THE UNIVERSITY of ADELAIDE

Annual Report
2019

INSTITUTE FOR PHOTONICS AND ADVANCED SENSING

adelaide.edu.au/ipas

WELCOME.

WE HOPE THAT, THROUGH THE POWER OF LIGHT, WE CAN ENHANCE OUR COMMUNITY'S HEALTH, PROSPERITY AND SAFETY.

A strong commitment to research excellence and impact has defined the University's history, and our research mission will be increasingly important in a world defined by accelerated knowledge creation and transition to a more resilient economy.

The University's research institutes showcase and strategically support some of our finest talent in pursuit of multidisciplinary, large-scale research and innovation outcomes, with the capacity to pursue higher-risk, cutting-edge projects.

The Institute for Photonics and Advanced Sensing (IPAS) brings together a significant number of researchers, working towards creating knowledge and disruptive new technologies to address opportunities in areas including health, the environment, mining and defence. One of its major strengths is combining scientific and technical excellence with a track record of strong external engagement to facilitate industry development.

The 10th anniversary for IPAS was marked in 2019, providing an opportunity to reflect on the Institute's remarkable journey. Since its creation, IPAS has generated over $180M in research funding, over 1,600 scientific publications and has worked with over 90 companies. IPAS has grown from approximately 30 members at its start to over 260 today. Major successes for IPAS and its members include the awarding of the $38M ARC Centre of Excellence for Nanoscale Biophotonics, winning over 20 prestigious national and international fellowships, and launching 7 start-up companies.

IPAS has an inspirational culture, deeply rooted in engagement, whether with university stakeholders, industry partners, students of all ages or the broader community. IPAS members strive to inspire communities and future generations of scientists through exciting outreach activities and showcasing the incredible research taking place in their labs.

This report provides an overview of the substantial range of high-quality activities undertaken throughout 2019. It provides excellent examples of how world-class fundamental research driving impact can be undertaken in partnership with industry for the greater benefit of society.

Professor Anton Middelberg

Deputy Vice-Chancellor and Vice-President (Research)

REPORT FROM THE BOARD CHAIR

Dr Warren Harch, IPAS Board Chair

2019 marked the 10th anniversary for IPAS. It all started with the formation of the Centre of Expertise in Photonics (CoEP) in July 2005 as a joint venture between the University of Adelaide, the Defence Science and Technology Organisation, precursor to the Defence Science and Technology Group (DSTG) and the South Australian State Government. The success of the CoEP led to the creation of IPAS in 2009. 10 years later, IPAS has become a major partner for Australian Defence, with a third of its research funding coming from Defence collaborations, a number of our postgraduates having gone on to successful careers in DSTG and the Institute proudly delivering game-changing technologies for Defence's most critical assets. What a proud legacy!

As you will see from this report, 2019 was once again a highly productive year for IPAS with continued substantial growth and capabilities demonstrating that IPAS is tracking well in the key research strategies of IPAS excellence, innovation, global and enabled. Specific highlights include:

- IPAS winning over $1.7M from the Defence Next Generation Technologies Fund, securing 4 of 11 nationally funded projects under the Quantum technology call;
- Launch of the world-class Atom Trap Trace Analysis capability in collaboration with CSIRO;
- Securing a further $6.3M investment from National Collaborative Research Infrastructure Strategy in acknowledgement of the critical work performed over the years by the IPAS Optofab team to support and enable academic-industry collaborations and support SMEs.

I would like to acknowledge and thank my fellow members onthe IPAS Board, IPAS Director Prof Andre Luiten, the IPAS Executive Team, and the researchers, staff and students for their tireless and instrumental contributions.

300+ PUBLICATIONS

10+ JIF* **13** PUBLICATIONS

5+ JIF* **71** PUBLICATIONS

* Journal impact factor

26 PROFESSORIAL RESEARCH LEADERS

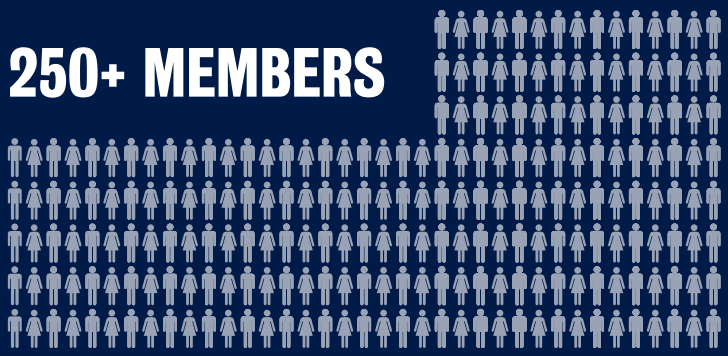
$14M+ RESEARCH FUNDING (2019)

07 START-UPS LAUNCHED

06 AREAS OF STRENGTH

RATED 5, 'WELL ABOVE WORLD STANDARD', ACROSS THE BOARD IN ALL FOUR AUSTRALIAN RESEARCH COUNCIL EXCELLENCE IN RESEARCH FOR AUSTRALIA ASSESSMENT ROUNDS (2010, 2012, 2015, 2018)

250+ MEMBERS



7 HONOURS STUDENTS
13 MASTER-DEGREE STUDENTS
78 PHD STUDENTS

IPAS's vision is to develop innovative sensors to make the world healthier, wealthier and safer. I think you can see from the stories contained in this document that we are accomplishing across the spectrum of our vision.

Professor Andre Luiten,
FAIP GAICD, Chair of Experimental Physics

DIRECTOR'S REPORT

IPAS' mission is to transform breakthrough science into technology that makes the world healthier, wealthier and safer.

Our success in this mission was recognised at last year's SA Science Excellence Awards which showcase the critical importance of science and research to SA industries and communities. I was privileged to be a finalist for SA Scientist of the Year and Dr Danny Wilson was named one of 2019's Young Tall Poppies. I am especially proud that IPAS was recognised for its leading "Women in STEM" researchers. This year saw our innovation trailblazers, Dr Jiawen Li and Dr Katharina Richter, being awarded the Winnovation Awards in Engineering and Science respectively. Dr Cheryl Law was awarded the 2019 University's Women's Research Excellence Award and the William Culross award for her research in advanced engineering of new chemical and biological sensing technologies while Dr Jiawen Li was awarded the Geoff Opat Early Career Researcher Prize by the Australian Optical Society for outstanding research contributions in the field of optics.

2019 saw IPAS involved in the establishment of three new capabilities that are set to underpin our future growth in sectors of critical importance to the State and the Nation:

- Launch of two new Molecular Beam Epitaxy facilities on our campus – one created by Silanna Semiconductor (see inside for more details) and a second facility created by Defence Science and Technology Group. These two facilities give us the capability to create next generation electronics and photonic devices by manipulating matter on the quantum scale. Believe it or not: these machines allow the user to engineer at the single atom level! As you can imagine, this gives a designer incredible flexibility to create new devices that deliver on the IPAS missions.
- Launch of the Atom Trap Trace Analysis (ATTA) Facility. Developed in collaboration with CSIRO and Griffith University, the ATTA is a unique new facility that will help protect Australia's precious groundwater from overuse and contamination, and contribute to our understanding of the impact of climate change through measurements on Antarctic ice cores. ATTA is only one of several deep and meaningful research collaborations between IPAS and CSIRO and we are excited about what is in store for the future.
- Co-creation of a new independent Centre for Radiation Research, Education and Innovation (CRREI), and the appointment of A/Prof Tony Hooker as its Director. Tony will work closely with Prof Nigel Spooner, a founding member of IPAS, to deliver on the 4 key missions of the Centre, including the expansion and provision of radiation-related services to the health, mining and environment monitoring sectors as well as food irradiation testing and chronological dating services. CRREI was a winner almost from the day it was born! It was named the most inspiring research institute for a career in the space industry at the 2019 Australian Research Space Conference.

This year also saw us hosting a series of high-profile workshops including:

- The first Defence Innovation Partnership/Defence Science and Technology Group workshop to highlight the amazing South Australian photonics capabilities for defence;
- An international Precision and Quantum Sensing workshop in Adelaide, attended by almost 100 leading experts in the precision and quantum sensing field. This workshop included a session that addressed the necessary requirements for building a quantum workforce for Australia's future needs;
- And a workshop on quantum devices and quantum materials as we build our way to an internationally leading capability in this rapidly changing field.

Noting the critical need for Australia to create a vibrant, entrepreneurial and educated STEM workforce for its future, IPAS redoubled its efforts in 2019 to advocate for the value of STEM and inspire the next generation of scientists and engineers from the ranks of SA's young people. This year we not only ran our annual IPAS Research Open Day (where we open our labs to the general public and schools), but we also ran an IPAS booth at INGENUITY, an outstanding annual event created by the Faculty of Engineering, Computer and Mathematical Sciences at the University of Adelaide. This event allowed us to showcase our research to over 5000 attendees including high school students, industry representatives, university staff and the general public.

As you read this annual report, I am sure that you will be impressed by the amazing impact and outcomes that have been achieved by the collective and collaborative efforts of our truly brilliant researchers and members. As always, if you can see ways in which we can help you, or you us, then do not hesitate to get in contact with me.

Prof Andre Luiten
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CONGRATULATIONS

IPAS ECRs win big at the 2019 Winnovation Awards

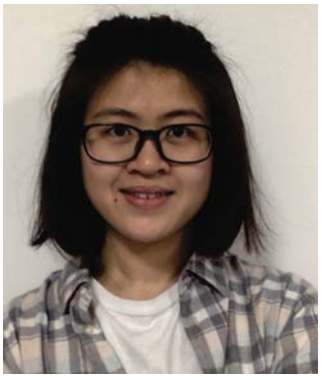
Congratulations to Dr Jiawen Li and Dr Katharina Richter for being awarded the 2019 Winnovation Awards in Engineering and Science respectively. Katharina's research focuses on new therapies including silver nano-bullets and "toxic chocolate" to treat infections and antibiotic resistant superbugs; while Jiawen has developed the world's thinnest multimodal imaging catheter to study and prevent heart attack.

IPAS Start Up wins 2 Defence Awards

Congratulations to Cryoclock Pty Ltd for winning both the Innovation Award for Autonomous and Unmanned Systems and ISR and The Defence SME Innovation Prize at the at the 2019 Avalon Airshow.

CRREI – most inspiring for a career in space industry

The award recognising the newly established Centre for Radiation Research, Education and Innovation was voted by the Australian Space Agency, South Australian Space Industry Centre and the Advanced Technology Program through the Space Passport activity at the 2019 Space Conference.



University's Women's Research Excellence and William Culross Awards

Congratulations to Dr Cheryl Law who was recognised by two prestigious awards for her PhD research in advanced engineering of photonics and plasmonic structures for optical chemo- and biosensing applications.

Geoff Opat ECR Prize

Congratulations to Dr Jiawen Li for being awarded the Geoff Opat Early Career Researcher Prize by the Australian Optical Society for her outstanding research contribution in the field of optics.

VC Award for Outstanding Achievements

Congratulations to Prof Mark Hutchinson, recognised by our Vice-Chancellor for establishing and nurturing "a culture of impact and excellence" as the Director of the Australian Research Council Centre for Excellence in Nanoscale Biophotonics.

Finalist for SA Scientist of the Year

Congratulations to Prof Andre Luiten for being shortlisted as finalist for the South Australian Science Excellence Scientist of the Year award. Andre was also appointed as a member of the South Australian Premier's Science and Innovation Council, that provides advice to the State Government on the strategic priorities and major advances in science and technology to drive the State's growth agenda.

2019 AIPS Tall Poppy Award

Congratulations to Dr Danny Wilson who was named one of the 2019 South Australian Tall Poppies. Danny's research is focused on developing new drugs that kill malaria parasites and a vaccine for the parasites. He has identified new drug chemotypes to develop as antimalarials, and developed new parasite tools to fast-track malaria vaccine development.

IPAS welcomes Ramsay Fellow

Congratulations to Dr Fiona Whelan. This is the fifth time in six years that the Ramsey fellow has been appointed within IPAS. Dr Whelan will focus on harnessing the natural sensing ability of bacteria as a potential biosensors in various areas such as medical diagnostics, food security, biomonitoring and bioremediation.

FHMS Executive Dean Awards

Congratulations to Prof Robert McLaughlin and Dr Sanam Mustafa for being awarded the Faculty of Health and Medical Sciences Executive Dean Prizes for Innovation & Engagement respectively.

George Southgate Fellowship

Congratulations to Dr Ruth Shaw who was awarded a George Southgate Fellowship that allowed her to attend the International Conference on Solid State Dosimetry & the Marko Moscovitch School of radiation dosimetry in Japan.

Best postgraduate poster presentations at the 2019 Space Conference

Congratulations to IPAS students, Daniel Field and Kathryn McDonnell who were awarded the winner and runner-up for the best postgraduate poster presentations respectively at the 2019 Space Conference.

RESEARCH WITH IMPACT

The Institute for Photonics and Advanced Sensing drives a transdisciplinary approach to science and excellence in research through the development of disruptive new sensing and measurement technologies.

At IPAS we give businesses and organisations a competitive advantage through next-generation technologies offering greater sensing reach and more precise measurement.

Our engagement with industry ranges from solving specific end-user problems to providing access to cutting-edge manufacturing infrastructure for proof-of-concept materials and prototype devices.

This work's outcomes and impacts, some of which you'll learn about in the following pages, range from scientific discoveries and innovations, to spin-out companies and job creation. Over 40 per cent of our income is connected to industry.

Our areas of strength

IPAS's industry-leading research is focused on six key areas:

- Defence and Security
- Space Science & Astrophysics
- Health and Biotech
- Energy, Mining and Resources
- Advanced Manufacturing
- Agri-food and Wine

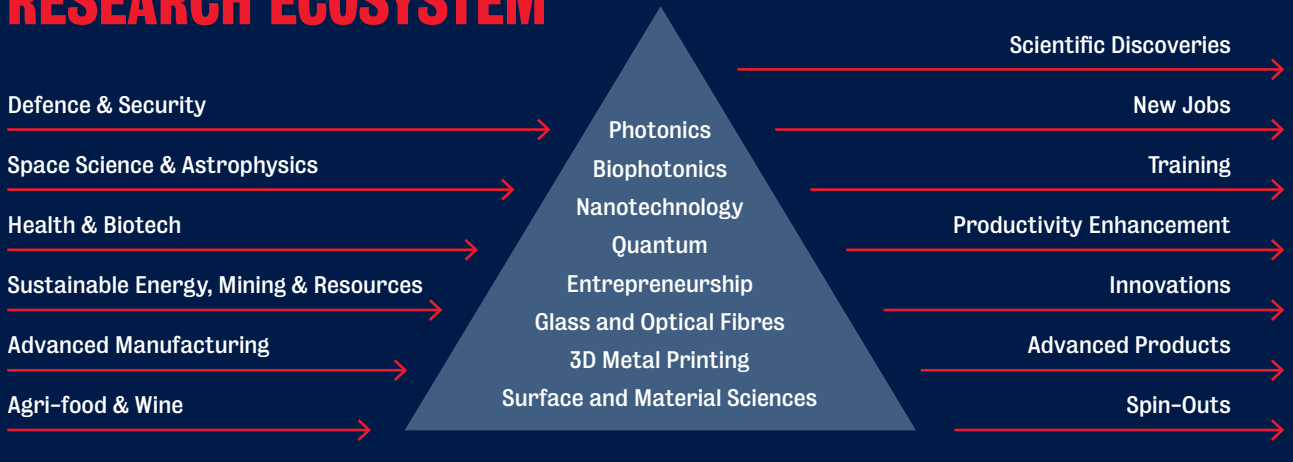
Outstanding transdisciplinary headquarters

Our $96M headquarters, The Braggs, is a unique transdisciplinary University of Adelaide building that enables IPAS researchers to be co-located with students from a broad range of scientific fields.

The building also houses a similarly wide range of state-of-the-art facilities. These support research in:

- precision measurement—time, temperature and frequency
- photonic sensor development
- advanced manufacturing, including 3D ceramic and metal printing
- glass and optical-fibre development and processing
- laser development
- luminescence dating and radiation measurement
- synthetic and surface chemistry.

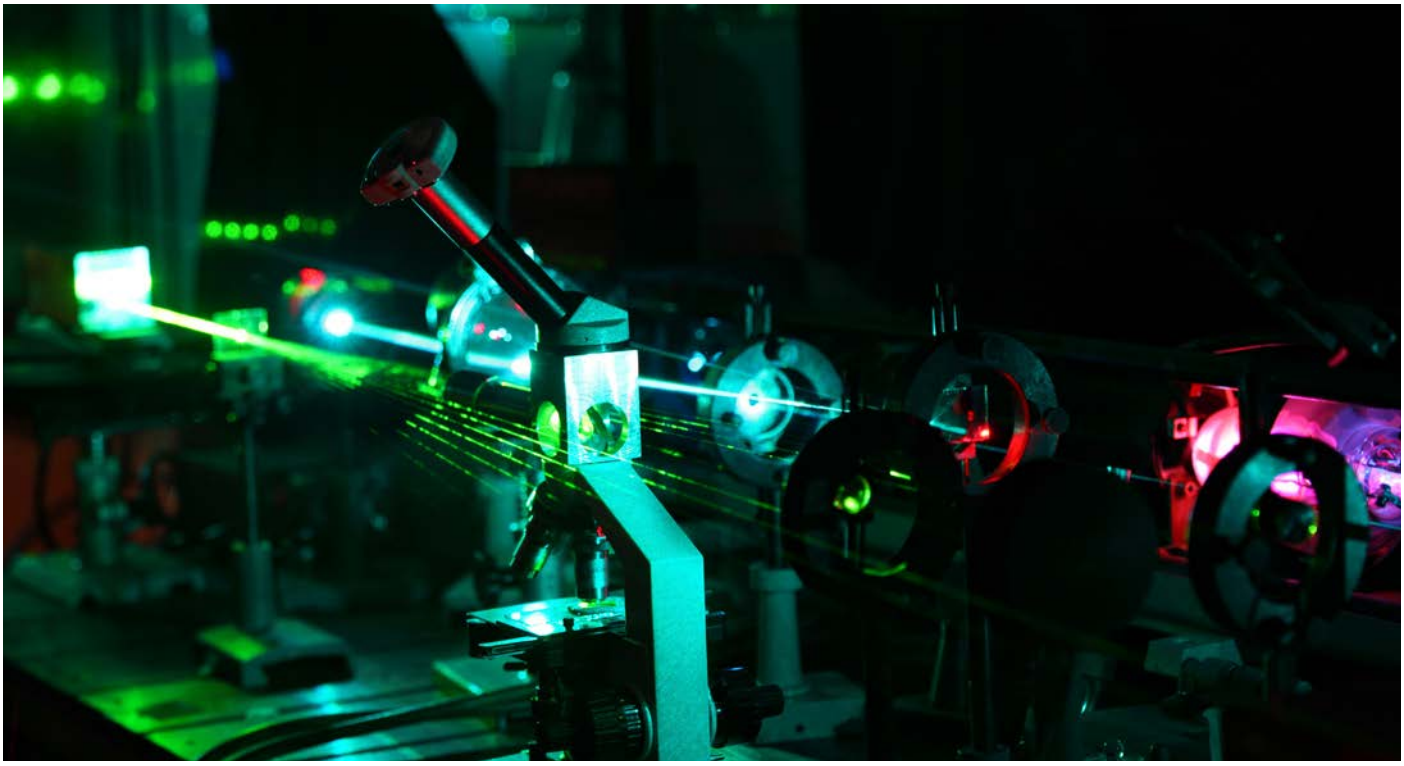
IPAS TRANSDISCIPLINARY RESEARCH ECOSYSTEM



Themes **Capabilities** **Impact**

Research Themes

DEFENCE & SECURITY



Portable Quantum Clock

Prof Andre Luiten in collaboration with Curtin University, University of Queensland, Griffith University and the Defence Science and Technology Group

Funded under a $1M Defence Industry and Innovation Next Generation Quantum Technologies grant, this project is developing a portable cold-atom quantum clock with a performance that matches the best clocks on the globe, but unlike those laboratory-scale devices, this clock will be a portable package that is robust and suitable for rack-mounting.

With a target specification of frequency accuracy more than 100 times better than any commercial device, this clock will target the broad suite of applications that simultaneously need accuracy and small size by disrupting the current nexus between Size, Weight and Power (SWaP) and performance. Such a device will deliver electronic signals that have the same accuracy as its optical output which means that it is immediately useful in current defence systems that rely on good timing (radar, communications, navigation, synchronisation, time-stamping and detection of GPS disruption).

Quantum Magnetometer Array for Anti-Submarine Warfare

Prof Andre Luiten, Dr Chris Perrella, Dr Philip Light in collaboration with the Defence Science and Technology Group

Detection of small deviations in magnetic field is extremely valuable in many applications, including: medical, for detection of fluctuating magnetic fields in the heart or brain; defence, for passive detection of submarines and geology, for geomagnetic surveys.

Funded under a $450k Defence Industry and Innovation Next Generation Quantum Technologies grant, IPAS is developing a deployable quantum magnetometer array designed to enable novel approaches to Anti-Submarine Warfare (ASW).

The sensitivity of the magnetic sensor within the array will match that of the very best existing commercial sensors and will be packaged into robust, compact and low-power devices in contrast to the bulky and expensive existing technologies. Such sensors will enable an absolute measurement of the magnetic field magnitude (scalar sensor) that require no calibration, making them ideally suited for mobile and remote applications.

Research Themes

SPACE SCIENCE & ASTROPHYSICS

Credit: HESS/Vikas Chander

Optical Fibre manufacture in Space

Prof Heike Ebendorff-Heidepriem, Dr Erik Schartner in collaboration with Flawless Photonics

The fabrication of extreme low-loss fibres for telecommunications applications has been an area of major research interest in recent years. Ultra-high speed long-distance undersea cables could be built without the need for very expensive repeater stations. Conventional silica fibres are very close to their theoretical loss limits. Fluoride fibres present an ideal alternative, but real-world results from these fibres have never lived up to expectations as yet, due to chemistry issues with terrestrially fabricated fibres. Manufacturing these fluoride fibres in the microgravity environment of space has the potential to enable this and Flawless Photonics, our commercial partner, has recently demonstrated a proof-of-concept for this by drawing meaningful lengths of fibre aboard the International Space Station (ISS). This project, funded under a $50k Global Connection Grant, is developing a prototype furnace and improved drawing method, with the ultimate goal of deploying this technology to the ISS to make commercial quantities of fibre in space.

First detection of supernova extreme afterglow

Prof Gavin Rowell in collaboration with the High Energy Stereoscopic System (H.E.S.S.) team

IPAS is part of a multinational team of researchers, the High Energy Stereoscopic System (H.E.S.S.) team, that has shown for the first time that certain kinds of supernova explosions can emit gamma-ray bursts of extreme energies that can be detected from the Earth's surface. A very-high-energy component deep in the gamma-ray burst afterglow.

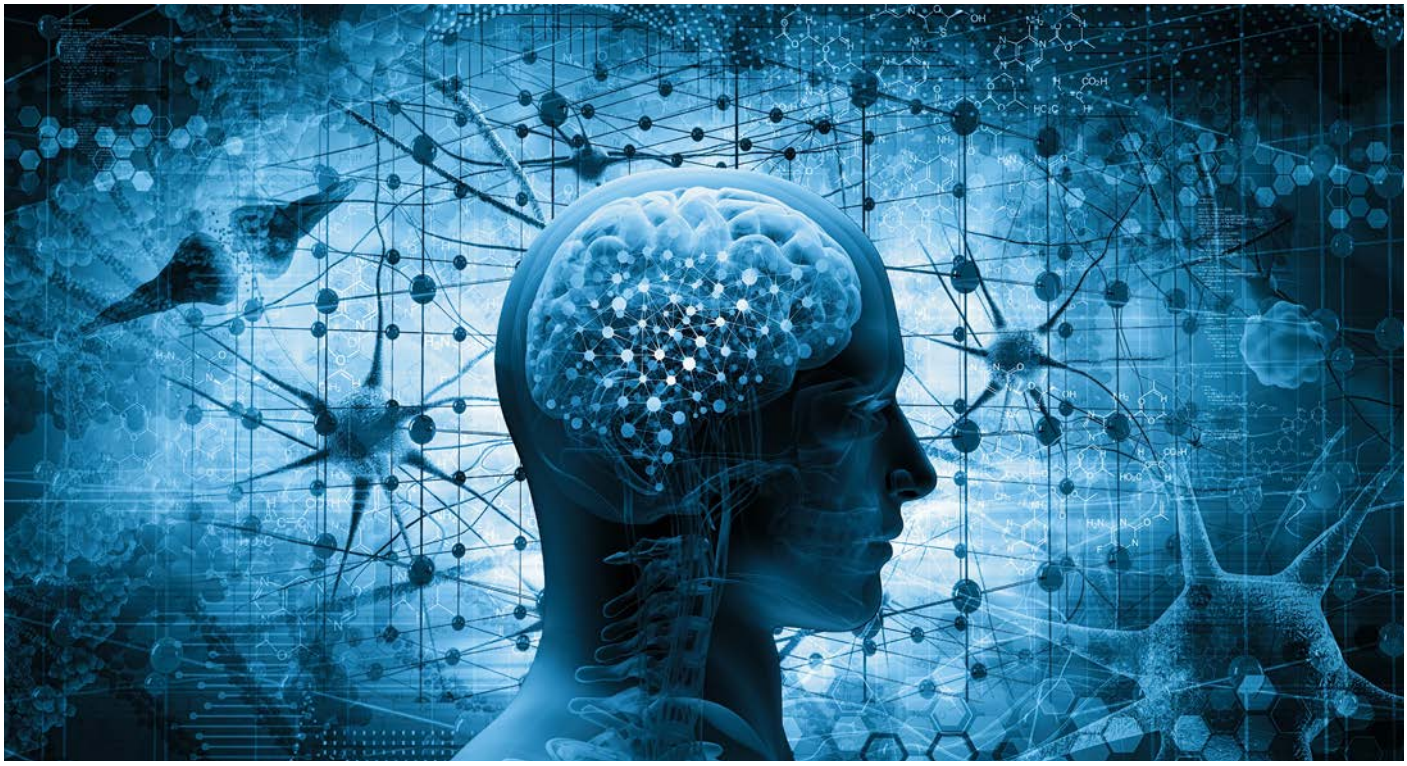
The exciting findings, published in Nature (H. Abdalla et al, Nature (575), pages464–467, 2019), challenge existing knowledge of gamma-ray bursts (GRBs) and their origin.

This observation of a gamma-ray burst suggests the accelerated particles creating the gamma-rays still exist or are created a long time after cosmic explosions.

These results present new challenges to theoretical models of particle acceleration in gamma-ray bursts and, indeed, to where we believe cosmic-rays come from.

Research Themes

HEALTH & BIOTECH



NHMRC Development Grant for safer, faster brain biopsies

Prof Robert McLaughlin in collaboration with the Royal Adelaide Hospital and Specialised Therapeutics Glio Pty Ltd

Brain tumours are the leading cause of cancer-related death in children and have one of the largest disease burdens across all ages because of the high fatality rate. Surgical complications can be debilitating or fatal. Accurate diagnosis is essential to minimising collateral damage. Needle brain biopsies are a standard part of diagnosis, and over 37,000 brain biopsies are performed each year in the USA and Europe. However, inserting a needle into the patient's brain carries significant risk, and 2-3% of patients will suffer permanent disability and 1% will die.

Funded under a $750k NHMRC Development Grant, this project will finalise clinical translation of the IPAS smart needle technology and validate its use through ex vivo and in vivo human trials.

Revealing molecular detail of DNA triplexes to underpin antigene technology

A/Prof Tara Pukala

Variations from the classic DNA double helix structure are proposed to play key roles in a range of cellular processes, particularly gene regulation. However, the biological function and therapeutic potential of these unusual DNA structures are poorly explored, since the fundamental molecular details which govern their formation and interactions with cellular machinery are not well described.

Funded under a $450k ARC Discovery Grant, this project aims to develop innovative methods to investigate, and importantly modulate, DNA and RNA triple helix assembly, specificity and molecular interactions. Resulting insights will underpin novel approaches to gene regulation, principally in the context of designing new antibacterial agents to address the antibacterial resistance problem.

Research Themes

SUSTAINABLE ENERGY, MINING & RESOURCES

Trapping atoms to protect Australia's groundwater

Prof Andre Luiten, Dr Philip Light, Dr Rohan Glover in collaboration with Griffith Univesrity and the Commonwealth Scientific and Industrial Research Organisation (CSIRO)

In September 2019, IPAS was honoured to host the launch of the Atom Trap Trace Analysis (ATTA) Facility by the SA Premier The Hon Steven Marshall MP and the unveiling of a commemorative plaque by Dr Larry Marshall – CSIRO Chief Executive and Prof Peter Rathjen AO - the University of Adelaide Vice Chancellor and President.

This unique facility will help protect Australia's precious groundwater from overuse and contamination, and contribute to our understanding of the impact of climate change through measurements on Antarctic ice cores.

It uses advanced laser physics to count individual atoms of the noble gases, such as Argon and Krypton, which are naturally found in groundwater and ice cores.

This collaboration will deliver significant capacity to the Australian market to support the exploration of traditional resources, rare earths and groundwater. It also develops new knowledge to allow safe, environmentally sensitive and economically viable resource extraction. ATTA will also contribute to building Australia's capacity to respond to environmental changes and integrate research outcomes from biological, physical, social and economic systems.

Upconversion fluorescence for real-time mineral identification

Prof Nigel Spooner in collaboration with the CRC ORE

Laser-based sensing technology is a rapidly evolving field and recent advances in other industries and non-mining applications are revolutionising the possibilities of decisions based on real-time data.

Identifying fluorine in real-time within mineral structures is currently challenging as it relies upon off-line laboratory analysis with long turn-around times that are insufficient both for grade engineering and for efficient online decision-making. Common fast real-time analysis methods such as PGNAA and x-ray analysis are not suitable for light elements such as fluorine. Fast offline analysis methods such as XRF and ICP still need sample preparation and typically a 24-hour turnaround for results. Techniques which allow for speciation such as XRD and automated mineralogy need highly trained operators and are time-consuming, labour-intensive techniques.

Funded under a $620k CRC ORE grant, this project aims to develop a new cross-belt sensor technique requiring no sample preparation and based on novel fluorescence signatures, for real-time identification of fluorine abundance and mineral speciation.

Research Themes

ADVANCED MANUFACTURING

$6.3M boost for Optofab Advanced Manufacturing Capabilities

Prof Heike Ebendorff-Heidepriem, Luis Lima-Marques, Piers Lincoln and the Optofab Adelaide team.

The IPAS Optofab Adelaide team was awarded $6.3M under the National Collaborative Research Infrastructure Strategy (NCRIS), including $1.5M from the SA Government. The team will upgrade and extend its world-class optical fibre and glass fabrication facilities. It will ensure Australia stays at the forefront of glass and fibre research, fabricating optical components and devices used for fundamental and applied research projects in defence, environmental monitoring, medical technology, mineral exploration and processing, agriculture and food and wine.

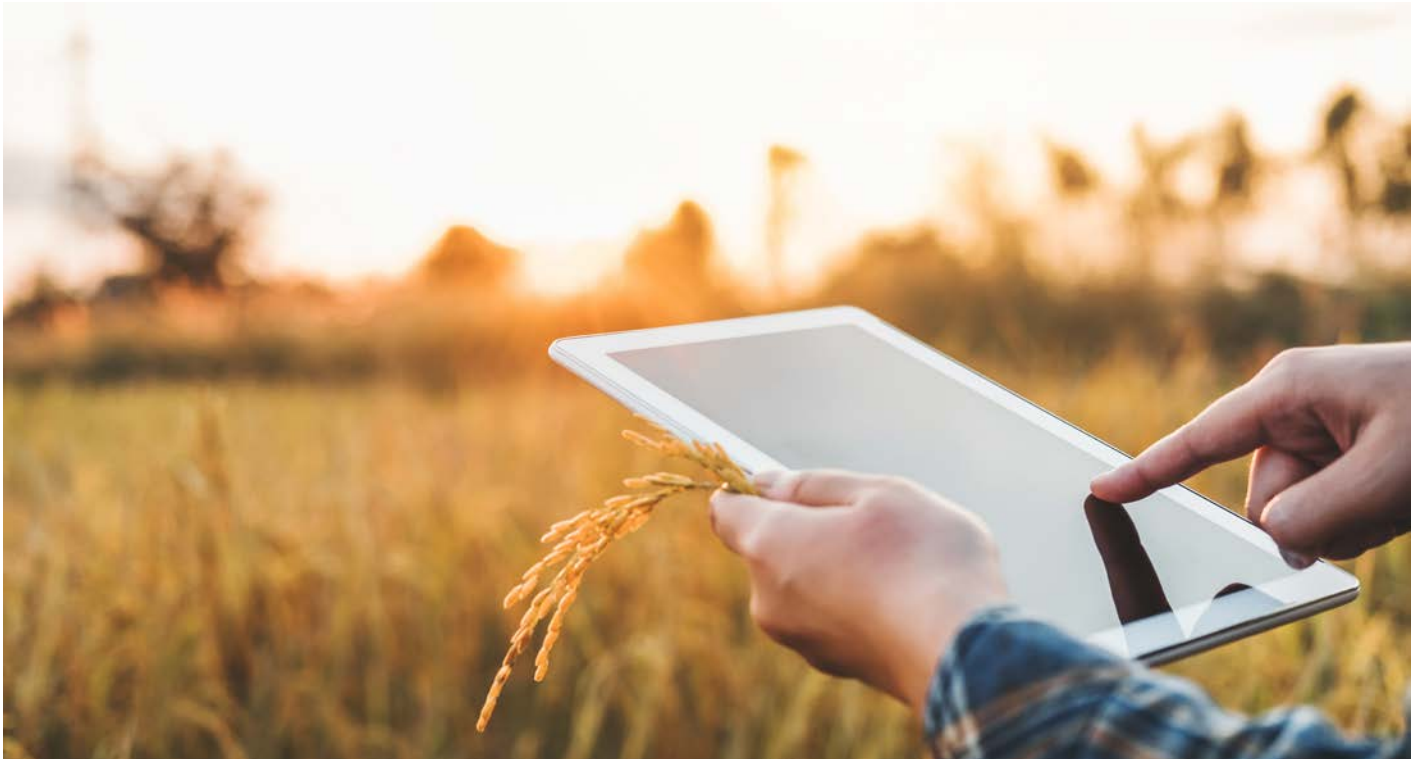
3D glass printing: the next step in advanced manufacturing

Prof Heike Ebendorff-Heidepriem, Prof Robert McLaughlin, A/Prof Reza Ghomashchi in collaboration with Macquarie University and UniSA

Funded under a $260k ARC Linkage Infrastructure and Equipment Fund, this project aims to establish the first 3D glass printing capability in Australia. The similarity of the 3D printing technology to that of the world-class glass extrusion technique in Australia makes for an unprecedented opportunity to advance the field of 3D glass printing from modern art to the fabrication of glass components with both high transparency and new structures not possible with any other technology. These 3D printed glass materials and structures are expected to revolutionise photonics and microfluidics devices by enabling new ways of light and fluidics control. This will keep Australia at the forefront of scientific research and development, specifically in biomedical devices, fibre optics, and analytical instrumentation.

Research Themes

AGRI–FOOD & WINE



Mid-IR laser nose for wine quality and health

Dr Ori Henderson-Sapir, Dr Ka Wu in collaboration with LumoScribe

Wine is a major industry with rapidly growing revenue in Australia. To ensure quality, wine samples are removed from barrels during fermentation and either smelled by winemakers, a subjective process, or chemically analysed. Both approaches are time consuming and costly, with delayed results risking spoilage due to problematic fermentations. Laser-based gas sensing of the headspace above the wine has the potential for near-instantaneous, objective and sensitive fermentation analysis without disturbing the wine.

Funded under a $50k Global Connection Grant, this project will develop a compact laser-based detection system for sensing trace amounts of undesirable volatile compounds that may develop in wines during fermentation, responsible for unpleasant odours and offensive flavours in the final product. The use of laser technology can enable monitoring of the fermentation process without disturbing the wine, providing early warning for potential issues to minimise spoilage and improving wine quality.

Measuring irradiation to ensure food safety

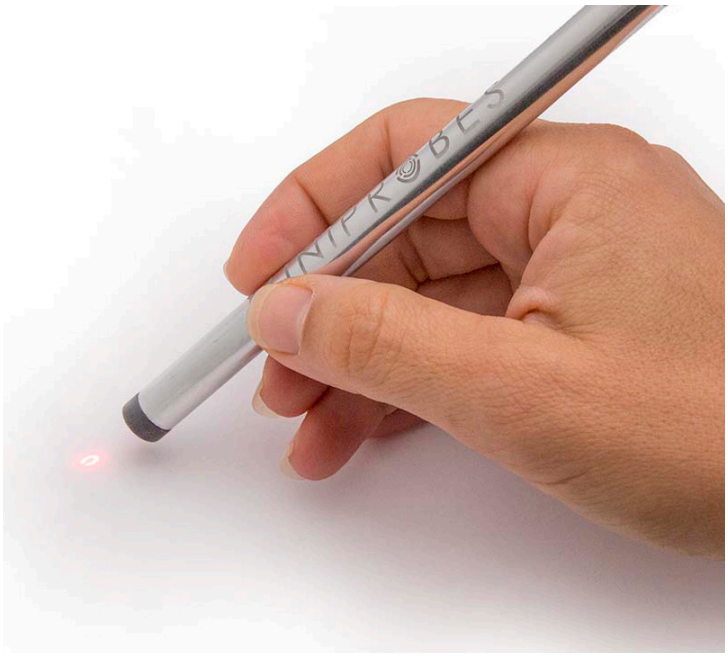
Prof Nigel Spooner, Kathryn McDonnell in collaboration with the Waite Research Institute (WRI)

Food irradiation with specified doses is permitted in Australia for certain fruits, vegetables, herbs and spices the purposes of pest disinfestation, controlling sprouting and bacterial decontamination. Regulation regarding irradiated food products varies in different countries and therefore it can be a market access issue for Australian products. Irradiation is also known to be used illegally to mask the poor microbiological quality of foods. Currently there is no laboratory in Australia that can detect whether food products have been irradiated.

Under a seed partnership grant with the WRI, this project is looking at leveraging IPAS world-class expertise and facilities in radiation measurement to establish a national Food Irradiation Testing reference laboratory within the newly launched Centre for Radiation Research Education and Innovation (CRREI) to provide:

- detection of irradiation used as spoilage masking on imported foodstuffs;
- monitoring to ensure compliance with regulations; and
- certification of non-irradiation for export market access.

RESEARCH SPIN-OUTS



MINIPROBES

Miniprobes Pty Ltd commercialises high-precision, low-cost optical scanning technology developed at IPAS. The company's initial foci will be producing and distributing the Smart Needle and the 'Miniprobe' —a handheld device ideally suited for the livestock industry.

The Miniprobe provides high-resolution imaging under the skin. With seed funding from the South Australian Government, the company is pursuing applications in the sheep and cattle industries where their probes are able to provide farmers with new insights into animal selection, identifying livestock with improved production capacity or greater heat resilience in the hot Australian climate. They are working with investors to release an initial commercial product for the sheep industry by 2021.

MINIPROBES

HT SENSING

HT Sensing Pty Ltd, launched in December 2018, is commercialising optical fibre high temperature sensors that were developed at IPAS. These sensors can incorporate many measurement points along a single cable, greatly expanding the capability to profile temperatures in industrial furnaces.

The technology has recently been demonstrated to be suitable for operating in extremely harsh environments, including the Port Pirie smelter. HT Sensing is now working in close partnership with SJ Cheesman, a 110-year-old engineering firm based in Port Pirie, to find applications for these sensors in smelters and other heavy industries across Australia and globally.

HT sensing

CRYOCLOCK

Cryoclock Pty Ltd commercialises the Institute's exceptional Sapphire Clock technology. Cryoclock will supply the Australian Defence Forces with multiple units for use in the nation's Jindalee Over-the-Horizon Radar Network, pending successful field tests.

The company is also fielding significant interest from quantum-computer manufacturers seeking to boost their machines' performance. In 2019 Cryoclock began commercialisation of its technology.

CryoClock

MIRAGE PHOTONICS

Mirage Photonics Pty Ltd commercialises IPAS-developed cutting-edge mid-infrared (mid-IR) fibre lasers for advanced research-and-development and atmospheric and environmental sensing applications.

The company's first product is the Mid-IR MFL-3500, a continuously tuneable 3.5 µm mid-IR fibre laser. Operating at room temperature and featuring broadband tuning, the MFL-3500 provides a new benchmark in efficiency and portability for 3.5 µm laser sources, with excellent beam quality.

MIRAGE PHOTONICS

PROF ANDRE LUITEN

IPAS Director and Chair of Experimental Physics

Prof Andre Luiten FAIP GAICD is Director of the Institute for Photonics and Advanced Sensing (IPAS) and Chair of Experimental Physics at the University of Adelaide. He is a Fellow of the Australian Institute of Physics. Prof Andre Luiten obtained his PhD in Physics from the University of Western Australia in 1997, for which he was awarded the Bragg Gold Medal. He has subsequently held three prestigious Fellowships from the ARC. For his efforts Andre was the joint inaugural winner of the WA Premier's Prize for Early Career Achievement in Science. Andre came to the University of Adelaide in 2013 to take up the Chair of Experimental Physics and a South Australian Research Fellowship from the Premier's Research and Innovation Fund.

He has published 6 book chapters and authored 125 journal papers (with over 5,180 citations), has over 110 conference papers, and has raised over $25.4M for research.

Prof Luiten's work is focussed on the development of state-of-the-art instruments across many diverse fields of physics. The excellence of his research has been recognised by the award of the Barry Inglis Medal from the National Measurement Institute, which acknowledges outstanding achievement in measurement research and excellence in practical measurements, the Australian Institute of Physics' Alan Walsh Medal for Service to Industry and the prestigious 2018 Eureka Prize for Outstanding Science in safeguarding Australia. Andre is also the co-founder and Managing Director of Cryoclock Pty Ltd, a start-up recently named Avalon 2019 Defence SME of the Year.

IPAS GOVERN

NANCE

PROF HEIKE EBENDORFF-HEIDEPRIEM

IPAS Deputy Director and Deputy Director of the Optofab node of the Australian National Fabrication Facility (ANFF)

Prof Heike Ebendorff-Heidepriem is Deputy Director of the Institute for Photonics and Advanced Sensing (IPAS) and Deputy Director of the Optofab node of the Australian National Fabrication Facility (ANFF). She is a Senior Investigator of the ARC Centre of Excellence for Nanoscale BioPhotonics (CNBP). In 2017 she became a Fellow of the Optical Society of America, an honour awarded by peers for having "made significant contributions to the advancement of Optics".

Heike obtained her PhD in chemistry from the University of Jena, Germany in 1994 and subsequently held two prestigious fellowships. From 2001-2004 she was with the Optoelectronics Research Centre at the University of Southampton, UK. Heike came to the University of Adelaide in 2005. She was awarded the Woldemar A. Weyl International Glass Science Award in 2001, the International Zwick Science Award in 2009, the University of Adelaide Women's Research Excellence Mid-Career Award in 2015, and the Winnovation SA Technology Award from the SA Women in Innovation and Technology in 2017.

Heike has published over 330 refereed journal papers and conference proceedings, including 5 review papers and 9 postdeadline papers, and raised over $31M in research funding. Heike's research focuses on the development of novel optical glasses, fibres, surface functionalization and sensing approaches.

IPAS EXECUTIVE COMMITTEE

Prof Andre Luiten
IPAS Director

Prof Heike Ebendorff-Heidepriem
IPAS Deputy Director

Piers Lincoln
IPAS Institute Manager

Elodie Janvier
IPAS Strategic Research Development Manager

Sara Leggatt
IPAS Senior Office Administrator & Executive Assistant

Thanh Nguyen
IPAS Research Support & Marketing Officer

Luis Lima-Marques
IPAS Laboratory Manager

Prof Robert McLaughlin

Prof David Ottaway

Dr Rohan Glover
IPAS Science Network Committee Co-Chair

Dr Erin Smith
IPAS Science Network Committee Co-Chair

Dr Georgina Sylvia
Project Manager, Defence Projects

Melissa Coleman
IPAS Administrative Assistant

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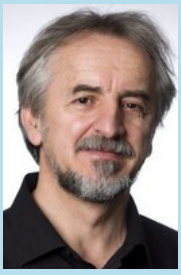
Prof Andre Luiten

Prof Heike Ebendorff-Heidepriem

Prof Andrew Abell

Prof Mark Hutchinson



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Prof David Ottaway

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Prof Martin Lambert

A/Prof Tony Hooker

Prof Carolin Plewa

A/Prof Martin O' Connor

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A/Prof Tak Kee

Dr Jiawen Li

Dr John Bruning

Dr Philip Light

Dr Ori Henderson-Sapir

Dr Abel Santos

Dr Tom Avery

Dr Yinlan Ruan

Dr Erik Schartner

Dr Ruth Shaw

Dr Ben Sparkes

Dr Sanam Mustafa

Dr Stephen Warren-Smith

Mr Luis Lima-Marques

Dr Steven Wiederman

Dr Giuseppe Carlo Tettamanzi

Dr Erin Smith

Dr Rohan Glover

THE IPAS STUDENT EXPERIENCE

OUR GRADUATES HAVE GONE ON TO POSTDOCTORAL ROLES AT LEADING RESEARCH ORGANISATIONS WORLDWIDE

Study at IPAS

IPAS Honours, Masters and PhD opportunities are world-class and guided by research scientists who are global leaders in their field. As well as working on blue sky research, we also work in partnership with government and industry on projects aimed at delivering real-world outcomes e.g. new products and starting new technology companies. Our graduates have gone on to postdoctoral roles at leading research organisations worldwide, while others have started up companies based on their research or have secured employment with industry partners or defence organisations (including Trajan Scientific and Medical, Ellex, Schlumberger, BAE Systems, Australian Bureau of Statistics, Maptek, Coherent, Lastek, the Defence Science and Technology Group and the Australian Antarctic Division).

IPAS Science Network

The Science Network has been created to strengthen the bond between science disciplines of the University and bring together members and non-members of IPAS for networking events and professional development activities. The IPAS Science Network represents the needs of the students and ECRs within IPAS, with the added focus of supporting students in all aspects of their postgraduate experience. The co-Chairs of the Science Network sit on the IPAS Scientific Leadership and Executive Committees.

IPAS SCIENCE NETWORK COMMITTEE

Dr Erin Smith
Co-chair

Dr Rohan Glover
Co-chair

Dr Ruth Shaw

Dr Erik Schartner

Dr Jiawen Li

Dr Sarah Scholten

Dr Stephen Warren-Smith

Dr Tom Avery

Rebecca Frkic

Craig Ingram

Elodie Janvier

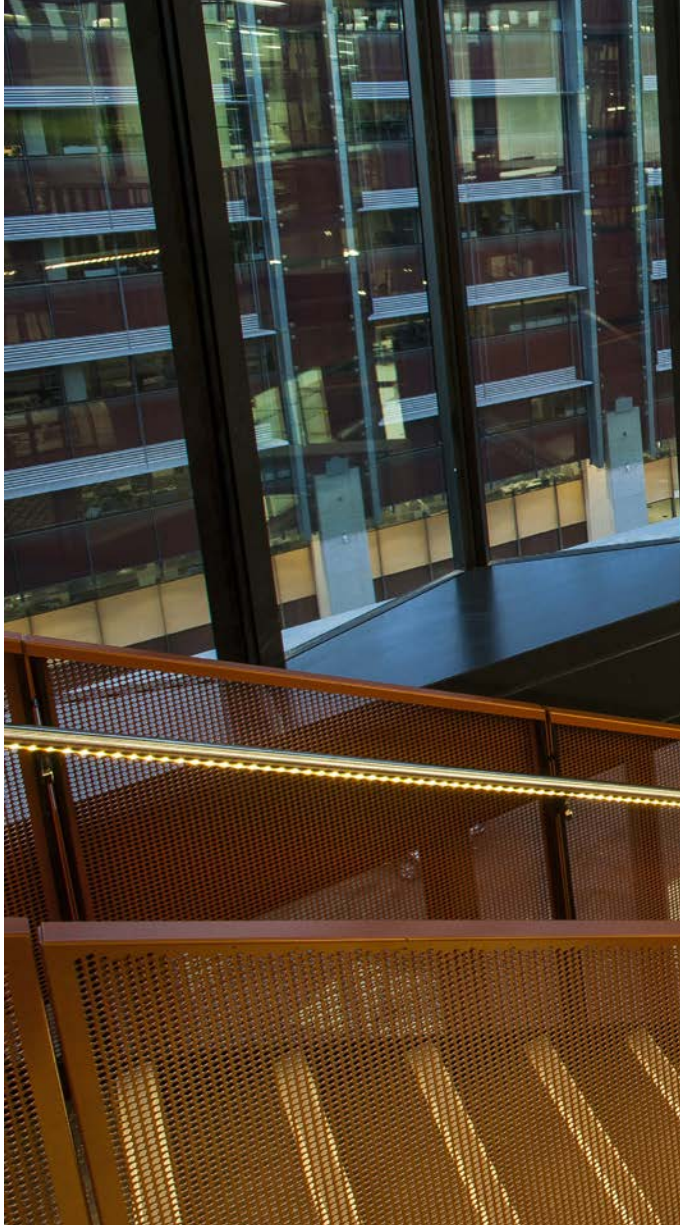
Thanh Nguyen

STUDENT PRIZES

Students were invited to present their 2019 research in a three-minute talk. The Tanya Monro best presentation prize and the Merry Wickes sponsored transdisciplinary prize were on offer.

The winners were announced at the IPAS annual New Year event. We would like to thank Merry Wickes for her ongoing support of the transdisciplinary prize.

- Mr Patrick Capon, PhD student - Tanya Monro Best Student Oral Presentation Prize
- Mr Faisal Karim, PhD student - Merry Wickes Transdisciplinary Oral Presentation Prize



Mr Patrick Capon, PhD student

Surface functionalisation is the process of attaching molecules, such as fluorescent sensors, onto material surfaces to create sensing devices. This is the focus of my PhD work, with Prof. Andrew Abell and Dr. Malcolm Purdey, which allows us to merge the advantages of fluorescent sensors (high specificity and sensitivity) with the inherent advantages of the material (highly localised). For example, optical fibres are excellent tools for delivering light to otherwise hard to reach places. Our approach uses mild peptide-based chemistry, with a modular approach which means we can rapidly translate it to detect many different analytes. Recently I have been investigating the direct attachment of a pH sensor onto optical fibres using silk. pH is an important factor in determining embryo viability, which is critical to increase pregnancy success rates in the IVF clinic.

My projects in IPAS are highly cross-disciplinary, and collaboration is critical. On a day to day basis we are constantly exposed to research outside our specialist fields, which I believe makes everyone a better scientist. It also means we must communicate our science effectively, and we receive numerous opportunities to do so within the Institute. The positive and collaborative working environment is definitely a major component of the research excellence consistently delivered by IPAS.

Mr Patrick Capon, recipient of the Tanya Monro Best Student Oral Presentation Prize

Mr Faisal Karim, recipient of the Merry Wickes Transdisciplinary Oral Presentation Prize

Mr Faisal Karim, PhD student

My project, under the supervision of Prof. Andre Luiten and Drs. Chris Perrella and Sarah Scholten, focuses on extraction of gas thermodynamic properties including temperature, pressure and concentration with high accuracy and precision, all from a single spectroscopic measurement. My method is based on an ultra-high-resolution spectroscopic technique that utilises an optical frequency comb (OFC), a broadband source that emits hundreds of thousands of laser-like frequencies in a single beam of light. This allows us to study complex molecular spectra and perform a complete thermodynamic and compositional characterization of a gas mixture, desired by many applications including for the diagnoses of: human breath analysis for underlying medical conditions, oil and gas industries to prevent pipeline blockages caused by the contaminants, and environmental monitoring of the greenhouse gases.

IPAS has a great research environment where peers and mentors have diverse research backgrounds and are leaders of their respective fields. This is particularly useful in solving problems efficiently as well as helps in generating new and exciting ideas leading to innovation and excellence in research. IPAS provides a number of opportunities to communicate our research to a variety of audiences, which brings out the best of ourselves as balanced researchers and promotes quality research and trans-disciplinary collaboration.

OPTOFAB – FACILITIES AT IPAS

Optofab – Facilities in Adelaide

Optofab – Facilities in Adelaide specialises in optical fibre, glass and functional optical materials production. The range of key services offered include:

- Soft glass fabrication
- Soft and hard glass and polymer preform extrusion
- Doped silica preform fabrication
- Soft glass fibre drawing, including microstructured fibres
- Silica fibre drawing, including microstructured fibres
- Surface functionalisation of glasses and fibres
- Scanning Near Field and Atomic Force Microscopy (SNOM/AFM)
- DMG DMU-20 Linear Ultrasonic, 5-axis milling machine with ultrasonic milling capability for machining of glass, ceramics and metals
- 3D printing – metals and ceramics

5-Axis Ultrasonic Mill

New high-tech materials and the higher demands being placed on surface quality and precision have made the utilisation of new manufacturing technologies and machining methods indispensable.

DMU-20 Linear Ultrasonic Mill offers the perfect solution by combining precision and versatility at a level of efficiency that was inconceivable only a few years ago. Specialised machining requirements are now available for soft, hard and advanced high-performance materials, which have been traditionally difficult to machine.

3D Metal and Ceramic Printer

3D printing facilitates rapid prototyping and manufacturing, allowing for the fast availability of functional prototypes for product development, as well as on demand manufacturing for research and industrial requirements. 3D printing complements traditional development and manufacturing methods, reducing the time and cost of designing metal or ceramic parts by printing them directly from digital input. In September 2014, IPAS commissioned a 3D Systems ProX 200 selective laser melting printer, and made it available to both researchers and industry for their 3D printing requirements. In October 2019, the University and Amaero International Limited signed a Strategic Partnership Agreement, making available three state of the art Renishaw AM 400 3D printing machines located at Amaero's Adelaide facilities, available to IPAS researchers and clients.

Accessing the Facilities

The ANFF seeks to enhance national and international collaborations and enable world-class research by providing access to specialised facilities. Direct access to instrumentation is provided at an hourly rate or via a Fee-for-Service basis. Research Collaborations, Contract R&D and Consulting are also welcomed. Dedicated staff are on hand to discuss your requirements and assist accessing these leading-edge research capabilities.

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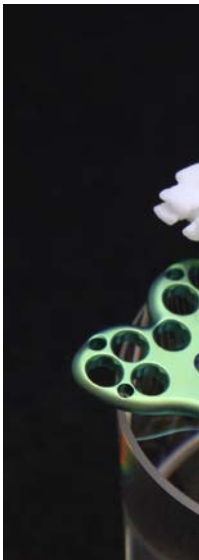
Optofab ANFF



IPAS RESEARCH FACILITIES

The Braggs is a unique transdisciplinary building that enables the co-location of IPAS researchers and students from a broad range of scientific disciplines and facilities including:

- Precision measurement of time, temperature and frequency
- Photonic sensor development
- Advanced manufacturing including 3D ceramic and metal printing (ANFF Optofab)
- Glass and optical fibre development and processing
- Laser development
- Luminescence dating and radiation measurement
- Synthetic and surface chemistry.

The Braggs is an accelerator facility, designed to speed up the pace of research by bringing together all the people working in these disparate disciplines and providing them with facilities required to progress further than would be possible in a traditional physics or chemistry lab. For example, we now have the ability to bring clinical samples into the laboratories to test them using new measurement tools developed within our labs, a critical enabler for our new ARC Centre of Excellence for Nanoscale BioPhotonics.

Other world-class research facilities underpinning the vital research conducted by IPAS members include:

- The Adelaide Proteomics Centre
- The STARR Lab (Reproductive BioPhotonics)
- Atmospheric Physics – Buckland Park
- Advanced LIGO and the Gingin Facility
- Bragg X-ray Crystallography Facility

These facilities service the needs of IPAS researchers and offer contract services to researchers and companies across the world.

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STRATEGIC PARTNERS

TRAJAN SCIENTIFIC AND MEDICAL

Trajan's strategic collaboration with IPAS, supported by the South Australian Government, sees the realisation of a research and development and manufacturing hub, based on a new generation of specialty glass products for the global science and medical equipment market.

Innovations in optical material components are in great demand for Mass Spectrometry (MS) analysis, technology that is used to identify specific compounds in samples, whether it be fresh food, river water or human blood. The field of MS has expanded significantly over the past decade, in part due to the translation of the technique from the traditional chemistry laboratory, into life science and clinical settings. Improved MS will underpin progress in medical diagnostic and disease research, resulting in more rapid and accurate diagnoses.

Trajan's goal is for their new business unit – "Instruments, Sensors and Devices", based in The Braggs, to become a global centre of excellence for speciality glass, sensing and medical device technologies.

The hub will also help IPAS researchers commercialise their research into products that ultimately benefit human health and wellbeing.

IPAS Deputy Director, Prof Heike Ebendorff-Heidepriem, leads the collaboration and is working closely with Dr Anne Collins, Trajan's General Manager - Instruments, Sensors and Devices.

Trajan's General Manager - Instruments, Sensors and Devices, Dr Anne Collins.

Trajan's Principal Scientist - Photonics, Dr Herbert Foo.

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TRAJAN

HIPS

THE SILANNA GROUP

IPAS, along with the Faculties of ECMS and Science, has partnered with global technology powerhouse Silanna Group and the South Australian government to set up a "picoFAB" lab at the University. The picoFAB allows a designer to engineer new semiconductor materials at the level of individual atoms.

The Silanna Group was founded in 2006 and is Australia's only semiconductor design and manufacturing company. With its head office in Brisbane and additional operational, manufacturing and design centres in Sydney, USA, UK and Singapore, Silanna supplies high-technology microelectronic chips to the global communications, space, defence and medical markets. The company's silicon-on-sapphire radio-frequency antenna switch, for example, is used extensively in smart phones and space satellites, as well as in NASA's Mars rovers.

The picoFAB has been collaboratively designed by Silanna and the University of Adelaide. At its heart is a remarkable piece of technology: a molecular beam epitaxy (MBE) semiconductor manufacturing tool. Custom-built by Veeco Instruments, this cutting-edge tool consists of three ultra-high-vacuum deposition chambers, each designed to grow crystalline materials at the quantum scale.

Located at the University of Adelaide's main North Terrace campus, the picoFAB brings world-leading capability to South Australia, not least to the Quantum- materials, sensing and communication research at IPAS, enabling precise engineering of new semiconducting crystal structures for use in the commercialisation of new and innovative semiconductor devices.

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Chief Scientist of the Silanna Group, Dr Petar Atanackovic, in the picoFAB facility at the University of Adelaide.

Silanna

OUR PARTNERS

HOW WE CAN HELP

At IPAS we're striving to establish our institute as a thriving research-and-development hub for the local and broader photonics industry, and all who benefit from it. In doing so we seek to enhance our State's -and Nation's- advanced manufacturing capabilities and global competitiveness, and create significant employment opportunities.

As part of this mission, we would be delighted to apply our capabilities in support of your own business' or organisation's goals. Partnering with IPAS will give you access to the world-class expertise and state-of-the-art facilities required to elevate your research and development to the next level.

So if you're ready to take that step, don't hesitate to contact us.

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SOUTH AUSTRALIA