TMOS

2025 ANNUAL REPORT

Collaborating for real-world impact

Contents

Centre

Message from the Centre Advisory Board

> “TMOS has always demonstrated that transformational science requires more than technical excellence alone. It depends on strong partnerships between academia, industry, government, and the broader community.

As TMOS enters the final phase of its ARC Centre of Excellence journey, the Centre stands at a pivotal moment: transitioning from scientific maturity toward an enduring legacy. Over the past five years, TMOS has established itself as a globally recognised leader in meta-optics research, building Australia's sovereign capability in advanced photonics while fostering an innovative, collaborative, and outward-facing research culture. The challenge now is not only to sustain scientific excellence, but to ensure that the knowledge, partnerships, talent, and technologies developed through TMOS continue to generate long-term impact for Australia beyond the life of the Centre.

The past year has marked an important period of strategic reflection and forward planning for TMOS. The Strategic Advisory Panel was established to guide TMOS in responding to key recommendations from the ARC Mid-Term Review and to help shape the Centre's long-term legacy. Bringing together leaders from industry, innovation, academia, and Centre governance, the Panel provided independent advice on research translation, industry engagement, strategic partnerships, and opportunities to maximise TMOS's impact beyond the lifetime of the Centre.

The 2025 Strategic Advisory Panel Report recognised the remarkable progress the Centre has made in leading fundamental research on meta-optics, together with establishing internationally competitive research capabilities. The Panel endorsed the Centre's flagship model as a strong foundation for translation, collaboration, and future growth. The Panel's recommendations also provide a clear and practical roadmap for ensuring that TMOS leaves a lasting national legacy.

TMOS has always demonstrated that transformational science requires more than technical excellence alone. It depends on strong partnerships between academia, industry, government, and the broader community. As the Centre moves into its final years of operation, there is now a growing emphasis on strengthening the pathways that connect discovery to deployment. This includes building translational capability, supporting intellectual property development, expanding engagement with industry partners, and creating opportunities for researchers to develop commercial and entrepreneurial experience alongside scientific expertise.

Importantly, the Strategic Advisory Panel recognised that TMOS's three flagship programs provide a compelling framework for achieving this vision. These programs are helping align foundational research with real-world applications in areas of national importance, including communications, sensing, quantum technologies, defence, health, and advanced manufacturing. They also position TMOS to deepen strategic international engagement and strengthen Australia's role within the global photonics and meta-optics ecosystem.

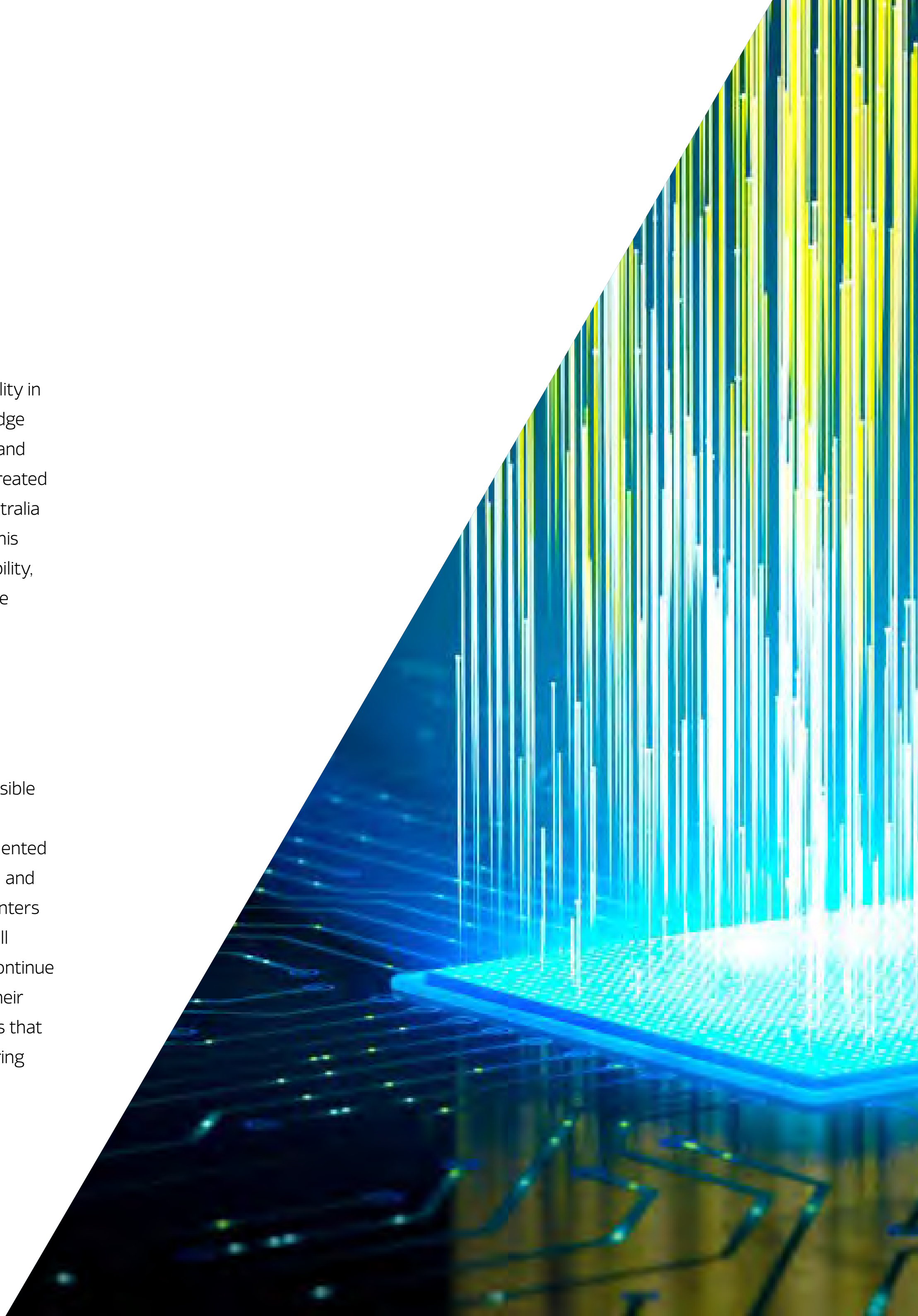
A key priority moving forward will be investing in people. Australia's future competitiveness in emerging technologies depends not only on infrastructure and research funding, but on cultivating researchers who are capable of working across disciplines and sectors. TMOS has already shown leadership in fostering collaboration, communication, and inclusion, and it is encouraging to see increasing attention being paid to commercial training, industry placements, and translational experience for early- and mid-career researchers. These experiences will help ensure that the next generation of scientists and engineers can successfully navigate the increasingly interconnected worlds of research, innovation, and industry.

The Strategic Advisory Panel also highlighted the importance of maintaining strong governance and strategic oversight during this final phase. The recommendation to further strengthen the engagement of the Centre Advisory Board and International Scientific Advisory Committee reflects the scale of the opportunity ahead. As TMOS approaches 2027, careful stewardship will be essential to maximise the Centre's long-term impact and ensure that its capabilities continue to benefit Australia well beyond the formal life of the Centre.

Perhaps most significantly, discussions about the future of TMOS signal an important shift in perspective: TMOS is no longer simply a research centre, but the foundation of a broader national capability in meta-optics and photonics. The knowledge networks, partnerships, infrastructure, and talent developed through TMOS have created momentum that should not be lost. Australia now has an opportunity to build upon this platform to strengthen sovereign capability, support future industries, and contribute solutions to complex global challenges.

TMOS represents the very best of Australian science: ambitious, collaborative, interdisciplinary, and deeply connected to national need. Its achievements demonstrate what is possible when governments invest in long-term fundamental research and empower talented researchers to work across institutional and disciplinary boundaries. As the Centre enters this important next stage, I encourage all members of the TMOS community to continue building partnerships, communicating their work widely, and pursuing opportunities that translate scientific excellence into enduring societal impact.

Professor Ian Chubb AC FAA FTSE
Chair, Centre Advisory Board



Message from the Director

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In 2025, the Centre has seen increased momentum towards transforming scientific breakthroughs into technologies with societal impact.

At TMOS, we are fully committed to our mission to transform how we control light using nanostructured materials and translate excellence in fundamental science into real-world impact across areas such as quantum technology, health monitoring, defence, and security. In 2025, the Centre has seen increased momentum towards transforming scientific breakthroughs into technologies with societal impact. To maximise the Centre's impact, in 2025, we have put together an expert panel led by Professor Steven Buckman and comprising esteemed Australian academics and entrepreneurs, with input from the Centre's executives. The panel praised the Centre’s scientific achievements and its strong culture of collaboration, underpinned by strategic initiatives in education, outreach, and people support. The panel acknowledged the Centre's efforts in research translation and its report on the Centre's Strategic Roadmap, and Legacy identified future opportunities to grow the Centre’s translational impact.

I would like to personally acknowledge Ms Mani Thiru for her outstanding contribution to this Strategic Report and, more importantly, for her exceptional leadership in advancing TMOS’s translational mission during her tenure on the Centre Advisory Board (CAB). As CEO of DeepTech Ventures Australia and a valued CAB member, Mani has played a pivotal role in shaping our vision for real-world impact and in embedding a strong deep-tech mindset across the Centre. Her influence has inspired many students and researchers to pursue translation, strengthening our collective drive to convert scientific excellence into transformative technologies.

In this opening message, I am proud to highlight some of our achievements and our future vision for delivering the Centre's legacy.

EXCELLENCE AND HIGH ACHIEVEMENTS

2025 was a year of significant accomplishments and recognition for many researchers at TMOS. I am especially proud of the younger generation, who received numerous awards, such as Ms Laura Valencia Molina, honoured with the Robert and Helen Crompton Award at ANU. Dr Wei Wen Wong earned the Research School of Physics EMCR Publication Award, while Dr Shiyu Wei received the Jagadishwar Mahanty Prize for the best PhD thesis. Our senior researchers also attained prestigious honours. Notably, Professor Ann Roberts was awarded the Australian and New Zealand WH (Beattie) Steel Medal, the highest accolade of the Australian and New Zealand Optical Society. Distinguished Professor Chennupati Jagadish was elected to the Royal Society, the UK’s National Academy of Sciences, and Distinguished Professor Madhu Bhaskaran was listed among Australia’s top 100 innovators by The Australian in 2025. Additionally, Professor Igor Aharonovich and I were honoured as 2025 Highly Cited Researchers by Web of Science.

The Centre's research output continues to produce top-notch publications in Nature Photonics, Nature Physics, eLight, and Science Advances, to mention a few. Notably, cross-node collaborations are steadily increasing, enhancing both high-level research and societal impact. The Centre is buzzing as a cohesive community where ideas flow freely, and friendships are forged without geographical boundaries. This was evident at the 2025 TMOS Annual Conference – Meta-Together, which featured cross-node presentations and scientific tutorials on novel topics in nanoscale optics and photonics. The conference culminated in a Shark Tank event, where several teams pitched their commercialisation ideas to elite judges and won development grants to prototype their ideas.

DRIVING TRANSLATION THROUGH FUNDAMENTAL SCIENCE AND INNOVATION

Building on our strong foundation of world-leading research, TMOS is sharpening its focus on translation, culminating in three flagship programs that bridge fundamental discoveries and real-world applications. The strategic planning process to define the TMOS legacy roadmap resulted in the Buckman report, which provided several recommendations that shape our translational strategy. Following these recommendations, we are enhancing our translational capacity by investing in targeted business development, building internal expertise in commercialisation and IP, and supporting researchers to engage actively in translation.

By prioritising flexible funding, deeper industry engagement, international partnerships, and enhanced training opportunities, TMOS is positioning its research to deliver tangible outcomes in areas such as healthcare, defence, and quantum technologies. This coordinated approach ensures that our scientific excellence continues to evolve into impactful technologies, while building the capabilities and partnerships needed to sustain Australia's leadership in meta-optics beyond the Centre's lifetime.

INTERNATIONAL DEVELOPMENT

Meta-optics technologies are rapidly gaining popularity across various consumer products and fields such as quantum tech, space, and security. For instance, meta-optics is now a trusted technology for on-chip ion traps in quantum computing and components in advanced robotic vision. The key to this widespread adoption is the scaling of meta-optics fabrication, with major foundries now providing silicon-on-glass nanofabrication services. Leading foundries like TSMC & UMC in Taiwan, STMicroelectronics in France, and the National Semiconductor Translation and Innovation Centre in Singapore are involved. Additionally, nano-imprint companies are enhancing their processes and developing new materials suitable for visible and ultraviolet applications. The question has shifted from whether meta-optics will scale to where, when, and who will lead this growth. In Australia, our partners at the Australian National Fabrication Facilities (ANFF) are continuously strengthening our local fabrication capabilities and supporting market exploration and development. Consequently, TMOS is well-placed to leave a significant mark on this global progress.

ACTIONS AND INITIATIVES FOR 2026

Looking ahead, TMOS is focused on accelerating the translation of its worldleading science into transformative technologies that deliver longterm benefit for Australia. Building on a foundation of scientific excellence, the Centre will strengthen its translational capability through a coordinated approach that brings together business development, industry engagement, and commercialisation expertise. A dedicated Translation Team - comprising a Business Development Manager, external advisors, Flagship Program leaders, and the Industry Liaison Committee - will play a central role in driving this effort.

Through targeted partnerships, global engagement, and flexible support for highpotential opportunities, TMOS will accelerate pathways from discovery to application, ensuring our research contributes to future industries and a highly skilled workforce. As metaoptics continues to expand into new domains, the Centre will actively pursue emerging research opportunities and collaborate across disciplines to amplify impact, fostering innovation that extends well beyond the lifetime of TMOS.

I thank all members of the TMOS community for their commitment and contributions, and I look forward to another year of progress and opportunity.

Professor Dragomir Neshev
Centre Director

2025 Key Moments

- **2025** – Collaboration with Magic Wavelength - Development of a game-changing MEMS-based infrared sensor technology
- **30 JAN 2025** – Lan Fu elected as Fellow Optica
- **24 FEB 2025** – Questacon Outreach Workshop
- **11 MAR 2025** – Presentations at Bendigo Science & Technology Centre Girls in STEM program
- **11 MAR 2025** – Meta-Active Annual meeting held in Canberra
- **5 MAY 2025** – Gabriel Oyarzo Ojeda - Awarded the Graeme Clark Institute Top-Up Scholarship
- **20 MAY 2025** – Chennupati Jagadish - Elected to the Royal Society, the UK's National Academy of Sciences
- **20 MAY 2025** – Dragomir Neshev - Organised celebration of the International Day of Light and the International Year of Quantum Science and Technology at ANU
- **27 MAY 2025** – inSTEM Conference
- **27 MAY 2025** – Wei Wen Wong - Led forum for advances at Compound Semiconductor Week 2025, Canada
- **3 JUN 2025** – Sharath Sriram - Named Western Australia's new Chief Scientist
- **22 JUL 2025** – ECR and Student Conference 2025
- **21 AUG 2025** – Basic Photon Clicker Production
- **10 SEPT 2025** – Madhu Bhaskaran - Awarded one of Australia's top 100 innovators by The Australian in 2025
- **12 OCT 2025** – Ann Roberts - Awarded Australian and New Zealand WH (Beattie) Steel Medal
- **23 OCT 2025** – Chennupati Jagadish - Elected as an International Honorary Member of the American Academy of Arts and Sciences at Harvard University in the Area of Mathematical and Physical Sciences; Specialty of Engineering and Technology
- **24 OCT 2025** – Wei Wen Wong received the EMCR Publication Award 2025
- **NOV 2025** – TMOS Legacy and Impact Roadmap
- **3 NOV 2025** – TMOS Strategic Planning process
- **5 NOV 2025** – The Governor General's Design Challenge 2025
- **18 NOV 2025** – TMOS Conference 2025
- **29 NOV 2025** – ANU Quantum Science Open day
- **2 DEC 2025** – Sharath Sriram - Presentation at Science meets Parliament
- **8 DEC 2025** – Sydney Science Trail - Hologram and optics activities with over 1,000 primary school students Y3 to Y6
- **22 DEC 2025** – Shiyu Wei received the 2025 J G Crawford Prize for her outstanding PhD thesis

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.

OUR LEGACY

Our priority is to secure a legacy that integrates scientific excellence, translation, talent development, and collaboration. Through flagship translation programs, we will advance discoveries toward late-stage technologies, spin-out companies, and deep industry engagement demonstrating Australia's leadership in deep-technology innovation.

We will exemplify how an ARC Centre of Excellence can deliver both transformative science and tangible societal and economic value through our alumni, enduring partnerships, and flagship technologies.

Message from the International Scientific Advisory Committee

> “Over the past several years, the Centre has established itself as an internationally visible and scientifically ambitious research environment that brings together expertise across physics, engineering, materials science, nanofabrication, chemistry, and device integration.

Scientific breakthroughs rarely emerge in isolation. They arise from environments that encourage curiosity, support long-term thinking, and bring together researchers with different perspectives, expertise, and ambitions. As TMOS progresses to the final years of its ARC Centre of Excellence funding, it is increasingly evident that the Centre has created precisely this kind of environment: one where foundational science, interdisciplinary collaboration, and translational vision coexist productively to advance the rapidly evolving field of meta-optics.

The field of meta-optics is evolving at an extraordinary speed. What was once considered a highly specialised research area has now become central to global conversations about the future of communications, sensing, imaging, quantum technologies, artificial intelligence, and advanced manufacturing. Both academia and industry increasingly acknowledge that precise nanoscale light control is fundamental to many transformative technologies.

TMOS has played an important role in this evolution. Over the past several years, the Centre has established itself as an internationally visible and scientifically ambitious research environment that brings together expertise across physics, engineering, materials science, nanofabrication, chemistry, and device integration. Importantly, it has done so while maintaining a strong commitment to curiosity-driven research—the essential foundation upon which future technological revolutions are built.

One of the most encouraging aspects of TMOS's progress is the way the Centre has matured scientifically without losing its willingness to explore difficult and high-risk questions. This balance is not easy to achieve. As research fields become more commercially visible, there is often pressure to focus narrowly on short-term outcomes and incremental advances. Yet many of the most important discoveries emerge from unexpected directions, interdisciplinary dialogue, and sustained exploration over long time horizons. TMOS continues to demonstrate that ambitious foundational research and translational impact are not opposing goals, but deeply interconnected ones.

The recommendations emerging from the 2025 Legacy Strategic Advisory Panel reflect this important transition point in the Centre's journey. The emphasis on strengthening translational capability, developing industry engagement pathways, and creating structures that support intellectual property and commercialization is timely and necessary. Equally important, however, is ensuring that TMOS preserves the scientific culture that made these opportunities possible in the first place: openness to new ideas, collaboration across disciplines, and support for early-career researchers to pursue bold scientific questions.

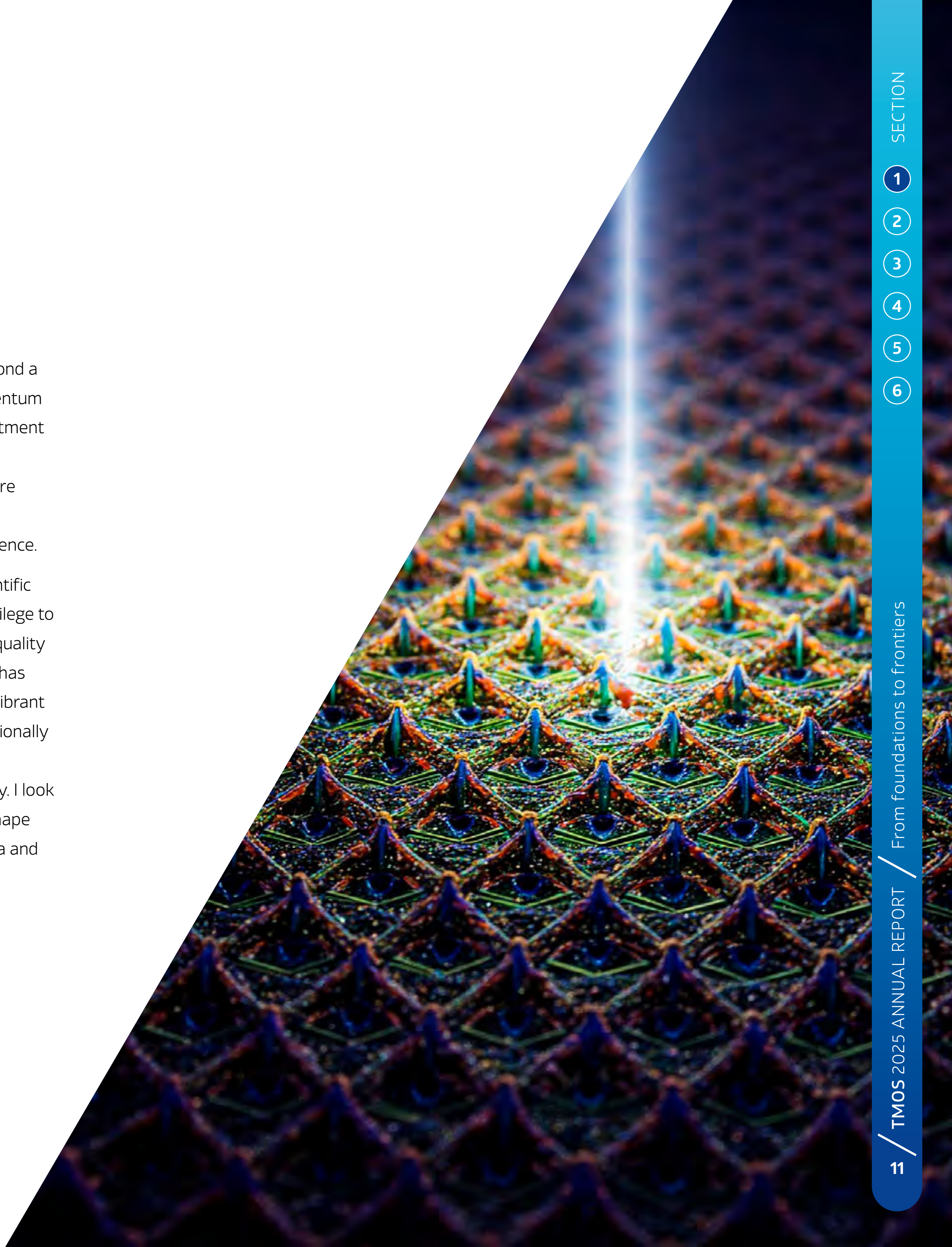
I have been particularly encouraged by the Centre's growing international engagement. Scientific progress increasingly depends on strong global networks, and TMOS is well-positioned to deepen collaborations with leading institutions, industry partners, and emerging technology ecosystems worldwide. Strategic international exchanges, workshops, and collaborative projects will not only accelerate research outcomes but also strengthen Australia's visibility and leadership in photonics and meta-optics.

Another defining strength of TMOS has been its investment in researchers at all career stages. The Centre has created opportunities for students and postdoctoral researchers to work in highly interdisciplinary teams while gaining exposure to both fundamental science and emerging applications. This kind of environment is invaluable. The next generation of scientific leaders will need to move comfortably between disciplines, understand both discovery and translation, and collaborate effectively across academia and industry. TMOS is helping prepare that generation.

Looking ahead, the discussion surrounding the possible next stage of research and translational activities is particularly exciting. The achievements of the Centre suggest that Australia now has the opportunity to build a sustained international capability in meta-optics and photonics that extends beyond a single funding cycle. Maintaining momentum in this field will require continued investment in people, infrastructure, partnerships, and scientific ambition. It will also require preserving the spirit of curiosity and openness that drives breakthrough science.

As a member of the International Scientific Advisory Committee, it has been a privilege to observe the growth of TMOS and the quality of its scientific community. The Centre has built a collaborative and intellectually vibrant environment that is respected internationally and positioned to make enduring contributions to science and technology. I look forward to seeing TMOS continue to shape the future of optical science in Australia and around the world.

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



Action Items for 2026

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. Integration of metalens structures with MCT detectors.
2. Characterise and evaluate integrated metalens–detector prototypes.
3. Advance application pathways through field testing and industry engagement.

Read the report

FLAGSHIP PROGRAM: ADVANCED QUANTUM TECHNOLOGIES

1. Characterisation of NV and Vsi through SiC metalense with efficiency equal to 0.8NA objective.
2. Coupling a single NV to fibre using SiC metalense with 40-50% efficiency.
3. Demonstration of fibre-based QKD with BB86 protocol at room temperature.
4. Writing white papers and contacting possible industry partners.

Read the report

THEME 1 GENERATE

1. Electrically injected photonic cavity surface emitting lasers.
2. Flatband and chiral lasers.
3. Nonlinear image processing with dynamic kernels.
4. Demonstrate coherent hBN sources; integrated sources with metalenses in SiC.
5. Asymmetric generation of photon-pairs and demonstration of quantum hyper-entanglement from nonlinear metasurfaces.

Read the report

THEME 2 MANIPULATE

1. Non-volatile, rewritable, multi-level reflective displays based on antimony selenide thin films.
2. Advancing light-induced tuning of metasurfaces using liquid crystals.
3. Development of metasurface-based optical sensors for non-invasive skin monitoring.
4. Negative photoconductivity effect in liquid-metal-based ultra-thin ceria-rich oxides for broadband photodetectors.
5. Tunable thermal emitter using phase change materials.
6. Strain-Engineered Flexible Sb2Se3 for Optoelectronic Applications.

Read the report

THEME 3 DETECT

1. Demonstrate top-down etched InGaAs metasurface SWIR polarisation-sensitive photodetector.
2. Finalise research on InAs nano sheet polarisation detector and spectrometer.
3. Demonstrate circular polarisation sensitive InAs nano sheet array photodetectors.
4. Demonstrate reconstructive spectroscopy with tuneable filter for SWIR and metasurface filters for LWIR.
5. Demonstration metalens-enabled mid-wave infrared polarisation imaging.
6. Demonstrate multi-wavelength polarization imaging of small satellites.
7. Demonstrate quantitative phase microscopy using a polarization and wavelength-multiplexed metasurface.
8. Demonstrate nonlocal metasurfaces for wavelength-selective optical feature extraction.

Read the report

CENTRE EXECUTIVE COMMITTEE

1. Implement the recommendations of the strategic review related to translation.
2. Maintain and deepen our engagement with the CAB and ISAC.
3. Maintain the strength of our fundamental research program and pursue opportunities to publicise its successes.
4. Strengthen collaboration within the Centre. Maintain and strengthen leadership opportunities provided to students and early career researchers.

Read the report

INDUSTRY LIAISON COMMITTEE

1. Advance translational readiness and commercialisation support across TMOS flagship programs.
2. Strengthen industry, defence and government engagement through targeted partnerships, outreach and training initiatives.
3. Develop sustainable translation and legacy pathways to maximise the long-term impact of TMOS technologies beyond 2027.
4. Plan for a 2026 industry show case.
5. Host a 'Shark Tank' or alike at the TMOS conference for Centre members to gain external feedback on their ideas.

Read the report

EDUCATIONAL AND PROFESSIONAL DEVELOPMENT COMMITTEE

1. Refresh EPD Committee membership.
2. Deliver the 6th TMOS ECR & Student Conference.
3. Enhance professional development programming aligned with ECR needs.
4. Expand career development and industry engagement initiatives.
5. Strengthen cross-node networking opportunities.
6. Launch the NanoSteps Mentoring Program.
7. Improve evaluation and feedback mechanisms across EPD initiatives.

Read the report

IDEA COMMITTEE

1. Implementing the NanoSteps internal mentoring program.
2. Increasing visibility and awareness of TMOS's cultural diversity through events, communications, and cultural diversity training.
3. Expanding the Social Committee's activities to include a broader range of themes, including IDEA, wellbeing, and collaboration.
4. Supporting the delivery of an inclusive and accessible 2026 Annual Conference, with both the IDEA Director and IDEA Officer serving on the organising committee.

Read the report

OUTREACH COMMITTEE

1. Continue to develop Senior STEM Engagement Program across all nodes.
2. Deliver Science Communication Training Workshop with Partner Organisation Questacon for the outreach committee members.
3. Finalise Advanced Photon Clicker Prototype between UWA and Questacon.
4. Develop workshops for primary and high schools.
5. Develop new connections with large outreach bodies for collaboration in areas of space, quantum and optics research.
6. Develop new connections with the communities via public libraries and museums.
7. Prepare a Science Bus Outreach Program to travel in November in Tasmania.
8. Develop Laser Ice Hockey kit and Interference kit.

Read the report

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

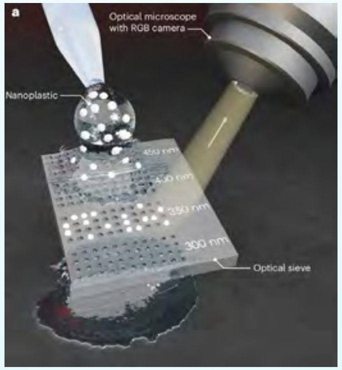
Research Highlights

NATURE PHOTONICS

Optical sieve for nanoplastic detection, sizing and counting

A new technique using optical sieves, standard microscopes, and RGB camera sensors finally provides the potential for a cheap and accessible method to enable the environmental and medical study of sub-micrometre microplastic pollution.

Read More



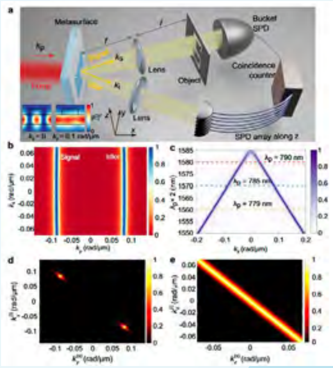
https://doi.org/10.1038/s41566-025-01733-x

ELIGHT

Quantum Imaging Using Spatially Entangled Photon Pairs from a Nonlinear Metasurface

Nonlinear metasurfaces are demonstrated to be able to serve as practical platforms for quantum imaging by embedding them in a complete imaging protocol, highlighting their potential for compact quantum imaging and future quantum imaging and sensing technologies based on engineered photon correlations."

Read More



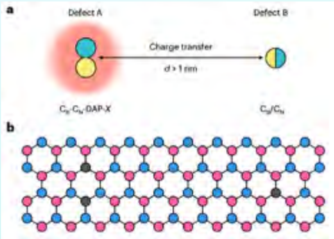
https://doi.org/10.1186/s43593-024-00080-8

NATURE PHYSICS

A charge transfer mechanism for optically addressable solid-state spin pairs

A new understanding of how neighbouring atomic defects interact in a two-dimensional material opens fresh opportunities for engineering quantum devices at the atomic scale.

Read More



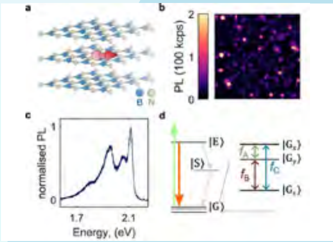
https://doi.org/10.1038/s41567-025-03091-5

NATURE COMMUNICATIONS

A single spin in hexagonal boron nitride for vectorial quantum magnetometry

A new quantum sensor based on spin defects in hexagonal boron nitride can directly measure magnetic fields in three dimensions at the nanoscale, combining high sensitivity, large dynamic range, and room-temperature operation.

Read More



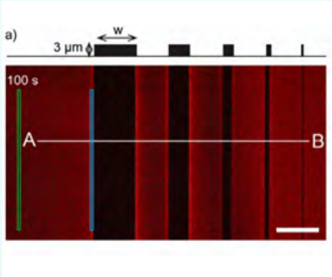
https://doi.org/10.1038/s41467-025-59642-0

ADVANCED SCIENCE

Stirring Without Stirrers: Polymer Fouling-Driven Mass Transport Unlocks Order-of-Magnitude Gain in Electrochemiluminescence

Turning electrode fouling from a problem into a design feature opens new possibilities for controlling and accelerating electrochemical processes.

Read More



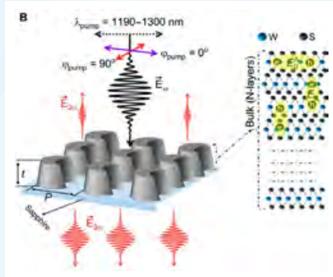
https://doi.org/10.1002/advs.202506610

SCIENCE ADVANCES

Dynamic Control of Nonlinear Emission by Exciton-Photon Coupling in WS2 Metasurfaces

Combining quantum materials with advanced metasurface design creates a powerful new platform for actively controlling how light is generated and manipulated at the nanoscale.

Read More



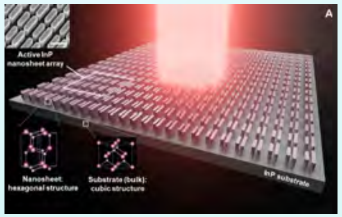
https://doi.org/10.1126/sciadv.ady2108

SCIENCE ADVANCES

Near-unity spontaneous emission factor InP surface-emitting lasers based on quasi-bound states in the continuum

Harnessing exotic light-trapping states enables surface-emitting lasers that operate with remarkably low thresholds and exceptional mode control.

Read More



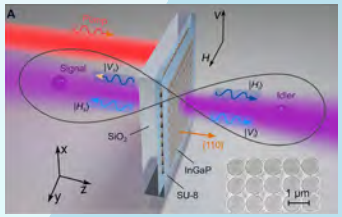
https://doi.org/10.1126/sciadv.adx6527

SCIENCE ADVANCES

Nonlinearity symmetry breaking for generating tunable quantum entanglement in semiconductor metasurfaces

A structurally asymmetric semiconductor metasurface enables continuous tuning of biphoton quantum entanglement, providing a compact and highly efficient platform for generating on-demand quantum states.

Read More



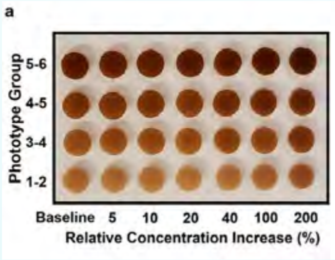
https://doi.org/10.1126/sciadv.adu4133

ADVANCED SENSOR RESEARCH

A Compact Optical Sensor to Self-Assess Skin Health after Sun Exposure

Advanced optical sensing is bringing personalized skin-health monitoring closer to reality, offering new ways to measure and manage the effects of UV exposure.

Read More



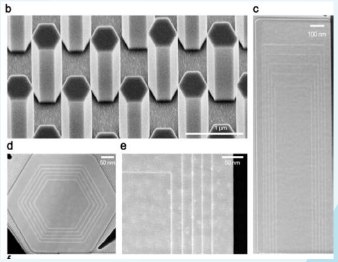
https://doi.org/10.1002/adsr.202500096

APPLIED PHYSICS LETTERS

Normal-incidence mid-infrared photodetection via intraband transitions in InGaAs/InP multiple quantum well nanowire arrays

A novel nanowire architecture enables efficient detection of mid-infrared light at normal incidence, paving the way for more compact and versatile infrared imaging and sensing technologies.

Read More



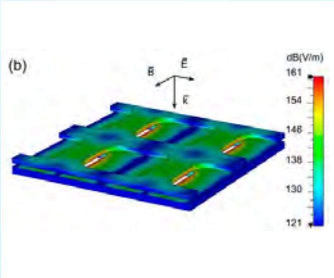
https://doi.org/10.1063/5.0242858

ADVANCED PHOTONICS RESEARCH

Micromachined double-membrane mechanically tunable metamaterial for thermal infrared filtering

A MEMS-enabled plasmonic metamaterial has demonstrated mechanically tunable infrared filtering across the long-wavelength infrared spectrum, offering a compact and energy-efficient approach to spectral sensing.

Read More



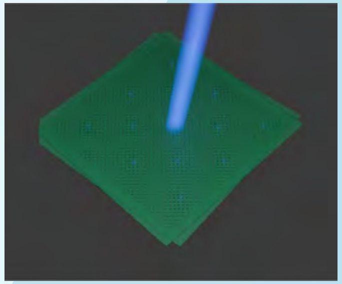
https://doi.org/10.1002/adpr.202400185

NANO LETTERS

A van der Waals Moiré Bilayer Photonic Crystal Cavity

Extending the concept of moiré physics to photonic systems reveals new possibilities for designing optical states and functionalities that do not exist in conventional structures.

Read More



https://doi.org/10.1021/acs.nanolett.5c03959

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.

tmos@anu.edu.au

COMMUNITY AND EDUCATORS

The Centre is committed to the development of STEMM 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 quarterly newsletter.

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Governance

Centre Executive Committee Directorate Report

2025 was a highly productive year for TMOS, marked by scientific advances that attracted international attention and resulted in publications in leading journals. Alongside these research achievements, the Centre's students and early career researchers demonstrated leadership and initiative by organising a successful conference in Melbourne, while TMOS researchers engaged broadly with local and regional communities through a range of outreach activities.

AUTHORS:

The Centre Directorate (Professor Dragomir Neshev, Professor Kenneth Crozier, and Dr Mary Gray/Galina Shadrivova) 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 2025 goals.

A major highlight of the year was the Annual Centre Conference, which brought together researchers from across the Centre to share progress, exchange ideas, and gain insight into the latest developments across all nodes. Regular tutorials further supported skills development and encouraged open, cross-nodal knowledge exchange, reinforcing a collaborative and inclusive research culture.

This strong foundation underpinned TMOS's progress against its strategic priorities in 2025. One of the four primary objectives for the year was to engage deeply with the Centre Advisory Board (CAB) and the International Scientific Advisory Committee (ISAC). TMOS worked closely with both advisory bodies and placed strong value on the guidance and perspectives they provided. Members of the Centre Advisory Board, Emeritus Professor Ian Chubb, Dr Greg Clark, Dr Simon Poole, and Mani Thiru, played a significant role in shaping strategic thinking, including through an all-day planning meeting held at ANU in November. Engagement with the ISAC, comprising Professor Federico Capasso, Professor Mark Brongersma,

> “Through its people, partnerships, and technologies, TMOS is committed to creating a legacy of scientific excellence and real-world impact that endures beyond the life of the Centre.

and Professor Alexandra Boltasseva, also remained a priority, with TMOS researchers benefiting from regular interaction with committee members. Professor Mark Brongersma's invited lecture at the Centre's Annual Conference was a particular highlight and an important opportunity for high-level scientific exchange.

Another principal objective in 2025 was to grow the Flagship Program. TMOS strengthened its three Flagship programs through targeted advice obtained during strategic planning processes. A key outcome of this work was the decision to appoint a Business Development Manager, a step that will significantly enhance the Centre's ability to support industry engagement, drive translation activities, and accelerate the pathway from discovery to impact.

Throughout the year, TMOS remained firmly committed to maintaining the strength of its fundamental research program while actively promoting its successes. Researchers delivered a strong portfolio of high-quality outcomes published in leading international journals, including *Nature Photonics, eLight, Science Advances, Advanced Materials,* and *Light: Science & Applications*. These achievements were further amplified through a coordinated communications program, with multiple press releases extending the reach and impact of TMOS research to national and international audiences.

TMOS also made continued progress toward strengthening collaboration and leadership opportunities for students and early career researchers. Students and ECRs played an active role in Centre governance, with representation on all TMOS committees, including the Centre Executive Committee. They also participated in initiatives such as the Cross-node Exchange Awards, Partner

Investigator Exchange Awards, and the TMOS ECR & Student Conference. Together, these activities underscored the vital contribution of students and ECRs to both the research culture and leadership capability of the Centre.

Building on the achievements of 2025, we undertook a comprehensive strategic planning process to ensure that activities in the final phase of the Centre (2026–2027) are clearly focused for maximum impact. A central priority for 2026 will be to implement the recommendations of the strategic review related to translation. TMOS will strengthen its translation capability through the appointment of a Business Development Manager, the targeted deployment of strategic funds, and the delivery of industry engagement events. These efforts will be complemented by renewed engagement with industry partners and broader participation in commercialisation and translation-focused training.

Engagement with the CAB and ISAC will also continue to be strengthened in 2026, with TMOS deliberately leveraging the expertise of these advisory bodies to inform strategic decision-making and support the progression of research outcomes toward industry-ready impact. The objective to maintain the strength of the fundamental research program while publicising its successes will remain central, with continued support for excellence in discovery-driven research alongside targeted efforts to enhance visibility and impact.

The Centre will continue promoting cross-node collaboration and supporting students and ECRs in meaningful leadership roles as the Centre enters its final phase. Collaboration and leadership development will remain a key focus in the year ahead through the objective to strengthen collaboration within the Centre, to maintain and expand leadership opportunities for students and early career researchers.

We extend our best wishes to all Centre members, partners, and advisors for a productive and impactful 2026, as the community builds on a successful year and works collectively toward delivering lasting scientific, technological, and societal outcomes.

Galina Shadrivova, Dr May Gray, Professor Kenneth Crozier and Professor Dragomir Neshev

> “The objective to maintain the strength of the fundamental research program while publicising its successes will remain central, with continued support for excellence in discovery-driven research alongside targeted efforts to enhance visibility and impact.

ACTION ITEMS FOR 2026

1. Implement the recommendations of the strategic review related to translation.
2. Maintain and deepen our engagement with the CAB and ISAC.
3. Maintain the strength of our fundamental research program and pursue opportunities to publicise its successes.
4. Strengthen collaboration within the Centre. Maintain and strengthen leadership opportunities provided to students and early career researchers.

Message from the Chief Operations Officer

2025 was a significant and rewarding year for the Centre, marked by strong research achievements and meaningful progress in strategy and implementation. Considerable work was undertaken to ensure the Centre is well positioned to maximise impact and opportunity in its final years, all while continuing to deliver at a high level during a period of sustained pressure on the Business Team. The outcomes achieved this year are a testament to the resilience, dedication, and collaborative spirit of the team.

I would like to sincerely thank Sharyn McFarlane for her leadership during the mid-term review, where she successfully guided the Centre through a critical milestone and set a strong foundation for the work accomplished throughout the year. I also want to acknowledge Galina Shadrivova and Samara Thorn, who both stepped into higher duties to support the ongoing operations of the Centre during a particularly demanding period.

The dedication and leadership shown by Galina throughout the year was truly exceptional. Alongside playing a pivotal role in delivering the previous Annual Report, she provided steady operational leadership across a wide range of Centre activities, often balancing complex priorities with professionalism, care, and an unwavering commitment to supporting both people and processes. Her ability to maintain momentum during periods of high pressure, while fostering a collaborative and supportive environment around her, has had an enormously positive impact on the Centre. Her recognition as Business Team Member of the Year 2025 is a well-deserved acknowledgment of these outstanding contributions.

Special thanks also go to Kathy Palmer for her continued support, experience, and reliability. Her long-standing knowledge of ARC Centres and steady contribution across many aspects of the Centre's operations have been greatly valued throughout the year. The TMOS Member of the Year Award is a testament to her dedication, professionalism, and the significant impact she continues to make across the Centre and its community.

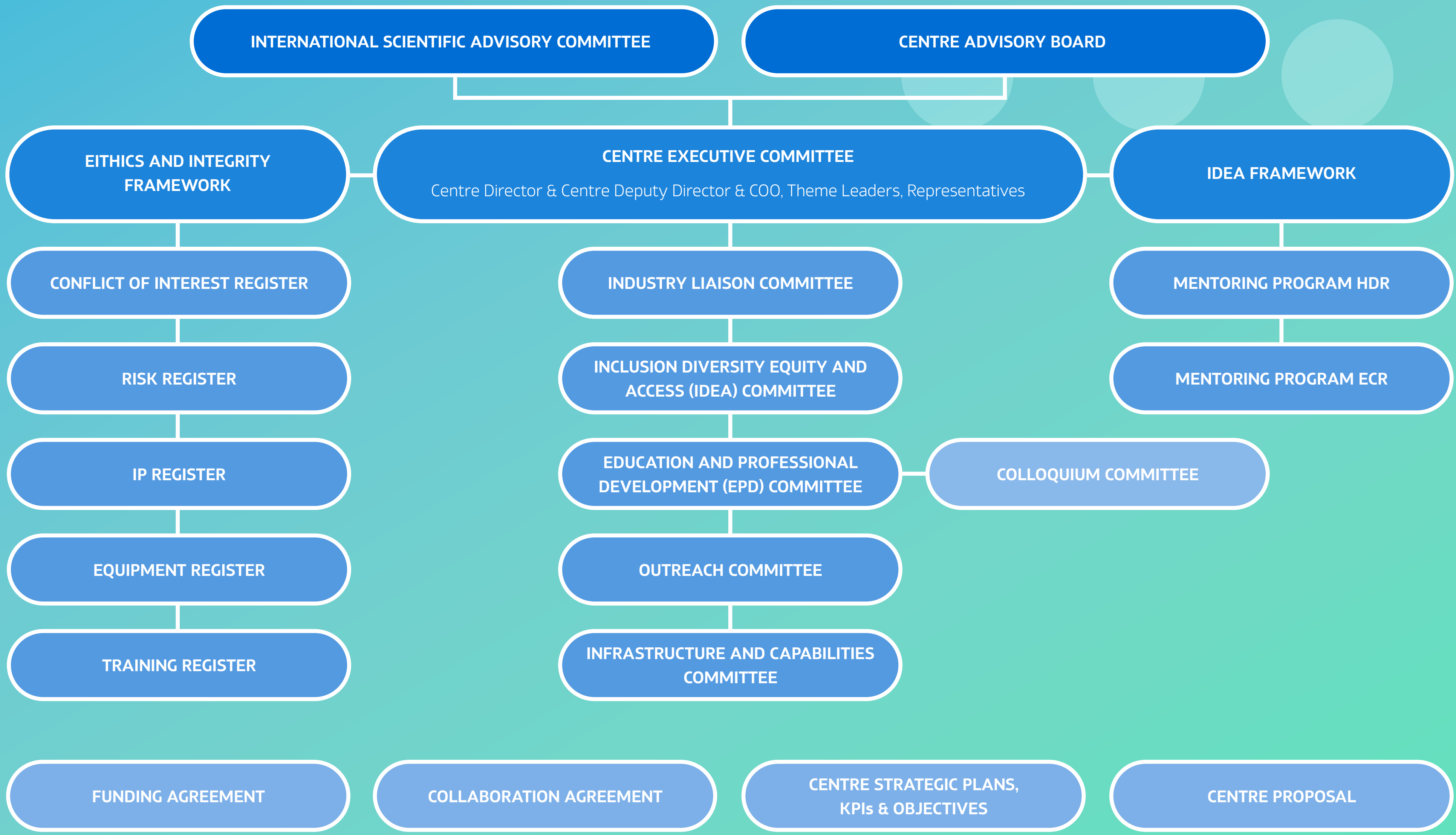
I also want to recognise the broader Business Team, Julie Arnold, Sophia Aharonovich, Karen Kader, Eleanor Luond, Liz Micaleff, and Krisztina Thurzo, for their professionalism, adaptability, and commitment. The sustained effort, care, and teamwork demonstrated across the Centre during a demanding period did not go unnoticed. Each of these team members contributed in important ways to maintaining the smooth operation of TMOS and supporting the wider research community, often under significant pressure. Their dedication and collaborative spirit have always been appreciated by the Centre members and external community.

Looking ahead, the Centre is exceptionally well placed for the years to come. The Legacy Impact Roadmap and the recommendations of the Strategic Planning Committee, led by Professor Steven Buckman, provide a clear, ambitious, and focused direction for the next phase of work. With its talented people, strong foundations, and renewed strategic clarity, the Centre has enormous potential to deliver lasting impact.

I'm excited about what lies ahead and have every confidence the team will continue to build momentum and achieve great things - I hope you absolutely smash it, team!

Dr Mary Gray
Chief Operations Officer

Governance: Structure



Centre Advisory Board

COMMITTEE MEMBERS:

PROFESSOR IAN CHUBB
AC FAA FTSE

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
ALEXANDRA BOLTASSEVA

Purdue University

PROFESSOR
MARK BRONGERSMA

Stanford University

People

Chief Investigators

PROFESSOR
DRAGOMIR NESHEV

Centre DIrector

Australian National University

PROFESSOR
KENNETH CROZIER

Deputy Director

University of Melbourne

PROFESSOR
IGOR AHARONOVICH

Chief Investigator

University of Technology Sydney

PROFESSOR
MADHU BHASKARAN

Chief Investigator

RMIT University

PROFESSOR
LORENZO FARAONE

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University of Western Australia

PROFESSOR LAN FU

Chief Investigator

Australian National University

PROFESSOR
CHENNUPATI JAGADISH

Chief Investigator

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PROFESSOR
MARIUSZ MARTYNIUK

Chief Investigator

University of Western Australia

PROFESSOR
ANN ROBERTS

Chief Investigator

University of Melbourne

PROFESSOR ILYA SHADRIVOV

Chief Investigator

Australian National University

PROFESSOR SHARATH SHRIRAM

Chief Investigator

RMIT University

PROFESSOR ANDREY SUKHORUKOV

Chief Investigator

Australian National University

PROFESSOR HARK HOE TAN

Chief Investigator

Australian National University

PROFESSOR MILOS TOTH

Chief Investigator

University of Technology Sydney

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Australian National University

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Postdoctoral Research Associate

Australian National University

DR CHAOHAO CHEN

Postdoctoral Fellow

Australian National University

DR TUOMAS HAGGREN

Research Fellow

Australian National University

Collaboration Award 2025

DR YANA IZDEBSKAYA

Research Fellow

Australian National University

DR ZHE LI

Postdoctoral Research Fellow

Australian National University

DR JINYONG MA

Research Fellow

Australian National University

DR JOSEPHINE MUNRO

Postdoctoral Fellow

Australian National University

DR SARANYA SHRIRAM

Postdoctoral Research Associate

Australian National University

DR VLADLEN SHVEDOV

Postdoctoral Fellow

Australian National University

DR WEI WEN WONG

Postdoctoral Fellow

Australian National University

ECR of the Year Award 2025

SRUTHI CHANDRASEKHARAN

Research Assistant

RMIT University

DR PETER FRANCIS MATHEW ELANGO

Research Fellow
RMIT University

DR PHUONG LE

Research Fellow
RMIT University
Cross-node Award 2025

DR MINGJIE YANG

Research Fellow
RMIT University

DR NEUTON LI

Postdoctoral Research Fellow
University of Melbourne

DR JIAJUN MENG

Research Fellow
University of Melbourne

DR NIMA SEFIDMOOYE AZAR

Research Fellow
University of Melbourne

DR SHABAN SULEJMAN

Postdoctoral Research Associate
University of Melbourne

DR NITU SYED

Research Fellow
University of Melbourne

DR LUKAS WESEMANN

Postdoctoral Research Fellow
University of Melbourne

DR YANG XU

Research Fellow
University of Melbourne

DR HOSSEIN ALIJANI

Postdoctoral Research Associate
University of Technology Sydney

DR MEHRAN KIANINIA

Chancellor Fellow
University of Technology Sydney

DR JIYUN (CHLOE) KIM

Postdoctoral Research Associate
University of Technology Sydney

DR HUGO QUARD

Postdoctoral Research Associate
University of Technology Sydney

DR KONOSUKE SHIMAZAKI

Postdoctoral Research Associate
University of Technology Sydney

DR NICHOLAS SLOANE

Postdoctoral Research Associate
University of Technology Sydney

DR ANASTASIIA ZALOGINA

Chancellor's Research Fellow
University of Technology Sydney
Best poster, TMOS 2025 Conference

DR NIMA DEHDASHTIAKHAVAN

Research Fellow
University of Western Australia

DR HEMENDRA KALA

Research Fellow
University of Western Australia

DR WENWU PAN

Research Fellow
University of Western Australia

ASSOCIATE PROFESSOR DILUSHA SILVA

Associate Professor
University of Western Australia

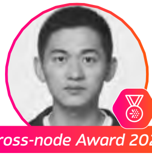
DR MICHAL ZAWIERTA

Research Fellow
University of Western Australia
Leadership Award 2025

Students

AUSTRALIAN NATIONAL UNIVERSITY

PHD STUDENTS:



YUE BIAN

MARCUS CAI

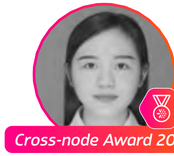
DEEPANSHU CHAUDHARY

SARAH DEAN

KOSALA DHANAWANSHA

TONGMIAO FAN

ANNA FITRIANA



XIAOYING HUANG

SIBO HUANGLONG

LUKAS JAEGER

MIN JIANG

JOSHUA JORDAAN

SEBASTIAN KLIMMER

FEDOR KOVALEV

BENJAMIN LAUDERT

NEUTON LI

DAWEI LIU

SHRIDHAR MANJUNATH

ELIZAVETA MELIK-GAYKAZYAN

MARTIN MIČULKA

CARLO PANU

PARUL PARUL

XIWEN QIU

JINLIANG REN

RAHIL REZWAN

MARIJN RIKERS

SANIYA SHINDE

YUZI SONG

LAKSHMI ULLATIL

LAURA DANIELA VALENCIA MOLINA

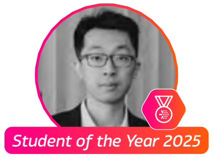
RISHABH VASHIST

LUYAO WANG

AUSTRALIAN NATIONAL UNIVERSITY

PHD STUDENTS:


FENGKAI WEI



ZIWEI YANG


YANG YU

MASTERS STUDENTS:


YIFAN ZHANG


HAN ZHENG

HONOURS STUDENTS:


TASKIL DASTOOR


KRISHNA KARTHIK

UNDERGRADUATE STUDENTS:


DHRUV EASWAR


CAMPBELL MCTERNAN

RMIT UNIVERSITY

PHD STUDENTS:


YING ZHI CHEONG


NAHIYA MUSHTAQ

UNIVERSITY OF MELBOURNE

PHD STUDENTS:


JINYUAN CHEN


LINCOLN CLARK


YIYANG CUI


Best Conference Poster
DAYANTHA LANKANATH KARUNASENA DANTHURE ARACHCHIGE


FARID KHOSHKHATI


SUDHANSHU KUMAWAT


HUAN LIU


EPD Award 2025
SEYED SALEH MOUSAVI KHALEGHI


DAMIAN KEITH NELSON


Industry Eng. Award 2025
GABRIEL OYARZO OJEDA


NIKEN PRISCILLA


BENJAMIN RUSSELL


MARYAM SETAREH


SRISHTI SRISHTI


SHABAN SULEJMAN


HENRY TAN


Outreach Award 2025
HAIWEI WANG

UNDERGRADUATE STUDENTS:


EDAN BARCLAY

UNIVERSITY OF TECHNOLOGY SYDNEY

PHD STUDENTS:

OTTO CRANWELL SCHAEPER

JAKE HORDER

JAMES LIDDLE-WESOLOWSKI

SERGEI NEDIC

RITIKA RITIKA

LESLEY SPENCER

BENJAMIN WHITEFIELD

EVAN WILLIAMS

KARIN YAMAMURA

XINYANG YU

MASTERS STUDENT:

SAMUEL STEPHENS

UNIVERSITY OF WESTERN AUSTRALIA

PHD STUDENTS:

OLEG BANNIK

YAN LIU

SHUO MA

DANIEL MORLEY

FAHIA TARANNUM MUNNA

DAMINI RANGASWAMY

POSTGRADUATE STUDENT:

AAYUSHI NANDA

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University of Technology Sydney

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Australian National University

DR MARY GRAY

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Australian National University

KAREN KADER

Node Administrator
University of Western Australia

ELEANOR LUOND

IDEA and Administrative Officer
RMIT University

SHARYN MCFARLANE

Chief Operations Officer
(until 2 February 2025)
Australian National University

LIZ MICALLEF

Senior Centre Administrator
Australian National University

KATHY PALMER

Node Administrator
University of Melbourne
Centre Member of the Year 2025

GALINA SHADRIVOVA

Business Manager
Australian National University
Business Team Member of the Year 2025

SAMARA THORN

PR Manager
Australian National University

KRISZTINA THURZO

Centre Administrator
Australian National University

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DR JEFFERY ALLEN

Associate Investigator

Air Force Research Laboratory, USA

DR MONICA ALLEN

Associate Investigator

Air Force Research Laboratory, USA

DR VICTORIA COLEMAN

Associate Investigator

National Measurement Institute

DR TIM DAVIS

Associate Investigator

University of Melbourne

DR BLANCA DEL ROSAL RABES

Associate Investigator

RMIT University

ASSOCIATE PROFESSOR DANIEL GOMEZ

Associate Investigator

RMIT University

ASSOCIATE PROFESSOR MARTIN HILL

Associate Investigator

University of Western Australia

DR NIAN (JENNY) JIANG

Associate Investigator

Australian National University

ASSOCIATE PROFESSOR ALEXANDER KHANIKAEV

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DR SEJEONG KIM

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Sungkyunkwan University, South Korea

DR JIAWEN LI

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PROFESSOR CHRISTINA LIM

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University of Melbourne

ASSOCIATE PROFESSOR YUERUI LU

Associate Investigator
Australian National University

PROFESSOR ANDREY MIROSHNICHENKO

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PROFESSOR THOMAS PERTSCH

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DR MOHSEN RAHMANI

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DR HAORAN REN

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DR NITU SYED

Associate Investigator
RMIT University

DR JEAN-PHILIPPE TETIENNE

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RMIT University

PROFESSOR ANTONIO TRICOLI

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University of Sydney

DR SARAH WALDEN

Associate Investigator

Griffith University

Partner Investigators

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Partner Investigator

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PROFESSOR HARRY ATWATER

Partner Investigator

California Institute of Technology, USA

DR AURELIEN BOTMAN

Partner Investigator

Thermo Fisher Scientific, USA

PROFESSOR DEMETRIOS CHRISTODOULIDES

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PROFESSOR YESHAIAHU (SHAYA) FAINMAN

Partner Investigator

University of California San Diego, USA

PROFESSOR ANDREI FARAON

Partner Investigator

California Institute of Technology, USA

DR NORBERT HERSCHBACH

Partner Investigator

IEE, Luxembourg

PROFESSOR LAURA HERZ

Partner Investigator

University of Oxford, UK

PROFESSOR MICHAEL JOHNSTON

Partner Investigator

University of Oxford, UK

PROFESSOR HANNAH JOYCE

Partner Investigator

University of Cambridge, UK

PROFESSOR SANJAY KRISHNA

Partner Investigator

The Ohio State University, USA

PROFESSOR TERI ODOM

Partner Investigator

Northwestern University, USA

PROFESSOR WILLIE PADILLA

Partner Investigator

Duke University, USA

ASSOCIATE PROFESSOR CHENGWEI QIU

Partner Investigator

National University of Singapore, Singapore

PROFESSOR ISABELLE STAUDE

Partner Investigator

Friedrich Schiller University of Jena, Germany

PROFESSOR ANDREW WEE

Partner Investigator

National University of Singapore, Singapore

TMOS Cross-Node and Partner Investigator Exchange Awards Program

The ARC Centre of Excellence for Transformative Meta-Optical Systems (TMOS) continues to place collaboration at the heart of its research, connecting researchers, infrastructure, and expertise across its Australian nodes and international partners.

The Cross-Node and Partner Investigator Exchange Awards Program supports PhD students, Early Career Researchers (ECRs), and Partner Investigators to undertake targeted research visits that advance Centre projects and strengthen inter-institutional collaboration.

These exchanges provide access to specialised facilities, enable the transfer of technical expertise, and foster the development of joint research initiatives with national and international partners. By supporting researcher mobility, the program plays a critical role in strengthening TMOS integration and accelerating high-impact research outcomes.

During 2025, 5 awards were granted comprising four Cross-Node Awards and one Partner Investigator Award. In addition, awardees from 2024 who had deferred travel were able to complete their exchange activities.

2025 AWARD RECIPIENTS

Partner Investigator Exchange Awards

Kosala Dhanawansha (ANU)

Cross-Node Exchange Awards

Yue Bian (ANU)
Xiaoying Huang (ANU)
Phuong Le (RMIT)
Yuzi Song (ANU)

2025 EXCHANGE AWARDS HIGHLIGHTS

STRENGTHENING CROSS-NODE RESEARCH LEADERSHIP

Kosala Dhanawansha

Kosala Dhanawansha's Partner Investigator Exchange Award supported a collaborative research visit to Dr Sanjay Krishna's group at The Ohio State University, focused on strengthening connections between TMOS nodes and advancing shared nanophotonics research capabilities. Working closely with host investigators, Kosala developed new experimental approaches by combining complementary expertise in fabrication and optical characterisation.

The visit delivered several tangible outcomes, including the establishment of joint experimental workflows, progress toward co-authored publications, and the identification of new collaborative funding opportunities. Access to specialised infrastructure also enabled the generation of preliminary data to support future grant applications and longer-term research partnerships.

Beyond these outputs, the exchange reinforced the strategic value of PI-level mobility in fostering Centre integration, deepening collaboration, and accelerating high-impact research across TMOS.

ACCELERATING INTERNATIONAL COLLABORATION

Laura Valencia Molina
(2024 award recipient travelled in 2025)

Supported by the Cross-Node and Partner Exchange Award, Laura Valencia Molina completed a research visit with Andrea Alù's group at the CUNY Advanced Science Research Center. Working within a leading metasurface research environment, Laura strengthened her technical skills and contributed to refining the joint project roadmap. The initial work began in New York, the final experimental and simulation stages will now continue at ANU. The collaboration is paving the way for a planned 2027 publication and has already sparked discussions for a follow-up project, reinforcing long-term international collaboration.

BUILDING CROSS-NODE CAPABILITY

Xiaoying Huang

Xiaoying Huang's exchange, hosted by Professor Igor Aharonovich (UTS), focused on advancing next-generation quantum light sources, contributing to scalable single-photon device development. The collaboration combined complementary expertise across nodes, resulting in promising experimental outcomes and a manuscript submitted to Nano Letters. The experience also supported career progression, with Xiaoying securing a postdoctoral research position following the visit.

FROM PLANNING TO RESULTS

Phuong Le

During a focused visit to ANU, Phuong Le translated months of planning into experimental outcomes, using advanced laser systems to develop rewritable thin-film devices. The visit generated high-quality data for publication and significantly accelerated the project timeline. The exchange also strengthened cross-node collaboration and provided valuable hands-on experience with new experimental techniques.

Over 2026–27, the Cross-Node and Partner Investigator Exchange Awards Program will continue to support TMOS's collaborative research model and strengthen its distributed expertise. It will foster HDR and early career researcher development through enhanced capability and lasting collaborations.

In 2026, the Program will deliver targeted funding, including $1,000 exchange awards, $2,000 project-based awards, and a $5,000 Partner Investigator Exchange Award, alongside a new Research Professional Development Program offering $2,000 grants for skills development, training, and industry engagement.

Together, these initiatives will sustain cross-node collaboration, build researcher capability, and drive impactful research outcomes.

TMOS Awards 2025

Tuomas Haggren
Collaboration Award

Galina Shadrivova
Business Team Member Award

Ziwei Yang
Student of the Year Award

Wei Wen Wong
ECR of the Year Award

Kathy Palmer
Member of the Year Award

Sarah Dean
Science Communication Award

Haiwei Wang
Outreach Award

Gabriel Oyarzo Ojeda
Industry Engagement Award

Michal Zawierta
Leadership Award

Seyed Saleh Mousavi Khaleghi
Education and Professional Development Award

Damini Rangaswamy
IDEA Award


Tuomas Haggren


Ziwei Yang


Wei Wen Wong


Sarah Dean


Haiwei Wang


Gabriel Oyarzo Ojeda


Seyed Saleh Mousavi Khaleghi

INTERVIEW
COLLABORATION AWARD

TUOMAS HAGGREN

Postdoctoral Researcher
Australian National University

What were the collaboration highlights of 2025 for you?

One major highlight was the publication of a collaborative article in Science Advances. We also finalised the results for two additional collaborative papers, one based on a cross-node project and another developed with a TMOS PI. Together, these outcomes highlight the strength of TMOS's collaborative framework and its ability to drive high-impact research across institutions.

How did combining different node specialities change the final outcome of your research?

Combining expertise across different TMOS nodes significantly strengthened the research outcomes. In one instance, the original dataset could be explained by two possible mechanisms. Through collaboration with another node, the team was able to undertake additional experiments using specialised capabilities that verified which mechanism was correct. This not only strengthened the manuscript, but also increased confidence in the overall conclusions of the study.

What is your "pro-tip" for turning a casual chat into a productive research partnership?

A good approach is to identify what you can offer a colleague or how their expertise might strengthen your project. Often this creates a natural win–win. For example, applying a specialised method from one researcher to another's work may be straightforward but can greatly enhance the outcomes. TMOS's broad expertise makes these opportunities especially valuable.

INTERVIEW
EARLY CAREER RESEARCHER OF THE YEAR AWARD

WEI WEN WONG

Postdoctoral Researcher
Australian National University

How did you become a Centre member?

Initially, I joined TMOS as a PhD student at ANU, supervised by Professors Hoe Tan and Chennupati Jagadish. After completing my PhD in 2023, I became TMOS's postdoctoral fellow and later its research fellow. My research focuses on designing and fabricating nanolasers based on semiconductor nanostructures. Since 2025, I am also a Research Program Manager for Theme 1, where I help develop and refine the theme structure and ensure our research aligns with TMOS's strategic objectives.

What are the new or existing relationships that helped you through your journey?

Our projects are highly collaborative and draw on diverse expertise across TMOS nodes, including theoretical modelling, nanofabrication, and material and optical characterisation. For example, optical measurements for our single-photon emitter projects are carried out at the UTS node, while we work closely with the TMOS's UniMelb node on mid-infrared laser simulations and cavity fabrication.

Looking ahead, what's next ?

Although we have demonstrated several novel nanolasers in recent years, all have been optically pumped, which limits practical use. A major focus of Theme 1 is now achieving electrically pumped lasing, an essential step toward moving these devices from laboratory proof-of-concepts to viable real-world technologies.

INTERVIEW

STUDENT OF THE YEAR AWARD

ZIWEI YANG

PhD Student

Australian National University

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

Yes. I gradually moved from functional static dielectric metasurfaces (metalens) and simple tuning schemes to complex, functional, dynamically tunable metasystems, driven by collaborative opportunities, practical application demands, and the growing need for active light control.

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

TMOS provided a globally connected, cross-disciplinary environment that encouraged ambitious ideas, while my supervisors offered both scientific freedom and clear strategic direction. That balance allowed me to confidently expand into new tuning mechanisms and research directions.

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

As part of an experimental physics group, I am excited by the opportunity to uncover new physical mechanisms, directly observe and interact with previously unseen phenomena, and demonstrate their first practical implementations.

Could you please summarise in a couple of words what you were working on in 2025?

Two directions: Electrically and all-optical tunable metasurfaces; time-variant photonics.

INTERVIEW

LEADERSHIP AWARD

MICHAL ZAWIERTA

Postdoctoral Researcher

University of Western Australia

Can you tell us about some of your key research and development contributions in 2025?

In 2025, I contributed to the development of MEMS-enabled, tunable metamaterial filters for infrared and terahertz applications. During the same period, I played a leading role in the development of the Photon Clicker, working in collaboration with the TMOS Outreach Committee and Questacon – The National Science and Technology Centre (Canberra, Australia)

What kind of research environment do you aim to create within your teams?

I am committed to fostering a safe, inclusive research environment grounded in open communication, mutual respect, and intellectual curiosity. I encourage researchers to share ideas, including unconventional ones, and to support this process with constructive feedback to stimulate creativity and innovation.

How do you approach leading and motivating diverse research teams?

In leading and motivating diverse teams, I personally aim to recognise and leverage each member's unique perspectives and skills, ensuring all voices are heard and valued. I also prioritise setting clear goals, providing appropriate resources, and acknowledging both individual contributions and collective achievements.

INTERVIEW
MEMBER OF THE YEAR AWARD

KATHY PALMER

Node Administrator

University of Melbourne

What past experiences proved especially valuable in your work with TMOS this year?

Having worked in three previous CoE Lead Node administration teams, including two roles as Finance Officer, I was able to draw on that experience in my work with TMOS. I supported Galina Shadrivova, Centre Business Manager, in gathering and collating financial data from across the TMOS nodes, helping the Directorate build a clearer picture of node budgets and improve Centre-wide planning and outcomes. Throughout this process, I was also able to share insights and observations about the overall state of the budgets.

Was there a particular task or process you stepped into this year that helped support the Centre more effectively?

Taking on CEC minute writing was another familiar task for me, and I was happy to help support the Centre's administration team at ANU who were over-stretched during an especially busy period in 2025.

What advice would you give to others looking to contribute positively to the TMOS community?

My advice to everyone in the Centre is to take every opportunity to collaborate and communicate with one another. We are only brought together as a group for a limited time, and the chance to share knowledge, experiences, and camaraderie across our TMOS community is something truly special.

INTERVIEW
2025 BUSINESS TEAM MEMBER AWARD

GALINA SHADRIVOVA

Business Manager

Australian National University

What were the highlights of 2025 for you?

A key highlight of 2025 was stepping into a senior operational leadership role during a particularly demanding period for the Centre. Acting as COO for part of the year, I supported continuity of operations, governance, and coordination at a time of change, helping to maintain stability and momentum across TMOS. It was a valuable opportunity to provide leadership and support the Centre and its people through transition. I was grateful to receive the TMOS Business Team Member Award, which was a meaningful acknowledgement and another highlight of the year.

What challenges did you face?

The main challenge was managing a broad portfolio in a fast-moving and, at times, uncertain environment. This included competing priorities, tight timeframes, and extended periods of significantly reduced management capacity, where I was the sole manager supporting operations.

What excites you most about the future of the Centre?

I am excited by the continued evolution of TMOS as a collaborative community. I'm looking forward to seeing how the Centre builds on its strategic review to strengthen its legacy and continue delivering real-world impact through its world-class research.

Research

Message from the Deputy Director

At TMOS, our primary objective is to bridge the gap between fundamental optical science and real-world impact. The year 2025 served as a definitive period for this mission, characterised by significant milestones in researcher development and cross-institutional scientific output.

A cornerstone of our success is the growth of our early-career researchers (ECRs) and students. In July, this was exemplified by the **TMOS ECR and Student Conference** held at UniMelb. It was notable not only for its technical merit but for the fact that it was led and coordinated by our student and ECR cohort. Delivering the Opening Address, I observed firsthand their professional rigour and high engagement.

The conference program was designed to address the multifaceted nature of a modern research career. Alongside traditional academic exchange, it included workshops on "The Resilient Researcher" and "Researcher Feedback," as well as practical training in "Art of the Presentation," "Pitch Training," and "Blender for Scientists." These initiatives ensure our researchers possess the communication and resilience required for impactful careers. I extend my sincere thanks to the organising committee: Hossein Alijani, Jinyuan Chen, Peter Elango, Phuong Le, Eleanor Luond, Seyed Saleh Mousavi Khaleghi, Fahia Tarannum Munna, and Haiwei Wang.

The TMOS commitment to integrated research is best reflected in our 2025 publication record. We have seen a steady increase in journal papers involving co-authors from multiple Nodes. I have highlighted a few such papers below. These underscore how diverse approaches to imaging can yield significant advances.

In the domain of **Quantum Imaging**, a collaboration between ANU and UniMelb made notable progress. In *eLight* (5:2(2025)), Ma *et al.* demonstrated a nonlinear metasurface comprising a silica structure on a lithium niobate thin film. By tuning the pump beam wavelength, the team achieved control over photon emission angles, enabling 2D imaging through a combination of quantum ghost imaging and optical scanning. This work establishes a new foundation for metasurface-based quantum light sources.

> “TMOS advances in quantum imaging, mid-infrared photodetection, and multimodal microscopy demonstrate both the growing maturity of our talent pipeline and the scientific impact achieved through coordinated, interdisciplinary cross-node research.”

Simultaneously, an ANU-UWA collaboration addressed critical limitations in **Mid-Infrared Photodetection**. While Quantum Well Infrared Photodetectors (QWIPs) are highly effective, traditional in-plane configurations often restrict absorption at normal incidence. In *Applied Physics Letters* (vol. 126, 041105 (2025)), Bian *et al.* reported on mid-infrared intraband transitions using InP nanowire arrays with radially grown InGaAs quantum wells. This architecture enables efficient photodetection at 3 microns and beyond, offering a pathway toward low-cost, high-performance focal plane arrays.

Finally, a multi-partner initiative involving UniMelb, ANU, RMIT, and clinical contributors (**St Vincent’s Private Hospital** and the **Florey Institute of Neuroscience**) advanced the field of microscopy. In *ACS Photonics* (vol. 12, 1494 (2025)), Sulejman *et al.* developed a silicon-based metasurface for multimodal microscopy. By adjusting illumination polarisation, the system can switch between phase contrast and bright-field imaging. This development is a vital step toward the miniaturisation of optical systems for point-of-care medical testing.

These achievements reinforce the value of our collaborative model. On behalf of the Centre, I wish all our members and stakeholders continued success in their scientific endeavours in 2026.

Professor Kenneth Crozier
Centre Deputy Director

Infrastructure and Capabilities Committee Chair Report

ICC Chair, Professor Kenneth Crozier

In the Infrastructure and Capabilities Committee (ICC), our goal is to make sure that each TMOS researcher can make, measure and simulate something. Our 2025 objectives 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. We are happy to report that these were all met.

It is fair to say that the ICC achieves many of its goals by promoting collaboration across TMOS. In 2025, the ICC supported numerous researcher visits between Nodes and international partner institutions, facilitating access to specialised infrastructure, new collaborations and shared expertise. Selected examples of these activities are outlined below.

"I visited UWA in 2025 to collaborate with A/Professor Gilberto Umana-Membreno, using their spectroradiometer to characterise my mid-infrared metasurface microspectrometer. Additional measurements were conducted to support spectral reconstruction studies. Grateful to the UWA team for their support!" – Dr Jiajun Meng (TMOS Research Fellow, UniMelb).

"I was awarded the TMOS Cross-Node Exchange Award to visit the University of Melbourne. I collaborated with Jinyuan Chen and Seyed Saleh Mousavi Khaleghi to demonstrate high-resolution unpolarized and polarized short-wave infrared single-pixel imaging using bottom-up grown heterojunction p–n InAs–InP core–shell nanowire and nanosheet photodiodes." – Mr Yang Yu (TMOS PhD student, ANU).

> "Collaboration remained central to the work of the Infrastructure and Capabilities Committee (ICC) in 2025, with the Committee continuing to support researchers through shared infrastructure, facility access and cross-node engagement."

"I was awarded a Fulbright Scholarship to undertake four months of research at CUNY with Professor Andrea Alù. My proposal was on all-optical object recognition using metasurfaces based on the concept of matched filtering. I worked with group members Mehdi Kiani, Prachi Thureja and Lin Jing to experimentally demonstrate wavelength-tunable object recognition." – Mr Shaban Sulejman (TMOS PhD student, UniMelb).

"Supported by the Partner Investigator Award, I was able to travel internationally from Duke University to access facilities at the University of Western Australia. We performed many collaborative measurements under the guidance of A/Professor Gilberto Umana-Membreno, harnessing UWA's spectroradiometry know-how to characterise a prototype device designed and fabricated in a collaborative fashion between Duke Univ., UWA and ANU." – Ms Amanda Gregg (PhD student, Duke University).

Wishing all TMOS members a highly productive year of discovery in 2026.

Professor Kenneth Crozier
Infrastructure and Capabilities Committee Chair

ACTION ITEMS FOR 2026

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.

COMMITTEE MEMBERS:

PROFESSOR KENNETH CROZIER
Chief Investigator, UniMelb (Chair)

PROFESSOR HARK HOE TAN
Chief Investigator, ANU

PROFESSOR MARIUSZ MARTYNIUK
Chief Investigator, UWA

PROFESSOR SHARATH SRIRAM
Chief Investigator, RMIT

PROFESSOR IGOR AHARONOVICH
Chief Investigator, UTS

PROFESSOR MILOS TOTH,
Chief Investigator, UTS

DR WEI WEN WONG
ECR member, ANU

KATHY PALMER
Node Administrator,
UniMelb (Secretary)

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 will have a visible impact on technology beyond the seven-year timeframe of its research program.

Guided by our three research themes we build foundations for next-generation optical systems and positioning Australia at the forefront of global photonics innovation:

GENERATE

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

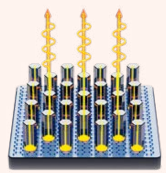
MANIPULATE

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

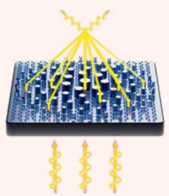
DETECT

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

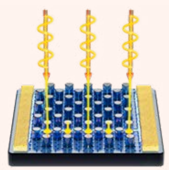
Together, these themes provide the scientific foundations, capabilities and infrastructure that support and accelerate research across the Centre.



GENERATE



MANIPULATE



DETECT

Find out more about our themes on our website tmos.org.au

As discoveries mature, they are translated into application-focused flagship programs that bring together expertise from multiple nodes and drive progress towards high-impact, high-TRL outcomes. Our flagship programs are specialised cross-node initiatives designed to transform foundational research into technologies with strong commercial and societal impact.

Current flagship programs focus on three strategic translational areas:

ADVANCED QUANTUM TECHNOLOGIES

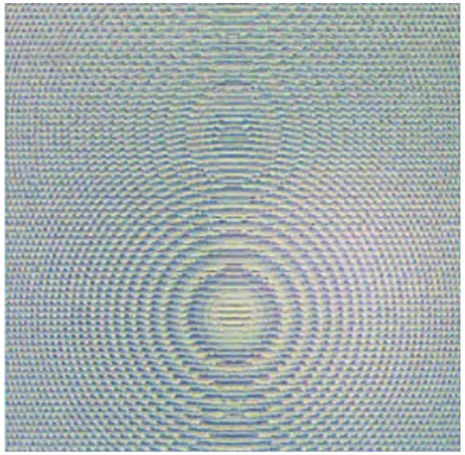
Developing miniaturised hardware for next-generation quantum computing, communication and sensing through quantum light sources, single-photon detectors and quantum imaging technologies for secure communications, defence and aerospace applications.

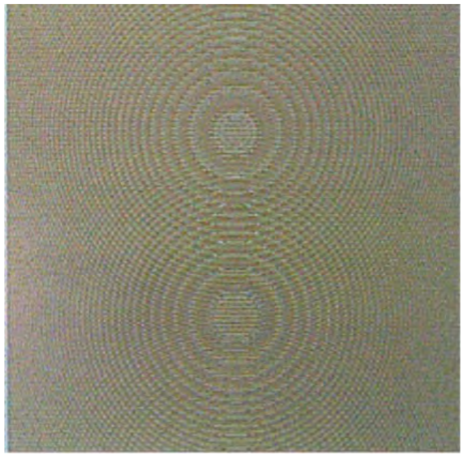
META HEALTH SENSORS

Creating wearable and minimally invasive diagnostic technologies based on metamaterials and nanophotonics, enabling continuous health monitoring, non-invasive glucose sensing and portable medical diagnostics.

ENHANCED INFRARED VISION

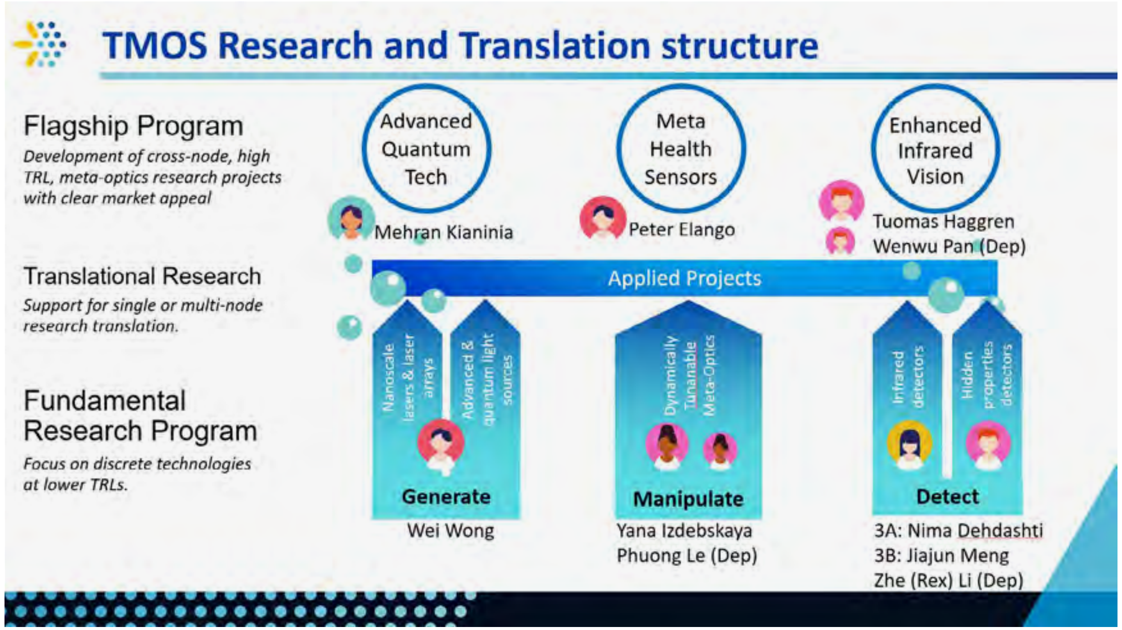
Advancing infrared imaging and sensing through ultra-thin photodetectors, tunable gas sensors and integrated metalens technologies for applications in LIDAR, night vision, consumer electronics, space and defence.





In 2026–27, we work to establish a legacy that combines scientific excellence, translation, talent development, and collaboration. The 2026–27 Roadmap outlines how this legacy will be achieved:

- Collaborative activities within the Generate, Manipulate, and Detect themes that involve multiple Centre nodes will evolve into applied projects and become part of the Centre's flagship programs.
- Applied projects led within individual Centre nodes will continue to be supported for translation and impact, even where they do not form part of the flagship program structure.



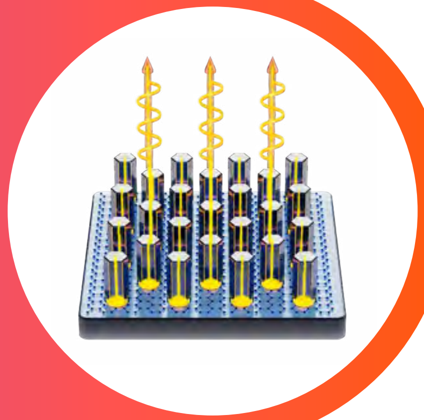
The overall TMOS research program structure with the identified program managers

By integrating world-leading fundamental research with translation-focused flagship programs, TMOS is creating a pipeline of technologies that will strengthen Australia's sovereign capabilities, accelerate industry innovation, and deliver tangible benefits to society. Through collaboration across disciplines, institutions, and industry partners, the Centre is building both the scientific foundations and the translational pathways needed to shape the future of photonics and meta-optics.

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:

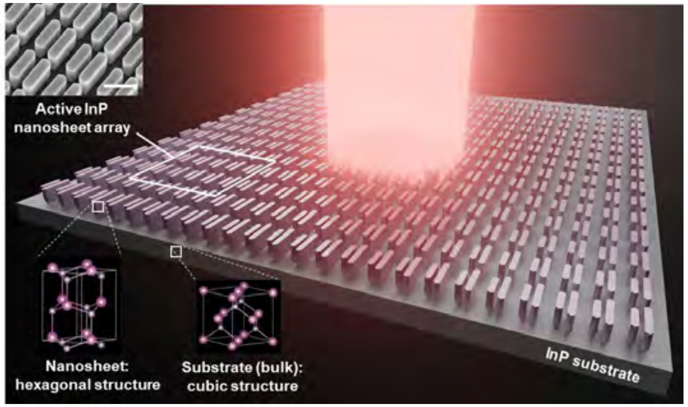
PROFESSOR IGOR AHARONOVICH
University of Technology Sydney

PROFESSOR HOE TAN
Australian National University

In 2025, we continued to advance miniaturised meta-optical light emitters through strong cross-node collaboration and internationally connected research. These collaborative efforts drove progress in photonic integrated circuits, room-temperature quantum emitters, infrared quantum imaging and ultra-compact light-generation technologies, with applications spanning sensing, communications, imaging and quantum technologies. The year produced strong research outcomes, including several joint publications across the ANU, UTS and UniMelb nodes within the Generate Theme, as well as more than half a dozen publications involving partner investigators and a similar number involving the Centre's associate investigators.

The following highlights showcase some of the key achievements from 2025:

In 'nanoscale lasers and laser arrays' sub-theme, we worked with our collaborators in USA to optimise the cavity designs for low-threshold lasing in InP nanowire photonic crystal surface-emitting lasers (PCSELs). We further demonstrated that by using a PCSEL-in-PCSEL (hetero-PCSEL) structure, lasing threshold could be markedly reduced further. Building on this approach, we extended the design and fabrication to



Schematic diagram and electron microscopy image of a bottom-up metasurface laser fabricated from an array of semiconductor nanosheets.

InAs nanowire PCSELs targeting lasing near 3.5 μm. This ongoing work on mid-infrared nanoscale lasers provides a promising platform for on-chip sensing, nonlinear optics and integrated photonics.

The cross-node ANU-UTS collaboration on electrically injected nanoscale emitters has resulted in the demonstration of electrically driven single-photon sources based on III-V quantum dots embedded in nanowire cavities. These emitters exhibit high brightness and exceptional long-term stability in both emission wavelength and photon count under continuous-wave current injection.

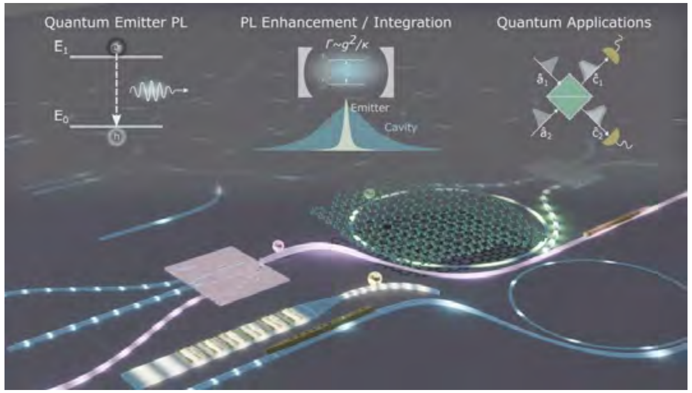
In the 'advanced and quantum light sources' sub-theme, the UTS team continues to lead advances in hexagonal boron nitride (h-BN) quantum emitter technology. In collaboration with US partners, they achieved the highest-purity single-photon emission reported from h-BN to date, with a $g^{(2)}(0)$value of 0.015 at room temperature. This was enabled by incorporating carbon directly during the synthesis of centimetre-scale h-BN films. Such high-purity emission is essential for achieving high-fidelity quantum devices.

Using our specially engineered InP nanomembranes featuring large-area biphasic wurtzite-zincblende interfaces, our collaborators demonstrated more than a 200-fold enhancement in second-harmonic generation in the short-wave infrared. These nanostructures open new opportunities for efficient wavelength conversion and integrated nonlinear photonic circuits.

In collaboration with our partner investigators in Jena, we demonstrated a metasurface-based approach for tuning quantum entanglement by overcoming the symmetry constraints of conventional nonlinear materials. Our design based on InGaP nanoresonators enables continuous tuning of polarisation-entangled photon pairs across a wide range, achieving a coincidence-to-accidental ratio two orders of magnitude higher than existing semiconductor flat-optics sources. This work paves the way for compact, tunable quantum light sources.

ACTION ITEMS FOR 2026

1. Electrically injected photonic cavity surface emitting lasers.
2. Flatband and chiral lasers.
3. Nonlinear image processing with dynamic kernels.
4. Demonstrate coherent hBN sources; integrated sources with metalenses in SiC.
5. Asymmetric generation of photon-pairs and demonstration of quantum hyper-entanglement from nonlinear metasurfaces.



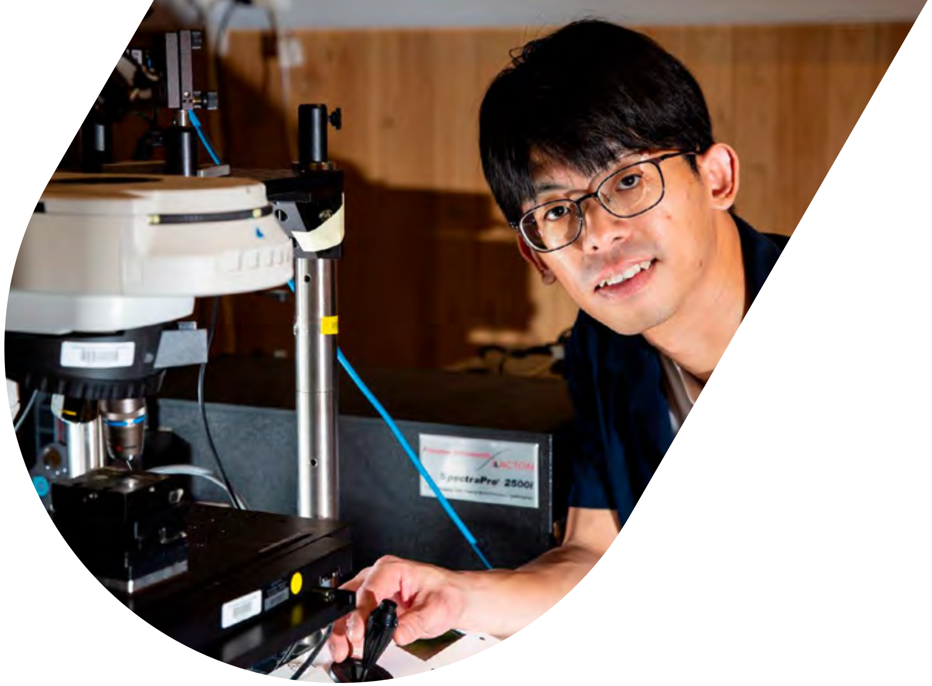
Artistic illustration of an integrated quantum photonic platform consisting of quantum emitter-cavity systems, waveguides, and multiplexers.

PUBLICATION HIGHLIGHTS

1. Robertson IO, Whitefield B, Scholten SC, Singh P, Healey AJ, Reineck P, Kianinia M, Barcza G, Ivády V, Broadway DA, Aharonovich I, Tetienne JP. A charge transfer mechanism for optically addressable solid-state spin pairs. Nat Phys. 2025;21:1981-1987. https://doi.org/10.1038/s41567-025-03091-5
2. M Gilardoni, C., Eizagirre Barker, S., Curtin, C. L., Fraser, S. A., Powell, O. F. J., Lewis, D. K., Deng, X., Ramsay, A. J., Adhikari, S., Li, C., Aharonovich, I., Tan, H. H., Atatüre, M., & Stern, H. L. (2025). A single spin in hexagonal boron nitride for vectorial quantum magnetometry. Nature Communications, 16(1), 4947. https://doi.org/10.1038/s41467-025-59642-0
3. Ma, J., Fan, T., Haggren, T., Molina, L. V., Parry, M., Shinde, S., McManus-Barrett, C., Zhang, J., Morales, R. C., Setzpfandt, F., Tan, H. H., Jagadish, C., Neshev, D. N., & Sukhorukov, A. A. (2025). Nonlinearity symmetry breaking for generating tunable quantum entanglement in semiconductor metasurfaces. Science Advances, 11(28), eadu4133. https://doi.org/10.1126/sciadv.adu4133

GENERATE CASE STUDY

Growing crystals for metasurface lasers gives record efficiency



Growing crystals for lasers, rather than sculpting them, could be the key to a new generation of nanoscopic lasers, that will be embedded in communication and processing technology of the future.

Dr Wei Wen Wong said the new technique can streamline manufacturing of lasers a tenth of the diameter of a human hair, as well as open the door for further miniaturisation, without sacrificing efficiency.

"We have achieved a record high – 80 percent of the light emission was converted into laser light," said Dr Wong, from the Department of Electronic Materials Engineering, and the ARC Centre of Excellence for Transformative Meta-Optical Systems (TMOS). "We think this is because of the elegance in our fabrication approach, which allowed us to combine a high-quality cavity and active material into one."

Dr Wong is the first author of the paper reporting the research in Science Advances.

The team were exploring making lasers from metasurfaces, which use sub-wavelength structures to manipulate light in novel ways not observed in everyday materials. Metasurfaces can be used to make devices such as lasers or sensors compact enough to be used in novel technologies – for example biochemical sensors that detect protein shapes without the need to alter their behaviour with the use of fluorescent biomarkers.

To date, nanoscale manufacturing has relied on sculpting structures through lithography and etching processes. These processes selectively carve into material surfaces via chemical reactions and physical bombardment, and are capable of the precision required to create nanostructures. These carving processes, however, have a major drawback: The resulting structures have rough surfaces. This is bad for optical uses as this roughness reduces lasing efficiency by causing detrimental light scattering.

This roughness is of a fixed size, and doesn't scale down with the size of nano structures being manufactured. So, for smaller structures, surface roughness becomes a proportionately bigger issue, which limits how much smaller these kinds of devices can be made.

However, many researchers believed there was no alternative, arguing that that metasurface lasers could not be produced using bottom-up crystal growth methods, or at least would be very inefficient.

Dr Wong was undeterred: Instead of carving into the surface, he tried techniques to selectively grow crystals with the desired sidewall facets, through a process called selective area epitaxy. This not only simplified the manufacturing process, but the team were able to grow nanostructures with atomically smooth sidewalls (surface roughness around 1.6 Angstrom).

The crystal design was based around bound-states in the continuum (BIC) to produce laser light, using structures that create resonances and trap light at a specific frequency. To do this the team created pairs of subwavelength nano sheets. These sheets each established a pair of magnetic dipole BICs whose symmetry prevents light leakage. By varying the size of one of the nano sheets in each pair they introduced an asymmetry that allowed light to leak out and produce laser radiation.

Optically pumping the laser they achieved a lasing efficiency of 0.8 – on-par with the current best etched room-temperature metasurface lasers (many of which need cryogenic temperatures).

The next step on the road to proving commercial viability of this crystal growth technique for these devices is to have the lasers powered electrically, to enable integration with semi-conductor electronics. However, attaching electrodes to the crystals is tricky, because it can create new areas where light can leak out.

Dr Wong hopes the work will benefit the wider industry, especially for applications that use LEDs, for example as pixels in augmented reality goggles.

"A lot of people had doubts, but we have proved that bottom-up nanolasers really work," he said. "Etching damage issue is much more critical for microLEDs, so people are paying serious attention to bottom-up techniques now."

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

Near-unity spontaneous emission factor InP surface-emitting lasers based on quasi-bound states in the continuum

SCIENCE ADVANCES, 5 SEPTEMBER 2025

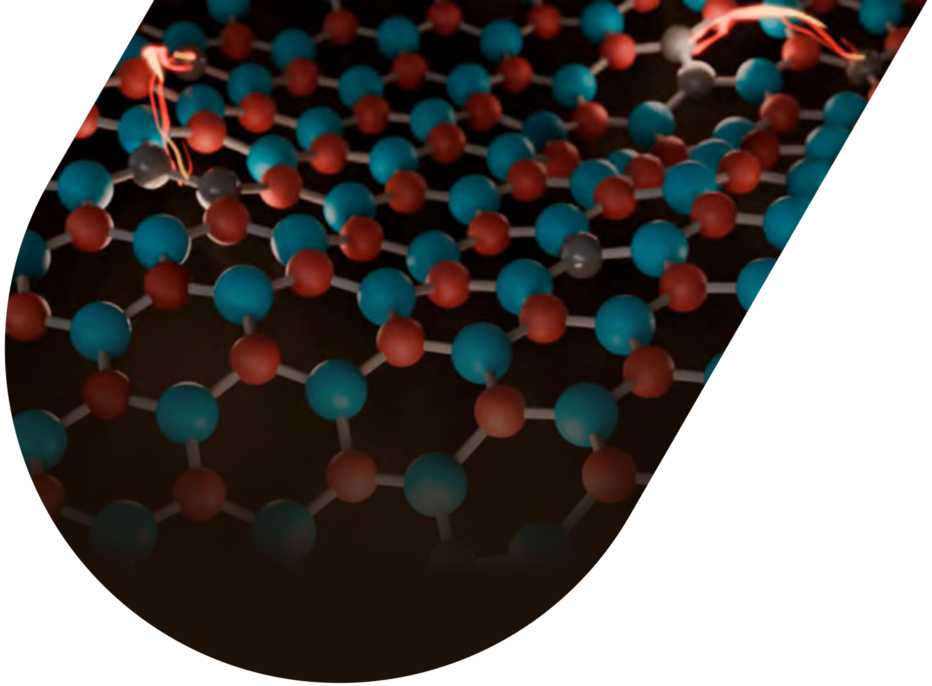
Wei Wen Wong, Xiaoying Huang, Olivier Lee Cheong Lem, Chennupati Jagadish, Hark Hoe Tan

Surface-emitting lasers featuring optical bound states in the continuum (BICs) have recently emerged as a promising alternative to vertical cavity surface-emitting lasers. However, structural damage caused by top-down fabrication processes remains as a major obstacle that limits device performance. Here, we overcome this bottleneck by demonstrating surface-emitting quasi-BIC lasers fabricated with a bottom-up, etching-free process. We epitaxially grow arrays of crystal phase–engineered InP nanosheets with atomically smooth sidewalls as both the laser active medium and a symmetry-broken quasi-BIC cavity, strategically optimizing coupling between spontaneous emission and the lasing mode. Furthermore, we leverage the dipole selection rule associated with the wurtzite crystal structure of the nanosheets for side mode suppression, achieving single-mode lasing at room temperature with lasing threshold as low as 14 μJ cm-2 pulse-1. Optimal light-cavity coupling is evidenced by spontaneous emission factors as high as 0.8, showcasing the potential of bottom-up BIC lasers in realizing near-thresholdless lasing at room temperature.

Read the full article

GENERATE CASE STUDY

Quantum double-act the key to bright magnetic sensors



Physicists have solved the puzzle of glowing atoms in semiconductors that can be magnetically controlled.

The answer – that the emission actually comes from two coupled atoms – opens the way for researchers to design much more efficient quantum sensors, by leveraging the magnetic spin response of the emitter, said leader of the research group, Associate Professor Jean-Philippe Tetienne.

"This simple elegant model solved many puzzles in one strike. For researchers trying to explain their observations suddenly everything makes a lot more sense," said A/Prof Tetienne, from the ARC Centre of Excellence for Transformative Meta-Optical Systems (TMOS) and the Royal Melbourne Institute of Technology (RMIT).

A sensitive and accurate quantum sensor for magnetic fields has potential for a wide range of uses, from material analysis to medical diagnoses.

The research, published in Nature Physics , was a joint effort between the University of Technology Sydney (UTS), led by Professor Igor Aharonovich (TMOS), and RMIT, led by Associate Professor Jean-Philippe Tetienne.

The team were investigating atomic emitters in the semiconductor hexagonal boron nitride (hBN). The emitters are irregularities in the semiconductor lattice – individual atoms that are out of place or missing – and when light shines on the semiconductor these atoms gleam.

A nice quirk of these emitters is that the brightness of the emission is dependent on the spin properties of the emitter, which is a reflection of the surrounding magnetic fields, making them of value as quantum sensors.

Previously one emitter mechanism had been unravelled and shown to be a boron vacancy, but it was too dim for practical use, unlike the ones the TMOS team were studying.

"Researchers had previously observed these bright emitters and measured their spin properties, but no one really knew what they were measuring," said the lead author of the paper, Islay Robertson, a PhD student at RMIT.

"They had been linked to carbon defects, but their exact chemical structure was disputed."

The key to solving the puzzle came when the team noticed a similarity to a phenomenon in chemistry, known as radical pair mechanism, in which two electrons, from nearby molecules, or separated within a large molecule, couple to create the emission phenomenon.

Although the radical pair mechanism initially challenged the previous hypotheses about the bright hBN emitter's quantum spin, requiring it to be spin ½ instead of spin 1, modelling quickly showed consistency with the experimental observations.

The model explained that the brightness depended on the combination of the spins of the two atoms – with antiparallel spins appearing brighter and parallel dimmer.

"Understanding the defect structure is a crucial step towards fine tuning their properties. It's exciting to be able to start turning knobs to make them into something useful," Mr Robertson said.

"Our system also allows for a wide range of tunability for the optical properties of the defect."

Already the team have found they can tune the wavelength of the emission, usually a fixed property of such emitters.

They also realised the radical pair mechanism is not tied to hBN, but could work in all kinds of semiconductors, said Associate Professor Tetienne.

"It provides a new way to design spin systems for quantum tech applications, in a much more flexible way than before."

"Previously researchers were looking for point defects that satisfy a very strict set of requirements, like looking for a needle in a haystack."

"In our new paradigm, all you need essentially is a pair of nearby point defects that can exchange charge, which turns out to be very common in many materials, and here we go you have a quantum sensor!" he said.

To emphasise the flexibility of the material, the TMOS team's results were achieved in hBN, a two-dimensional Van der Waals material, Mr Robertson said.

"These are a special class of materials which are like atomically thin lego bricks that can be stacked together to create new devices."

"They have potential to be useful as quantum sensors in the magnetic imaging space, because they are extremely thin, and can be placed so close to the target system," he said.

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

A charge transfer mechanism for optically addressable solid-state spin pairs

NATURE PHYSICS, 19 NOVEMBER 2025

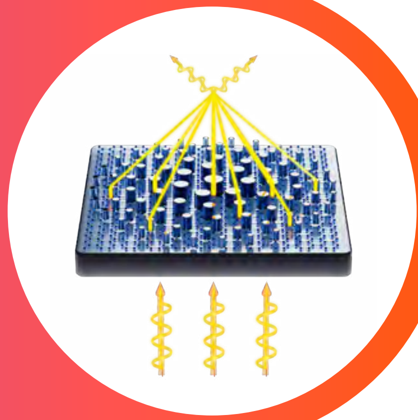
Islay O. Robertson, Benjamin Whitefield, Sam C. Scholten, Priya Singh, Alexander J. Healey, Philipp Reineck, Mehran Kianinia, Gergely Barcza, Viktor Ivády, David A. Broadway, Igor Aharonovich & Jean-Philippe Tetienne

Bright point-defect emitters in hexagonal boron nitride have potential applications in quantum sensing and other technologies. However, it can be difficult to correctly identify the microscopic nature of observed defects, creating challenges for further development. A class of bright emitters exhibiting optically detected magnetic resonance with no resolvable zero-field splitting has been observed in hexagonal boron nitride across a broad range of wavelengths. However, the microscopic structure of the defects and the physical origin of their optically detected magnetic resonance signal have still not been identified. Here we describe a model that accounts for and provides a physical explanation for all key experimental features of the spin-resolved photodynamics of ensembles and single emitters. The model, inspired by the radical-pair mechanism from spin chemistry, assumes a pair of nearby point defects, one of which is optically active. Using first-principles calculations, we show that simple defect pairs made of common carbon defects provide a plausible realization of our model. As well as addressing open questions about defects in hexagonal boron nitride, our model may also explain similar phenomena observed in other wide-bandgap semiconductors.

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.



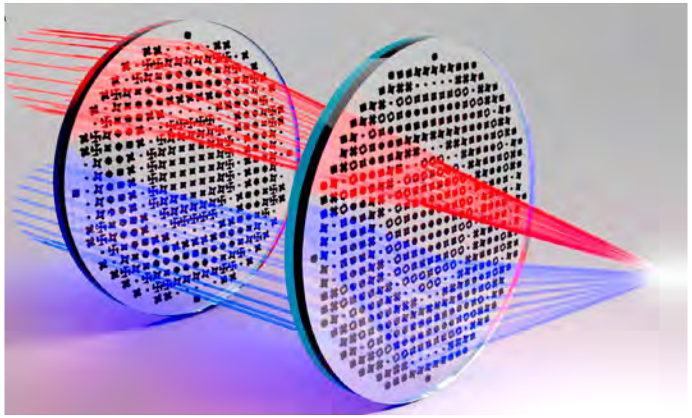
THEME LEADERS:

PROFESSOR ILYA SHADRIVOV
Australian National University

PROFESSOR MADHU BHASKARAN
RMIT University

In 2025, Theme Two, Manipulate continued to strengthen its leadership in next-generation metasurface and optical technologies through major advances in tunable, dynamic and hybrid photonic systems. Building on strong momentum from 2024, the Theme achieved significant progress in MEMS-based tunable metamaterial filters, thermo-optic tuning in dielectric metasurfaces, hybrid metasurface–optoelectronic platforms for broadband photodetection, and chromatic metasurface-enabled 3D terahertz imaging. These achievements further demonstrate the Theme's commitment to fundamental discovery, translational innovation and collaborative research across TMOS and international partner institutions.

Strong collaborations across TMOS nodes and international partners continued to drive major advances within Theme 2 during 2025. A key example was the cross-node collaboration between ANU and UWA, A key example is the cross-node collaboration between ANU and UWA, which developed micro-electromechanical systems (MEMS)-based double-membrane metamaterial filters for thermal infrared spectral filtering (Bannik et al., *Adv. Photonics Res*). This tunable device exploits air-gap tuning between perforated gold and silicon membranes to reversibly shift extraordinary optical transmission resonances.



Multilayer Huygens' metalens design

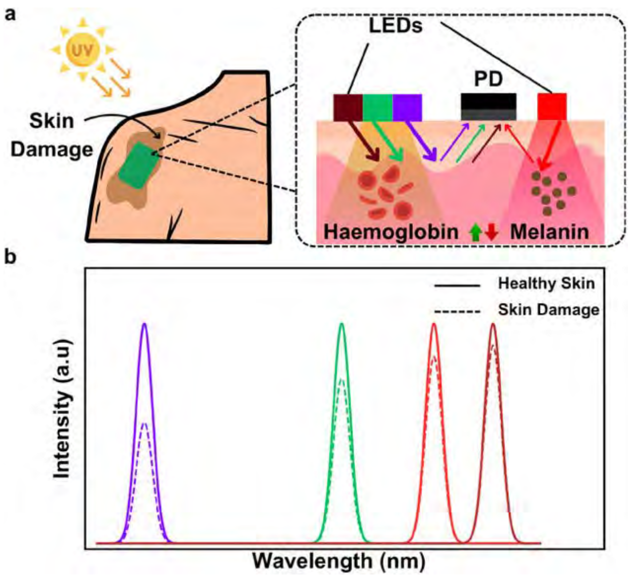
Complementary work within this collaboration introduced a MEMS-based approach to realise and dynamically control quasi-bound states in the continuum through hybridisation of one- and two-dimensional metasurfaces (Kovalev et al., *Nanophotonics*), resulting in tunable high-Q resonances via out-of-plane symmetry breaking.

At the TMOS' RMIT University node, the groups of Professors Madhu Bhaskaran and Sharath Sriram made significant advances in application-driven metasurfaces and hybrid optoelectronic systems. Three-dimensional terahertz confocal imaging was demonstrated using chromatic metasurfaces, with frequency-dependent focal shifts enabling depth-resolved imaging within a compact planar platform (You et al., *Laser Photonics Rev.*). This approach enables volumetric imaging without mechanical scanning, highlighting the potential of metasurfaces for integrated terahertz sensing and imaging applications. Beyond imaging, ultrathin BIC metasurfaces based on low-loss Sb_2Se_3 phase-change materials were developed in collaboration with AI Haoran Ren, providing a pathway to dynamically reconfigurable, low-loss photonic devices (Xie et al., *Nano Lett.*). Reconfigurable metasurfaces further enabled bias-free nonreciprocal image processing by combining spatial asymmetry with dynamic reconfiguration, producing direction-dependent image transmission without external bias fields. Hybrid material systems were also explored via $FePS_3$–MoS_2 p–n heterojunctions that exhibit a broadband optoelectronic response, with efficient charge separation at the van der Waals interface enabling broadband, self-powered photodetection (Low et al., *npj 2D Materials and Applications*).

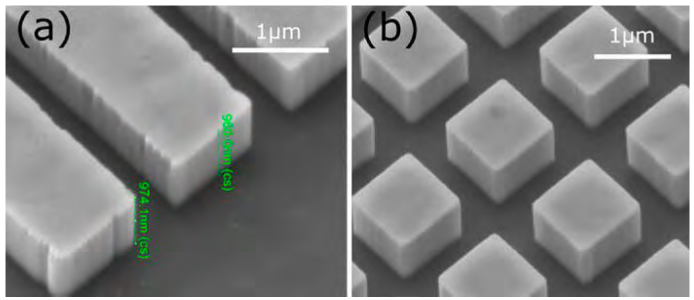
Further advances in hybrid photonic systems were demonstrated by Professor Lan Fu's group, in collaboration with researchers from the Beijing Institute of Technology and Nottingham Trent University – they developed hybrid nanoantenna–nanopillar silicon Schottky photodetectors with ultrawide wavelength tunability (Yu et al., *Adv. Opt. Mater.*), thereby enabling highly responsive broadband photodetection.

Strong progress has been achieved in thermo-optic tuning. Professor Ilya Shadrivov's group at the ANU node, together with collaborators from Nottingham Trent University, Guizhou Minzu University, and East China Normal University, demonstrated reversible thermal tuning of high-Q nonlocal lithium niobate metasurfaces (Wang et al., *Laser Photonics Rev.*), enabling precise and repeatable control of resonant responses. Professor Ken Crozier's TMOS group at the University of Melbourne developed thermo-optically tunable mid-infrared bandpass filters based on ultra-thin silicon-on-sapphire metasurfaces (Russell et al., *Laser Photonics Rev.*), advancing compact and efficient mid-infrared filtering technologies. The same group also advanced structured light generation, demonstrating solenoid beams (non-diffracting helical beams) capable of optical manipulation and tractor-beam-type functionalities (Setareh et al., *APL Photonics*).

Work led by Professor Dragomir Neshev's group at ANU, in collaboration with researchers from Jena, demonstrated a multiwavelength, polarisation-insensitive



Concept of the compact optical skin sensor



Thermo-optically tunable 1D and 2D zero-contrast grating filters near-infrared metalens, representing a significant step towards robust and multifunctional metasurface optics (Jordaan et al., *Opt. Express*). In parallel, the ANU node advanced optical tuning in soft-matter platforms, enabling fast, dynamic, and reversible modulation of metasurface responses.

Collectively, these outcomes demonstrate the successful integration of multiple tuning mechanisms at the forefront of reconfigurable photonics, establishing clear pathways toward real-world applications in sensing, imaging, communications, and integrated optical systems. Together, these advances underscore Theme Two's strong momentum and its growing capability to deliver actively controlled high-performance meta-optical technologies.

ACTION ITEMS FOR 2026

1. Non-volatile, rewritable, multi-level reflective displays based on antimony selenide thin films.
2. Advancing light-induced tuning of metasurfaces using liquid crystals.
3. Development of metasurface-based optical sensors for non-invasive skin monitoring.
4. Negative photoconductivity effect in liquid-metal-based ultra-thin ceria-rich oxides for broadband photodetectors.
5. Tunable thermal emitter using phase change materials.
6. Strain-Engineered Flexible Sb2Se3 for Optoelectronic Applications.

PUBLICATION HIGHLIGHTS

1. Oleg Bannik, Fedor Kovalev, Mingkai Liu, Michal Zawierta, Dilusha Silva, Lorenzo Faraone, Mariusz Martyniuk, Ilya Shadrivov, Micromachined double-membrane mechanically tunable metamaterial for thermal infrared filtering. Advanced Photonics Research 6 (5), 2400185 (2025). https://doi.org/10.1002/adpr.202400185
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3. M. X. Low, T. Ahmed, S. K. Saini, M. Panahandeh-Fard, J. O. Mendes, A. S. R. Chesman, C. Xu, J. Van Embden, L. Wang, M. Kumar, S. Sriram, M. Bhaskaran, S. Walia, $FePS_3$–MoS_2 p–n Junctions for Broadband Optoelectronics. npj 2D Materials and Applications 9, 21 (2025). https://doi.org/10.1038/s41699-025-00541-9

MANIPULATE CASE STUDY

Cross-node TMOS team develops miniature tunable infrared filter for thermal imaging

Researchers from TMOS at the University of Western Australia and the Australian National University have developed a compact, mechanically tunable metamaterial filter for the long-wavelength infrared, a spectral range that is central to thermal imaging, remote sensing and spectroscopy. The device combines a perforated gold membrane with a parallel silicon membrane separated by a tiny air gap, enabling the transmission wavelength of the filter to be tuned through MEMS actuation. This approach opens a pathway towards low-cost, low-power and highly compact infrared filtering technologies.

The work is a strong example of cross-node collaboration within TMOS, bringing together complementary expertise from UWA and ANU. The paper includes researchers from UWA's Microelectronics Research Group and ANU's Research School of Physics, with both institutions linked through the ARC Centre of Excellence for Transformative Meta-Optical Systems. By combining expertise in metamaterials, MEMS, infrared photonics and device modelling, the collaboration successfully designed, fabricated and experimentally validated the new concept.

The target wavelength range is the long-wavelength infrared (8–12 μm), also known as the thermal imaging band. This range is especially important because objects near room temperature emit strongly in it, and because the atmosphere is relatively transparent in this range. Technologies operating in this band are valuable for applications such as target recognition, geological mapping, gas sensing, environmental monitoring and contactless medical diagnostics. However, current multispectral and hyperspectral infrared systems often rely on bulky spectrometers, creating strong

SPOTLIGHT

Professor Ilya Shadrivov

Chief Investigator

Professor Ilya Shadrivov is a Head of the Department of the Fundamental and Theoretical Physics at the Research School of Physics, the Australian National University (ANU). He has received BSc (1998) and MSc (2000) degrees in Radiophysics from Nizhny Novgorod State University, Russia, and PhD degree in Physics from the Australian National University in 2005. He held Postdoctoral Fellowship (2007), QEII Fellowship (2010) and Future Fellowship (2017) from the Australian Research Council. He is the recipient of the 2016 Pawsey Medal from the Australian Academy of Science and Geoff Opatt prize from the Australian Optical Society. Ilya is a Fellow of Optica and the Australian Institute of Physics.

His main research areas include metamaterials in various frequency ranges, from microwaves to Terahertz and Optics. He leads Terahertz spectroscopy and microwave labs at the Department of Fundamental and Theoretical Physics. Being one of the pioneers in the field of nonlinear metamaterials, his interests are focused mostly on tunable and nonlinear structures. He is a Vice Chair of the OSA 'Spotlight in Optics' and writes highlights for some of the most exciting discoveries published in the OSA journals.

demand for compact tunable filters that can be integrated directly at chip level.

To address this challenge, the researchers developed a double-membrane metamaterial structure only slightly more than one micrometre thick. Numerical modelling predicted that the spectral response could be tuned across the entire LWIR range by changing the membrane spacing by only 500 nm, far smaller than the multi-micron gaps typically required in conventional Fabry-Perot systems. This result demonstrates a promising pathway towards more compact devices and lower actuation voltages for future thermal infrared technologies.

To test the concept, the researchers fabricated MEMS-enabled devices and experimentally measured their optical transmission. The results showed good agreement with numerical modelling and confirmed that the transmission peak could be shifted by changing the air gap between the membranes. In one striking result, changing the average gap by only 95 nm shifted the transmission peak by 1.5 μm, highlighting the exceptional sensitivity of the structure to nanoscale mechanical motion.

Although the first-generation devices also revealed fabrication challenges, including membrane flatness and pull-in behaviour, the study successfully demonstrated the feasibility of actively controlling extraordinary optical transmission in a MEMS-integrated metamaterial filter. With further refinement, the technology could enable a new class of miniature on-chip infrared filters for spectroscopy, thermal imaging and multispectral sensing applications.

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

Micromachined double-membrane mechanically tunable metamaterial for thermal infrared filtering

ADVANCED PHOTONICS RESEARCH, 26 MARCH 2025

Oleg Bannik, Fedor Kovalev, Mingkai Liu, Michal Zawierta, Dilusha Silva, Lorenzo Faraone, Mariusz Martyniuk, Ilya Shadrivov

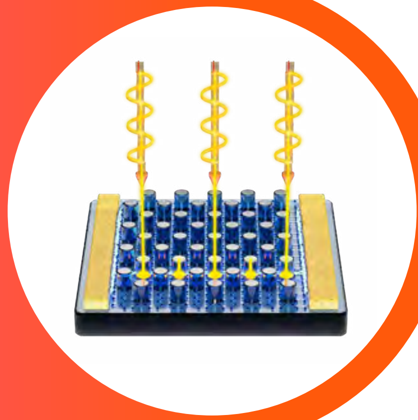
A mechanically tunable metamaterial concept for transmissive spectral discrimination within the long-wavelength infrared (LWIR) range (8–12 μm) is proposed and validated. The metamaterial consists of a periodically perforated gold membrane that exhibits the extraordinary optical transmission (EOT) effect, combined with a parallel silicon membrane separated by an air gap. This structure acts as a band-pass filter, with its spectral position highly sensitive to the separation gap between the membranes, which influences the resonance conditions for EOT. Numerical simulations predict tunability across the entire LWIR range with a membrane displacement of just 0.5 μm. This concept is experimentally demonstrated through vertical electrostatic actuation of the silicon membrane relative to the gold layer facilitated by a micro-electromechanical systems (MEMS) approach. The measured optical transmission of the fabricated MEMS-enabled, spectrally tunable plasmonic metamaterial shows good agreement with the numerically modeled spectral filter characteristics. Further refinement of this method could pave the way for a variety of low-cost, low-power miniature devices, enhancing spectroscopy and multispectral imaging capabilities in the thermal infrared range.

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:

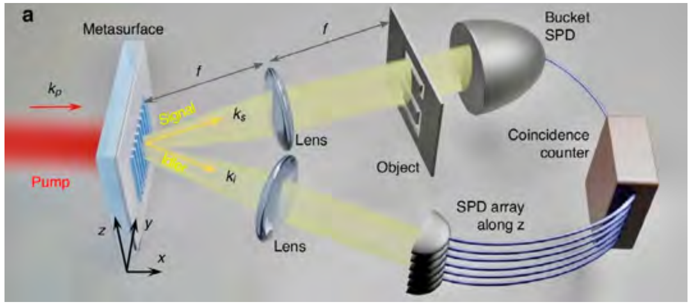
PROFESSOR ANN ROBERTS
University of Melbourne

PROFESSOR LORENZO FARAONE
University of Western Australia

As our devices shrink and our demands grow, the race is on to integrate increasingly powerful detection capabilities into ever-smaller packages. From augmented reality glasses that overlay digital worlds onto reality, to autonomous drones navigating through bushfire smoke, to medical imaging systems that save lives—compact sensors for visible and infrared light have become indispensable. Yet traditional infrared detectors face a stubborn problem: they're noisy at room temperature, power-hungry, and too heavy for weight-critical applications like satellites and drones.

Rather than accept these limitations, TMOS is pursuing a bold strategy: engineering semiconductor nanowires from the ground up and embedding metasurfaces—microscopic structures smaller than the wavelength of light itself—directly into mercury cadmium telluride (MCT) detectors. These innovations promise to reduce noise, boost performance, and unlock new capabilities.

Furthermore, light carries hidden information in its polarisation, and phase—data that conventional sensors simply ignore. Moreover, spectroscopy that discriminates wavelength information, is widely used for the reliable optical detection of chemical contaminants in environmental science, agriculture, heavy industry, and defense contexts where portability is critical but current technologies are large,



Optical setup for quantum imaging with spatially entangled photon pairs from a nonlinear metasurface. 2D imaging of the object was obtained via quantum ghost imaging and all-optical scanning in the z- and y-direction, respectively.

heavy, power hungry and of high cost. TMOS is harnessing metaoptics to make this invisible information visible, all within energy efficient systems compact enough to fit in your hand.

In 2025, TMOS researchers have pushed capabilities in the demonstration of novel spectrometers. A cross-node collaboration between the groups of Lan Fu (ANU) and Kenneth Crozier (UniMelb) has produced multi-pixel InAs nanowire arrays on a single InP substrate with tailored nanowire height, pitch and diameter to tune absorption peaks across the NIR and SWIR regions of the spectrum with computational spectral reconstruction demonstrated. The Crozier's group at UniMelb has integrated guided mode resonance spectral filter arrays into a thermal infrared camera to realise a reconstructive mid-infrared microspectrometer. This team has also utilised the thermo-optic effect in silicon zero contrast gratings to create tunable, narrowband filters for a range of optical sensing applications. Research into an InGaAs metasurface SWIR polarisation-sensitive photodetector by CI Lan Fu's group at ANU has progressed.

TMOS has also advanced the use of nonlocal metasurfaces for ultracompact approaches to phase contrast microscopy. Firstly, Lincoln Clark and UniMelb researchers published work investigating neural-network based parameterisations for the robust inverse design of freeform nonlocal metasurfaces and proposed a design for an angular bandpass filter. Secondly, Jinliang Ren and other members of CI Andrey Sukhurokov's group at ANU in collaboration with CI Roberts' team at UniMelb, demonstrated a compact quantum ghost imaging system leveraging quantum correlations and nonlocal resonances to permit phase gradient extraction. A manuscript was submitted in late 2025.

The Sukhurokov's group also presented the design of an ultra-thin topology-optimised diffractive metasurface that encodes polarisation states in five different diffraction orders with the outcomes published in Nanoscale Advances. This work enables the development of compact and lightweight devices suitable for integration into small satellites permitting full Stokes polarisation imaging for remote Earth observations. Finally, in collaboration with the University of Stuttgart, members of CI Roberts' team demonstrated an optical 'sieve' that could trap and provide colour discrimination of nanoplastic particles which are of significant current health and environmental concern.

KEY ACTION ITEMS FOR 2026

1. Demonstrate top-down etched InGaAs metasurface SWIR polarisation-sensitive photodetector.
2. Finalise research on InAs nano sheet polarisation detector and spectrometer.
3. Demonstrate circular polarisation sensitive InAs nano sheet array photodetectors.
4. Demonstrate reconstructive spectroscopy with tuneable filter for SWIR and metasurface filters for LWIR.
5. Demonstration metalens-enabled mid-wave infrared polarisation imaging.
6. Demonstrate multi-wavelength polarization imaging of small satellites.
7. Demonstrate quantitative phase microscopy using a polarization and wavelength-multiplexed metasurface.
8. Demonstrate nonlocal metasurfaces for wavelength-selective optical feature extraction.

PUBLICATION HIGHLIGHTS

1. J. Ma, J. Ren, J. Zhang, J. Meng, C. McManus-Barrett, K. B. Crozier, A. A. Sukhorukov, Quantum Imaging Using Spatially Entangled Photon Pairs from a Nonlinear Metasurface. eLight 5, 2 (2025) https://doi.org/10.1186/s43593-024-00080-8.
    - Highlighted in News & Views - Light Sci. Appl. 14, 150 (2025) https://doi.org/10.1038/s41377-025-01830-0.
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3. D. Ludescher, L. Wesemann, J. Schwab, J. Karst, S. B. Sulejman, M. Ubl, B. O. Clarke, A. Roberts, H. Giessen & M. Hentschel, Optical sieve for nanoplastic detection, sizing and counting. Nat. Photon. 19, 1138–1145 (2025). https://doi.org/10.1038/s41566-025-01733-x

DETECT CASE STUDY

Quantum imaging breakthrough achieved with ultra-thin nonlinear metasurfaces

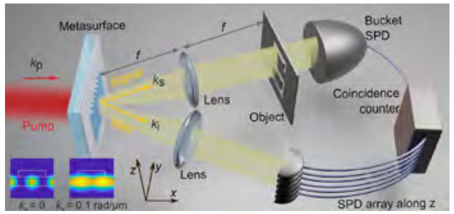
Scientists from the ARC Centre of Excellence for Transformative Meta-Optical Systems (TMOS) nodes at the Australian National University (ANU) and the University of Melbourne (UniMelb) have pioneered a new quantum imaging protocol using spatially entangled photon pairs generated by an ultra-thin nonlinear metasurface. This revolutionary approach combines ghost imaging and all-optical scanning methods to reconstruct images with exceptional resolution, demonstrating a significant leap forward in the field of quantum optics and imaging technology.

The study, published in eLight, addresses the limitations of conventional quantum imaging systems that rely on bulky nonlinear crystals. Traditional methods are restricted by their size, narrow angular emission, and limited field of view, making them impractical for many real-world applications. In contrast, the TMOS team utilised a subwavelength-scale silica meta-grating integrated with a thin film of lithium niobate. This nanoscale structure enables the efficient generation of spatially entangled photon pairs while offering a compact and highly tunable platform for quantum imaging.

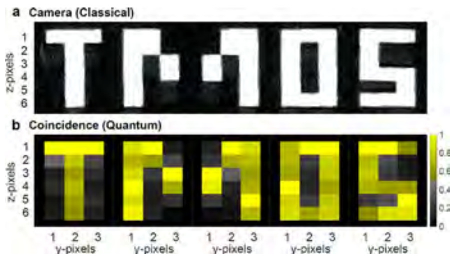
“A key innovation of the study lies in the ability to manipulate photon emission angles all optically by simply tuning the wavelength of the pump beam. This unique property eliminates the need for mechanical scanning, allowing seamless and precise optical scanning in one dimension while maintaining broad anti-correlated photon emissions in the other,” said co-lead author Jinliang Ren, PhD student at TMOS, ANU.

Using these features, the researchers successfully combined optical scanning with ghost imaging to reconstruct two-dimensional objects. This approach uses a simple one-dimensional detector array in the idler path and a bucket detector in the signal path, dramatically reducing the hardware requirements compared to conventional systems. The researchers experimentally validated their method by reconstructing images of two-dimensional objects at infrared wavelengths and predicted a significant improvement in both resolution and field of view. They found that the number of resolution cells achieved by their metasurface-based imaging system can exceed conventional quantum ghost imaging setups by over four orders of magnitude. This remarkable performance stems from the absence of longitudinal phase-matching constraints, which limit the field of view in conventional bulk crystals.

Dr Jinyong Ma, the study’s lead researcher, highlighted the potential impact of this innovation. “Our work demonstrates the



Setup



Result

first practical potential of metasurface-based quantum imaging systems for real-world applications. Their compact design and tunability make them ideal for free-space applications, where size, stability, and scalability are critical. This technology enables integration into modern photonics systems, paving the way for advancements in free-space quantum communication, object tracking, and sensing applications." Furthermore, performing optical scanning without mechanical components allows for ultra-fast imaging, essential for dynamic imaging scenarios such as quantum LiDAR and object tracking.

Looking ahead, the researchers are exploring ways to further enhance the photon pair generation efficiency of metasurfaces. "We are investigating new materials with higher nonlinear coefficients and optimizing the metasurface design for triple resonances at the pump, signal, and idler wavelengths, which can potentially achieve photon-pair generation rates comparable to or exceeding those of conventional bulky systems. This development will significantly improve the speed, sensitivity, and signal-to-noise ratio of metasurface-based quantum imaging systems, bringing them closer to widespread practical use." said co-author Dr Jihua Zhang, a former TMOS research fellow who recently moved to Songshan Lake Materials Laboratory.

"The implications of this work extend beyond imaging alone. Quantum technologies relying on entangled photon pairs, such as secure communication networks, quantum LiDAR, and advanced sensing systems, could benefit from the compact, highly efficient photon-pair sources enabled by nonlinear metasurfaces. Combining optical tunability, nanoscale integration, and high-resolution imaging provides a versatile platform for a wide range of quantum applications," said Professor Andrey Sukhorukov, the leader of the research group.

This research represents a major milestone in quantum optics and highlights the transformative potential of metasurface-based technologies. By replacing bulky and rigid optical components with scalable, ultra-thin structures, the TMOS team has laid the foundation for a new generation of quantum imaging and sensing devices that are more compact, efficient, and adaptable than ever.

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

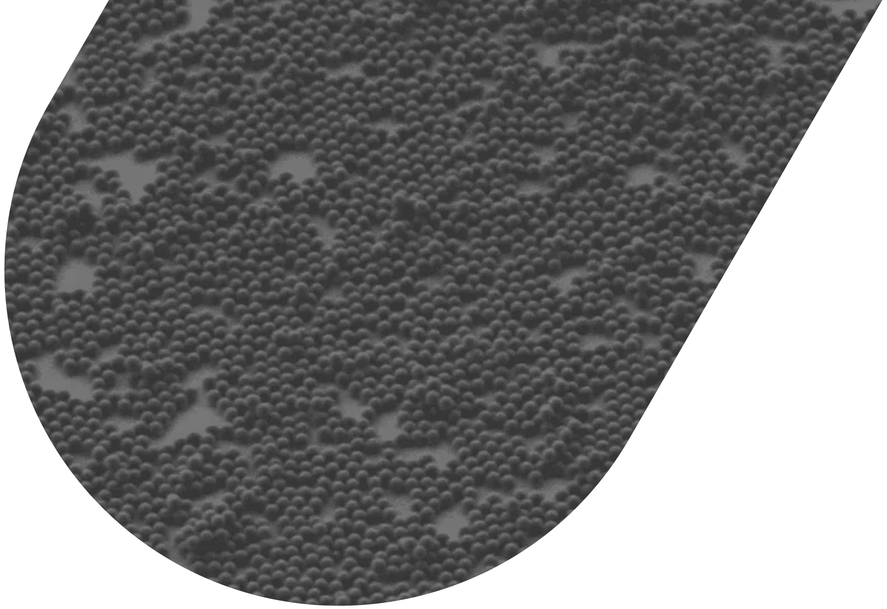
Quantum Imaging Using Spacially Entangled Photon pairs from a Nonlinear Metasurface

ELIGHT, 10 FEBRUARY 2025

Jinyong Ma, Jinliang Ren, Jihua Zhang, Jiajun Meng, Caitlin McManus-Barrett, Kenneth B. Crozier & Andrey A. Sukhorukov

Nonlinear metasurfaces with subwavelength thickness were recently established as versatile platforms for the enhanced and tailorable generation of entangled photon pairs. The small dimensions and inherent stability of integrated metasurface sources are attractive for free-space applications in quantum communications, sensing, and imaging, yet this remarkable potential remained unexplored. Here, we formulate and experimentally demonstrate the unique benefits and practical potential of nonlinear metasurfaces for quantum imaging at infrared wavelengths, facilitating an efficient protocol combining ghost and all-optical scanning imaging. The metasurface incorporates a subwavelength-scale silica metagrating on a lithium niobate thin film. Its distinguishing feature is the capability to all-optically scan the photon emission angle in the direction across the grating simply by tuning the pump beam wavelength. Simultaneously, the photon emission is broad and anti-correlated along the grating direction, allowing for ghost imaging. Thereby, we reconstruct the images of 2D objects using just a 1D detector array in the idler path and a bucket detector in the signal path, by recording the dependencies of photon coincidences on the pump wavelength. Furthermore, we theoretically demonstrate the quantum imaging of objects with an ultra-large field of view and improved imaging resolution. Remarkably, the corresponding number of resolution cells can exceed the performance of quantum ghost imaging with conventional bulky crystals by over four orders of magnitude. The demonstrated concept can be extended to multi-wavelength operation and other applications such as quantum object tracking, paving the way for advancements in quantum technologies using ultra-compact nanostructured metasurfaces.

Read the full article



DETECT CASE STUDY

Detection Chip Revolutionises Plastic Pollution Monitoring

A groundbreaking technology developed by an international research collaboration is set to transform how the world detects and monitors nanoplastics – one of the most urgent and insidious forms of pollution threatening our health and environment.

Published in *Nature Photonics*, researchers from the University of Melbourne and the University of Stuttgart, in collaboration with the ARC Centre of Excellence for Transformative Meta-Optical Systems (TMOS), have unveiled a novel optical sieve capable of cost-effectively detecting, classifying, and counting nanoplastic particles.

Why nanoplastics matter

While the dangers of microplastics are already well established, nanoplastics – even smaller fragments – pose a far greater risk. They infiltrate food, water, and even human organs, crossing biological barriers such as the blood–brain barrier and persisting in tissues for decades. Yet, until now, detecting them has been expensive, complex, and largely restricted to specialised laboratories.

The optical sieve innovation

Led in Australia by Dr Lukas Wesemann (University of Melbourne), the research team created a microchip made from gallium arsenide containing an array of microscopic cavities. When a liquid containing nanoplastics flows across the chip, particles are trapped in cavities matching their size – some as small as 200 nanometres in diameter.

These trapped particles reveal themselves through distinct colour changes in reflected light. Remarkably, this process requires only a standard optical microscope and a basic camera, making it accessible, portable, and affordable.

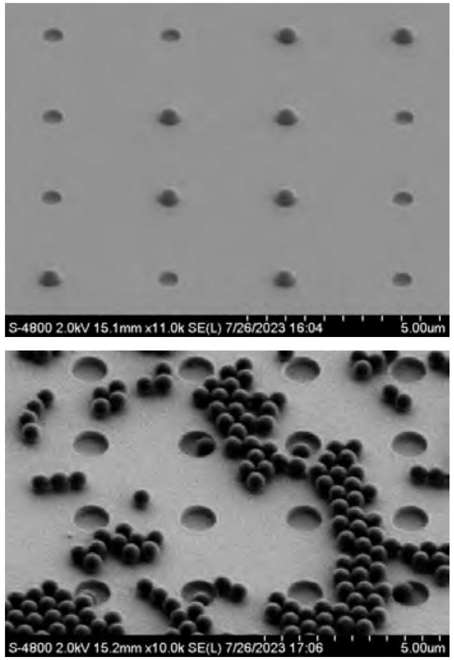
"This innovation finally gives us the ability to reveal the true scale of nanoplastic pollution outside specialised labs," said Dr Wesemann. "It opens the door to widespread, scalable monitoring of this critical global challenge."

Beyond the lab

Associate Professor Brad Clarke (University of Melbourne) highlighted the significance of this breakthrough:

"By making nanoplastic monitoring affordable and mobile, we can begin to truly assess their impact on health, aquatic systems, and soils. This technology is a step forward in protecting ecosystems and people."

Unlike existing methods, such as dynamic light scattering, the optical sieve does not require plastics to be separated from surrounding biological matter. Initial validation with lake water has shown promise, and future research will expand testing into even more complex environments – including the possibility of analysing blood samples.



Single nanoplastic spheres

TMOS and transformative impact

This work embodies the TMOS mission: pioneering next-generation meta-optical systems that address global challenges. By harnessing nanophotonics and meta-optics to develop real-world solutions, TMOS researchers are creating tools that can safeguard health and the environment.

With further development, the team is exploring pathways to scale this technology into commercially available environmental testing kits. Such devices could one day be used worldwide to monitor water sources, food supplies, and even human health, transforming how we confront plastic pollution.

This research was supported by the Australian Research Council, the European Research Council, the Australia–Germany Joint Research Cooperation Scheme (Universities Australia-DAAD), the University of Stuttgart, and the University of Melbourne.

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

Optical sieve for nanoplastic detection, sizing and counting

NATURE PHOTONICS, 8 SEPTEMBER 2025

D. Ludescher, L. Wesemann, J. Schwab, J. Karst, S. B. Sulejman, M. Ubl, B. O. Clarke, A. Roberts, H. Giessen & M. Hentschel

Micro- and nanoplastic particles are ubiquitous environmental pollutants, threatening human health, aquatic and soil ecosystems. These minute synthetic fragments, persisting for centuries, infiltrate the food chain, posing potential health risks through bioaccumulation in various tissues, toxicity and exposure to associated chemicals. Although macro- and microplastics are intensively examined in environmental and biological research, information on nanoplastics with diameters below 1 μm is limited. Such particles can cross biological borders, including the blood–brain barrier, posing a greater health risk than microplastics. Apart from the mere detection of such particles, gaining an understanding of size distribution, numbers and size limits will be crucial in assessing their impact on global ecosystems and human health. Here we establish an optical sieve that uses Mie void resonances for nanoplastic detection and sizing. The optical sieve consists of arrays of optically resonant voids with different diameters that simultaneously serve as filtering and sorting elements, as well as all-optical reporters, requiring only an optical microscope and a standard camera with an RGB sensor in combination with colorimetric analysis. The system is evaluated using a synthesized real-world sample with a plastic particle mass concentration of 150 μg ml-1. Our approach consequently delivers statistical information on numbers, size and size distribution via the observation of distinct colour changes, overcoming the need for advanced techniques such as scanning electron microscopy. The proposed method offers a straightforward, highly accessible and mobile solution, making it an efficient and easily implemented tool for environmental and biological research.

Read the full article

Industry Liaison Committee Chair Report

Industry Liaison Committee Chair, Professor Lorenzo Faraone

The translation of TMOS research toward practical and industry-relevant outcomes gained further momentum in 2025 through flagship activities, strategic engagement and growing collaboration with external stakeholders.

Throughout 2025, the Industry Liaison Committee (ILC) provided strategic guidance to TMOS researchers in support of the Centre's mission to translate meta-optical research into outcomes with industry, defence and societal impact. A major focus of the Committee was oversight of the TMOS flagship programs, ensuring projects aligned with national priorities, end-user needs and translational opportunities. The ILC also supported cross-node collaboration, industry engagement, intellectual property strategy and targeted outreach activities designed to strengthen pathways from research to real-world application.

This translational focus was evident across the TMOS flagship programs, which achieved important progress toward technology maturity, industry relevance and end-user engagement:

In 2025, the **Enhanced Infrared Vision Flagship** advanced toward prototype-level development in 2025, progressing metalens-enabled infrared detector architectures designed to improve performance and reduce system complexity. The ILC supported engagement with defence and civilian stakeholders and endorsed exploration of bushfire early-warning detection as a potential operational pathway, reinforcing the relevance of TMOS infrared technologies for dual-use applications.

Throughout the year, **Meta-Health Sensors Flagship** demonstrated strong translational momentum, highlighted by continued progress on a miniaturised optical glucose sensor for wearable healthcare applications. With performance demonstrated across physiological ranges and increasing technology readiness, the project attracted growing industry interest. The ILC supported strategies that position this platform for broader health-monitoring applications and future commercialisation opportunities.

The **Quantum Flagship Program** progressed from proof-of-concept demonstrations toward fibre-compatible quantum communication systems. In 2025, activity focused on integrating quantum light sources with meta-optical components to enable compact, deployable systems aligned with existing infrastructure. The ILC supported alignment with national quantum priorities and encouraged outcomes that strengthen sovereign capability, generate intellectual property, and foster future industry collaboration.

Across all programs, the ILC provided guidance on intellectual property and patenting. Recognising the diversity of institutional IP frameworks, the Committee endorsed a flexible, case-by-case approach to patent support, enabling timely protection of high-value outcomes while minimising barriers to translation.

Industry engagement and compliance remained key focus areas. The ILC highlighted the importance of due diligence, particularly for defence-aligned and dual-use technologies, and supported activities to increase awareness of regulatory and foreign-interference considerations. Outreach strategies were refined to prioritise targeted, high-value engagements, including focused trade-show participation and the development of a standalone translation showcase to complement the annual report.

With the establishment of a dedicated ILC budget, planning commenced for a more proactive investment in patent support, industry engagement, and communications to enhance the impact of TMOS research and the long-term legacy of TMOS translation activities. Overall, in 2025 the ILC strengthened TMOS's translational pipeline, supported flagship program delivery, and reinforced the Centre's role in advancing meta-optical technologies toward real-world impact.

For 2026–27, and in alignment with recommendations from the 2025 TMOS Legacy Strategic Advisory Panel, the ILC will focus on strengthening business development, intellectual property support, industry engagement, and internal translation capability across the flagship programs. Priority areas will also include building sustainable industry partnerships and expanding commercial training and internship opportunities for HDRs and ECRs to support the long-term legacy of TMOS and Australian meta-optics research.

Professor Lorenzo Faraone
Industry Liaison Committee Chair

ACTION ITEMS FOR 2026

1. Advance translational readiness and commercialisation support across TMOS flagship programs.
2. Strengthen industry, defence and government engagement through targeted partnerships, outreach and training initiatives.
3. Develop sustainable translation and legacy pathways to maximise the long-term impact of TMOS technologies beyond 2027.
4. Plan for a 2026 industry show case.
5. Host a 'Shark Tank' or alike at the TMOS conference for Centre members to gain external feedback on their ideas.

COMMITTEE MEMBERS:

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PROFESSOR ILYA SHADRIVOV
Chief Investigator, ANU (Deputy Chair)

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DR PETER FRANCIS MATHEW ELANGO
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Chief Investigator, RMIT

INTERVIEW
INDUSTRY ENGAGEMENT AWARD

GABRIEL OYARZO OJEDA

PhD Student
University of Melbourne

What is the most exciting potential application of your work that came out of an industry discussion?

The most exciting potential application is non-invasive glucose monitoring using light. One day, this could lead to smartwatches that can measure your blood sugar levels.

How has working with industry impacted your research? Has it helped your research grow or has your research slowed down a little while you work on this project?

In some ways it has slowed things down, because commercialisation brings a different set of challenges from research itself. More importantly, however, it has broadened my perspective on the impact my work could have, while also opening new opportunities for funding, collaboration, and translation.

If you could give advice to a young researcher looking to translate their work, what would that advice be?

My advice would be to seek out as many opportunities as possible to discuss your research with non-scientists. Explaining your work to broader audiences not only improves your communication, but can also uncover unexpected applications and help build the connections needed to translate research into real-world impact.

Flagship Program – Advanced Quantum Technologies

The Quantum Flagship Program focuses on advancing quantum technologies through the integration of meta-optical systems and quantum light sources, both pioneered within TMOS nodes. The program aims to deliver compact, tunable, and deployable platforms for the generation and control of quantum light, enabling applications in quantum communication, computing, and next-generation sensing.

ACTION ITEMS FOR 2026

1. Characterisation of NV and Vsi through SiC metalense with efficiency equal to 0.8NA objective.
2. Coupling a single NV to fibre using SiC metalense with 40-50% efficiency.
3. Demonstration of fibre-based QKD with BB86 protocol at room temperature.
4. Writing white papers and contacting possible industry partners.

The development of quantum light sources integrated with meta-optical systems provides a pathway toward scalable platforms for quantum communication within Australia. By enabling miniaturised and robust quantum photonic devices, this work supports the advancement of secure communication technologies essential for protecting sensitive data across government, industry, and critical infrastructure. These innovations align with Australia's strategic priorities in quantum technologies, strengthening sovereign capability, fostering industry growth, and contributing to the development of next-generation secure networks and advanced photonic systems.

TMOS has already made significant progress in this field, including the demonstration of free-space quantum key distribution (QKD) between two buildings and a proof-of-concept for underwater quantum communication, both critical milestones toward secure data transmission using meta-optical systems and quantum light sources.

In 2025, the focus shifted towards fibre-based secure quantum communication, where meta-optical systems play a crucial role in generating ideal qubits compatible with existing fibre networks. Researchers at TMOS nodes at UTS and ANU have joined forces to develop the first room-temperature quantum light source integrated with metasurfaces. Operating in the near-infrared range, this source enables low-loss transmission through optical fibres, paving the way for long-range quantum communication leveraging existing infrastructure.

Throughout the year, the ANU team designed and simulated a multifunctional meta-optical lens combining light collection with wavelength and polarisation separation. In parallel, the UTS team finalised the development of quantum light sources operating at frequencies compatible with current fibre communication networks. In early 2025, the first set of metalenses was successfully fabricated and is currently under characterisation. The next phase will focus on integrating the quantum light source with these meta-optical lenses to demonstrate a secure quantum channel in optical fibre based on TMOS-developed technologies. This milestone will support the generation of intellectual property and foster industry collaboration, key objectives of the Quantum Flagship Program by the end of 2026.

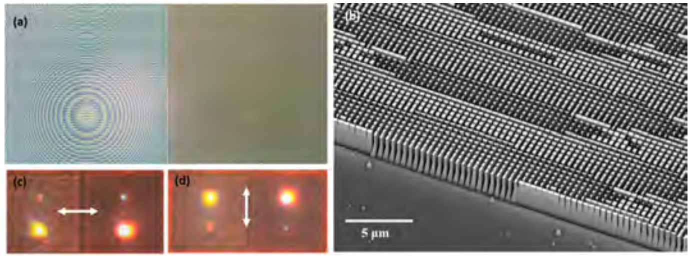


Figure 1. (a) Optical and (b) electron microscope images of the fabricated multifunctional metalens. The lens incorporates filtering functionalities, including polarisation selectivity, as demonstrated by the measurements in (c) and (d).

Beyond secure communications, this research opens pathways to advanced quantum sensing, precision navigation, and next-generation photonic technologies, demonstrating how fundamental advances in quantum light can translate into real-world impact across emerging high-value sectors.

Dr Mehran Kianinia
Flagship Program Research Manager

INTERVIEW

FLAGSHIP PROGRAM – META HEALTH SENSORS

DR MEHRAN KIANINIA

Flagship Program Research Manager

University of Technology Sydney

What motivated you to take on the role of Flagship Program Manager?

My strong interest in quantum and meta-optical systems is complemented by a desire to see how fundamental research can be translated into real-world industrial applications. The Flagship Program Manager role provides a valuable opportunity to bridge this gap—allowing me to continue advancing my research while elevating it to a stage where it can be effectively communicated and positioned for engagement with industry partners.

How would you describe your leadership approach when working across a diverse research team?

My approach is collaborative, inclusive, and outcome-driven. I engage closely with all team members to understand their diverse perspectives and foster open, transparent communication. At the same time, I ensure the team is aligned around clear goals and shared objectives, so everyone understands how their contributions support the broader vision.

What has been the most rewarding aspect of managing this Flagship so far?

The most rewarding aspect for me has been working with diverse expertise across different TMOS nodes to translate cutting-edge research into meaningful, real-world impact. It has been particularly rewarding to facilitate connections between researchers and industry, helping to position our work in a way that highlights its value and potential beyond academia.

What have you found most challenging in balancing research, coordination, and leadership responsibilities?

What I found most challenging was balancing my own research with the coordination and leadership responsibilities of the Flagship project. At times, competing priorities required careful time management and clear prioritisation. To manage this, I adopted a more structured approach to planning, delegated tasks where appropriate, and maintained clear communication with team members. This has helped ensure that both the research objectives and the broader program goals continue to progress effectively.

How do you support collaboration across nodes and disciplines within your Flagship?

Effective collaboration relies on understanding the strengths and expertise across the different TMOS nodes. By actively engaging with researchers from each team, I can help connect complementary capabilities and integrate them into the development of the Flagship project.

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.

ACTION ITEMS FOR 2026

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.

Currently identified project is an innovative optical glucose sensor that offers real-time operation, with glucose-specific reading capabilities, and high accuracy. This project is led by CIs Professor Madhu Bhaskaran and Professor Sharath Sriram at the RMIT University TMOS node. 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}.

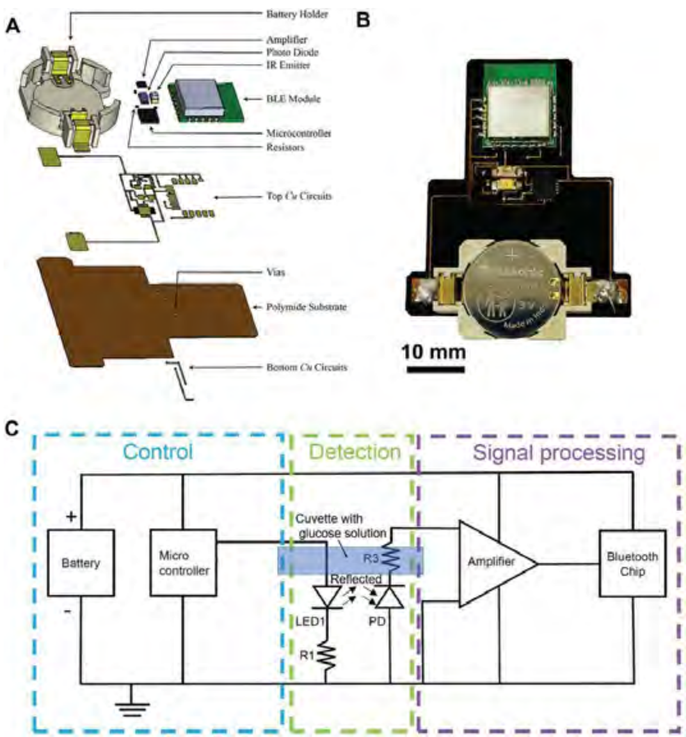
With a TRL >4 and increasing industry interest, this project has been promising in its commercial viability. A paper has been published titled, 'Miniaturized Optical Glucose Sensor Using 1600–1700 nm Near-Infrared Light' in Advanced Sensor Research, and a non-provisional patent has been filed following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

FUTURE IMPLICATIONS OF THIS WORK:

Beyond Diabetes: While the current focus is glucose, the Meta-Health framework suggests a modular future. The same miniaturized optical platform could be tuned to different wavelengths to monitor lactate (for athletes), cortisol (for stress), or oxygenation, turning the wearable into a comprehensive "biometric dashboard:

Decentralized Care: This technology enables "hospital-at-home" models. Real-time, high-accuracy monitoring allows clinicians to monitor patients remotely, reducing hospital admissions and freeing up critical resources in the Australian healthcare system.

Dr Peter Elango
Flagship Program Research Manager



Prototype of the developed optical glucose sensor

INTERVIEW

FLAGSHIP PROGRAM – META HEALTH SENSORS

DR PETER FRANCIS MATHEW ELANGO

Flagship Program Research Manager

RMIT University

What motivated you to take on the role of Flagship Program Manager?

I was driven by a desire to evolve from a specialized researcher into a strategic leader. I wanted to move beyond the lab bench and focus on research translation-bridging the gap between fundamental science and real-world impact. This role offered the perfect intersection: staying deeply connected to cutting-edge research while acquiring the high-level management skills necessary to drive large-scale innovation.

How would you describe your leadership approach when working across a diverse research team?

I view myself as a facilitative strategist. In a diverse research environment, leadership isn't about top-down direction; it's about aligning top-tier talent toward a shared vision. I focus on removing silos and creating the strategic framework that allows our researchers to do their best work while staying synchronized with broader TMOS goals.

What has been the most rewarding aspect of managing this Flagship so far?

The most rewarding part has been the 'front-row seat' to the future of MedTech. Seeing the sheer calibre of innovation coming out of the various TMOS nodes is incredibly inspiring. Witnessing a theoretical concept transition into a tangible application that could fundamentally change healthcare is exactly why I took this role.

What have you found most challenging in balancing research, coordination, and leadership responsibilities?

The primary challenge is context-switching. Moving from the granular, technical details of research to the high-level, multi-node coordination of a Flagship Program requires a constant shift in perspective. Balancing the immediate needs of researchers with the long-term milestones of the program is a delicate act, but it's precisely what makes the role so dynamic.

How do you support collaboration across nodes and disciplines within your Flagship?

Collaboration doesn't happen by accident; it requires a shared 'North Star.' My role is to ensure that despite geographical and disciplinary distances, every team member understands how their work feeds into our translation objectives. I act as the connective tissue—facilitating communication between nodes and ensuring we are chasing collective outcomes on top of isolated wins.

Is there a moment or experience in this role that has stayed with you?

It's less about a single moment and more about a recurring realization: the incredible juxtaposition of ambition and humility. I am constantly fascinated by researchers who develop world-changing, breakthrough technologies, yet maintain a deeply collaborative and humble approach. That culture of 'brilliance without ego' is what makes this environment so unique and has stayed with me throughout my tenure.

Flagship Program – Enhanced Infrared Vision

The Enhanced Infrared Vision flagship within the TMOS Translational Program aims to advance next-generation infrared sensing technologies by integrating meta-optical functionality directly with semiconductor detectors. The primary focus is the development of high-operating temperature (HOT) mid-wave infrared (MWIR) detectors based on metalens-enabled architectures, targeting improved performance and reduced system complexity compared to conventional HgCdTe (MCT) focal plane arrays.

ACTION ITEMS FOR 2026

1. Integration of metalens structures with MCT detectors.
2. Characterise and evaluate integrated metalens–detector prototypes.
3. Advance application pathways through field testing and industry engagement.

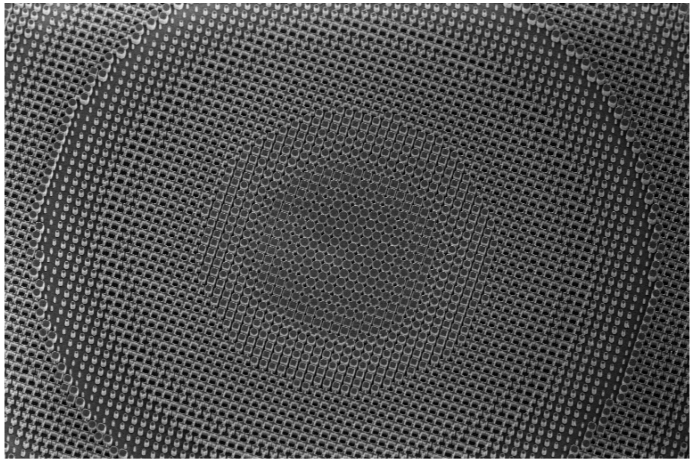
In 2025, the program progressed from concept development toward experimental realisation of key components. Silicon-based metalenses were designed, fabricated, and characterised, with initial measurements showing performance consistent with modelling and confirming their suitability for integration with infrared detector platforms. In parallel, system designs were refined and practical pathways for integrating metalens structures with MCT detectors were established, laying the groundwork for prototype-level demonstrations.

The flagship also maintained a focus on translation and real-world relevance. Discussions with potential industry stakeholders are ongoing, with an emphasis on identifying application pathways for infrared sensing technologies. In addition, collaboration with external partners has enabled access to bushfire monitoring infrastructure in Western Australia, providing a pathway for future field testing and evaluation in operational environments.

Complementary activities within the flagship include the continued development of metasurface-enabled microspectrometers, led by the University of Melbourne in collaboration with the University of Western Australia. This effort expanded in 2025 and contributes to broadening the sensing capabilities addressed within the program.

In 2026, the flagship will focus on demonstrating and evaluating integrated metalens-detector prototypes, including initial optical and functional characterisation. Further priorities include strengthening industry collaboration and progressing toward application-driven validation in relevant environments, supporting the transition of these technologies toward real-world deployment.

Dr Tuomas Haggren
Flagship Program Research Manager



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

INTERVIEW

FLAGSHIP PROGRAM – ENHANCED INFRARED VISION

What motivated you to take on the role of Flagship Program Manager?

I was motivated by the opportunity to help translate TMOS research into real-world impact and contribute to its long-term legacy. The role also provides a platform to develop leadership skills while working across disciplines and institutions. I am particularly interested in industry engagement and the strong application potential of infrared sensing.

How would you describe your leadership approach when working across a diverse research team?

My approach is to align the technical goals of the flagship with the capabilities across TMOS and the needs of potential end users. This requires clear communication, coordination across nodes, and identifying where different expertise can contribute most effectively. The focus is on directing efforts toward outcomes that are both scientifically and practically relevant.

What has been the most rewarding aspect of managing this Flagship so far?

The most rewarding aspect has been seeing clear external interest and application potential for the technology. It is satisfying to facilitate connections between researchers and help align efforts toward shared goals that can lead to tangible outcomes.

What have you found most challenging in balancing research, coordination, and leadership responsibilities?

Balancing these responsibilities requires prioritisation in a distributed program where participants have existing commitments. Maintaining alignment and momentum across nodes can be challenging, but it reinforces the importance of clear goals and focused coordination.

How do you support collaboration across nodes and disciplines within your Flagship?

I support collaboration by connecting complementary expertise across TMOS nodes and aligning efforts around shared objectives. Facilitating communication and maintaining visibility of ongoing work helps ensure that contributions are coordinated and progress is cohesive.

DR TUOMAS HAGGREN

Flagship Program Research Manager

Australian National University

CASE STUDY

Microfocussing system set to transform infrared detectors

Researchers have developed a highly sensitive method for detecting hotspots in the environment, such as bushfires or military threats, by harnessing the focussing power of meta-optical systems.

The key to the approach is innovative lens technology thinner than a human hair, which can collect and process infrared radiation from fires and other heat sources with much improved efficiency. Crucially it does not need cryogenic cooling, unlike current sensors.

The result is sensor technology that promises to enhance devices in both the civilian and military spheres, said Dr Tuomas Haggren, lead researcher on the project.

"It's elegant engineering with real-world payoff: a single layer that behaves like millions of tiny lenses, manufactured at scale," said Dr Haggren, a research fellow at the Australian National University and the ARC Centre of Excellence for Transformative Meta-Optical Systems (TMOS).

"It directly improves the cameras that communities rely on."

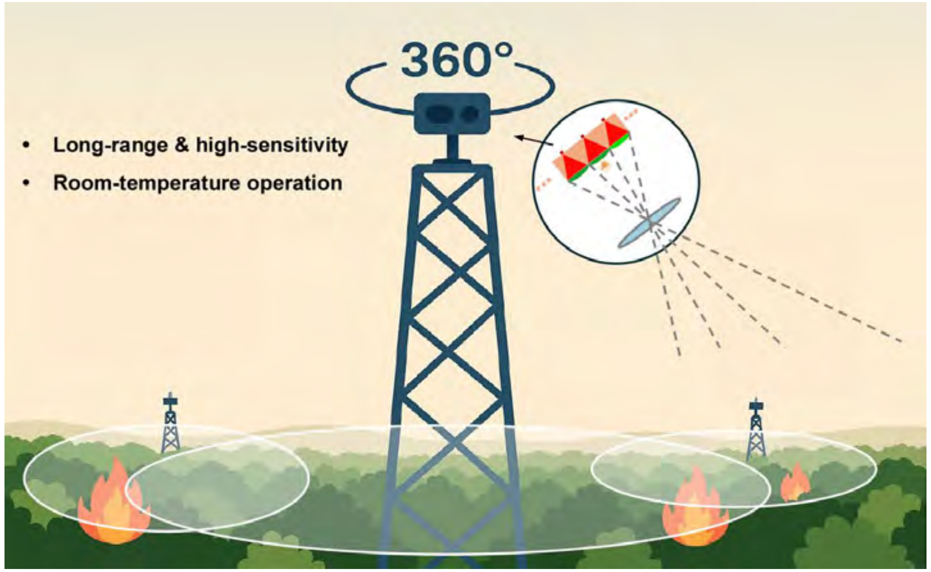
The team propose that their technology could be deployed to provide constant surveillance for bushfires, by mounting the sensors onto telecom network towers.

"Fire detection technologies are of national importance, and our solution addresses a critical gap in scalable, cost-effective bushfire detection," said Dr Wenwu Pan, a research fellow at the University of Western Australia (UWA) and TMOS.

"The same advances enable compact, low-power sensors that provide 360-degree situational awareness on defence platforms."

The sensors operate at wavelengths between 3 and 5 µm, known as the mid-wavelengths infrared (MWIR), which offer good visibility in both night and day, combined with good thermal contrast for identifying heat sources.

However, efforts to make MWIR cameras sharper have run into manufacturing and



1D linear MWIR microlens-detector array

performance limits. Firstly, as pixels get smaller it's harder to stop light spilling over between pixels and blurring the image.

Secondly, there is a noise issue in trying to collect more light with larger detectors: the detectors function on the same principle as solar cells, with a PN junction converting the light to electrical signals. But PN junctions constantly generate low levels of signal, known as dark current: increasing the collection area generates proportionately more of this noise.

This dark current can be reduced with cryogenic cooling, but that is not a satisfactory solution for field or remote use, as it increases costs and reduces practicality significantly.

Instead the team came up with the idea that they could focus the light, so it could be collected by a smaller detector – reducing dark current. Better yet if an array of lenses were used – one for every pixel – then each pixel could be smaller, and separated from its neighbours, which would cut out spillover.

"The system brings together three key advances — mid-wave infrared sensing for round-the-clock, long-range detection; operation without cryogenic cooling for low power and high reliability; and real-time data for faster response," said Associate Professor Gilberto Umana-Membreno, from UWA and TMOS.

But how to create the thousands of tiny lenses needed for this idea? The answer is by using a metasurface, a surface covered in an array of nanoscopic shapes smaller than the wavelength of light, that can produce remarkable effects not possible with natural materials.

"These flat metalenses allow us to bring photolithographic, wafer-scale optics directly into the detector stack – a practical way to boost performance," Associate Professor Gilberto Umana-Membreno said.

The team used electromagnetic modelling to design a flat metasurface that concentrates mid-infrared light onto each detector pixel, improving sensitivity and reducing noise. The design is detailed in the Journal of Electronic Materials.

Various nano-pillar designs were tested through simulation to optimise light focusing efficiency and showed great promise for increasing accuracy and reducing losses, Dr Wenwu said.

"By patterning a flat single-layer film we concentrate more light where it's needed."

The new design promises widespread impact – beyond heat detection, infrared sensors are used for remote sensing, night vision, environmental monitoring, national security, defence, meteorology, astronomy, spectroscopy and medical imaging.

As well as simple focussing, metalenses can be designed to carry out advanced optical processing, by separating and manipulating different components of light based on polarisation, phase or wavelength.

"The project is highly eligible for a range of grants, and would support scalable roll out." Associate Professor Gilberto Umana-Membreno said.

"There are significant commercial opportunities."

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

Design and Simulation of Metalens Arrays for Enhanced MWIR Imaging Array Performance

JOURNAL OF ELECTRONIC MATERIALS, 30 JUNE 2025

Wenwu Pan, Gilberto A. Umana-Membreno, Nima Dehdashti Akhavan, Hark Hoe Tan, Dragomir Neshev, Lukas Wesemann, Patrick Leslie, Ronald Driggers & Lorenzo Faraone

Emerging flat optical components based on single layers of metamaterials and metasurfaces have introduced a new approach to microlens arrays. These components hold promise for seamless integration with narrow-bandgap semiconductor-based infrared focal plane arrays, aiming to increase operating temperatures and improve imaging sensitivity. This study focuses on the design and rigorous coupled-wave analysis-based simulation of dielectric-transmissive metalens arrays, specifically tailored to optimize the performance of mid-wavelength infrared imaging arrays. Both Si and Ge metalenses are modeled and compared to spherical lenses, with Ge requiring a smaller aspect ratio than Si due to its higher refractive index, simplifying fabrication. Simulations demonstrate that pixel-registered flat metalenses achieve focusing efficiencies comparable to conventional spherical lenses by reducing the pillar pitch to 1 μm, improving phase profile accuracy and minimizing high-order diffraction losses. These findings highlight the potential of customized metalenses to advance infrared imaging technology and provide practical insights for optimizing imaging array performance through integration with microlens arrays.

Read the full article

The Meta Shark Tank at TMOS

The Meta Shark Tank at TMOS Meta Together 2025 was a translation exercise embedded into the annual meeting. Held within the conference program on 18 November 2025, the session gave each of four teams 15 minutes to pitch an idea to a panel – the "sharks" – with props permitted but only a single static slide. It was framed around commercial viability, creativity and potential impact rather than academic merit. The aim was not just to reward the best idea on the day, but to back the "coolest" idea and see it realised within 12 months, with prizes of $20,000 for the winning team and $10,000 for the runner-up.

The atmosphere was more exciting and animated than a standard talk/tutorial session because the format invites creative delivery and performance in addition to the regular metrics of presentation quality. The panel — Laura Droessler, Dan Bennett, and Simon Poole — acted less like a conventional academic Q&A group and more like a referee bench testing whether an idea can survive first contact with commercial and translational scrutiny. Across four pitches, the session showcased collaborative stagecraft rather than solo presentation. The pitched ideas included an open-source educational concept and several product/startup-style proposals built around meta-optical systems. Each team presented and answered questions collectively as a group, and the pitches comprised:

1. Photon Sensitive – Photon Clicker Live Classroom: An interactive software with a low-latency wireless link for real-time visualisation of single-photon counts and photon statistics with TMOS-developed photon clickers. By Michal Zawierta (UWA), Sergei Nedic (UTS), Benjamin Whitefield (UTS), Daniel Morley (UWA), Yan Liu (UWA).
2. MetaPassion – Revolutionising IR Sensing with Metalens Technology. By Jiajun Meng (UniMelb), Yang Xu (UniMelb), Wenwu Pan (UWA), Yan Liu (UWA), Tuomas Haggren (ANU), Rishabh Vashist (ANU).
3. Terachrom – Next-Gen Terahertz Flat Optics: Achromatic Polarization Control. By Peter Elango (RMIT), Oleg Kameshkov (ANU), Yana Izdebskaya (ANU).
4. Blu Tongue – Blu Tongue. The world's first fully open-source, fully hackable quantum light device. By Jake Horder (UTS), Xiaoying Huang (ANU), Karin Yamamura (UTS), Ivan Zhigulin (UTS).

What made the session distinctive is that it shifted the emphasis from reporting scientific results to translation

and discussions of commercial viability. The panellists, consisting of VCs and industry insiders rather than academics, grounded the discussions in reality and delivered great educational value to the participants and the audience. In the Q&A sessions, instead of defending completed work, the teams were asked to make a case for possibility: why an idea matters, who it is for, how it might translate and scale, and whether the people on stage look capable of carrying it forward. More broadly, the Shark Tank functioned as a compact demonstration of the TMOS culture of cross-node collaboration and entrepreneurial training.

Professor Milos Toth

CONGRATULATIONS TO THE WINNING TEAMS:

1st place: Terachrome

Peter Francis Mathew Elango (RMIT), Yana Izdebskaya (ANU), Oleg Kameshkov (ANU)

2nd place: Photon Sensitive

Michal Zawierta (UWA), Sergei Nedic (UTS), Benjamin Whitefield (UTS), Daniel Morley (UWA), Yan Liu (UWA)

Magical technology enables crops to tell farmers how to save money and reduce footprint

Because plants can't speak it can be a puzzle to work out what they need. More water or less? More nutrients or less light? Every gardener and farmer has wished for a way to connect with their plants.

The start-up company Magic Wavelength is making that wish come true.

Their hand-held sensor PlantTell uses infrared radiation to measure exactly what a plant needs. This information prevents over-watering and unnecessary use of fertilisers, says MagicWavelength co-founder, Professor Lorenzo Faraone.

"It will improve productivity for farmers and save them money. For small farms fertilisers can be a major chunk of their running costs," said Professor Faraone, from the ARC Centre of Excellence for Transformative Meta Optical Systems (TMOS).

"Efficient use of water and fertiliser will also make a significant improvement in the negative environmental impacts of agriculture."

"It's a pretty feel-good package!"

As well as a hand-held sensor, Magic Wavelength are developing a drone mounted sensor (AgTell), which could carry liquid fertiliser and feed the crops as it measures their needs.

The ability to use infrared radiation to measure plants' well-being is not new – it uses optical parameters at a number of specific infrared wavelengths, that are known as vegetation indices.

But miniaturising infrared systems to the point where they can be carried by a drone is a big step forward that the TMOS scientists have enabled.

Small infrared sensors were originally developed for defence purposes and bushfire monitoring, and the MagicWavelength team realised they could be used for agriculture in a way that could have global impact.

The team combined tiny chip-mounted sensors with cheap infrared LEDs to illuminate the plants, but needed a way to pick out the very specific infrared wavelengths needed to measure the vegetation indices.

The spectrometers used for this purpose in traditional infrared systems are bulky and employ moving parts to scan through the spectrum.

To miniaturise this function Professor Faraone's team used a micro-electro-mechanical system (MEMS) based Fabry–Pérot interferometer.

A Fabry–Pérot interferometer is a simple device consisting of two reflective surfaces – the distance between the surface defines the wavelength that is selected. The MEMS device provides the way to shift one of the reflecting surfaces and change the wavelength, easily and with very low power.

Professor Faraone says there is no one revolutionary technology in the PlantTell sensor, but a lot of very clever engineering. For example, The MEMS system provides almost constant wavelength calibration, while still being robust.

"We wanted a unit that a farmer could throw in the front seat of their ute and bump around the paddock without damaging it."

To achieve that the team needed to make compromises. The most precise vegetation indices are in the mid-wavelength infrared, but sensors at that wavelength need to be cooled cryogenically.

Instead the team opted for near/shortwave-infrared wavelength, where sensors are small, common and low-cost. They built their optics from aluminium coated plastic – but it hasn't compromised the results: their tests have shown PlantTell's data matches precisely with more complex and higher-cost systems.

The potential of their system has drawn funding from the Ignite program of the Australian Economic Accelerator, which, alongside two angel investors, has set them up well.

They are now at Stage 2, with sizeable partners in China and India, and are looking for significant investment to develop the systems further – especially the drone system.

"We envisage a village sharing a drone, or it being brought in by a service provider," Professor Faraone says.

"Throughout Asia there are a lot of small farms, and a huge population. It's a big market!"

CASE STUDY

Life changing nanotechnology makes diabetes care a breeze

Professor Lan Fu is waiting for a call from the hospital about someone ill with diabetes.

It's not a sick friend or family, but the first patient in her first pilot clinical study of the Ketowhistle breath test.

The Ketowhistle is a ground-breaking device that can detect the tell-tale signs of diabetes – and other diseases – from the gases we exhale.

Professor Fu's career in nanotechnology, combining a knowledge of quantum physics with exquisite fabrication techniques to design structures many times smaller than the point of a syringe, has led her to this point.

"I'm interested in fundamental research, I had no idea that I would change a person's life in this way," says Professor Fu, from the Department of Electronic Materials Engineering and the ARC Centre for Transformative MetaOptical Systems (TMOS).

"People are so passionate and excited about this project when I talk to them – they can so easily relate to it. Everyone knows someone with diabetes."

Diabetic ketoacidosis (DKA) is a life-threatening acute complication of diabetes, in which ketone molecules accumulate in the blood. A well-correlated fraction of these ketones are exhaled in the breath, giving an easy way to monitor the disease, and provide much better care than current urine or pinprick tests.

With such a beneficial product it is not surprising that there is a lot of interest.

Solentropy is a company that specialises in medtech commercialisation. Together with Professor Fu they have set up Ketone Innovation to focus on commercialisation of the Ketowhistle for medical applications.

From a different angle the company Agscent is working with Professor Fu to use the technology for monitoring cattle health – it promises a boost to dairy farmers needing to track the crucial nutrition levels of their herd, as they channel their calories into producing milk.

Solentropy, Agscent and Canberra Health Services partnered with the KetoWhistle team to win an Ignite grant for ~$500K from the Australian Economic Accelerator, to translate the technology to real applications.

"From an optoelectronics point of view we have a very good understanding of how to design a device that's very sensitive to a surface interaction with gas molecules," Professor Fu says.

"But to write a business case is a big learning curve – do you have a market, what's the risk, how do you keep data secure, how's it going to be engineered to work in the real world?"

"It's a really important experience to find out what the real world is like, it's quite different from your ideal lab-based study.

"People in industry have a very different perspective, they get you to broaden your thinking and consider practical things, that you then bring to your research design."

As well as industry, Professor Fu is getting the medical perspective from endocrinologist Professor Christopher Nolan, now with Canberra Health.

Professor Nolan has been involved in the project since the very first collaborative ANU project, Our Health In Our Hands, received Grand Challenge funding in 2017, and then went on to win a seed funding from the Australian Centre for Accelerating Diabetes Innovations in 2023. As well as advice on the design and application of the device, he's also opened the door to patients, and helped with the set up of the imminent clinical study.

Working with industry partners has been a good experience for Professor Fu.

"They are really collaborative and understanding, and they've given us lots of really good tips."

As well as tips, Agscent have supported an industry partner PhD student, to work on animal health monitor.

"It's a very important experience for students too, to work with the reports and deadlines that industry expect."

Professor Fu says she sees herself moving back to research once the commercialisation is well underway, but would love some of her students to follow that path.

"Maybe one of my students will take on the journey of full commercialisation, and become the CEO of a company!" she says.

In fact the commercialisation process is what has fired up Professor Fu's research inspiration, generating ideas for future directions.

"A lot has happened very quickly, and this focussed work has enabled us to overcome barriers and move our technology forward quickly."

The fundamental technology has not changed – a nanowire sensor with a Schottky junction to enable sensitive and low power operation – but how to make it work in the real world has many challenges. Each human's breath is a cocktail of molecules, including oxygen, carbon dioxide and water vapour, which all affect the sensor's behaviour. This is the kind of problem machine learning could solve, Professor Fu hopes.

"I never thought I would need AI, as my sensor is so sensitive. But the more I do, the more I realise the limitations, and AI may help. This leads to exciting new directions for my research."

Professor Fu encourages other researchers not to shy away from commercialisation, and she says she has been strongly supported by her talented team, from TMOS, the Research School of Physics, the ANU commercialisation team, and the Australian National Fabrication Facility.

"The journey is certainly worthwhile - I would encourage anyone who thinks their work has potential to give it a try!"

"The journey is certainly worthwhile - I would encourage anyone who thinks their work has potential to give it a try!"

Engagement & Culture

Education and Professional Development Committee Chair Report

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

The strength of TMOS lies in its people, the EPD Committee remains committed to creating opportunities that support the growth, collaboration, and future success of our students and early career researchers.

In 2025, the Education and Professional Development (EPD) Committee continued to play a central role in supporting TMOS students and early career researchers (ECRs) through targeted professional development initiatives, collaborative programs, and career-focused engagement across the Centre.

A major highlight of the year was the TMOS ECR & Student Conference 2025, held in July in Melbourne and themed *"The Power of Collaboration."* The three-day program brought together researchers from across TMOS nodes to participate in keynote presentations, hands-on workshops, poster sessions, and networking activities. Sessions focused on research communication, resilience, presentation delivery, and visualisation tools, equipping participants with practical skills to support both academic and industry career pathways. The conference also fostered meaningful cross-node connections and enabled new research collaborations, reinforcing the value of dedicated ECR development forums.

In recognition of outstanding service to the TMOS research community, the 2025 EPD Award was presented to **Seyed Saleh Mousavi Khaleghi**, a member of the EPD Committee and Head of the Student/ECR Conference Organising Committee. Seyed made an exceptional contribution to the delivery of the 2025 conference through his leadership and coordination. Through effective communication with Chief Investigators, the EPD Committee, and professional staff, coordination with the TMOS IDEA Committee, collaboration with peers, and careful organisation of a well-balanced meeting program, he played a pivotal role in ensuring the success of the event.

The committee also contributed to the professional development program at the TMOS Annual Conference through delivery of an **EPD Career Panel** featuring speakers from academia and industry across career stages. The session provided valuable perspectives on career pathways, recruitment practices, and work–life balance.

The EPD committee supported Centre-wide professional development through the Science Tuesday seminar program and the TMOS Colloquia Series. In 2025, a total of **16 Science Tuesday sessions** and **3 Colloquia** were delivered, providing accessible forums for knowledge exchange, interdisciplinary engagement, and research visibility across the Centre.

Building on priorities identified in 2024, the committee progressed development of a new cross-Centre mentoring initiative, **NanoSteps**. Designed for TMOS PhD students and postdoctoral researchers, the program supports participants to set achievable short-term career and professional goals over a 12-month period. Through structured mentor matching, guided career discussions, and peer learning, NanoSteps provides practical development support while fostering community and knowledge exchange. Applications opened in early 2026.

Reflecting on the 2025 action plan. The committee successfully supported delivery of the ECR & Student Conference and expanded professional development programming, including seminars, colloquia, and career development initiatives. The planned mentorship expansion evolved into the NanoSteps initiative, aligning more closely with ECR needs. Progress on supervisory panel evaluation was limited, with committee efforts prioritised toward high-impact training, career development, and engagement initiatives during the reporting period.

Looking ahead, the committee remains committed to strengthening professional development pathways and fostering an inclusive, collaborative research environment across TMOS.

Professor Lan Fu and **Professor Milos Toth**, Co-chairs

ACTION ITEMS FOR 2026

1. Refresh EPD Committee membership.
2. Deliver the 6th TMOS ECR & Student Conference.
3. Enhance professional development programming aligned with ECR needs.
4. Expand career development and industry engagement initiatives.
5. Strengthen cross-node networking opportunities.
6. Launch the NanoSteps Mentoring Program.
7. Improve evaluation and feedback mechanisms across EPD initiatives.

COMMITTEE MEMBERS:

PROFESSOR LAN FU
Chief Investigator, ANU (Chair)

PROFESSOR MILOS TOTH
Chief Investigator, UTS (Co-Chair)

DR HOSSEIN ALIJANI ALIJANVAND
Postdoctoral Research Associate, UTS

KOSALA DHANAWANSHA
PhD Student, ANU

DR PETER FRANCIS MATHEW ELANGO
Research Fellow, RMIT

FAHIA MUNNA
PhD Student, UWA

SEYED SALEH MOUSAVI KHALEGHI
PhD Student, UniMelb

XIWEN QIU
PhD Student, ANU

KRISZTINA THURZO
Centre Administrator, ANU (Secretary)

INTERVIEW

2025 EDUCATION AND PROFESSIONAL DEVELOPMENT AWARD

SEYED SALEH MOUSAVI KHALEGHI

PhD Student
University of Melbourne

What was something you particularly wanted to improve through this year's events?

I wanted to strengthen collaboration across TMOS nodes, particularly for newer HDRs and ECRs who may not yet be familiar with the facilities, expertise, and capabilities available across the Centre. Creating more opportunities for networking and connection helped researchers engage more effectively with TMOS-wide resources.

What was the most challenging aspect of organising the HDR conference?

A significant challenge was coordinating keynote speakers while working with an evolving budget, which became more difficult when a confirmed speaker had to withdraw unexpectedly shortly before the conference. The experience really highlighted the strength of the TMOS community, with Hossein Alijani stepping in to help secure an alternative speaker under tight time constraints and ensure the program remained strong.

Are there any additional professional development opportunities you would like to see TMOS offer?

More cross-node technical workshops and hands-on training sessions that highlight available equipment and expertise across TMOS would be extremely valuable for new HDRs and ECRs.

The TMOS ECR and Student Conference 2025: Fostering Collaboration and Professional Growth

The TMOS ECR – Student Conference is a key annual event within the Centre's professional development program, designed to support connection, collaboration, and career development among HDRs and early career researchers across TMOS.

L-R: Yue Bian, Seyed Saleh Mousavi Khaleghi, Jinyuan Chen

The 2025 conference, themed "The Power of Collaboration," brought together researchers from all TMOS nodes for three days of keynote presentations, workshops, networking activities, and research discussions focused on strengthening collaboration and professional skills development.

Hosted at the Art West building's flexible learning space in Melbourne, the three-day program strategically combined keynote presentations, hands-on workshops, and social activities to create a comprehensive professional development experience. The conference's foundational message was delivered by Professor Kenneth Crozier, whose opening presentation emphasized that researchers who work in isolation become "blind to opportunities in other fields" and cannot achieve truly impactful outcomes. This powerful framing set the stage for subsequent sessions focused on practical collaboration skills, beginning with Rachel Service's workshop on "Managing Stress and Building Resilience," which equipped participants with tools for networking within TMOS, building confidence through understanding personal stress zones, and implementing effective time management strategies.

The second day demonstrated the conference's commitment to practical skill development through innovative workshops designed to enhance research communication and visualization capabilities. Dr Chris Wilmer's Blender workshop provided participants with cutting-edge tools for visualizing research concepts and device schematics, with the entire session recorded for future reference. Professor Jen Martin's presentation training proved immediately valuable, as participants applied these skills in afternoon practice sessions specifically designed as preparation for the upcoming TMOS Shark Tank competition. Adrian Keating's presentation skills workshop, strategically positioned between two poster sessions, allowed attendees to immediately implement their learning in real-time interactions. The day's social activities, including dinner at Max on Hardware and a group visit to the Winter Night Market at Queen Victoria Market, extended collaborative opportunities beyond formal academic settings and strengthened the emerging research community bonds.

The conference's impact extended beyond individual skill development to demonstrate tangible collaborative outcomes. Dr Shimul Kanti Nath's presentation on successful collaborative research provided concrete evidence of how strategic partnerships elevate research quality and broaden impact potential. He shared twelve approaches for starting successful partnerships. Rachel Service's final workshop on "Giving & Receiving Feedback" equipped participants with essential skills for managing supervisor relationships and processing constructive criticism effectively. Most significantly, the conference itself generated immediate collaborative results, with participants Yue Bian, Jinyuan Chen, and Seyed Saleh Mousavi Khaleghi initiating a research partnership during the event—a living example of the conference's core mission. Delivered efficiently within a budget, the conference balanced high-quality professional development with careful resource management, supporting international speaker travel, professional workshops, comprehensive catering, and essential infrastructure. The positive participant feedback and the tangible collaborative outcomes validate the conference's success in reinforcing collaboration, mentorship, and professional growth as cornerstones for the next generation of meta-optics researchers.

Seyed Saleh Mousavi Khaleghi

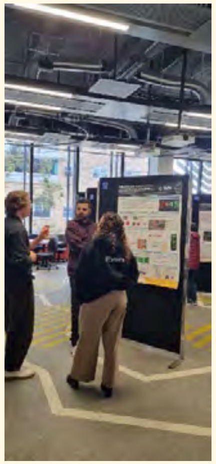
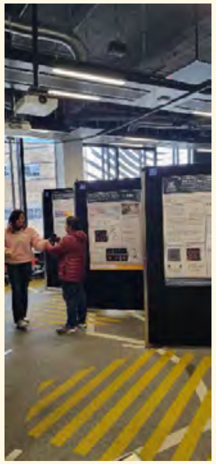
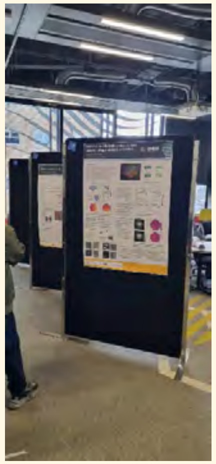
ORGANISING COMMITTEE:

HOSSEIN ALIJANI (UTS)
JINYUAN CHEN (UniMelb)
DR PETER FRANCIS MATHEW ELANGO (RMIT)
DR PHUONG LE (RMIT)
ELEANOR LUOND (RMIT)
SEYED SALEH MOUSAVI KHALEGHI (UniMelb)
FAHIA TARANNUM MUNNA (UWA)
XIWEN QIU (ANU)
HAIWEI WANG (UniMelb)

ACKNOWLEDGEMENTS TO:

PROFESSOR LAN FU
PROFESSOR MILOS TOTH
DR MARY GRAY




Colloquia and Science Tuesdays 2025

2025 COLLOQUIA

Date	Speaker	Institution	Title
12 February 2025	Professor Jason Valentine	Vanderbilt University	Meta-optics for Edge Computing
27 February 2025	Dr Hyeon Suk Shin	Sungkyunkwan University	Wafer-Scale, Thickness-Controlled Growth of Hexagonal Boron Nitride and Its Applications
19 August 2025	Ass. Professor Deep Jariwala	University of Pennsylvania	Strong and Tunable Light-Matter Interactions in Excitonic Materials and Devices

2025 SCIENCE TUESDAYS

Date	Speaker	Institution	Title
25 February 2025	Professor Dragomir Neshev	ANU	TMOS Director Opening Address
11 March 2025	Ivan Zhigulin	UTS	Electrical Generation and Modulation of Single Photon Emitters for Solid State Quantum Photonics
25 March 25	Professor Fan Wang	Beihang University, China	Ion resonance optical tweezers and its applications
8 April 2025	Dr Jinyong Ma	ANU	Biphoton entanglement from nonlinear metasurfaces and its applications
13 May 2025	Dr Aleksandr (Alex) Krasnok	Florida International University	Complex Frequency Excitations in Classical and Quantum Photonics
27 May 2025	Dr Rocio Camacho Morales	ANU	Functional Metaphotonics: From Frequency Up-Conversion to Multimodal Imaging
10 June 2025	Ben Russell presenting, Dr Yang Xu hosting	UniMelb	Tunable infrared metasurfaces for spectral sensing and beyond
24 June 2025	Dr Kevin Fynn	Magic Wavelength Ltd	Magic Wavelength Ltd. - Progressive Agtech engineering making a global difference in sustainable agriculture and gardening
12 August 2025	Professor Dragomir Neshev	ANU	Mid-year update of TMOS research and operations
26 August 2025	Professor Yves-Alain Peter	Polytechnique Montréaal	Sensing and Tuning with Optical Microresonators on Chip
9 September 2025	Professor Raymond R. Dagastine	UniMelb/ Tiny Bright Things	HaloMicroscopy: Multi-Source evanescent wave scattering for fast, label-free imaging in life sciences and complex materials
23 September 2025	Dr Wendy Lee, Dr Lukas Wesemann	UNSW (Lee); Maincode (Wesemann)	TMOS Career chats
14 October 2025	Dr Nicholas Sloan	UTS	Excitonic processes in perovskites: from photon upconversion to magneto-optical applications
28 October 2025	Dr Forest Zhu	UTS	From Analog Design to Heterogeneous Integration: Enabling Electronics-Photonics Co-Design
11 November 2025	Dr Wei Wen Wong	ANU	Bottom-up quasi-bound states in the continuum metasurface lasers
25 November 2025	Professor Arnan Mitchell	RMIT	Centre of Excellence in Optical Microcombs for Breakthrough Science: microcomb technology to unlock a new wave of photonic solutions

IDEA Committee Chair Report

IDEA Committee Chair, Professor Madhu Bhaskaran

The TMOS Inclusion, Diversity, Equity and Access (IDEA) Committee continued to foster a welcoming, collaborative, and people-focused Centre environment throughout 2025. Informed by feedback from the TMOS Culture Survey, the Committee delivered initiatives that strengthened professional growth, career development, wellbeing, mentoring, and community engagement, supporting members to feel connected, encouraged, and able to succeed throughout their time at TMOS.

In 2025, the IDEA Committee focused on three key priority areas identified through the TMOS Culture Survey.

Under **Professional Development**, the Committee expanded IDEA training opportunities to provide more in-depth, flexible, and accessible learning experiences for members across TMOS. **Career Development** initiatives focused on supporting members' confidence in future career pathways and professional growth beyond TMOS. A strong emphasis was also placed on **Social and Wellbeing**, with initiatives designed to strengthen social connection, inclusion, and mental health support across the Centre.

Beyond these internal priorities, TMOS also contributed significantly to the *inSTEM Conference*, a STEM Centres of Excellence initiative focused on advancing equitable practices in STEM and supporting marginalised individuals through inclusive professional development opportunities.

Professional Development Initiatives

Constructive Feedback Training was delivered to Chief Investigators and Program Managers to strengthen skills in providing constructive feedback. Feedback from supervisors is a primary mechanism through which members understand expectations and areas for improvement; however, not all leaders have received formal training in delivering feedback effectively. Given the significant power dynamics present in supervisory relationships, this training was designed to equip leaders with practical tools to engage in supportive and development-focused conversations. The same facilitator also delivered a complementary session for students and Early Career Researchers (ECRs). This top-down and bottom-up approach was intended to reinforce consistent practices and embed constructive feedback into the Centre's culture.

Under **In-depth and Flexible IDEA Training**, the Committee responded to Culture Survey feedback indicating that the previous online-only training model lacked depth and did not adequately support members who preferred more interactive or in-person learning experiences. As IDEA training remains an annual KPI requirement for all TMOS members, the Committee worked to deliver more engaging, flexible, and accessible training opportunities across the Centre.

These included IDEA-focused content at the inSTEM Conference (May), a wellbeing session at the Student/ECR Conference (July), an online micro-credential on everyday sexism in academia (from September), and a psychological safety workshop at the Annual Conference (November). While feedback indicated improved training quality and impact, overall participation declined. Unlike online training, in-person sessions were more difficult to track and required members to attend at specific times. A short follow-up survey indicated that research workload pressures were the primary reason for lower engagement. In 2026, the Committee will place greater emphasis on communicating the relevance of IDEA training to members' long-term careers, including its value for research practice, teamwork and people management.

Improving Visibility of Professional Development Opportunities was also identified as a key focus area following survey feedback that many members were unaware of the activities and opportunities available across TMOS, contributing to perceptions of unequal access. To address this, the induction workbook was redesigned to more clearly showcase professional development pathways, and a TMOS Refresher Course was introduced to provide longstanding members with updates on Centre initiatives, structures, and opportunities.

Member-Led Professional Development Planning marked a shift toward a more member-centred approach to professional development. While previous offerings had largely been shaped by Centre leadership perspectives, in 2025 the Committee sought to better reflect the needs and priorities of PhD students and postdoctoral researchers through the introduction of the TMOS Evaluation Survey. The survey invited members to self-assess a range of people and professional skills and identify priority areas for research training, with the findings directly informing the program design of the three-day Student/ECR Conference held in July.

Through **Extending Equal Access Beyond TMOS – Re-Spark Program**, the Committee broadened access to professional development opportunities beyond the Centre through the launch of Re-Spark, a career re-entry initiative supporting individuals returning to the workforce after extended breaks due to caring responsibilities, relocation, or other life circumstances. Piloted at the RMIT node, the program led to the appointment of a Postdoctoral Researcher on a six-month contract. The successful candidate had previously encountered barriers to employment associated with visa uncertainty, a highly competitive academic job market, and the challenges of transitioning between sectors.Reflecting on the program, the successful candidate noted: “The Re-Spark initiative has been instrumental in this transition to a new sector. It provided structured support and a pathway back into research, recognising that career paths are not always linear, and enabling inclusion, confidence, and the opportunity to continue making meaningful contributions to science.”

Career Development Initiatives

Many members expressed uncertainty about future career pathways following their time at TMOS. In response, the Committee piloted **TMOS Career Chats** toward the end of 2025. The program features speakers drawn from TMOS alumni and senior leadership who share their career journeys, reflect on how TMOS influenced their professional trajectories, and provide practical advice for members considering their next steps. Speakers are encouraged to speak openly about both successes and challenges, with the program aiming to showcase a diverse range of lived experiences within STEM.

In response to consistently low engagement with a previously used external mentoring platform connecting members across STEM Centres of Excellence, the Committee also developed the Internal **Mentoring Program – NanoSteps**. Designed specifically for TMOS students and postdoctoral researchers, NanoSteps focuses on short-term, goal-oriented mentoring while addressing key barriers identified in the earlier model. The program is scheduled for formal launch in 2026.

Social and Wellbeing Initiatives

A strong focus on wellbeing and community connection continued throughout 2025, with several initiatives introduced to support members across TMOS. In response to Culture Survey feedback relating to feelings of safety among peers and leaders, the Committee selected **Psychological Safety Training** as the IDEA training theme for the Annual Conference, recognising psychological safety as a foundational component of workplace wellbeing and inclusion. The Committee also coordinated **Student/ECR Conference Wellbeing and Social Activities**, including a dedicated wellbeing workshop and social events designed to strengthen connection among members.

To further support member wellbeing, the Committee developed the **TMOS Wellbeing Guide**, providing access to node-based counselling services, external support organisations, and general wellbeing resources. In parallel, **Social Committee Implementation** continued following the establishment of the TMOS Social Committee in late 2024, with 2025 marking its first full year of operation. The Committee was tasked with delivering social events across each node to strengthen community connection and foster a greater sense of belonging throughout TMOS.

Collaboration and Looking Ahead

Throughout 2025, the IDEA Committee worked closely with the Education and Professional Development (EPD) Committee to deliver initiatives aligned with shared goals. Key collaborative initiatives included the Student/ECR Conference, the TMOS Evaluation Survey, and TMOS Career Chats. This partnership will continue into 2026, particularly in the planning of the Student/ECR Conference, the ongoing delivery of Career Chats, and the rollout of the NanoSteps mentoring program.

The IDEA Committee remains committed to championing inclusion, diversity, equity, and access across TMOS and to supporting members at all stages of their IDEA journey.

Professor Madhu Bhaskaran
IDEA Committee Chair

COMMITTEE MEMBERS:

PROFESSOR MADHU BHASKARAN
Chief Investigator, RMIT (Chair)

ELEANOR LUOND
IDEA and Administrative Officer (Secretary)

DR MARY GRAY
Chief Operations Officer, ANU

PROFESSOR DRAGOMIR NESHEV
Centre Director, ANU

PROFESSOR ANN ROBERTS
Chief Investigator, UniMelb

ACTION ITEMS FOR 2026

1. Implementing the NanoSteps internal mentoring program.
2. Increasing visibility and awareness of TMOS's cultural diversity through events, communications, and cultural diversity training.
3. Expanding the Social Committee's activities to include a broader range of themes, including IDEA, wellbeing, and collaboration.
4. Supporting the delivery of an inclusive and accessible 2026 Annual Conference, with both the IDEA Director and IDEA Officer serving on the organising committee.

INTERVIEW

2025 IDEA AWARD

DAMINI RANGASWAMY

PhD Student
University of Western Australia

What was the most impactful step you took this year to make our Centre a more inclusive environment?

I organised "Canvas and Conversation" event to help people connect in a relaxed environment. I wanted to create a space where students and staff from different backgrounds and career stages could talk more easily, without the pressure of formal networking. It was really nice to see people naturally start conversations, share ideas, and just enjoy being together.

Why is IDEA so important to you? What is one "invisible barrier" to equity in STEM that you are most passionate about dismantling?

One invisible barrier I am especially passionate about dismantling is the hesitation to connect with others because of fear of being judged, misunderstood, or dismissed. Sometimes, the barrier is not an official rule or policy, but the assumptions we make about what others might think of us. That hesitation can stop people from asking questions, seeking mentorship, sharing ideas, or pursuing opportunities they deserve.

What advice would you offer to senior academics or industry professionals who have not personally experienced marginalisation?

Senior academics often understand struggle, because academia and research is already demanding and difficult, most of them would have walked that path. It is important to recognise that not all barriers look the same, and some people face additional invisible challenges related to belonging, confidence, identity, or access to support. In practice, small actions matter - being approachable, checking in, mentoring intentionally, and using your influence to sponsor and advocate for those who may be overlooked.

Social Committee Report

Eleanor Luond, IDEA Officer

2025 was the first year our Social Committee was in operation. The Social Committee was established in response to feedback from the 2024 TMOS Culture Survey, which highlighted a strong desire among members for greater opportunities for social connection both within and across Centre nodes.The goal of this committee is to strengthen the TMOS community and people's sense of belonging.

The 2025 Social Committee included Yang Xu from the University of Melbourne, Damini Rangaswamy from the University of Western Australia, and Phuong Le Yen from the University of Melbourne. Throughout the year, each member organised events at their respective nodes aligned with the Committee's goal of strengthening members sense of belonging and fostering a greater sense of community across TMOS.

Damini at UWA hosted the ' Canvas and Conversation' – a casual and fun, drop-in social session held on Friday 29 August 2025 as a National Science Week wrap-up and to mark Faraday's 1831 discovery of electromagnetic induction. She organised a light lunch and invited staff and students to contribute a short message, quote, or sketch to a shared canvas. The canvas encouraged conversations that started from simple questions ('What are you drawing?, What does this represent?") and then expanded into broader discussions about research, motivation, and shared experiences.

Damini said that the highlight was seeing senior scientists completely lean into the activity – almost like kids – taking their time to

RUOK Day 2025, RMIT

University of Melbourne Laser Tag

translate ideas into something they wanted to communicate on the canvas. The space naturally encouraged conversation across career stages, with people sharing what inspires them, laughing, and collaborating informally while painting. Additionally, she received feedback that the event felt like a genuine "stress-buster".

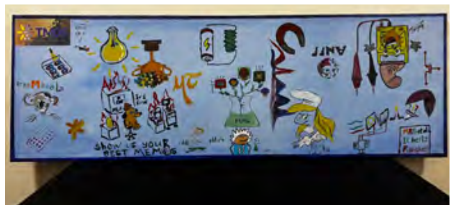
The event concluded with a completed canvas that is now kept within MRG as a lasting memento of the afternoon. Damini Rangaswamy won the IDEA Award this year for her thoughtful contributions to the social committee.

Phuong at RMIT University held a special event for RUOK Day on 11th September. The team spent a few hours playing minigolf and sharing light lunch together. This relaxed activity naturally encouraged teamwork and helped break down formal work barriers, especially for their newest members who hadn't had the opportunity to meet everyone. The RMIT node reported that it was a wonderful opportunity to connect and get to know our colleagues better outside the office.

Yang at University of Melbourne hosted a VR laser tag event in September 2025 to promote social connection and team bonding. The activity was chosen for its engaging, tech-forward theme, aligning with the node's research in optics and metasurfaces. With two rotating teams and catered refreshments, the event encouraged fun, inclusivity, and informal networking across the group.

In addition to these node-based events, the whole of the committee offered to work with the Education and Professional Development committee when they were organising the Student/ECR Conference. The social committee took charge of the evening activities which included Trivia and organising dinner at a games venue where attendees could try out a wide range of board games.

Eleanor Luond
IDEA Officer



Canvas and Conversation

Building Bridges in STEM

Building a more inclusive STEM community begins with creating spaces where people feel safe to share their experiences, connect authentically, and lead with confidence.

inSTEM is a bi-annual conference for Centre of Excellence (CoE) members, designed to advance equitable practices for marginalised and underrepresented people in STEM. This year, the conference also welcomed those seeking to strengthen their allyship.

TMOS, alongside eight other CoEs (Dark Matter, COMBS, QUBIC, EQUS, GETCO2, OzGrav, Synthetic Biology, and ADM+S), formed the organising committee and collaboratively developed the program over six months. Weekly meetings ensured steady progress and collective problem-solving—an excellent example of cross-CoE collaboration at its finest.

The conference created a safe, supportive environment for participants to connect, share experiences, and learn from experts in the equity, diversity, and inclusion space. This year's slogan, "Building Bridges in STEM: Empowering Voices, Cultivating Leaders," reflected the conference's central goals.

Held across two days, the program included sessions aimed at leaders, allies, and individuals from marginalised groups. Participants explored the current landscape of STEM, reflected on the progress made, and discussed the work still needed to create genuinely inclusive environments. The conference's timing during Reconciliation Week was fitting, grounding discussions in the broader context of Australia's ongoing journey toward reconciliation with First Nations peoples.

A consistent theme throughout the conference was vulnerability—speakers, facilitators, and attendees openly shared their experiences and demonstrated a willingness to learn from one another.

The event began with a Welcome to Country from Wurundjeri Elder Tony Garvey, followed by a keynote from Professor Emma Lee, a trawlwulwuy woman from tebrakunna country, north-east Tasmania. She shared her story of choosing to replace anger with love in her activism—an approach that contributed to the Tasmanian government amending its constitution to recognise Aboriginal people as Tasmania's First People.

This was followed by a panel titled "Navigating STEM as a Culturally and Linguistically Diverse (CALD) Individual," featuring Ruwangi Fernando (Founder, STEM Sisters), Ayesha Salgadu (Research Fellow, University of Melbourne), and Elisabetta Barberio (Centre Director, CoE Dark Matter). Concurrent sessions included a discussion on intersectionality and allyship with Professor Robyn Barnacle and Shelley Hewson-Munro, and a practical workshop on networking fundamentals.

Later, neurodivergent leadership coach Ani Moller delivered a keynote on creating "neuro-psychologically safe" work environments. A subsequent panel explored trans, gender-diverse, and gender-fluid experiences in the workplace, featuring Jay Heylen, a non-binary COO for CoE Synthetic Biology, Deanne Fisher, a trans-women and previous node leader for CoE Astro 3D, Ro Bersten (Xe/Xyr), a queer Jewish autistic parent and activist and Dani Montoya, a trans-women and PhD student for CoE Synthetic Biology.

The first day concluded with roundtable discussions focused on the question: "How do we bring systemic change and support diversity in the workplace?"

Day two was split into two focus areas, the first was Mental Health and Wellbeing. During this segment of the conference we heard from Dr Chris Perrella, Associate Investigator for CoE COMBS. Chris spoke about his experience of burnout while doing his PhD. Ani Moller, who ran a workshop that provided practical steps to ensure neurodivergent individuals don't burn out. Psychologist, Liv Downing, ran a workshop on learning self-compassion and Allison Fish, CI at CoE Quantum Biotechnology guided individuals through a yoga Nidra session.

The second focus area was career development; this segment involved a series of workshops which aimed to help attendees get "career ready". Anna Knudsen, Senior Communications Officer for CoE GETCO2 delivered a workshop on 'Building your Profile & Getting Noticed on LinkedIn", Jonathan Lacey delivered a workshop on the 'Different pathways for researchers', Dr Kirsten Banks delivered a workshop on 'Using social media to amplify your research' and lastly Dr Ruwangi Fernando delivered a workshop on the 'Power of Mentoring'.

Overall, inSTEM 2025 was a standout success, showcasing the strength of collaboration across Australia's CoE network. The most impactful component was the Mental Health and Wellbeing segment, which received outstanding feedback. Many attendees expressed the need to prioritise their wellbeing more intentionally.

Going forward, TMOS will focus on implementing stronger wellbeing initiatives and embedding supportive wellbeing practices into our ways of working across the Centre.

PARTICIPANT REFLECTION

"When I was going for the inSTEM conference I did not even know what experience and memories I would come back with as it was my first one for inSTEM. There were excitement, hope and nervousness as well. I met so many people there who were generous, kind and helpful always. Each one of them were different but there were so many things to learn from them. I had a wonderful time chating with them sharing our experiences with each other.

At the very beginning there was a session of Professor Emma Lee which I want to mention. She had a very different story of her life but somehow I could relate and I was crying through her whole session. Just after the session we had a tea break and I just went to her, talked with her and she gave me a big tight hug. This was the most beautiful feeling from a lady like her and I am grateful.

There were other sessions which were related to well being and mental health which I found were really useful. Among them I want to mention one which was self-compassion session of Liv Downing who is a registered psychologist, meditation teacher. I was just blown away by her session and could calm myself like I had not done before. I could find mental peace and also got a great hug from this lady.

Lastly, I just want to say it was a great experience for me and the connections and memories that I had from this would be with me for the rest of my life. Grateful for everything."

Fahia Tarannum Munna, Conference Attendee and PhD student

Outreach Committee Report

Professor Igor Aharonovich, Outreach Committee Chair and Dr Sophia Aharonovich, Outreach Coordinator

In 2025, researchers and students from TMOS delivered a broad program of outreach activities aimed at inspiring curiosity in science, promoting STEM education, and engaging the community with advances in photonics, nanotechnology, and materials science. These initiatives support the Centre's mission to share knowledge, strengthen scientific literacy, and encourage the next generation of scientists and engineers.

Throughout the year, TMOS members participated in outreach activities including school visits, science festival presentations, public lectures, hands-on workshops, classroom demonstrations, and national education programs. Events were hosted across Australia at schools, including rural schools in Port Lincoln, Wudinna, and Kalgoorlie, as well as at universities (ANU, UTS, RMIT, UniMelb, and UWA), community venues such as public libraries, and major science engagement platforms including the Australian Museum and Questacon. These activities ensured that audiences from diverse regions could experience contemporary scientific research in accessible and engaging ways.

A large group of TMOS researchers and students contributed to these activities across all nodes of the Centre. The TMOS Outreach Committee for 2025 represented a mixture of nodes and career stages and was led by Outreach Director Professor Igor Aharonovich. Committee members included Benjamin Whitefield (UTS), Sergei Nedic (UTS), Fedor Kovalev (ANU), Sarah Dean (ANU), Michal Zawierta (UWA), Daniel Morley (UWA), Haiwei Wang (UniMelb), and Jinyuan Chen (UniMelb). Administrative coordination was provided by Outreach Coordinator Sophia Aharonovich. Their efforts highlighted the strong commitment within TMOS to science communication and public engagement.

During these outreach activities, TMOS members engaged with school students, teachers, families, and members of the public through interactive demonstrations and presentations introducing concepts such as light–matter interactions, nanomaterials, and advanced optical technologies. Hands-on experiments helped make complex ideas accessible while also introducing participants to potential pathways in science and engineering. These community based outreach activities reached approximately 1,200 students and members of the public.

A particularly significant national initiative in 2025 was TMOS participation in the Governor General's Design Challenge, which encouraged students to apply creativity, design thinking, and scientific knowledge to real-world problems. The 2025 challenge, under the theme "Designing with Photons: How Light Shapes Life," provided a national platform for translating contemporary photonics research into hands-on STEM learning for Australian students exploring how light interacts with living systems and the environment.

TMOS researchers contributed scientific leadership and supported the development of educational materials for participating schools. As part of this initiative, the TMOS team designed and produced Photon Clicker devices, which were distributed to classrooms and used during student investigations. These devices allowed students to directly explore and measure the behaviour of light while connecting classroom activities with real scientific research.

The 2025 Governor-General's Design Challenge achieved strong national engagement. Based on Expressions of Interest data, 68 schools participated nationally, with 189 classes implementing the challenge and an estimated 4,898 students involved. Schools from all eight Australian states and territories were represented, including 34 schools in major cities, 10 in inner regional areas, 9 in outer regional communities, and one very remote school. This distribution demonstrates the program's ability to support equitable STEM engagement across metropolitan, regional, and remote Australia.

Across all reported outreach activities, TMOS members delivered more than 300 hours of outreach engagement, reaching over 6,000 students and community participants including through the Governor-General's Design Challenge. These efforts highlight the scale and impact of TMOS outreach and the Centre's commitment to sharing scientific knowledge beyond the research environment.

In recognition of outstanding contributions to outreach and community engagement, the 2025 TMOS Outreach Award was presented to Haiwei Wang (UniMelb).

Going forward, TMOS researchers will continue to inspire curiosity, creativity, and interest in science while strengthening connections between research institutions, schools, and the wider community.

Professor Igor Aharonovich
Outreach Committee Chair

ACTION ITEMS FOR 2026

1. Continue to develop Senior STEM Engagement Program across all nodes.
2. Deliver Science Communication Training Workshop with Partner Organisation Questacon for the outreach committee members.
3. Finalise Advanced Photon Clicker Prototype between UWA and Questacon.
4. Develop workshops for primary and high schools.
5. Develop new connections with large outreach bodies for collaboration in areas of space, quantum and optics research.
6. Develop new connections with the communities via public libraries and museums.
7. Prepare a Science Bus Outreach Program to travel in November in Tasmania.
8. Develop Laser Ice Hockey kit and Interference kit.

COMMITTEE MEMBERS:

PROFESSOR IGOR AHARANOVICH
Chief Investigator, UTS (Chair)

DR SOPHIA AHARANOVICH
Outreach Coordinator, UTS (Secretary)

JINYUAN CHEN
PhD Student, UniMelb

SARAH DEAN
PhD Student, ANU

FEDOR KOVALEV
PhD Student, ANU

DANIEL MORLEY
PhD Student, UWA

SERGEI NEDIC
PhD Student, UTS

HAWEI WANG
PhD Student, UniMelb

BENJAMIN WHITEFIELD
PhD Student, UTS

DR MICHAL ZAWIERTA
Postdoctoral Researcher, UWA

INTERVIEW

2025 OUTREACH AWARD

HAIWEI WANG

PhD Student
University of Melbourne

You've been recognised for your ability to make meta-optics accessible. How do you describe your research to someone who has no scientific background without losing the "wow" factor?

Ever seen a rubber band that shrinks when you pull it, or a real life invisibility cloak? These seemingly impossible feats are now possible with metamaterials. At TMOS, we are using light manipulating metamaterials to bring Sci-Fi level technologies to life.

What has been your favourite moment of outreach? How do you use outreach to encourage people from diverse backgrounds to see themselves as future scientists?

My favorite moment of outreach has been when a child asked me a question I never thought about. This reminded me that everyone can contribute something to science because everyone brings a unique experience. Using outreach, I hope to show people from diverse backgrounds that they can make big discoveries by investigating things in their own experiences carefully. I try to do this by engaging with their scientific questions, instead of just conveying facts.

Why should every PhD student get involved in outreach?

It's really fun, and you gain communication skills that you wouldn't be able to get elsewhere.

In 2025, we held a science show for primary school students in Bendigo, and hologram workshops in Sydney libraries and in regional South Australia.

International Year of Quantum

INTERNATIONAL DAY OF LIGHT

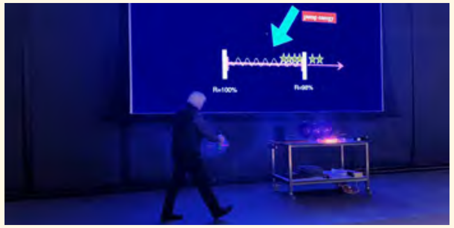
To celebrate the International Day of Light and the International Year of Quantum, TMOS collaborated with the ANU Optica and SPIE Student Chapter to present a public lecture at the Australian National University, streamed simultaneously online.

The talk, entitled "From laser to teleporter – will dreams become reality?", was delivered by Emeritus Professor Hans Bachor, who is both a leading figure in experimental quantum optics and heavily involved in Australian scientific outreach through work with Questacon.

Professor Bachor combined scientific depth with accessible explanations and live demonstrations, such as lasers and photon detectors, to illustrate key quantum principles and engage a general audience.

The event was supported by Questacon, allowing us to utilise their knowledge on public outreach to strengthen the connection between advanced research and public outreach. Additional support was provided by the ANU Research School of Physics and the IEEE Photonics Society for the running of this event.

The public lecture was a success, with approximately 100 attendees between the in-person attendance in Canberra and online stream viewership. This public lecture, and the collaboration required to organise it, highlights TMOS's ongoing commitment to promoting public understanding of quantum science, and to fostering engagement between researchers, students, and the broader community.



QUANTUM SCIENCE OPEN DAY

On 29 November of 2025, the Research School of Physics at ANU hosted the Quantum Science Open Day: a celebration of the 2025 International Year of Quantum and an opportunity to showcase the research conducted at the Research School of Physics. Attendees explored quantum science through talks, laboratory tours and interactive activities. The event was supported by over 50 volunteers who contributed on the day across various activities such as manning the reception, giving talks, conducting laboratory tours, and organising the experiment zone which included quantum games, quantum food, and "Ask a Scientist" areas.

Some key highlights of the event include:

- 280+ attendees across the day
- 2.4 kg of holographic chocolate made and eaten
- 250+ portions of liquid nitrogen ice cream served

The Quantum Open Day welcomed a diverse group of visitors, from high school students to retirees, all eager to learn more about physics. The feedback of the event was overwhelmingly positive: visitors valued the opportunity to interact directly with scientists, appreciated the enthusiasm of volunteers and praised the talks for their quality and accessibility. Attendees also highlighted the experience of visiting spaces that are not typically open to the public.

Contributions from TMOS, alongside Quantum Brilliance, HIA, ANFF and CQC2T, were instrumental to the success of the Quantum Open Day. TMOS sponsored the volunteer lunch and refreshments, helping to keep volunteers energised and available throughout the day, thereby minimising disruptions and supporting the smooth delivery of the event. The laser games TMOS provided were especially popular with younger attendees and a fantastic way to engage them with science in a fun and interactive way. The inclusion of a TMOS-developed quantum clicker in the Probability in quantum physics talk brought physics to life for the audience, thereby, making difficult concepts easy to understand. TMOS merchandise included in the giveaway bags was also very well received.

A major contribution from TMOS was its volunteer cohort, which constituted the largest group supporting the event. Coordination of the TMOS team was led by Rocio Camacho Morales, who oversaw tour organising, volunteer recruitment, sourcing of the quantum clicker and engagement with the local student chapter. Postgraduate TMOS students including Anna Fitriana, Joshua Jordaan, Sarah Dean, Tongmiao Fan and Xiwen Qiu supported the event across all areas, including talks, foyer activities and lab tours, interacting with a diverse audience throughout the day. Their time, dedication, and enthusiasm before, during, and after the event were integral in delivering a highly successful and memorable event.

INTERVIEW

2025 SCIENCE COMMUNICATION AWARD

SARAH DEAN

PhD Student

Australian National University

Whether it's through videos, social media, or live talks, what is your favourite medium for communication, and why does it work best for your specific research?

I don't think any particular medium is the best for communicating my research, as the different mediums work well to highlight different aspects of my work. Generally I prefer to do live talks, as I can see the audience and tailor my explanations as I go.

How do you ensure your communication is both engaging and scientifically accurate?

I try to simplify my explanations by using more general language, sacrificing precise language in favour of ensuring how a metasurface works is conveyed adequately. The nuances of precise language and detailed information is where someone without a scientific background is likely to get lost, whereas describing the physics in mostly qualitative ways and linking it to cool applications keeps them engaged.

In addition, could you please summarise in a couple of words what you were working on in 2025?

The design and testing of metasurfaces for compact multispectral polarisation imaging.

Governor General's Design Challenge 2025

DESIGNING WITH PHOTONS: HOW LIGHT SHAPES LIFE

Partners:

- Questacon
- ARC Centre of Excellence for Transformative Meta Optical Systems (TMOS)
- Office of the Governor General of Australia

The 2025 Governor-General's Design Challenge (GGDC), delivered in partnership with Questacon and the Office of the Governor-General of Australia, represented one of the most significant national outreach initiatives undertaken by TMOS in 2025.

Under the theme *Designing with Photons: How Light Shapes Life*, the program engaged **almost 5,000 students nationwide**, reaching **68 schools**, **189 classes**, and communities across **all eight Australian states and territories**. Importantly, the Challenge extended well beyond metropolitan centres, with participation from regional, outer regional, and very remote schools, highlighting the program's strong national reach and accessibility.

68 schools participated nationally

189 classes were involved

4,898 estimated student reach

34 schools in major cities

10 inner regional schools

9 outer regional schools

TMOS provided scientific leadership for the initiative, ensuring the investigations reflected contemporary research in photonics and light-based technologies. A major contribution was the development and supply of **100 Photon Clickers**, innovative devices created by TMOS PhD students that transformed photon interactions into audible signals. These tools enabled students to explore light as a measurable and testable phenomenon, making advanced scientific concepts tangible, interactive, and engaging for learners of all ages.

The program generated exceptionally strong engagement among both students and teachers. Educators reported high levels of curiosity-driven inquiry, collaboration, and experimentation, with students independently investigating how variables such as filters, distance, and materials influence light energy. Many teachers highlighted that the Challenge fostered confidence and ownership in learning, particularly because students were trusted to work with authentic scientific tools associated with the Governor-General's initiative. The open-ended design of the investigations encouraged inclusive participation and supported creative problem-solving without reliance on predetermined answers.

The impact of the Challenge extended beyond student learning outcomes. Teachers described the Photon Clicker as a catalyst for deeper scientific thinking and noted that the experience influenced their own approaches to STEM education and inquiry-based teaching. The success of the program also demonstrated the effectiveness of translating cutting-edge photonics research into classroom-ready experiences that can be delivered at scale across diverse educational settings.

Overall, the 2025 Governor-General's Design Challenge showcased TMOS's leadership in science engagement and education outreach, demonstrating how advanced photonics research can inspire the next generation of Australian scientists and innovators through meaningful, hands-on learning experiences.

Partner Contributions and Acknowledgements

- **TMOS:** Scientific leadership in photonics, including the development and provision of 100 Photon Clickers by TMOS PhD students to support classroom investigations
- **Questacon:** Program coordination, resource development, teacher engagement, and national delivery
- **Office of the Governor General:** National endorsement and launch visibility The 2025 GGDC demonstrated the power of combining cutting edge research with classroom ready design challenges to inspire young Australians and their teachers.

TMOS Rural Outreach Program in 2025

The 2025 TMOS Rural Outreach Program was highly successful in bringing engaging, interactive science education to regional communities, fostering curiosity, creativity, and enthusiasm for STEM among students across South Australia and Western Australia.

Workshops in Port Lincoln and Wudinna Primary Schools, South Australia were delivered by Jinyuan Chen, Haiwei Wang, and Sudhanshu Kumawat. Their sessions focused on introducing students to core optics concepts such as light, reflection, diffraction, interference, and holography.

Through a combination of clear explanations and live demonstrations, they created highly engaging learning experiences. Highlights included laser demonstrations, diffraction glasses, and the “TMOS” diffraction pattern, as well as hands-on interaction with hologram kits. Students were particularly fascinated by observing diffraction patterns and real holograms, and the team further extended the impact by leaving equipment with schools for continued exploration.

At East Kalgoorlie Primary School in Western Australia, the outreach activities were led by Daniel Morley, Aayushi Nanda, and Veda Chettuvakandiyil Dinesh. Their workshop centred on an interactive communication activity using LEDs and optical fibre. Working in small groups, students designed their own coding systems to transmit messages using coloured light signals.

This activity encouraged problem-solving, teamwork, and creativity, while also introducing real-world concepts such as data transmission and communication protocols. Older students (Stage 3: Y5 and Y6) successfully developed structured coding systems, while younger students (Stage 2: Y3 and Y4) explored simpler approaches, leading to valuable discussions about the importance of standardisation in communication.

Across all locations, the outreach events were highly effective in combining foundational science with hands-on learning. The clear division of roles and tailored activities ensured that each session was both educational and engaging. Most importantly, the program succeeded in inspiring students, many of whom began asking thoughtful questions about future learning opportunities and scientific concepts, demonstrating the program’s meaningful and lasting impact.

Encouraged by the strong engagement and positive outcomes of the 2025 program, TMOS will continue its rural outreach initiatives across regional communities in 2026 – 2027.

TMOS Meta-Together Conference

Meta-Together 2025 provided an opportunity for the TMOS community to reflect on achievements, strengthen collaborations, and shape the next phase of the Centre's journey.

From 17–21 November 2025, members of the TMOS community gathered in the beautiful coastal suburb of Coogee, NSW, for the fourth Meta-Together TMOS Conference. Hosted at the iconic Coogee Bay Hotel overlooking Coogee Beach, the conference brought together researchers, students, Partner Investigators, industry representatives, and collaborators from across Australia and around the world. The relaxed beachfront setting once again provided an ideal environment for collaboration in action, combining inspiring scientific discussions with opportunities for informal networking and community building.

The focus of this year's conference was collaboration between TMOS nodes, with end-users and industry partners, and across disciplines and career stages. The conference commenced with a planning day for TMOS Chief Investigators, who reflected on the Centre's recent mid-term review and discussed future strategic directions and the long-term legacy of TMOS. These themes were later shared with the broader community during a keynote presentation by TMOS Director Professor Dragomir Neshev.

The scientific program featured an exceptional lineup of invited speakers and workshops showcasing advances in photonics, nanotechnology, quantum materials, and advanced manufacturing. A defining feature of the conference was the strong participation of TMOS students and Early and Mid-Career Researchers (EMCRs), with presentations intentionally highlighting ongoing and emerging collaborations between TMOS nodes. The quality of the presentations reflected the creativity, ambition, and collaborative spirit of the TMOS research community.

One of the highlights of Meta-Together 2025 was the inaugural "Shark Tank at Meta" competition, where PhD candidates and EMCRs pitched innovative translation, outreach, and technology ideas developed through cross-node collaboration. Judged by a panel of academic entrepreneurs and industry leaders, the competition encouraged participants to develop skills in innovation, teamwork, and research communication.











The conference created so many opportunities to connect with people across TMOS and start conversations that will hopefully grow into future collaborations.

Alongside the scientific program, delegates participated in a vibrant range of social and professional development activities, including an Amazing Race-style team challenge, morning yoga sessions, and a workshop on psychological safety and inclusive research culture. The Gala Dinner and Awards Night provided an opportunity to celebrate the achievements and contributions of TMOS members across the Centre.

Ultimately, Meta-Together 2025 was much more than a scientific conference. It was an opportunity for the TMOS community to come together face-to-face, celebrate achievements, strengthen collaborations, and collectively shape the future direction and impact of the Centre.

The balance between outstanding scientific content and informal networking made the conference both productive and enjoyable.

CONGRATULATIONS TO OUR 2025 TMOS POSTER AWARD WINNERS:

Photo poster winners (L–R): Dayantha Lankanath Karunasena Danthure Arachchige, Anastasiia Zalogina, Xiaoying Huang

Digital Media

64,010
Website page views

TOP 5 PAGES

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

19,975
Unique website visitors

TOP 5 VISITOR COUNTRIES

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

18 blogs
Posts on the TMOS website in 2025

TOP 3 POSTS

1. New all-optical approach to revolutionise night vision technology
2. Continuous non-invasive glucose sensing on the horizon with the development of a new optical sensor
3. Quantum double-act the key to bright magnetic sensors

LINKEDIN

TOP 5 PAGES

1. Meta Together Conference 2025 Day 2
2. Outreach workshops
3. Meta Together Conference 2025 Day 1
4. TMOS ECR Conference & Mid-year planning workshop
5. ANU Quantum Science Open Day

85
TOTAL POSTS

123,381
TOTAL IMPRESSIONS

11,636
TOTAL CLICKS

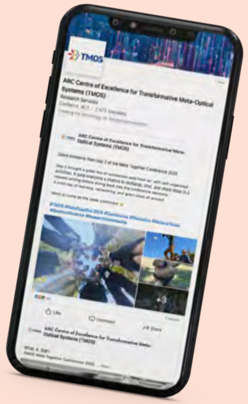
9.43%
Overall CTR

14,288
Total Engagements

11.58%
Engagement Rate

+473 (organic)
Follower Growth

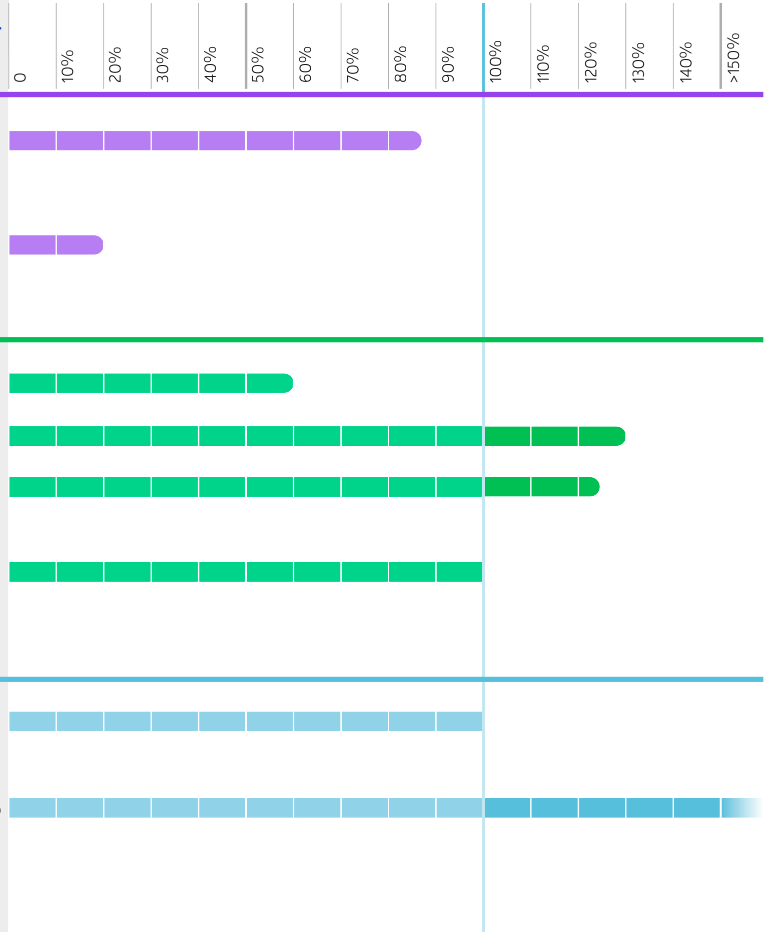
2,475
Total followers (end of 2025)



Performance

Key Performance Indicators

Performance Measure		Actual Y0 2020	Actual Y1 2021	Actual Y2 2022	Actual Y3 2023	Actual Y4 2024	Target Y5 2025	Actual Y5 2025	Perform. rate 2025
Number of research outputs	Journal articles[1]	92	87	100	119	136	100	87	87%
	Book chapters[2]	1	1	0	3	6	3	0	0%
	Patents (filing provisional patents and higher)[3]	1	1	2	8	5	5	1	20%
Quality of research outputs	Cross-node publications[4]	2	2	4	4	9	20	12	60%
	Publications with PIs	3	2	4	4	5	10	13	130%
	High impact publications (in top 10% in the field, e.g. IF>9)	17	20	28	28	33	25	31	124%
	Top-impact publications (in top 3% of the field, e.g. Nature/ Science family)	10	7	5	9	9	5	5	100%
Number of workshops/ conferences held/offered by the Centre	Centre annual workshop (conference)	0	0	2	1	1	1	1	100%
	Conference facilitation	0	4	8	9	8	2	10	500%



1. Although the overall numbr of publications is lower than expected, >36% of our publications are high impact publications (in top 10% in the field).
2. Book chapters are low volume outputs in physics and engineering so we expect these numbers to fluctuate annually but over the course of the Centre meet the total target.
3. The current level of patent activity reflects the early-stage and discovery-focused nature of much of TMOS research. As projects mature and commercial opportunities are further developed, patent filings are expected to increase.
4. We are contining to address our low cross-node publication rate with travel awards and centre events.

Performance Measure		Actual Y0 2020	Actual Y1 2021	Actual Y2 2022	Actual Y3 2023	Actual Y4 2024	Target Y5 2025	Actual Y5 2025	Perform. rate 2025
Number of training courses held/offered by the Centre	Professional development courses	0	3	4	5	11	3	15	500%
	Topical workshops and courses	0	19	11	8	4	3	6	200%
	Centre-wide Seminar Program, number of presentations[5]	0	18	21	20	18	20	16	80%
Number of additional researchers working on Centre research	Postdoctoral researchers (new)	3	15	5	2	8	6	6	100%
	Honours and undergraduate students (new)[6]	1	6	1	4	5	6	4	67%
	TMOS HDR students (PhD and Masters new)	0	11	16	10	8	5	7	140%
	Masters by coursework students (new)	0	0	0	3	0	6	0	0%
	Associate Investigators (new)	0	0	1	4	5	0	0	0%
Number of postgraduate completions	Number of postgraduate completions[7]				4	4	15	10	67%
	Women HDR completions (percentage of the cohort)	0	0	31	25	38	35	40	114%
Number of mentoring programs offered by the Centre	PI-Student Exchange Program[8]	0	0	0	3	4	6	1	17%
	Mentors within the Centre[9]	0	0	19	13	14	20	8	40%
	Number of mentees[10]	0	0	21	22	23	30	15	50%

5. The number of ScienceTuesdays seminars was slightly lower than anticipated due to scheduling considerations associated with major conferences, Centre events, and academic commitments across the year.
6. The number of honours and undergraduate students is influenced by broader trends in higher education, including declining enrolments in some STEM disciplines and a reduced pipeline of students progressing into research pathways.
7. The lower number of postgraduate completions reflects normal fluctuations in the research training pipeline, with a substantial cohort of students expected to complete in future reporting periods.
8. We may broaden the scheme to AIs for 2026 to provide a broader range of travel destinations.
9. Efforts are underway to promote the Mentoring program in 2026.
10. New mentoring formats will be implemented to increase engagement, accessibility, and the diversity of mentoring opportunities available to researchers/PhD students.

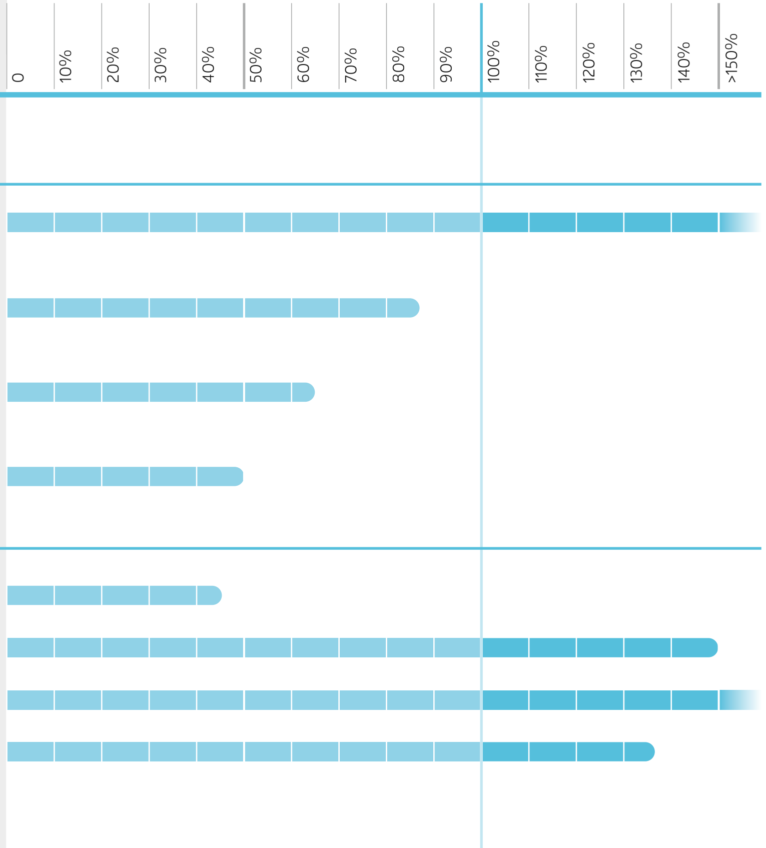
Performance Measure		Actual Y0 2020	Actual Y1 2021	Actual Y2 2022	Actual Y3 2023	Actual Y4 2024	Target Y5 2025	Actual Y5 2025	Perform. rate 2025
Number of presentations/ briefings	To the public (Outreach/public engagement events, public lectures)	4	4	14	12	13	15	19	127%
	To government (parliamentarians and department/agencies at both State and Federal level)	1	0	6	7	9	3	3	100%
	To industry/business/end users (documented) incl. DSTG, CSIRO	3	5	3	20	20	10	21	210%
	To non-government organisations	1	3	6	8	4	3	2	67%
	School visits[11]	2	4	6	13	6	8	5	63%
Number of new organisations collaborating with, or involved in, the Centre	Academic collaborations (new)	4	6	10	8	6	3	14	467%
	Industry and end user partnerships (new)	4	10	7	9	12	3	3	100%
Number of female research personnel	Women and diverse gender, % (double the discipline mean)[12]	33	25	36	32	38	37	34	92%

11. We have increased our relationships with Public and delivered a substantial array of Outreach activities. In 2026 we will focus on School visits (regional schools in Tasmania)
12. Female representation within the research workforce continues to be influenced by broader challenges in the STEM talent pipeline and is remaining a key consideration in TMOS recruitment, development, and retention activities.

Performance Measure		Actual Y0 2020	Actual Y1 2021	Actual Y2 2022	Actual Y3 2023	Actual Y4 2024	Target Y5 2025	Actual Y5 2025	Perform. rate 2025
Centre-specific KPIs									
Research	Plenary talks at international conferences	2	3	12	11	17	3	8	267%
	Keynote and Invited talks at international conferences	21	41	41	63	64	45	47	104%
	Awards and fellowships to CIs, ECRs and AIs	11	10	14	23	21	10	28	280%
	Additional research income secured by Centre staff ('000)	4,410	19,749	5,957	21,362	3,371	2,000	7,766	388%
Equity and Diversity	Leadership Skills Training, % of Centre personnel (CIs)[13]	100	0	0	100	100	100	100	100%
	IDEA Training, % of Centre personnel[14]	0	100	90	87	93	100	57	57%
IP uptake by end-users	Start-up companies	0	1	2	3	0	0	1	Unplanned delivery
	IP uptake by end-users[15]	0	0	6	0	0	3	0	0%
	Number of TMOS alumni employed in industry	0	0		2	2	3	5	167%

13. All CIs completed the Leadership course as required.
14. We are improving our IDEA training offerings and expect a higher attendance rate.
15. 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	Actual Y4 2024	Target Y5 2025	Actual Y5 2025	Perform. rate 2025
Centre-specific KPIs									
Education	Associate TMOS HDR students (PhD and Masters, new)	16	26	1	3	5	5	10	200%
	Centre-member attendees at training workshops (total)[16]	0	0	129	109	94	90	78	87%
	Non-Centre member attendees at training workshops[17]	0	0	16	26	12	20	13	65%
	HDRs visiting PIs[18]	1	0	3	5	1	10	5	50%
Outreach	Media releases[19]	2	10	13	22	15	20	9	45%
	Media mentions	38	170	20	21	231	20	30	150%
	Twitter followers (new)	477	445	396	394	300	100	517	517%
	Outreach hours (Direct contact hours only)	22	26	59	79	190	70	95.5	136%



16. The ECR Conference attendance is not included
17. The lower-than-expected participation of non-Centre members likely reflects competing training opportunities across the sector and the specialised focus of several TMOS workshops.
18. The number of HDR visits to Partner Investigators was influenced by project timing, partner availability, and the need to align placements with individual research milestones and student commitments.
19. We had reduced resources for media release development.

Finance

INCOME STATEMENT 2025

REPORTING PERIOD	2025	2026
	Actual ($)	Forecast ($)
Opening Balance (total funds)	**12,043,024**	12,874,069
INCOME		
ARC[1]	6,058,597	6,185,347
Australian National University	426,695	413,357
University of Melbourne	148,297	169,760
RMIT University	155,100	188,352
University of Technology Sydney	378,769	404,857
University of Western Australia	159,725	159,725
Consultancies	–	–
Government grant/sponsorship	–	
TOTAL INCOME	**7,327,182**	**7,521,397**

REPORTING PERIOD	2025	2026
EXPENDITURE	Actual ($)	Forecast ($)
Personnel	4,051,496	4,456,646
Equipment	166,441	183,085
Scholars Expenses	642,306	687,267
Travel	408,930	572,502
Other[2]	1,226,963	1,621,897
TOTAL EXPENDITURE	**6,496,137**	**7,521,397**
CARRY FORWARD (TOTAL)	**12,874,069**	
CARRY FORWARD TO 2026	**6,423,948**	
CARRY FORWARD TO 2027[3]	**6,450,121**	

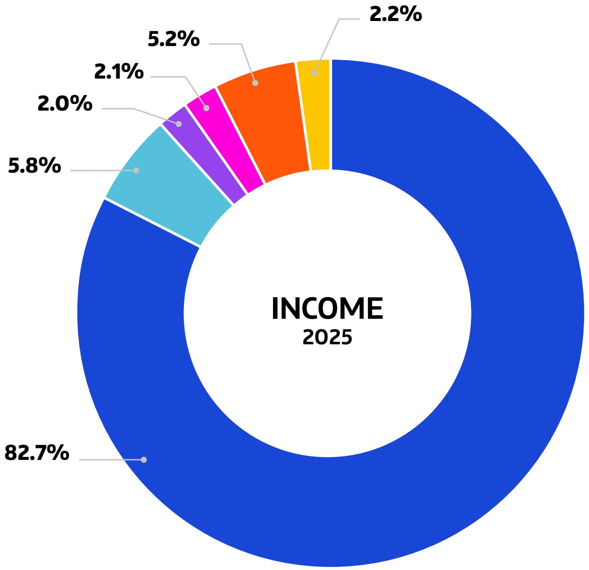
IN-KIND CONTRIBUTIONS 2025

REPORTING PERIOD	2025	2026	2026
	Actual ($)	Commitment ($)	Forecast ($)
IN-KIND			
Australian National University	1,426,454	1,121,068	1,490,401
University of Melbourne	563,163	391,390	484,163
RMIT University	396,466	334,870	442,281
University of Technology Sydney	564,864	370,836	511,345
University of Western Australia	480,460	317,968	480,460
Partners' contributions	736,629	736,629	736,629
TOTAL IN-KIND CONTRIBUTIONS	**4,168,037**	**3,272,761**	**4,145,280**

Notes on the Financial Statement:

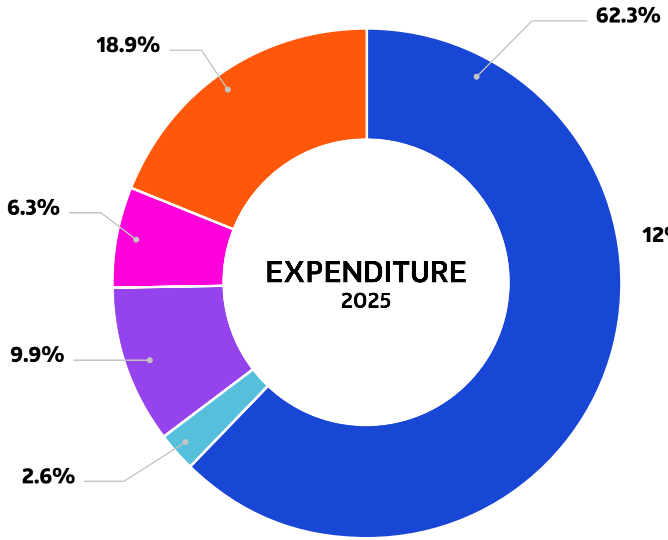
1) includes indexation and 2025 ARC funding
2) incl Materials, R&M, Branding, Outreach, Consultancies, Recruitment, Administrative support, Strategic Initiatives
3) unspent balance from 2020 reserved for 2027 (year 7) operations incl $5,530,785 ARC funds

CASH INCOME SOURCES 2025:



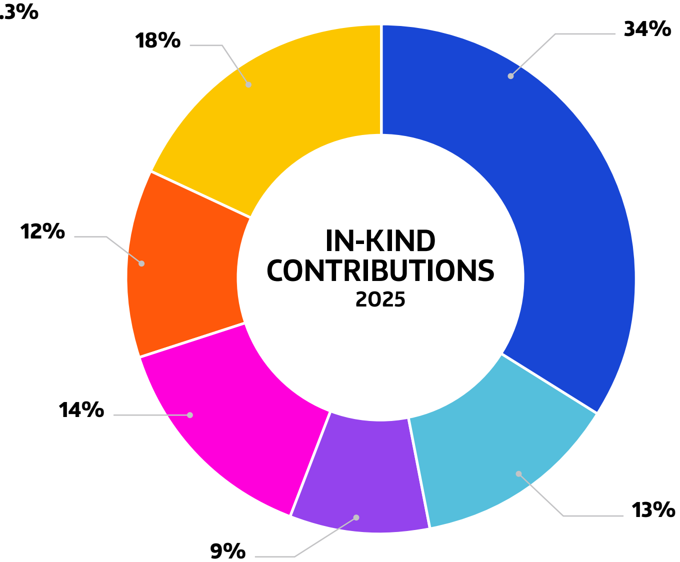
- ARC[1] **82.7%**
- Australian National University **5.8%**
- University of Melbourne **2.0%**
- RMIT University **2.1%**
- University of Technology Sydney **5.2%**
- University of Western Australia **2.2%**
- Consultancies **0%**
- Government grant/sponsorship **0%**

EXPENDITURE 2025:



- Personnel **62.3%**
- Equipiment **2.6%**
- Scholars Expenses **9.9%**
- Travel **6.3%**
- Other **18.9%**

IN-KIND CONTRIBUTIONS 2025:



- Australian National University **34%**
- University of Melbourne **13%**
- RMIT University **9%**
- University of Technology Sydney **14%**
- University of Western Australia **12%**
- Partners' contributions **18%**

Notes on the Financial Statement:

1) includes indexation and 2025 ARC funding

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Awarded Funding and Awards

AWARDS, HONOURS AND PRIZES

TMOS Member	Node	Details
Sharath Sriram	RMIT	Western Australia's new Chief Scientist
Chennupati Jagadish	ANU	Elected to the Royal Society, the UK's National Academy of Sciences
Lan Fu	ANU	Appointed as the President of Australian Materials Research Society
Ann Roberts	UoM	Australian and New Zealand WH (Beattie) Steel Medal
Madhu Bhaskaran	RMIT	Recognised as one of Australia's Top 100 Innovators for 2025 by The Australian
Chennupati Jagadish	ANU	Selected in the panel for the L'Oréal-UNESCO For Women in Science Young Talents Fellowships
Lan Fu	ANU	Elected Fellow Optica "for outstanding contributions to semiconductor materials, optoelectronic devices, and nanotechnology and for broad leadership of the profession"
Lan Fu	ANU	Elected Academician (Fellow) of the Asia-Pacific Academy of Materials
Dragomir Neshev	ANU	Highly Cited Researcher 2025 in the "Cross-Field" category, Web of Science
Igor Aharonovich	UTS	Highly Cited Researcher 2025 in the "Cross-Field" category
Chennupati Jagadish	ANU	Elected as an International Honorary Member of the American Academy of Arts and Sciences at Harvard University in the Area of Mathematical and Physical Sciences; Specialty of Engineering and Technology
Chennupati Jagadish	ANU	Elected as a Fellow of the Royal Society of London for playing a pivotal role in shaping science policy in Australia
Chennupati Jagadish	ANU	2026 IEEE Technical Field Award "For contributions to compound semiconductor nanotechnology for optoelectronic devices and impact on the Photonics community."
Lan Fu	ANU	Selected as external review panel for International Peer Review of School of Materials Sciences and Engineering, University of Electronic Science and Technology of China
Lan Fu	ANU	Selected as external review panel for International Peer Review of School of Materials Sciences and Engineering, University of Electronic Science and Technology of China
Dragomir Neshev	ANU	Co-Chair of the Faculty Track Committee for the 2025 Rising Stars of Light program
Igor Aharonovich	UTS	Co-Chair of the Before Faculty Track Committee for the 2025 Rising Stars of Light program
Lan Fu	ANU	Appointed as the Chair of National Committee for Materials Science and Engineering, Australian Academy of Science

TMOS Member	Node	Details
Shiyu Wei	ANU	Jagadishwar Mahanty Prize (Most outstanding PhD thesis): Dr Shiyu Wei (EME) - for thesis "Indium Phosphide Nanowire Arrays for Gas Sensing Applications"
Laura Valencia Molina	ANU	Robert and Helen Crompton Award to ANU Research School of Physics and Engineering (RSPE) PhD student to undertake part of the research program overseas or make a collaborative visit to an overseas institution
Tongmiao Fan	ANU	Director's Award - PhD Student Publication Award 2025, ANU Research School of Physics
Shiyu Wei	ANU	Awarded the 2025 J G Crawford Prize for her outstanding PhD thesis on "Indium Phosphide Nanowire Arrays for Gas Sensing Applications"
Farid Khoshkhati	UoM	The Australian Government Research Training Program Scholarship (Stipend) to undertake the Doctor of Philosophy - Science at the University of Melbourne
Deepanshu Chaudhary	ANU	PhD Student awarded the Department of Education Industry PhD program Scholarship, Prof Lan Fu's research group
Gabriel Oyarzo Ojeda	UoM	Graeme Clark Institute Top-Up Scholarship
Wei Wen Wong	ANU	Director's Award - EMCR Publication Award 2025, ANU Research School of Physics
Farid Khoshkhati	UoM	The Rowden White Scholarship
Tongmiao Fan	ANU	Received the 2025 EPSQEOD Travel Grant Student Award at the CLEO/EuropeEQEC

AWARDED FUNDING

TMOS Member	Node	Title of Funding Scheme	Project ID	Total Amount (AUD)	Collaborators	Funding Source
Igor Aharonovich, Hark Hoe Tan, Milos Toth	UTS, ANU	ARC Linkage Infrastructure, Equipment and Facilities (LIEF)	LE260100016	$1,330,000	Prof Hark Hoe Tan, A/Prof Jean-Philippe Tetienne, Prof Glenn Solomon, Prof Jan Seidel, A/Prof Nathan Langford, Dr Natalie Holmes, Dr Daria Smirnova, A/Prof Shery Chang, Prof Sumeet Walia, A/Prof Gilberto Umana-Membreno, Dr David Broadway, Prof Milos Toth, A/Prof Martin Hill	Australian Government, Australian Research Council (ARC)
Lan Fu	ANU	ARC Discovery Projects 2026 round 1	DP260104454	$687,567	Dr Chaohao Chen, Dr Zhe Li	Australian Government, Australian Research Council (ARC)
Kenneth Crozier	UoM	ARC Discovery Projects 2026 round 1	DP260101407	$690,000	Associate Professor Peter Reece, Dr Sejeong Kim	Australian Government, Australian Research Council (ARC)
Rocio Camacho Morales	ANU	Discovery Early Career Researcher Award (DECRA)	DE260100906	$517,509		Australian Government, Australian Research Council (ARC)
Lorenzo Faraone	UWA	ARC Linkage Project	LP230201028	$918,488	Prof Wen Lei (CI), A/Prof Gilberto Umana-Membreno (CI), Mr Yu-Heng Lee (PI), Mr Zhaoguang Chen (PI)	Australian Government, Australian Research Council (ARC)
Lorenzo Faraone	UWA	National Collaborative Research Infrastructure Strategy (NCRIS)		$2,500,000		Western Australian Government, Co-investment through the National Collaborative Research Infrastructure Strategy (NCRIS)
Lorenzo Faraone	UWA	Australia's Economic Accelerator (AEA) – Seed Grants, Tranche 3		$443,602		Australian Government – Department of Education, Australia's Economic Accelerator (AEA) – Seed Grants, Tranche 3
Dragomir Neshev	ANU	Collaboration Agreement		$52,500		Industry partner (confidential)
Milos Toth	UTS	Thermo Fisher Scientific		$154,000		Thermo Fisher Scientific
Milos Toth	UTS	Australias Economic Accelerator		$472,128		Australias Economic Accelerator
				$7,765,794		

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