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qCSI

QUANTITATIVE CHEMICALLY-SPECIFIC IMAGING INFRASTRUCTURE FOR MATERIAL AND LIFE SCIENCES

LAUNCH SYMPOSIUM

27TH JANUARY 2023
A111 AUDITORIUM, EXACTUM
KUMPULA CAMPUS, HELSINKI

PROGRAM

9:00 – 9:15 Welcome/opening
Clare Strachan, University of Helsinki and Mika Pettersson, University of Jyväskylä

SESSION I: INTRODUCTION TO qCSI

Chair: Markku Vainio, Department of Chemistry, University of Helsinki

9:15 – 9:35 Mika Pettersson and Eero Hulkko, University of Jyväskylä
Scattering-type near-field optical microscopy (SNOM)

9:35 – 9:55 Clare Strachan and Teemu Tomberg, University of Helsinki
Fast multiplex coherent-Raman spectroscopy imaging

9:55 – 10:15 Erik Vartiainen, Lasse Lensu, and Teemu Härkönen, LUT University
Spectral data analysis platform

10:15 – 10:45 Coffee break
Lobby

SESSION II: CHEMICAL AND BIOLOGICAL APPLICATIONS

Chair: Antti Isomäki, Biomedicum Imaging Unit, Faculty of Medicine, University of Helsinki

10:45 – 11.30 *Plenary*

Herman Offerhaus, Chair Optical Sciences group, University of Twente, Netherlands
Development and applications of coherent Raman microscopy

11:30 – 11:50 Lauri Vanharanta, Department of Anatomy, University of Helsinki and Minerva Foundation Institute for Medical Research
Lipid analysis in cells

11:50 – 12:10 Romain Chevigny, Nanoscience Centre and Department of Chemistry, University of Jyväskylä
Near-field spectroscopy and imaging of molecular gels

12:10 – 12:30 Teemu Härkönen, LUT University
Machine learning CARS data processing

12:30 – 13:30 Lunch
Lobby

SESSION III: MATERIALS SCIENCE AND PHARMACEUTICAL APPLICATIONS

Chair: Mika Pettersson, Nanoscience Centre and Department of Chemistry, University of Jyväskylä

13:30 – 14.15 *Plenary*

Rainer Hillenbrand, Nanooptics Group Leader, Nanoscience Research Center CIC nanoGUNE, San Sebastian and Joint Professor , University of the Basque Country, Spain
SNOM for nanoscale characterisation

14:15 – 14.35 Charles Rambo, Nanoscience Centre and Department of Physics, University of Jyväskylä
Characterizing silicon photonic crystal structures with s-SNOM

14:35 – 14:55 Jukka Saarinen, University of Helsinki
Pharmaceutical applications of coherent Raman microscopy

14:55-18:00 Reflections, drinks, mingling and lab tour
Lobby and Chemicum, 4th floor (lab tour)

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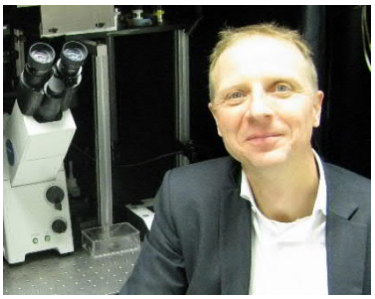
An Academy of Finland funded FIRI Research Infrastructure

Registration (deadline Jan 12th 2023)

Development and applications of coherent Raman microscopy



Herman L. Offerhaus

Optical Sciences group, fac. Of Applied Sciences, University of Twente, The Netherlands

ABSTRACT

Coherent Anti-Stokes Raman Scattering (CARS) is a label free microscopy technique that allows for relatively fast imaging based on inherent vibrational contrast. In this talk I will try to explain how different implementations of CARS work and what that means in terms of sensitivity, specificity, chemical selectivity and review some applications.

BIO

Prof. Offerhaus received his masters degree in 1993 from Delft University of Technology (NL) and obtained his PhD in 1997 in laser physics from the University of Twente (NL). Since then he has worked on fiber lasers, nonlinear conversion, vibrational imaging, medical/pharmaceutical analysis, plasmonics, Fourier optics, molecular spectroscopy, holography, gyroscopes, dielectric sensing, optical sensors and microfluidics. In 2002 he joined the Optical techniques group in Twente. He chairs the Optical Sciences group since 2006, becoming a full professor in 2021. He teaches courses on electromagnetism, optics, ethics and general physics. He has published more than 125 papers in refereed journals, holds 4 patents and chairs the Atomic Molecular and Optical physics division of the Dutch national physics organization.

Group website: http://opticalsciences.nl

ResearcherID: https://publons.com/researcher/AAD-8742-2021/

Studying mechanisms of cellular lipid transport and storage by imaging

Lauri Vanharanta[1,2], Abel Szkalisity[1,2], Elina Ikonen[1,2]

[1]Department of Anatomy and Stem Cells and Metabolism Research Program, Faculty of Medicine, University of Helsinki, Helsinki, Finland.
[2]Minerva Foundation Institute for Medical Research, Helsinki, Finland.

ABSTRACT

Lipids are important components of cellular membranes and used for energy storage. Defects in lipid metabolism cause significant morbidity and mortality. In order to combat lipid-related diseases we need detailed knowledge on the regulation of cellular lipid homeostasis. Various microscopy techniques can be utilized to study transport and storage of cholesterol and other lipids in cells. Here we present examples of both fluorescent and label-free imaging that can be used for studying cellular lipid trafficking.

BIO

Lauri Vanharanta, MD, graduated from the University of Helsinki in 2020 and is currently doing his PhD in professor Elina Ikonen's research group at the University of Helsinki. His research focuses on cholesterol transport and storage in cells and utilizes methods in cell biology with the emphasis on imaging techniques.

Nanoscale probing of the supramolecular assembly in a two-component gel by near-field infrared spectroscopy

Romain Chevigny

Department of Chemistry, Nanoscience Center, University of Jyväskylä

ABSTRACT

The design of soft biomaterials requires a deep understanding of molecular self-assembly. We introduce a nanoscale infrared spectroscopy study of a two-component supramolecular gel to assess the system´s heterogeneity and supramolecular assembly. In contrast to far-field IR spectroscopy, near-field IR spectroscopy reveals differences in the secondary structures (α-helix and β-sheet) of the gelator molecules and non-covalent interactions (hydrogen bonding and π-π stacking) depending on the gel network's features. We investigated the forces driving gelation for features such as single, parallel and crossed fibres.

BIO

I completed my bachelor and master's degree at the Université de Lorraine (France) focusing on solid-state chemistry. After that, I started my PhD studies at the University of Jyväskylä in the field of supramolecular chemistry. My research focuses on the development of transient supramolecular gels, and the fundamental chemistry leading to gelation, for applications ranging from delivery systems to self-abolishing cell culture media.

Machine learning for CARS data processing

Teemu Härkönen

LUT University

ABSTRACT

Convolutional neural networks have seen widespread use in a plethora of fields in science and engineering. Such techniques provide a tool for learning a complex mapping between data and the desired result. Coherent anti-Stokes Raman scattering spectra are one such case. We present convolutional neural techniques for extracting the underlying Raman signal in coherent anti-Stokes Raman scattering spectra. The model is trained with synthetic and semi-synthetic spectra with the latter combining simulated spectral features with real-life Raman measurements.

BIO

Teemu Härkönen is a junior researcher at LUT University specializing in applied mathematics and Bayesian statistics. His research interests include sequential Monte Carlo techniques, stochastic processes, and statistical modelling.

Snom for nanoscale characterisation

Rainer Hillenbrand

CIC nanoGUNE BTRA, San Sebastian, Spain

ABSTRACT

Scattering-type scanning near-field optical microscopy (s-SNOM) and nanoscale Fourier transform infrared spectroscopy (nano-FTIR) open a new era in modern nanoanalytics, including the chemical identification of organic and inorganic materials, protein secondary structure mapping, free-carrier profiling in semiconductors, or mapping of polaritons in 2D materials such as graphene and h-BN, all with a spatial resolution of about 10 - 20 nm. s-SNOM and nano-FTIR are based on elastic light scattering at an atomic force microscope tip, employing either monochromatic laser illumination or broadband illumination from a supercontinuum laser or a synchrotron. Acting as an optical antenna, the tip converts the illuminating field into a strongly concentrated near field at the very tip apex (nanofocus), which provides a means for local excitation of molecule vibrations, plasmons or phonons in the sample surface. Recording of the tip-scattered field as a function of sample position (employing monochromatic illumination) yield nanoscale-resolved IR and THz images, while Fourier-transform spectroscopy of the tip-scattered field (employing broadband illumination) allows for nanoscale IR point spectroscopy and IR hyperspectral nanoimaging. In this talk I will introduce the microscopy basics and discuss a few applications.

BIO

Rainer Hillenbrand is an Ikerbasque Research Professor and Nanooptics Group Leader at the nanoscience research center CIC nanoGUNE BRTA in San Sebastian (Basque Country, Spain), and a Joint Professor at the University of the Basque Country. He is also co-founder of the company neaspec GmbH (Germany), which develops and manufactures near-field optical microscopes. From 1998 to 2007 he worked at the Max-Planck-Institute for Biochemistry (Martinsried, Germany), where he led the Nano-Photonics Research Group from 2003 to 2007. He obtained his PhD degree in physics from the Technical University of Munich in 2001. Hillenbrand pioneered the development of infrared near-field nanoscopy and nanospectroscopy, and its applications in nanophotonics, polaritonics, materials sciences and soft matter sciences. In 2014 he received the Ludwig-Genzel-Price “for the design and development of infrared near-field spectroscopy and the application of the novel spectroscopy method in different fields of natural sciences”.

Characterizing Silicon Photonic Crystal Structures with s-SNOM

Charles Rambo, Juha Muhonen

Department of Physics, University of Jyväskylä, Finland

ABSTRACT

We will present our work on characterizing silicon photonic crystal structures using scattering-scanning nearfield optical microscopy (s-SNOM). Photonic crystals (PhCs) are periodic structures that can manipulate the flow of light and have potential applications in a range of fields, including telecommunications, sensing, and quantum devices. We aim to produce quantum devices where emitters in silicon are integrated with the PhC structures. To maximize the coupling from the emitters to the PhC modes, it is crucial to place the emitters at locations where the electric field of the desired mode is maximized. Through s-SNOM, we aim to obtain high-resolution images of photonic crystal structures and extract information about their detailed optical mode properties; without relying solely on simulations, which are generally not accurate enough in the presence of fabrication errors. In this talk, I will discuss the advantages of s-SNOM over other characterization techniques and the experimental setup we are using to characterize the crystal structures and show preliminary results from several different PhC devices. The objective of the talk is to demonstrate that s-SNOM is a powerful tool for the characterization of photonic crystals and can provide valuable information for the design and optimization of the wide variety of PhC devices and their integration with quantum emitters.

BIO

Charles Rambo is a PhD researcher at the University of Jyväskylä working in the Hybrid Quantum Technologies group of Associate Professor Juha Muhonen focusing on developing silicon-based devices for quantum computing. Charles has an AS from North Lake College, BA in Physics from Austin College, and MSc from the University of Eastern Finland.

Pharmaceutical applications of coherent Raman microscopy

Jukka Saarinen

Division of Pharmaceutical Chemistry and Technology, University of Helsinki, Finland

ABSTRACT

Coherent Raman microscopy combined with other non-linear optical imaging methods are gaining interest in pharmaceutical applications. Multimodal non-linear optical imaging can be used in various stages of drug development. In this presentation some examples of coherent Raman microscopy and non-linear optical imaging in solid-state analysis and biopharmaceutical applications will be presented.

BIO

Dr. Jukka Saarinen received his Masters degree in Pharmacy in 2014 and obtained his PhD in 2018 from the University of Helsinki at the Division of Pharmaceutical Chemistry and Technology. He is a member of Professor Clare Strachan's research group, Pharmaceutical Spectroscopy and Imaging. His research is focused on pharmaceutical applications of non-linear optical imaging, especially coherent Raman microscopy. His special interest is biological and biopharmaceutical applications. Currently he holds the position a University Lecturer in the discipline of Pharmaceutical Chemistry. He has published several articles about non-linear optical imaging and Raman spectroscopy in refereed pharmaceutical journals and has also authored book chapters in this field.