Table of Contents

1 Executive Summary
2 IPAS Director’s Snapshot
3 Director’s Message
4 Chairman’s Report
5 2010 Highlights
6 IPAS Launch
7 illumin8 Project – IPAS new headquarters

9 IPAS Structures and Management
10 IPAS Structures
11 Mapping of IPAS SMC members to the IPAS Science Theme Areas
18 Industry links
19 DSTO Projects

20 Stakeholders and IPAS Facilities
21 Silica Fibre Fabrication Facility
22 Buckland Park Facility
23 LIGO Development and the Gingin Facility
24 The University of Adelaide OptoFab Node
26 PSRF Projects – State Support
27 IPAS Global Linkages

28 IPAS Research
29 Research Overview
30 Research Theme 1: Optical Materials & Structures
32 Research Theme 2: Lasers & Nonlinear Optics
34 Research Theme 3: Remote Sensing
36 Research Theme 4: Chemical & Radiation Sensing
38 Research Theme 5: Surface Science & Synthetic Chemistry
40 Research Theme 6: Medical Diagnostics & Biological Sensing

42 IPAS Members and 2010 Outputs
43 IPAS Members
50 Research Team Growth
51 2010 Conference
53 2010 Publications
IPAS exists to deliver breakthrough science, drive innovation and thus enable illuminated decision making for a safer, healthier and wealthier world.
Executive Summary

IPAS Structures and Management

Stakeholders and IPAS Facilities

IPAS Research

IPAS Members and 2010 Outputs

We are developing novel photonic, sensing and measurement technologies.

IPAS Director’s Snapshot

The Institute for Photonics & Advanced Sensing (IPAS) is one of five world-leading research institutes at The University of Adelaide. These institutes are central to the University’s strategy of supporting areas of recognised research excellence within the University and creating the research capacity required to tackle the major research challenges facing Australia and the world.

Many of the best opportunities for scientific breakthroughs over the next few decades sit between the conventional scientific disciplines. Similarly, pressing problems in health, the environment and national security require the fusion of technologies and approaches from many areas of science.

IPAS has been created to bring together physicists, chemists and biologists to pursue a transdisciplinary approach to science. We are developing novel photonic, sensing and measurement technologies that will create new tools for scientific research, stimulate the creation of new industries, and inspire a new generation to engage in science and technology. IPAS is supported by modern infrastructure and an innovation culture, and we work in partnership with government and industry on projects aimed at delivering real-world outcomes.

IPAS is working on a range of scientific challenges and future technologies via our six Research Themes:

- **Optical Materials & Structures** – that enable the creation of optical devices with enhanced properties, with a particular focus on the development of new optical glasses for photonic applications, including mid-infrared transmission, new laser materials and nanoparticulate enriched materials.
- **Lasers & Nonlinear Optics** – including research on new types of lasers, including fibre lasers, for medicine, defence and precision measurement, including the detection of gravitational waves.
- **Surface Science & Synthetic Chemistry** – modifying and controlling the functionality of surfaces, particularly glass surfaces, and new approaches to synthesising chemicals to support the development of novel chemical and biological sensors.
- **Chemical & Radiation Sensing** – new platform technologies for detecting chemicals and radiation, including optical fibre sensors, luminescence sensing for trace material detection, environmental and medical dosimetry.
- **Medical Diagnostics & Biological Sensing** – harnessing photonics, proteomics and DNA technologies to create rapid photonics-based approaches for improved tools for medical diagnostics, forensic science and environmental impact assessments.
- **Remote Sensing** – including high energy astrophysics and new laser-based tools for monitoring the atmosphere including wind profiling and green house gas emission.

The Australian Federal Government, South Australian State Government, DSTO, Defence SA and The University of Adelaide have invested over $40M to construct a headquarters for IPAS, which will house a unique suite of transdisciplinary laboratories. These facilities include glass development and processing, optical fibre fabrication, laser and device development, luminescence dating, environmental genomics, photonic sensor development, and synthetic, surface and bio-chemistry laboratories in addition to offices to co-locate IPAS researchers and students from across our broad range of scientific disciplines. This will all be located in the University’s new illumin8 building, which is due for completion by early 2013.

IPAS has had significant funding activity and success in 2010 with grants valued at over $22.5M submitted by IPAS members. A total of $7.3M was secured including six ARC Super Science Fellowship positions and NCRIS infrastructure funding, ARC Discovery, Linkage and LIEF grants and NHMRC project grants. The pipeline of future projects and grant submissions is looking strong and bodes well for the future. The total research funding expended on IPAS research projects in 2010 was $6.25M.

Professor Tanya Monro
Director’s Message from Professor Tanya Monro

IPAS is now just over one year old, and it is very exciting for me to be able to share our vision and achievements so far in this, our first annual report.

Since our launch in late 2009 our research programs, infrastructure, collaborations, outcomes and engagement activities have grown substantially. IPAS now has 140 members, twice the number we had at the date of our launch. This growth has been achieved through IPAS success in attracting research funding allowing us to recruit new researchers and also by the growing engagement of researchers from cognate disciplines from across the University in the Institute’s activities.

Our research programs span from novel optical materials, new types of lasers and new architectures for sensing using light to water quality monitoring and creating point of decision medical diagnostic technologies. We engage in big science experiments and collaborations, including work on new ultra-stable lasers for gravitational wave detection and on the development of measurement tools that will enable us to look at the very earliest stages of life by monitoring developing embryos.

A transdisciplinary approach to science such as ours is risky and requires courage. Many of our current systems for research funding and assessment are geared to encourage a monodisciplinary approach to science, and this works well for fields where advances require a narrowness of focus.

Despite this, the riches promised by the transdisciplinary approach are great. In addition to rich seams of untapped knowledge between the traditional disciplines, the technological problems we face as a society do not respect discipline boundaries.

We are developing technologies in four key market areas; defence & national security, environmental monitoring, preventative health and food & wine.

But IPAS is not just about driving forward new devices and technologies. We are also actively pursuing strong fundamental blue sky programs in our core areas of research excellence, because it isn’t possible to know where the next big technologies are going to come from.

I am very proud to be able to share with you the strong outcomes emerging from IPAS in this report. Imagine what we will be able to achieve when we have our new headquarters, the illumin8 building. We have a tremendously exciting journey ahead of us, and I would like to thank all our members, collaborators and stakeholders for their ongoing support and engagement.

We are already starting to achieve outcomes that would not have been possible without the University’s faith in our vision for transdisciplinary research, or without the Federal and State Government’s support for our research and investment in our building program.

What is Transdisciplinary Science?

A transdisciplinary approach brings discipline specialists together to work side by side with the common purpose of evolving new research methodologies and frameworks that span the traditional discipline boundaries and drive innovation. In this way disciplinary depth and expertise nourishes transdisciplinary problem solving and leads to the effective translation of methodologies between areas.

IPAS works to blend the disciplinary expertise that drives forward knowledge in our core areas of strength, particularly optical physics, surface science and molecular biology, with teams and projects operating at the boundaries between these areas. These interface areas provide rich opportunities for new knowledge and allow us to advance solutions for a diverse range of real-world problems.
Chairman’s Report

I am delighted to be writing to you as Inaugural Board Chair of IPAS to highlight the many achievements since the IPAS launch in November 2009 at the RiAus.

The Institute is changing the way science is done by bringing together scientists of different disciplines to solve real-world problems in collaboration with professionals from leading market areas and industries.

At our launch we highlighted four early stage projects. These ranged from a smart bung technology for improving wine production to new medical diagnostic technologies to help control flu epidemics. I’m pleased to report that these projects have all received significant funding over the last year from a range of sources including traditional research funding bodies, Government departments, commercial accelerator schemes and industry. Significant intellectual property has been developed and IPAS is actively seeking partnerships to help us bring these technologies to market. The Institute is demonstrating its vision and we look forward to seeing how these important new technologies will progress to market over the coming years.

DSTO continues to provide significant support for a range of Defence-related projects and I would like to thank DSTO for their ongoing support. The South Australian State Government has also been instrumental in our success through their continued support, and I acknowledge and thank them.

The IPAS Board met three times in 2010 and there were numerous one-on-one meetings with Board members and IPAS Director Professor Tanya Monro to pursue initiatives.

This year the IPAS Board has focused on establishing the governance structures and developing the strategic plan to drive future outcomes. This plan has five key drivers:

<table>
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<tr>
<th>Research Impact</th>
<th>Excellence and impact in research</th>
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<tbody>
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<td>Effective Teamwork</td>
<td>Inspired people working in effective teams</td>
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<tr>
<td>Global Reputation</td>
<td>Global research reputation and high quality communications</td>
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<tr>
<td>Adaptive systems</td>
<td>Adaptive, responsive internal business systems</td>
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<tr>
<td>Driving Commercialisation</td>
<td>Building partnerships to bring breakthroughs to market</td>
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This plan will empower IPAS to continue to grow from strength to strength as a global centre recognised for developing innovative light-based sensing technologies.

IPAS has had a very impressive first year of operations and the future looks very bright indeed. I would like to acknowledge and thank my fellow members of the Board of Governors, IPAS Director Professor Tanya Monro, IPAS Institute Manager Mr Piers Lincoln, and the researchers and staff for their invaluable contributions.

Joe Flynn
### 2010 Highlights

The year has seen many positive outcomes for IPAS including:

1. **Grants**: $7.3M grants won in 2010 and $22.7M applied for.
2. **Grant Pipeline**: We are awaiting decisions on over $16M of grants.
3. **illumin8 Project**: The 98% Design Development stage for illumin8 was reached in December 2010 – the projected completion date is early 2013.
4. **IPAS Silica Fibre Fabrication Facility**;
   - Stage 1 – Preform Facility: North Terrace Campus, Completed April 2010
   - Stage 2 – Fibre Drawing Facility: Thebarton Campus: Construction due for completion April 2011.
5. **IPAS Fibre Laser Laboratory**: Project completed enabling testing of fibre lasers from our Silica Fibre Fabrication Facility.
6. **Super Science Fellowships**: Appointments have been made for the 3 positions starting in 2010; dedicated PhD positions have been created to complement these projects.
7. **IPAS members**: IPAS has 140 research members.
9. **Luminescence research**: Professor Nigel Spooner has been seconded from DSTO for three years to lead this area of research and IPAS has invested in a new RISO reader.
10. **New Major Equipment Items**: New glovebox for glass research and development funded under an ARC LIEF grant, a high temperature glass extrusion facility and SNOM Microscope funded by the NCRIS / Super Science scheme.
11. **2010 IPAS Equipment Scheme**: Funding totalling $200k was allocated by the IPAS Science Management Committee on items including support for synthetic chemistry, laser sources, and materials characterisation equipment.
12. **Patents**: Three new patent applications have been filed.
13. **IPAS Student Committee**: An IPAS student committee has been established to ensure that the students have an active voice within IPAS.
14. **Outreach**: IPAS hosted a number of visits for high school students and several IPAS members have applied to the Scientists in Schools scheme.
15. **Scholarships**: IPAS funded 10 summer scholarships for 1st to 3rd year students.
16. **Art & Science**: A team of artists was selected to develop a public artwork in the Rundle Mall celebrating light and science. This project is called “Connecting with Light” and is a collaboration between IPAS and Adelaide City Council.

**Individual achievements:**
- Tanya Monro was voted South Australian Scientist of the Year for 2010; won the Telstra Business Woman of the Year Award in the Government and Community category; and was a finalist in the Eureka Prize for Scientific Leadership and the Scopus Young Researcher of the Year Award.
- Kristopher Rowland was awarded the Wanda Henry Prize for being the most outstanding student at the ACOFT Conference (Australian Conference on Optical Fibre Technology), December 2009.
- Stephen Warren-Smith was awarded the Australian Optical Society (AOS) Postgraduate Student Prize, December 2009.
IPAS Launch

IPAS members, key stakeholders and collaborators from around the world gathered to celebrate the IPAS launch event which was held on Friday 13th of November 2009 at the new RiAus Science Exchange Building in Adelaide.

His Excellency Rear Admiral Kevin Scarce AC CSC RANR Governor of South Australia and Professor James McWha Vice-Chancellor and President of the University of Adelaide joined Professor Tanya Monro to launch IPAS and share their vision for how this institute will be able to contribute to Australia’s future.

Professor Rob Morrison and Dr Deane Hutton, former presenters of the Curiosity Show, helped explain photonics to the audience of distinguished guests and researchers.
illumin8 Project
IPAS new headquarters

The Australian Federal Government, South Australian State Government, DSTO, Defence SA and The University of Adelaide have invested over $40M to construct a headquarters for IPAS, which will house a unique suite of transdisciplinary laboratories. These facilities include glass development and processing, optical fibre fabrication, laser and device development, luminescence dating, environmental genomics, photonic sensor development, and synthetic, surface and bio-chemistry laboratories and offices to co-locate IPAS researchers and students from a broad range of scientific disciplines. This will all be located in the University’s new illumin8 project, which is due for completion in early 2013.

The illumin8 project will also incorporate a 420-seat lecture theatre and other teaching and research facilities.
IPAS Structure and Management
**IPAS Structures**

IPAS is one of five University of Adelaide Research Institutes. The organisational chart below illustrates the governance structure for IPAS. Further details on IPAS key governance, scientific and operational committees are provided later in this report.
IPAS Board

IPAS has a Board with the skills to support IPAS in achieving its goals and oversee its activities.

The Board provides strategic advice on external linkages and opportunities and recommendations for shaping IPAS research capabilities.

This advisory board contains representatives from a broad range of sectors, including industry, defence, academia, education and government.

Mr Joe Flynn
IPAS Chairman
CEO, Water Industry Alliance

Mr Joe Flynn has an international infrastructure background with experience at MD and GM levels having run water and electricity utilities. Joe has led some of Australia’s largest infrastructure service businesses and chaired government-industry economic development initiatives. He is currently the CEO of the Water Industry Alliance.

Professor Mike Brooks
Deputy Vice-Chancellor and Vice-President (Research), The University of Adelaide

Professor Mike Brooks was appointed to the position of Deputy Vice-Chancellor and Vice-President (Research) at The University of Adelaide in 2008. He is a leading international researcher in computer vision and image analysis, with wide commercial success in the security and defence industries.

Professor Bob Hill
Executive Dean, Faculty of Sciences, The University of Adelaide

The University of Adelaide Professor Robert Hill is the Executive Dean, Faculty of Sciences at The University of Adelaide. He is a graduate of The University of Adelaide. During his career he has won many awards including the Clarke and Burbidge Medals for his research into the impact of long-term climate change on the evolution of Australian vegetation.

Professor Andrew Holmes
University Laureate Professor and CSIRO Fellow, The University of Melbourne

Professor Andrew Holmes is a distinguished researcher, focussing on applications of synthesis to problems in biology and materials science. He is presently a CSIRO Fellow at the Division of Molecular and Health Technologies, a University Laureate Professor at the University of Melbourne and Distinguished Research Investigator at Imperial College.
IPAS Board

Dr Warren Harch
Deputy Chief Defence Scientist (Information and Weapon Systems), DSTO

Dr Warren Harch is the Deputy Chief Defence Scientist (Information and Weapon Systems) at DSTO, supporting Australia’s current and future military capability and national security.

Dr Jurgen Michaelis
CEO, BioInnovation SA

Dr Jurgen Michaelis has more than 20 years’ experience as a senior executive in the international life science industry, having worked in Europe, Australia and New Zealand. He has raised more than $120 million in private equity and venture capital for biotechnology companies and has participated in the full life cycle of technology development and commercialisation.

Dr Neil Bryans
Executive Director, Counter Terrorism and Security Technology Centre, DSTO

Dr Neil Bryans has had an association with the University of South Australia’s Institute of Telecommunications Research and its predecessors dating back to the mid nineties. His interactions with the University have broadened to include assisting the University in a number of initiatives and strategies it has undertaken. Neil is currently the Executive Director of the Counter Terrorism and Security Technology Centre at DSTO, working previously as Deputy Chief Defence Scientist at DSTO.

Professor Tanya Monro
IPAS Institute Director

Professor Tanya Monro is an ARC Federation Fellow at the University of Adelaide. Tanya is a Fellow of the Australian Academy of Technological Sciences and Engineering (ATSE), a member of the Future Manufacturing Industry Innovation Council (FMIC), a member of the National Committee for Physics, a member of the SA Premier’s Science & Research Council and an inaugural Bragg Fellow of the Royal Institution of Australia. In 2010 she was named South Australian Scientist of the Year, and Telstra Business Woman of the Year at both National and State levels (in the Community & Government category).
IPAS Scientific Management Committee

This committee has been selected to span the six research themes within IPAS and its role is to:

- Grow research funding and capacity
- Define the research priorities of IPAS
- Define and focus resources on research strengths
- Create a visible front door for external engagement
- Advise on mechanisms to deliver on these priorities
- Support the Director by growing research and delivering the KPIs of the Institute
- Communicate IPAS strategies and initiatives to the broader IPAS community
- Engage their research teams with the activity of IPAS

Each of the six core Scientific Themes within IPAS has two Theme Leaders, and these theme leaders sit on the Scientific Management Committee (SMC).

Tanya Monro
Optical fibres, Theoretical and Experimental Photonics, Optical Sensors

Peter Hoffmann
Proteomics, Biomarker Discovery, Biological Sensors

Nigel Spooner
Luminescence, Radiation sensing, Optical Dating Technique Development

Andrew Abell
Surface Chemistry, Protein and Peptide Synthesis

Heike Ebendorff-Heidepriem
Glass science, Fibre Fabrication and Characterisation

Tanya Monro
Optical fibres, Theoretical and Experimental Photonics, Optical Sensors

Peter Hoffmann
Proteomics, Biomarker Discovery, Biological Sensors

Nigel Spooner
Luminescence, Radiation sensing, Optical Dating Technique Development

Andrew Abell
Surface Chemistry, Protein and Peptide Synthesis

Heike Ebendorff-Heidepriem
Glass science, Fibre Fabrication and Characterisation

Tanya Monro
Optical fibres, Theoretical and Experimental Photonics, Optical Sensors

Peter Hoffmann
Proteomics, Biomarker Discovery, Biological Sensors

Nigel Spooner
Luminescence, Radiation sensing, Optical Dating Technique Development

Andrew Abell
Surface Chemistry, Protein and Peptide Synthesis

Heike Ebendorff-Heidepriem
Glass science, Fibre Fabrication and Characterisation

Gavin Rowell
High Energy Astrophysics, Cosmic Ray Detection

Chris Sumby
Synthetic Chemistry, Functional Organic Materials, Analytical Chemistry

David Ottaway
Solid State Lasers, LIDAR Sensors, Gravitational Wave Detection

David Lancaster
Fibre Lasers, Silica Glass and Fibre Fabrication

Tilanka Munasinghe
IPAS Student Committee Chair
IPAS Science Themes and Theme Leaders

- **Optical Materials & Structures**
  - Heike Ebendorff-Heidepriem
  - Tanya Monro

- **Lasers & Nonlinear Optic**
  - David Ottaway
  - David Lancaster

- **Remote Sensing**
  - (including Astrophysics, LIGO, Lidar)
  - Gavin Rowell
  - David Ottaway

- **Medical Diagnostics & Bio Sensing**
  - Peter Hoffmann
  - Tanya Monro

- **Chemical & Radiation Sensing**
  - Nigel Spooner
  - Tanya Monro

- **Surface Science & Synthetic Chemistry**
  - Chris Sumby
  - Andrew Abell
The IPAS Senior Advisory Group advises the IPAS Director on the strategic and scientific directions for IPAS.

- **John Carver**: Protein Structure, Function and Interactions
- **Roger Clay**: Astronomy, Astrophysics, Palaeocology, Biogeography
- **Alan Cooper**: Ancient DNA, Palaeocology, Biogeography
- **TuckWeng Kok**: Virology, Biotechnology, Diagnostics
- **Shaun McColl**: Proteomics, Immunology, Chemokine Biology
- **Jesper Munch**: Solid State Lasers, Lidar Sensors, Gravitational Wave Detection
- **John Prescott**: Luminescence, Radiation Sensing
- **Iain Reid**: Atmospheric Physics, Atmospheric Radar
- **Bob Vincent**: Atmospheric Physics, Atmospheric Radar
IPAS Executive Committee

The IPAS Executive Committee is an operational management committee that meets fortnightly to address high-level operational issues at the juncture between Institute, School and Faculty activities. It comprises staff from IPAS, the Faculty of Sciences and the School of Chemistry & Physics.

Tanya Monro
IPAS Director

Derek Leinweber
Head of School, Chemistry & Physics

Carol Maelzer
Manager School of Chemistry & Physics

Raelene Wildy
Manager, Faculty of Sciences

Piers Lincoln
IPAS Institute Manager

Sara Boffa
IPAS Executive Assistant Senior Office Administrator
IPAS have six professional staff as well as the IPAS Director:

**Prof Tanya Monro**  
**IPAS Director**  
Responsible for providing leadership to the institute and driving the strategic direction of IPAS.

**Mr Piers Lincoln**  
**IPAS Manager**  
Responsible for helping to define the strategic direction of IPAS and ensuring the smooth operations of the Institute. Commercialisation activities within the institute.

**Mr Mark Saunders**  
**IPAS Grants Developer**  
Responsible for supporting the development of new grant applications with the research teams.

**Ms Ruth Shaw**  
**IPAS Commercial Development Manager**  
Responsible for development of contract research, confidentiality agreements and other commercialisation activities.

**Ms Sara Boffa**  
**IPAS Executive Assistant**  
Senior Administrative Officer  
High-level executive support to the Director of (IPAS) and financial management.

**Ms Olivia Towers**  
**IPAS Administration Officer**  
First point of contact for enquiries and provides administration support to the IPAS team including marketing support.

**Mr Jason Dancer**  
**IPAS Financial Accountant (Part Time)**  
Financial support and budgeting for the institute.
Industry links

IPAS engages with industry via consultancy, contract research, collaborative research and Federal Government grants such as industry-linkage schemes.

Commercial contracts with IPAS are handled by Adelaide Research and Innovation (ARI), who manage The University of Adelaide’s commercial research and consultancy partnerships, form new business ventures based on University expertise and develop the University’s innovative ideas and technologies with commercial potential.

IPAS welcomes interactions from potential collaborators in all scientific fields.

IPAS already collaborates with many commercial and development organisations including:

- AOFR Pty Ltd
- Asahi Glass, Japan
- BAE Systems Australia
- BHP Billiton
- Bruker Daltonics
- Cook Medical
- CPR Pharma Services Pty Ltd
- DSTO
- Diemould Tooling Services Pty Ltd
- Gallo Wines
- IMVS Pathology
- Micromet
- Nomacorc SA
- RISΦ, Denmark
- Schott Glass, Germany
- Tangent Technologies
- Task Exchange
- Treasury Wines Estates
- Yakumba Wines
The CoEP is a joint venture between The University of Adelaide and the Defence Science and Technology Organisation (DSTO) Australia, with strong support from the South Australian State Government.

The CoEP was originally formed to create an internationally leading research centre focused on the development of new classes of optical fibres and fibre devices at The University of Adelaide. The Centre now covers all optics and photonics activities at the University of interest to Defence including: fibre development, fibre lasers, transmission fibres, nonlinear fibres & devices, electro optic devices, free space laser development and atmospheric sensing.

The CoEP is supported by a Management Committee comprised of senior staff from DSTO and The University of Adelaide:
- Dr Warren Harch, (Deputy Chief Defence Scientist (DCDS), DSTO)
- Dr Jackie Craig (Chief, Electronic Warfare and Radar Division, DSTO)
- Dr Barnaby Smith (Head, Optoelectronics Hub, DSTO)
- Prof Robert Hill (Exec Dean of Science, UoA)
- Mr Paul Arthur (ARI, UoA)
- Prof Tanya Monro (Director, CoEP, UoA)

The aims of the CoEP are to:
- Undertake research programs spanning from conceptual & theoretical research, to materials & fabrication research, which culminate in experimental and device work.
- Establish research platforms with broad application potential.
- Build the research teams, facilities and infrastructure required to underpin these platforms.
- Facilitate engagement between DSTO and The University of Adelaide researchers.
- Foster a strong interdisciplinary approach to research and problem solving.

The CoEP has a complete suite of soft glass fabrication and experimental capabilities that are continually being enhanced and the complementary silica optical fibre component is scheduled to be fully functional in early 2011.

The agreement between DSTO and The University of Adelaide that forms the CoEP provides an efficient mechanism for DSTO to place projects (referred to as Tasks) with the University. Since 2005 fifteen projects have been managed under the agreement, as well as a number of postdoctoral fellowships. These projects have ranged from the development of corrosion monitoring sensors to new laser radar (LIDAR) systems. The new $4.5m silica fibre fabrication facility which was jointly conceived by Defence SA, DSTO and the University will be completed in early 2011 and will further strengthen these links. During 2010 IPAS has had eight active collaborative projects with DSTO.

DSTO Projects

The University of Adelaide and DSTO have enjoyed a long and successful relationship which was enhanced when Prof Tanya Monro was brought to Australia in early 2005 to be the inaugural DSTO funded Chair of Photonics and inaugural Director of the Centre of Expertise in Photonics (CoEP), which was officially launched in May 2006. The CoEP is a joint venture between The University of Adelaide and DSTO Australia, with strong support from the South Australian State Government.

The CoEP was originally formed to create an internationally leading research centre focused on the development of new classes of optical fibres and fibre devices at The University of Adelaide. The Centre now covers all optics and photonics activities at the University of interest to Defence including: fibre development, fibre lasers, transmission fibres, nonlinear fibres & devices, electro optic devices, free space laser development and atmospheric sensing.

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- Dr Barnaby Smith (Head, Optoelectronics Hub, DSTO)
- Prof Robert Hill (Exec Dean of Science, UoA)
- Mr Paul Arthur (ARI, UoA)
- Prof Tanya Monro (Director, CoEP, UoA)
Stakeholders and IPAS Facilities
Silica Fibre Fabrication Facility

The IPAS Silica Fibre Fabrication Facility is dedicated to the production of research grade silica fibres. We can design, develop and fabricate a wide range of specialised rare-earth doped and passive silica fibres for research purposes.

Facilities include: state of the art modified chemical vapour deposition equipment, ultrasonic drilling and milling of preforms, fibre drawing and characterisation equipment, as well as high power fibre laser test beds.

IPAS actively collaborates with academia, industry and government agencies to produce custom fibres for their research requirements.

Research Capability

- Active program in rare-earth doped silica fibre laser development for short infrared (1-2.1μm) lasers.
- Rare-earth doped fibres (Er, Yb, Tm, Ho, etc.) for laser and amplifier applications.
- Single-mode silica fibres.
- Double/triple clad fibres.
- Novel fibre designs.

An open access model:

- Fee-for-service, e.g. the production of specialty optical fibres.
- Direct access to instrumentation based on an hourly rate.
- Dedicated staff are on hand to provide services, training and technical support to users where appropriate.
- Contract R&D.
- Consultancy.
- Research collaborations.

We encourage you to contact us if you have a requirement for silica fibre fabrication.
Buckland Park Facility

IPAS researchers working in atmospheric physics and laser physics are setting up a new LIDAR facility at Buckland Park, 32km from the centre of Adelaide. The aim is to measure atmospheric temperature, wind and dynamical processes with high spatial and temporal resolution from 10 to 110 km altitudes.

Investigating the middle atmosphere by LIDAR is a well-established method and utilised at many sites around the world. However, these sites are predominately in the northern hemisphere and there are very few LIDAR stations in the southern hemisphere. In particular the southern sub-tropics are important as there is significant demand for measurement with high spatial and temporal resolution. This facility is the first of its kind in Australia and at a unique location in the southern hemisphere, 35° S 138° E.

In addition, IPAS researchers are developing a range of new advanced LIDAR technologies.

First stage:
- LIDAR building finished and power laser under development
- Implement all parts for LIDAR in building
- From 2010 on Rayleigh temperatures measured from 30 to 60 km altitude

Second stage from 2011 onwards:
- Power laser for resonance measurements
- Extend altitude range for Rayleigh measurements 15 to 80 km
- Combined Rayleigh and Resonance measurements
- Continuous observation from 15 to 100 km on a regular basis

Scientific aims:
- Study seasonal temperature structure at 36°S
- Study dynamical processes such as tidal, planetary and gravity waves
- Validate these local observations with Satellite and Model results
- Intercomparison of South-North hemisphere and along 36° longitude
LIGO Development and the Gingin Facility

The Laser Interferometer Gravitational-Wave Observatory (LIGO) is dedicated to the detection of cosmic gravitational waves and the measurement of these waves for scientific research. It consists of two widely separated installations within the United States, funded by the National Science Foundation (NSF) and operated in unison as a single observatory. This observatory is available for use by the world scientific community, and is a vital member in a developing global network of gravitational wave observatories.

IPAS researchers actively engage in LIGO and have worked in senior positions in the USA headquarters of the project. They have designed and developed a range of laser systems, architectures and components for LIGO. Current work includes the development of ultra-sensitive optical wavefront sensors for installation on the advanced LIGO detector.

“The LIGO Laboratory, California Institute of Technology”
The University of Adelaide OptoFab Node

Introduction

NCRIS (http://ncris.innovation.gov.au) is an Australian Federal Government program that has provided $542 million over 2005-2011 to provide researchers with major research facilities, support infrastructure and networks necessary for world-class research. In November 2006, funding for twelve priority NCRIS areas of investment was announced. One of these priority areas was Fabrication, and the Australian National Fabrication Facility (ANFF www.anff.org.au) was established to serve this priority area.

The ANFF OptoFab Node offers specialised services for the fabrication and micro processing of optical materials for researchers and industry. Applications of these materials include telecoms, biotechnology, biomedicine, microelectronics, optical sensing, industrial processing, defence and security.

The OptoFab Node incorporates facilities at Macquarie University, The University of Sydney (including Bandwidth Foundry International) and the Institute for Photonics & Advanced Sensing (IPAS) at The University of Adelaide. The services offered at IPAS include: fabrication of novel optical glasses, preform fabrication, soft glass and silica optical fibre fabrication and glass and device surface functionalisation.

The optical fibre manufacturing facilities at IPAS comprise state-of-the-art fabrication equipment, know-how and capability. IPAS brings together a rare combination of glass science, glass processing, fibre drawing facilities, research facilities and expertise. This has enabled the realisation of fibres with unique and novel properties, IPAS has expertise spanning the full spectrum of glass materials from silica glass to a diverse range of soft glasses. IPAS’ internationally leading team in soft glass extrusion have achievements to date which include the production of glass fibres with the broadest range of structures, unmatched anywhere else in the world.

Optical Fibre Manufacturing

Soft Glass Fibre Fabrication

IPAS’s soft glass fabrication facilities support the manufacture of a range of optical glasses including fluoride, tellurite and germanate compositions. These facilities include equipment for controlled batching, melting, casting and annealing, which in turn enables production of novel glass compositions, including undoped and doped glasses.

IPAS has pioneered methods for extruding glass to form structured preforms. These structured preforms can be produced using soft glass and polymer billets. These preforms are then drawn down in scale into optical fibres. Fibres can be produced as core-clad and microstructured fibres. A large range of custom, specialised and microstructured fibres can be produced; such microstructured fibres having hole sizes in the range of 20nm - 20µm, with almost arbitrary hole shapes and distributions.

Preforms can be made from in-house fabricated glasses and commercially sourced glasses, including: tellurite, bismuth, fluoride (ZBLAN), fluoride-phosphate (Schott: N-FKS, N-FKS1A), lead silicate (Schott: LLF1, F2, SF6, SF57) and chalcogenide glasses as well as polymers. The structures can include rods of 1 - 20mm diameter, tubes of 10–20mm outer diameter and 0.5–8mm inner diameter, wagon-wheel small-core fibre structures (also known as suspended core fibres), exposed core optical fibres, and arrays of 1–7 rings of air holes and spider-web like structures with large air filling fractions.

A 4m soft glass drawing tower is currently used to draw preforms of 8–15mm diameter and up to 180mm lengths into canes of silica glass to a diverse range of soft glasses. IPAS’ internationally leading team in soft glass extrusion have achievements to date which include the production of glass fibres with the broadest range of structures, unmatched anywhere else in the world.

In November 2006, funding for twelve priority NCRIS areas of investment was announced.
Silica Fibre Fabrication

The silica fabrication facility comprises silica preform production via MCVD, sonic milling and drilling equipment and preform characterisation instruments. The facility houses a 6-meter fibre drawing tower, and enables the drawing of silica fibres in the temperature range of 1800–2200°C.

Instrumentation available includes a Photon Kinetics 2600 preform analyser, allowing for the fully automated refractive index characterisation of optical fibre preforms.

Specific Capabilities

Production of Novel Optical Materials

- Formulating glass materials with novel optical properties (glass billets 100–300g)
- Design and fabrication of micro and nanostructured optical fibres
- Fabrication of Soft Glass and Silica fibres
- Advanced fibre drawing capabilities
- Mid-infrared, THz and nonlinear optical fibres

Surface Science

The production of specialised biological and chemical coatings, including polyelectrolyte and silane in order to realise sensors for specific chemicals and biomolecules.

Key Instrumentation

- Open air glass melting capability:
  - One melting furnace
  - Two annealing furnaces
- Controlled atmosphere glass melting capability:
  - 5-port controlled atmosphere glove box with integrated melting and annealing furnaces

- Glass Extruder:
  - Up to 100kN at up to 700°C
- 4 meter soft glass fibre drawing tower (900°C furnace):
  - Polymer coating unit
  - Unit to apply vacuum/pressure to preforms and canes
  - Fibre rewinder
- 6 meter silica fibre drawing tower (2200°C furnace)
- MCVD lathe
- Sonic mill/drill
- SNOM/AFM (collection and transmission mode, IR detector and in-built red laser)
- PK 2600 preform analyser
- PK 2200 optical fibre analysis system
- PK 2400 fibre geometry system
- Two microwave synthesisers (one with automated peptide synthesis)
- Optical microscopes
- Glass cutting, etching and polishing equipment

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PSRF Projects – State Support

IPAS has received significant support from the South Australian Premier’s Science and Research Fund (PSRF). Two strategically important projects worth a total of $2.5M that have been supported by this fund include:

1. High power fibre lasers for defence applications
   (July 2008 – June 2011)

   In collaboration with DSTO and BAE Systems Australia, the aim of this project is to create capability to enable SA to develop high power fibre lasers for use in a range of defence applications. This capability will allow investigation and production of materials, fibre design and laser architectures suitable for scaling to high power in infrared wavelengths. It will strengthen the SA Defence Photonics Cluster and the national focus on defence photonics in the defence industry and a continuation of excellence in education of students and future high-tech employees for SA in photonics engineering.

2. Sensing Technologies for Advanced Reproductive Research (STARR), announced 24 December 2010

   The STARR facility will be a state-of-the-art suite of equipment dedicated to the development of photonics-based reproductive health technologies. It aims to enable Australian reproductive health researchers and clinicians to lead in adopting emerging optical fibre-based technologies, and seed the development of new biotechnology innovations. The sensing platforms that are currently being developed will provide a richer understanding of the science of early embryo development as well as improved diagnostics endometriosis, reproductive cancers and infertility. This initiative brings together leading photonics and reproductive health researchers with medical instrument providers and clinicians to ensure that the technologies developed are suited for clinical uptake as well as the needs of researchers. The STARR lab is a collaboration between IPAS, The Robinson Institute, and our industry partners - Cook Medical, Reproductive Health Science Pty Ltd, Fertility SA and Flinders Reproductive Medicine.
IPAS Global Linkages

IPAS collaborates with academic teams across the world. We are always seeking complementary skills and teams in order to solve global research challenges.

In 2010 IPAS collaborated with researchers located in the following organisations:

**AUSTRALIA:**
- Australian National University, Australian Defence Force Academy, CSIRO, DSTO, Flinders University, Monash University, Macquarie University, SARDI, South Australian Government, South Australian Museum, Swinburne University, University of Melbourne, University of Queensland, University of South Australia, University of Sydney, University of Western Australia.

**USA:**
- CALTECH University, Clemson University, University of California, University of Central Florida, USA Air Force Research Labs.

**GERMANY:**
- Centre of biomaterial development, IPHT Jena, University of Erlangen-Nuremberg.

**ITALY:**
- University of Bari, University of Trento.

**JAPAN:**

**NEW ZEALAND:**
- Lincoln University, University of Auckland, University of Canterbury.
IPAS Research
Research Overview

IPAS research is organised into six major themes. These comprise:

Optical materials & structures

Our research focuses on developing new glasses with novel optical properties, fabricating micro and nanostructured soft glass optical fibres, developing novel silica and polymer fibres including the capacity for rare-earth and nanoparticle doping. We have a strong focus on developing glass and fibres capable of transmitting light in the mid-infrared and THz spectral regions. Our modeling capability allows us to develop new theoretical frameworks for understanding waveguides and fibres with extreme properties and nanoscale features.

Lasers & nonlinear optics

We research and develop novel free space, fibre and chip laser architectures operating at new wavelengths, regimes and high powers. The need for these is driven by applications in astronomy (guidestar), gravitational wave detection (LIGO), supercontinuum generation, defence applications and laser radar (LIDAR).

Surface science & synthetic chemistry

Our chemistry teams develop new novel biological and chemical surface coatings and surface functionality to enable the realisation of sensors for specific chemicals and biomolecules. There are research programs synthesising novel molecules for ion trapping and fluorescence-based sensing architectures. Other programs are developing new materials for catalysis and efficient storage of gases.

Chemical & radiation sensing

Using in-house and specialty optical fibre with unique surface coatings developed by our chemistry teams, we have research programs developing novel optical fibre based chemical sensors for water quality, corrosion sensing and environmental monitoring. We are also researching new fibre based radiation dosimetry sensors for medicine, industry and defence. Our Environmental Luminescence facility, which houses the most comprehensive collection of these systems in the world, develops new forensic luminescence techniques and provides a range of training and dating services to industry.

Medical diagnostics & biological sensing

We are developing new technologies in conjunction with clinicians and biologists, which push the boundaries of speed, sensitivity and sample volumes. We have produced optical fibre-based dip sensors capable of measuring chemicals and biomolecules in concentrations as low as <0.2nM and/or picolitre (pL) volume samples. Our novel Surface Plasmon Resonance systems are capable of label free diagnostics of pathogens and biomarkers.

Remote sensing

From the search for gravitational waves using ultra-precise lasers (LIGO), the development of LIDAR systems for measuring wind fields for wind farms, to pollutants at industrial sites and the detection of cosmic and gamma rays, the research teams within remote sensing develop, deploy and refine a range of photonic technologies for sensing at a distance.
Research Theme 1: Optical Materials & Structures

IPAS has facilities dedicated to the fabrication and characterisation of new forms of soft and silica glass and optical fibres.

Our Optical Materials & Structures research focuses on the development of new glasses with novel optical properties, advanced technologies for processing and shaping glass, the fabrication of micro and nanostructured soft glass optical fibres and the development of novel silica and polymer fibres, including the capacity for rare earth and nanoparticle doping. Key areas of strength include tellurite and fluoride glasses (both passive and active), and advanced preform technologies (both extrusion and MCVD based).

We have a strong focus on developing glasses and fibres capable of transmitting light in the mid-infrared that underpin new sensing platforms and lasers.

Our fabrication capabilities are complemented by our modelling research which focuses on predicting the optical properties of waveguides and fibres with micro and nanoscale structures. This includes new theoretical frameworks that enable us to explore waveguides and fibres with extreme properties and nanoscale features. IPAS has complete vertical integration of expertise and facilities from modelling to device fabrication.

Theme Leaders

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Prof Tanya Monro
Soft Glasses & Fibres
The activity on the fabrication and characterisation of novel soft glasses & fibres ranges from fundamental science to application driven design and development. IPAS boasts highly specialised glass fabrication and processing facilities - controlled atmosphere, large capacity, high-temperature glass batching, melting & annealing, high temperature preform extrusion and fibre drawing with a 4m tower.

IPAS’ characterisation facilities include state-of-the-art high resolution environmental electron and atomic force/scanning near-field optical microscopes (AFM/SNOM) as well as transmission spectrometers and ellipsometers spanning from the ultraviolet to the far-infrared spectral region (200nm-30µm).

This capability underpins many of our research programs from glass development to novel nanocomposite materials. The University of Adelaide is currently the only institution in the Australia that can fabricate soft glasses and produce optical fibres from in-house materials.

Optical Structure Modelling
Our Optical Structure Modelling researchers develop light propagation theory within our optical fibres and planar waveguides. The group works closely with Silica and Soft Glasses and Fibres groups, incorporating experimental evidence to feedback into our existing theories, driving the fabrication of new structures and underpinning the creation of new devices.

The group’s work has led to IPAS fabricating the first soft glass photonic band gap fibre and more recently extending the theories of light propagation using high index waveguides, terahertz (THz) fibres or ‘porous’ fibres, and microstructured optical fibres with nanoscale holes.

Silica Glasses & Fibres
IPAS Silica Glasses & Fibres research is dedicated to the production of research grade silica and silica fibres on a 6m fibre drawing tower. We design, develop and fabricate a wide range of specialty rare-earth doped and passive silica fibres, including single mode germano-silica and double/triple clad fibres.

We have state-of-the-art modified chemical vapour deposition (MCVD), ultrasonic milling, fibre drawing and characterisation equipment and several fibre laser test beds. We actively collaborate with academia and industry to produce custom fibres via research collaborations, contract R&D and consultancy.

ANFF Optofab Node Materials Facility
The glass and fibre fabrication facilities at IPAS bring together glass fibre and device development. Our capabilities have been recently been strengthened via investment from the LIEF and NCRIS/Super Science schemes. Through the ANFF Optofab Node we offer a range of services to external parties.

We are open to interaction with academia and industry and offer products and services in the form of contract R&D, consultancy and research collaborations. Examples of these products and services are:

- Supply of novel rare-earth doped soft glasses and microstructured optical fibres;
- Production of rare-earth doped silica preforms and fibres;
- Characterisation of glasses and fibres;
- Training and technical support where required;
- Direct access to instrumentation;
- Dedicated staff are on hand to provide services, training and technical support to users where appropriate.

Case Study: Nanodiamond-doped Glass & Fibres
Funded by the IPAS Pilot Project scheme, we have recently collaborated with The University of Melbourne to demonstrate the incorporation of nanoparticle diamond into tellurite glass. We have shown that this hybrid material can be made into optical fibres without destroying the unique characteristics of the diamond. The single photon emission properties of the nitrogen vacancy centre within the nanoparticle diamond survive, and are actually enhanced, by incorporating the diamond into the glass. This work has already led to publications in international journals including ‘Advanced Materials’. 
Research Theme 2: Lasers & Nonlinear Optics

IPAS’ Lasers and Nonlinear Optics research combines fundamental and applied physics to access new laser wavelengths through development of new laser architectures and nonlinear frequency conversion. We pride ourselves on our end-to-end laser development capability bridging laser glass R&D, optical fibre manufacture, and testing of new laser architectures.

We conduct research to develop fibre, solid-state, planar waveguide, supercontinuum lasers, and fibre-based nonlinear devices such as frequency converters and optical switches. Our specialties include the short to mid-infrared spectral regions; narrow linewidth; broadband and tunable lasers; and high power composite devices. Our research is underpinned by the development of a range of silica and soft glasses for fibre lasers, planar waveguide lasers, and fibre-based nonlinear devices.

Our research also has a strong emphasis on developing new laser and fibre architectures guided by commercial needs. Applications include atmospheric and coherent laser radars; gravitational wave detectors; spectroscopic sensors; surgery; and laser based electronic warfare systems.

Theme Leaders

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Fibre & Planar Waveguide Lasers
Our Fibre & Planar Waveguide Lasers research is focused on developing and optimising composite fibre and planar chip laser architectures using rare-earth doped short to mid-infrared transmitting glasses fabricated at IPAS (see case study below).

The fibre lasers we are developing operate at non-standard wavelengths, allowing new applications in molecular spectroscopy, remote sensing, surgery, and meet unique Defence needs in optical countermeasures and sensor testing.

The Silica & Soft Glass Laser Development Facility that supports this area has demonstrated internationally competitive fibre and waveguide laser performance.

Nonlinear Optics
Work within the area of nonlinear optics at IPAS focuses on nonlinear phenomena within optical fibres, which are based on the concept of controlling light with light. This area interacts with several other research areas in IPAS, especially fibre fabrication and the fibre laser laboratories within this theme.

In addition to our experimental expertise, we also specialise in modeling of nonlinear processes based on a new full vectorial theoretical framework. This is capable of describing nonlinear processes within all optical waveguides, including those with subwavelength dimensions and a high refractive index contrast that exhibit 'extreme nonlinearity'.

This work heralds several possible new applications and research opportunities.

Phenomena such as four wave mixing, supercontinuum generation and Kerr nonlinearity provide new solutions for high speed optical switches, new laser sources and new sensing architectures.

Solid State Lasers
Solid State Lasers research at IPAS specialises in developing low-noise and high-power lasers for targeted applications. These systems are generally used for ultra high precision measurements including spectroscopy and remote sensing.

This area represents over 60 years experience and know-how and the team have worked extensively on international projects such as LIGO, developed lasers for LIDAR and have interests in DIAL LIDAR applications. This has led to a world-leading reputation in cryogenic and compact eye-safe laser systems.

Silica & Soft Glass Laser Development Facilities
The ANFF Optofab node and Soft Glass & Silica Fibre Fabrication facility provides the in-house glasses which underpin many of our novel laser technologies.

Complementing this, our laser development and optics laboratories translate our fabricated glasses into new laser sources.

We collaborate extensively with Defence organisations; DSTO and BAE Systems Australia are two examples of our activity towards Defence applications.

The case study below describes how these facilities have enabled IPAS to produce world leading results in this area of research.

Case Study: Chip Laser Development
The direct laser writing of waveguides in glasses is an emerging technology that enables the rapid fabrication of 'close to' perfect beam quality and efficient lasers in bulk rare-earth doped glasses (effectively a CNC process that rapidly imprints or writes lasers into laser glass).

This work is based on our recent joint invention and demonstration with Macquarie University of a new highly efficient and flexible waveguide laser architecture. New direct-write fabrication regimes have been pioneered, and fabrication of the rare-earth doped glasses required for device development is routine.

We have recently achieved the highest power in a glass waveguide laser, and reported world record slope efficiency (~50%) in the short infrared region using our thulium doped fluoride glass laser operating near 1.9µm. By changing the laser dopant to holmium we have demonstrated its flexibility to produce other laser wavelengths, and our device focus is now to demonstrate low-cost manufacture of a versatile laser device that will potentially enable many new commercial and Defence applications.
Research Theme 3: Remote Sensing

Remote Sensing research at IPAS includes the search for gravitational waves using ultra-precise lasers (LIGO), the development of LIDAR systems for measuring wind fields for wind farms, pollutant monitoring (SOx, NOx, dust) at industrial sites and high energy astrophysics research on the detection of cosmic and gamma rays.

The team has a wealth of experience in developing technologies that underpin remote sensing devices and specialises in refining and deploying high precision photonic technologies for sensing at a distance.

IPAS contributes to and actively engages with several international research projects in this theme, including the Laser Interferometer Gravitational Wave Observatory (LIGO) and the High Energy Stereoscopic System (HESS).

Our extensive facilities, including laser & detector development laboratories and optical detection systems are situated on The University of Adelaide campus or at our Buckland Park Field Station & Observatory.

Theme Leaders

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Light Detection & Ranging (LIDAR)
The Light Detection & Ranging (LIDAR) researchers are developing coherent laser radar (CLR) systems for a range of eyesafe LIDAR applications. Current interests include monitoring dust and pollution surrounding mining and industrial sites, mapping wind speeds for wind farm site assessment and turbine protection, and turbulence detection for aerospace applications.

We are also developing differential absorption LIDAR (DIAL) to remotely sense specific compounds in the atmosphere. Water vapour sensing has been demonstrated, and NOx, SOx and CH4 detection is also an active research interest.

Gravitational Wave Detection (LIGO)
IPAS has strong links to the global LIGO project. IPAS researchers have worked in senior positions in the LIGO project, including Head of the LIGO advanced system test-bed interferometer (LASTI).

We have designed and developed a range of laser systems, architectures, and components for the LIGO project. We are currently developing ultra-sensitive optical wave-front sensors for installation on the advanced LIGO detector.

High Energy Astrophysics
Using high energy cosmic messengers such as gamma and cosmic rays to study the universe is a particular focus of the High Energy Astrophysics activity. This work is motivated by the search for the origin of high energy particles in the universe and how they can be accelerated by extreme astrophysical systems.

Advanced visible to UV detectors are used to detect the passage of high energy particles travelling through the Earth's atmosphere. These detectors use advanced techniques to filter the particles' light from the atmospheric background and require a detailed knowledge of atmospheric transmission conditions.

Current projects include the design of multi-Teraelectronvolt gamma ray telescopes and ultra high energy cosmic ray detectors.

Buckland Park Field Station & Observatory
The Buckland Park Field Station & Observatory facility occupies an 80ha coastal site approximately 40km north of Adelaide. The site boasts an array of equipment dedicated to studying the atmosphere, including radars (MF, VHF & VHF BL), a radio acoustic sounding system (RASS) and a 3-field photometer.

Recently this facility has been extended to include LIDAR capability, which permits measurements of atmospheric temperature, wind velocity and dynamical other processes with high spatial and temporal resolution at altitudes between 10km and 105km. Combined with the co-located radar and passive optical systems, the Buckland Park Field facility delivers a unique atmospheric measurement capability extending from the troposphere up to the lower thermosphere.

Case Study: LIDAR Detection
In collaboration with DSTO, we are developing light detection and ranging LIDAR systems to measure water vapour up to about 12km height. The aims of this work is to gain an understanding of the variability of water vapour, and of the extinction of transmitted radiation due to liquid water, ice and aerosols.

Our previous work in this area includes the demonstration of a system capable of measuring water mixing ratios that correlate very accurately to the Bureau of Meteorology radiosondes up to a height of 700m. We are now extending the range of our system, as well as developing a Rayleigh LIDAR, adding two Raman channels, in which light that is wavelength shifted through Raman scattering by water and by nitrogen molecules is detected.
Research Theme 4: Chemical & Radiation Sensing

Using in-house and specialty optical fibre with unique surface coatings developed by our chemistry team, we have research programs developing novel optical fibre based chemical sensors. We are using these sensors for monitoring: water quality, corrosion, wine maturation, embryo development, soil nutrients and fuel degradation.

We are also researching new fibre based radiation dosimeters for medicine, industry and Defence.

The IPAS Environmental Luminescence facility is home to the most comprehensive suite of luminescence research equipment anywhere in the world. Using this capability we develop new forensic luminescence techniques and provide a wide range of training and archaeological dating services to industry.

Theme Leaders

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Prof Nigel Spooner
Optical Dating & Environmental Dosimetry

Our Optical Dating & Environmental Dosimetry researchers specialise in the physics of luminescence, particularly of minerals and artificial building materials. This has led to the advancement of luminescence techniques for forensic dosimetry, dose reconstruction following radiological incidents, and the application of thermoluminescence (TL) and optical dating to a diverse range of questions in archaeology, geomorphology and palaeohydrology. This includes the dating of ancient ceramics, megafaunal extinctions, and human migrations across Australia (publications in Science and Nature).

Environmental Luminescence facility

The radiation sensing and optical dating work described above takes place in our Environmental Luminescence facility. The facility is unsurpassed globally in terms of luminescence research and dating capabilities and equipment.

The apparatus suite includes the world’s most sensitive TL spectrometer, a photon-counting imaging system (PCIS) developed in collaboration with ANU, and state-of-the-art TL/OSL Risø readers. In addition, we have specialised TL apparatus for the measurement of luminescence kinetics, and a single-aliquot low-light level detection chamber for characterising signal stability. Luminescence techniques are highly versatile, being able to accurately measure ages of up to 500,000 years before present, down to doses as low as a fraction of one day’s background radiation.

We undertake fundamental research to advance these techniques and further extend the applicability of luminescence analysis. We also provide training and contract research and dating services to industry, Defence and academia.

Chemical Sensing

Chemical Sensing research at IPAS focuses on a range of applications, including corrosion sensing, wine monitoring, embryo monitoring and soil & water quality monitoring. We are developing new ways to target analytes such as aluminium ions (Al³⁺), free SO² and hydrogen peroxide (H₂O₂) on a suite of platforms including dip sensors, distributed sensors and exposed core fibre sensors. Working closely with our Optical Materials & Surface Functionalisation researchers, we are developing new techniques with irrigation companies, Defence organisations, embryologists and oenologists.

Our new biophotonics facility at the University’s Medical School, the STARR laboratory, allows us to perform novel biomedical research which we were unable to do within our existing photonics laboratories.

Radiation Sensing

The Radiation Sensing work at IPAS focuses on the development of new radiation dosimetry techniques for both fundamental research and applications for health, Defence and industry. Protection from harmful radiation is a key area of our work, particularly towards the improvement of cancer treatment safety. This includes the development of a dosimeter that uses optically stimulated luminescence (OSL) to sense radiation. This novel approach involves an optical fibre capable of producing OSL intrinsically, meaning the optical fibre becomes the active sensing material.
Research Theme 5: Surface Science & Synthetic Chemistry

Our chemistry teams develop novel chemical surface coatings and surface functionalisation strategies to enable the realisation of sensors for specific chemicals and biomolecules. This includes the synthesis of novel compounds for ion trapping and fluorescence based sensing architectures.

Other programs focus on the study of electron transfer within surface bound peptides, and the development of new materials for catalysis and efficient separation of gases essential for renewable energy and environmental applications.

Our researchers in this space include ARC Future and Super Science Fellows. This expertise spans from fundamental chemistry to analyte-specific sensor development, highlighting this as an identified strength of IPAS.

Theme Leaders

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### Executive Summary

Using Marcus Theory. This research provides invaluable information and understanding on the exact nature of charge transfer occurring in biological processes and moves us closer to the realisation of peptides and protein-based electronics.

### IPAS Structures and Management

The Biological & Chemical Surface Functionalisation work at IPAS combines organic synthesis, supramolecular chemistry and surface science to functionalise the surface of a glass optical fibre or waveguide, enabling the detection of specific chemicals and biomolecules. Where conformation control of the sensing molecule is required, we attach peptide-based ionophores that contain an appended fluorophore and a light dependent actuator to a surface. This construct is then able to bind, sense, and release specific ions.

Ionophores, actuators, fluorophores and other molecular tools are designed and synthesised in-house. These are tailored to the requirements of the sensor being developed and the analyte under detection.

### Novel Materials Synthesis

Our Novel Materials Synthesis group design and synthesise supramolecular structures and nanostructured materials. Some of these compounds display novel interactions which we then exploit to develop sensors. Research is focussed on the design and construction of these new materials, including molecular assemblies and solid-state materials, which can be utilised as the next generation of functional materials, such as porous materials, catalysts, molecular devices and sensors.

### Functional Organic Materials

IPAS researchers working on groundbreaking research in the area of Functional Organic Materials are developing the chemistry of ‘networked polymers’. This emerging field has tremendous potential for new, more efficient catalysis platforms, sensing, storage and separation solutions. Specifically, the group are developing covalent organic frameworks (COF) that are synthesised from high symmetry building blocks, linked via strong, irreversible covalent bonds, to give open 3D extended polymer materials.

### Charge Transfer & Bioelectronics

Our Charge Transfer & Bioelectronics work concerns the design and synthesis of peptides with specific secondary structures, whose electronic properties we then evaluate using both theoretical and experimental strategies. Experimental work includes the investigation of charge transfer mechanisms through surface attachment approaches, while computational techniques provide theoretical rationalisation of experimental results using Marcus Theory. This research provides invaluable information and understanding on the exact nature of charge transfer occurring in biological processes and moves us closer to the realisation of peptides and protein-based electronics.

### IPAS Large Scale Facilities

The Bragg X-ray Crystallography facility (predominately ARC LIEF funded) provides IPAS with extensive molecular and crystal structure determination capabilities, including high throughput, small molecule, protein and macromolecule structure determination and screening for large protein samples.

The facility is equipped with a variety of characterisation tools, including an STA (DSC/TGA), an adsorption analyser, two state-of-the-art diffractometers, a Mo-target Oxford Diffraction X-Calibur X-ray diffractometer for small molecule structure determination, and a Cu-target Rigaku Hiflux Homelab rotating anode X-ray diffractometer for macromolecular structure determination.

We use our Peptide Synthesis & Purification facility to conduct surface studies and synthetic chemistry research. This facility is equipped with a CEM liberty peptide synthesiser for solid phase synthesis and a semi-preparative and analytical HPLC machine.

Forming part of the Australian National Fabrication Facility (ANFF) Optofab node (which is headquartered at Macquarie University), our sub-node includes a surface science capability that supports IPAS research in this area and will soon be extended, due to recent additional South Australian State funding.

### Case Study: Fibre-bound Nanomachines (ARC Super Science Fellowship)

In 2010 IPAS was awarded six ARC Super Science Fellowships, worth over $2.4M. One of these Fellows, Dr Sabrina Heng, is creating light-based nanomachines for the detection of biologically relevant ions (such as Na+, K+, Ca2+, PO43-, NO3-, Cl-). These fibre-bound nanomachine sensors include supramolecular compounds that can change their conformation via an external stimulus. In these sensors, light has a twofold role. Firstly, light drives the change in geometric conformation of the supramolecular compounds, controlling the binding of specific ions and conferring reversibility. Secondly, light is the medium for detecting and quantifying the binding of analytes via absorption or fluorescence.
Research Theme 6: Medical Diagnostics & Biological Sensing

IPAS research in Medical Diagnostics & Biological Sensing is driven by fundamental questions in biology and the urgent need for improved medical diagnostic techniques. We develop new technologies in conjunction with clinicians and biologists, pushing the boundaries of speed, sensitivity and sample volumes.

We have produced optical fibre-based dip sensors capable of measuring biomolecules in small sample volumes and/or low concentrations. We have also developed novel label free systems that are capable of sensing pathogens and biomarkers. These have the potential to underpin future ‘point of decision’ medical diagnostic technologies.

Our researchers in this area investigate the chemistry of proteins and peptides and discover new biomarkers to answer important biological questions about the development and prevention of diseases.

We also work on drug design and development, including the identification and synthesis of novel small molecules to block or activate cellular targets.

Theme Leaders

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Methathesis and Click Chemistry
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Protein Structure, Function and Interactions
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Biosensing Platform Development
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Adelaide Proteomics Centre
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STARR Laboratory
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Biomarker Discovery
The Biomarker Discovery work investigates cancers and diseases through the identification of new biomarkers. Focusing on increasing our ability to detect, identify and quantify proteins and peptides with the highest sensitivity and accuracy is a key motivation of this work.

The area uses the latest mass spectrometry for structure determination, protein identification and quantification. Posttranslational modifications are characterised and changes in protein expression levels are quantified using techniques such as 2D fluorescence difference gel electrophoresis and quantitative mass spectrometry using isotopic labelling and label-free approaches. Ultimately this work is driven by the need for new tools for early diagnosis and to treat diseases through a better understanding of changes at the molecular level.

Metathesis & Click Chemistry
Our Metathesis & Click Chemistry researchers design, synthesise and test inhibitors towards clinical solutions. Our investigations concentrate on proteolytic enzymes and also small heat-shock chaperone proteins (sHsp) that are associated with amyloid fibril formation. An important extension of this work is to incorporate molecular ‘switches’ into the structures which, when activated, then mimic a key protein or peptide. This provides an opportunity to develop treatments and diagnoses of diseases such as Alzheimer’s, traumatic brain injury, cataract, and cancer.

Protein Structure, Function & Interactions
The Protein Structure, Function & Interactions researchers undertake chemical, spectroscopic and biophysical investigations on the structures, functions and interactions of peptides and proteins. Nuclear magnetic resonance spectroscopy, circular dichroism, fluorescence spectroscopy, electron microscopy, ultracentrifugation techniques and site directed mutagenesis are used to investigate structurefunction relationships of specific amino acids within peptides and proteins.

Biosensing Platform Development
The Biosensing Platform Development work at IPAS is focused on the development of new and improved tools for biomolecule detection. Harnessing the breakthroughs achieved in other research themes, we create new measurement tools for advancing biological research, and by collaborating with medical researchers we enable translation to clinical applications. The strength of this area of research has been recognised by the award of six ARC Super Science Fellowships. Three of these Fellowships are focused on creating new sensing platforms and three on advancing new applications. Examples of platforms being developed include new forms of whispering gallery mode, surface plasmon resonance and fluorescence sandwich assays. Applications include rapid disease diagnosis, blood analysis at crime scenes and in vivo embryo monitoring.

Adelaide Proteomics Centre (APC)
The Adelaide Proteomics Centre (APC) offers researchers and industry a state-of-the-art proteomics facility. The APC has the latest mass spectrometry (MS) technologies for proteins identification and characterisation of posttranslational modifications, such as 2D fluorescence difference gel electrophoresis, isotopic labelling and label free quantitative MS. The APC is the leading research laboratory in tissue imaging MS in Australia and SE Asia.

STARR Laboratory
The Sensing Technologies for Advanced Reproductive Research (STARR) laboratory is dedicated to the development of photonics-based reproductive health technologies. Co-locating sensor development and embryology laboratories in the University of Adelaide enhances interactions between physicists and biomedical researchers and greatly accelerates the integration of sensor development with existing medical instrumentation and animal models.

The STARR facility is a $1.4M initiative by the State SA’s Premier’s Science and Research Fund (PSRF) and is a partnership between The University of Adelaide, Cook Medical Reproductive Health Science Pty Ltd, Fertility SA and Flinders Reproductive Medicine.

Case Study: Gastric Cancer Diagnostics
An NHMRC Project Grant awarded to Dr Peter Hoffmann, Prof Tanya Monro and collaborators is currently underway. Using a new fibre-based SPR sensor developed by Dr Alexandre Francois, postdoctoral researcher Dr Beniamino Sciacca has recently demonstrated the detection of key gastric cancer biomarkers. This project aims to build on serum protein biomarkers of early-stage gastric cancer discovered by the Adelaide Proteomics Centre to create a fibre-based screening tool for early stage gastric cancer.
IPAS Members and 2010 Outputs
# IPAS Members

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**RESEARCH STAFF**

**Professors Level E (Research Only)**

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**Lecturer Level A**

**STUDENTS**

**Post Graduate Student**

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</tr>
<tr>
<td>PhD Student</td>
<td>Ms</td>
<td>Karina</td>
<td>Martin</td>
<td>School of Molecular &amp; Biomedical Sciences</td>
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<tr>
<td>PhD Student</td>
<td>Mr</td>
<td>H. Tilanka</td>
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<tr>
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<tr>
<td>PhD Student</td>
<td>Ms</td>
<td>Jessica</td>
<td>Wadley</td>
<td>School of Earth &amp; Environmental Sciences</td>
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</tbody>
</table>
### IPAS Members and 2010 Outputs

<table>
<thead>
<tr>
<th>Role</th>
<th>Title</th>
<th>First name</th>
<th>Last name</th>
<th>Organisation Unit</th>
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</thead>
<tbody>
<tr>
<td>PhD Student</td>
<td>Ms</td>
<td>Claire</td>
<td>Weekley</td>
<td>School of Chemistry &amp; Physics</td>
</tr>
<tr>
<td>PhD Student</td>
<td>Mr</td>
<td>Danielle</td>
<td>Williams</td>
<td>School of Chemistry &amp; Physics</td>
</tr>
<tr>
<td>PhD Student</td>
<td>Mr</td>
<td>Ka</td>
<td>Wu</td>
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<tr>
<td>PhD Student</td>
<td>Ms</td>
<td>Ho</td>
<td>Yining</td>
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<tr>
<td>PhD Student</td>
<td>Mr</td>
<td>Wen Qi</td>
<td>Zhang</td>
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<tr>
<td>PhD Student</td>
<td>Ms</td>
<td>Xiao</td>
<td>Zhang</td>
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<td>Undergraduate Students</td>
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<tr>
<td>Masters Student</td>
<td>Mr</td>
<td>Samiul</td>
<td>Sarker</td>
<td>School of Chemistry &amp; Physics</td>
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<tr>
<td>RESEARCH ASSISTANTS</td>
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<tr>
<td>Visiting Research Fellow</td>
<td>Mr</td>
<td>Don</td>
<td>Creighton</td>
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<tr>
<td>Research Assistant</td>
<td>Ms</td>
<td>Rachel</td>
<td>Moore</td>
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<tr>
<td>Research Assistant</td>
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<td>Sebastian</td>
<td>Ng</td>
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<tr>
<td>Research Assistant</td>
<td>Ms</td>
<td>Mai-Chi</td>
<td>Nguyen</td>
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<tr>
<td>Visiting Research Fellow</td>
<td>Dr</td>
<td>Frances</td>
<td>Williams</td>
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<td>TECHNICAL OFFICERS</td>
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<td>Mr</td>
<td>Alastair</td>
<td>Dowler</td>
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<tr>
<td>Senior Technical Officer</td>
<td>Mr</td>
<td>James</td>
<td>Eddes</td>
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<td>Technical Officer</td>
<td>Mr</td>
<td>Peter</td>
<td>Henry</td>
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<td>Blair</td>
<td>Middlemiss</td>
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<tr>
<td>Technical Officer</td>
<td>Ms</td>
<td>Jennifer</td>
<td>Templeton</td>
<td>School of Earth &amp; Environmental Sciences</td>
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</table>

**IPAS ASSOCIATES**
<table>
<thead>
<tr>
<th>Role</th>
<th>Title</th>
<th>First name</th>
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<th>Organisation Unit</th>
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</thead>
<tbody>
<tr>
<td>DEF Cluster Facilitator - ARI</td>
<td>Mr</td>
<td>Paul</td>
<td>Arthur</td>
<td>ARI</td>
</tr>
<tr>
<td>Senior Project Director</td>
<td>Mr</td>
<td>Jeremy</td>
<td>Kwan</td>
<td>Property Services</td>
</tr>
<tr>
<td>Administration Officer</td>
<td>Ms</td>
<td>Maria</td>
<td>Lekis</td>
<td>School of Earth &amp; Environmental Sciences</td>
</tr>
<tr>
<td>Research Marketing Coordinator</td>
<td>Ms</td>
<td>Michelle</td>
<td>Reeve</td>
<td>Marketing</td>
</tr>
<tr>
<td>Commercial Development Manager ARI</td>
<td>Ms</td>
<td>Ruth</td>
<td>Shaw</td>
<td>ARI</td>
</tr>
</tbody>
</table>
Research Team Growth

As well as the creation of the IPAS core team, who provide support for the growth of IPAS research capacity, the following staff joined the University as a direct result of grants won in 2010:

Research & Teaching Staff
- Prof Nigel Spooner (secondment from DSTO)
- A/Prof David Lancaster
- Dr Dominic Murphy
- Dr Andrew Richardson
- Dr Florian Englich (Super Science Fellow 1)
- Dr Kris Rowland (Super Science Fellow 2)
- Dr Sabrina Heng (Super Science Fellow 3)
- Mr Sean Manning

Research Assistants
- Mr Roman Kostecki
- Mr Sebastian Ng
- Mr Anthony Scoble
- Ms Sawyn Oh
- Ms Mai-Chi Nguyen
- Ms Katarina Markulic

Senior Technical Officer
- Mr Peter Henry
## 2010 Conference

<table>
<thead>
<tr>
<th>Name of Conference</th>
<th>Date</th>
<th>Location</th>
<th>Attendee/s</th>
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</thead>
<tbody>
<tr>
<td>International Conference On Nanoscience and Nanotechnology (ICONN)</td>
<td>22–26 February 2010</td>
<td>Sydney, Australia</td>
<td>Tanya Monro</td>
</tr>
<tr>
<td>CleverGreen Conference &amp; Showcase</td>
<td>15–16 February 2010</td>
<td>Adelaide, Australia</td>
<td>Tanya Monro</td>
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<tr>
<td>10th Annual Intelligence Community Postdoctoral Research Fellowship Program Colloquium</td>
<td>26–29 April 2010</td>
<td>Virginia, USA</td>
<td>Richard White</td>
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<tr>
<td>17th International Symposium on Non-Oxide and New Optical Glasses (ISNOG)</td>
<td>13–18 June 2010</td>
<td>Ningbo, China,</td>
<td>Heike Ebendorff-Heidepriem</td>
</tr>
<tr>
<td>Nonlinear Photonics, OSA Technical Digest (CD)</td>
<td>21–24 June 2010</td>
<td>Karlsruhe, Germany</td>
<td>Shahraam Afshar, Wenqi Zhang</td>
</tr>
<tr>
<td>The 5 Asia-Pacific Conference on Transducers and Micro-Nano Technology (APCOT)</td>
<td>6–9 July 2010</td>
<td>Perth, Australia</td>
<td>Tanya Monro</td>
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<tr>
<td>15th OptoElectronics and Communications Conference (OECC)</td>
<td>5–9 July 2010</td>
<td>Sapporo, Japan</td>
<td>Tanya Monro</td>
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<tr>
<td>10th International Conference on Numerical Simulation of Opto-electronic Devices (NUSOD)</td>
<td>6–9 September, 2010</td>
<td>Georgia Tech, Atlanta, USA</td>
<td>Tanya Monro</td>
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<tr>
<td>Frontiers in Optics Conference (FiO)</td>
<td>24–28 October 2010</td>
<td>Rochester, New York, USA</td>
<td>Shahraam Afshar</td>
</tr>
<tr>
<td>Giant Magellan Telescope Adaptive Optics Conference (GMTAO),</td>
<td>22–24 Nov 2010</td>
<td>Canberra Australia</td>
<td>Jesper Munch</td>
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<tr>
<td>16th International Solid State Dosimetry Conference (SDD-16)</td>
<td>19–24 September 2010</td>
<td>Sydney, Australia</td>
<td>Nigel Spooner</td>
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<tr>
<td>Fertility Society of Australia Conference</td>
<td>10–13 October 2010</td>
<td>Adelaide, Australia</td>
<td>Tanya Monro</td>
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<tr>
<td>The 23rd Annual Meeting of the IEEE Photonics Society</td>
<td>7–11 November 2010</td>
<td>Denver, Colorado, USA</td>
<td>Heike Ebendorff-Heidepriem</td>
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<tr>
<td>Frontiers in Optics/Laser Science (FiO)</td>
<td>24–28 October 2010</td>
<td>Rochester, New York, USA</td>
<td>Shahraam Afshar</td>
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<tr>
<td>Name of Conference</td>
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<tr>
<td>Koala Student Conference</td>
<td>28 Nov–4 December</td>
<td>Dunedin, New Zealand</td>
<td>Erik Schartner, Tilanka Munasinghe, Chris Kahlins</td>
</tr>
<tr>
<td>Australian Conference on Optical Fibre Technology (ACOFT),</td>
<td>5–9 December</td>
<td>Melbourne, Australia</td>
<td>Heike Ebendorff, Jesper Munch, Tanya Monro, Miftar Ganija, Nick Chang, Peter Veitch, Keiron Boyd, Wenqi Zhang, Tilanka Munasinghe, David Ottaway, Florian Englich, Jesper Munch, Tanya Monro, David Lancaster, Michael Oermann, Shahraam Afshar</td>
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2010 Publications

2010 IPAS publications

Journal Publications


Executive Summary

IPAS Structures and Management

Stakeholders and IPAS Facilities

IPAS Research

IPAS Members and 2010 Outputs


Executive Summary


Stakeholders and IPAS Facilities


CONFERENCE PROCEEDINGS


