TMOS 2024 ANNUAL REPORT

From foundations to frontiers

Contents

Centre

> 2024 was a busy year for the Centre, marked by numerous exciting scientific highlights and notable personal recognitions.

Message from the Director

The year 2024 marked a significant milestone for the ARC Centre of Excellence for Transformative Meta-Optical Systems (TMOS) as we completed the first half of the Centre's journey and successfully passed our mid-term review. All TMOS personnel worked together as a cohesive team to highlight and elaborate on these accomplishments.

Before we discuss the details, I want to thank two executive team members who have left the Centre to pursue further career opportunities. Our founding Chief Investigator (CI), Professor Francesca Iacopi, Chair of the Industry Liaison Committee and Head of Integrated Nano Systems Lab at UTS, has been appointed Director of IMEC's semiconductor R&D site in Indiana, USA. With this new role, Francesca will oversee the site's operations and establish its strategic vision for growth and impact. We sincerely thank Francesca for her outstanding contributions to TMOS over the past four years and wish her every success in her new endeavours in the USA. We also acknowledge the departure of Sharyn McFarlane, our Chief Operations Officer, who led the Centre's entire operations throughout 2024. Sharyn devoted enormous effort and significant knowledge to guide the Centre through its mid-term review, achieving excellent performance and recognition for the Centre. We thank Sharyn for her remarkable efforts and professionalism in managing TMOS operations and wish her the best as she returns to the Australian Research Council.

Excellence and high achievements

2024 was a busy year for the Centre, marked by numerous exciting scientific highlights and notable personal recognitions. TMOS members received numerous awards for their work. Shaban Sulejman (University of Melbourne) was awarded the Australian and New Zealand Optical Society (ANZOS) Postgraduate Research Prize for his "outstanding research focused on designing optical metasurfaces for imaging applications such as phase imaging of transparent biological samples and multi-modal microscopy." Dr. Rocio Camacho Morales (Australian National University) was awarded the ANZOS Geoff Opat Early Career Researcher Prize for her "research which focuses on nonlinear optical metasurfaces and their application for conversion enhancement and imaging capabilities." We take great pride in these emerging talents of TMOS and wish them success in their future endeavours. The full list of prizes and awards can be found at the end of the report. Congratulations to all.

The research output of the Centre was presented in over 110 scientific publications, with 22% published in top-tier scientific journals. TMOS researchers co-authored papers in some of the world's leading journals, including Nature (634, 1096), Nature Materials (23, 1379), and Nature Photonics (18, 309). Importantly, this year we have seen a dramatic increase in collaborative projects across our five nodes and with partner investigators.

In July, TMOS students and ECRs convened for their conference at RMIT University. Moreover, TMOS students took a prominent leadership role at the 15th KOALA Student Conference on Optics, Atoms, and Laser Applications in November, where they set a new attendance record. Finally, we wrapped up the year with the TMOS Meta-Together Conference 2024, which provided three days filled with science, networking, and skills development, all set against the stunning backdrop of Scarborough Beach in Western Australia.

Translation built upon fundamental science and innovation

As we transition into the second half of the Centre, we observe several fundamental projects maturing and poised to deliver a real-world impact. In recognition of this translational development, TMOS has instituted an integrated research program, culminating in the newly established TMOS Flagship Program. The TMOS Flagship Program centres on the development of cross-node, high-technology readiness Level (TRL) meta-optics research projects that exhibit clear market appeal. To concentrate resources and provide optimal support for translation and impact, three programs were chosen: Advanced Quantum Technologies, Meta Health Sensors, and Enhanced Infrared Vision. These programs are overseen by Flagship Program Managers, who facilitate the transition of projects from fundamental to applied research and, consequently, outline the path for translation and future commercialisation. Additionally, these projects are actively promoted to foster industry engagement and the adoption of technology. To date, we are proud to witness the uptake of TMOS technology through targeted hires in sectors leveraging our innovations, including the appointment of Dr. Andrei Komar at Seeing Machines, Australia, and Dr. Neuton Li at Meta, USA.

International development

The field of meta-optics is expanding rapidly, significantly influencing related areas. Meta-optics has created new opportunities in sectors such as quantum technologies, enabling robust and programmable modifications of single-photon emitters, quantum imaging, and communications. It has also unlocked vital opportunities for innovative photonic neural networks and optical computing. TMOS has dedicated resources to these new advancements through related educational colloquia, set to begin in 2025. Additionally, there is immense interest in applying meta-optical systems to groundbreaking augmented reality (AR) technologies and space applications. TMOS is proactively collaborating with industries in these fields to maximise the impact of our fundamental science.

We are also witnessing remarkable advancements in the use of meta-optics for medical imaging and diagnostics. Examples include the work from our Melbourne node in novel multi-modal microscopy, which could enhance the accuracy of tumour detection and classification. An exciting new development in this area was presented by Prof. Mark Brongersma (Stanford University) at the 2024 TMOS Annual Conference. Mark, a member of the TMOS International Scientific Advisory Committee, captured our team's imagination by demonstrating the ability to render biological tissue transparent through controlling its scattering with composite materials. I believe that the limit to the opportunities is only our imagination.

Actions and initiatives for 2025

The Centre's actions for 2025 will be largely driven by the recommendations from the ARC detailed in our mid-term report. More details on these can be found later in our report. However, two actions stand out. The first step is to undertake a strategic planning of the Centre's activities, enabling TMOS to deliver maximum impact. The second one is to "maintain strong basic science effort". The latter one is of utmost importance as fundamental science is the foundation for innovation and long-term economic prosperity. At TMOS, we fully embrace this value.

I am incredibly enthusiastic about our potential achievements in 2025. I look forward to collaborating with the TMOS team to ensure that our research receives the utmost recognition and has a significant impact on both the Australian industry and the global community.

Prof. Dragomir Neshev
Centre Director

OUR VISION

The Australian Research Council Centre of Excellence for Transformative Meta-Optical Systems (TMOS) will develop the next generation of miniaturised optical systems with functionalities beyond what is conceivable today.

By harnessing the disruptive concept of meta-optics, we will overcome complex challenges in light generation, manipulation and detection at the nanoscale. Our research outcomes will underpin future technologies, including real-time holographic displays, artificial vision for autonomous systems to see the invisible, wearable medical devices and ultra-fast light-based Wi-Fi, meeting the evolving demands of Industry 4.0.

OUR MISSION

We will become a trans-disciplinary team of world leaders in science, technology, and engineering to deliver scientific innovations in optical systems.

We will translate research into innovative technologies in transport, health, security, defence, agriculture, entertainment and education with significant benefit to society and economic growth.

We will prepare outstanding innovators from diverse backgrounds to be future leaders for decades to come.

OUR VALUES

COLLABORATION

We work together to make a team culture that is inclusive, values diversity, strives for equity, and accessibility (you get the IDEA!) so that everyone can participate.

EDUCATION

We embrace learning and failing forward, gaining insight from each iteration of our experiments, processes and beyond.

DISCOVERY

We do research at the highest international level as an interdisciplinary team. We make the unknown knowable through the pursuit of fundamental science.

INNOVATION

We have a passion for technology innovation due to the positive impact it has on the world. Our science has a purpose.

ENGAGEMENT

Internally, we connect with each other, celebrating our wins and creating a fun and safe workplace. Externally, we engage with partners and the public to share the joy of science, and to translate our research into novel technologies.

Message from the Centre Advisory Board

As we move further into a decade defined by global uncertainty and rapid technological change, one thing is clear: the nations that will lead are those that invest in foundational scientific research today. The ARC Centres of Excellence, including TMOS, are proof of the long-term value that arises when we support homegrown research talent. These Centres not only deliver world-leading science but also build sovereign capability and help shape Australia's strategic direction.

This year, TMOS reached an important milestone, the Mid-Term Review conducted by the Australian Research Council. The outcome, I'm pleased to say, was exceptional. The reviewers provided unusually strong and positive commentary, commending the quality of the research and the maturity of the Centre. While some low-level recommendations were provided, none went to the substance of TMOS's operations or governance. On behalf of the Advisory Board, I extend my congratulations to the leadership and research teams. The review is a well-earned recognition of their sustained efforts and impact and positions TMOS well for the next stage.

TMOS is now visibly extending from foundational research toward translational impact. Its latest structure, with three foundational research themes and three flagship programs, reflects a thoughtful and strategic approach to bridging fundamental discovery with real-world applications. It is a model of what future-oriented science can look like.

A critical part of that journey from foundation to frontier is public engagement. In 2024, TMOS took significant steps to enhance scientific outreach. In collaboration with Questacon and Professor Hans Bachor, the Centre developed low-cost photon clickers designed for use in school classrooms. These tools are making complex quantum and optical science accessible to students and teachers, inspiring the next generation of scientists and showing the tangible value of research in everyday life.

It is heartening to see TMOS researchers not only making scientific breakthroughs but also taking seriously their role as communicators and advocates. For example, Professor Madhu Bhaskaran presenting on the importance of MedTech to the Victorian Parliament and hosting the Federal Education Minister and Indian Education Minister at RMIT, or Professor Dragomir Neshev presenting to the ACT Government and the Federal Department of Industry, Science, and Resources Quantum Division. Chief Investigator Professor Sharath Sriram, as President of Science and Technology Australia, continues to press the case for increased national investment in research and development. As he rightly highlighted in his National Press Club address, Australia's R&D investment remains well below the OECD average. If we are to remain competitive and sovereign in emerging technologies, this must change.

And we must keep pressing. As I have said before, foundational research underpins the technologies, economies, and societies of the future. It is not optional; it is essential. We must also be vigilant in protecting the independence of science and the integrity of our research institutions. As I noted recently, there are growing concerns about political interference in scientific review processes. This trend must be reversed if Australia is to maintain public trust in science and evidence-based policymaking.

TMOS represents the best of what Australian science can be: rigorous, collaborative, creative, and outward facing. I urge every researcher and partner of the Centre to keep sharing their work, building partnerships, and showing Australians how science shapes their future. From foundations to frontiers, TMOS is creating knowledge, capacity, and opportunity that deserves to be seen, heard, and supported.

Professor Ian Chubb AC FAA FTSE
Chair, Centre Advisory Board

Message from the International Scientific Advisory Committee

The theme of this year's TMOS Annual Report, *From Foundations to Frontiers*, captures precisely what makes this Centre of Excellence so inspiring. TMOS continues to lay solid scientific foundations through rigorous research, while also pushing the boundaries of what's possible in the world of light manipulation and meta-optical devices.

One of the most exciting frontiers in nanophotonics is the development of active optical metasurfaces—ultrathin materials that can dynamically manipulate light. These platforms enable radically new ways for humans to interact with technology. Semiconductors provide maturity and integration with electronics, while soft, flexible materials offer new possibilities with their compliance and large, stimulus-responsive behaviours. Imagine a flat, micron-thick surface that can electrically switch between multiple holographic images or adjust the focus of a lens in real time. This is no longer science fiction—it's an active area of research where TMOS plays a crucial role.

These advances were recently discussed in the review article I co-authored, titled "Optoelectronic metadevices," *Science* 386, eadm7442(2024). This review emphasises how dynamically tunable metasurfaces could transform displays, sensors, and optical computing. TMOS's contributions to this area are helping to bridge the gap between conceptual designs and real-world applications.

In 2024, I had the pleasure of strengthening my collaboration with TMOS. A notable highlight was hosting TMOS postdoctoral fellow Dr. Patrick Rufangura (UTS) at Stanford for a month-long research exchange. His visit allowed hands-on work on the design, fabrication, and IR characterization of semiconductor metagratings for mid-IR thermal emission. We are currently exploring the possibility of a longer exchange visit by TMOS PhD student Ziwei Yang, which could accelerate progress on novel tunable optical systems.

I continue to be impressed by TMOS's distinctive structure—its capacity to foster cross-institutional collaborations, its strategic focus on flagship research areas, and its dedication to training the next generation of scientific leaders. These foundations are crucial for creating long-term impact.

Looking ahead, I would be eager to help promote TMOS's work more widely across the United States. A future TMOS-led workshop at Stanford could connect leading scientists like Jennifer Dionne, Shanhui Fan, Jelena Vučković, and Jonathan Fan, while also encouraging collaboration with industry partners in Silicon Valley—including Meta and Samsung—who are actively exploring applications of metasurface technologies.

TMOS is well-positioned to lead in shaping the future of optical science and its many real-world applications. From foundational materials and device physics to the frontiers of adaptive, intelligent optical systems, this Centre exemplifies what a research powerhouse should be.

It is a pleasure to serve on the International Scientific Advisory Committee and to contribute to TMOS's exciting journey.

Professor Mark Brongersma,
Stanford University
Member, TMOS International Scientific Advisory Committee

2024 Key Moments

- **1 JAN 2024** – Francesca Iacopi – IEEE Fellow 2024
- **1 JAN 2024** – Igor Aharonovich – SPIE Fellow Member
- **12 JAN 2024** – Igor Aharonovich – Highly cited researcher Clarivate
- **13 FEB 2024** – ICONN 2024 – TMOS Team highly represented: 2 Co-Chairs, 4 invited talks, 2 keynote talks, 10 oral presentations amongst the members
- **20 MAR 2024** – Science Meets Parliament 2024 Session: STEM Leadership. Panel: STA President Sharath Sriram chaired this session
- **21 MAR 2024** – Mingjie Yang – Media Release in Medical Forum: Optical sensor for diabetes
- **3 APR 2024** – Samara Thorn – Presentation about TMOS meta-optics in health at Canberra Innovation Network's First Wednesday Connect event. Hosted by the ANU College of Health and Medicine
- **8 APR 2024** – Agile Project Management Training for Program, Flagship Managers and Business Team
- **17 APR 2024** – Francesca Iacopi – IEEE Electron Devices Society Distinguished Lecture (open to the public)
- **6 MAY 2024** – Fedor Kovalev received the Crompton Award
- **16 MAY 2024** – Dragomir Neshev – Presentation to ACT government: Department of Industry, Science, and Resources (DISR) Quantum Division.
- **16 MAY 2024** – International Day of Light interactive exhibits
- **21 MAY 2024** – Hoe Tan – Elected as Academician of the Asia Pacific Academy of Materials
- **21 MAY 2024** – Boron Nitride Workshop 2024 in Sydney organised by Igor Aharonovich
- **26 MAY 2024** – Mariusz Martyniuk was the International Chair of Organizing Committee and Chief Delegate for Australia at the MMS 2024, The 27th World Micromachines Summit
- **17 JUN 2024** – Mid-year Planning Day
- **17 JUL 2024** – Chennupati Jagadish – Honorary Doctorate, Doctor of the University (honoris causa) from his Royal Highness Duke of Kent and Chancellor of the University of Surrey, UK
- **24 JUL 2024** – ECR and Student Conference 2024
- **31 JUL 2024** – Wei Wen Wong – Ran a three-day FDTD workshop at Hokkaido University
- **12 AUG 2024** – Lan Fu is part of the NSSN (NSW Smart Sensing Network) Women in Sensing Panel Discussion
- **2 SEPT 2024** – Meta Active Annual Meeting 2024
- **12 SEPT 2024** – Maryam Setareh and Kenneth Crozier – UoM Media Release How science is making the sci-fi 'tractor beam' a reality"
- **18 SEPT 2024** – CE20 Mid-Term Review Site Visit and Interview
- **23 OCT 2024** – Madhu Bhaskaran and Sharath Sriram – Showcase and hosting Dharmendra Pradhan, the Indian Education Minister and Jason Clare, Federal Education Minister at RMIT
- **24 OCT 2024** – Performance Review Report and Outcomes received from ARC
- **6 NOV 2024** – Madhu Bhaskaran – Presentation at Victorian Parliament on MedTech
- **6 NOV 2024** – Science Communication Workshop organised by the EPD Committee
- **19 NOV 2024** – TMOS Conference
- **25 NOV 2024** – KOALA Conference
- **27 NOV 2024** – Madhu Bhaskaran – Parliamentary Friends of Science event presentation
- **13 DEC 2024** – TMOS – Mid-Term Review Response to ARC

Action Items for 2025

FLAGSHIP PROGRAM: META HEALTH SENSORS

1. Refining current version using additional LEDs with supplemental wavelength
2. Optimisation of the electronics using an improved electronics arrangement
3. Exploring integration of miniaturised band pass filters using TMOS technologies for enhanced performance

Read the report

FLAGSHIP PROGRAM: ENHANCED INFRARED VISION

1. Finalisation of first prototype of high-operating temperature (HOT) MWIR detector
2. Establish first R&D collaboration with an industry partner
3. Design of application with direct market appeal based on HOT MWIR detector technology
4. Grant application for major joint industry/academia funding

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FLAGSHIP PROGRAM: ADVANCED QUANTUM TECHNOLOGIES

1. Improve the nanofabrication of SiC (aspect ratio 1:10) and set up measurement of single photons in IR
2. Design metalenses and multifunctional metasurfaces for the IR wavelength
3. Demonstration of QKD protocol with a single photon emitter coupled with a metalens in SiC
4. Fabrication of Nanobeam cavities in SiC for high collection efficiency of single photons in IR

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THEME 1 GENERATE

1. Electrically injected metasurface and nanoscale lasers
2. Wide bandgap metasurface emitters
3. Metasurface mid-IR lasers
4. Enhance the nonlinear emission from 2D materials and heterostructures
5. Coupling quantum dot single photon emitters into micro-ring resonators
6. Biphoton polarization entanglement from an InGaP nonlinear metasurface

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SUBPROGRAM 1A

1. Bottom-up fabricated nanolaser arrays for tailorable emission
2. Development of electrical UV nano-emitters
3. Perovskite-based metasurface light-emitters

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SUBPROGRAM 1B

1. Nonlinear Frequency Conversion in Topology-Optimised Dielectric Metasurfaces
2. Couple QD emission into whispering-gallery mode of InP-micro-ring resonator
3. Electrically driven single photon source of quantum dots in single nanowire
4. Optically tunable generation of biphoton polarization entanglement from an InGaP nonlinear metasurface

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THEME 2 MANIPULATE

1. Demonstration of MEMS-based tunable metamaterial filters
2. Development of tunable metasurfaces using phase-change materials
3. Advancing soft-matter-based metasurfaces for dynamic light control

Read the report

SUBPROGRAM 2

1. Demonstration of MEMS-based tunable metamaterial filters
2. Development of tunable metasurfaces using phase-change materials
3. Advancing soft-matter-based metasurfaces for dynamic light control

Read the report

THEME 3 DETECT

1. Demonstrate SWIR nanowire array on-chip spectrometer
2. Demonstrate top-down etched InGaAs metasurface SWIR polarisation-sensitive photodetector
3. Experimental demonstration of mid-infrared spectrometer consisting of guided mode resonance filters integrated with detector array
4. Demonstrate phase imaging with inverse-designed nonlocal metasurfaces
5. Demonstrate metasurface-enabled small-satellite polarisation imaging

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SUBPROGRAM 3A

1. InAs Nanowire Short-Wave Infrared Photodetector
2. Metasurface-Enabled Wavelength Demultiplexing Based on Nanowire Quantum Well Infrared Photodetectors
3. MCT Detector Enhanced with Self-Integrated On-Pixel All-Dielectric Metamaterial Resonance (metaMCT-Pixel)

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SUBPROGRAM 3B

1. Complete the fabrication and characterisation of a laboratory prototype and evaluate its performance for hazardous agent detection using infrared spectroscopy with the fabricated device
2. Continue the electrical and optical characterisation of the fabricated MEMS devices in collaboration with other TMOS nodes, incorporating data processing techniques developed at the University of Melbourne for spectral reconstruction
3. Conduct experiments targeting higher imaging resolution and single-shot 2D ghost imaging using broad-angle photon emission in both directions
4. Conduct a collaborative experiment with the University of Jena to compare the performance and characteristics with a conventional bulky photon-pair source
5. Conduct characterisation of the plasmonic nanogratings and submit the results for publication. Since ITO shows potential for voltage tunability, this may support cross-node collaboration in 2025. A potential collaboration with the nonlinear research group is also being considered for device characterisation
6. Characterise the EG/SiC filter and demonstrate edge-detection image processing in the next phase of the project
7. Extend work to single-shot polarization imaging
8. Finalise the fabrication and conduct measurements of SiN/SiO_2 metasurfaces to verify the design parameters

Read the report

CENTRE EXECUTIVE COMMITTEE

1. Grow the Flagship Program
2. Maintain the strength of our fundamental research program and pursue opportunities to publicise its successes.
3. Strengthen collaboration within the Centre. Strengthen leadership opportunities provided to students and early career researchers

Read the report

INDUSTRY LIAISON COMMITTEE

1. Continue to refine the Flagship Project Processes, strengthening cross-node collaboration
2. Hold a planning day for the ILC
3. Begin planning a 2026 industry show case
4. Host a 'shark tank' at the TMOS conference for Centre members to gain external feedback on their ideas

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EDUCATIONAL AND PROFESSIONAL DEVELOPMENT COMMITTEE

1. Organising the 5th TMOS ECR/HDR mid-year conference with enhanced interactivity and career-focused sessions
2. Expanding the Centre's mentorship program through the Mentorloop platform, with clearer tracking mechanisms to improve engagement
3. Strengthening the effectiveness of the supervisory panel by improving feedback collection and implementation
4. Continuing to develop professional development opportunities through workshops, colloquia, and industry engagement initiatives

Read the report

IDEA COMMITTEE

1. Partner with the Education and Professional Development (EPD) Committee to deliver impactful and engaging training programs to the Centre
2. Work with the Outreach Committee to develop activities that support and celebrate our culturally and linguistically diverse (CALD) community
3. Focus on proactive initiatives to sustain and improve gender balance within the Centre

Read the report

OUTREACH COMMITTEE

1. Continue to develop Senior STEM Engagement Program across all nodes
2. Demonstrate working prototype of Photon Clicker in Science EXPO Japan with Partner Organisation Questacon
3. Deliver Science Communication Training Workshop with Partner Organisation Questacon for the outreach committee members.
4. Develop new connections through education conferences and networking
5. Develop new connections with the communities via public libraries
6. Develop Photon clicker related workshops for Public School teachers use
7. Develop DIY Photon Clicker kit
8. Prepare a Science Bus Outreach Program to travel in October-November from Perth to Sydney, 2025 or in 2026 based on public school schedules

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INFRASTRUCTURE AND CAPABILITIES COMMITTEE

1. Expand the Centre's equipment register by adding new infrastructure
2. Promote awareness of existing facilities within the Centre to foster greater collaboration
3. Assist with funding and access proposals from TMOS researchers and others, including initiatives like the ARC LIEF program and NCRIS funding

Read the report

INDUSTRY LIAISON COMMITTEE

1. Continue to refine the Flagship Project Processes, strengthening crose-node collaboration
2. Secure necessary funding to align with long-term strategic goals

Read the report

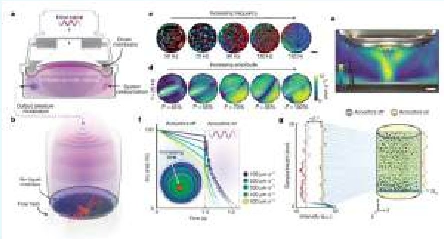
Publication Highlights

In 2024, TMOS research was published in several top-tier journals most notably Nature highlighting our global impact and leadership in the field of meta-optics.

NATURE

Dynamic interface printing

A new 3D printing method Dynamic Interface Printing uses sound waves and a liquid surface to form complex shapes in seconds, bypassing the need for layers, lasers, or chemicals. It's a faster, more versatile approach that works with a wide range of materials, including those for medical applications.



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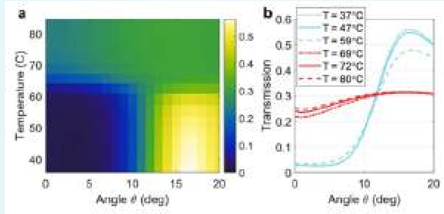
NATURE COMMUNICATIONS

Reconfigurable image processing metasurfaces with phase-change materials

Flat, light-speed lenses known as optical metasurfaces are revolutionising image processing no electronics required. A new design uses vanadium dioxide to enable reconfigurable edge detection with just a small temperature shift, paving the way for energy-efficient, chip-compatible optical computing.



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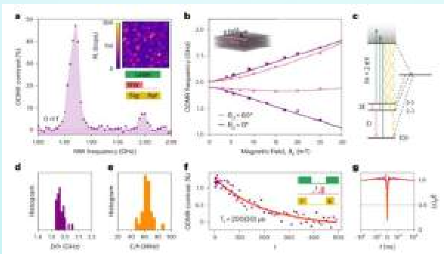
NATURE MATERIALS

A quantum coherent spin in hexagonal boron nitride at ambient conditions

A breakthrough in quantum tech shows that hexagonal boron nitride with specific carbon defects can generate single photons and control spin at room temperature. This sidesteps the need for extreme cooling and opens the door to more practical quantum devices.

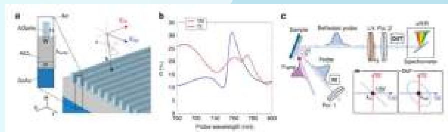


Read More

LIGHT SCIENCE & APPLICATIONS

Giant ultrafast dichroism and birefringence with active nonlocal metasurfaces

Ultrafast control of light's polarization is key to next-gen communication and imaging tools. A new optical surface called a dielectric metasurface can switch polarization in under a trillionth of a second using only light, not electronics, enabling faster, low-energy photonic technologies.



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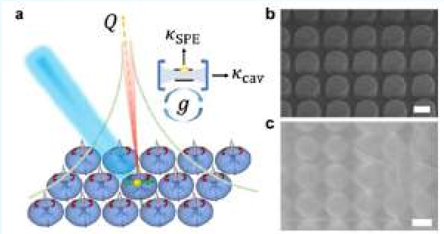
NATURE COMMUNICATIONS

Room-temperature strong coupling in a single-photon emitter-metasurface system

Single-photon sources are key to quantum computing and sensing, but maintaining their performance at room temperature is a major challenge. By coupling hexagonal boron nitride to a specially designed light-trapping cavity, scientists have shown it's possible to better preserve quantum properties without the need for extreme cooling.

Read More

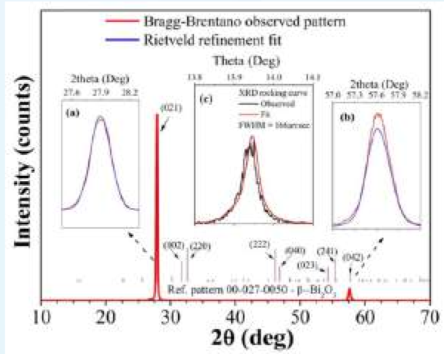


JOURNAL OF MATERIALS RESEARCH

Highly Oriented as-grown beta-phase bismuth oxide for optical MEMS

Highly oriented β-phase Bi_2O_3 thin films were fabricated using reactive sputtering at 120 °C, forming vertically aligned nanofilaments with excellent optical and mechanical properties. Their wide bandgap, low absorption, and high refractive index make them well suited for optical MEMS applications, including Fabry–Pérot microspectrometers across visible to mid-infrared wavelengths.

Read More



ADVANCED MATERIALS

Optically Tunable Electrical Oscillations in Oxide-Based Memristors for Neuromorphic Computing

Next-gen smart tech needs hardware that reacts to the environment like a real nervous system. A new light-responsive artificial neuron made from V_3O_5 mimics this behavior firing in response to light and heat. It's simple to operate, highly tunable, and ideal for advanced sensing and brain-inspired computing.

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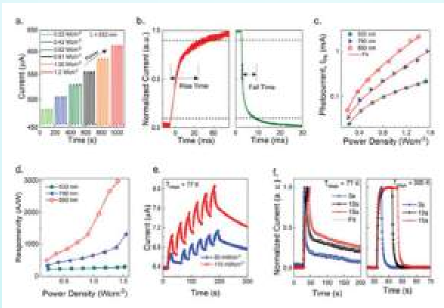

APPLIED MATERIALS TODAY

Tunability of Sb2Se3 phase change material for multi-domain optoelectronics

Unlike traditional optics, phase change materials can be reconfigured on demand. TMOS researchers are studying Sb_2Se_3, a chalcogenide that switches states with heat, light, or electricity without continuous power. Their findings reveal new intermediate states, unlocking multi-level control for advanced memory and tunable optical devices.

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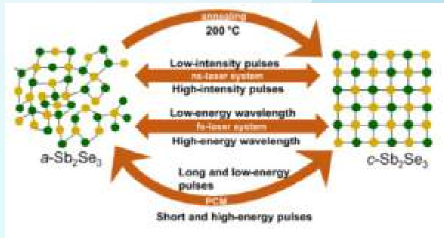
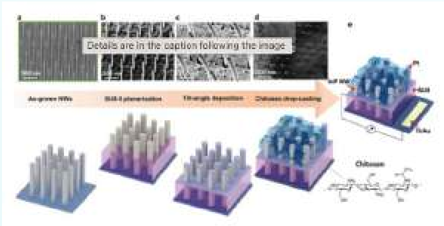


ADVANCE SCIENCE

Nanowire Array Breath Acetone Sensor for Diabetes Monitoring

A new non-invasive breath sensor can detect acetone an early warning sign of diabetic ketoacidosis across a wide range of levels. Using a nanowire material enhanced with chitosan and platinum, the sensor provides accurate, self-powered detection at room temperature, making early intervention easier and safer.



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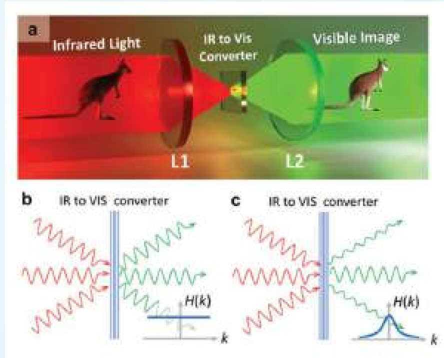
ADVANCED MATERIALS

Enhanced Infrared Vision by Nonlinear Up-Conversion in Nonlocal Metasurfaces

Infrared imaging is vital for night vision and medical diagnostics, but current systems are often bulky and limited. A new lithium niobate metasurface changes that converting infrared light into clear, visible images through a compact, high-resolution process called nonlinear up-conversion, all in a much smaller and more efficient package.



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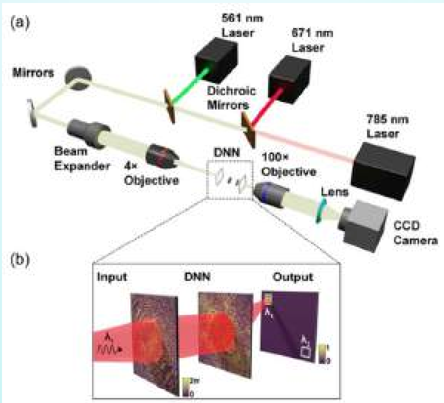
ADVANCED PHOTONICS RESEARCH

Broadband Diffractive Neural Networks Enabling Classification of Visible Wavelengths

Diffractive neural networks use light instead of electricity to process information, offering an energy-efficient alternative to traditional AI. A new miniaturised version, built with laser-fabricated optical layers, can classify colours of visible light mimicking how our eyes distinguish red from green, all without active power or bulky hardware.



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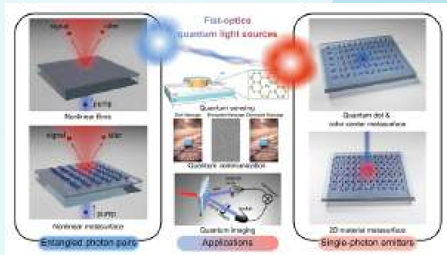
ADVANCED MATERIALS

Engineering Quantum Light Sources with Flat Optics

Quantum light sources are key to future tech like secure communication and quantum computing but they're often bulky and complex. TMOS researchers are now using ultra-thin "flat optics" to create compact, scalable sources that can be tailored for multiple functions, making quantum technologies more practical and accessible.



Read More

Connect with us

INDUSTRY AND RESEARCHERS

We are interested in connecting with any researchers or potential industry partners that want to explore ways to further our research or apply it to their areas of expertise. If you're interested in having a conversation about ways we might work together, get in touch.

COMMUNITY AND EDUCATORS

The Centre is committed to the development of STEM education in Australia. If you're interested in learning more about how we support science educators through resources or in-school programs, please connect with us.

MEDIA

For all media enquiries please contact TMOS via email:

tmos@anu.edu.au

NEWSLETTER

Stay up to date with the latest meta-optics news from across the globe by subscribing to our newsletter.

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Governance

Centre Executive Committee Directorate Report

The Centre Directorate (Professor Dragomir Neshev, Professor Kenneth Crozier, and Sharyn McFarlane) and the Centre Executive Committee led the Centre's Research and Management objectives for the year. We continued to meet fortnightly and held two in-person planning days. Thanks to the joint efforts of the entire team, we are also pleased to report that we completed our 2024 goals.

> Collaboration at TMOS took many forms in 2024, ranging from students from different nodes working together on committees to collaborative research that spanned from theory to materials science and to device engineering.

Our first goal for 2024 was to "Undertake mid-term review led by the Australian Research Council." A huge amount of effort went into the preparation of review documents, and we are very grateful for the efforts of everyone involved in it. We want to highlight, in particular, our Chief Operating Officer, Sharyn McFarlane. Her expertise and professionalism guided our team through the process, resulting in a great outcome. We thank her for her support during 2024. The ARC assessed TMOS on 17 criteria. Of these, 11 were assessed as "Exceeds expectations", 5 were "Meets expectations," and 1 was rated "Requires improvement." The ARC panel wrote that our "outcomes to date are particularly impressive", that we are making a very strong contribution to the field of metamaterials for photonics, that we have "a high proportion of publications in journals recognised as most influential in the field" and "recognition of research excellence through awards." This was a most gratifying outcome.

Our second goal for 2024 was to: "Continue to drive collaborative initiatives, events, and funding to enhance impact". Collaboration at TMOS took many forms in 2024, ranging from students from different nodes working together on committees to collaborative research that spanned from theory to materials science and to device engineering. We continued to strive to bolster inter-node collaborative research via our TMOS Cross-node Exchange and the PI Student Exchange funding programs. These achieved good outcomes for those involved but were under-subscribed.

Our third goal for 2024 was to: "Continue to refine the research strategy and goals." To this end, we were ably supported in 2024 by our Research Program Managers (RPMs) and Flagship Project Managers (FPMs). Our RPMs and FPMs are early-career researchers at the forefront of the TMOS research program. Their input into strategy and planning has been instrumental.

Our fourth goal for 2024 was to: "Continue to focus on succession planning by providing leadership opportunities to all TMOS members, in particular our PhD students and early career researchers." These leadership opportunities took several forms in 2024, including the RPM/FPM program, the organisation of the TMOS ECR & Student Conference, outreach events, and other ad hoc opportunities.

This naturally leads to a discussion of the 2025 goals. Our first goal is to "Engage deeply with CAB and ISAC." This was one of the "Actions Required" from the Mid-Term Review, so it will be addressed as a matter of priority. We will accomplish this by increasing the number of meetings we hold in 2025, focusing on shorter but more frequent engagements.

Our second goal for 2025 is to: "Grow the Flagship Program". This program is for cross-node projects on meta-optics with a market opportunity. An ideal outcome for our applied projects is that they become part of the Flagship Program. We currently have one project in each of our three Flagship sub-programs (three projects total). We aim for two projects per sub-program by the end of 2025.

“

To ensure continued focus on basic science, we aim to implement targeted initiatives such as workshops and special colloquia that encourage growth in emerging research areas such as nanophotonics and materials.

Our third goal for 2025 is to “Maintain the strength of our fundamental research program and pursue opportunities to publicise its successes.” This was one of “Actions Required” from the Mid-Term Review, which TMOS fully embraces as the highest priority. To ensure continued focus on basic science, we aim to implement targeted initiatives such as workshops and special colloquia that encourage growth in emerging research areas such as nanophotonics and materials.

Our fourth goal for 2025 is to “Strengthen collaboration and leadership opportunities provided to students and early career researchers.” As evidenced by an increasing number of research publications with authors from multiple TMOS nodes, it is fair to say that we are on a positive trajectory toward enhancing collaboration. However, improvements can be made, so we will retain this as a critical goal for 2025. Similarly, leadership skills, including the ability to work in teams, are essential attributes of today’s workforce. By emphasising this in 2025, we hope to improve the success of all members in their future endeavors beyond TMOS.

In closing, we wish all TMOS members and our friends around the globe all the best for 2025.

Professor Ken Crozier and
Professor Dragomir Neshev

ACTION ITEMS FOR 2024

1. Engage deeper with CAB and ISAC.
2. Grow the Flagship Program.
3. Maintain the strength of our fundamental research program and pursue opportunities to publicise its successes.
4. Strengthen collaboration and leadership opportunities provided to students and early career researchers.

Message from the Chief Operations Officer

2024 has been a year of momentum and reflection for TMOS. Building on structural and strategic reforms, we have continued to strengthen the Centre's foundation and prepare for the future.

A defining milestone was the successful mid-term review in September. We were proud to receive excellent scores across all assessed areas—an outcome that reflects the dedication, expertise, and collaborative spirit of our entire community. We are already acting on the panel's suggestions, using them to inform our next strategic planning phase in 2025.

Another highlight was the TMOS Conference in Perth, an event that brought together members, partners, and guests from across the country. This conference showcased the strength of our research community and underscored the power of collaboration. It was a moment to reflect, to connect, and to celebrate the shared vision that drives TMOS forward.

Throughout 2024, we've remained focused on key priorities:

- **Research Governance:** Our revised executive structure is now fully embedded, providing clarity in decision-making and focused space for research and operational discussions. The inclusion of both research and professional staff in executive processes continues to foster shared ownership and enhance communication across the Centre.
- **Public Engagement:** We are seeing growing interest in our work through engagement with industry, the public, and collaborators. Several promising conversations with potential partners are now underway as a result.
- **Supporting Talent:** We remain deeply committed to supporting our researchers. In 2024, we expanded initiatives introduced last year—such as cross-node collaboration and inter-centre mentoring—to further support career development and community building. Our focus on diversity and inclusion remains central to everything we do, ensuring that TMOS continues to reflect the excellence and richness of the research community.

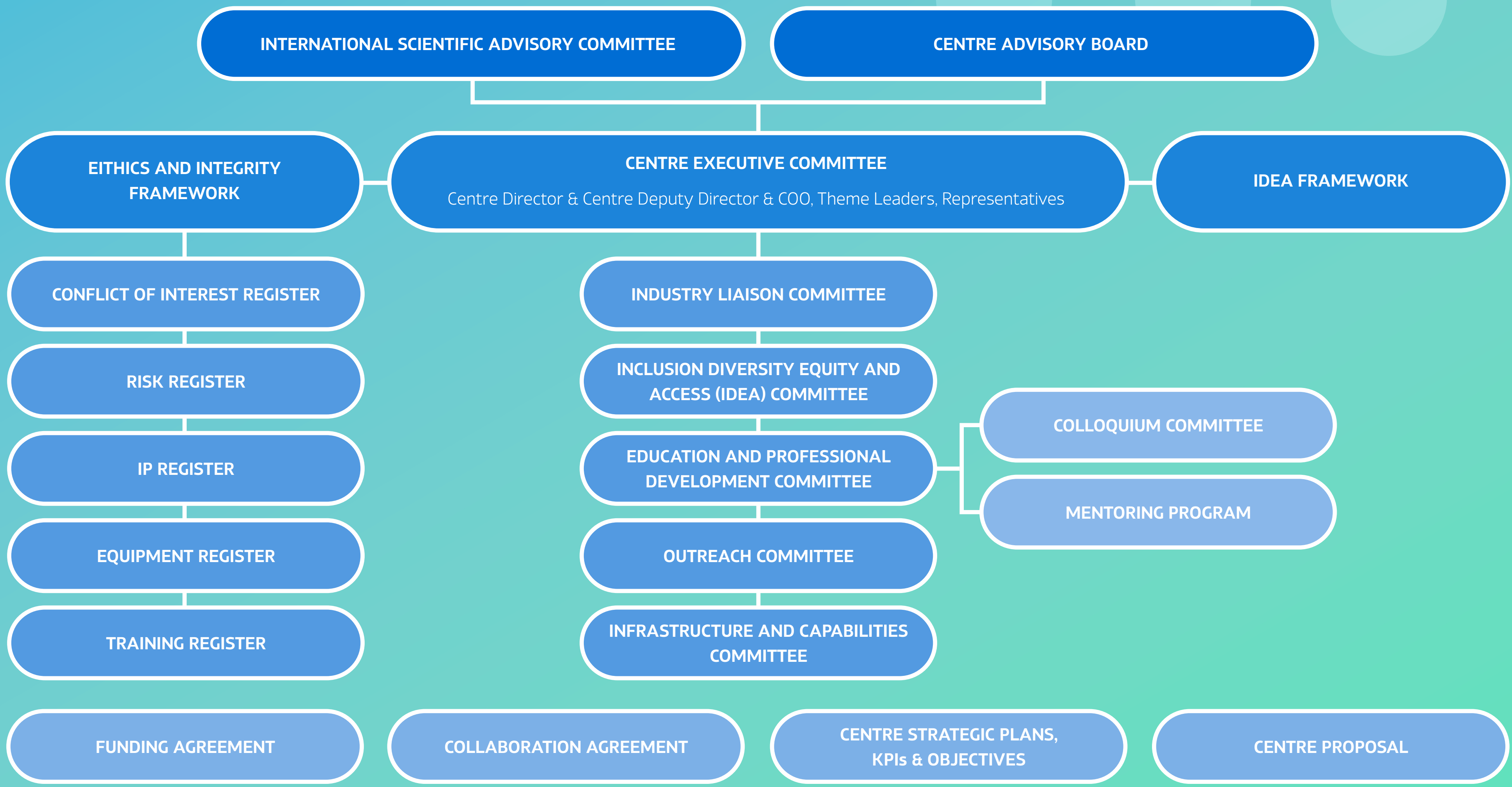
This was my final year as Chief Operations Officer at TMOS. It has been a privilege to serve in this role and to work alongside such a talented and committed group of people.

I am deeply grateful for the collaboration, generosity, and shared sense of purpose that defines this Centre. TMOS is well positioned for continued success, and I will be watching its next chapter unfold with great pride and admiration.

Thank you for the opportunity to contribute to this extraordinary community.

Sharyn McFarlane
Chief Operations Officer

Governance: Structure



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AC FAA

Australian Chief Scientist (former)
(Chair)

DR. GREG J CLARK AC

IBM Australia (former Director)

DR. SIMON POOLE
AO FAA FTSE

Finisar Australia (Director of New Business Opportunties)

MANI THIRU

DeepTech Ventures

International Scientific Advisory Committee

COMMITTEE MEMBERS:

PROFESSOR FEDERICO CAPASSO

Harvard University

(Chair)

PROFESSOR MARK BRONGERSMA

Stanford University

PROFESSOR ALEXANDRA BOLTASSEVA

Purdue University

Australian Research Council Mid-Term Review: Summary of Actions and Strategic Priorities

In 2024, the ARC Centre of Excellence for Transformative Meta-Optical Systems (TMOS) underwent a comprehensive Mid-Term Review (MTR) by the Australian Research Council, assessing progress since its establishment in 2020. The ARC assessed TMOS on 17 criteria. Of these, 11 were assessed as "Exceeds expectations", 5 were "Meets expectations," and 1 was rated "Requires improvement."

> TMOS is entering a dynamic new phase, with renewed focus on translational impact, international engagement, researcher development, and sustainable excellence.

The Review Panel commended TMOS for its performance, highlighting the Centre's strong research outputs, translation achievements, collaborative culture, and commitment to equity, diversity, and inclusion.

KEY FEEDBACK AND CENTRE ACTIONS

The MTR identified several strategic opportunities to amplify TMOS's impact in its second phase over six required actions and nine recommendations. TMOS has embraced this feedback and is implementing the following high-level actions:

- **International Engagement & Industry Collaboration:** TMOS will deepen its industry partnerships, particularly in the United States and Asia-Pacific, with new efforts including an international research-industry event in Silicon Valley (proposed 2026) and strengthened connections via our existing advisory boards.
- **Strategic Planning:** A Centre-wide strategic review will be undertaken in 2025 to shape a flexible, post-2024 action plan. This will ensure TMOS is well-positioned for sustainability and future opportunities.
- **Enhanced Training & Industry Exposure for ECRs/HDRs:** TMOS will expand wherever possible access to entrepreneurial training, industry placements, and practical experiences for early-career researchers and students, including a Centre-wide industry showcase event (2026).
- **Equity, Diversity & Inclusion (EDI):** Building on strong EDI foundations, TMOS will implement initiatives to better support culturally and linguistically diverse communities, including data-driven programs, a diversity map, and new partnerships with STEM equity organisations.
- **Governance Improvements:** TMOS will increase the frequency of Advisory Board meetings and expand board expertise to better align research strategy with emerging opportunities.
- **Basic Science & Emerging Themes:** TMOS remains deeply committed to fundamental research. It is launching new programs in quantum materials and photonic AI, while also leading cutting-edge work in biosensing and reconfigurable meta-optical systems.

LOOKING AHEAD

TMOS is entering a dynamic new phase, with renewed focus on translational impact, international engagement, researcher development, and sustainable excellence. The Centre thanks the ARC and Review Panel for their guidance and is confident the planned actions will strengthen its long-term legacy and contributions to science, industry, and society.

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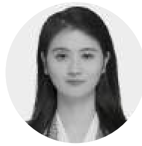
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INTERVIEW

TMOS Member of the Year: Lukas Wesemann

The TMOS Member of the Year Award recognises individuals who have made substantial contributions to the Centre, with a particular focus on teamwork and support for others. All Centre members—including researchers and the professional team – are eligible for this award.

“I got to collaborate with brilliant researchers across all nodes, and I didn’t just work with them – I made friends."

In 2024, Lukas Wesemann was honoured with the TMOS Member of the Year Award.

Lukas has consistently exemplified the values of teamwork and inclusivity. He actively fosters a collaborative environment, encourages cross-node cooperation, and is always ready to support his peers. His dedication to building connections, mentoring others, and promoting continuous learning has made a lasting impact on the culture of TMOS.

“What I’ve loved most about TMOS is the chance to bring ideas to life across research groups and disciplines. There have been too many great examples to list, but two really stand out.”

“The first was launching the TMOS Flagship Program. Working with the Centre Directorate and Industry Liaison Committee, we helped shape some of TMOS’s highest-impact projects. One highlight was developing our metasurface-enabled MWIR sensors for military applications and bushfire detection – from the first pitch by Dragomir and Lorenzo at the TMOS conference to building our first prototype. I got to collaborate with brilliant researchers across all nodes, and I didn’t just work with them – I made friends.”

“The second highlight was kicking off the ‘Bright Minds: Metaoptics meets AI’ colloquium series. The idea came out of a dinner chat with Dragomir at ANU about how AI and photonics could reshape each other. We clearly struck a chord – the series attracted top speakers working at the cutting edge of meta-optics and AI. It was a glimpse into the future of both fields, and it could only happen in a place with TMOS’s collaborative culture.”

“I’ve learned so much from the incredible people I’ve had the chance to work with at TMOS, and I hope that sharing my own experiences has been valuable to others in the Centre.”

Congratulations, Lukas – and thank you for your outstanding contributions to the TMOS community!

INTERVIEW

2024 Student of the Year: Maryam Setareh

Can you summarise in a couple of sentences what you were working on in 2024?

I was working on a special type of structured beam known as solenoid beams, which can show interesting behaviours, such as applying a pulling force. In 2024, my main focus was on finding ways to observe this pulling force experimentally and studying the different parameters that impact its strength and direction.

What were the highlights of 2024 for you?

The main highlight of 2024 was winning the TMOS Student of the Year award, which was very exciting for me. Also, it was nice that different news outlets covered our work.

How has TMOS and your supervisors helped you manage growth and change in your research direction?

It has been a great experience being part of TMOS. TMOS conferences provided a valuable opportunity to meet professionals in the field of optics, including experts from outside Australia, and learn from them. Most of what I have gained in my PhD comes from my supervisor (Prof. Ken Crozier) through his guidance and support. Whether in our weekly meetings or whenever I needed help, he has always been kind and supportive.

You got quite a lot of attention on your research – it went viral! What has that experience been like?

It was a great feeling when different websites covered our work. But I think people are more interested in the science fiction aspect of this work rather than its actual nature. So, it puts more pressure on me to demonstrate the pulling force in the experiment, which I find challenging.

Influencers have since interpreted your work on their own platforms. What has been your impression of their videos?

I was impressed by the animation they created. It was a nice way to present the work, making it easier for viewers to understand the concept in a simple and engaging manner. I also hope that the discussion around the potential application in biopsy, whether in the YouTube video or through the outlets, clearly conveys that this is still a "potential" application, meaning it's not something expected in the near future.

Has your research evolved since you first started your PhD? What factors influenced that?

I believe so. Coming from an electrical engineering background, I had no experience working in an optics lab. While there is still a lot to learn, I think I have improved significantly. Many factors have helped, the main one is working in a group with more experienced colleagues who could guide me and having a supportive and knowledgeable supervisor.

MARYAM SETAREH

PhD Student

University of Melbourne

INTERVIEW

2024 Student of the Year: Fedor Kovalev

Can you summarise in a couple of sentences what you were working on in 2024?

My research focused on dynamic metasurfaces, where meta-atoms are modulated, tuned, or moved, unlike in their static precursors. I published two articles, conducted extensive electromagnetic modeling for my new research projects, and prepared two more papers. I also prepared for experiments on amplified up-conversion of electromagnetic waves with parametric metasurfaces. Additionally, we finalised a collaborative article with UWA, which will be published soon.

What were the highlights of 2024 for you?

As co-president of our ANU Optica and SPIE student chapter, I organised several exciting events, including an Optica Traveling Lecturer's visit to ANU. I also participated in outreach for the first time. I also received two research travel awards and the 2024 SPIE Optics and Photonics Scholarship.

You are very active on TMOS committees. What benefits does that bring to you both professionally and personally?

I really enjoy being a member of the outreach committee. While I already teach as a tutor for Advanced Electromagnetism course at ANU, engaging with school students through science demonstrations is especially interesting – their enthusiasm is very inspiring! I wanted to be more involved in preparing presentations and demonstration kits, which led me to join the outreach committee.

Has your research evolved since you first started your PhD? What factors influenced that?

My previous work focused on developing metamaterials operating in the microwave and terahertz ranges, but through collaborations with experts from the TMOS node at UWA and Dr. Jiawen Li from the University of Adelaide, I expanded my research into the infrared and optical ranges. Collaborative work has been essential in broadening my expertise and advancing my research.

How has TMOS and your supervisors helped you manage growth and change in your research direction?

My supervisors provide valuable guidance in addressing complex research challenges, and their support is essential to my progress. TMOS provides essential funding for my PhD research and organises key events like conferences, which foster networking and knowledge exchange. These opportunities, along with co-organising outreach activities, have helped me develop important skills.

Where do you think you'll be in 5 years?

I plan to continue teaching, advancing my scientific career, expanding collaborations, and conducting research in academia. I really hope for peaceful and stable conditions in my homeland, allowing me to contribute to the development of science in Russia in the future.

FEDOR KOVALEV

PhD Student

Australian National University

Fedor is a PhD student at the Australian National University. His research interests include tunable metasurfaces and parametric metadevices for microwave, terahertz and infrared communication, remote sensing, and imaging. As an engineer, Fedor Kovalev has developed microwave devices such as filters, diplexers, splitters, and couplers.

INTERVIEW

EMCR (Early and Mid-Career Researcher) of the Year Award: Dr Yana Izdebskaya, Australian National University

Can you summarise in a couple of sentences what you were working on in 2024?

In 2024, my research focused on developing tunable metasurfaces for photonic applications. One of the key achievements was a successful cross-node collaboration between RMIT and ANU on the tunability of Sb_2Se_3 phase-change materials for multi-domain optoelectronics. At ANU, we also demonstrated full control over the orientation and periodicity of laser-induced surface structures on metals and published an overview on tunable metasurface devices based on soft matter in collaboration with TMOS Associate Investigator Dr Sarah Walden.

What non-research TMOS activities have you been involved in and what benefit have you seen from that?

At TMOS, I also serve as the Research Program Manager for Theme 2 “Manipulate” by facilitating collaborations and tracking the project's progress to support the centre’s research goals. It’s been exciting to see the theme grow with so many new interesting projects. This role has helped me develop my project management skills while also expanding my research experience and knowledge by learning from diverse projects.

Has your research evolved since you first started your PhD? What factors influenced that?

Yes, my research has evolved significantly since my PhD. I initially focused on singular optics, studying the dynamics and properties of optical vortices. Later, I moved into nonlinear optics, particularly the dynamics of optical waveguides in liquid crystals. Now, my research is focused on tunable metasurfaces for photonic applications. This shift happened gradually, influenced by technological advancements and the growing demand for dynamic light control in nanophotonics.

How has TMOS and your supervisors helped you manage growth and change in your research direction?

TMOS and my supervisor have provided essential support in managing the growth and evolution of my research. They foster a collaborative environment and provide access to advanced facilities, encouraging the exploration of new directions. Additionally, seminars and colloquiums with experts have broadened my perspective, refining my focus and inspiring new directions in tunable metasurfaces.

What is it about being at the forefront of science that excites you?

The most exciting part is pushing the boundaries of what is possible, turning ideas and theoretical concepts into real experimental results. I am particularly inspired by the challenge of finding new ways to manipulate light at the nanoscale using various external stimuli and materials for photonic technologies.

DR. YANA IZDEBSKAYA

Postdoctoral Researcher

Australian National University

Dr Izdebskaya’s current research focuses on the development of dynamically tunable dielectric metasurfaces using liquid crystals for reconfigurable devices that enable efficient light modulation for various applications. Dr Izdebskaya holds a PhD degree in Optics and Laser Physics from Taurida National University in Ukraine.

Research

Message from the Deputy Director

At TMOS, we aim to advance the next generation of miniaturised optical systems and to develop future research leaders. Achieving this requires collaboration. This is because the approaches being developed in TMOS for miniaturised optical systems require expertise from many different fields. Collaboration is also key to nurturing the next generation of leaders. It's not hard to find evidence that the concerted push of the last few years to enhance collaboration is bearing fruit. Let me spend the remainder of this message showcasing some examples.

TMOS members collaborated in the leadership of several events in 2024. One such event was the TMOS ECR and Student Conference that was held at RMIT on 24-26 July 2024. I had the honour of being asked to give the Closing Address. I was delighted to see that meeting attendees were still full of energy and enthusiasm on the last day of the conference. The program included not only scientific presentations but also opportunities to interact with industry and social activities. TMOS PhD students also played leadership roles in the organisation of the 15th KOALA Student Conference on Optics, Atoms, and Laser Applications. This was held at the University of Melbourne in November 2024. TMOS was a sponsor. Approximately one hundred students attended, which was the largest in the history of the conference series.

One does not need to look hard in the literature for evidence of successful TMOS research collaborations in 2024. Two examples are as follows.

First, the United Nations has designated 2025 as the International Year of Quantum Science and Technology. High-quality quantum light sources are essential for the development of practical and reliable quantum technologies. A major challenge, however, is the absence of scalable, deterministic single-photon sources that can be reproducibly produced. An ANU-UTS collaboration reported on important progress on this front in 2024 (Huang et al, ACS Nano 18, 5581 (2024)). They combined droplet epitaxy with selective area epitaxy to achieve the controlled growth of single quantum dots in nanowire arrays. Interestingly, the nanowires acted as waveguides, i.e. they were akin to optical fibres, leading to enhanced light emission (Purcell enhancement). The team furthermore showed that their single photon sources were very bright, with millions of counts per second with nanowatt excitation power, a short radiative lifetime, and excellent single-photon purity. Importantly, the technology could be used for single photon sources that are on-chip and scalable, so it could be used in future quantum applications such as quantum networks.

Second, a common theme in modern imaging research is how to reduce power consumption. It has been realised that optical metasurfaces present opportunities in this regard because they can be used for analogue image processing. One of the long-standing drawbacks has been the fact that almost all metasurfaces developed for image processing have been static, i.e. with fixed properties. A collaboration between the City University of New York (group of PI Andrea Alu), the University of Melbourne (group of CI Roberts) and RMIT (group of CI Bhaskaran) has addressed this issue. They produced a metasurface that operates in the near-infrared and performs edge detection. Its response could be tuned merely by changing its temperature. Dramatic changes were observed even for modest changes (temperature variations smaller than 10°C around an operating temperature of 65°C). The metasurface made use of the insulator-to-metal phase transition of vanadium dioxide. The work was published in the journal Nature Communications (15:4483 (2024)).

In closing, let me convey as Deputy Director my best wishes to all readers for their endeavours in 2025.

Professor Kenneth Crozier
Centre Deputy Director

Research Overview

Our research excellence in meta-optics enables us to overcome complex scientific and engineering challenges in light generation, manipulation, and detection at the nanoscale. We lead internationally esteemed innovations, inspiring others, and creating positive impacts on society.

Our research outcomes underpin future technologies, including real-time holographic displays, artificial vision for autonomous systems to see the invisible, wearable medical devices and ultra-fast light-based Wi-Fi, meeting the evolving demands of Industry 4.0. The Centre has a visible impact on technology beyond the seven-year timeframe of its research program.

Our Centre has three Research Themes and our goals for each are to:

GENERATE

Prepare for next-generation optical systems by developing miniaturised, energy-efficient laser-light nano-emitters.

MANIPULATE

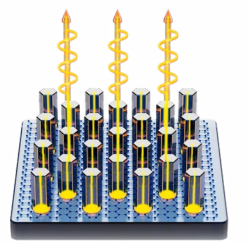
Cater for the exponential growth of image-processing data and emerging exascale problems by developing photonic problem-specific processors.

DETECT

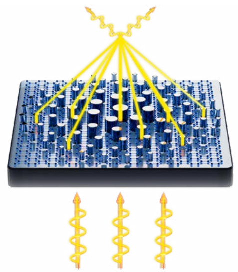
Realise access to currently unavailable optical information by integrating metasurfaces into photodetectors to expand their functionality.

In addition, our research program will provide the Centre with capabilities and infrastructure that supports and expedites research.

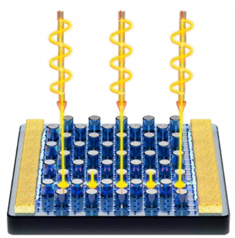
Find out more about our themes on our website



GENERATE



MANIPULATE



DETECT

Flagship Program – Meta Health Sensors

Our Flagship project on Meta-Health focuses on developing miniaturised optical technologies for wearable and portable applications. Using specific wavelengths of light offers enhanced sensitivity and selectivity for key molecules of choice. Capitalising on TMOS technologies, this application-focused project aims to deliver outcomes at higher technology levels, particularly focused for industry translation and with a key target market of healthcare.

The current project within this program is an innovative optical glucose sensor that offers real-time operation, glucose-specific reading capabilities, and high accuracy.

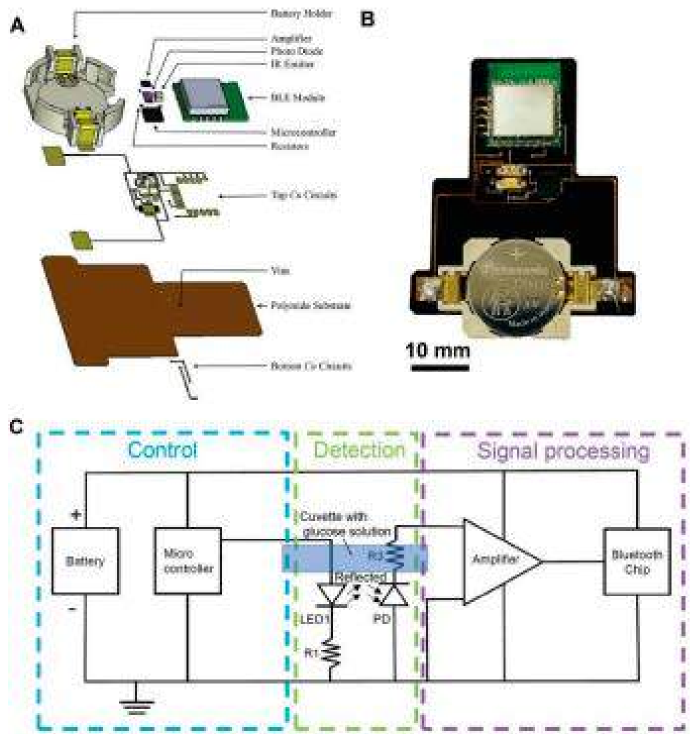
Dr Mingjie Yang leads this project at the RMIT TMOS node, with the support of CIs Prof. Madhu Bhaskaran and Prof. Sharath Sriram. The performance of the device is rigorously evaluated using aqueous glucose solutions that simulate biological environments, demonstrating glucose detection in a physiological range (50–400 mg dL^{-1}) and a remarkably low limit of detection (LOD) of 10 mg dL^{-1}.

With a TRL >4 and increasing industry interest, this project has been promising in its commercial viability. A paper has been published titled, 'Miniaturized Optical Glucose Sensor Using 1600–1700 nm Near-Infrared Light' in Advanced Sensor Research, and a non-provisional patent has been filed following a provisional patent filed earlier.

Peter Elango
Flagship Program Research Manager

ACTION ITEMS FOR 2025

1. Refining current version using additional LEDs with supplemental wavelength
2. Optimisation of the electronics using an improved electronics arrangement
3. Exploring integration of miniaturised band pass filters using TMOS technologies for enhanced performance



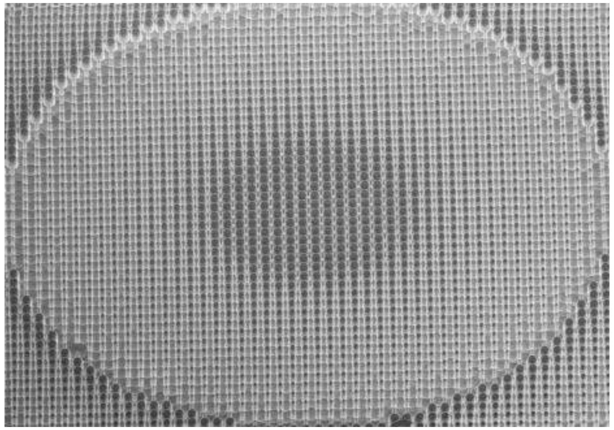
Prototype of the developed optical glucose sensor

Flagship Program – Enhanced Infrared Vision

The Enhanced Infrared Vision theme within the TMOS Translational Flagship Program is driving the development of next-generation mid-wave infrared (MWIR) sensors with capabilities beyond existing technology.

The project is led by CI's Prof. Neshev, Prof. Tan and Prof. Faraone as well as flagship program manager Dr. Lukas Wesemann. Our primary focus is on creating a high-operating temperature (HOT) MWIR detector, leveraging meta-optical technology to overcome the limitations of current HgCdTe (MCT) focal plane arrays, which require cryogenic cooling for effective performance. This innovation is critical for defence applications, such as missile launch detection and infrared search and track (IRST) systems, where reducing thermal noise, pixel crosstalk, and cooling requirements can significantly enhance operational efficiency, especially for smaller aerial and ground-based platforms. By integrating metalens arrays directly onto MCT detectors, our approach aims to improve detector performance while enabling a more compact and practical solution for real-world deployment.

Significant progress has been made in advancing this technology. The conceptualisation and design phase has been completed, with numerical simulations finalised for the metalens system. A first prototype has been fabricated and is currently in the testing phase, marking a major step toward demonstrating the feasibility of this approach. In parallel, efforts to secure external funding and industry engagement have been a priority. A White Paper entitled 'High temperature MWIR focal plane using pixel metalens and small-area junctions', co-authored with Prof. Ron Driggers team from the University of Arizona, has been submitted to international funding agencies, aiming to attract further investment into this research. The project was presented at the "U.S. Workshop on the Physics and Chemistry of II-VI and Infrared Materials" in San Antonio, Texas, increasing awareness within the defence industry and fostering new connections with potential stakeholders. Discussions with industry partners in the defence and space sectors are now underway to explore R&D collaborations that can accelerate the pathway to real-world implementation. Looking ahead, the program is preparing for major grant applications alongside R&D partners in 2025, ensuring continued funding for the project's next phase.



Prototype of GaAs Metalens enabling high operating temperature (HOT) mid-wave infrared detector

Beyond the HOT MWIR detector, this flagship theme is expanding with additional high-impact projects. One emerging initiative, led by Prof. Kenneth Crozier at the University of Melbourne, focuses on metasurface-enabled microspectrometers for drone-based bushfire detection, while another, led by Prof. Dragomir Neshev in collaboration with L3 Harris, explores infrared imaging with nonlinear metasurfaces.

Lukas Wesemann
Flagship Program Research Manager

ACTION ITEMS FOR 2025

1. Finalisation of first prototype of high-operating temperature (HOT) MWIR detector
2. Establish first R&D collaboration with an industry partner
3. Design of application with direct market appeal based on HOT MWIR detector technology
4. Grant application for major joint industry / academia funding

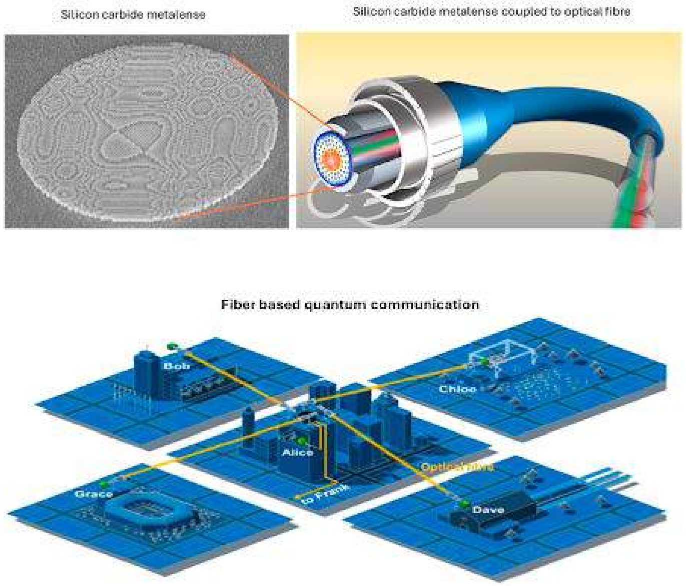
Flagship Program – Advanced Quantum Technologies

The Quantum Flagship Program focuses on the integration of meta-optical systems with quantum technologies. The research aims to develop multifunctional and dynamic meta-optical platforms for the generation and manipulation of quantum light sources. These technologies have broad applications, ranging from quantum information processing to quantum sensing and navigation.

The program is based on national research priorities, contributing to the advancement of quantum technologies in Australia, as outlined in the National Quantum Strategy and the Defence Innovation, Science and Technology priorities. TMOS has already demonstrated significant capabilities in free-space quantum communication, including successful building-to-building demonstrations. The current emphasis has shifted toward fibre-based secure quantum communication, where meta-optical systems play a critical role in generating ideal qubits compatible with fibre networks.

The primary quantum system explored is point defects in silicon carbide that emit in the near-infrared range. This work is conducted in collaboration with TMOS nodes at ANU and UTS. At ANU, efforts focus on defect engineering and metasurface design, while at UTS, the emphasis is on nanofabrication and quantum communication measurements.

Mehran Kianinia
Flagship Program Research Manager



Fiber-based quantum communication is enabled by metasurface structures that efficiently couple qubits into optical fibres, facilitating secure links between multiple buildings (or locations).

ACTION ITEMS FOR 2025

1. Improve the nanofabrication of SiC (aspect ratio 1:10) and set up measurement of single photons in IR
2. Design metalenses and multifunctional metasurfaces for the IR wavelength
3. Demonstration of QKD protocol with a single photon emitter coupled with a metalens in SiC.
4. Fabrication of Nanobeam cavities in SiC for high collection efficiency of single photons in IR

THEME ONE
Generate

Light emitting diodes (LEDs) and semiconductor lasers are pervasive in our daily lives in applications such as high efficiency low-power lighting, traffic lights, displays, Playstations®, Xboxes® and optical fibre links for the internet. As good and efficient as these devices are now, it is expected that the next-generation optical systems would be integrated onto micro/nano-electronic platforms with added functionalities. As such, miniaturised, highly compact and energy-efficient light sources are needed. To obtain added functionalities, the properties of the emitted beams must also be easily manipulated in terms of colour (frequency), coherence, polarisation, directions and spatial profile.

THEME LEADERS:

PROFESSOR IGOR AHARONOVICH
University of Technology Sydney

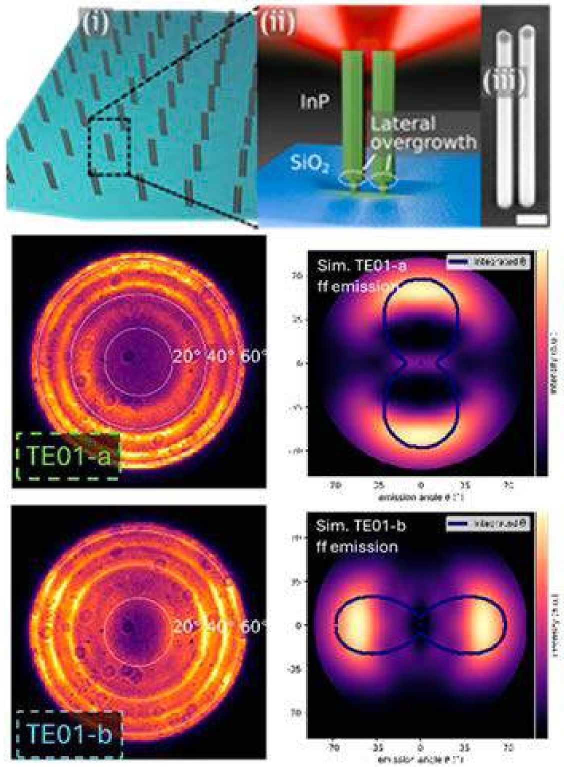
PROFESSOR HOE TAN
The Australian National University

Theme 1, we not only continue to develop novel miniaturised meta-optical light emitters but in 2024, we also focus on expanding our collaborative effort across nodes, groups, partner/associate investigators and other collaborators.

The shape engineered nanostructures pioneered at ANU are further developed into arrays of nanosheet pairs to create surface emitting lasers. An asymmetry is incorporated into the nanosheet pairs to break the symmetry, which then allows the laser to operate at room temperature in the quasi-bound states in continuum with high-quality factor. Optimisation of the asymmetry of the nanosheet pairs enables us to operate the device near thresholdless lasing.

We also use our semiconductor nanowire lasers to couple the emission from several nanowires to control their emission directionality and shape their beam profile. This is further extended to large arrays to create photonic crystal surface emitting lasers, including a novel design that incorporates a hetero-lattice architecture, where an outer array is used for enhanced light confinement.

Work on electrically injected nanoscale lasers is continuing with our endeavour in microring lasers and top-down based bound states in



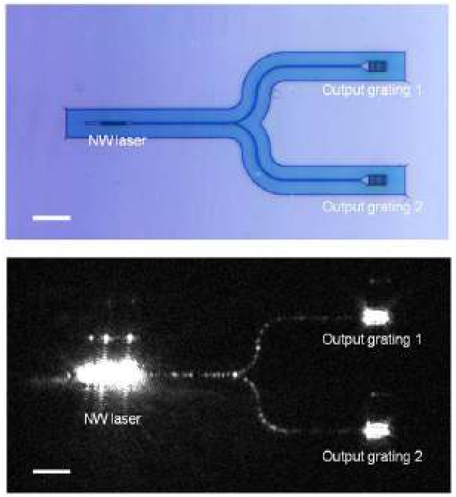
Coupled nanowires

continuum lasers. Fabrication challenges need to be addressed, particularly the optical loss created by doped regions and contact layers. LED operation has been observed and with further optimisation, we are confident lasing can be achieved.

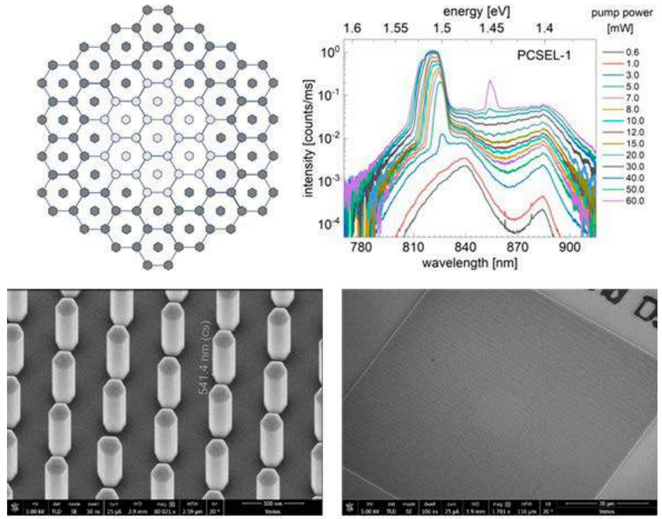
Another collaboration involves integrating a semiconductor nanowire laser in a silicon nitride waveguide to silicon nitride waveguides and beam splitters for photonic integrated circuit applications.

The strong collaboration between the ANU and UTS teams have successful led to the demonstration of single quantum dots in incorporated into nanowire arrays which have excellent single photon emission properties. The UTS group continues to lead in hBN technology for quantum emitter applications and joint effort with RMIT and collaborators in Cambridge has led to identifying spin defects in hBN which can be used to realize a room-temperature spin qubit coupled to a multiqubit quantum register or quantum sensor with nanoscale sample proximity.

In the area of nonlinear metasurfaces for light generation, the ANU team, together with collaborators from Melbourne and Jena, have successfully demonstrated infrared quantum imaging and up-conversion of infrared light to visible light with an ultra-compact metasurface chip, respectively. These developments provide the bridge to low light imaging, LIDAR applications, and miniaturised night vision googles.



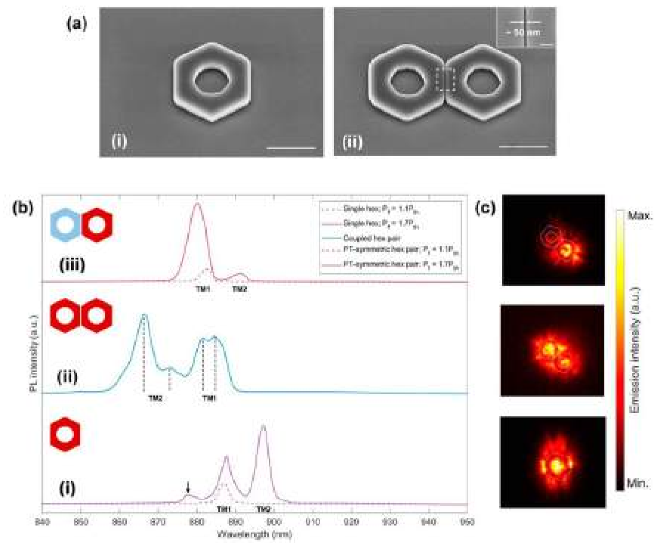
Nanowire-beam splitter



Hetero-pcsel

ACTION ITEMS FOR 2025

1. Electrically injected metasurface and nanoscale lasers
2. Wide bandgap metasurface emitters
3. Metasurface mid-IR lasers
4. Enhance the nonlinear emission from 2D materials and heterostructures
5. Coupling quantum dot single photon emitters into micro-ring resonators
6. Biphoton polarization entanglement from an InGaP nonlinear metasurface



PT symmetry ring lasers

GENERATE

Subprograms

This theme supports two sub-programs aimed and developing new meta-optical light emitters.

1A. NANOSCALE LASERS AND LASER ARRAYS

Theme 1A aims to create nanolasers and miniaturised light emitters that enable tailorable emission and wavefront, both of which can be utilised in light manipulation and detection applications. In addition, electrical pumping of nanolasers is investigated for easier integration into practical devices.

With these goals in mind, research in 2024 focused on metamaterial lasers and electrical injection schemes. In metamaterials, TMOS researchers demonstrated the first bottom-up fabricated metasurface laser based on bound states in continuum. The bottom-up fabrication resulted in excellent surface quality of the nanoresonators, enabling low threshold and near-unity spontaneous emission factor. Metasurface lasers such as these are excellent building blocks for tailored emission and wavefront engineering.

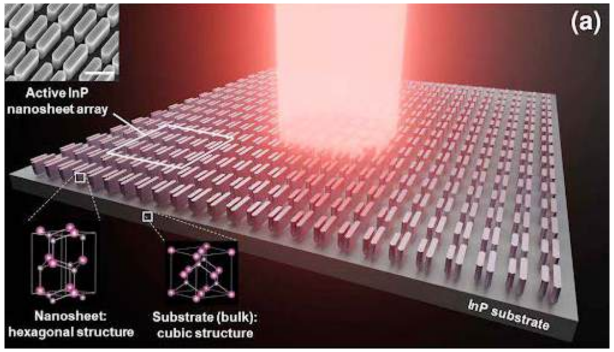


Illustration of a surface-emitting InP nanosheet metasurface laser

In other studies, semiconductor nanowires were used to create photonic crystal lasers with hetero-lattices, where a surface-emitting region was surrounded by a mirror-like photonic crystal for enhanced light confinement. This structure enabled a significant reduction in lasing threshold power as well as the use of extremely small surface-emitting regions. In electrical injection, electroluminescence was achieved from microrings with multiple quantum wells. With minor further adjustments under research this year, these structures are expected to act as miniaturized electrical lasers.

Overall, year 2024 was productive for Theme 1A, with many exciting demonstrations achieved towards the goals and overarching visions of the theme.

Tuomas Haggren, Subprogram 1A Research Program Manager

PUBLICATION HIGHLIGHTS

1. *Reversible carrier modulation in InP nanolasers by ionic liquid gating with low energy consumption,* C.H. Wu, C.W. Chen, H.J. Shen, H.Y. Chuang, H.H. Tan, C. Jagadish, T.C. Lu, S. Ishii and K.P. Chen, Advanced Science 2412340 (2024). https://doi.org/10.1002/advs.202412340
2. *Data-driven discovery for robust optimization of semiconductor nanowire lasers*, S.A. Church, F. Vitale, A. Gopakumar, N. Gagrani, Y.Y. Zhang, N. Jiang, H.H. Tan, C. Jagadish, H.Y. Liu, H.J. Joyce, C. Ronning and P. Parkinson, Laser and Photonics Reviews 2401194 (2024). https://doi.org/10.1002/lpor.202401194
3. *Telecom-band multiwavelength vertical emitting quantum well nanowire laser arrays,* X.T. Zhang, F.L. Zhang, R.X. Yi, N.Y. Wang, Z.C. Su, M.W. Zhang, B.J. Zhao, Z.Y. Li, J.T. Qu, J.M. Cairney, Y.R. Lu, J.L. Zhao, X.T. Gan, H.H. Tan, C. Jagadish and L. Fu, Light – Science and Applications 13, 230 (2024). https://doi.org/10.1038/s41377-024-01570-7
4. *Mode management in bottom-up, parity-time-symmetric micro-cavity lasers,* W.W. Wong, J.H. Zhang, G. Garg, C. Jagadish and H.H. Tan, Laser and Photonics Reviews 18, 2400222 (2024). https://doi.org/10.1002/lpor.202400222
5. *Integrating a semiconductor nanowire laser in a silicon nitride waveguide,* R.X. Yi, X.T. Zhang, X.M. Yuan, J.G. Wang, Q. Zhang, Y. Zhang, L. Fang, F.L. Zhang, L. Fu, H.H. Tan, C. Jagadish, J.L. Zhao and X.T. Gan, ACS Photonics 11, pp. 2471-2479 (2024). https://doi.org/10.1021/acsphotonics.4c00393

ACTION ITEMS FOR 2025

1. Bottom-up fabricated nanolaser arrays for tailorable emission
2. Development of electrical UV nano-emitters
3. Perovskite-based metasurface light-emitters

1B. ADVANCED AND QUANTUM LIGHT SOURCES

2024 has been a landmark year for cross-node collaboration in theme 1B.

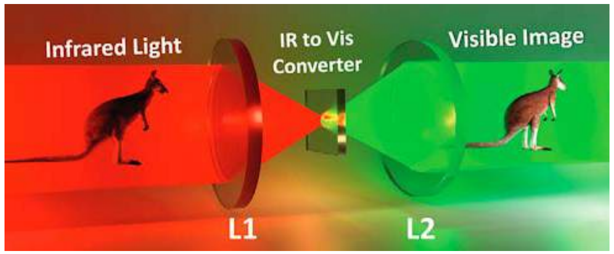
A collaboration between UTS and ANU successfully grew singleInsp quantum dots in selectively grown InP nanowire arrays using the droplet epitaxy technique. These quantum dots exhibit exceptional optical performance of single-photon emission, with high brightness and purity at low excitation powers.

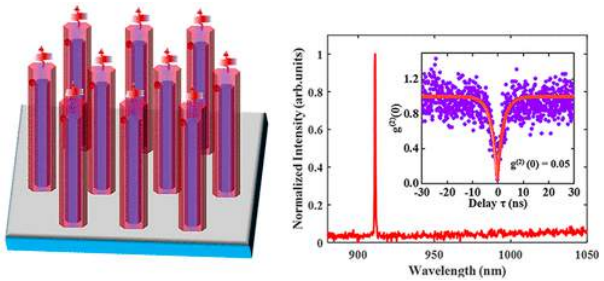
UTS and RMIT explored VB- spin defects in boron nitride nanotubes (BNNTs). Unlike hBN flakes, these spin defects align directionally with external magnetic fields, consistent with the tubular BNNT geometry.

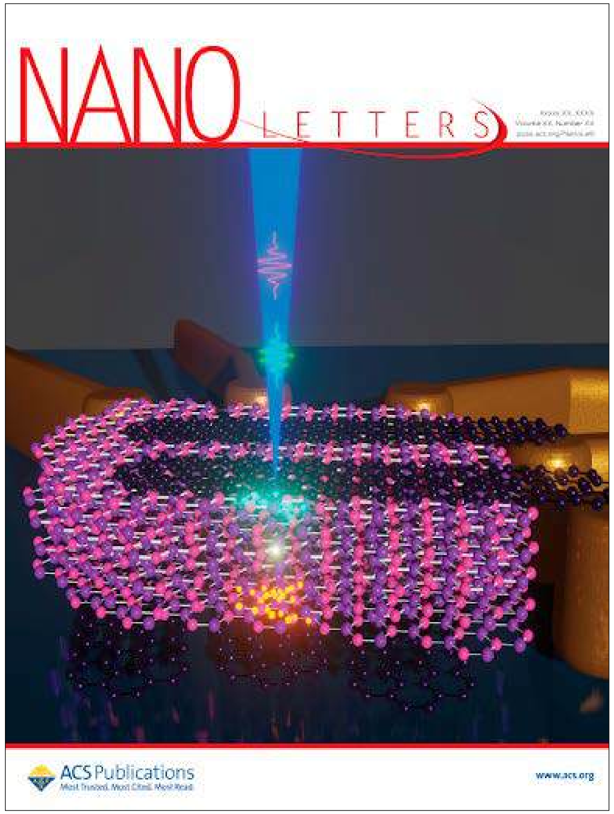
ANU and the University of Melbourne demonstrated the benefits of nonlinear metasurfaces for infrared quantum imaging, developing an efficient protocol that integrates ghost imaging with all-optical scanning techniques.

The UTS and ANU teams co-authored a review on advances in flat optics for quantum light generation, covering entangled photon pair production in nonlinear metasurfaces and single-photon emission from quantum dots and color centers in 3D and 2D materials.

The ANU team achieved infrared imaging through nonlinear up-conversion to visible light using a compact, high-quality-factor lithium niobate resonant metasurface. This innovation





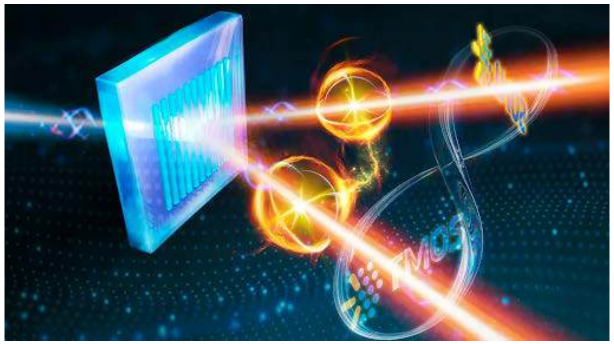


has potential applications in night vision, sensors, and multi-color imaging at room temperature. This work is in collaboration with Friedrich Schiller University Jena.

Jingyong Ma, Subprogram 1b Research Program Manager

KEY ACHIEVEMENTS 2024:

1. Experimental characterization of VB- spin defects in boron nitride nanotubes.
2. Experimental demonstration of single-photon emission from quantum dots coupled with nanowires with high brightness and purity.
3. First demonstration of quantum imaging using photon pairs generated from nonlinear metasurfaces.
4. Experimental demonstration of infrared imaging with high quality factor resonant metasurfaces.



ACTION ITEMS FOR 2025

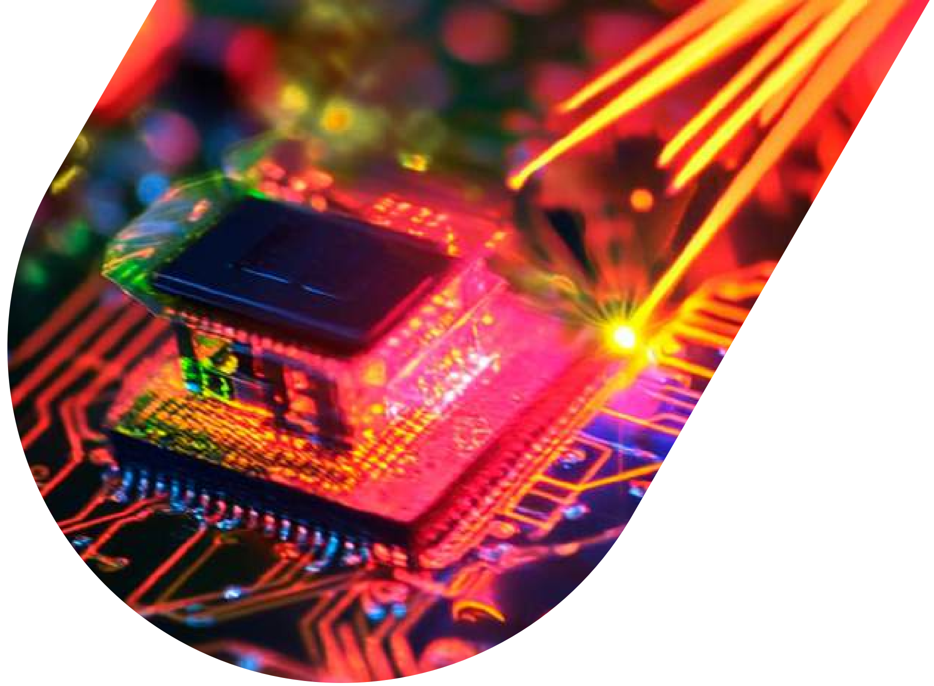
1. Nonlinear Frequency Conversion in Topology-Optimised Dielectric Metasurfaces
2. Couple QD emission into whispering-gallery mode of InP-micro-ring resonator
3. Electrically driven single photon source of quantum dots in single nanowire
4. Optically tunable generation of biphoton polarization entanglement from an InGaP nonlinear metasurface

PUBLICATIONS

1. L. Valencia Molina, R. Camacho Morales, J. Zhang, R. Schiek, I. Staude, A. A. Sukhorukov, and D. N. Neshev, Enhanced Infrared Vision by Nonlinear Up-Conversion in Nonlocal Metasurfaces, Advanced Materials 36, 2402777 (2024).
2. X. Huang, J. Horder, W. W. Wong, N. Wang, Y. Bian, K. Yamamura, I. Aharonovich, C. Jagadish, and H. H. Tan, Scalable Bright and Pure Single Photon Sources by Droplet Epitaxy on InP Nanowire Arrays, ACS Nano acsnano.3c11071 (2024).
3. K. Yamamura, N. Coste, H. Z. J. Zeng, M. Toth, M. Kianinia, and I. Aharonovich, Quantum efficiency of the B-center in hexagonal boron nitride, Nanophotonics (2024).
4. M. A. Weissflog, J. Ma, J. Zhang, T. Fan, S. Lung, T. Pertsch, D. N. Neshev, S. Saravi, F. Setzpfandt, and A. A. Sukhorukov, Directionally tunable co- and counterpropagating photon pairs from a nonlinear metasurface, Nanophotonics 13, 3563 (2024).
5. J. Ma, J. Zhang, J. Horder, A. A. Sukhorukov, M. Toth, D. N. Neshev, and I. Aharonovich, Engineering Quantum Light Sources with Flat Optics, Advanced Materials 36, 2313589 (2024).

GENERATE CASE STUDY

A New Advancement in Photonic Chips Set to Unlock an Industry



Researchers from TMOS, the ARC Centre of Excellence for Transformative Meta-Optical Systems, have developed a new engineering approach to on-chip light sources that could lead to widespread adoption of photonic chips in consumer electronics.

In research published today in Light: Science & Applications, the team from Australian National University and their collaborators at Northwestern Polytechnical University outline a method for growing high-quality multi-quantum well nanowires made from semi-conductor materials Indium Gallium Arsenide and Indium Phosphide.

Optical transmission of information outperforms electrical transmission in terms of speed and efficiency, which is why the photonic chip industry has boomed in the past decade. These chips, also known as photonics integrated circuits, can now be found in telecommunication devices, autonomous vehicles, biosensors, and consumer devices such as mobile phones.

A key shortfall of current photonic chips is the lack of an on-chip light source. Currently, these chips require an external light source, preventing the further miniaturization of the chips and the devices they enable.

Nanowire lasers are an excellent candidate for these light sources, but high-quality nanowires with smooth sidewalls, controlled dimensions, and precise crystal composition that operate at room temperature have been difficult to fabricate at scale.

TMOS researchers and their collaborators have developed an innovative multi-step facet engineering approach for nanowire growth using selective area epitaxy by metal-organic chemical vapour deposition technique.

Co-first author, TMOS PhD student Fanlu Zhang, says, "Through this new method

SPOTLIGHT

Professor Lan Fu

Chief Investigator

Lan Fu is currently a Professor and Head of the Department of the Electronic Materials Engineering at the Research School of Physics, the Australian National University (ANU). Professor Lan Fu's main research interests include design, fabrication and integration of optoelectronic devices (LEDs, lasers, photodetectors and solar cells) and chemical sensors based on low-dimensional III-V compound semiconductor structures including quantum wells, self-assembled quantum dots and nanowires grown by metal-organic chemical vapour deposition (MOCVD). She has published ~200 publications (including ~150 journal papers), 3 book chapters, co-edited 6 conference proceedings/journal special issue, and holds 2 US patents. Professor Lan Fu was the recipient of the IEEE Photonic Society Graduate Student Fellowship (2000) and Distinguished Lecturer Award (2021-2022), Australian Research Council (ARC) Postdoctoral Fellowship (2002), ARF/QEII Fellowship (2005) and Future Fellowship (2012).

of epitaxial growth, we can precisely control the diameter and length of quantum well nanowires with high crystal quality and uniform morphology. This makes it possible to design controllable nanowire optical cavities, enabling the regulation of spatial modes and longitudinal modes. Then, by modulating the composition and thickness of quantum wells in the nanowires, the lasing wavelength of the nanowires can be adjusted, achieving coverage of a wide spectral range in the near-infrared telecommunication band."

Co-first author Xutao Zhang says, "The technology we present is well-suited for large-scale epitaxial growth of uniform nanowire arrays. It will enable the batch construction of nanoscale laser light sources in the near-infrared telecommunication band. This approach has the potential to overcome the obstacles associated with traditional methods of fabricating on-chip integrated light sources through bonding or heterogeneous epitaxy, demonstrating a promising path for large-scale photonic integration."

TMOS Chief Investigator Lan Fu says, "This is significant progress towards on-chip light sources and the growth of the photonic chip industry. Importantly, it sets the scene for the mass manufacture of these devices. The next step for this research will be to design and fabricate electrical contacts to achieve electrical injected lasing."

For more information about this research, contact connect@tmos.org.au

Telecom-band Multi-wavelength Vertical Emitting Quantum Well Nanowire Laser Arrays

LIGHT: SCIENCE & APPLICATIONS, 4TH SEPTEMBER 2024

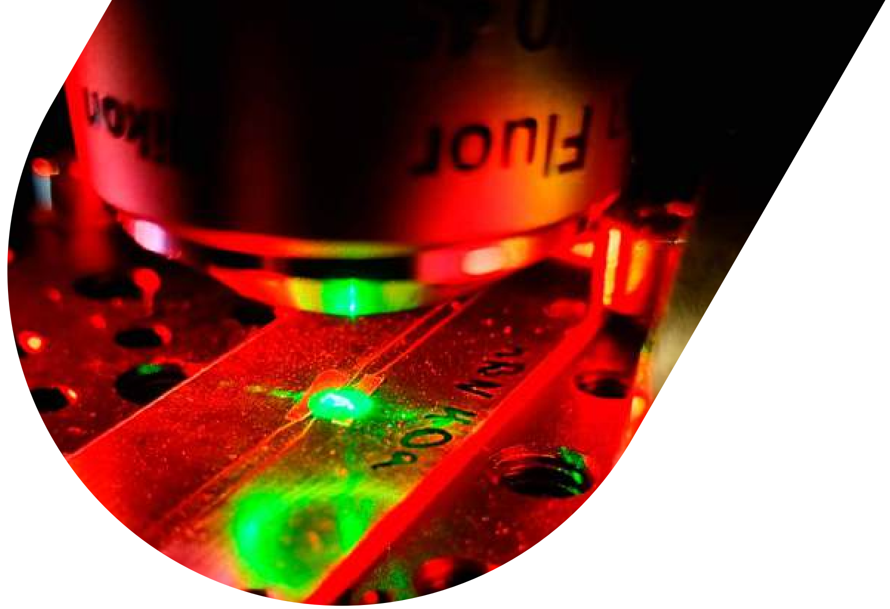
Xutao Zhang, Fanlu Zhang, Ruixuan Yi, Naiyin Wang, Zhicheng Su, Mingwen Zhang, Bijun Zhao, Ziyuan Li, Jiangtao Qu, Julie M. Cairney, Yuerui Lu, Jianlin Zhao, Xuetao Gan, Hark Hoe Tan, Chennupati Jagadish and Lan Fu

The demand for telecom-band and compact nanoscale lasers that seamlessly integrate into next-generation optoelectronic and photonic integrated systems is paramount. Here, we report on-substrate vertical emitting lasing emanating from InGaAs/InP multi-quantum well core-shell nanowires epitaxially grown on InP (111) A substrates by selective area epitaxy method. To achieve uniform nanowire morphology with controllable dimensions and high crystal quality, a facet engineering approach is employed, reducing optical losses and engineering of the cavity mode. Then, a vertical Fabry-Pérot (F-P) cavity is formed through the top nanowire facet, whilst the bottom facet is formed at the interface between the nanowire and SiO2 mask. Leveraging multiple InGaAs quantum wells, a potent quantum confinement effect and ample optical gain is attained to enable stimulated emission at low lasing thresholds, even at room temperature. By fine-tuning the In composition of the quantum wells, single-mode lasing is achieved in the vertical direction across a broad near-infrared spectral range, spanning from 940 nm to the telecommunication O and C bands with low thresholds and a high characteristic temperature. Our research underscores that the facet engineering strategy, which yields highly ordered, uniform nanowire arrays with precise dimension control, offers a promising avenue for simultaneously delivering thousands of nano lasers, paving scalable pathway towards future advanced photonic systems.

Read the full article

GENERATE CASE STUDY

Tiny Quantum Sensor to Make Big Impact



Researchers at TMOS, the ARC Centre of Excellence for Transformative Meta-Optical Systems, and their collaborators at RMIT University have developed a new 2D quantum sensing chip using hexagonal boron nitride (hBN) that can simultaneously detect temperature anomalies and magnetic field in any direction in a new, groundbreaking thin-film format. In a paper released in Nature Communication today, they detail a sensor that is significantly thinner than current quantum technology for magnetometry, paving the way for cheaper, more versatile quantum sensors.

To date, researchers have made quantum sensing chips from diamond because it is a very robust platform. The limitations of diamond-based sensors, though, is that they can only detect magnetic fields when aligned in the direction of the field. If unaligned, they have large blind spots. As a result, magnetometers made of diamond must contain multiple sensors at varying degrees of alignment. This increases the difficulty of operation and, as a result, the versatility to use in different applications. In addition, the rigid and three-dimensional nature of the quantum sensor means that its ability to get close to samples that aren't perfectly smooth is restricted.

TMOS Associate Investigator Jean-Philippe Tetienne (RMIT University) and Chief Investigator Igor Aharonovich (University of Technology Sydney) and their teams are pioneering a new quantum sensing platform using hBN. These hBN crystals comprise layers of atomically thick sheets and are flexible, which allows the sensing chips to conform to the shape of the sample being studied, getting far closer to the sample than diamond can.

SPOTLIGHT

Professor Igor Aharonovich

Chief Investigator

Igor Aharonovich received his B.Sc (2005) and M.Sc (2007) in Materials Eng from the Technion – Israel Institute of Technology under the supervision of Prof Yeshayahu Lifshitz. He then moved to Australia and pursued his PhD studies at the University of Melbourne under the supervision of Prof. Steven Prawer. During his PhD, Igor developed experimental techniques to engineer novel, ultra bright single photon emitters in diamond.

In 2011, Igor took a postdoctoral position at Harvard University at the group of Prof. Evelyn Hu. His research was focused on nanofabrication of optical cavities out of diamond, SiC and GaN. He also carried out nanophotonic experiments including coupling of emitters to optical cavities, turning of cavity resonances and low temperature high resolution spectroscopy.

In 2013 Igor joined the University of Technology Sydney, where he leads the quantum nanophotonics laboratory. His research is focused on exploring single defects in wide bandgap semiconductors for quantum technologies. Specifically, his team was the first to discover single emitters in hexagonal boron nitride and the first to isolate spin defects in this material. In 2018, together with Carlo Bradac, Igor co-founded http://www.writeitupnow.com – a scientific writing company that assists scientists in communicating their scientific results.

Igor received several international awards including the CN Yang Award – honors young researchers with prominent research achievements in physics in the Asia-Pacific region (2019), the Pawsey medal from the Australian Academy of Science (2017), David Syme Research Prize (For the best original research in biology, physics, chemistry or geology, produced in Australia during the preceding two years (2017), the IEEE Photonics Young Investigator Award (2016)

Different defects exist in the hBN that produce different optical phenomena. A recently discovered carbon-based defect, the atomic structure of which remains unidentified, detects magnetic fields in any direction but until now has not been used for magnetic imaging.

To determine the structure of the unidentified defect, the team ran a Rabi measurement experiment and compared the results with the well-understood boron vacancy defect that also exists in hBN. This boron vacancy defect can measure temperature at a quantum level. Through this comparison, they discovered the new defect behaves as a spin half system. This half spin nature of the carbon defect allows for the sensor to detect magnetic fields in any direction.

The team determined that this new carbon-based half spin sensor could be controlled through electrical excitation, in the same way that the boron vacancy sensor can, and that they could be tuned to interact with one another. Energised by these discoveries, they set out to demonstrate a hBN sensing chip that could use both spin defects simultaneously to measure magnetic field and temperature. Their paper shows the first magnetic images ever taken with this unidentified isotropic sensor.

Cofirst author, Sam Scholten from RMIT University says, "Optically addressable spin defects in solids form a vital toolkit in the realm of quantum materials because of their potential to be used as nanoscale quantum sensors and as robust room temperate quantum systems.

"What makes hBN unique and exciting is its 2D form, which allows our sensors to get much closer to the sample."

Co-first author, Priya Singh from RMIT University says, "Diamond spins have been used for over a decade in biological systems as an in-situ probe. I am eager to take our hBN into the continuously moving cellular environment, where the directional independence of the sensor would be an advantage."

TMOS Chief Investigator Igor Aharonovich says, "hbN has many advantages over diamond as a quantum light source for communications and sensing. In addition to its ultra-thin form factor, it can also operate as a quantum light source for communications at room temperature, where diamond often requires cryogenic cooling. hBN is also much cheaper and more accessible than diamond."

Generally, these new low-dimensional materials offer the chance of discovering new physics due to their extreme anisotropy. Potential future applications for this quantum sensing technology include in-field identification of magnetic geological features. The spin half nature of the defect will also allow for radio spectroscopy across a wider band than competing technologies.

TMOS Associate Investigator Jean-Phillipe Tetienne says, "The next step for this research is to identify what the atomic defects in the hBN are. By understanding the composition of these, we can make progress toward engineering sensor devices for optimal performance.

"I am excited about exploring the properties and opportunities of this new optical spin defect. Its spin half nature is novel in our community, and there are many questions to answer."

For more information about this research, contact connect@tmos.org.au

Multi-species optically addressable spin defects in a van der Waals material

NATURE MATERIALS, AUGUST 2024

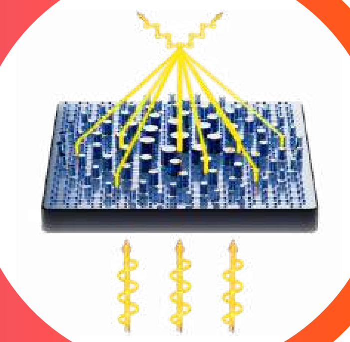
Sam C. Scholten, Priya Singh, Alexander J. Healey, Islay O. Robertson, Galya Haim, Cheng Tan, David A. Broadway, Lan Wang, Hiroshi Abe, Takeshi Ohshima, Mehran Kianinia, Philipp Reineck, Igor Aharonovich, Jean-Philippe Tetienne

Optically addressable spin defects hosted in two-dimensional van der Waals materials represent a new frontier for quantum technologies, promising to lead to a new class of ultrathin quantum sensors and simulators. Recently, hexagonal boron nitride (hBN) has been shown to host several types of optically addressable spin defects, thus offering a unique opportunity to simultaneously address and utilise various spin species in a single material. Here, we demonstrate an interplay between two separate spin species within a single hBN crystal, namely $S = 1$ boron vacancy defects and carbon-related electron spins. We reveal the $S = \frac{1}{2}$ character of the carbon-related defect and further show room temperature coherent control and optical readout of both $S = 1$ and $S = \frac{1}{2}$ spin species. By tuning the two spin ensembles into resonance with each other, we observe cross-relaxation, showing strong inter-species dipolar coupling. We then show magnetic imaging using the $S = \frac{1}{2}$ defects and leverage their lack of intrinsic quantization axis to probe the magnetic anisotropy of a test sample. Our results establish hBN as a versatile platform for quantum technologies in a van der Waals host at room temperature.

Read the full article

THEME TWO
Manipulate

Theme II focuses on the design, development, and understanding of dynamic and reconfigurable metasurfaces, which are foundational to the future of flat optics. Our vision is to enable ultra-compact, multifunctional optical devices that can adapt to their environment or user needs in real-time. These capabilities are central to emerging technologies in augmented reality, on-chip photonic computing, biomedical diagnostics, and adaptive imaging. Theme II bridges fundamental science and application, driving innovations that are expected to have transformative impacts across information processing, sensing, and communications.



THEME LEADERS:

PROFESSOR ILYA SHADRIVOV
The Australian National University

PROFESSOR MADHU BHASKARAN
RMIT University

In 2024, we contributed to a wide range of impactful studies and collaborations, reinforcing our leadership in cutting-edge optical technologies. One of our key achievements was the development of a miniaturized optical glucose sensor operating in the 1600–1700 nm near-infrared range (Yang et al., Adv. Sensor Res.). This represents a critical step towards compact, non-invasive biomedical sensing. The underlying technology was further protected through a patent, establishing a path for future translation and commercialisation.

We also demonstrated broadband diffractive neural networks capable of classifying visible wavelengths (Cheong et al., Adv. Photonics Res.), opening exciting avenues for all-optical machine learning and integrated optical computing.

Phase-change materials (PCMs) continue to play a central role in Theme II. We showcased tunable optical properties of Sb_2Se_3 for multi-domain optoelectronics (Murali et al., Appl. Mater. Today), a collaborative effort between RMIT and ANU. In another landmark cross-node and cross-theme project (Themes II and III), we demonstrated reconfigurable image processing metasurfaces using PCMs (Cotrufo et al., Nat. Commun.) in partnership with UoM and PI

Andrea Alù, highlighting the synergy between hardware photonics and algorithmic design.

We also advanced fundamental understanding of wave manipulation. Kovalev and Shadrivov reported parametric metasurfaces for electromagnetic wave amplification (Opt. Mater. Express), and Shvedov et al. developed laser-induced surface structuring techniques with controlled periodicity (Adv. Mater. Interfaces). These studies underpin future design of metasurfaces with tailored responses.

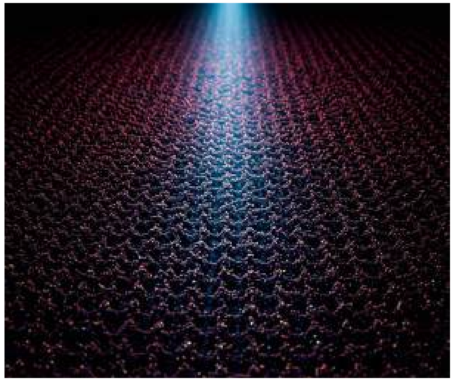
Bound states in the continuum (BICs) received further attention through collaboration with AI Miroshnichenko, where we reported active control of BICs in toroidal metasurfaces (Kovalev et al., Adv. Photonics Res.). Soft-matter-based tunable metasurfaces were reviewed in a comprehensive book chapter (Walden et al., Elsevier), reflecting the growing interest in adaptable materials for flat optics.

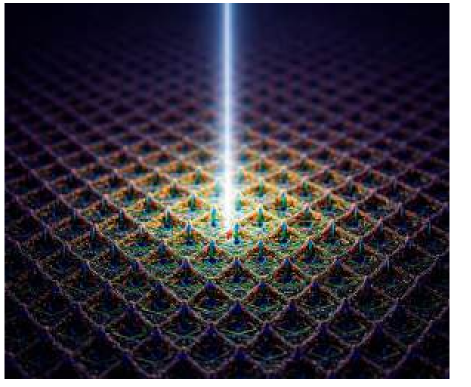
We also contributed to international efforts on ultrafast photonic devices. A joint study with Friedrich Schiller University Jena demonstrated ultrafast Q-boosting in semiconductor metasurfaces (Yang et al., Nanophotonics), pushing temporal boundaries of metasurface resonances. Finally, we contributed to the design of structured light beams using dielectric metasurfaces, generating a high-efficiency triple-helix solenoid beam (Setareh et al., ACS Photonics).

Together, these achievements underscore Theme II's strong presence in both fundamental research and translational innovation, highlighting our commitment to international collaboration and next-generation meta surface technology.

ACTION ITEMS FOR 2025

1. Demonstration of MEMS-based tunable metamaterial filters
2. Development of tunable metasurfaces using phase-change materials
3. Advancing soft-matter-based metasurfaces for dynamic light control





MANIPULATE
Subprograms

SUBPROGRAM 2

Our research program focuses on developing compact, high-efficiency, dynamically reconfigurable metasurfaces to manipulate light, pushing the boundaries of traditional optics. By addressing key challenges, such as amplitude and phase tuning, polarisation control, and ultra-fast pixel-sized devices, we accelerate the transition from fundamental research to real-world applications. This year, we strengthened our collaborations and, together, achieved significant breakthroughs in phase-change materials, ultrafast semiconductor metasurfaces, electro-optic materials, and soft-matter systems. These advancements have driven progress in next-generation imaging, sensing, and laser manipulation technologies.

Glucose Sensor

KEY ACHIEVEMENTS IN 2024:

Miniaturized Optical Glucose Sensor.
Prof. Madhu Bhaskaran's group at RMIT University, in collaboration with the Meta Health Sensors Flagship program, achieved a key breakthrough in non-invasive diagnostics with the development of a miniaturised near-infrared optical glucose sensor. This high-sensitivity device enables continuous, non-invasive glucose monitoring, advancing next-generation diabetes management and wearable healthcare technologies.

Tunable Sb_2Se_3 Phase-Change Materials.
A cross-node collaboration between RMIT and ANU led to significant advancements in the tunability of Sb_2Se_3 phase-change materials for multi-domain optoelectronics. This innovation paves the way for high-capacity optical switches, photonic memory, and displays with an extended colour range.

Bound States in the Continuum (BIC) in Toroidal Metasurfaces.
Prof. Shadrivov's group at ANU successfully achieved

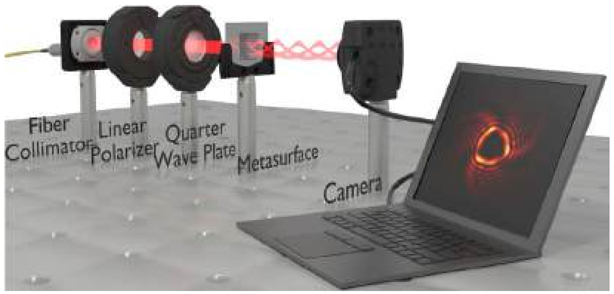
PUBLICATIONS

1. K. Murali, L. Thekkekara, M.A. Rahman, S. Sen, V. Shvedov, Y. Izdebskaya, C. Zou, S.A. Tawfik, I. Shadrivov, S. Sriram, and M. Bhaskaran, *Tunability of Sb2Se3 phase change material for multi-domain optoelectronics*, Applied Materials Today 40, 102338 (2024). doi.org/10.1016/j.apmt.2024.102338
2. F. Kovalev, A. Miroshnichenko, A. Basharin, H. Toepfer, and I. Shadrivov, *Active Control of Bound States in the Continuum in Toroidal Metasurfaces*, Advanced Photonics Research (2024). doi.org/10.1002/adpr.202400070
3. Z. Yang, M. Liu, D. Smirnova, A. Komar, M. Shcherbakov, T. Pertsch, and D. Neshev, *Ultrafast Q-boosting in semiconductor metasurfaces*, Nanophotonics 13, 12, 2173 (2024). doi.org/10.1515/nanoph-2023-0718
4. M. Setareh, R. De Gille, J. Cadusch, D. Wen, S. Kim, and K. B. Crozier, *High Efficiency Triple-Helix Solenoid Beam Generated by Dielectric Metasurface*, ACS Photonics 11 (9), 3486-3491 (2024). doi.org/10.1021/acsphotonics.4c00874
5. M. Yang, S.S. Dhanabalan, M.R. Robel, L.V. Thekkekara, S. Mahasivam, M.A. Rahman, S. brighter, S. Sen, S. Walia, S. Sriram, and M. Bhaskaran, *Miniaturized Optical Glucose Sensor Using 1600–1700 nm Near-Infrared Light,* Adv. Sensor Res. 2300160 (2024). doi.org/10.1002/adsr.202300160
6. S. Walden, Y. Izdebskaya, and I. Shadrivov, *Tunable metasurface devices based on soft matter,* book chapter in Semiconductors Metamaterials: Part 1, 1st Edition, Vol 115, Elsevier, pp. 67-109 (2024). doi.org/10.1016/bs.semsem.2024.08.002
7. Y.Z. Cheong, L. Thekkekara, M. Bhaskaran, B. del Rosal, and S. Sriram, *Broadband Diffractive Neural Networks Enabling Classification of Visible Wavelengths*, Adv. Photonics Res., 5: 2300310 (2024). doi.org/10.1002/adpr.202300310

active control of Bound States in the Continuum in toroidal metasurfaces by integrating thin-film vanadium dioxide patches. This breakthrough offers exciting possibilities for ultra-sensitive and multifunctional metadevices.

Ultrafast Q-Boosting in Semiconductor Metasurfaces.
Prof. Dragomir Neshev's group at ANU, in collaboration with Friedrich Schiller University Jena, achieved a breakthrough in ultrafast Q-boosting in semiconductor metasurfaces. This work demonstrated significantly enhanced optical resonances for highly efficient, ultrafast optical switching devices critical for next-generation communication systems.

Tractor Beam Metasurface Laser.
Another notable contribution comes from Ken Crozier's group at UoM, which demonstrated high-efficiency solenoid beam generation using dielectric metasurfaces, gained international recognition with widespread publicity. This work unlocks new possibilities for optical trapping and structured light applications.



Tractor beam

Liquid Crystal-Based Metasurfaces.
Prof. Shadrivov's group at ANU presented an overview of dynamically reconfigurable optical properties in metasurfaces using liquid crystals and polymetric materials, highlighting key achievements and challenges in soft-matter-based metasurfaces and next-generation smart materials.

Broadband Diffractive Neural Networks.
Researchers at RMIT and Monash University pioneered broadband diffractive neural networks for visible-wavelength classification. By integrating computational and optical functionalities, these metasurface-based neural networks enable real-time optical information processing, opening new frontiers for AI-driven imaging and spectroscopy.

These advancements open new possibilities for precise control of light at sub-wavelength scales, expanding functionalities beyond conventional optics. Next year, we will continue advancing by strengthening collaborations and driving innovation to develop new capabilities in tunable metasurfaces.

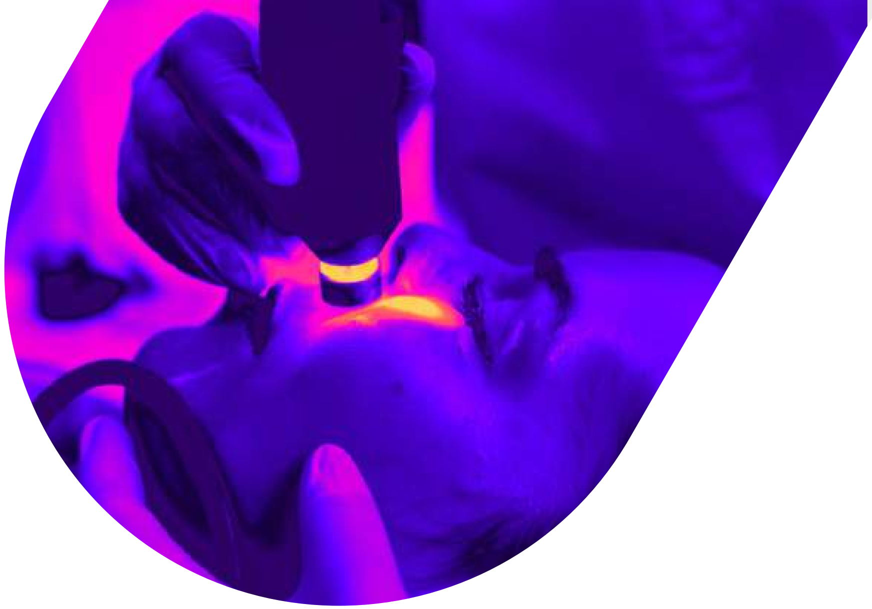
Yana Izdebskaya, Subprogram 2 Research Program Manager

KEY ACTION ITEMS FOR 2025

1. Demonstration of MEMS-based tunable metamaterial filters
2. Development of tunable metasurfaces using phase-change materials
3. Advancing soft-matter-based metasurfaces for dynamic light control

MANIPULATE CASE STUDY

Beam Me Out, Scotty. A new tractor beam technology aims to minimize biopsy trauma



Researchers at TMOS, the ARC Centre of Excellence for Transformative Meta-Optical Systems, have taken an important first step in the development of metasurface-enabled tractor beams—rays of light that can pull particles toward it, a concept that fictional tractor beams featured in science fiction are based on.

In research published in ACS Photonics today, the University of Melbourne team describes their solenoid beam that is generated using a silicon metasurface. Previous solenoid beams have been created by bulky special light modulators (SLMs), however, the size and weight of these systems prevent the beams being used in handheld devices. The metasurface is a layer of nanopatterned silicon only about 1/2000 of a millimetre thick. The team hopes that one day it could be used to take biopsies on a non-invasive manner, unlike current methods such as forceps that cause trauma to the surrounding tissues.

Beams of light tend to exert a pushing force, moving particles away from the light source. Solenoid beams have been proven to draw particles toward the light source. Consider the way a drill works, pulling wood shavings up the drill bit. Solenoid beams work similarly.

This particular solenoid beam has several benefits over previously generated solenoid beams in that the required conditions of the input beam are more flexible than with previous beams, it doesn't require an SLM, and the size, weight and power requirements are significantly less than previous systems.

SPOTLIGHT

Professor Kenneth Crozier

Chief Investigator

Kenneth Crozier is Deputy Director of the Australian Centre of Excellence (ARC) for Transformative Meta-Optical Systems (TMOS). He is also Professor of Physics and Electronic Engineering at the University of Melbourne. This is a joint appointment between the School of Physics and the Department of Electrical and Electronic Engineering.

Prior to joining the University of Melbourne, Kenneth Crozier was an Associate Professor at Harvard University. He joined Harvard as an Assistant Professor of Electrical Engineering in 2004, and was promoted to Associate Professor in 2008. His research interests are in nano- and micro-optics, with an emphasis on plasmonics for surface enhanced Raman spectroscopy and optical forces, optofluidics and semiconducting nanowires. He received his undergraduate degrees in Electrical Engineering (with first class honours, with LR East Medal) and Physics at the University of Melbourne. He received his MSEE and PhD in Electrical Engineering from Stanford University in 1999 and 2003, respectively. In 2008, he was a recipient of a CAREER Award from the National Science Foundation (USA) and a Loeb Chair at Harvard, an endowed position for junior faculty. In 2014, he was awarded an Innovation Fellowship from VESKI (Victorian Endowment of Science, Knowledge and Innovation) and an ARC Future Fellowship on his return to Australia. He is a Senior Member of the Institute of Electrical and Electronics Engineers (IEEE), of the Optical Society (OSA) and of the International Society for Optics and Photonics (SPIE).

The metasurface was created by mapping the phase hologram of the desired beam. This was used to create a pattern. The metasurface was then fabricated from silicon using electron beam lithography and reactive ion etching. When the input beam, in this case a Gaussian beam, filters through the metasurface, most of it (approximately 76%) is converted into a solenoid beam and bends away from the unconverted beam, allowing the researchers to work with it without obstruction. They were able to characterize the beam at a distance of 21 centimeters. Lead researcher Maryam Setareh says, "The compact size and high efficiency of this device could lead to innovative applications in the future. The ability to pull particles using a metasurface might have the potential to impact the field of biopsy by potentially reducing pain through less invasive methods."

Setareh says, "We are excited to investigate the performance of our device in particle manipulation, which could offer valuable insights."

Chief Investigator Ken Crozier says, "The next stage of this research will be to experimentally demonstrate the beam's ability to pull particles, and we'll be excited to share those results when they're available."

Crozier says "This work opens new possibilities for using light to exert forces on tiny objects."

For more information about this research, contact connect@tmos.org.au

High Efficiency Triple-Helix Solenoid Beam Generated by Dielectric Metasurface

ACS PHOTONICS, 17TH JULY 2024

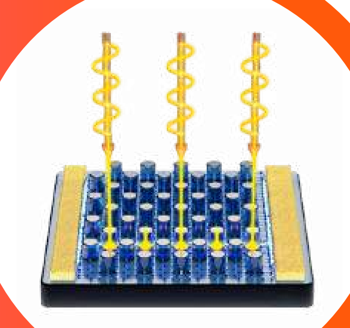
Maryam Setareh, Robert De Gille, Jasper Cadusch, Dandan Wen, Sejeong Kim, and Kenneth B. Crozier

Solenoid beams are structured beams exhibiting patterns of light that rotate around the axis of propagation. They can exert forces on objects in a direction opposite to the light propagation direction and are thus referred to as tractor beams. Previous studies have produced solenoid beams using spatial light modulators (SLMs), but cost, weight, and size limit their widespread application. Here, we experimentally demonstrate a silicon metasurface that generates a triple helix solenoid beam. The beam is equivalent to the superposition of Bessel beams with orbital angular momentum (OAM) values of -10 and -7 and internal angles of 0.005 and 0.004 rad, respectively. Our metasurface demonstrates a diffraction efficiency of >90% and a transmission of >75%, a significant improvement over SLMs. We map the beam's intensity profile at up to ~21 cm from the metasurface, showing its triple helix profile with negligible diffraction. We furthermore experimentally investigate interference between the solenoid beam and a Gaussian beam. This allows us to unravel the OAM information embedded in our two-component solenoid beam.

Read the full article

THEME THREE
Detect

Detecting visible and infrared light with compact sensors and imaging systems is essential to meet the increasing demand for smaller mobile electronic devices used in various applications such as chemical sensing, 3D imaging, virtual and augmented reality, and enhancing visibility in difficult conditions such as fog and bushfire smoke. Infrared detectors are vital for defence, medical, and a range of Industry 4.0 applications, but they face challenges due to their poor signal-to-noise ratio at room temperatures, limiting their use in weight-sensitive applications like drones and space systems. To overcome this, and broaden detection capabilities, TMOS is exploring new semiconductor nanowire devices for sensing and imaging, and integrating metasurfaces and subwavelength structures into mercury cadmium telluride (MCT) detectors. There is also a high demand for optical sensors that can capture information such as the polarization and phase of electromagnetic waves, and TMOS is leveraging meta-optics to make this hidden information accessible in compact optical systems.

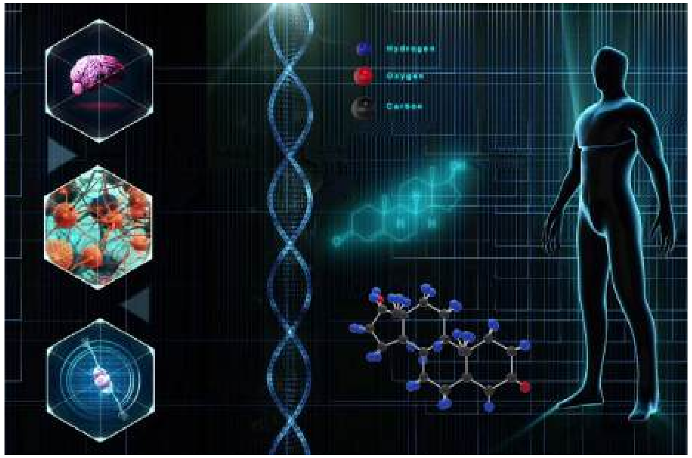


THEME LEADERS:

PROFESSOR ANN ROBERTS
University of Melbourne

PROFESSOR LORENZO FARAONE
The University of Western Australia

Excellent progress was made on the 2023 action items and highlights include significant progress in performing single pixel and ghost imaging using a range of strategies and detectors has been demonstrated in various projects across different TMOS nodes. Cross node collaborative projects between the groups of Lan Fu at ANU and Ken Crozier at the University of Melbourne demonstrated single pixel imaging in the Short Wave Infrared (SWIR) using InAs/InP nanowire array photodetectors, a radial heterojunction based InGaAs nanowire array photodetector fabricated by a top-down etching technique and a black phosphorous/MoS2 photodetector. In collaboration with TMOS members at UWA and UTS, Lan's group also demonstrated metasurface/GaAsSb nanowire array single pixel polarisation imaging by direct integration of L-shaped metasurface elements onto MOCVD-grown GaAsSb nanowire array photodetectors. Several manuscripts reporting these ground-breaking studies are in preparation. Andrey Sukhurokov's group at ANU, in collaboration with researchers at Jena, have recently published work describing an ultra compact quantum ghost imaging system, and in 2024 extended this work to quantum ghostimaging of phase objects using metasurfaces. Other work led by Ken Crozier demonstrated gas sensing with a meta surface-integrated



detector which has recently been published, and research extending this approach to other devices exhibiting quasi bound modes in the continuum is ongoing. The team based in Engineering at UTS has demonstrated tunability of epitaxial graphene on silicon carbide by top-gating in a field-effect transistor configuration. The final action item for 2024 involved the integration of a superpixel metalens with an MCT imaging array to enable operation of detectors well above the cryogenic temperatures usually required. Progress on this cross-node collaboration between ANU, UWA and UoM has reached a point where it has been moved to the TMOS flagship program. The initial design phase has been completed and a first prototype fabricated and characterisation currently underway. The flagship team are currently in conversation with potential end-users in the defence and space sectors to investigate implementation in various applications.

KEY ACTION ITEMS FOR 2025

1. Demonstrate SWIR nanowire array on-chip spectrometer
2. Demonstrate top-down etched InGaAs metasurface SWIR polarisation-sensitive photodetector
3. Experimental demonstration of mid-infrared spectrometer consisting of guided mode resonance filters integrated with detector array
4. Demonstrate phase imaging with inverse-designed nonlocal metasurfaces 5. Demonstrate metasurface-enabled small-satellite polarisation imaging

DETECT
Subprograms

3A. ADVANCED IMAGING

TMOS Theme 3A focuses on advancing infrared (IR) detection technologies by developing high-performance materials and devices operating in the short-wave (SWIR) and mid-wave (MWIR) infrared spectrum. The primary goal is to improve the key performance indicators—such as responsivity, detectivity, and noise performance—or introduce novel material systems and device architectures that enable enhanced functionality. Below is a summary of the key research developments achieved in 2024:

NANOWIRE DETECTORS BASED ON III-V ALLOYS IN SWIR AND MWIR

1. InAs Nanowire Short-Wave Infrared Photodetector
   The design, growth, and fabrication of core-shell InAs/InP nanowires were optimised. These devices demonstrated high-speed, broadband detection capabilities with spectral tunability, offering a strong foundation for next-generation IR sensing applications.
2. InAs Nanosheet Infrared Photodetector for Polarisation Imaging
   Optical simulations were conducted to optimise the geometry of InAs nanosheets to achieve maximum dichroic response. The InAs nanosheets were successfully grown using MOCVD, and photodetectors were fabricated. The resulting device exhibited a high dichroic ratio of 44 at a wavelength of 2.9 μm, with reliable operation at room temperature.
3. Ultra-Sensitive Self-Powered InGaAs Nanowires for Infrared Photodetection and Imaging
   A high-performance InGaAs nanowire photodetector was developed for short-wave infrared operation (1310 nm). The device achieved single-photon-level sensitivity, detecting signals as weak as 6.5 pW at 223 K. The fast response time (~22 ns) supports its suitability for high-bandwidth applications and real-time imaging.
4. Nanowire Quantum Well Infrared Photodetector (QWIP)
   A selective area growth method was used to fabricate a nanowire array consisting of five InGaAs/InP quantum wells. The device exhibited normal-incidence photoresponse at 4 μm, attributed to intraband transitions within the quantum wells. Additionally, the device demonstrated ultra-low dark current density due to the reduced material volume in the nanowire array, improving signal-to-noise characteristics.
5. Metasurface-Enabled Wavelength Demultiplexing Based on Nanowire QWIPs
   Various gold (Au) gratings were fabricated using focused ion beam (FIB) techniques, with resonance properties closely matching simulation results. These gratings were integrated with nanowire QWIP devices and demonstrated promising results for wavelength demultiplexing, enabling more selective and tunable IR detection functionality.

Nima Dehdashti, Subprogram 3A Research Program Manager

ACTION ITEMS 2025

1. InAs Nanowire Short-Wave Infrared Photodetector
    - The device design will be further modified to enable operation at higher temperatures, improving practicality and deployment flexibility.
    - A Focal Plane Array (FPA) will be fabricated using the previously developed nanowire-based detector architecture, aiming to demonstrate scalability and array-level functionality.
2. Metasurface-Enabled Wavelength Demultiplexing Based on Nanowire Quantum Well Infrared Photodetectors
    - A more advanced and sophisticated random metasurface will be designed and fabricated for integration with the nanowire detectors, enhancing their performance and functionality.
    - Additional features, including polarization demultiplexing and orbital angular momentum (OAM) demultiplexing, will be developed to further expand the detection capabilities of the nanowire platform.
3. MCT Detector Enhanced with Self-Integrated On-Pixel All-Dielectric Metamaterial Resonance (metaMCT-Pixel)
    - Following the successful fabrication of meta-pixels in 2024, detailed optical and electrical characterisation of these devices will be conducted in 2025.
    - This work will be carried out collaboratively with research teams from UWA, ANU, and Duke University to validate performance and refine the technology.

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1. Nitu Syed, Gus O. Bonin, Chung Kim Nguyen, Mei Xian Low, Jiajun Meng, Ali Zavabeti, Billy James Murdoch, Anthony S. R. Chesman, Shifan Wang, Pallavi Punj, Kibret A. Messalea, Sumeet Walia, James Bullock, Kenneth B. Crozier, Daniel E. Gómez, and Ann Roberts, "Plasmonic Gold Nanoparticle-Decorated Ultrathin SnO2 Nanosheets with Superior Ultraviolet and Visible Photoresponsivity" ACS Applied Nano Materials 2024 7 (10), 11184-11194, https://doi.org/10.1021/acsanm.4c00680
2. Henry Tan, Jiajun , Meng, and Kenneth B. Crozier "Multianalyte Detection with Metasurface-Based Midinfrared Microspectrometer", ACS Sensors 2024 9 (11), 5839-5847, https://doi.org/10.1021/acssensors.4c01220
3. Meng, J., Balendhran, S., Sabri, Y. et al. "Smart mid-infrared metasurface microspectrometer gas sensing system", *Microsyst Nanoeng* **10**, 74 (2024). https://doi.org/10.1038/s41378-024-00697-2
4. S. K. Nath, S. K. Das, S. K. Nandi, C. Xi, C. V. Marquez, A. Rúa, M. Uenuma, Z. Wang, S. Zhang, R.-J. Zhu, J. Eshraghian, X. Sun, T. Lu, Y. Bian, N. Syed, W. Pan, H. Wang, W. Lei, L. Fu, L. Faraone, Y. Liu, R. G. Elliman, "Optically Tunable Electrical Oscillations in Oxide-Based Memristors for Neuromorphic Computing", Adv. Mater. 2024, 36, 2400904. https://doi.org/10.1002/adma.202400904

3B. HIDDEN PROPERTIES OF LIGHT

TMOS Theme 3B focuses on the detection of 'hidden' properties of light such as wavelength, quantum, phase, polarisation, and angular momentum, that cannot be accessed using conventional photon or thermal detector technologies. Among the various technologies explored within TMOS, metamaterials represent a key breakthrough, enabling the detection of these properties with potential applications across space, defence, healthcare, science, and telecommunications. A promising direction for future research includes applying the metasurface-based isometric differential interference contrast imaging, demonstrated in 2023, to investigate polarisation/spectral multiplexing for phase imaging.

Below is a summary of the key research developments achieved in 2024:

1. Plasmonic Filter Array Microspectrometer
   The two main activities in 2024 were:
   (1) Characterisation of the fabricated micro-bolometer camera with integrated guided mode resonance filters using a spectral radiometer at UWA;
   (2) Characterisation of the fabricated guided mode resonance filters using a custom-modified FTIR microscope at the University of Wisconsin.

   Action items for 2025:
   Complete the fabrication and characterisation of a laboratory prototype and evaluate its performance for hazardous agent detection using infrared spectroscopy with the fabricated device

2. MEMS-based gas sensing microspectrometer
   The characterisation of UWA-fabricated MEMS spectrometer devices is ongoing at UWA.

   Action items for 2025:
   Continue the electrical and optical characterisation of the fabricated MEMS devices in collaboration with other TMOS nodes, incorporating data processing techniques developed at the University of Melbourne for spectral reconstruction.

3. *Quantum imaging using entangled photon pairs from nonlinear metasurfaces*
   Experimental and theoretical studies have been completed. A manuscript has been submitted and is currently under review, with publication expected in 2025.

   Action items for 2025:
   Conduct experiments targeting higher imaging resolution and single-shot 2D ghost imaging using broad-angle photon emission in both directions.

4. Quantum ghost imaging of phase objects using metasurfaces
   The preliminary phase of the project, involving experiments with a metasurface photon-pair source, has been completed.

   Action items for 2025:
   Conduct a collaborative experiment with the University of Jena to compare the performance and characteristics with a conventional bulky photon-pair source.

5. *Plasmonic Polarisation sensitive photodetection with plasmonic nanogratings on TSMO*
   Design and fabrication of plasmonic nanogratings is currently ongoing, with over 50% of the fabrication phase completed.

   Action items for 2025:
   Conduct characterisation of the plasmonic nanogratings and submit the results for publication. Since ITO shows potential for voltage tunability, this may support cross-node collaboration in 2025. A potential collaboration with the nonlinear research group is also being considered for device characterisation.

6. EG/SiC Edge-Detection Filter in MIR
   This project consists of filter and detector components. Test transfer of the SiC grating onto a MIR-transparent BCB

substrate has been completed, and the fabrication of the filter component is also complete.

Action items for 2025:
Characterise the EG/SiC filter and demonstrate edge-detection image processing in the next phase of the project.

7. Polarisation-tunable phase imaging and bright field microscopy
Design, fabrication, and characterisation of the system have been completed. The manuscript will be published in ACS Photonics in early 2025.

Action items for 2025:
Extend work to single-shot polarization imaging.

8. *Multifunctional nonlocal metasurface for directional phase gradient contrast imaging and quantitative wavefront recovery*
Optical design and simulation of the metasurface for phase gradient detection were successfully completed.

Action items for 2025:
Finalise the fabrication and conduct measurements of SiN/SiO_2 metasurfaces to verify the design parameters.

Nima Dehdashti, Subprogram 3B Research Program Manager

PUBLICATIONS

1. J. Ren, J. Ma, J. Zhang and A. A. Sukhorukov, "Quantum Imaging Using Entangled Photon Pairs From Nonlinear Metasurfaces," 2023 Seventeenth International Congress on Artificial Materials for Novel Wave Phenomena (Metamaterials), Chania, Greece, 2023, pp. X-288-X-290, https://doi.org/10.1109/Metamaterials58257.2023.10289268
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3. Tan, H., Meng, J., Crozier, J.B., Multianalyte Detection with Metasurface-Based Midinfrared Microspectrometer. ACS Sensors, 9 (11), pp 5839-5847 (2025) https://pubs.acs.org/doi/abs/10.1021/acssensors.4c01220
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5. Meng, J., Balendhran, S., Sabri, Y., Bhargava, S.K., Crozier, K.B., Smart mid-infrared metasurface microspectrometer gas sensing system, Microsystems & Nanoengineering, 10 (1), 74 https://www.nature.com/articles/s41378-024-00697-2

DETECT CASE STUDY

Continuous non-invasive glucose sensing on the horizon with the development of a new optical sensor

For decades, people with diabetes have relied on finger pricks to withdraw blood or adhesive microneedles to measure and manage their glucose levels. In addition to being painful, these methods can cause itching, inflammation and infection.

Researchers at TMOS, the Australian Research Council Centre of Excellence for Transformative Meta-Optical Systems, have taken an important step towards eliminating this discomfort. Their RMIT University team has discovered new aspects of glucose's infrared signature and have used this information to develop a miniaturised optical sensor only 5mm in diameter that could one day be used to provide continuous non-invasive glucose monitoring in diabetes management.

Non-invasive glucose sensing has been a target for almost 30 years due to its implications for pain-free monitoring. Optical glucose sensing techniques have been reported; however, they require complex optical instrumentation usually found in laboratories, making them unsuitable for regular patient use.

The primary challenging facing affordable, wearable optical glucose testing has been miniaturisation and filtering out the glucose signals from water absorption peaks in the near infrared (NIR) spectrum. Essentially, it has been almost impossible to accurately differentiate between water and glucose in the blood. Until now.

In a first-of-its-kind research published in Advanced Sensor Research today, the team has identified four infrared peaks in glucose that allow selective and sensitive identification in aqueous and biological environments. The team is keen to collaborate with academic and industry partners to continue this work and conduct pre-clinical and clinical research, which would open the door to the development of wearable optical glucose sensors.

SPOTLIGHT

Dr Mingjie Yang

Postdoctoral Researcher

Dr Mingjie Yang is a dedicated researcher, committed to application of science. With an educational background in engineering, he specializes in optical sensing, wearable electronics, nanomaterials, biosensors, and biomedical devices. His passion lies in leveraging advanced sensing technologies and wearable electronics to enhance disease prevention and management, pushing the boundaries of healthcare. Mingjie began his academic journey with a Bachelor of Engineering at Sichuan University in China, focusing on optoelectronic information and technology.

In 2017, he started his postgraduate journey at Monash University in Australia, dedicating himself to research in soft and wearable electronics. His PhD at RMIT University was on optical sensors and biosensors aimed at chronic disease monitoring, offering pain-free, non-invasive alternatives to traditional methods. Among his significant achievements is the development of a miniaturized optical glucose sensor, a breakthrough that earned him the 1st place award at the Falling Walls Lab Melbourne, where he proudly represented Victoria at the Australian national final. Today, Mingjie continues his research as part of the ARC Centre of Excellence for Transformative Meta-Optical Systems (TMOS) at RMIT University, furthering innovations that promise to apply new sensing technologies into practical solutions.

The team has fabricated a miniaturised glucose sensor established on a 1600-1700nm waveband that is Bluetooth enabled and operates using a coin battery, which allows for continuous glucose monitoring. This compact sensor has demonstrated its viability detecting glucose levels in the human body range from 50 to 400mg/dL in blood plasma, with a comparable limit of detection and sensitivity to larger, laboratory-based sensors. Its small dimensions could see it one day integrated into smart watches and other pain-free wearable health trackers.

Lead author, RMIT PhD scholar Mingjie Yang, says "Until now, there is no consensus on the unique spectroscopic signature of glucose, largely because the O-H bonds targeted in near-infrared (NIR) spectroscopy for glucose detection are also abundant in water. This similarity makes it challenging to distinguish between glucose and water signals, especially in complex biological fluids and tissues. We optimized spectroscopy setup and analysed transmittance to identify peaks unique to glucose. Our discovery finally provides the information necessary to move forward with miniaturised optical glucose sensing and we have developed a device prototype to suggest the foundation for futuristic non-invasive glucose sensor."

The device prototype utilises a surface-mounted device light emitting diode (SMD LED) and circuits made of thin-film copper coated polymide (Cu/PI) only 110 microns thick developed with a laser patterning technology. The millimeter-scale and lightweight design of this device makes it considerably more compact than traditional bench top spectrophotometers. The flexible patch-like design offers the future possibility of direct reading as a wearable device on human skin.

The performance of the device has been rigorously evaluated using aqueous glucose solutions as well as in blood plasma. Computational analysis of light-skin interference has been conducted that indicates how the SMD LED will penetrate the skin. Simulation results suggest the promising locations for future exploration of optical glucose sensing in clinical setups.

TMOS Chief Investigator Madhu Bhaskaran says, "The non-invasive nature of optical glucose sensors has the potential to improve patient compliance, reduce discomfort, and lower the risks of infections associated with invasive glucose monitoring. With the right collaborators/partners and the right funding, this can represent an important shift towards continuous and pain-free glucose sensing."

Wearable sensors, such as this one developed by TMOS researchers at RMIT, are part of Centre's Meta Health Sensors Flagship Program—an applied research program dedicated to the development of meta-optical sensors for Medtech applications.

RMIT University has filed a patent application related to the optical glucose sensor technology that the team developed.

For more information about this research, please contact connect@tmos.org.au

Miniaturized Optical Glucose Sensor Using 1600–1700 nm Near-Infrared Light

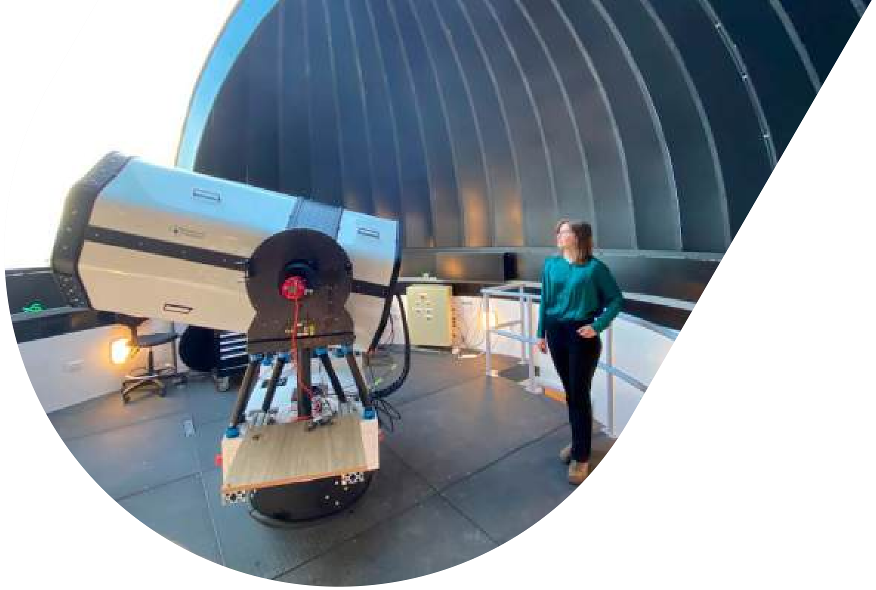
ADVANCED SENSOR RESEARCH, 15TH MARCH 2024

Mingjie Yang, Shanmuga Sundar Dhanabalan, Md Rokunuzzaman Robel, Litty Varghese Thekkekara, Sanje Mahasivam, Md Ataur Rahman, Sagar Borkhatariya, Suvankar Sen, Sumeet Walia, Sharath Sriram, Madhu Bhaskaran

Blood glucose measurement is crucial for diabetes diagnosis and treatment, but invasive sampling methods have drawbacks. Non-invasive near-infrared (NIR) spectroscopy-based optical glucose sensing has gained attention but faces challenges due to the strong absorbance of NIR light by water and the need for complex equipment. Here, four distinct glucose fingerprints at specific NIR wavelengths: 1605, 1706, 2145, and 2275 nm are identified. Utilising a surface-mounted LED with a spectral range of 1600–1700 nm and focusing on the most prominent peaks at 1605 and 1706 nm, a miniaturized and non-invasive glucose sensor is developed. The device successfully detects in vitro assays of glucose solutions within the physiological range of 50–400 mg dL-1, attaining a limit of detection as low as 10 mg dL-1. The findings show the feasibility of NIR spectroscopy-based glucose sensing and its potential applications in non-invasive point-of-care diagnostics, with the potential for extension of other biomarkers in the future.

Read the full article

Old movies and new tech to allow us to see back in time with deep space imaging



Observing distant galaxies, stars and cosmic events is the closest thing we have to time travel. Because light can take millions or even billions of years to get to us, by looking into deep space, we can see moments of cosmic history that tell us how the universe formed and evolved.

Looking into deep space also plays a part in the search for extraterrestrial life, as we examine potentially habitable exoplanets and look for signs of microbial life. By studying the atmospheres of planets outside of our solar system, we can look for biosignatures, like specific gases, that could indicate life.

However, it is our own atmosphere that makes this difficult, as the light that travels unimpeded from planets and stars quadrillions of kilometers away is distorted at the last moment by the layers of gas that envelope the Earth.

Researchers from TMOS, the ARC Centre of Excellence for Transformative Meta-Optical Systems, are working to counter this interference using the new field of meta-optics alongside an optical technique popularized in the 1950s when 20th Century Fox devised a way to capture a wide-screen film image onto a standard 35mm lens, and then reverse the process as the movie was projected to deliver wide-screen images to audiences.

Anamorphic compression used two cylindrical lenses, and it allowed cinematographers to capture a wider field of view than had been possible. Filmmakers could now show more scenery, bigger crowds, and elaborate action sequences.

Researchers from the Centre's team at the Australian National University are employing this same concept of anamorphic compression to the adaptive optics systems that are currently used by large telescopes to counter the effect of the atmosphere when looking into space. However, instead of using an array of double-layer traditional lenses, which are too bulky for adaptive optics and too complicated to manufacture with the required variation of focal distances, the team has designed metasurface-based anamorphic lens arrays.

Meta-lenslet arrays are made from surfaces thinner than a piece of cling wrap and have nanostructured patterns on them that are smaller than a wave a light. These surfaces can manipulate light as if it had interacted with traditional lenses, but with a much, much smaller footprint. The two-layer design of this array creates the anamorphic compression that sets this technology apart from other attempts to improve adaptive optics.

Adaptive optics changes the shape of a telescope mirror to adjust for atmospheric

SPOTLIGHT

Josephine Munro

Postdoctoral Researcher

Josephine is a postdoctoral fellow at the Australian National University. She is currently working on the instrumentation for a remote sensing project. The project aims to demonstrate the improved functionality of satellite imaging using metasurfaces. Josephine completed her PhD in optical aberration characterisation for astronomical instrumentation and has since refocused her research on the rapidly expanding field of metasurfaces. She is particularly interested in manipulating the optical domain of imaging systems; from both a biological and artificial perspective.

turbulence, resulting in a clearer, more detailed image of deep space and providing astronomers with more information. A laser guide star is projected into the sodium layer of the atmosphere and measuring the distortion of the laser light with a wavefront sensor enables the control system to adjust the shaped the telescope's mirror to compensate for how the various gases refract the light.

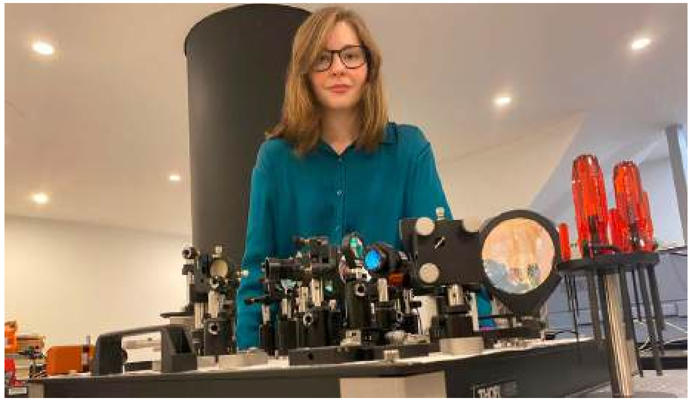
Traditional wavefront sensors use traditional spherical lenses, but like early films, their field of view is limited, so many lenses are needed to capture the full image. Each lens increases the level of noise in the image, obscuring a clear picture. Because the meta-lenslet array uses anamorphic compression and captures more of the picture, it requires fewer lenses, reducing the amount of noise and delivering a clear image of galaxies far from ours.

First author, TMOS post-doctoral researcher Josephine Munro says, "This lenslet array has been designed for the Giant Magellan Telescope, one of three next-generation extremely large telescopes that are scheduled to begin operation in the next decade. Its mirror will be twenty-four meters in diameter and, with adaptive optics, its resolution will be ten times sharper than the Hubble Telescope. With the significant amount of funding that has gone into the development of this telescope by governments, universities, private donors and philanthropic organisations, it is essential that the images produced are the highest possible quality, hence our research into improving adaptive optics with cutting edge meta-optics technology."

The primary challenge of using traditional lenses in an adaptive optics system is that because the laser is a column of light and not a point of light like a star, lenses farther from the laser experience elongated focal spots. Elongated focal spots have a detrimental effect on the computer algorithm that determines how the mirror needs to adapt. This is particularly true when the elongation extends beyond the boundaries of a size pixel on the detector. The researcher's anamorphic compression meta-lenslet array corrects the focal spot distortion.

Munro says, "This study presents the first design of a metasurface-based array to directly and uniquely minimize the effects of laser guide-star elongation for Slack-Hartmann wavefront sensors. In modelling, the meta-lenslets achieved an image size reduction of 50–100% compared with traditional spherical lenses."

"Overall, the anamorphic compression does not affect the sensitivity achieveable with the meta-lenslet array. This is because the anamorphic compression has two effects on the wavefront sensor behaviour that cancel each other out. The first relates to the decrease in effective focal



length and the second relates to the decrease in the full-width-half-maximum of the spot. There is some residual laser guide star image elongation, but it offers a significant improvement."

TMOS Chief Investigator Andrey Sukhorukov says, "The next steps for this research will be to fabricate a prototype made with silicon to verify the performance of the meta-lenslets with a range of anamorphic compression ratios. Once the design is validated, further samples can be made with titanium dioxide, which will gain a higher throughput efficiency. It is our hope that this work will integrate with existing plans for the Giant Magellan Telescope and that the resulting deep-space images that come from it provide insights that change our understanding of the universe."

For more information about this research, please contact connect@tmos.org.au

Metasurface-based toroidal lenslet array design for addressing laser guide star elongation

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Josephine Munro, Sarah E. Dean, Neuton Li, Israel J. Vaughn, Andrew W. Kruse, Tony Travouillon, Dragomir N. Neshev, Robert Sharp, Andrey A. Sukhorukov

The Giant Magellan Telescope will use laser tomography adaptive optics to correct for atmospheric turbulence using artificial guide stars created in the sodium layer of the atmosphere (altitude ≈90km≈90km). The sodium layer has appreciable thickness (≈11km≈11km), which results in the laser guide star being an elongated cylinder shape. Wavefront sensing with a Shack–Hartmann is challenging as subapertures located further away from the laser launch position image an increasingly elongated perspective of the laser guide star. Large detectors can be used to adequately pack and sample the images on the detector; however, this increases readout noise and limits the design space available for the wavefront sensor. To tackle this challenge, we propose an original solution based on nano-engineered meta-optics tailored to produce a spatially varying anamorphic image scale compression. We present meta-lenslet array designs that can deliver ≈100%≈100% of the full anamorphic image size reduction required for focal lengths down to 8 mm and a greater than 50% image size reduction for focal lengths down to 2 mm. This will allow for greatly improved sampling of the available information across the whole wavefront sensor while being a viable design within the limits of current-generation fabrication facilities.

Read the full article

Infrastructure and Capabilities Committee Chair Report

ICC Chair, Professor Kenneth Crozier

The TMOS Infrastructure and Capabilities Committee (ICC) is dedicated to ensuring that all TMOS researchers have the infrastructure they need. We are happy to report that the 2023 ICC objectives were met. These included expanding the equipment register, increasing awareness of facilities, supporting bids for the ARC Linkage Infrastructure Equipment Facilities (LIEF) program, utilising computing time through the National Computational Infrastructure (NCI), and maintaining strong communication with ANFF.

HIGHLIGHTS OF THE YEAR FOR 2024:

The ICC facilitated inter-node collaborations in TMOS. This included Dr Sejeong Kim (AI, UniMelb) visiting the quantum photonics lab at UTS in late 2024 to perform photoluminescence measurements. Mr Henry Tan and Dr Jiajun Meng (both from UniMelb) visited UWA to perform measurements on infrared spectrometers in late 2024. Lastly, electron beam lithography was performed at ANU to support a project being led by UWA.

The ICC farewelled Professor Francesca Lacopi, who left TMOS for an exciting opportunity in the semiconductor industry in the USA. The ICC welcomed Professor Igor Aharonovich and Professor Milos Toth, who will now represent UTS on the ICC.

ACTION ITEMS FOR 2025

1. Expand the Centre's equipment register by adding new infrastructure.
2. Promote awareness of existing facilities within the Centre to foster greater collaboration.
3. Assist with funding and access proposals from TMOS researchers and others, including initiatives like the ARC LIEF program and NCRIS funding.

The ICC plays a key role in promoting collaboration – for example, facilitating visits by Dr Jiajun Meng and Mr Henry Tan to UWA.

"I visited UWA in November 2024 to collaborate with Dr Umana Membreno. We used their spectroradiometer to measure the spectral responsiveness of my mid-infrared metasurface microspectrometer. We obtained promising results and submitted a conference abstract."- Dr Jiajun Meng (TMOS Research Fellow, UniMelb).

"In December 2024, I travelled to UWA for a week to collaborate with Dr Dilusha Silva and Dr Gurpreet Singh. We used their shortwave infrared monochromator setup to perform spectral reconstruction with Dr Singh's. MEMS-tunable Fabry-Perot filters. This was generously supported by a cross-node exchange award." Mr Henry Tan (TMOS PhD student, UniMelb).

The ICC also facilitated progress on a collaborative multi-node TMOS project between UWA, ANU and Duke. The aim is to demonstrate infrared detection using molecular beam epitaxy MBE-grown HgCdTe active layers that are only 100 nm thick. A prototype device is being made at UWA using established in-house know-how that was complemented by access to ANU's newly established EBL capability.

The ICC wishes all TMOS members the best of luck with their experiments and simulations in 2025.

Professor Kenneth Crozier
Infrastructure Committee Chair

COMMITTEE MEMBERS:

PROFESSOR KENNETH CROZIER
Chief Investigator
UoM (Chair)

PROFESSOR HOE TAN
Chief Investigator
ANU

ASSOCIATE PROFESSOR MARIUSZ MARTYNIUK
Chief Investigator
UWA

PROFESSOR FRANCESCA IACOPI
Chief Investigator
UTS

PROFESSOR MILOS TOTH
Chief Investigator
UTS

PROFESSOR IGOR AHARONOVICH
Chief Investigator
UTS

PROFESSOR SHARATH SRIRAM
Chief Investigator
RMIT

KATHY PALMER
Node Administrator
UoM

Industry Liaison Committee Chair Report

Industry Liaison Committee Director, Lorenzo Faraone

In 2024, the Industry Liaison Committee (ILC) had a highly successful year, focusing on refining the management of Flagship Projects, improving IP handling within the Centre, and strengthening strategic collaboration both across nodes and with external industry partners. We also had a change of leadership with the Chair Professor Francesca Iacopi taking up the role of Director at IMEC Indiana R&D, passing on her ILC duties to Professor Lorenzo Farone.

Key discussions emphasized the acceptance of Flagship Project submissions year-round, prioritizing project readiness and flexibility over competition for funding. The importance of cross-node collaboration and regular communication with research program managers was reinforced, with action items including clearer communication around the Flagship Project submission process and the exploration of alternative funding mechanisms.

Major highlights for 2024 include:

- **Establishment and consolidation of the Flagship Project on Advanced Infrared Detectors**, aiming to develop technology that merges a meta-lens array with a mid-infrared imaging array. Success in this project would enable higher performance imaging arrays capable of operating at higher temperatures than current cryogenic standards.
- **Award of an Australian Economic Accelerator seed grant**, titled "Towards passive long-range missile detection based on adaptive multi-spectral mid-wave infrared thermal imaging," in collaboration with industrial partner Arkeus (Melbourne).
- **Signing of an IP licensing agreement with Magic Wavelength** for the commercialization of MEMS-based spectroscopic sensing technology, targeting precision agriculture applications.

The committee also addressed intellectual property (IP) management, highlighting the need for clear guidelines and processes to navigate the differing policies across universities. A proposal was made to expand Key Performance Indicators (KPIs) to include formal collaboration agreements and to recognize a broader range of IP, such as know-how and trade secrets. Additionally, the scope of the "TMOS area of work" was confirmed to encompass all optics-related industries, and tracking TMOS alumni in industry was prioritized to help measure the Centre's economic impact.

Progress was made toward transitioning key projects into cross-node initiatives, although challenges were identifiedThe results of the ADSTAR program were also presented, showcasing significant achievements and potential for future collaboration. Future plans include enhancing the TMOS conference with more interactive activities and ensuring strong PhD student representation.

Looking ahead, the committee remains focused on refining Flagship Project processes, strengthening cross-node collaboration, and acting on the actions and recommendations coming from the ARC mid-term review. Key next steps include a planning day to review progress and further refine KPIs to align with the Centre's evolving needs.

Lorenzo Faraone
Industry Liaison Director

ACTION ITEMS FOR 2025

1. Continue to refine the Flagship Project Processes, strengthening cross-node collaboration
2. Hold a planning day for the ILC
3. Begin planning a 2026 industry show case
4. Host a 'shark tank' at the TMOS conference for Centre members to gain external feedback on their ideas

COMMITTEE MEMBERS:

PROFESSOR FRANCESCA IACOPI

Chief Investigator

UTS (Chair)

PROFESSOR LORENZO FARAONE

Chief Investigator

UWA (Deputy Chair)

PROFESSOR DRAGOMIR NESHEV

Centre Director

ANU

PROFESSOR ANN ROBERTS

Chief Investigator

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Associate Investigator

UTS

SAMARA THORN

Public Relations Specialist

ANU (Engagement Manager)

DR. ROCIO CAMACHO MORALES

Postdoctoral Researcher

ANU

DR. PETER FRANCIS MATHEW ELANGO

Postdoctoral Researcher

RMIT (Flagship Manager)

DR. MEHRAN KIANINIA

Associate Postdoctoral Researcher

UTS (Flagship Manager)

DR. LUKAS WESEMANN

Postdoctoral Researcher

UoM (Flagship Manager)

PROFESSOR KEN CROZIER

Chief Investigator

UoM

PROFESSOR DILUSHA SILVA

Associate Investigator

UWA

PROFESSOR SHARATH SRIRAM

Chief Investigator

RMIT

KAREN KADER

Secretary

UWA (Admin)

TMOS Cross Node and Partner Investigator Exchange Award

The ARC Centre of Excellence for Transformative Meta-Optical Systems (TMOS) is delivering an ambitious program of research across five Australian Universities. It is also collaborating closely with its international Partner Investigators to further the field of meta-optics globally. To deliver on its research program, it must work collaboratively across all universities and research groups.

Each year, TMOS invites applications from HDR and Early Career Researchers to propose and implement projects of work that require engagement across two or more nodes or with a Partner Organisation. The award is up to $2000 for domestic projects and $4000 for international projects to cover travel and accommodation costs.

PARTNER EXCHANGE AWARD

Fedor Kovalev (Australian National University) to visit City University of New York

Project: Advancing Parametric Metasurfaces for Electromagnetic Wave Amplification and Up-Conversion

This project aims to develop and experimentally validate parametric metasurfaces capable of amplifying and converting electromagnetic waves to higher frequencies. The research investigates a novel time-varying metasurface design that utilises split-ring resonators (SRRs) with embedded varactor diodes for frequency up-conversion.

Researchers will explore a parametric amplification method that enables electromagnetic waves to be converted to higher frequencies with amplification. The metasurfaces will be designed and modeled at the Australian National University (ANU) before being fabricated and tested at the City University of New York (CUNY). The experimental validation, conducted in collaboration with CUNY's Advanced Science Research Center, will confirm the effectiveness of the metasurfaces and refine their design. The study also aims to develop new metasurface concepts and publish findings in a joint research article.

This project has significant implications for advancing metamaterials and electromagnetic wave manipulation. The findings could contribute to the development of more efficient communication technologies, improve small antenna performance, and overcome fundamental electromagnetic limitations. By validating new up-conversion techniques, this research paves the way for innovative applications in microwave, terahertz, and higher frequency ranges.

Valencia Molina, Australian National University, to visit City University of New York

Project: Infrared Imaging Processing by Nonlinear Up-Conversion in Nonlocal Metasurfaces.

This project aims to develop advanced infrared (IR) imaging techniques by utilising nonlinear up-conversion in nonlocal metasurfaces. The goal is to efficiently convert IR light into visible wavelengths, enabling high-quality imaging with reduced noise and improved resolution for applications such as night vision, environmental monitoring, and medical diagnostics.

Traditional IR imaging relies on semiconductor-based detectors, which face challenges such as high noise and low-temperature operation requirements. This project explores an innovative approach using sum-frequency generation (SFG) in high-Q lithium niobate ($LiNbO3$) meta surfaces to overcome these limitations. By leveraging the unique properties of nonlocal metasurfaces, the research aims to enhance conversion efficiency while preserving image quality. The project also investigates Fourier-based image processing techniques for real-time edge detection and improved imaging capabilities. The experimental phase will be conducted in collaboration with the City University of New York (CUNY) under the guidance of Prof. Andrea Alù's research group, a leader in metasurface engineering.

The successful implementation of this technology could revolutionise infrared imaging by providing compact, high-resolution, and efficient imaging systems. Applications include enhanced night vision, improved medical imaging techniques, and more accurate environmental monitoring. By integrating cutting-edge materials and advanced image processing, this research paves the way for next-generation IR imaging solutions with widespread industry impact.

CROSS NODE EXCHANGE AWARD

JiJuang Meng, University of Melbourne, visited the University of Western Australia

Project: Reconstructive Infrared Microspectrometers

The aim of this project was to enhance infrared (IR) spectroscopy by developing compact, low-power microspectrometers using cutting-edge metasurface and micro-electromechanical systems (MEMS). The research focuses on two prototypes: a longwave infrared (LWIR) device from the University of Melbourne (UoM) and a shortwave infrared (SWIR) device from the University of Western Australia (UWA).

The visit to the University of Western Australia (UWA) in November 2024 was highly successful. In collaboration with A/Prof Gilberto Umana Membreno, we utilized their advanced spectroradiometer system to measure the spectral responsivity of my mid-infrared metasurface microspectrometer device. Despite the complexity and time-intensive nature of the experiments, we successfully obtained promising results that substantiate the efficacy of the device.

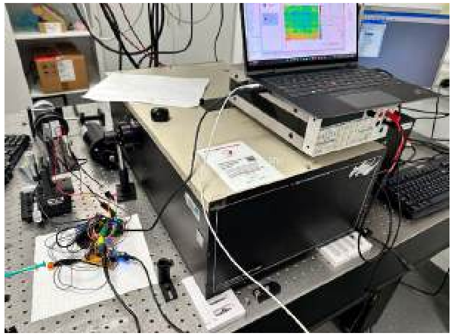
This collaboration has highlighted the importance of access to specialized equipment and expertise in advancing research in optical technologies. The opportunity to work hands-on with UWA's spectroradiometer was instrumental in achieving our research objectives. I am deeply grateful for the support and hospitality provided by A/Prof. Umana Membreno and his team, which not only facilitated our successful measurements, but also offered critical insights that will guide the next stages of our Project.

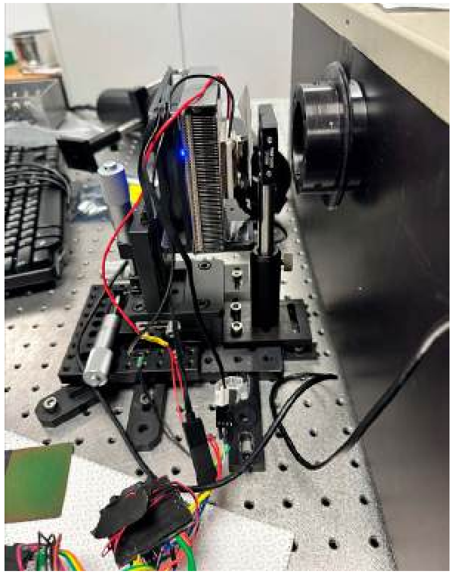
Henry Tan, University of Melbourne, visited the University of Western Australia

Project: MEMS-based reconstructive infrared microspectrometer

The goal of the collaboration was to show spectral reconstruction with UWA's microelectromechanical-tunable Fabry-perot filters for chemical identification. In this setup, the tunable filter is illuminated with a background source, and the unknown sample is placed in between. As the filter is swept across its tuning range, the material's spectrum can be reconstructed from the resulting detector measurements. This setup for chemical identification has been demonstrated extensively at the University of Melbourne for metasurface filter-arrays. Unfortunately, material spectra could not be reconstructed from the measurements collected during the cross-node exchange.

"The cross-node exchange program offers a valuable opportunity to engage with other TMOS nodes. The chance to work together with others, using their labs and equipment, further deepens your professional connections within the TMOS community. There are many spontaneous interactions that do not emerge in online settings, such as sharing practical tips and tricks about experimental setups and methods. Outside of the research outcomes, the chance to expand your professional network beyond your own node is invaluable."





Reconstructive Infrared Microspectrometers

Engagement & Culture

IDEA Committee Chair Report

IDEA Committee Chair, Professor Madhu Bhaskaran

In 2024, the IDEA Committee welcomed a new IDEA Officer, Ms Eleanor Luond, to TMOS. Reintroducing the Culture Survey provided valuable insights into TMOS members' experiences. The Committee's focus was to improve Centre member experience and provide more education on how the IDEA Committee can support them.

Our 2024 major IDEA action items:

- Reintroduced and conducted the TMOS Culture Survey twice to assess the effectiveness of new initiatives and guide IDEA activity.
- Launched a new IDEA sub-page on the TMOS website to showcase our achievements and offer best practice resources, supporting other Centres at the start of their IDEA journey.
- Partnered with operations to establish robust gender tracking systems, ensuring effective implementation of the women-first recruitment procedure which was approved in 2023.

The IDEA Committee remains committed to Centre-wide and leadership training. In 2024, we introduced TalentLMS, an online learning platform, requiring all members to complete four training modules on Encouraging Different Opinions, Celebrating Diversity, Neurodiversity, and Recognising Privilege.

For leadership training, we incorporated survey feedback and conducted a short survey for Chief Investigators and Research Program Managers to tailor learning approaches. This informed a 90-minute session during the mid-year Planning Day in Sydney (17 June 2024), facilitated by Associated EAP, focusing on empathy, psychological safety, and inclusive leadership.

To evaluate progress, we conducted Culture Surveys in February and November. Recognising the need for more real-time feedback, we introduced an ongoing feedback form and exit interviews. Together, these mechanisms provide data-driven insights to inform leadership decisions and continuous improvement.

*The University of Technology Sydney hosted a purple themed afternoon tea for **Wear it Purple Day** on 30th August*

Following survey results, we implemented actions to enhance member experience, including:

- **Social Engagement:** Forming a social committee and integrating team-building exercises into major conferences.
- **Leadership Development:** Expanding training and encouraging more one-on-one check-ins.
- **Communication Improvements:** Enhancing the bi-weekly newsletter with updates from nodes and committees and using Science Tuesday events for Centre-wide updates.

*RMIT University spent an afternoon playing board games and eating food for **RUOK Day** on the 12th September.*

*University of Western Australia spent an afternoon eating traditional food and sharing the history of **Diwali** on the 31st October*

A key focus has been increasing awareness of IDEA resources. While we have developed strong support structures over the past three years, we recognize that Centre members may not always be aware of available resources. To address this, we launched a dedicated IDEA webpage, which highlights our achievements and serves as a best-practice guide and central hub for policies, procedures, and news. Additionally, we updated our induction workbook and created an internal resource banner for calendar invites and newsletters to improve accessibility.

The women-only recruitment procedure, a key 2023 initiative, required significant operational coordination to ensure alignment across TMOS and affiliated universities. Before policy implementation, we refined data reporting by clarifying membership definitions and identifying critical roles to proactively address capability gaps. Collaboration with university recruitment teams ensured adherence to the procedure.

Throughout 2024, we also worked with the IDEA working group to organise five key events: National Reconciliation Week, Wear It Purple Day, RUOK Day, Mid-Autumn Festival, and Diwali, reinforcing our commitment to inclusion and cultural awareness.

Our event for National Reconciliation Week (27th May to 3rd June) was held at ANU. We partnered with an Indigenous owned catering company called Ribanas Catering who work with Supply Nation to offer our TMOS members a range of delouse cakes, some of which included strawberry gum brownies and lemon myrtle cupcakes.

The UTS organised an event for Wear it Purple Day (30th August). We hosted a purple themed afternoon tea to show our support from the LGBTQIA+ community. In addition to this, we featured a QR code on all our newsletters and at our events which asked the questions "What's your passion?" to highlight the theme "your pride, your passion."

RMIT University organised an event for RUOK Day (12th September). We spent a few hours playing board games, giving our team a chance to step away from their daily routines, disconnect from screens, and reconnect with each other. Building a strong sense of community has never been more important in today's fast-paced world.

The University of Melbourne organised an event for Mid-Autumn Festival (17th September). We celebrated by spending the afternoon sharing personal stories about the moon and enjoying a variety of delicious mooncakes. The festival takes place when the moon is at its fullest, symbolising completeness and unity.

The University of Western Australia organised an event for Diwali (31st October). We celebrated by spending an afternoon sharing presentations, enjoying some traditional food, listening to music, and having some great conversations together about the meaning of Diwali.

The IDEA Committee remains committed to championing the importance of IDEA across our Centre and supporting members throughout their IDEA journey.

Professor Madhu Bhaskaran
IDEA Committee Chair

ACTION ITEMS FOR 2025

- Partner with the Education and Professional Development (EPD) Committee to deliver impactful and engaging training programs to the Centre.
- Work with the Outreach Committee to develop activities that support and celebrate our culturally and linguistically diverse (CALD) community.
- Focus on proactive initiatives to sustain and improve gender balance within the Centre.

COMMITTEE MEMBERS:

PROFESSOR MADHU BHASKARAN

Chief Investigator

RMIT (Chair)

ELEANOR LUOND

IDEA Officer

RMIT

SHARYN MCFARLANE

Chief Operations Officer

ANU

PROFESSOR DRAGOMIR NESHEV

Centre Director

ANU

WORKING GROUP MEMBERS:

MARCUS CAI

HDR Representative

ANU

LONGSIBO HUANG

PhD Student

ANU

YAN LIU

PhD Student

UWA

DR. PETER FRANCIS MATTHEW ELANGO

Postdoctoral Researcher

RMIT

DR. JIAJUN MENG

Postdoctoral Researcher

UoM

DR. KRISHNA MURALEEDHARAN NAIR

Postdoctoral Researcher

RMIT

DR. PHUONG LE YEN

Postdoctoral Researcher

RMIT

DR. KHOSRO ZANGENEH

Postdoctoral Researcher

ANU

BEN WHITEFIELD

PhD Student

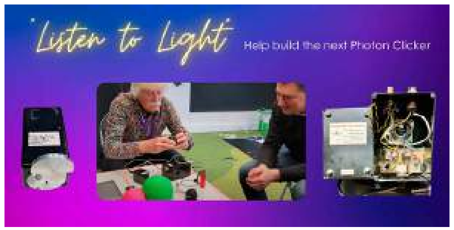
UTS

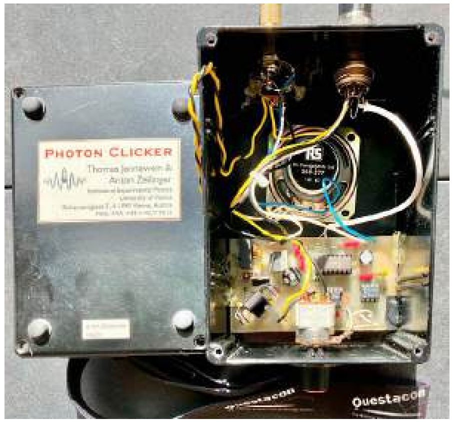
Outreach Committee Report

Igor Aharonovich, Outreach Director and Camilla Gazzana, Outreach Officer

In 2024, our collaboration with Questacon remained strong, focusing on the Photon Clicker project, science communication training, and partnerships. Key milestones included completing Photon Clicker prototypes, developing learning materials, and launching the project on International Day of Light (May 16, 2024). Work on the 'Catalogue of Cool' exhibition continues with Questacon's exhibition team. The Photon Clicker Team, alongside Patrick Helean and Hans Bachor, is leading these efforts, with the Outreach Committee playing a significant role.

Photon Clicker project





Our school outreach visits expanded, with Loxton Lutheran Primary School (SA) engaging us through the STA Superstars of STEM program. We spoke to around 110 Year 3-6 students about STEM careers and interacted with Year 5 students in their science class. Additional visits included John Edmondson High School (NSW), Garran Primary School, Radford College (ACT), and Coolbinia Primary School (WA), where we discussed holograms and light diffraction for students in year 4 and above. Coolbinia students also toured UWA's laboratories, while Mac.Robertson Girls' High School students spent a week at RMIT for hands-on work experience in electronics labs.

Beyond schools, we participated in key outreach events, including a presentation at Science Meets Parliament in Victoria on increasing GDP spending on R&D. We also celebrated International Day of Light on university campuses, with hands-on demonstrations at Monash University, where students could learn about holograms, and a well-received seminar at the University of Melbourne's Physics Students Society on meta-surfaces.

The TMOS Outreach team also supported several STEM education initiatives, such as the STEM Education and Industry Forum 2024 event in Parramatta, NSW, the NSW Smart Sensing Network (NSSN) series for women leaders, and the opening of the new accelerator at the Ion Beam Centre by Professor Jagadish Chunnupathi, President of the Australian Academy of Science, at Surrey University, Guildford, England.

This year, the Outreach team bid farewell to their Outreach Coordinator, Camilla Gazzana, who stepped down from her position in June. The team warmly welcomed Sophia Aharonovich as the new Outreach Coordinator in October.

School visit: John Edmondson High School

ACTION ITEMS FOR 2025

1. Continue to develop Senior STEM Engagement Program across all nodes
2. Demonstrate working prototype of Photon Clicker in Science EXPO Japan with Partner Organisation Questacon
3. Deliver Science Communication Training Workshop with Partner Organisation Questacon for the outreach committee members
4. Develop new connections through education conferences and networking
5. Develop new connections with the communities via public libraries
6. Develop Photon clicker related workshops for Public School teachers use
7. Develop DIY Photon Clicker kit
8. Prepare a Science Bus Outreach Program to travel in October-November from Perth to Sydney, 2025 or in 2026 based on public school schedules

COMMITTEE MEMBERS:

PROFESSOR IGOR AHARONOVICH

Chief Investigator
UTS (Chair)

CAMILLA GAZZANA

Outreach Officer
UTS (Secretariat)

SOPHIE AHARONOVICH

Outreach Coordinator
UTS

HENRY TAN

HDR Representative
UoM

PATRICK RUFANGURA

HDR Representative
UTS

BENJAMIN RUSSELL

HDR Representative
UoM

FEDOR KOVALEV

ECR Representative
ANU

DANIEL MORLEY

HDR Representative
UWA

MICHAL ZAWIERTA

ECR Representative
UWA

YING ZHI CHEONG

HDR Representative
RMIT

SARAH DEAN

HDR Representative
ANU

MADELINE HENNESSEY

HDR Representative
UTS

NEUTON LI

HDR Representative
ANU

A/PROF. MARIUSZ MARTYNIUK

Chief Investigator
UWA

SHARYN MCFARLANE

Chief Operations Officer
ANU

JINLIANG REN

HDR Representative
ANU

Hands on Experience at National Science Week

In August 2024, the TMOS Outreach Committee took an active role in National Science Week as part of The Sydney Science Trail. This annual event ignites curiosity and fosters a deeper understanding of scientific concepts among both primary and secondary students. With a series of interactive programs and excursions, the Trail offered visitors an immersive, hands-on experience that aligned perfectly with our outreach objectives.

At the heart of our participation was the Photon Clicker, an innovative outreach activity designed to engage and educate. Delivered by our enthusiastic and knowledgeable team—Sergei Nerdic, Angus Gale, and Otto Cranwell Schaeper—the Photon Clicker brought the complex world of optics into an accessible and interactive format. The activity illustrated how light can be manipulated and measured, creating a tangible connection between abstract scientific principles and real-world applications.

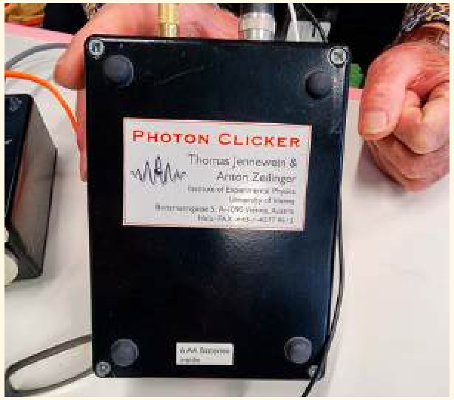
As part of TMOS's mission to promote understanding and enthusiasm for cutting-edge optics and photonics, our presence at the Trail helped bring advanced science directly to the public in an accessible and interactive format.

A key component of the Photon Clicker program was its focus on engaging primary school students. Our team worked closely with children, guiding them through a series of hands-on experiments using diffraction glasses, colored cellophane filters, prisms, and other optical tools. These experiments allowed students to observe how light bends, splits, and changes color, thereby introducing foundational principles of optics in a fun and memorable way.

This direct, interactive engagement not only sparked curiosity but also strengthened the bond between TMOS and educational institutions. By integrating these practical demonstrations within the classroom context, we strived to make advanced optical science both accessible and exciting, ultimately inspiring the next generation of scientists and engineers.

Through the Outreach Committee's involvement, we aimed to inspire the next generation of scientists and engineers by showing how light can be manipulated and measured in ways that are both powerful and transformative. The team's work at the Trail not only reflected our commitment to outreach and education but also embodied TMOS's broader goals of making science accessible, exciting, and relevant to the community.

By engaging directly with students, educators, and the wider community, we have not only sparked interest in STEM fields, but we have also enriched our members' experiences as science communicators. Our continued commitment to outreach is vital in inspiring future innovators and ensuring that science remains a vibrant part of everyday life.



Education and Professional Development Committee Chair Report

Education and Professional Development Committee Co-Chairs, Professor Lan Fu and Professor Milos Toth

The Education and Professional Development (EPD) Committee is dedicated to supporting TMOS students and early career researchers (ECRs) by providing targeted training, professional development opportunities, and fostering collaboration across nodes. The committee strives to equip TMOS members with the necessary skills for academic and industry careers while enhancing research excellence.

In 2024, the committee implemented the objectives outlined in the 2023 action plan, which focused on professional development, mentorship, and inter-node collaboration. The Centre's professional development program was strengthened through initiatives such as Science Tuesdays, a Science Communication Workshop, and grant writing sessions tailored to the needs of ECRs and HDR students. Additionally, the committee organised five colloquia featuring cutting-edge topics, including nanoelectronics, quantum technologies, and machine learning for photonics.

A key milestone was the successful delivery of the **2024 TMOS ECR & Student Conference**, held from July 24 to 26 at RMIT. The conference provided an engaging platform for technical talks, workshops, a poster session, and a pitch competition. Highlights included a career planning session and an industry panel featuring representatives from META Reality Labs, CSIRO, Andromeda Robotics, and MOGLabs. Participant feedback was overwhelmingly positive!

The Science Communication Workshop, delivered on November 6 at ANU by Dr. Janie Brooks, the Communication Officer of ANFF, focused on enhancing the effectiveness of PowerPoint presentations. Attended by 15 ECRs and PhD students, the workshop provided essential skills in content organisation, visual impact, and audience engagement.

Another significant event was the **KOALA Conference**, held from November 25 to 29, at the University of Melbourne. TMOS members played an active role as committee members and presenters, with attendees including plenary speaker Blanca del Rosal Rabes and other PIs and CIs from TMOS.

In alignment with the 2024 mid-term review recommendation of evaluating the supervisory panel's effectiveness, a **Cross-Node Supervision Survey** was conducted to assess student engagement with external supervisors. The findings highlighted the need for a more structured feedback mechanism, which will be a focus in 2025.

The committee also facilitated 18 **Science Tuesday** sessions throughout the year, including two Centre Addresses by the Director.

Professor Lan Fu and Professor Milos Toth
Education and Colloquia Committee Co-Chairs

ACTION ITEMS FOR 2025

Building on the progress made in 2024, the committee will focus on the following initiatives in the coming year:

- Organising the 5th TMOS ECR/HDR mid-year conference with enhanced interactivity and career-focused sessions.
- Expanding the Centre's mentorship program through the Mentorloop platform, with clearer tracking mechanisms to improve engagement.
- Strengthening the effectiveness of the supervisory panel by improving feedback collection and implementation.
- Continuing to develop professional development opportunities through workshops, colloquia, and industry engagement initiatives.

COMMITTEE MEMBERS:

PROFESSOR LAN FU

Chief Investigator

ANU (Chair)

PROFESSOR MILOS TOTH

Chief Investigator

UTS (Chair)

DR. PETER FRANCIS MATHEW ELANGO

ECR Representative

RMIT

DR. FARHAD FOROOZANDEH

HDR representative

UWA

JOSHUA JORDAAN

HDR representative

ANU

DR. JINYONG MA

ECR Representative

ANU

DR. MATTHEW PARRY

ECR Representative

ANU

DR. AISWARYA PRADEEPKUMAR

ECR Representative

UTS

NIKEN PRISCILLA

HDR representative

UoM

LESLEY SPENCER

HDR representative

UTS

KRISZTINA THURZO

ANU (Secretariat)

SHARYN MCFARLANE

ANU

2024 ECR and Student Conference

The 2024 TMOS ECR-Student Conference, held at RMIT University in Melbourne from July 24th to 26th, was a resounding success! It was a truly inspiring gathering, bringing together bright and enthusiastic early career researchers (ECRs) and students for a wonderful exchange of ideas and invaluable professional development. The conference was a celebration of innovation and collaboration, featuring a dynamic program packed with engaging workshops, insightful technical talks, lively poster sessions, collaborative discussions, and an exciting pitch competition.

We kicked off this incredible event with a warm welcome and opening ceremony led by the inspiring Professor Madhu Bhaskaran (RMIT University). Day 1 was filled with practical learning, including empowering workshops on grant writing and budgeting led by the fantastic Dr. Carolyn Dancevic (RMIT University), equipping attendees with essential skills to propel their research careers forward. The day concluded with laughter and connection at a fun trivia night and social event at The Oxford Scholar, fostering a strong sense of community.

Day 2 was a whirlwind of intellectual excitement! We were treated to fascinating technical talks, including a captivating presentation by Dr. Haoran Ren from Monash University on nanophotonic manipulation of light. The afternoon was dedicated to sharing and exploring new research directions through impactful research sessions, vibrant poster sessions, and collaborative discussions. A true highlight was the thrilling pitch competition, where teams showcased their groundbreaking research ideas. Huge congratulations to the Meta Vision team from ANU, UTS, and UoM, winners of the

EVENT ORGANISERS

DR. PETER FRANCIS MATHEW ELANGO

Postdoctoral Researcher

RMIT

JOSHUA JORDAAN

PhD Student

ANU

YING ZHI CHEONG

PhD Student

RMIT

HENRY TAN

PhD Student

UoM

DR. PHUONG LE YEN

Postdoctoral Researcher

RMIT

ELEANOR LUOND

Professional Staff

RMIT

DR. AISWARYA PRADEEPKUMAR

Postdoctoral Researcher

UTS

Judges Choice Award for their innovative "metalens sensing of chiral amino acids for indirect sensing of Parkinson's disease" concept! And a round of applause to the Light and Seek team from UoM and UWA, who captured the People's Choice Award with their brilliant "smart solar cell windows enabled by metasurfaces and photo-switchable molecules" idea. Attendees also had the fantastic opportunity to tour the state-of-the-art Discovery to Device (D2D) and Micro-Nano Research Facility (MNRF) at RMIT University.

Day 3 focused on empowering attendees with valuable professional development. Rachel Service from Happiness Concierge led an uplifting career planning session, followed by an insightful hybrid careers panel featuring the incredible Dr. Aram Arash from META Reality Labs, Dr. Sruthi Kuriakose from CSIRO, Mani Thiru from Andromeda Robotics, and Rob Scholten from MOGLabs. We were also proud to celebrate Wear It Purple Day, fostering a welcoming and inclusive environment for the LGBTQIA+ community. The conference concluded with an inspiring closing ceremony speech by Professor Kenneth Crozier.

The feedback from our ECRs and students was overwhelmingly positive and heartwarming! Conference sessions were highly praised, with the careers panel receiving a phenomenal 99% approval rate, professional development sessions at 96%, collaboration sessions at 90%, technical talks at 90%, and poster sessions at 85%. We value all feedback, and we're excited to incorporate suggestions for future conferences, such as providing fun merchandise, offering more diverse lunch options, and exploring fully in-person careers panels.

Here's what our delighted participants had to say:

"This was the absolute best TMOS ECR-student Conference I've attended! It was packed with everything I needed, from career insights to amazing research collaboration opportunities."

"I absolutely loved the careers panel discussion. It was so insightful and has given me a clear direction for my post-PhD journey."

"The networking and research idea pitching sessions were fantastic. I made wonderful friends and even formed new project collaborations."

The 15th Conference on Optics, Atoms, and Laser Applications (KOALA) 2024

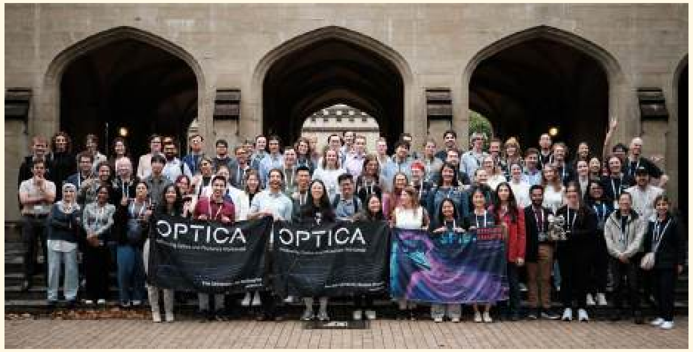
EVENT ORGANISERS:

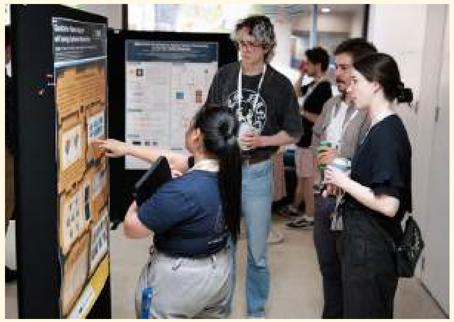
TMOS Students on the committee: Benjamin Russell, Damian Nelson, Niken Priscilla, Ying-Zhi Cheong, Lincoln Clark, and Henry Tan

TMOS Staff who provided significant assistance: Kathy Palmer, Kenneth Crozier, Ann Roberts, Galina Shadrivova

KOALA has returned to Melbourne for the first time in eight years. The 2024 edition saw the student optics societies of The University of Melbourne and Monash University join forces to host the best and brightest optics graduate students from around Australia and New Zealand in the final week of November for a range of academic, social, and career oriented activities.

On the back of KOALA 2023's success, an eleven-strong committee comprising another six TMOS students rose to the challenge of organising the conference. This committee was once again fortunate enough to leverage the guidance and resources available from TMOS' academic and professional staff, and the members of the outgoing KOALA committee. Kathy Palmer provided substantial assistance and advice at almost every step of the way, including the bookkeeping, invoicing, university compliance, venue and equipment hire, and ticketing, and was crucial to the success of the conference. We were also very grateful to have received direct financial support with TMOS joining as silver sponsors.





This edition saw an unprecedented number of attendees, with 91 students descending on Melbourne, and just a single withdrawn registrant. These students hailed from 16 distinct tertiary institutions across Australia, New Zealand, Germany, and Poland. Of note were three TMOS nodes (UoM, ANU, RMIT) and one affiliated University (University of Jena) which contributed 20 attendees between them.

The program brimmed with the usual fare for an academic conference: a dense schedule of plenaries (inc. Blanca del Rosal Rabes), 49 contributed talks, 42 posters, and several social events. It also featured significant IDEA programming, including a KOALA-first IDEA panel. This panel incidentally featured past TMOS IDEA officer, Greg Dennis, who rounded out a trio of academics and advocates who provided thoughtful, and, at times, conflicting insights into what can be done for the advancement of marginalised folks in STEM academia. We also saw the return of an old favourite: the rapid-fire, poster preview session, in which poster contributors lined up to pitch their poster to the audience in just 60 seconds. We saw TMOS' own Fengkai Wei take home the shark tank award at the presentation night.

This year served as the culmination of three years' hard work from three incredibly dedicated committees to reignite Australia and New Zealand's optics student network in the wake of COVID, and TMOS has played a pivotal part in this success. KOALA saw a great mix of first-timers, regulars, and even a handful of alumni at the Industry night. And we expect it to produce many more alumni in the years to come.

EVENT ORGANISERS: STUDENT COMMITTEE

BENJAMIN RUSSELL

PhD Student
UoM

DAMIAN NELSON

PhD Student
UoM

NIKEN PRISCILLA

PhD Student
UoM

YING-ZHI CHEONG

PhD Student
RMIT

LINCOLN CLARK

PhD Student
UoM

HENRY TAN

PhD Student
UoM

TMOS Meta-Together Conference

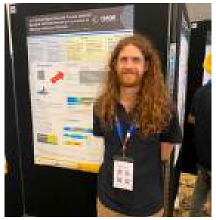
During November 19th-22nd, 2024, the Indian Ocean sands of Scarborough Beach on the West Coast of Australia hosted the third TMOS Meta-Together Conference. Team members gathered at the Rendezvous Hotel Perth Scarborough in an iconic beachfront hotel overlooking the soft white sands and the sparkling blue water. The setting provided an ideal location for collaboration in action, entangling inspiring research discussions with rich opportunities for social beach activities.

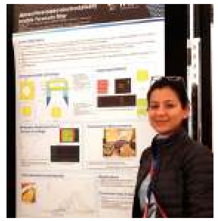
The conference was a perfect blend of knowledge sharing and community building. Thank you to Len Yarran and family members for a stirring Welcome to Country which encouraged us to think about togetherness, shared knowledge and looking after each other.

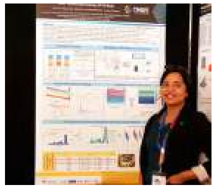
The focus of this conference was on collaboration—between TMOS nodes, with end-users or industry, and with Partner Investigators (PIs). We came together with a shared purpose to connect members of TMOS, exchange research, and foster engagement across the Centre.

Commencing with a planning day, the Chief Investigators engaged in a spirited debate about the Centre's mid-term review and its favourable outcome, as well as constructive suggestions on the Centre's performance measures. Our Director Prof. Dragomir Neshev then addressed the important questions: What have we accomplished? Where are we going next? What is life after TMOS?

> There was plenty of new information and lots of opportunities for collaboration."







Successive conference talks, along with an impressive lineup of invited speakers from around the world, were purposefully selected to be delivered by the student TMOS cohort, with each talk emphasising an ongoing or potential internode collaboration. Everyone did an incredible job!

Social activities kicked off before breakfast at 7am, and we enjoyed a variety of activities including beach volleyball, beach walks, yoga with certified instructor Aayushi Nanda, morning swims, and surfing. These activities were a great way to kick-start conference days and connect with fellow delegates.

A special highlight was the “Bikes for Tykes” team-building activity, where we came together to assemble bikes for children in need. It was great to see everyone collaborating with such enthusiasm and purpose.

The opportunity to meet face to face, share progress made, and celebrate established relationships while developing new collaborative ones was embraced by the entire TMOS team throughout the conference. Our highly anticipated awards night celebrated the achievements of colleagues, recognising their exceptional commitment to TMOS values, their work, and their contributions to our community. Congratulations to all our award winners!

Laurie Faraone, Mariusz Martyniuk and Dragomir Neshev

> We can’t wait to see how research next year builds on what was shared and discovered when we were all #metatogether."

> We had so much fun at the Meta Together conference in Perth! The sun was out (for most of it) and good times were had."

CONGRATULATIONS TO OUR TMOS AWARD WINNERS IN 2024:

Collaboration Award: Jinyong Ma

Industry Engagement Award: Jiajun Meng

Business Team Member of the Year: Kriszti Thurzo

Science Communication Award: Josephine Munro

Education and Professional Development Award: Ying Zhi Cheong

Leadership Award: Peter Elango

Student of the Year Award: Fedor Kovalev

Student of the Year Award: Maryam Setareh

EMCR of the Year: Yana Izdebskaya

TMOS Member of the Year Award: Lukas Wesemann

Better Futures Innovation Challenge: A science meets industry hackathon

On March 19-20, 2024, Australia's brightest research minds joined forces with industry and innovation professionals for a unique deep-tech hackathon. TMOS was proud to be a partner in this unique deep-tech event.

THE GOAL

The hackathon aimed to break down silos between academia and industry, build a pipeline of commercially valuable research, and train the next generation of Australian innovators.

WHAT IS A HACKATHON?

Hackathons are intensive innovation events where teams collaborate to develop new solutions within a set timeframe. These events encourage creativity, teamwork, and problem-solving, often resulting in working prototypes that address real-world challenges.

Hackathons can focus on a wide range of topics, from software development and process improvements to hardware innovations. They typically last from a single day to a full week, culminating in a showcase where teams present their prototypes to judges. Winning teams may receive funding or mentorship to further develop their ideas.

KEY OUTCOMES

Over the two-day event, teams of researchers—including Luke Wesemann, Postdoctoral Researcher from TMOS—developed dozens of innovative solutions to industry challenge which they then pitched to a judging panel.

- **Lukas Wesemann** (from TMOS) was part of the *AidMate* team, which focused on *accelerating logistics in disaster situations.* They went through the whole process of problem discovery, interviewing real potential users, and learned what went wrong initially, developed a business case and build a prototype.
- **Three teams received financial backing and mentorship** to further validate and prototype their ideas.
- **Team Q1** demonstrated their entrepreneurial spirit by using their winnings to prototype an *ultra-sensitive, affordable, and portable quantum seismometer*. In under two months, they developed a feasible pathway to impact and are now working with mentors and universities to patent, publish, and explore commercial opportunities for their innovation.

Hackathon Event Attendees

While not every idea made it to the final pitches, the event fostered incredible creativity and collaboration, reinforcing the value of connecting research with industry.

Here's what TMOS's attendee Lukas Wesemann had to say about the event:

> "The event was a really refreshing experience, because we were exposed to so many different deep-tech industries in a short amount of time. That's quite unusual for academics and gave us the opportunity to learn first-hand how industry approaches research and development.
>
> Overall, great vibe, great people and super interesting topics! Thanks to all the organisers for making this happen."

CASE STUDY

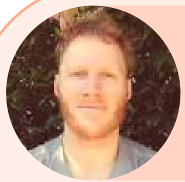
Behind the Scenes with Nobel Laureates: Jake Horder's Insightful Experience at the 2024 Lindau Meeting of Physics

After a very competitive 6-month application process, Jake Horder was selected by the Australian Academy of Science to be among the 10 promising young Australian scientists to attend the Lindau Meeting of Physics Nobel Prize laureates in Lindau, Germany. This meeting happens only once every four years, providing Jake with a unique opportunity to engage one-on-one with the biggest names in the field.

I spent an amazing week in Lindau, southern Germany, among 30 Physics Nobel Laureates and around 500 of the brightest young scientists in the world. The Lindau Meeting is a unique opportunity for emerging researchers to connect with some of the biggest names in the field, and to talk candidly about their lives inside and outside of science. I was honoured to be selected among the Australian delegation, and the success of my application was due to the support of my team at UTS and TMOS.

My lasting impression from the meeting is that the Laureates are mostly normal people like anyone else, and although I had kind of anticipated that, the exact type of normalcy I saw was unexpected. Really, the only thing in common among the Laureates is their passion for their work – in all other respects, they are just as varied in thought and behaviour as any random group of people. It was very helpful to meet personally the people behind the Prize, and not just the image you develop of the persona from reading about their achievements and impact.

It was also a reminder that progress and innovation in physics are not possible alone. Working in groups, and across groups, is essential, and seeing the Laureates communicate in casual conversation it was clear that having the Nobel Prize on your CV is not enough to get your research out there – things happen when individuals talk together, and here the real currency is



SPOTLIGHT

Jake Horder

PhD Student

Jake has pivoted from a career as a structural design engineer (USYD, 2012) to engage with the development of new scientific and commercial technologies built from quantum systems. He is the inaugural graduate (2021) of the Master of Science in Quantum Technology degree at the Australian National University, which he completed with highest honours. Jake joined the UTS group in early 2022 under the competitive RTP scholarship. His PhD work focuses on cryogenic spectroscopy of single photon emitters in hBN, with the dual aim to develop prototype commercialisable quantum devices and to illuminate long-standing questions around the ontology of quantum states.

personability, humility, humour, soft leadership, encouragement. I think my experience at the meeting has given me a new perspective on the real image of a Nobel Prize winner that I ought to be looking up to. It is a much more grounded and honest image, and in that way, it is much more emulatable.

I especially enjoyed hearing from Alain Aspect, who did influential work in my field of quantum optics several decades ago. He was surprisingly blunt and honest about his interpretation of the results seen in entanglement experiments, essentially saying that the results confirmed what the theory predicted, but he didn't have any strong opinion on what physically happens. In fact, he was far more interested in the technological and eventual commercial applications of his discovery. I found this very motivating since I also have many deep philosophical questions about quantum mechanics, but I also have a desire to transform our control of quantum systems into commercial products. So chatting with Alain, I saw he had made that trade off and was still very excited about his work – he had given up trying to understand exactly how the quantum world works and had instead dived into helping build the quantum technology industry.

> Seeing the Laureates communicate in casual conversation it was clear that having the Nobel Prize on your CV is not enough to get your research out there – things happen when individuals talk together, and here the real currency is personability, humility, humour, soft leadership, encouragement."

Digital Media

63,609

Website page views

TOP 5 PAGES

1. New all-optical approach to revolutionise night vision technology
2. What is Meta-Optics
3. News
4. About TMOS
5. Work with TMOS

17,497

Unique website visitors

TOP 5 VISITOR COUNTRIES

1. Australia
2. United States
3. Germany
4. India
5. China

27

Posts on the TMOS website in 2024

TOP 3 POSTS

1. Old movies and new tech to allow us to see back in time with deep space imaging.
2. New all-optical approach to revolutionise night vision technology.
3. Continuous non-invasive glucose sensing on the horizon with the development of a new optical sensor.

SOCIAL MEDIA

2,012 (300 new)

X FOLLOWERS

2,002 (424 new)

LINKEDIN FOLLOWERS

50 (6 new)

TIKTOK FOLLOWERS

87 (2 new)

INSTAGRAM FOLLOWERS

132 (27 new)

YOUTUBE SUBSCRIBERS

26

YOUTUBE VIDEOS

8,884

YOUTUBE VIEWS

Performance

Key Performance Indicators

Performance Measure		Actual Y0 2020	Actual Y1 2021	Actual Y2 2022	Actual Y3 2023	Target Y4 2024	Actual Y4 2024	Perform. rate 2024
Number of research outputs	Journal articles	92	87	100	119	100	136	136%
	Book chapters	1	1	0	3	3	6	200%
	Patents (filing provisional patents and higher)	1	1	2	8	5	5	100%
Quality of research outputs	Cross-node publications[1]	2	2	4	4	30	9	30%
	Publications with PIs[2]	3	2	4	4	15	5	33%
	High impact publications (in top 10% in the field, e.g. IF>9)	17	20	28	28	15	33	220%
	Top-impact publications (in top 3% of the field, e.g. Nature/ Science family)	10	7	5	9	3	9	300%
Number of workshops/ conferences held/offered by the Centre	Centre annual workshop (conference)	0	0	2	1	1	1	100%
	Conference facilitation	0	4	8	9	2	8	400%

1. We are contining to address our low cross-node publication rate with travel awards and centre events
2. International travel is proving increasingly expensive and complex, limiting travel options for many of the team. We continue to offer travel awards and bring PIs to Centre Events

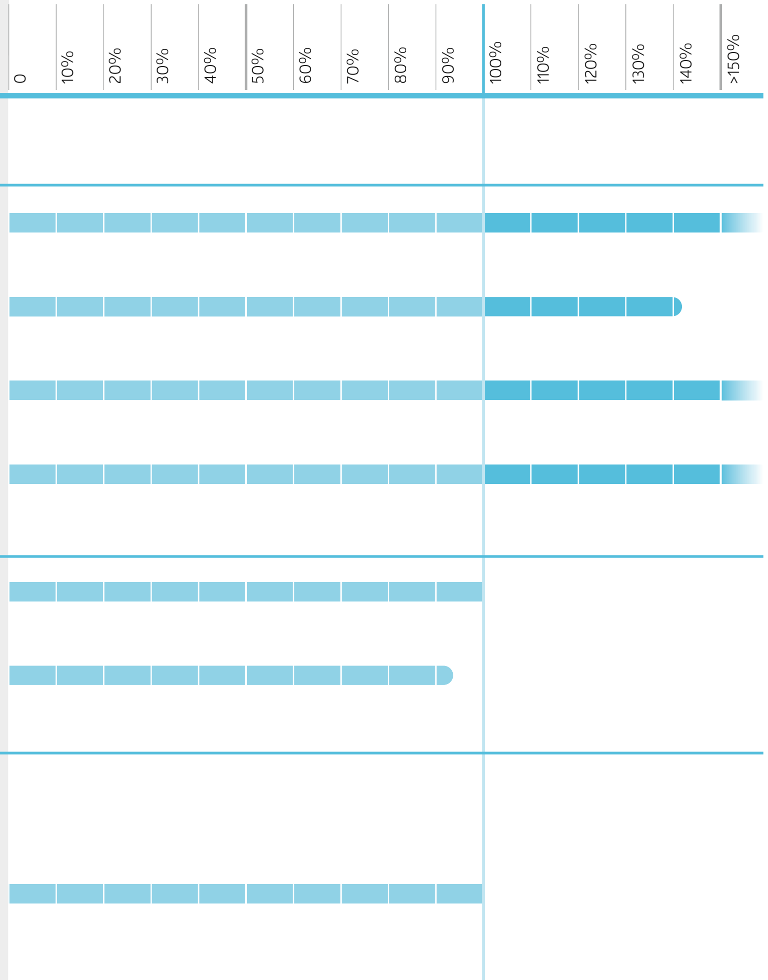
Performance Measure		Actual Y0 2020	Actual Y1 2021	Actual Y2 2022	Actual Y3 2023	Target Y4 2024	Actual Y4 2024	Perform. rate 2024
Number of training courses held/offered by the Centre	Professional development courses	0	3	4	5	3	11	367%
	Topical workshops and courses	0	19	11	8	3	4	133%
	Centre-wide Seminar Program, number of presentations	0	18	21	20	20	18	90%
Number of additional researchers working on Centre research	Postdoctoral researchers (new)	3	15	5	2	6	8	133%
	Honours and undergraduate students (new)	1	6	1	4	6	5	83%
	TMOS HDR students (PhD and Masters new)[3]	0	11	16	10	15	8	53%
	Masters by coursework students (new)	0	0	0	3	6	0	0%
	Associate Investigators (new)	0	0	1	4	2	5	250%
Number of postgraduate completions	Number of postgraduate completions				4	15	4	27%
	Women HDR completions (percentage of the cohort)	0	0	31	25	35	38	109%
Number of mentoring programs offered by the Centre	PI-Student Exchange Program[4]	0	0	0	3	6	4	67%
	Mentors within the Centre[5]	0	0	19	13	20	14	70%
	Number of mentees	0	0	21	22	30	23	77%

3. Student recruitment is an increasingly challenging space for the Centre but we continue to develop new recruitment campaigns to target potiential students
4. We may broaden the scheme to AIs for 2025 to provide a broader range of travel destinations
5. Efforts are underway to promote the program for 2025

Performance Measure		Actual Y0 2020	Actual Y1 2021	Actual Y2 2022	Actual Y3 2023	Target Y4 2024	Actual Y4 2024	Perform. rate 2024
Number of presentations/ briefings	To the public (Outreach/public engagement events, public lectures)	4	4	14	12	15	13	87%
	To government (parliamentarians and department/agencies at both State and Federal level)	1	0	6	7	3	9	300%
	To industry/business/end users (documented) incl. DSTG, CSIRO	3	5	3	20	10	20	200%
	To non-government organisations	1	3	6	8	3	4	133%
	School visits[6]	2	4	6	13	8	6	75%
Number of new organisations collaborating with, or involved in, the Centre	Academic collaborations (new)	4	6	10	8	3	6	200%
	Industry and end user partnerships (new)	4	10	7	9	3	12	400%
Number of female research personnel	Women and diverse gender, % (double the discipline mean)	33	25	36	32	37	38	103%

6. Due to staffing changes we were not able to meet our target in 2024

Performance Measure		Actual Y0 2020	Actual Y1 2021	Actual Y2 2022	Actual Y3 2023	Target Y4 2024	Actual Y4 2024	Perform. rate 2024
Centre-specific KPIs								
Research	Plenary talks at international conferences	2	3	12	11	3	17	567%
	Keynote and Invited talks at international conferences	21	41	41	63	45	64	142%
	Awards and fellowships to CIs, ECRs and AIs	11	10	14	23	10	21	210%
	Additional research income secured by Centre staff ('000)	4,410	19,749	5,957	21,362	2,000	3,371	169%
Equity and Diversity	Leadership Skills Training, % of Centre personnel (CIs)	100	0	0	100	100	100	100%
	IDEA Training, % of Centre personnel	0	100	90	87	100	93	93%
IP uptake by end-users	Start-up companies	0	1	2	3	0	0	N/A
	IP uptake by end-users[7]	0	0	6	0	3	0	0%
	Number of TMOS alumni employed in industry	0	0		2	2	2	100%



7. We have increased our relationships with industry but have not converted this to IP uptake yet

Performance Measure		Actual Y0 2020	Actual Y1 2021	Actual Y2 2022	Actual Y3 2023	Target Y4 2024	Actual Y4 2024	Perform. rate 2024
Centre-specific KPIs								
Education	Associate TMOS HDR students (PhD and Masters, new)[8]	16	26	1	3	15	5	33%
	Centre-member attendees at training workshops (total)	0	0	129	109	90	94	104%
	Non-Centre member attendees at training workshops	0	0	16	26	20	12	60%
	HDRs visiting PIs[9]	1	0	3	5	10	1	10%
Outreach	Media releases[10]	2	10	13	22	20	15	75%
	Media mentions	38	170	20	21	20	231	1,155%
	Twitter followers (new)	477	445	396	394	100	300	300%
	Outreach hours (Direct contact hours only)	22	26	59	79	70	190	271%

8. Refer to 3
9. Refer to 4
10. We had reduced resources for media release development

Finance

INCOME STATEMENT 2024

REPORTING PERIOD	2024	2025
	Actual ($)	Forecast ($)
Opening Balance (total funds)	**11,867,117**	
INCOME		
ARC[1]	5,825,226	6,058,597
Australian National University	415,988	413,357
The University of Melbourne	179,548	159,011
RMIT University	246,792	226,564
University of Technology Sydney	404,857	404,857
The University of Western Australia	159,725	159,725
Consultancies	–	–
Government grant/sponsorship	–	
TOTAL INCOME	**7,232,136**	**7,422,110**

REPORTING PERIOD	2024	2025
EXPENDITURE	Actual ($)	Forecast ($)
Personnel	4,497,519	4,947,271
Equipment	107,746	118,521
Scholars Expenses	664,328	710,831
Travel	549,624	577,105
Other[2]	1,237,012	1,068,383
TOTAL EXPENDITURE	**7,056,229**	**7,422,110**
CARRY FORWARD (TOTAL)	**12,043,024**	
CARRY FORWARD TO 2025	**5,592,903**	
CARRY FORWARD TO 2027[3]	**6,450,121**	

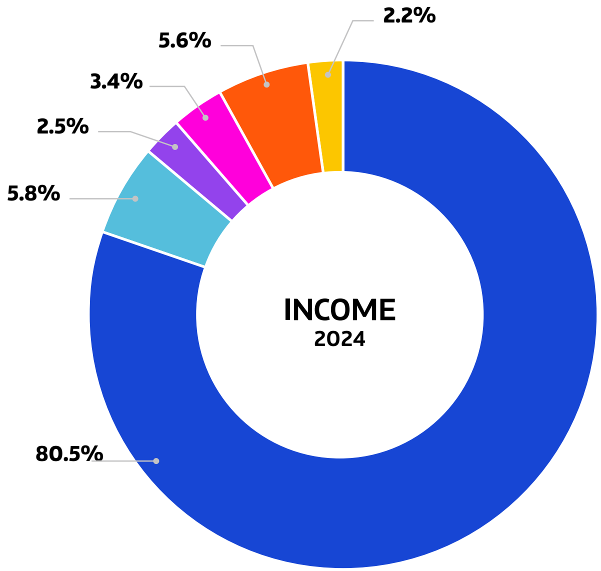
IN-KIND CONTRIBUTIONS 2024

REPORTING PERIOD	2024	2025	2025
	Actual ($)	Commitment ($)	Forecast ($)
IN-KIND			
Australian National University	1,389,996	1,121,068	1,426,984
The University of Melbourne	744,375	391,390	730,000
RMIT University	418,260	334,870	418,260
University of Technology Sydney	564,864	370,836	511,345
The University of Western Australia	476,443	317,968	476,443
Partners' contributions	736,629	736,629	736,629
TOTAL IN-KIND CONTRIBUTIONS	**4,330,567**	**3,272,761**	**4,299,661**

Notes on the Financial Statement:

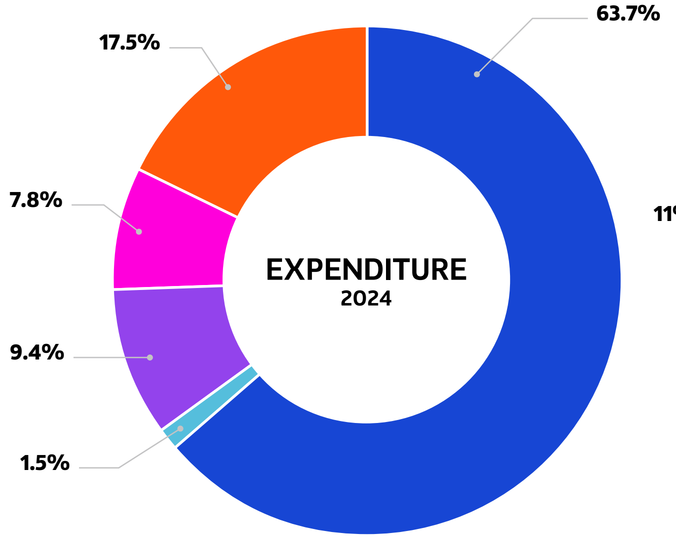
1) includes indexation and 2024 ARC funding
2) incl Materials, R&M, Branding, Outreach, Consultancies, Recruitment, Administrative support, Strategic Initiatives
3) unspent balance from 2020 reserved for 2027 (year 7) operations incl $5,530,785 ARC funds

CASH INCOME SOURCES 2024:



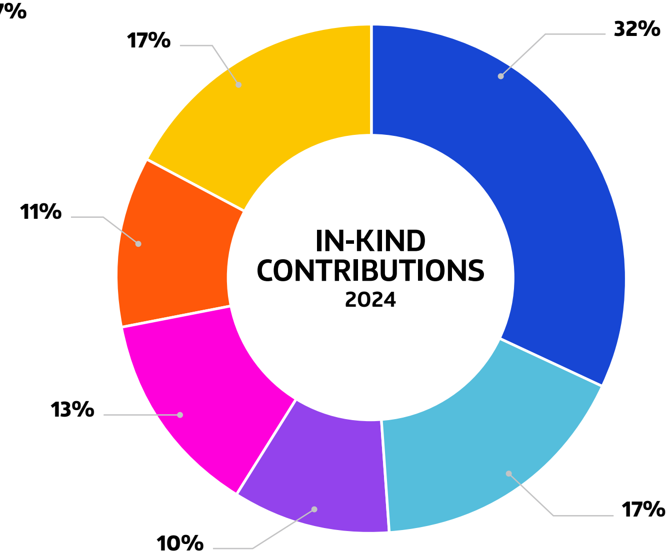
- ARC[1] **80.5%**
- Australian National University **5.8%**
- The University of Melbourne **2.5%**
- RMIT University **3.4%**
- University of Technology Sydney **5.6%**
- The University of Western Australia **2.2%**
- Consultancies **0%**
- Government grant/sponsorship **0%**

EXPENDITURE 2024:



- Personnel **63.7%**
- Equipiment **1.5%**
- Scholars Expenses **9.4%**
- Travel **7.8%**
- Other **17.5%**

IN-KIND CONTRIBUTIONS 2024:



- Australian National University **32%**
- The University of Melbourne **17%**
- RMIT University **10%**
- University of Technology Sydney **13%**
- The University of Western Australia **11%**
- Partners' contributions **17%**

Notes on the Financial Statement:

1) includes indexation and 2024 ARC funding

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9. Crotti, Giulia, Mert Akturk, Andrea Schirato, Vincent Vinel, Anton A. Trifonov, Ivan C. Buchvarov, Dragomir N. Neshev, et al. 'Giant Ultrafast Dichroism and Birefringence with Active Nonlocal Metasurfaces'. *Light: Science & Applications* 13, no. 1 (23 August 2024): 204. https://doi.org/10.1038/s41377-024-01545-8.

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BOOK CHAPTERS

1. Camacho Morales, Rocio, Khosro Zangeneh Kamali, Lei Xu, Andrey Miroshnichenko, Mohsen Rahmani, and Dragomir Neshev. 'Nonlinear Phenomena Empowered by Resonant Dielectric Nanostructures'. In *All-Dielectric Nanophotonics*, 329–64. Elsevier, 2024. https://doi.org/10.1016/B978-0-32-395195-1.00016-8.

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Awards, Honours and Prizes

Awardee Name	Node	Details
Chennupati Jagadish	ANU	Honorary Doctorate, Doctor of the University (honoris causa) from his Royal Highness Duke of Kent and Chancellor of the University of Surrey, UK on 17th July 2024
Fedor Kovalev	ANU	2024 Optics and Photonics Scholarship
Francesca Iacopi	UTS	Appointment as Founder and Inaugural Editor-in-Chief of the IEEE Transactions on Materials for Electron Devices Volunteering position/ non remunerated
Lan Fu	ANU	Australian Research Council National Intelligence and Security Discovery Research Grants (NISDRG) Selection Advisory Committee Panel (2024) Appointee (up to a total commitment of 10 days per calendar year)
Francesca Iacopi	UTS	Elevation to IEEE Fellow class of 2024
Igor Aharonovich	UTS	Highly cited researcher 2024 Clarivate
Francesca Iacopi	UTS	Elected member to the IEEE Electron Devices Society Board of Governors for another 3-years term 2024–2026
Fedor Kovalev	ANU	Crompton Award ANU for a research visit to Andrea Alu's (TMOS PI) group at the City University of New York (USA)
Chennupati Jagadish	ANU	Selected to be a member of the Prime Minister's Science Prizes Committee and Chairing the Sub-Committee on Physical Sciences
Dragomir Neshev	ANU	Highly cited researcher 2024 Clarivate – in the field of Cross-Field – 2024 in the Subject Categories: Optics; Physics; Engineering; Materials Science; Science & Technology – Other Topics
Chennupati Jagadish	ANU	Doctor of Science (honoris causa) from Nottingham Trent University Deputy Vice-Chancellor Prof. Sharon Huttly.
Mingjie Yang	RMIT	A finalist in the 2024 Falling Walls Lab Australia – organisers are from the Falling Walls Foundation. Hosted by the Australian Academy of Science
Igor Aharonovich	UTS	SPIE, the international society for optics and photonics, is welcoming 47 Members as new Fellows of the Society. They join their Fellow Member colleagues in being honored for their technical achievements, as well as for their service to the optics and photonics community and to SPIE. The 2024 Fellows cohort includes: University of Technology Sydney Professor and physicist and materials engineer Igor Aharonovich
Hark Hoe Tan	ANU	Elected as Academician of the Asia Pacific Academy of Materials
Fengkai Wei	ANU	KOALA 2024 Shark Tank award for delivering a compelling pitch for his poster presentation

Awardee Name	Node	Details
Madhu Bhaskaran	RMIT	Selected to be part of the Equal State Reference Group for Victoria's Gender Equity Strategy: https://www.vic.gov.au/our-equal-state-reference-group The reference group's term will end in 2028, aligning with the lifespan of Our equal state
Igor Aharonovich	UTS	Science Advances – Associate Editors 2D materials, boron nitride, single emitters, quantum photonics, diamond
Sarah Dean	ANU	SPIE Student Conference Support program – SPIE Photonics Europe 2024 in Strasbourg, France. Awarded US$1000 for airfare and/or lodging as well as a conference registration fee waiver
Rocio Camacho Morales	ANU	The ANZOS Geoff Opat Early Career Researcher Prize for her research which focuses on nonlinear optical metasurfaces and their application for conversion enhancement and imaging capabilities
Shaban Sulejman	UoM	ANZOS Postgradwuate Student Prize. This prize recognises outstanding contributions by postgraduate students to the field of optics and photonics in Australia and/or New Zealand. Shaban Sulejman (University of Melbourne) was awarded the ANZOS Postgraduate Research Prize for his outstanding research focused on designing optical metasurfaces for imaging applications such as phase imaging of transparent biological samples and multi-modal microscopy

Awarded Funding

TMOS Member	Node	Title of Funding Scheme	Project ID	Total Amount (AUD)	Collaborators	Funding Source
Chaohao Chen	ANU	Discovery Early Career Researcher Award 2025 (DECRA)	DE250100406	$475,614.00		Australian Government, Australian Research Council (ARC)
Igor Aharonovich	UTS	Discovery Project (DP)	DP250100973	$649,361.00	Jean-Philippe Tetienne, Igor Aharonovich, David Broadway	Australian Government, Australian Research Council (ARC)
Igor Aharonovich Milos Toth Dragomir Neshev	UTS	Linkage Infrastructure, Equipment and Facilities (LIEF)	LE240100004	$762,800.00	Timothy Schmidt, Rose Amal, Irina Kabakova, Dragomir Neshev, Girish Lakhwani, Igor Aharonovich, Michael Nielsen, Murad Tayebjee, Nicholas Ekins-Daukes, Deanna D'Alessandro, Daria Smirnova	Australian Government, Australian Research Council (ARC)
Hark Hoe Tan	ANU	ASPIRE, Japan Science and Technology Agency (JST)		$713,548.00	Prof. Katsuhiro Tomioka (University of Hokkaido)	
Lan Fu	ANU	AOARD US Airforce R&D grant	FA2386-24-1-4077	$163,205.00	FUMIKO KANO, ASIAN OFFICE OF AEROSPACE R&D;	
Milos Toth	UTS	AEA Australian Government		$606,238.00	Milos Toth, Trong Toan Tran, Carla Verdi, Mehran Kianinia	
TOTAL				**$3,370,766.00**		

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