cover Letter should describe your motivations for applying to PROTEMIC.*

STAGE 1: APPLICATION SUBMISSION AND CV SHORTLISTING

- *Submit your application using the **online form** on the website **www.protemic.eu**, before the deadline date. Only applications submitted using this form will be considered.*
- *You will be asked to: **1)** Enter your name and email address. This email will be used for all communications regarding your application. (Please add info@protemic.eu to your contacts to avoid spam filters); **2)** Confirm your eligibility under the MSCA rules; **3)** Select your 4 project preferences; **4)** Upload a single pdf containing your CV and Cover Letter; **5)** Click 'Submit'. N.B. it will not be possible to modify your application once submitted.*

After the Application Deadline, the PROTEMIC consortium will evaluate and rank the submissions for each project, according to set criteria. For each project, candidates scoring above a set threshold will be called for interview.

STAGE 2: INTERVIEWS

- *For those selected, interviews will be conducted **online**, using Microsoft Teams. Candidates will be asked to prepare a short, **10 minute presentation**.*
- *Interview panels will rank candidates according to set criteria, and a list of suitable candidates (if any) for each project will be agreed. The candidates' preference (indicated at application time) will then be taken into account, in order to arrive at a **Selected Candidate for each project** (if no suitable candidate is found for a particular project, that project may be re-advertised at a later stage).*

Following interviews, Selected Candidates will be sent a Letter of Selection.

STAGE 3: RECRUITMENT AT HOST INSTITUTION

- *Once a candidate has accepted the Letter of Selection, they will then proceed to the recruitment process at their host institution. **Note that each institution may have additional procedures which must be followed, including, inter alia, additional interviews and/or documentation**. The final decision on recruitment lies with the host institution.*

N.B. Refer to the website for full details and up-to-date information

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PROTEMIC

An EU MSCA Joint Doctoral Training Network

CONTACT

PROTEMIC is coordinated by:

MUNSTER TECHNOLOGICAL UNIVERSITY, Cork, Ireland

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