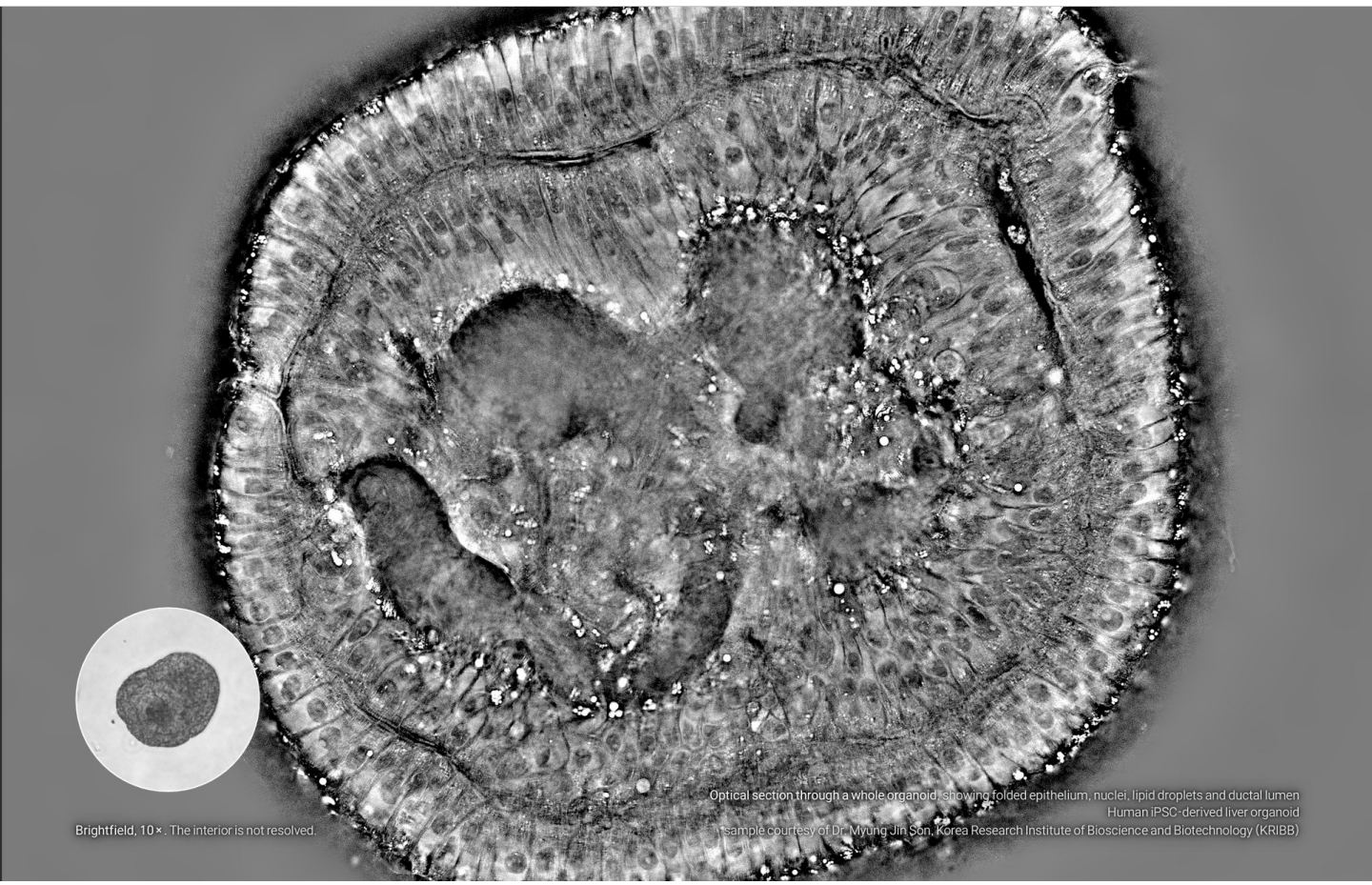
PROGRAM DRAFT v11

The 6th Quantitative Phase Imaging Symposium

19–21 November 2026
The Chinese University of Hong Kong



Organizers, co-organizer and supporters

KAIST 香港中文大學 The Chinese University of Hong Kong NRF 한국연구재단 Tomocube

Co-organizer: IEEE Photonics Society Hong Kong Chapter

Welcome remark

Dear Colleagues,

Welcome to the 6th Quantitative Phase Imaging Symposium at The Chinese University of Hong Kong.

The scientific program on Friday, 20 November 2026 brings together researchers working on quantitative phase imaging, computational optics, biological imaging and related approaches, including atomic-scale electron tomography. Six invited talks, four poster lightning talks and 31 poster presentations are included.

This year's symposium will take place exclusively in person. We look forward to discussing recent results, exchanging ideas and meeting colleagues from across the community.

A welcome dinner for symposium chairs and invited speakers is scheduled for 19 November. The scientific program and conference dinner take place on 20 November.

Thank you to our invited speakers, poster presenters, local organizers and supporters. We look forward to seeing you in Hong Kong.

Symposium co-chairs

YongKeun (Paul) Park, KAIST

Seung Ah Lee, Seoul National University

Renjie Zhou, The Chinese University of Hong Kong

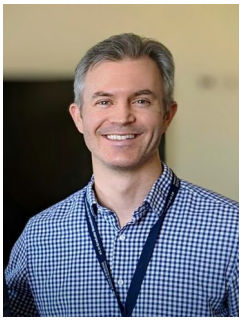
Yongsoo Yang, KAIST

Program committee

Qihang Zhang, The Chinese University of Hong Kong

Confirmed invited speakers

Listed in presentation order; the schedule is proposed.



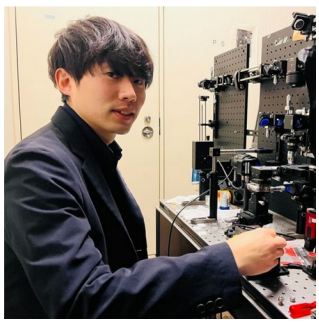
Nicholas Durr

Johns Hopkins University



Yuan Luo

National Taiwan University



Naru Yoneda

Kobe University



Kenneth K. Y. Wong

The University of Hong Kong



Yongsoo Yang

KAIST



Kevin Tsia

The University of Hong Kong

Registration

The symposium takes place exclusively in person. Registration is free. There is no online attendance or remote presentation option.

Registration and poster submission form

https://forms.gle/XYUY5wwuBPstPwc39

Symposium website

https://bmol.kaist.ac.kr/qpi-symposium/

The poster abstract submission deadline was 30 October 2026, 23:59 Hong Kong time. This draft includes 31 submitted posters and four selected lightning talks.

Conference dinner participation is subject to availability. Final attendance arrangements will be confirmed by the organizers.

Local coordination

Qihang Zhang qhzhang@cuhk.edu.hk

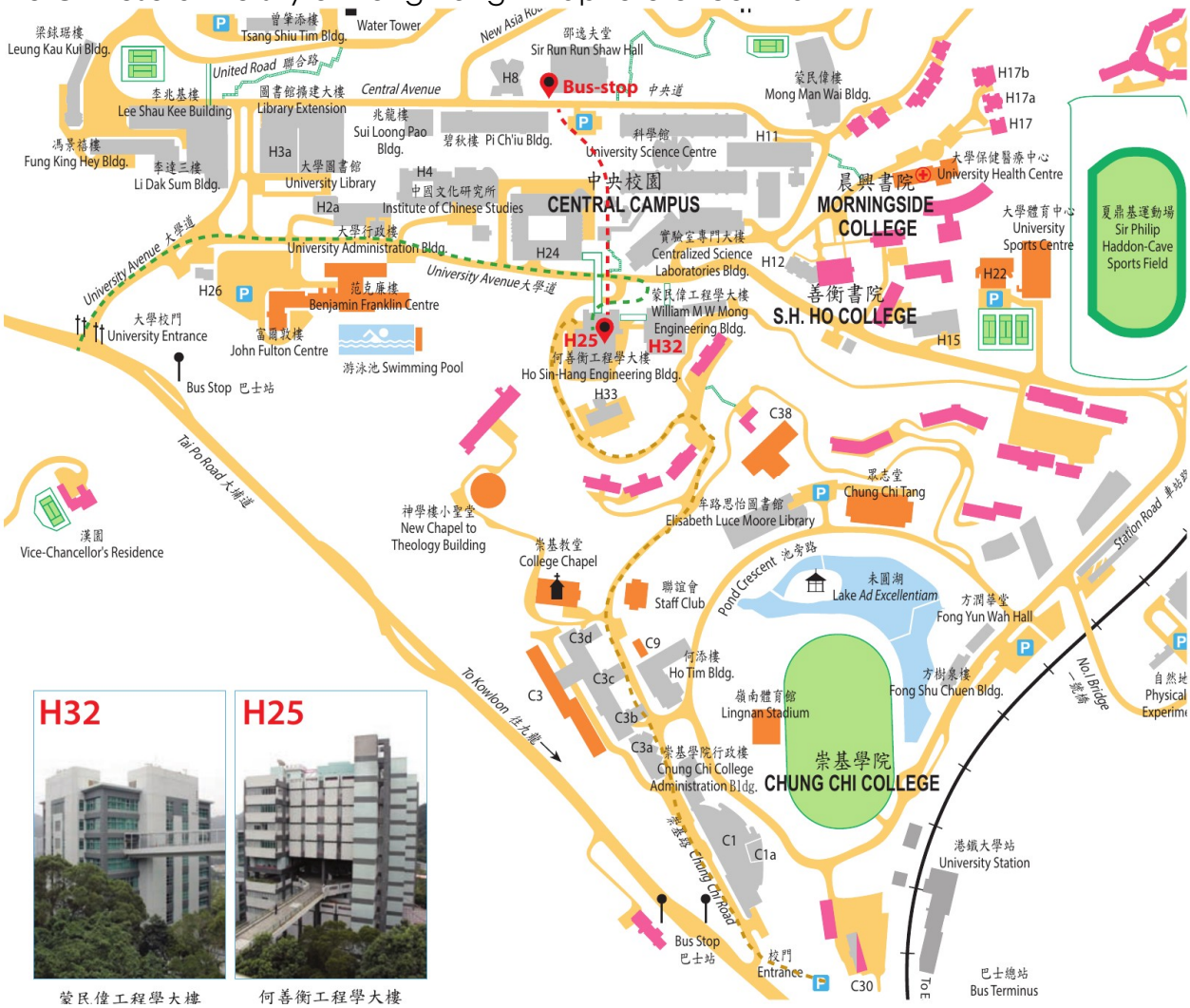
Program coordination

YongKeun (Paul) Park yk.park@kaist.ac.kr

Poster dimensions: 160 cm (height) × 90 cm (width).

Campus map and room access

20 November 2026 · Scientific program
Ho Sin-Hang Engineering Building (SHB), Room 603, 6/F
The Chinese University of Hong Kong · Map reference H25



Official CUHK map · H25 = SHB · Dashed gold line = walking route

From University MTR Station

Take the MTR East Rail line to University Station. Enter CUHK and follow Chung Chi Road uphill to SHB (H25); allow about 15 minutes on foot.

Finding Room 603

Go to 6/F, Room 603. From University Mall, the pedestrian route leads down steps to a bridge entering SHB at 5/F; continue to 6/F.
For a step-free route or help finding the room, contact Qihang below.

Campus entry and local assistance

Bring ID and any visitor-entry QR supplied by the organizers.
Qihang Zhang · qhzhang@cuhk.edu.hk · +852 5262 5245

Official SHB map | Building access guide | Visitor transport / entry

Accommodation and meals

Recommended accommodation

Hyatt Regency Hong Kong, Sha Tin

18 Chak Cheung Street · next to University MTR Station

Royal Park Hotel

8 Pak Hok Ting Street · Sha Tin MTR Station

Courtyard by Marriott Hong Kong Sha Tin

1 On Ping Street · Shek Mun MTR Station

ALVA Hotel by Royal

1 Yuen Hong Street · Shek Mun MTR Station

Thursday 19 November · Welcome dinner and steering meeting

18:00 · Sha Tin 18, Hyatt Regency Hong Kong, Sha Tin
For symposium chairs and invited speakers.

Friday 20 November · Lunch and conference dinner

12:00–13:30 · Lunch break
Chairs and invited speakers: Chung Chi College staff Canteen.

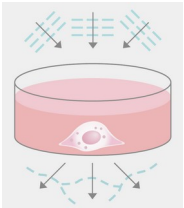
18:00–20:45 · Conference dinner
Chung Chi College Student Canteen, 1/F, South Wing.

Tomocube

Holotomography: 3D Label-free Live Cell Imaging

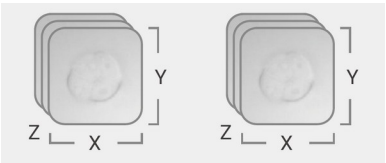
Innovate the way we see life

How holotomography (HT) works



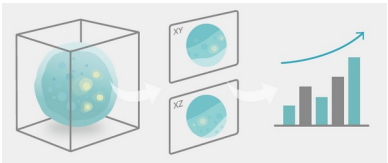
Multiple illumination

LED illumination module integrated with a digital micromirror device



2D optical measurements

Phase and amplitude information per illumination condition



3D RI tomogram

Computationally integrated into a detailed 3D refractive index (RI) tomogram

Label-free · Quantitative (dry mass, mass density) · Time-lapse imaging

HT-X1™ Plus + TomoAnalysis™

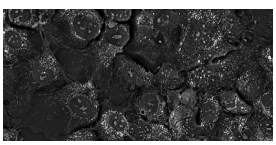


HT-X1™ Plus

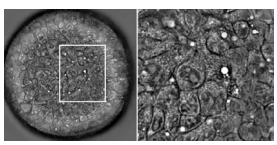
Efficient 3D imaging for plate-based screening: faster acquisition and a wider field of view than HT-X1™, plus expanded fluorescence options

TomoAnalysis™

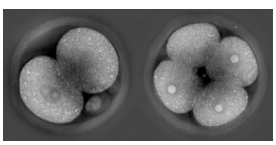
From 3D RI tomograms to quantitative data: automated, customizable analysis pipelines for cell volume, dry mass, and RI. AI-based segmentation with the AI Plus license.



Cancer biology Hep3B (Human Hepatocellular Carcinoma)



3D cell culture research Mouse hepatic organoid



Reproductive biology Mouse embryo · Courtesy: Y. Yamanaka, McGill

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Computational Imaging Engineer Reconstruction

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Forward/inverse problem modeling and solvers
Image quality enhancement (artifact removal, denoising)

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Open Positions

Technology
#Holography #Tomography #Reconstruction
#InverseProblem #Regularization #Metrology
Applications
#Organoid #IVF #TGV #VNAND #Waveguide #CPO

Program Friday 20 November 2026

Proposed schedule · Hong Kong time (HKT, UTC+8)
Invited talks: 35-minute presentation + 5-minute Q&A

Time	Program
08:45–09:20	Registration and poster setup
09:20–09:30	Opening remarks · Prof. Hon Ki Tsang (CUHK)
09:30–10:10	**Nicholas Durr** Invited talk 1 · Johns Hopkins University
10:10–10:50	**Yuan Luo** Invited talk 2 · National Taiwan University
10:50–11:10	Coffee break
11:10–11:50	**Naru Yoneda** Invited talk 3 · Kobe University
11:50–12:00	Group photograph
12:00–13:30	Lunch break Chairs and invited speakers: Chung Chi College staff Canteen
13:30–14:10	**Kenneth K. Y. Wong** Invited talk 4 · The University of Hong Kong
14:10–14:50	**Yongsoo Yang** Invited talk 5 · KAIST
14:50–15:10	Coffee break
15:10–15:50	**Kevin Tsia** Invited talk 6 · The University of Hong Kong
15:50–16:10	Poster lightning talks
16:10–17:20	Poster session and discussion
17:20–17:40	Poster awards and closing remarks
18:00–20:45	Conference dinner Chung Chi College Student Canteen, 1/F South Wing

Scientific program: SHB, Room 603
Lightning talks: P21, P27, P28 and P03 · Session chairs: to be announced.

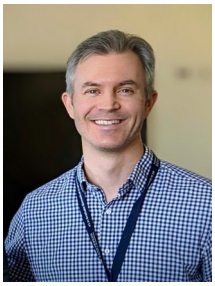
Saturday 21 November

Optional programme · Details will be announced on site.

Invited talk

Nicholas Durr

Johns Hopkins University



Backscattered phase microscopy for non-invasive blood analysis and direct-to-digital pathology

Abstract

Conventional phase microscopy uses transmission illumination. We present two back-illumination epi-mode microscopy designs that enable high-speed, high-resolution imaging of phase objects in thick, unlabeled specimens. These techniques encode lateral or axial phase gradients as intensity differences at the image sensor plane, producing high contrast to transparent features of the object. We apply these techniques to in vivo imaging of human blood cells flowing through superficial capillary vessels and ex vivo imaging of freshly resected pathology specimens. We present deep learning models to extract clinically relevant biomarkers from these video data, including rheology parameters, blood count estimates, and 3D H&E-staining. We report the first in-vivo visualization of the vaso-occlusion cascade with cellular resolution in sickle cell disease patients. We also show 3D renderings of virtual histopathology stains of unprocessed pathology blocks.

Biography

Nick Durr is an associate professor of biomedical engineering at Johns Hopkins University. His research combines optics, computational imaging, and deep learning to develop practical tools for clinical applications. His work includes back-illumination phase microscopy for non-invasive blood analysis and computational approaches to pathology imaging. He received a BS in electrical engineering and computer science from UC Berkeley and MS and PhD degrees in biomedical engineering from the University of Texas at Austin. He completed postdoctoral training at Harvard Medical School and was an M+Visión Medical Imaging and Innovation Fellow at MIT.

Invited talk

Yuan Luo

National Taiwan University



Flat Optics with Computational Imaging for Biomedical Applications

Abstract

Optical microscopy remains a cornerstone of biological research, offering indispensable insights into complex cellular processes. Recently, the strategic implementation of structured light has become pivotal in surmounting the diffraction limit and enhancing resolution. Simultaneously, the emergence of metasurfaces—engineered nanostructures capable of precise light manipulation—has revolutionized the field by enabling ultra-compact, high-performance optical functionalities. This talk showcases recent breakthroughs in structured light and meta-optical systems for biomedical applications. We explore the development of quantitative cell imaging and high-speed optical sectioning, with a focus on integrating metalenses into light-sheet fluorescence microscopy (LSFM) for enhanced deep-tissue observation. Additionally, we discuss the synergy between flat optics and computational imaging—specifically spatially variant aberration correction—as a powerful strategy for achieving exceptional image fidelity. By merging meta-optical design with advanced computational frameworks, this presentation illustrates a transformative frontier for next-generation biomedical diagnostics.

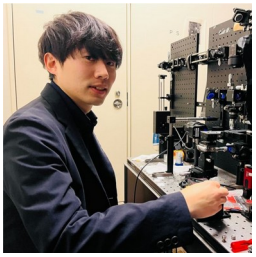
Biography

Yuan Luo received the MSc and PhD degrees in the College of Optical Sciences in 2007 and 2008, respectively, from the University of Arizona. After post-doctoral work at the Massachusetts Institute of Technology (MIT, 2009–2011), he joined the faculty at National Taiwan University (NTU) in 2011, where he is now Director and Professor of the Institute of Medical Device and Imaging (MDI) at NTU College of Medicine. He also serves as Program Director of Precision Health and Intelligent Medicine (PHIM) at the NTU Graduate School of Advanced Technology and holds the Associate Deanship in the NTU YongLin Institute of Health. He has worked or held visiting appointments at the Singapore-MIT Alliance for Research and Technology (SMART) Center in Singapore. He has recently been appointed as a Joint Appointment Researcher at the Research Center for Applied Sciences (RCAS) at Academia Sinica. His research interests are in the fields of novel optical microscopy and endoscopy, volume holography, development and applications of metasurface for biological imaging. He is a Fellow of the International Society for Optical Engineering (SPIE).

Invited talk

Naru Yoneda

Kobe University



Beyond Quantitative Phase Imaging: From Classical Wavefront Sensing to Quantum Imaging and Optogenetics

Abstract

Quantitative phase imaging (QPI) has emerged as a powerful tool for visualizing transparent specimens and characterizing optical wavefronts without the need for labeling. Beyond conventional phase measurement, wavefront sensing and control offer new opportunities for advanced imaging, optical manipulation, and quantum technologies. In this talk, I will present our recent research extending the capabilities of QPI, from classical computational imaging to holographic optogenetics and quantum imaging. First, I will introduce our development of transport-of-intensity equation (TIE)-based phase imaging using a commercially available confocal microscope without any modification to its optical system. This approach enables quantitative phase imaging of living cells using an existing microscope and allows multimodal imaging combining phase and fluorescence information. Next, I will discuss our ongoing research on holographic light shaping for optogenetics, aiming to achieve precise spatial control of two-photon excitation for manipulating biological activity. Finally, I will present our recent advances in quantum imaging with undetected photons. By combining quantum erasure with geometric phase shifting, we have demonstrated single-shot quantum holography, enabling real-time phase imaging of infrared objects using a silicon-based image sensor. Together, these studies illustrate how wavefront measurement and control can extend QPI beyond conventional imaging, opening new possibilities at the intersection of computational optics, biological photonics, and quantum technologies.

Biography

Naru Yoneda is an Associate Professor at the Graduate School of System Informatics, Kobe University, Japan. His research focuses on computational optical imaging, digital holography, quantitative phase imaging, and quantum optics. He has worked on advanced wavefront sensing and phase retrieval techniques, including methods based on the transport of intensity equation. His recent research explores the extension of holographic technologies to biological applications, including holographic light stimulation and optogenetics, as well as quantum imaging with undetected photons. In particular, his work on quantum holography aims to realize single-shot and real-time phase imaging by exploiting quantum interference and polarization control.

Invited talk

Kenneth K. Y. Wong

The University of Hong Kong



Axially arbitrary illumination technologies for multiphoton microscopy

Abstract

This talk will present our recent progress on axially arbitrary illumination microscopy with encoded depth (AIMED) through a multiplane compressive imaging approach for multiphoton microscopy (MPM) that enables rapid axial scanning via sub-sampling. Then we will also present an axially parallel excitation (APEX), parallelizing axial excitation with depth encoding for MPM, extending per-plane exposure without slowing acquisition or requiring higher power. These technologies are potentially adaptable to other microscopic modalities, providing new insights for advanced volumetric microscopy.

Biography

Kenneth K. Y. Wong is a professor and former Head of the Department of Electrical and Computer Engineering at the University of Hong Kong. He has received numerous awards, including the Best Teacher Award (2005-06), Outstanding Young Researcher (2008-09), and Outstanding Research Student Supervisor (2018-19). He is an Associate Editor of Optica and has served on the Publications Committee of SPIE, as well as an editor for IEEE Photonics Technology Letters and Optics Express. A senior IEEE member and recent SPIE and Optica Fellow, he also co-taught a course at MIT during the 2009-10 academic year and is the former Chair of the IEEE Hong Kong Section.

Invited talk

Yongsoo Yang

KAIST



3D quantitative phase imaging at the atomic scale based on electron tomography

Abstract

Modern science and technology rely on functional materials, and the physical properties of these materials often strongly depend on defects, local disorder, nanoscale heterogeneities, and grain structures at the atomic scale. However, traditional crystallography, which relies on periodicity, cannot determine these defects or other non-crystalline features. Without any prior assumption of the underlying structure, atomic electron tomography (AET) is now able to locate the 3D coordinates of individual atoms and their dynamics with picometer precision and elemental specificity. However, the majority of AET results have been based on incoherent imaging methods, which limit the application of AET for radiation-sensitive materials and light chemical elements. In this talk, I will briefly discuss the current capability of AET and introduce ideas based on quantitative phase imaging to enhance dose efficiencies and enable the detection of light elements. [1]. J. Lee et al., Phys. Rev. Applied 19, 054062 (2023).

Biography

Yongsoo has been a faculty member in the Department of Physics at the Korea Advanced Institute of Science and Technology (KAIST) since 2018. He received his Ph.D. in Physics from the University of Michigan in 2014 and subsequently worked as a postdoctoral scholar at UCLA before joining KAIST. His research focuses on multi-dimensional electron microscopy and its applications to the characterization of materials at the atomic scale.

Invited talk

Kevin Tsia

The University of Hong Kong



From Phase to Function: Decoding Cell State at Scale

Abstract

Molecular profiling has transformed our understanding of cell state. Yet cells also express a rich physical phenotype: their size, shape, dry-mass distribution, intracellular organization, deformability and responses to perturbation. These properties reflect how cells grow, divide, activate, transform and respond to therapy, offering a complementary—and often label-free—window into cellular function. The challenge is to move beyond describing these features to interpreting their biological significance across heterogeneous cell populations.

In this talk, I will present deep biophysical cytometry, an end-to-end platform integrating ultrahigh-throughput quantitative phase imaging, microfluidic imaging flow cytometry and AI-driven analysis. By profiling millions of individual cells per experiment, the platform translates label-free optical measurements into quantitative representations of biophysical cell state. I will discuss how these representations can be linked to molecular identity and functional responses, with applications spanning cancer detection and subtyping, immune-cell activation, image-based CRISPR screening and prediction of sensitivity to targeted therapies. Central to this approach is the interplay between imaging throughput, quantitative measurement and computational interpretation: acquiring more images is only useful if we can extract biologically meaningful information from them.

Biography

Kevin Tsia is currently a Professor in the Department of Electrical and Computer Engineering, Associate Dean (Teaching & Learning - UG) Faculty of Engineering and the Program Director of the BEng of Biomedical Engineering Program of the School of Biomedical Engineering at The University of Hong Kong. His research interest covers a broad range of subject matters including ultra-fast optical imaging for imaging flow cytometry and high-speed in-vivo brain imaging, and bioinformatics approaches for single-cell analysis. He is an elected Fellow of SPIE and Fellow of Optica. He is also the HK Research Grants Council (RGC) Research Fellow (2020). He received the Hong Kong Engineering Science and Technology (HKEST) Award 2024-25, the Outstanding Young Research Award 2015 at HKU, and the 14th Chinese Science and Technology Award for Young Scientists in 2016.

Poster lightning talks

Friday 20 November · 15:50–16:10 · SHB, Room 603

Four five-minute talks · Hong Kong time (HKT, UTC+8)

P21 · Chenjia Xi

The Chinese University of Hong Kong

Hyperspectral Phase Amplification Microscopy for 2D Material Characterization

P27 · Zhuoshi Li

Nanjing University of Science and Technology

Learning to self-interfere: zero-shot deconvolution enables replica-free, low-coherence common-path digital holographic microscopy

P28 · Baozhang Feng

Peking University

Holographic Optical Tweezer–Enabled Axial Scanning for 3D Label-Free Imaging of Suspended Particles

P03 · Herve Hugonnet

KAIST, South korea

Quantitative X-ray Schlieren Nanotomography for Hyperspectral Phase and Absorption Imaging

Full abstracts are included in the poster section under the same poster numbers.

Organizers and supporters

Organizing institutions

KAIST

The Chinese University of Hong Kong

Seoul National University

Co-organizer

IEEE Photonics Society Hong Kong Chapter

Institutional support

National Research Foundation of Korea

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Poster presentations 1/4

31 submitted posters · Numbered in submission order

16:10–17:20 · SHB, Room 603 · Poster size: 160 cm (H) × 90 cm (W)

Lightning talks: P21, P27, P28 and P03 · See lightning-talk page.

P01 **Morphology-Preserving Holotomography for Quantitative 3D Analysis of Organoid Dynamics**

Chulmin Oh · KAIST

P02 **A Next-generation Ultra-high Throughput Multimodal Platform for Intelligent Single-cell Characterization**

Jiang Zhou · The University of Hong Kong

P03 **Quantitative X-ray Schlieren Nanotomography for Hyperspectral Phase and Absorption Imaging**

Herve Hugonnet · KAIST, South korea

P04 **3D biaxial anisotropy imaging using incoherent dielectric tensor tomography**

Juheon Lee · KAIST

P05 **Digital Holographic Microscopy of Diatom Cells and Frustules**

Kazuo Umemura · Tokyo University of Science

P06 **Label-free holotomography for 3D subcellular phenotyping and developmental assessment of mouse embryos**

Chungha Lee · Korea Advanced Institute of Science and Technology (KAIST)

P07 **Holotomography reveals biophysical remodeling of mouse oocytes during in vitro post-ovulatory aging**

Minsu Kim · KAIST

P08 **A Practical Workflow for Analyzing Organelle Spatial Proximity with Super-Resolution Microscopy**

Xiaoyu Ren · Center for Excellence in Molecular Cell Science, Chinese Academy of Sciences

Poster presentations 2/4

31 submitted posters · Numbered in submission order

16:10–17:20 · SHB, Room 603 · Poster size: 160 cm (H) × 90 cm (W)

Lightning talks: P21, P27, P28 and P03 · See lightning-talk page.

P09 **4D Label-free analysis of lipid droplet dynamics in hepatic organoids**

Jimin Cho · KAIST

P10 **Label-Free 3D Sidewall Roughness and Form Mapping of Glass Vias by Incoherent Holotomography**

Dohyeon Lee · KAIST

P11 **Quantitative Phase Imaging for Label-Free Cellular Analysis: Advances and Applications in Biomedical Research**

Sharmila Ghosh · University of Calcutta, Department of Applied Optics & Photonics

P12 **Physics-informed Design Method for the Long-wave Infrared As2Se3 Metalens Imaging**

Qianqian Cheng · Ningbo University

P13 **Holotomography-Enabled Virtual Multiplexed Staining of Thick Kidney Tissue for 3D Renal Pathology**

Siwon Jeong · KAIST

P14 **Label-free volumetric refractive-index imaging of fibrillar collagen architecture, assembly, and cell-associated remodeling**

Sehyeon Lee · Department of Physics / KAIST

P15 **Label-Free Collagen Quantification from Unstained Skin Quantitative Phase Image Using Virtual Masson's Trichrome Staining**

Jongho Kim · Seoul National University

P16 **Gaussian Surfel-Based Surface Reconstruction for Reflective Fourier Ptychographic Microscopy**

Donggeon Bae · Seoul National University

Poster presentations 3/4

31 submitted posters · Numbered in submission order

16:10–17:20 · SHB, Room 603 · Poster size: 160 cm (H) × 90 cm (W)

Lightning talks: P21, P27, P28 and P03 · See lightning-talk page.

P17 **Nondestructive 3D Quantification of the Magnitude and Extent of Indentation-Induced Densification in Glass**

Sangmin Lee · KAIST

P18 **Split-Pupil Multiplexing for Vectorial Microscopy Based on Kramers–Kronig Relations**

Hyesuk Chae · Seoul National University

P19 **Label-free continuous scoring of cellular senescence via holotomography-based deep learning**

Taejung Moon · Kaist

P20 **Coherence-aligned speckle tomography for three-dimensional refractive-index characterization of 3D-printed parts**

Haoran Li · The Chinese University of Hong Kong

P21 **Hyperspectral Phase Amplification Microscopy for 2D Material Characterization**

Chenjia Xi · The Chinese University of Hong Kong

P22 **Coherence-gated quantitative phase microscopy through millimeter-scale tissue**

Chaodu Shi · The Chinese University of Hong Kong

P23 **Physics-Informed End-to-End Framework for Fabrication-Aware PSF and Height Profile Design in Gray-Scale Maskless Lithography**

Joonsik Park · Yonsei University

P24 **Neural Representations of Spatially Varying Pupil for Wide-Field Fourier Ptychography**

Sangjoon Lee · Seoul National University

Poster presentations 4/4

31 submitted posters · Numbered in submission order

16:10–17:20 · SHB, Room 603 · Poster size: 160 cm (H) × 90 cm (W)

Lightning talks: P21, P27, P28 and P03 · See lightning-talk page.

P25 **SiQT: Single-frame quantitative phase tomography for high-throughput volumetric imaging**

Ranhao Zhang · Department of Biomedical Engineering, The Chinese University of Hong Kong

P26 **Design-constrained linewidth estimation below the reconstruction resolution of reflective Fourier ptychographic microscopy**

Yong Guk Kang · Seoul National University

P27 **Learning to self-interfere: zero-shot deconvolution enables replica-free, low-coherence common-path digital holographic microscopy**

Zhuoshi Li · Nanjing University of Science and Technology

P28 **Holographic Optical Tweezer–Enabled Axial Scanning for 3D Label-Free Imaging of Suspended Particles**

Baozhang Feng · Peking University

P29 **Spatiotemporal fringe pattern analysis using physics-informed deep learning**

Yiheng Liu · Nanjing University of Science and Technology

P30 **Full dielectric tensor tomography using a multislice model**

Kai Zhang · Frontiers Science Center for Nano-optoelectronics, Peking University

P31 **Real-Time Live-Cell Quantitative Phase Imaging Enabled by Robust Phase Unwrapping**

Shiyuan Wei · Shenzhen BJR Biomedical Technology Co. Ltd.

Poster P01

Morphology-Preserving Holotomography for Quantitative 3D Analysis of Organoid Dynamics

Presenter: Chulmin Oh

KAIST

Authors and affiliations

ChulMin Oh (KAIST), Jimin Cho (KAIST), Juyeon Park (KAIST), Hoyeon Lee (Tomocube), YongKeun Park (KAIST, Tomocube)

Abstract

Organoids are 3D in vitro models that recapitulate key aspects of tissue architecture and function. Holotomography enables long-term, label-free imaging of live organoids by reconstructing volumetric RI distributions. However, quantitative analysis remains challenging due to the missing-cone artifact, which introduces anisotropic resolution and axial distortion. Here, we present morphology-preserving holotomography (MP-HT), a quantitative analysis framework that addresses missing-cone-induced distortion at the level of image representation rather than reconstruction. MP-HT employs torus-shaped spatial filtering to selectively enhance high-spatial-frequency RI texture while suppressing low-frequency components susceptible to axial distortion. Building on this representation, we develop a 3D segmentation pipeline for robust separation of epithelial and luminal structures and a model-based RI quantification method incorporating the system point spread function to estimate dry-mass density and total dry mass independently of organoid morphology. We further demonstrate long-term quantitative imaging of live hepatic organoids undergoing expansion, collapse, and fusion, revealing dynamic changes in epithelial-lumen morphology and biophysical properties. This framework provides a physically transparent and reproducible approach for quantitative, label-free characterization of 3D organoid dynamics, enabling longitudinal investigation of complex multicellular systems.

Submitted poster abstract

Poster P02

A Next-generation Ultra-high Throughput Multimodal Platform for Intelligent Single-cell Characterization

Presenter: Jiang Zhou

The University of Hong Kong

Authors and affiliations

Jiang Zhou The University of Hong Kong

Abstract

High-throughput single-cell imaging provides a powerful means of resolving cellular heterogeneity, but its broader application is constrained by trade-offs among imaging speed, spatial resolution, multimodal information content, and computational scalability. Here we presents a next-generation ultra-high-throughput multimodal imaging and analysis platform that integrates free-space angular-chirp-enhanced delay (FACED) microscopy, quantitative label-free and fluorescence imaging, and artificial intelligence for comprehensive single-cell characterization.

Submitted poster abstract

Poster P03

Quantitative X-ray Schlieren Nanotomography for Hyperspectral Phase and Absorption Imaging

Presenter: Herve Hugonnet

KAIST, South korea

Authors and affiliations

Authors: Herve Hugonnet1,2† , KyeoReh Lee1,2,4†* , Sugeun Jo3 , Jun Lim3* , and YongKeun Park1,2* 1 Department of Physics, Korea Advanced Institute of Science and Technology, Daejeon, 34141, Republic of Korea. 2 KAIST Institute for Health Science and Technology, Korea Advanced Institute of Science and Technology, Daejeon, 34141, Republic of Korea. 3 Pohang Accelerator Laboratory, Pohang University of Science and Technology, Pohang, 37637, Republic of Korea. 4 Current address: Department of Applied Physics, Yale University, New Haven, 06520, Connecticut, USA. † These authors contributed equally to this work

Abstract

Hyperspectral X-rays imaging is widely used for three-dimensional (3D) chemical microscopic imaging but remains limited to capturing transmitted absorption information rather than phase . To overcome this limitation, we introduce quantitative X-ray Schlieren nanotomography (XSN), a simple, fast, and high-resolution X-ray phase imaging technique that captures spectroscopic information . XSN uses a partially coherent illumination and a pupil-plane cutoff filter to encode directional phase contrast into the measured intensity. A quasi-Newton iterative algorithm reconstructs quantitative phase and absorption images even under strong scattering conditions. Scanning across X-ray energies further allows four-dimensional imaging (3D spatial + spectral). We apply our method to the imaging of lithium battery cathodes, visualizing nanoscale microcracks and chemical compositions.

Submitted poster abstract · Selected lightning talk

Poster P04

3D biaxial anisotropy imaging using incoherent dielectric tensor tomography

Presenter: Juheon Lee

KAIST

Authors and affiliations

Department of Physics, Korea Advanced Institute of Science and Technology (KAIST), Daejeon, Republic of Korea Juheon Lee, Herve Hugonnet, Chulmin Oh, Sehyeon Lee & YongKeun Park KAIST Institute for Health Science and Technology, KAIST, Daejeon, Republic of Korea Juheon Lee, Herve Hugonnet, Chulmin Oh, Sehyeon Lee & YongKeun Park Department of Pathology, Asan Medical Center, University of Ulsan College of Medicine, Seoul, Republic of Korea Yeon Wook Kim & Seung-Mo Hong Department of Materials Science and Engineering, Korea University, Seoul, Republic of Korea Hwanseok Chang & Seokwoo Jeon Tomocube Inc., Daejeon, Republic of Korea YongKeun Park

Abstract

Biaxial anisotropy, characterized by distinct optical responses along three principal directions, provides important structural information in crystalline, polymeric, and biological materials. However, conventional optical techniques generally require simplifying assumptions or suffer from noise and mechanical instability, limiting quantitative three-dimensional (3D) characterization of general biaxial media. Here, we present incoherent dielectric tensor tomography (iDTT), a non-interferometric imaging method for quantitative 3D reconstruction of the full dielectric tensor. iDTT combines polarization-diverse illumination and detection with angular-spectrum modulation to encode all independent tensor components into intensity measurements. Polarization-dependent optical transfer functions derived from the vectorial wave equation are used to reconstruct the dielectric tensor, which is subsequently diagonalized to retrieve three principal refractive indices and their corresponding 3D orientations. The use of spatially incoherent illumination suppresses speckle noise and reduces sensitivity to mechanical vibrations, enabling robust volumetric imaging of weak optical anisotropy. We experimentally demonstrate iDTT using liquid-crystal structures and uniaxial and biaxial crystalline samples, and quantitatively recover their principal refractive indices and orientation distributions. These results establish iDTT as a practical approach for quantitative 3D characterization of arbitrary anisotropy in heterogeneous materials.

Submitted poster abstract

Poster P05

Digital Holographic Microscopy of Diatom Cells and Frustules

Presenter: Kazuo Umemura

Tokyo University of Science

Authors and affiliations

Kazuo Umemura (Tokyo University of Science), Taishi Kodai (Tokyo University of Science), Haruki Yamada (Tokyo University of Science), Mohamed Gad Abdelghany (Ain Shams University)

Abstract

Diatom cells and diatom frustules are one of the attractive samples for digital holographic microscopy (DHM). The sizes of diatom cells are several microns to several hundred microns. Frustules have nano/mesoporous structures which are suitable sizes to evaluate resolution limits of DHM. Although some types of diatoms have cylindrical shapes, many of diatoms are rather flat morphologies. Because DHM struggles with thick samples, flat diatom cells are friendly samples. Major components of frustules are silica although organic components are contained. The sophisticated structures are attractive research targets from the viewpoints of fabrication techniques of nanodevices. We have observed several types of living diatom cells, purified frustules, and chemically/physically treated frustules. [1-2] In order to observe fully assembled frustule structures, physical annealing and chemical fixation of frustules were examined. Cross-section analysis of observed diatom images was effective to discuss asymmetry of cell structures. Morphological changes of diatom cells induced by chemical treatments were well evaluated in liquid. Our results revealed effectiveness of DHM techniques for the diatoms/frustules nanosciences.

[1] Saito et al., Microscopy and Microanalysis, 28(6), 2172-2176(2022). [2] Hamano et al., Applied Physics Letters, 120(13), 133701(2022).

Submitted poster abstract

Poster P06

Label-free holotomography for 3D subcellular phenotyping and developmental assessment of mouse embryos

Presenter: Chungha Lee

Korea Advanced Institute of Science and Technology (KAIST)

Authors and affiliations

Chungha Lee[1,2], Geon Kim[1,2], Taeseop Shin[3], Sangho Lee[3], Jae Young Kim[3], Kyoung Hee Choi[3], Jieun Do[4], Jaehyeong Park[5], Jaephil Do[5], Ji Hyang Kim[3], and YongKeun Park[1,2,5] [1] Department of Physics, Korea Advanced Institute of Science and Technology (KAIST), Daejeon, South Korea [2] KAIST Institute for Health Science and Technology, KAIST, Daejeon, South Korea [3] Fertility Center of CHA Bundang Women's Medical Center, Seongnam, South Korea [4] KAIST Laboratory Animal Resource Center, Daejeon, South Korea [5] Tomocube Inc., Daejeon, South Korea

Abstract

Embryo assessment in assisted reproductive technology primarily relies on morphological evaluation using conventional microscopy, which provides limited quantitative information about three-dimensional (3D) subcellular organization. Quantitative phase imaging (QPI) offers an alternative approach by exploiting intrinsic refractive index (RI) contrast to visualize biological specimens without exogenous labeling. Here, we apply low-coherence holotomography (HT), a 3D QPI technique, for longitudinal imaging and quantitative characterization of preimplantation mouse embryos.

We performed time-lapse HT imaging of mouse embryos from the 2-cell stage through blastocyst formation over 72 hours. Reconstructed 3D RI distributions enabled visualization of developmental processes and subcellular structures, including blastomeres, nuclei, and cytoplasmic features. Quantitative analysis revealed distinct early-stage phenotypes associated with subsequent blastocyst formation. Embryos that developed into blastocysts exhibited more advanced cleavage, lower cytoplasmic RI heterogeneity, and more compact nuclear organization, whereas arrested embryos showed delayed cleavage, increased cytoplasmic heterogeneity, and fewer, enlarged nuclei. Machine-learning models incorporating these features predicted blastocyst formation with an area under the receiver operating characteristic curve of up to 0.963.

These findings illustrate how label-free 3D QPI can extend conventional morphological assessment toward quantitative subcellular phenotyping. This approach highlights the potential of holotomography as a complementary imaging modality for studying early embryonic development and exploring quantitative indicators of developmental competence.

Submitted poster abstract

Poster P07

Holotomography reveals biophysical remodeling of mouse oocytes during in vitro post-ovulatory aging

Presenter: Minsu Kim

KAIST

Authors and affiliations

Minsu Kim(1,2+), Chungha Lee(1,2+), Jieun Do(3), Taeseop Shin(4), Daria Iliev(5,6), Kyoung Hee Choi(4), So Yeon Shin(7,8), Jieun Ko(7,8), Teodora Popa(5,9), Cristina Hickman(5), Ji Hyang Kim(4,8,*) and YongKeun Park(1,2,10,*) 1Department of Physics, Korea Advanced Institute of Science and Technology (KAIST), Daejeon 34141, Republic of Korea. 2KAIST Institute for Health Science and Technology, KAIST, Daejeon 34141, Republic of Korea. 3KAIST Laboratory Animal Resource Center, KAIST, Daejeon 34141, Republic of Korea. 4Fertility Center, CHA Bundang Women's Medical Center, Seongnam 13496, Republic of Korea. 5Avenues Life, London NW1 1AA, United Kingdom. 6UCL Hawkes Institute, University College London, United Kingdom. 7Department of Obstetrics and Gynecology, CHA University School of Medicine, Pocheon 11160, Republic of Korea. 8Fertility Center, CHA University Bundang Medical Center, Seongnam 13496, Republic of Korea. 9UCL EGA Institute for Women's Health, University College London, London WC1E 6BT, United Kingdom. 10Tomocube Inc., Daejeon 34127, Republic of Korea. +Equally contributed *Correspondence: bin0902@cha.ac.kr (J.H.K.); yk.park@kaist.ac.kr (Y.K.P.)

Abstract

In assisted reproductive technology (ART), post-ovulatory aging is a major concern because it progressively compromises oocyte quality, yet the underlying intracellular changes are difficult to assess without invasive or label-based assays. In clinical practice, oocytes are routinely evaluated using brightfield microscopy; however, brightfield imaging primarily captures morphological features and provides limited access to quantitative changes in intracellular composition and organization.

Here, we investigated live mouse oocytes at three stages of in vitro post-ovulatory aging using holotomography (HT). HT reconstructs volumetric refractive-index (RI) distributions without labeling, enabling depth-resolved characterization of intracellular morphology and mass density. Using the same oocytes, we extracted quantitative features from three imaging modalities: single-plane brightfield, multi-plane brightfield, and HT.

HT enabled depth-resolved measurements of volumetric morphology and RI-derived properties, including dry mass, RI statistics, and texture, in cells approximately 100 μm in diameter. Beyond morphology, which has been central to conventional oocyte quality assessment, RI-derived features provided clearer separation of aging stages than intensity-based features in multivariate analyses. These results demonstrate that volumetric RI imaging provides quantitative information on oocyte aging beyond conventional brightfield microscopy and highlight the potential of HT as a label-free tool for assessing oocyte quality.

Submitted poster abstract

Poster P08

A Practical Workflow for Analyzing Organelle Spatial Proximity with Super-Resolution Microscopy

Presenter: Xiaoyu Ren

Center for Excellence in Molecular Cell Science, Chinese Academy of Sciences

Authors and affiliations

Xiaoyu Ren, Junjing Yu, Center for Excellence in Molecular Cell Science, Chinese Academy of Sciences

Abstract

Organelles establish dynamic contacts to facilitate inter-organelle communication. Although their structures and dynamics are commonly observed by light microscopy, the spatial precision of organelle proximity is restricted by optical diffraction limit. While super-resolution microscopy has significantly advanced the visualization of subcellular ultrastructure, optimizing imaging parameters and robust downstream analysis remains a key challenge. Here we present a practical workflow for live-cell super-resolution imaging and quantitative analysis of organelle spatial proximity. By combining super-resolution microscopy and machine learning-driven batch image processing, this method enables accurate estimation of organelle morphology and juxtapositions. Notably, this workflow is broadly adaptable to different subcellular structures, labeling strategies and imaging conditions. It is designed to be accessible to most cell biology laboratories without requiring large-scale training datasets or extensive computational resources.

Submitted poster abstract

Poster P09

4D Label-free analysis of lipid droplet dynamics in hepatic organoids

Presenter: Jimin Cho

KAIST

Authors and affiliations

Jimin Cho,a Hoyeon Lee,b ChulMin Oh,c,d Juyeon Park,c,d Sujin Park,e Bon-Kyoung Koo,e YongKeun Parka,b,c,d, * a Graduate School of Stem Cell and Regenerative Biology, Korea Advanced Institute of Science and Technology (KAIST), Daejeon 34141, Republic of Korea b Tomocube Inc, Daejeon 34127, Republic of Korea c Department of Physics, KAIST, Daejeon 34141, Republic of Korea d KAIST Institute for Health Science and Technology, KAIST, Daejeon 34141, Republic of Korea e Center for Genome Engineering, Institute for Basic Science, Daejeon, 34126, Republic of Korea

Abstract

Hepatic organoids serve as advanced 3D in vitro models that closely recapitulate structural and functional features of liver tissue, providing a physiologically relevant platform for studying metabolic disorders. Steatosis, a hallmark of metabolic-associated steatotic liver disease (MASLD), is characterized by excessive lipid accumulation and can progress to nonalcoholic steatohepatitis (NASH). Understanding lipid droplet (LD) dynamics within hepatic organoids is critical for elucidating disease mechanisms and developing therapeutic interventions. However, conventional imaging techniques often rely on endpoint measurements or fluorescence-based labeling, which may alter LD morphology and limit real-time analysis. To overcome these challenges, we employ label-free holotomography (HT) to visualize and quantify LD accumulation and turnover in live hepatic organoids exposed to steatogenic stimuli. This approach enables high-resolution, three-dimensional refractive index (RI) mapping of LDs without exogenous dyes or fixation, allowing for longitudinal monitoring of steatosis onset and progression. Using a label-free, quantitative imaging approach, we track the formation, growth, and redistribution of LDs over time in live organoids. Our findings reveal distinct lipid phenotypes associated with different metabolic stressors, suggesting that hepatic organoids can effectively model the heterogeneity of steatosis progression. Moreover, the 3D microenvironment of organoids provides insights into tissue-level changes that cannot be captured in conventional monolayer cultures. By leveraging advanced imaging modalities, we demonstrate that hepatic organoids offer a robust platform for studying lipid metabolism in a physiologically relevant setting.

Submitted poster abstract

Poster P10

Label-Free 3D Sidewall Roughness and Form Mapping of Glass Vias by Incoherent Holotomography

Presenter: Dohyeon Lee

KAIST

Authors and affiliations

Dohyeon Lee(1,2), Herve Hugonnet(1,2), YongKeun Park(1,2,3*) 1. Department of Physics, Korea Advanced Institute of Science and Technology (KAIST), Daejeon, Republic of Korea 2. KAIST Institute for Health Science and Technology, KAIST, Daejeon, Republic of Korea 3. Tomocube Inc., Daejeon, Republic of Korea

Abstract

Through-glass vias (TGVs) are essential for glass-core substrates and interposers in advanced packaging, yet their 3D sidewall geometry and roughness are difficult to inspect non-destructively. Optical imaging is obscured by the large glass-air index contrast, and X-ray micro-CT is slow with limited resolution. We present a quantitative, non-destructive 3D metrology framework for TGVs based on incoherent holotomography (HT). Refractive index matching in TGVs suppress boundary distortion and enable acquiring deep volumetric refractive-index tomograms of TGVs. Morphology-preserving HT (MP-HT) edge filtering further mitigates missing-cone blur for accurate axial boundary localization (IoU 0.96 versus 0.93 for Otsu thresholding alone on a synthetic phantom). An hourglass form is fitted and removed, and ISO 25178-2 areal roughness (Sa) is computed from the unrolled sidewall height map. Applied to 192 TGVs, comprising 92 low-roughness (150 µm) and 100 high-roughness (500 µm) vias, the framework measured Sa of 0.477 ± 0.217 µm and 1.056 ± 0.057 µm, and waist constrictions of 25.7% and 9.2%, respectively. Measurements were invariant to sample inversion and agreed with X-ray micro-CT within the 95% limits of agreement, while HT resolved fine asperities that micro-CT smooth out. Each via was acquired in under 5 seconds, compared with 1.5–2.5 hours per field of view for micro-CT. These results establish HT as a high-throughput, quantitative route to TGV inspection for glass-based packaging.

Submitted poster abstract

Poster P11

Quantitative Phase Imaging for Label-Free Cellular Analysis: Advances and Applications in Biomedical Research

Presenter: Sharmila Ghosh

University of Calcutta, Department of Applied Optics & Photonics

Authors and affiliations

Sharmila Ghosh, Senior R&D Engineer

Abstract

Abstract

Quantitative Phase Imaging (QPI) has emerged as a powerful, non-invasive optical technique that enables label-free visualization and quantification of cellular morphology, dry mass, and refractive index at nanoscale sensitivity. By measuring the optical path length shifts introduced by biological specimens, QPI provides rich biophysical information without the need for exogenous labels or dyes, thereby preserving native cellular physiology and enabling long-term live-cell studies.

This poster presents recent advances in QPI modalities—including digital holographic microscopy, diffraction phase microscopy, and transport-of-intensity equation methods—and their integration with computational algorithms for enhanced phase retrieval, noise reduction, and 3D tomographic reconstruction. We highlight applications in biomedical imaging, such as real-time monitoring of cell growth, migration, and apoptosis; characterization of disease-related biophysical changes in cancer and neurodegenerative models; and high-throughput screening of drug responses.

Emphasis is placed on the synergy between QPI hardware innovations and machine-learning-based analysis pipelines that extract quantitative biomarkers from phase maps. Challenges related to temporal resolution, field-of-view limitations, and standardization of phase measurements are discussed, along with emerging solutions involving multi-modal correlative imaging and portable QPI systems.

By bridging optics, computational imaging, and life sciences, QPI continues to expand the frontiers of quantitative biology. We invite the community to explore collaborative opportunities in this rapidly evolving field at the 6th Quantitative Phase Imaging Symposium.

Submitted poster abstract

Poster P12

Physics-informed Design Method for the Long-wave Infrared As2Se3 Metalens Imaging

Presenter: Qianqian Cheng

Ningbo University

Authors and affiliations

Qianqian Cheng, Wenxiang Hu, Yi Ren, Xiang Shen; Faculty of Electrical Engineering and Computer Science, Ningbo University

Abstract

As a novel type of planar optical device featuring lightweight construction, integrability, and high-degree-of-freedom wavefront manipulation capabilities, metalens hold broad application prospects in fields such as lightweight infrared imaging for unmanned aerial vehicles. However, the strong dispersion characteristics of subwavelength structures make it challenging to maintain satisfactory phase compensation over a wide spectral range. Here, an inverse learning design method incorporating physics-informed priors is proposed, which integrates a diffractionlimit model with a deep learning framework to achieve efficient optimization of long-wave infrared metalenses over a broad bandwidth. Simulation results demonstrate that the designed As2Se3 metalens, with an aperture of 1 mm and a numerical aperture (NA) of 0.45, achieves an average focusing efficiency of 37.91% and a transmittance of 68% at five representative wavelengths within the 8–12 μm band. Experimental results further confirm the favorable thermal imaging performance of the fabricated metalens. The proposed method effectively suppresses dispersion-induced errors, offering a new design paradigm for achieving high-quality broadband imaging in the long-wave infrared.

Submitted poster abstract

Poster P13

Holotomography-Enabled Virtual Multiplexed Staining of Thick Kidney Tissue for 3D Renal Pathology

Presenter: Siwon Jeong

KAIST

Authors and affiliations

Siwon Jeong[1,2], Juyeon Park[1,2], Nakyeong Kim[3], Minsun Jung[3], and YongKeun Park[1,2,4] [1] Department of Physics, Korea Advanced Institute of Science and Technology (KAIST), Daejeon, Republic of Korea [2] KAIST Institute for Health Science and Technology, KAIST, Daejeon, Republic of Korea [3] Department of Pathology, Yonsei University College of Medicine, Seoul, Republic of Korea [4] Tomocube Inc., Daejeon, Republic of Korea

Abstract

Renal histopathology relies on complementary staining methods, including hematoxylin and eosin (H&E), periodic acid–Schiff (PAS), acid fuchsin–orange G (AFOG), and periodic acid–methenamine silver (PM), to examine glomerular, tubular, and interstitial structures. Conventional staining requires chemical processing and often serial tissue sections, introducing spatial discrepancies among staining results and limiting direct three-dimensional (3D) assessment of renal microarchitecture.

Here, we present a holotomography-based virtual multiplexed staining approach that generates four histological staining contrasts from a single label-free refractive index (RI) measurement of kidney tissue. Volumetric RI data were acquired using holotomography, and deep learning models for virtual staining were developed using spatially registered RI and histology image pairs.

The approach generated virtual H&E, PAS, AFOG, and PM images from unstained kidney tissue, enabling comparison of complementary staining contrasts in the same tissue region. Virtual multiplexed staining was demonstrated on two-dimensional images and across large tissue areas, visualizing glomerular, tubular, and interstitial morphology. We further applied the approach to volumetric RI data from thick kidney tissue and generated 3D virtual staining volumes, demonstrating its feasibility for volumetric visualization.

These results suggest that holotomography-based virtual multiplexed staining may support non-destructive, spatially aligned visualization of renal tissue and provide a basis for future 3D renal pathology applications.

Submitted poster abstract

Poster P14

Label-free volumetric refractive-index imaging of fibrillar collagen architecture, assembly, and cell-associated remodeling

Presenter: Sehyeon Lee

Department of Physics / KAIST

Authors and affiliations

Sehyeon Lee (1,2), Wei Sun Park (1,2), Juheon Lee (1,2), Juyeon Park (1,2), Hyeoncheol Park (3,4), Eun Hyun Ahn (3,4), Deok-Ho Kim (3,4,5)*, YongKeun Park (1,2,6)*; (1) Department of Physics, KAIST, Daejeon 34141, Republic of Korea; (2) KAIST Institute for Health Science and Technology, KAIST, Daejeon 34141, Republic of Korea; (3) Department of Biomedical Engineering, Johns Hopkins University, Baltimore, MD 21205, USA; (4) Center for Microphysiological Systems, Johns Hopkins University, Baltimore, MD 21205, USA; (5) Department of Medicine, Johns Hopkins University, Baltimore, MD 21205, USA; (6) Tomocube Inc., Daejeon 34109, Republic of Korea; *Corresponding authors

Abstract

Fibrillar collagen architecture regulates tissue mechanics and cell–matrix interactions, but following how collagen-rich matrices assemble and remodel in three dimensions requires non-destructive measurements that link structure to matrix-associated mass. Here we present holotomography (HT) as a label-free platform for volumetric refractive-index (RI) imaging and quantitative profiling of reconstituted fibrillar collagen. Volumetric RI tomograms resolved fibrillar collagen networks, and co-registration with second-harmonic generation (SHG) microscopy supported their identification as fibrillar collagen. Curvelet-transform-based segmentation of representative axial sections converted the tomograms into fiber-level descriptors, including fiber morphology and RI-derived fiber-associated dry mass. At the matched 0.8 mg/mL condition, HT resolved distinct network organization, with type I forming thicker, more sparsely distributed fibers and type III a finer, denser network, while mean fiber-associated RI remained comparable, placing the subtype difference in architecture, not per-fiber collagen density. Concentration series measured separately for each subtype showed increasing fiber width and RI-derived mass in type I gels and a persistently fine network in type III gels. Time-lapse HT then followed RI dynamics during type I fibrillogenesis and resolved local cell–matrix reorganization in HT1080 cell-embedded gels, capturing cells and matrix in one volume. Together, these results show that volumetric RI imaging reports collagen network architecture, fiber-associated mass and matrix dynamics without labels, contact or fixation. Because the readout is label-free and leaves the matrix intact, the same measurement can be repeated on engineered collagen-rich constructs, offering a candidate non-destructive quality readout for organoid and regenerative-medicine workflows.

Submitted poster abstract

Poster P15

Label-Free Collagen Quantification from Unstained Skin Quantitative Phase Image Using Virtual Masson's Trichrome Staining

Presenter: Jongho Kim

Seoul National University

Authors and affiliations

KIM Jongho 1, KANG Yong Guk 2, CHAE Hyesuk 3, YOON Doyeon 3, CHO Yena 1, KIM Minsang 4, KIM Misun 4, NHO Younhwa 4, PARK Chunho 4, LEE Seung Ah *1,2 1Department of Mechanical Engineering, Seoul National University 2School of Mechanical and Aerospace Engineering/SNU-IAMD, Seoul National University 3School of Electrical and Electronic Engineering, yonsei university 4BTI R&I Center, Cosmax

Abstract

Label-free collagen mapping could reduce reliance on chemical staining while enabling tissue-scale analysis of dermal architecture. Fourier ptychographic microscopy (FPM) is well suited to this goal because it provides quantitative phase imaging (QPI) over a large field of view at high spatial resolution. Here, we present a framework for quantitative collagen assessment from unstained skin QPI through virtual Masson's trichrome (MT) staining. Using FPM, paired stained-phase and ground-truth MT RGB-amplitude images were acquired for model training, followed by inference on age-stratified unstained tissue slides. Stained and unstained tissues exhibited slight differences in their phase distributions, causing a GAN baseline to degrade when transferred to unstained QPI. Our conditional rectified-flow model compensated for this phase-domain difference and generated coherent virtual MT images. In regions adjacent to the dermal–epidermal junction (DEJ), collagen area fraction, axial orientation, and alignment were quantified from the virtual stains. Their sample-wise and age-associated trends agreed with those measured from physical MT images of adjacent sections, supporting the high fidelity of our virtual staining. These results demonstrate that large-area, high-resolution unstained FPM QPI can support collagen quantification through virtual staining, enabling label-free assessment of collagen abundance and organization without staining the imaged specimen. Larger paired cohorts and precisely registered references are required for definitive quantitative validation.

Submitted poster abstract

Poster P16

Gaussian Surfel-Based Surface Reconstruction for Reflective Fourier Ptychographic Microscopy

Presenter: Donggeon Bae

Seoul National University

Authors and affiliations

Donggeon Bae (Seoul National University), Jaewoo Jung (Yonsei University), Jongho Kim (Seoul National University) and Seung Ah Lee (Seoul National University)

Abstract

Reflective Fourier ptychographic microscopy (R-FPM) reconstructs surface information from intensity images captured under different illumination angles. Recovering surface height, however, remains challenging because phase ambiguity and limited angular coverage can make different surface profiles appear similar. Gaussian surface elements can help constrain this reconstruction. We present SurfelSplat-FPM, a framework that represents surface height and orientation using overlapping Gaussian-weighted elements. These elements form a height field linking neighboring regions. For each illumination direction, a scalar wave-optical model calculates the complex reflected field from the surface geometry, thin-film reflection response, and optical paths to and from the sample. Changes in height alter the phase of the reflected light; near normal incidence, a height change produces approximately twice that change in optical path length. The model also includes approximate sidewall reflections and illumination-dependent shadowing. Reflected field contributions are coherently combined and filtered by the objective pupil to predict camera intensity. The Gaussian surface parameters are then iteratively updated to reduce the difference between predicted and measured bright-field and dark-field images. We evaluated the method on nine simulated reflective samples with height variations of approximately 60–200 nm and lateral feature sizes or spacings of approximately 0.5–3.4 μm. The average height RMSE was 10.8% lower than that of the conventional iterative phase retrieval method. The result suggests Gaussian-weighted representations can support quantitative topography reconstruction.

Submitted poster abstract

Poster P17

Nondestructive 3D Quantification of the Magnitude and Extent of Indentation-Induced Densification in Glass

Presenter: Sangmin Lee

KAIST

Authors and affiliations

Authors: Sangmin Lee (a,b), Dohyeon Lee (a,b), Juheon Lee (a,b), Herve Hugonnet (a,b), and YongKeun Park (a,b,c) Affiliation: a. Department of Physics, Korea Advanced Institute of Science and Technology (KAIST), Daejeon 34141, Republic of Korea b. KAIST Institute for Imaging, KAIST, Daejeon 34141, Republic of Korea c. Tomocube Inc., Daejeon 34109, Republic of Korea

Abstract

Vickers hardness testing is widely used to assess resistance to contact damage, but a single hardness value cannot distinguish the magnitude of local densification from the extent of the affected region. Here, we apply low-coherence holotomography (HT) as a three-dimensional method for characterizing these two aspects of Vickers indentation damage. The method reconstructs refractive-index (RI) maps of indented fused silica, borosilicate, and soda-lime glass, converts RI changes into densification-equivalent values using the Lorentz–Lorenz relation, and quantifies the spatial extent of the densified region by segmentation. The same reconstructions also reveal subsurface cracks and other structural features, providing a more complete view of indentation-induced damage. Across different loads and nominal dwell times, local densification and the spatial extent of elevated RI do not necessarily evolve together: the affected region can expand while peak densification changes little, and glasses with similar hardness can exhibit distinct subsurface responses. This approach provides information about three-dimensional indentation damage beyond hardness alone.

Submitted poster abstract

Poster P18

Split-Pupil Multiplexing for Vectorial Microscopy Based on Kramers–Kronig Relations

Presenter: Hyesuk Chae

Seoul National University

Authors and affiliations

Hyesuk Chae, Yong Guk Kang, Jongho Kim, Seung Ah Lee* (Seoul National University)

Abstract

Full Jones matrix recovery conventionally requires specialized polarization optics or large image sets. We present an efficient synthetic aperture method in which a square pupil is split into two rectangular half-pupils encoding orthogonal polarization channels, with the straight partition boundary and NA-matched illumination satisfying the half-plane analyticity condition of the Kramers–Kronig relations. Each complex field is then initialized in closed form without spectral overlap between measurements and refined by automatic-differentiation optimization of the multiplexed forward model, recovering both channels from only four intensity images in total. Simulations confirm accurate amplitude and phase recovery, and experiments on plant cell walls demonstrate quantitative birefringence imaging.

Submitted poster abstract

Poster P19

Label-free continuous scoring of cellular senescence via holotomography-based deep learning

Presenter: Taejung Moon

Kaist

Authors and affiliations

Taejung Moon[1,2], Weisun Park[1,2], Juyeon Park[1,2], YongKeun Park[1,2,3*] [1]Department of Physics, Korea Advanced Institute of Science and Technology (KAIST), Daejeon 34141, Republic of Korea [2]KAIST Institute for Health Science and Technology, Daejeon 34141, Republic of Korea [3]Tomocube Inc., Daejeon 34127, Republic of Korea

Abstract

Cellular senescence is a heterogeneous and progressive state, yet most image-based assessments reduce it to a binary label, depend on nuclear or cell segmentation, or analyse isolated single cells. Here we present a label-free framework that combines holotomography (HT), which measures the three-dimensional refractive index (RI) of cells as a quantitative physical contrast, with passage-supervised deep learning to score senescence on a continuous scale from whole fields of view (FOVs). Rather than using class outputs, we define a senescence score as the projection of the network's latent representation onto a passage-oriented axis, requiring no labelling, segmentation, or cropping. In human fibroblasts, the model assigned held-out validation images to the correct replicative passage with 97.98% accuracy, while the score resolved within-passage heterogeneity that tracked nuclear enlargement and senescence-associated β-galactosidase, lysosomal, lipid-radical, lipid-droplet, and F-actin readouts, none of which was used for training. After H_2O_2 exposure, early-passage cells shifted furthest, and identically treated fields ranged from untreated-like to late-passage-like. Applied without retraining to fixed dermal fibroblasts from another source, the score retained passage ordering and its association with nuclear size. By uniting segmentation-free, continuous scoring with non-invasive HT, this framework could enable longitudinal assessment of senescence heterogeneity and of responses to senescence-modulating interventions.

Submitted poster abstract

Poster P20

Coherence-aligned speckle tomography for three-dimensional refractive-index characterization of 3D-printed parts

Presenter: Haoran Li

The Chinese University of Hong Kong

Authors and affiliations

Haoran Li(The Chinese University of Hong Kong), Chaodu Shi(The Chinese University of Hong Kong), Qihang Zhang(The Chinese University of Hong Kong), Renjie Zhou (The Chinese University of Hong Kong)

Abstract

Three-dimensional printing enables the fabrication of components with complex internal structures, making reliable inspection of these structures essential for evaluating printing quality. Current inspection methods include optical microscopy and X-ray computed tomography, which offer different capabilities for resolving fine features, accessing the interior and accommodating sample dimensions. For thick, heterogeneous printed parts, obtaining high-resolution structural information throughout the sample remains challenging because imaging depth, material contrast and acquisition time impose practical constraints. Speckle diffraction tomography provides label-free, depth-resolved refractive-index imaging in scattering media by combining spatiotemporal gating with dynamic speckle encoding, offering an approach to visualizing internal structures without physical sectioning. However, in heterogeneous 3D-printed parts, spatially varying phase retardations result in an uneven interferometric fringe contrast across the field of view, forming a core depth-limiting bottleneck. In this work, we developed a coherence-aligned speckle tomography (CAST) to compensate the spatial phase retardation systematically. By scanning a tunable reference arm and fusing the electrical field from multiple acquisitions, CAST compensated for the position-varying optical path mismatches that locally exceed the source coherence length, restoring full-field high-contrast fringes without modifying the sample illumination. The recovered fields enable reconstruction of the refractive-index distribution within printed parts, allowing their internal geometry and local refractive-index variations to be examined together. CAST achieves a spatial resolution of 260 nm and a phase sensitivity on the order of 0.1 nm in length-equivalent units. These capabilities provide a non-destructive basis for evaluating the internal geometry and structural consistency of heterogeneous printed parts.

Submitted poster abstract

Poster P21

Hyperspectral Phase Amplification Microscopy for 2D Material Characterization

Presenter: Chenjia Xi

The Chinese University of Hong Kong

Authors and affiliations

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Abstract

Two-dimensional (2D) materials hold great promise for next-generation optoelectronic and microelectronic devices with their distinctive electronic, optical, and mechanical properties, which creates a growing demand for precise inspection and property characterization. Their atomically thin structures require metrology with both high precision and high throughput under ambient conditions that remains challenging for conventional atomic force microscopy and optical microscopy. Phase amplification microscopy (Φ-Amp) amplifies weak phase signals through resonance between a 2D material layer and a designed substrate. However, the phase gain factor G is sensitive to the imaging condition including illumination wavelength and substrate thicknesses, and film thickness deviations introduced during fabrication shift the resonant wavelength. Here, we integrate the spectral scanning into Φ-Amp to compensate for these fabrication-induced resonance shifts and achieve high-gain phase amplification. Specifically, we employed a bilayer phase cavity comprising SiO_2 and Si_3N_4 layers with measured thicknesses of 189.62 and 69.34 nm, respectively. We performed spectral scanning of monolayer and multilayer graphene, hBN, $MoSe_2$, and WSe_2, achieving high phase gain factors G at wavelengths near 555 nm, consistent with theoretical predictions. The enhanced phase sensitivity allows us to resolve weak signals associated with surface defects. This capability extends Φ-Amp to sensitive defect detection and quantitative characterization in 2D materials, providing an effective inspection tool for van der Waals heterostructures and devices.

Submitted poster abstract · Selected lightning talk

Poster P22

Coherence-gated quantitative phase microscopy through millimeter-scale tissue

Presenter: Chaodu Shi

The Chinese University of Hong Kong

Authors and affiliations

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Abstract

Label-free tissue imaging has been vital for non-invasively characterizing subcellular architecture, with quantitative phase microscopy (QPM) widely adopted across biological profiling. Currently, QPM's imaging depth is constrained by optical attenuation, typically limiting penetration to roughly 100 μm. Previously, we developed speckle-diffraction tomography incorporating spatiotemporal gating, achieving ~700 μm depth and diffraction-limited resolution. Yet, extending beyond this depth is fundamentally bottlenecked by the high tissue scattering, which rapidly induces multiple scattering and degrades resolution. Here, we proposed a coherence-gated QPM utilizing a 1300 nm laser source coupled with a speckle illumination scheme, and established a physical model for the influence of multiple inside the sample. By exploiting the reduced scattering cross-section at 1300 nm together with the anti-scattering capability of spatial gating and interferometry, our system achieves an imaging depth of 1.8 mm in a widely used tissue phantom, 2% intralipid solution, and exceeds 600 μm in fixed brain tissue slices. We also analysis the point spread function (PSF) by measuring 200-nm gold nanoparticles, and found that, with the increased depth of tissue phantom, the PSF decrease from 1033 nm (0 mm) to 930 nm (1.8 mm). This phenomenon arises because multiple scattering enhances the illumination numerical aperture at the detected depth, broadening the detectable spatial frequency bandwidth. By converting multiple scattering from a noise source into a mechanism for resolution improvement, our approach overcomes imaging depth and resolution trade-offs. This provides a novel technical strategy for high-resolution characterization of highly scattering samples.

Submitted poster abstract

Poster P23

Physics-Informed End-to-End Framework for Fabrication-Aware PSF and Height Profile Design in Gray-Scale Maskless Lithography

Presenter: Joonsik Park

Yonsei University

Authors and affiliations

Joonsik Park [Yonsei University], Donggeon Bae [Seoul National University], Yong Guk Kang [Seoul National University], Jaewoo Jung [Yonsei University], Nakkyu Baek [Yonsei University], Jongho Kim [Seoul National University], and Seung Ah lee [Seoul National University]

Abstract

Gray-scale maskless lithography enables single-shot fabrication of three-dimensional microrelief patterns by projecting digitally controlled UV intensity fields, eliminating the need for physical photomasks. In practice, the fabricated height profile often departs from the design because of spatially varying exposure, nonlinear photoresist response, and local process variations. These deviations distort the point spread function (PSF) of the resulting phase mask and limit high-fidelity phase modulation for engineered-PSF optics. We present a PSF-aware, learning-based mask design framework that aims to compensate fabrication-induced deviations using measured system responses. Our experimental platform is a digital micromirror device (DMD)-based projection lithography setup with a 385 nm UV DLP projector, an XYZ sample stage, and an inline microscope with a CMOS sensor, enabling up to ~15 μm height modulation in a single exposure. We fabricate phase masks, measure their PSFs, and curate paired datasets linking grayscale patterns to measured PSFs. Using these data, we train a fabrication-aware, differentiable digital twin that predicts the PSF produced by a candidate profile and can estimate the fabricated height map. For inverse design, we optimize grayscale patterns in an end-to-end differentiable loop by backpropagating the mismatch between predicted and target PSFs. Beyond PSF optimization, the framework provides a route toward designing grayscale patterns for desired height maps by accounting for fabrication-induced deviations. This measurement-grounded approach seeks to reduce the design-to-fabrication gap and support phase-mask fabrication for computational imaging and quantitative phase imaging.

Submitted poster abstract

Poster P24

Neural Representations of Spatially Varying Pupil for Wide-Field Fourier Ptychography

Presenter: Sangjoon Lee

Seoul National University

Authors and affiliations

Sangjoon Lee, Hyesuk Chae, Seung Ah Lee* / Seoul National University

Abstract

Fourier ptychographic microscopy (FPM) is a computational imaging technique that achieves high-resolution imaging over a wide field of view (FOV) by synthesizing low-resolution images captured under varying illumination angles. However, because optical aberrations and illumination conditions spatially vary across the FOV, achieving high reconstruction quality uniformly over the entire FOV is challenging. To address this, we propose a spatially varying physics-based model with implicit neural representations (INR) by jointly encoding the field position and the pupil-plane coordinates. In this model, the amplitude of the pupil function is represented by a Fourier-feature INR to capture fine spatial variations, and its phase by Zernike polynomials as a compact low-order wavefront basis, both initialized with a pupil prior learned from a small set of on-axis tiles and extrapolated across the FOV to reconstruct a wide FOV image. Our pupil representation outperformed both a single INR predicting the complex-valued pupil and interpolation from neighboring tiles, particularly in off-axis regions where reconstruction is inherently difficult.

Submitted poster abstract

Poster P25

SiQT: Single-frame quantitative phase tomography for high-throughput volumetric imaging

Presenter: Ranhao Zhang

Department of Biomedical Engineering, The Chinese University of Hong Kong

Authors and affiliations

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Abstract

Flow cytometry has become an essential tool for large-scale cell analysis, with applications in reproductive medicine and circulating tumor cell (CTC) detection. Conventional fluorescence-based flow cytometry enables high-throughput analysis of cells. Imaging flow cytometry (IFC) further enriches this analysis by providing spatial information about individual cells. Optical diffraction tomography (ODT) is a promising approach for IFC because it enables quantitative, label-free reconstruction of 3D cellular refractive index (RI) distributions. However, conventional ODT requires sequential measurements at multiple illumination angles, which demand a relatively stationary sample and generate large data volumes. To address these limitations, we propose single-frame quantitative phase tomography (SiQT), a framework designed to enable high-throughput, label-free IFC through single-frame 3D imaging with reduced data volume. SiQT uses a fiber-based illumination architecture. Fiber-optic couplers deliver light to collimators mounted on a rotatable disk. Rotating the disk enables acquisition of multi-angle interferograms for reconstructing reference 3D RI distributions for subsequent algorithm training and validation. With the disk stationary, simultaneous four-angle illumination is designed to encode angular information in a single exposure, enabling both acquisition modes on the same platform. The assembled system operates at 532 nm with an illumination numerical aperture (NA) of 0.8, a collection NA of 0.95, and a field of view of approximately 200 × 200 μm². We have obtained 3D reconstructions of cell phantom using angular scanning and are currently exploring simultaneous four-angle illumination for single-frame acquisition.

Submitted poster abstract

Poster P26

Design-constrained linewidth estimation below the reconstruction resolution of reflective Fourier ptychographic microscopy

Presenter: Yong Guk Kang

Seoul National University

Authors and affiliations

Yong Guk Kang(Seoul National Univeristy), Jongho Kim(Seoul National Univeristy), Yena Cho(Seoul National Univeristy), Hyesuk Chae(Seoul National Univeristy), Seung Ah Lee (Seoul National University)

Abstract

Optical metrology provides fast, non-destructive measurements for semiconductor manufacturing, but many device features are smaller than visible wavelengths. Conventional scatterometry infers dimensions from optical responses averaged over patterned targets, whereas imaging provides spatial information but cannot resolve such features. Combining wide-field imaging with dimensional information from unresolved structures in the same field would serve both needs. Fourier ptychographic microscopy (FPM), which synthesises a large aperture from angled illuminations through a low-magnification objective, offers a simple platform for examining this possibility. Here we show that nominal design information can be used to extract linewidth information below the reconstruction resolution of our visible-light reflective FPM system. The analysis uses the same multi-angle, polarisation-resolved measurements as image reconstruction, without further hardware modification. On dense silicon line arrays, reflectance for light polarised perpendicular to the lines varied strongly with linewidth. For the densest arrays, a fast normal-incidence lamellar grating model reproduced this response with agreement comparable to that of a slower oblique-incidence calculation, and linewidths estimated with this model followed the nominal design trend well below the reconstruction resolution. Reflectance measured from individual patterned regions was repeatable between acquisitions and stable under small defocus, and the same system reconstructed a resolution target close to the synthetic-aperture limit.

Reflective FPM can thus combine wide-field imaging with sub-resolution linewidth estimation from the same visible-light measurements, using the nominal design to constrain the structural model.

Submitted poster abstract

Poster P27

Learning to self-interfere: zero-shot deconvolution enables replica-free, low-coherence common-path digital holographic microscopy

Presenter: Zhuoshi Li

Nanjing University of Science and Technology

Authors and affiliations

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Abstract

Digital holographic microscopy enables full-field, label-free, and high-precision quantitative phase imaging (QPI), yet its performance is often limited by speckle noise, parasitic artifacts, and vibration sensitivity resulting from the use of highly coherent illumination and a separate reference beam path. While reducing illumination coherence facilitates suppressing speckle and parasitic fringes, it typically requires a common-path self-interference configuration, leading to replica images that hinder quantitative analysis of dense biological specimens. In this talk, I will introduce replica-free total-shear three-beam common-path digital holographic microscopy (RF-CPDHM), which resolves this long-standing dilemma by coupling physical modeling with a deconvolution-prior zero-shot learning strategy. By formulating replica removal as an ill-posed inverse problem and solving it in an unsupervised manner, RF-CPDHM achieves high resolution, high SNR, and full-field QPI without any ground truth or training data. RF-CPDHM enables quantitative visualization of organelle dynamics, including lipid droplets and vesicles, in PLC cells under oleic acid treatment, revealing lipid-homeostasis regulation and demonstrating its broad potential for label-free quantitative studies in cell biology, pathology, and pharmacology.

Submitted poster abstract · Selected lightning talk

Poster P28

Holographic Optical Tweezer–Enabled Axial Scanning for 3D Label-Free Imaging of Suspended Particles

Presenter: Baozhang Feng

Peking University

Authors and affiliations

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Abstract

Three-dimensional (3D) label-free imaging of suspended cells and particles remains challenging due to Brownian motion and the limitations of conventional mechanical axial scanning, which introduce motion artifacts and compromise the accuracy of refractive-index (RI) reconstruction. Here, we present a holographic optical tweezer (HOT)–enabled axial scanning approach for 3D label-free imaging of suspended specimens. By dynamically updating holographic phase patterns, HOTs enable precise axial positioning of trapped particles while suppressing Brownian motion, eliminating the need for mechanical axial scanning. We demonstrate this approach using 3D differential phase contrast (DPC) microscopy to reconstruct the volumetric RI distributions of suspended specimens. Compared with conventional stage-based scanning, HOT-enabled axial scanning effectively reduces motion artifacts, improves spatial registration, and enhances RI reconstruction quality. Furthermore, the multiplexing capability of HOTs enables simultaneous trapping and axial manipulation of multiple suspended particles, allowing parallel 3D label-free imaging of particle arrays arranged in various configurations. This approach provides a versatile and broadly applicable strategy for 3D RI imaging of suspended specimens, with potential applications in cell analysis, microfluidics, and high-throughput imaging.

Submitted poster abstract · Selected lightning talk

Poster P29

Spatiotemporal fringe pattern analysis using physics-informed deep learning

Presenter: Yiheng Liu

Nanjing University of Science and Technology

Authors and affiliations

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Abstract

In optical metrology, particularly in phase-based profilometry techniques, achieving both high measurement accuracy and high temporal resolution remains a challenge. For high-speed dynamic measurements, many existing methods still adopt a frame-by-frame processing strategy, tending to overlook the rich temporal information embedded across adjacent frames. This constraint makes it difficult to maintain robust performance under ultra-short exposure conditions. Taking fringe projection profilometry as a representative example, we propose a physics-informed spatiotemporal fringe pattern analysis (PIST-FPA) framework that unifies physical modeling with deep learning for high-speed, high-fidelity 3D reconstruction. Rather than processing each frame independently, PIST-FPA jointly analyzes a short sequence of fringe images within a temporal window, exploiting both spatiotemporal correlations and physics-based priors. PIST-FPA incorporates a background-estimation network for illumination correction, a physics-guided optical-flow alignment for motion compensation, and an attention-enhanced U-Net for spatiotemporal phase demodulation, forming a unified and interpretable learning-based processing pipeline. This hybrid paradigm effectively decouples object motion from surface morphology, enabling accurate and temporally consistent phase retrieval even under ultra-short exposure and low-signal-to-noise conditions. Both synthetic and real experiments at 10,000 frames per second demonstrate that PIST-FPA substantially outperforms both the conventional Fourier transform method and single-frame deep-learning method in terms of accuracy, robustness, and spatiotemporal consistency. By bridging physical modeling and data-driven learning in a unified spatiotemporal framework, PIST-FPA establishes a generalizable paradigm for physics-informed dynamic optical metrology, paving the way for next-generation high-speed phase-measuring profilometry and intelligent optical instrumentation.

Submitted poster abstract

Poster P30

Full dielectric tensor tomography using a multislice model

Presenter: Kai Zhang

Frontiers Science Center for Nano-optoelectronics, Peking University

Authors and affiliations

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Abstract

Optical anisotropy is widespread in biological tissues and engineered microstructures. Its quantitative characterization is important for disease diagnosis and materials science.

Conventional polarized-light microscopy provides only 2D projections. Jones-based polarization-sensitive optical diffraction tomography (PS-ODT) recovers a 2 × 2 transverse tensor and omits longitudinal components. Dielectric tensor tomography (DTT) can recover the full tensor, but its weak-scattering approximation breaks down for strongly birefringent or multiply scattering samples.

We develop a learning tomography (LT) framework based on a multislice vectorial scattering model to reconstruct the full 3 × 3 dielectric tensor in the presence of multiple birefringent scattering.

Submitted poster abstract

Poster P31

Real-Time Live-Cell Quantitative Phase Imaging Enabled by Robust Phase Unwrapping

Presenter: Shiyuan Wei

Shenzhen BJR Biomedical Technology Co. Ltd.

Authors and affiliations

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Abstract

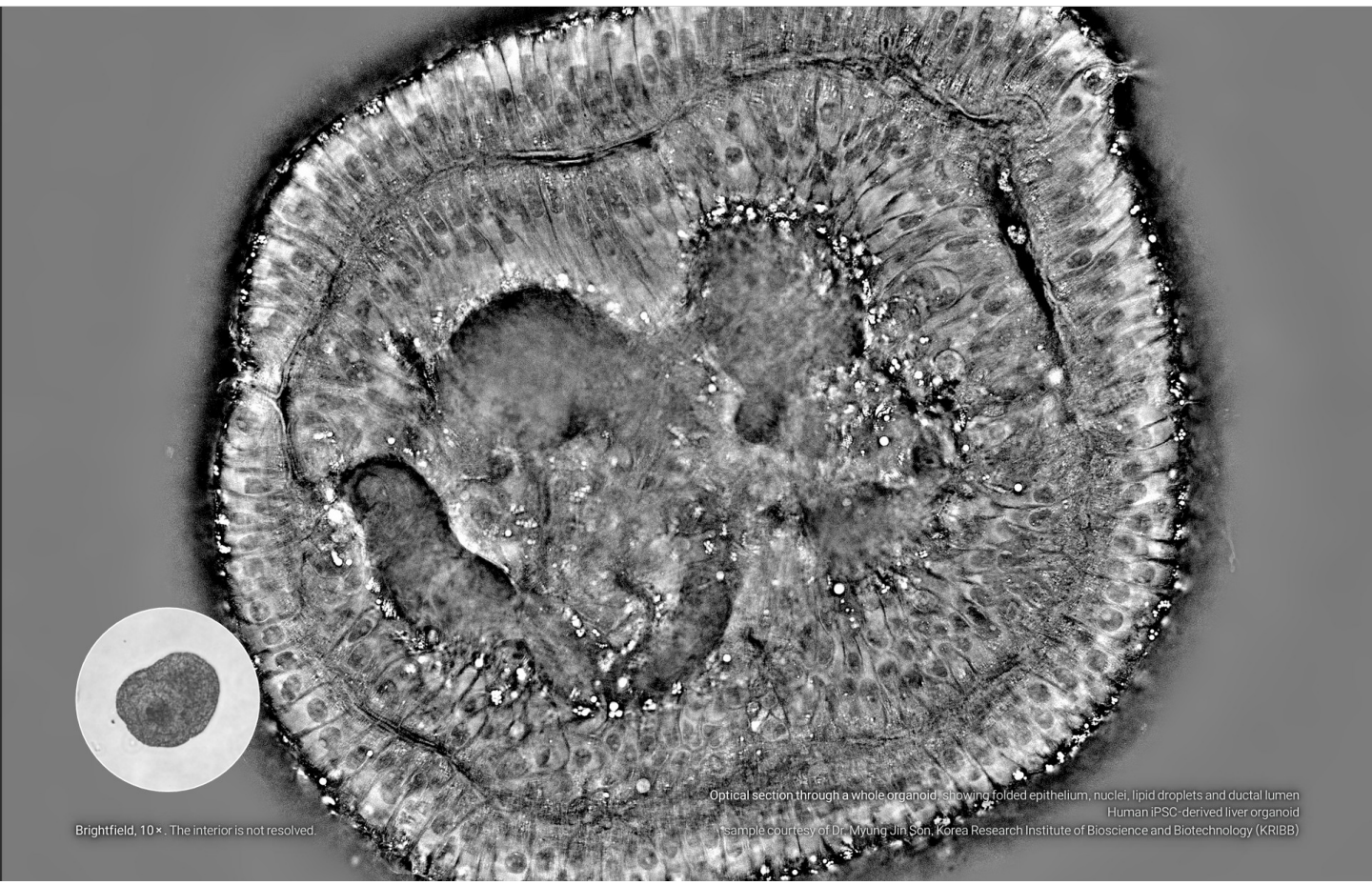
Quantitative phase imaging (QPI) enables label-free and quantitative imaging of biological samples. However, large phase excursions, steep local phase gradients, measurement noise, and low fringe contrast in some biological samples can cause phase-unwrapping errors and discontinuities, limiting the reliability of quantitative phase reconstruction and restricting QPI applications in such samples. Previous studies have advanced fast phase reconstruction, phase unwrapping, and integrated QPI software. Further integration of reliable phase-unwrapping methods into efficient off-axis QPI workflows remains important in complex biological samples. We propose a QPI workflow for complex biological samples that incorporates a versatile phase-unwrapping method based on the transport-of-intensity equation (TIE), enabling real-time quantitative phase imaging of living cells. The proposed workflow was evaluated using an off-axis quantitative phase microscopy (QPM) system under different configurations and with various biological samples. The experimental results demonstrate its effectiveness in improving phase continuity and supporting reliable quantitative phase reconstruction in complex biological specimens, with processing times on the order of tens of milliseconds per frame for approximately 2K × 2K-pixel images.

Submitted poster abstract

The 6th Quantitative Phase Imaging Symposium

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