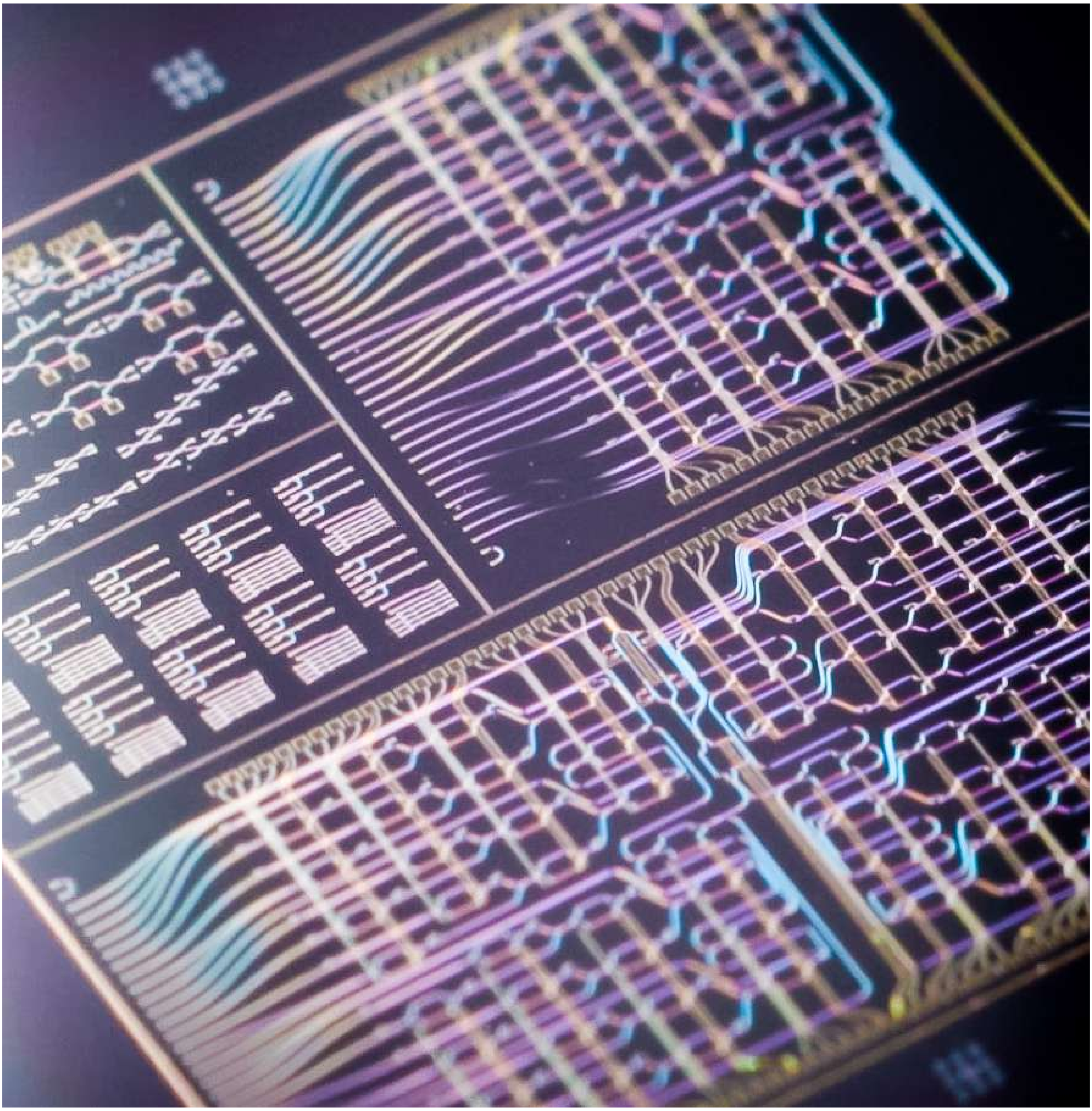
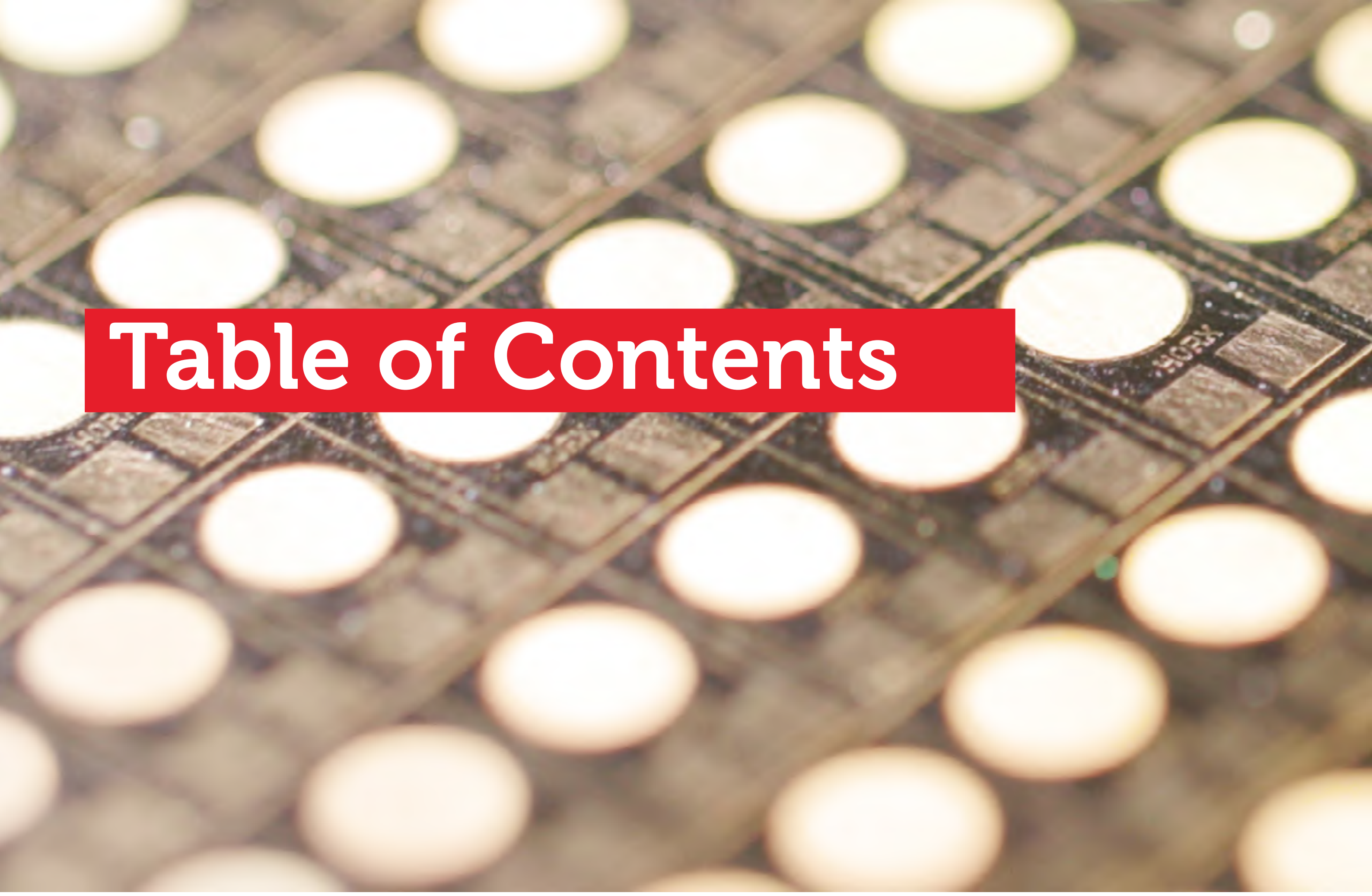


Integrated Photonics and Applications Centre

Annual Report 2021

RMIT UNIVERSITY

InPAC Integrated Photonics and Applications Centre



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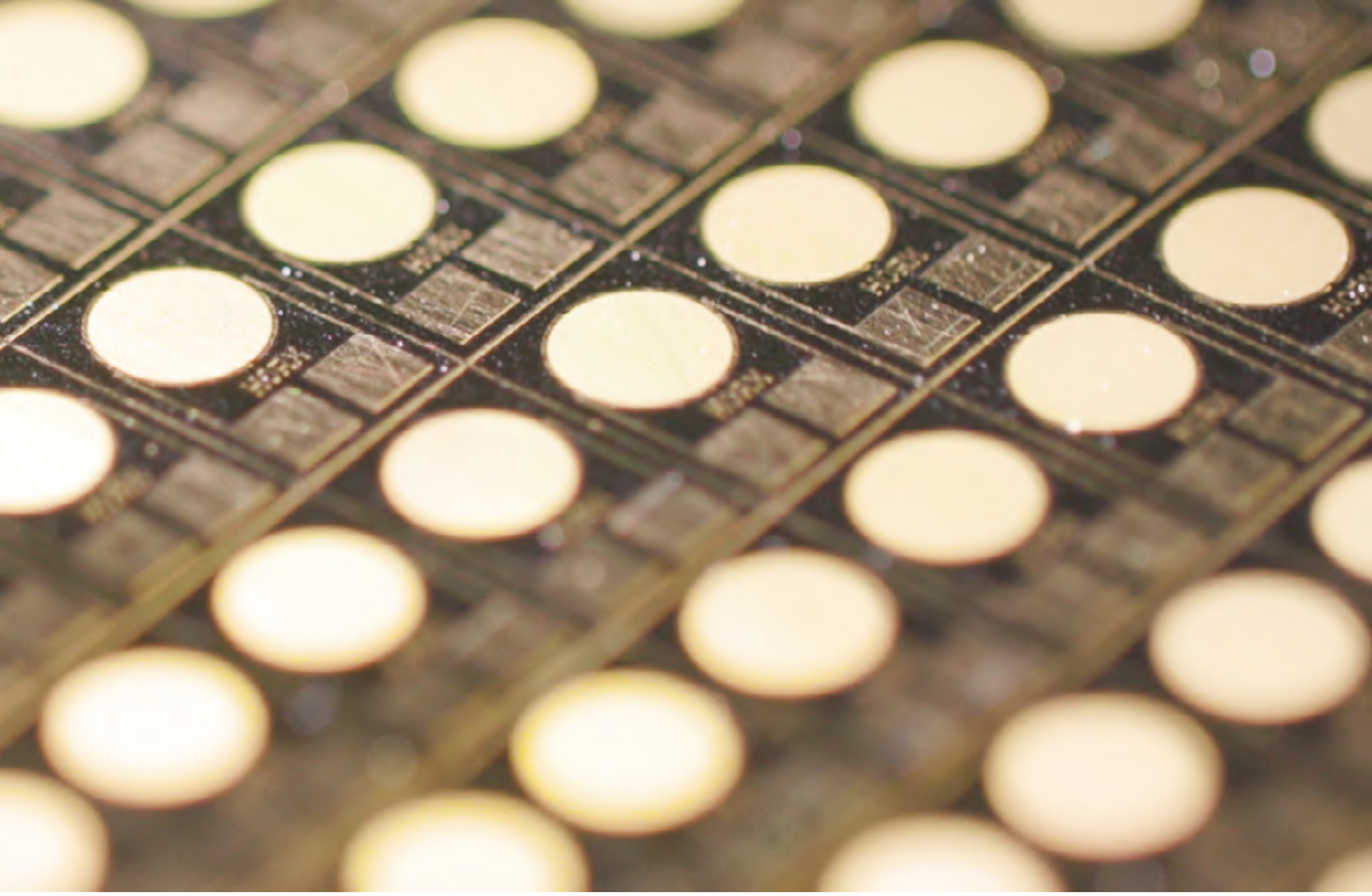


Centre Mission and Objectives

Centre Mission and Objectives

Centre Mission

Our mission is to create impactful integrated photonic technologies. This is achieved by continuous end-user engagement to deeply understand real-world problems. We pioneer breakthrough science in the field of integrated photonics coupled with rapid, systematic and disciplined iterations to deliver a consistent stream of significant outcomes to end users.

Centre Rationale

The rise of ‘big data’, artificial intelligence and the internet of things predicts that the world will be filled with ubiquitous highly integrated objects that can monitor and interact with the world without human interaction. This will create new paradigms for manufacturing and indeed for our way of life. However, to make this vision a reality, we will need new and diverse forms of sensors and technologies to manage the ever-growing volumes of data they will collect. All this will need to happen while maintaining environmental robustness and the low cost that we now take for granted in consumer electronics.

Electronic technologies are excellent for processing digital information but lack the precision and sensitivity to sense subtle features of our analogue world. They also lack the bandwidth to transport this detailed information to central processing hubs. Photonic approaches can provide orders of magnitude more sensitivity and millions of times more bandwidth than electronics can offer.

Integrated photonics is emerging as a technology, which enables photonic components to be integrated directly onto microchips using the same technology currently used to mass manufacture integrated electronics. Photonic Integrated Circuits (PICs) have been the subject of research for decades, but the manufacturing infrastructure and industrial demand has only recently reached the scale and intensity to match the same revolution that integrated electronics had, but in integrated photonics.

Objectives

Research: The Integrated Photonics and Applications Centre (InPAC) will perform world-leading research in photonic integrated circuits for applications in communications, biomedicine and defence.

Education and Training: InPAC will inspire, guide and educate the next generation of photonic engineers and scientists to strengthen and shape the Australian photonic community.

Translation: InPAC will create intellectual capital and translate it to benefit the Australian photonic industry, building industrial strength through new jobs and new companies.

Centre Vision

Our vision is that the Integrated Photonics and Applications Centre (InPAC) will be recognised as world leading in research and translation of photonic integrated circuit technology. We are determined to be pioneers of fundamental science and cutting-edge technology, but with a commitment and track-record in translating this technology into practical solutions to address real world problems spanning data, defence and biomedical fields.

We believe it is possible to transition from high volume, foundry mass manufacture that has grown the electronics industry for the last 50 years to advanced manufacture of highly customised solutions using modular building blocks, with easy and dynamic scaling between small and large volumes. Through this approach, we believe we can engage with a much broader range of end-users – especially small, specialised industries in Australia.

Director's Report

The second year of our Centre was the second year of a pandemic. We built on our strategy of pro-active online engagement, which worked well in 2020. This year brought new opportunities that stemmed from new challenges – including the sustained border closures and global supply chain issues. This year we focused on building momentum for the long-term so that we are well resourced and energised, ready for when the world springs back into action.

We grew our team to 40, up from 25 in 2020. I am immensely proud of our growing team for a number of achievements. These began within the first week of 2021, with a Nature paper that demonstrated the world's fastest and most powerful optical 'brain-like' processor. This was a collaborative effort led by Swinburne, in collaboration with our team and Monash University.

In 2021, our Centre's first spin out company, HatiSens, was launched, to allow faster heart attack detection to guide clinical treatment. This industry-pull is exactly the place the Centre wants to play in, and it's heartening to see a spinout so early on in our Centre's life.

I was also delighted to see RMIT University ranked in the top 250 universities in the world. Of particular relevance to our Integrated Photonics and Applications Centre (InPAC) was the positioning of Electrical and Electronic Engineering (80th) and Optics (85th) – well into the top 100 globally and still rising fast! We see this as recognition that RMIT is among the world's best research environments – particularly in optics and photonics. This will help us to attract world leading students and research translation partners to continue this upward trajectory.

This year we put extra effort into building new initiatives as an investment in the long term future. Early feedback is positive and I look forward to seeing these come to fruition in 2022. I see next year as a pivotal year in establishing InPAC as a world leader in research and translation of integrated photonic technology.

Distinguished Professor Arnan Mitchell

Director of the Integrated Photonics
and Applications Centre (InPAC)

Centre Members

New members recruited in 2021 are marked with an asterisk (*) beside their name.

Director

Dist. Prof. Arnan Mitchell

Arnan is responsible for the overall strategy of the Centre and is the initial contact for new collaborations with academics, industry and government.

Media and Communications

Staff

Rachael Vorwerk

Rachael is a science communicator and raises the profile of the Centre, whilst working with the team to make their research accessible to broader audiences such as the public, media, grant funders and industry.

Data Communications Team

Team Leader:
Communication and Information Systems

Dr. Bill Corcoran

Bill is a researcher in optical communications, focusing on using novel photonic technologies to fix problems in the systems that provide the backbone of the internet.

PhD Student

Park (Chawaphon) Prayoonyon

Chawaphon (Park) is investigating how optical frequency combs can support data communication systems, to reduce costs and the load on current internet infrastructure.

PhD Student

Yonghang Sun*

Yonghang is investigating ways to clone laser light after travelling over long distances of fibre, which aims to allow for ultra-high data rates in our internet infrastructure, but with lower energy consumption and cost.

Precision Sensing and Defence Team

Team Leader:
Precision Sensing and Defence

Dr. Andreas Boes

Andy is using the photonic integrated circuits for precision sensing and defence applications, such as inertial positioning sensors. These photonic integrated circuits are created by the simulation and fabrication teams.

Staff

Dr. Armandas Balčytis*

Armandas is working on interfacing and packaging the microscale integrated photonic circuits for real-world applications, like enhancing the precision of drones used for remote survey of land and infrastructure.

Staff

Nicholas Greig*

Nicholas explores how we can use light in the visible wavelength for applications like augmented reality.

Precision Sensing and Defence Team

Staff

Dr. Mengxi (Sim) Tan*

Sim designs integrated photonic circuits to reduce energy losses to make data communications transfer faster and more accurate, all with smaller infrastructure.

PhD Student

Luke Broadley*

Luke is working on signal processing techniques to improve the accuracy, size, and cost of optical sensors needed in assessing biological samples, monitoring the structural health of buildings and bridges, and defence applications.

PhD Student
(Ecole Centrale de Lyon)

Marina Raevskaia

Marina creates integrated non-linear broadband light sources to make the internet faster, more energy-efficient and capable of carrying larger bandwidths.

PhD Student

Rebecca Taube

Rebecca is researching how to integrate optical gyroscopes onto a fingernail-sized chip so they are more suitable from a cost and performance perspective in driverless cars.

Simulation and Design Team

Team Leader: Simulation and Design

Dr. Thach Nguyen

Thach is responsible for coordinating the simulation and design efforts of the Centre, and investigates new theoretical concepts for photonic integrated circuits.

Staff

Aditya Vashi

Aditya is automating a laboratory setup to help photonics researchers to check the behaviour of their optical chips with higher accuracy and precision, all in less time.

Staff

Hiep Dinh

Hiep designs light-powered components capable of simulating the complex behaviour of crystals, to experiment whether these unique properties could be used for high-speed processing in quantum computing.

PhD Student

Tasneem Akther

Tasneem is researching more efficient, accessible and less invasive scanning methods using on-chip optical filters that could be used to more accurately read glucose levels or the allergic components of food.

PhD Student

Haijin Huang

Haijin is researching how to use more efficient techniques like optical frequency microcombs, to send data faster and more efficiently through existing networks for faster internet speeds.

PhD Student (RMIT Vietnam)

Phuong Tang

Phuong is investigating how to develop more compact ways to implement a new type of filter, which is an essential component for a variety of applications including sensing and data communications.

Simulation and Design Team

PhD Student
(Ecole Centrale de Lyon)

Panteha Pedram

Panteha is working on developing new 2D materials, identify their nonlinear optical properties, and the integration of these 2D materials onto chip-based devices for applications such as data communications.

PhD Student
(Ecole Centrale de Lyon)

Kokou Firmin Fiaboe

Kokou designs, fabricates and integrates broadband sources into photonic chips using a lithium niobate platform for environmental monitoring, medical diagnosis and military applications.

Fabrication Team

Team Leader: Technology and Fabrication

Dr. Guanghui Renn

Guanghui looks after InPAC's current fabrication platforms and establishes new technologies for application teams and end-users, whilst ensuring all InPAC's photonic integrated circuits perform the way the design team intended.

Staff

Tanveer Mahmud

Tanveer is developing advanced technologies to create three-dimensional polymer structures on integrated photonic platforms for telecommunication and biochemical sensing applications.

Staff

Nitu Syed*

Nitu is working on developing a photonic integrated circuit platform made of silicon nitride to reduce the optical efficiency losses in the red, green, blue wavelengths.

Fabrication Team

Staff

Aditya Dubey

Aditya's research combines functional optical materials with novel two-dimensional materials to create more compact, sensitive and accurate applications in defence, data communications, and biotechnology.

Staff

Jackson Jacob Chakkoria*

Jackson is automating a laboratory setup to help photonics researchers to check the behaviour of their optical chips with higher accuracy and precision, all in less time.

PhD Student

Sonya Palmer

Sonya is looking at how integrated photonic circuits can be used to miniaturise precision measurement tools like quantum sensors for use in satellites in deep space exploration and more accurate mining.

PhD Student
(Ecole Centrale de Lyon)

Mohab Abdalla*

Mohab is investigating neuromorphic computing architectures using integrated photonics, aiming towards energy-efficient hardware with faster computational speeds for ever-demanding deep learning applications.

PhD Student
(Ecole Centrale de Lyon)

Marko Perestjuk*

Marko is working on trapping mid-infrared light to develop a tiny fingernail-sized photonic chip to make sensors more compact for detecting diseases in our breath, or the quality of the air in our environment.

PhD Student

Paramjeet Kaur

Paramjeet is creating a photonic integrated photodetector that will make sensors more accurate, compact and cost-effective to be used in driverless cars, infrastructure monitoring and drones.

Biomedical Applications Team

Team Leader:
Biomedical Applications

Dr. Cesar S. Huertas

Cesar combines photonic biosensors with microfluidic devices to give us more accurate insight into human biology and disease states for more personalised treatments in the future.

Staff

Dr. Crispin Szydzik*

Crispin is creating new microfluidics approaches to more accurately filter, sample and sense small amounts of liquid such as blood and saliva for more precise and personalised medical devices.

Staff

Dr. Francisco Lopez

Francisco investigates how to use microfluidics and micromechanics to ensure all components can be integrated seamlessly to allow for more precise biomedical fluid handling, personalised care devices and sensitive sensors.

Staff

Dr. Rebecca Soffe*

Rebecca develops microfabrication processes for lab-on-a-chip devices and microstructures for faster and more efficient sampling and disease diagnosis.

PhD Student

Siew Joo Beh

Siew is using photonic biosensors to create a handheld, compact devic that will revolutionise how heart attacks are currently diagnosed.

PhD Student

Jorge Lozano Lopez*

Jorge is working with optical sensors based on nano-structures and is researching how to improve the sensitivity of sensors by applying signal processing techniques to ensure everyone has access to high-quality healthcare.

Biomedical Applications Team

PhD Student

Madhuri Edla

Madhuri is researching simpler, faster and more accurate fabrication methods so larger numbers of samples can be analysed at the same time.

PhD Student
(Ecole Centrale de Lyon)

Syed Harris Hussain

Harris is working on developing an integrated optical-microfluidic biosensing device for real-time analysis of biomarkers from cancer cells that are circulating in the blood

Masters Student

Hina Amer*

Hina is investigating how effective a potential biomarker may be in determining early stages of ovarian cancer by using approaches that can give real-time feedback on many cancer cells at once.

Masters Student

Kaan Tekin-Sari*

Kaan investigates how to provide earlier diagnosis of ovarian cancer using specific biomarkers that may be associated with early stages of tumour development.

Masters Student

Mohammed Ali M Razqan*

Mohammed aims to create a miniature version of a laboratory – all on a fingernail-sized chip – to help to make cancer screening and diagnosis more effective, while being able to predict individual cancer outcomes.

Centre Recruitment and Integration

We will specifically look to address any gaps or imbalances that we have identified in the Centre, not only in terms of emerging science, technology and applications, but also in terms of diversity of gender and career stage.

Staff

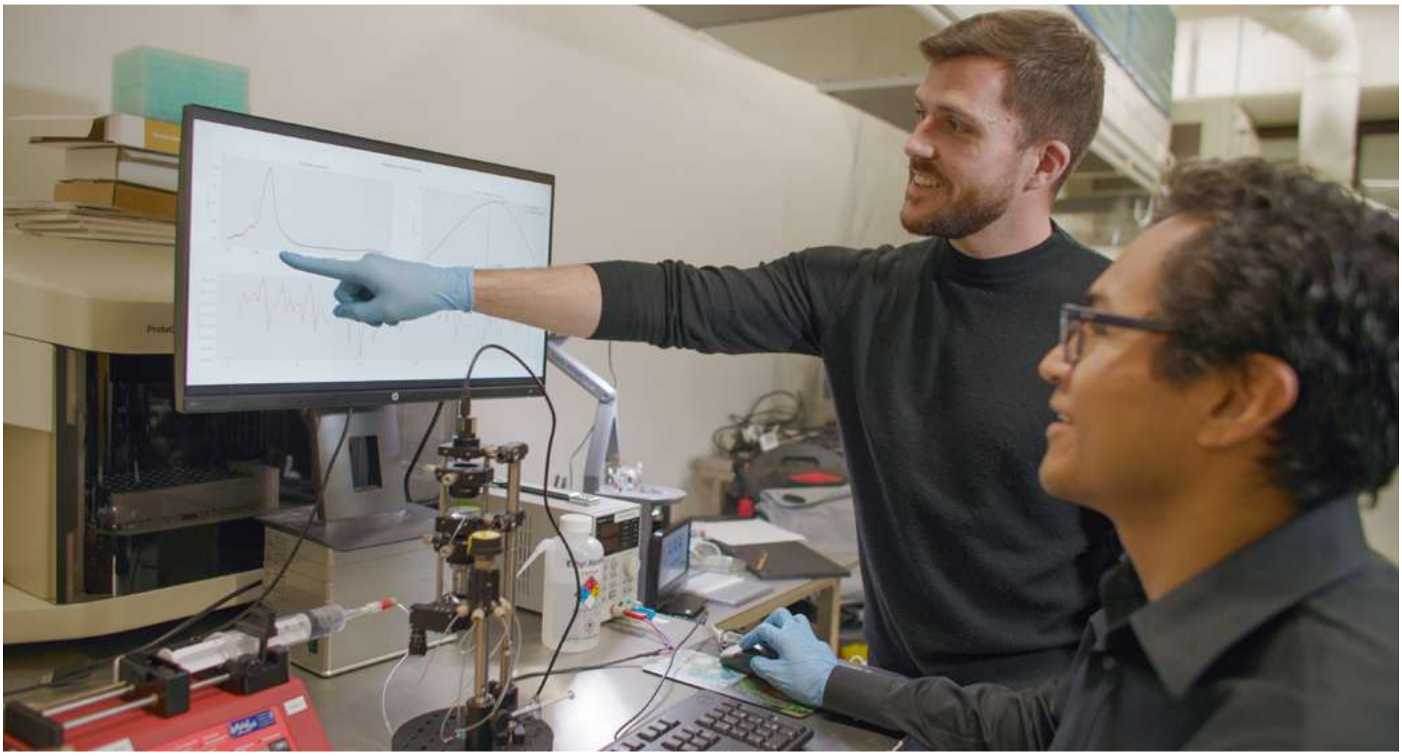
We advertise staff positions regularly on online recruitment sites, our social media channels (LinkedIn and Twitter) and within RMIT. These positions are generally aligned to specific research projects that are funded externally (eg. industry, ARC etc.).

Once staff are recruited, they undergo IPKISS photonic integrated circuit software training and are invited to attend the fortnightly InPAC Team Meetings. Shortly after they have begun, the team invites them to give a presentation about themselves and their research at the InPAC fortnightly Team Meeting.

Higher Degree by Research (HDR) students

Centre PhD positions are advertised throughout the year on the InPAC website and social media channels on LinkedIn and Twitter. We advertise regularly via online recruitment sites with open PhD positions that are funded externally through our industry partners and competitive grant funding. We are also primed to guide HDR students to apply for competitive scholarships and programs that can support their studies within our Centre.

Once HDR students are recruited, they are required to undergo IPKISS photonic integrated circuit software training. They are introduced at their teams' meetings and are invited to attend the fortnightly InPAC Team Meetings. HDR students are scheduled to present at the InPAC Team Meeting in the lead up to their First Milestone, to gain feedback about their research.

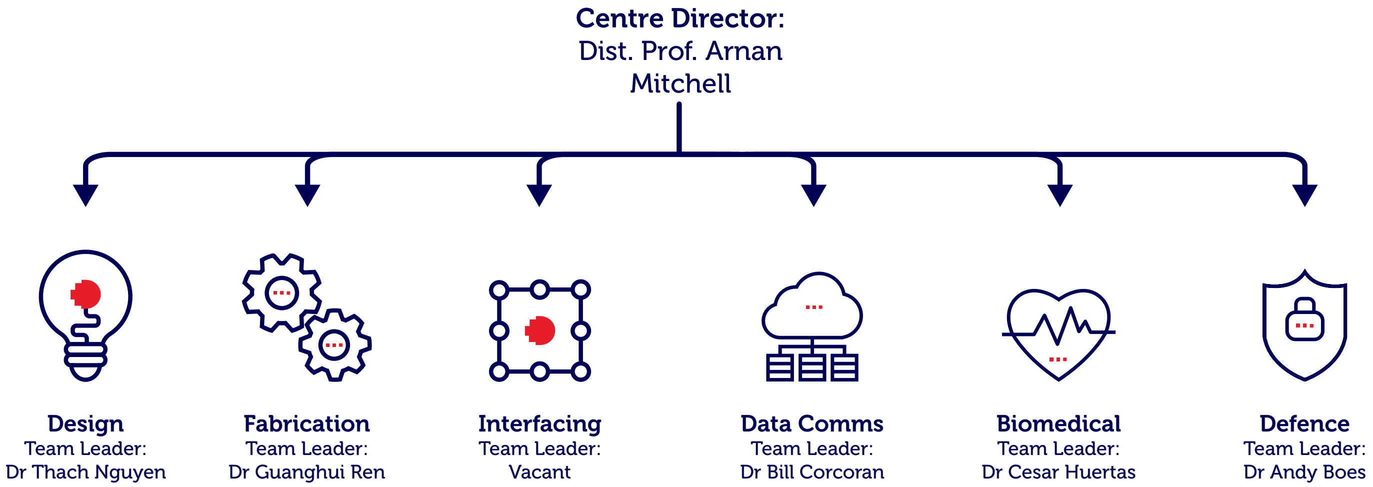


Structure and Governance

Structure and Governance

Organisation structure

InPAC comprises of one Centre Director coordinating six focused teams (Design, Fabrication, Interfacing, Data Communications, Biomedical and Defence), each of which is led by an early or mid-career researcher and includes a cohort of students. A schematic of the personnel organisation structure of InPAC is shown below.



InPAC Team Meetings

All InPAC members attend these Team Meetings which were held fortnightly on Tuesdays in 2021. The Team Meetings are not held in slow down periods or public holidays. These Team Meetings include various segments:

- **Update presentations** – InPAC team members provide an update about their research.
- **Milestone preparation presentations** – PhD students practice their presentation to gather feedback from the InPAC team before their milestone.
- **Journal Club** – InPAC team members analyse a relevant journal paper and describe its significance to the team.
- **News Article Club** – InPAC team members analyse a relevant news article and describe why it was a newsworthy science story.
- **Prizes and Awards overview** – our Centre's Science Communicator Rachael collects the latest prizes and awards and categorises these to PhD students, ECRs and other researchers. These upcoming opportunities are presented during the InPAC Team meeting for Centre members to apply for.

InPAC Team Leader Meetings

All Team Leaders and our Director attend these meetings, which were held once every month until June, and then roughly every two months for the second half of the year. These meetings included agenda items such as:

- Grant planning
- Planning for high impact paper publications for 2022
- Work Integrated Learning (WIL) – summer internship projects
- Equipment requirements
- Strategic PhD and Fellowship recruitment

Report on 2021 Achievements and Activities

Summary of 2021 plans, outcomes, key achievements and Centre impact

Key Achievements and Impact

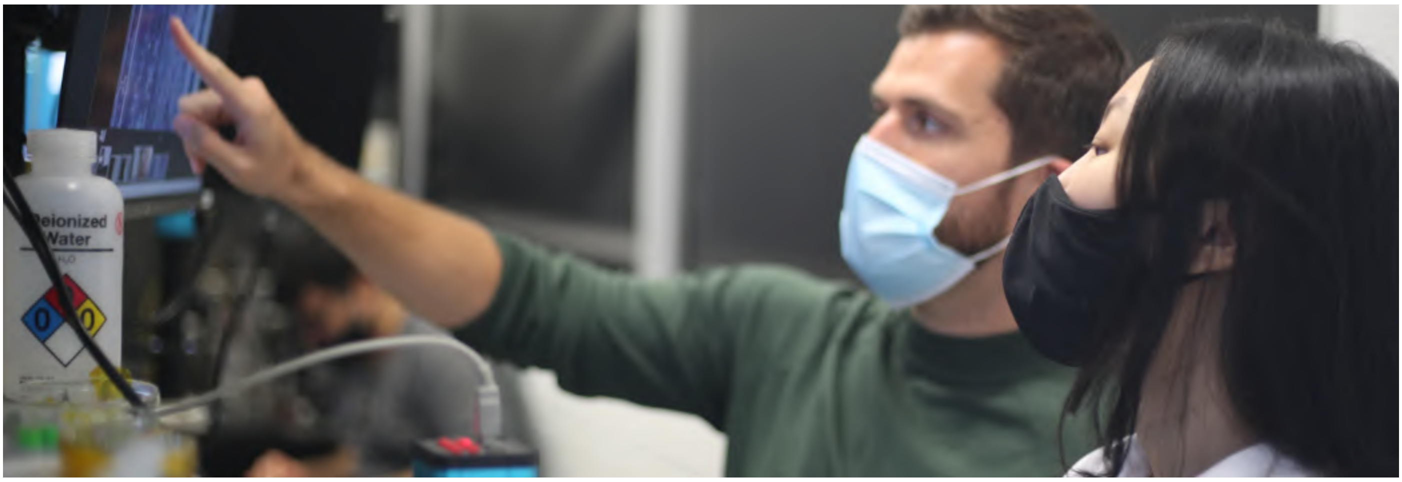
The Centre had many key achievements in 2021, as highlighted below.

Research Excellence

- The Centre members published a total of 35 journal publications, with the vast majority in Q1 journals.
- Highly significant, breakthrough demonstrations were reported in some of the leading journals in the research fields of the Centre, such as Nature, Nature Materials, Nano Today and Advanced Optical Materials.
- Centre members were recognised for the research excellence by being awarded a Fulbright Fellowship (Sonya Palmer) and Optica Fellow (Arnan Mitchell).

Research Funding

- InPAC was successful in attracting three research grants in 2021:
  - **NHMRC grant valued at $999,428** with Arnan Mitchell and Cesar S. Huertas in a multi-disciplinary collaboration with Magdalena Plebanski and April Kartikasari to rapidly determine the most effective treatments for ovarian cancer as early as possible.
  - **ARC Discovery Project valued at $510,000** including Andy Boes, Michael Steel and David Marpaung to create inexpensive, compact, stable and energy efficient microwave photonic processors, a key requirement for reference standards and precision measurements of time and frequency.
  - **Industry grant with a US-based company, one year project at $360,000** led by Arnan Mitchell, Guanghui Ren, Andy Boes and Thach Nguyen.



Centre Impact

The Centre has made the following impact in 2021:

- HatiSens spun out of InPAC, led by PhD student Siew Joo Beh, Cesar S. Huertas and Arnan Mitchell. HatiSens was created to detect heart attacks faster to guide clinical treatment.
- Members of the InPAC team co-authored a Nature paper that demonstrated the world's fastest 'brain-like' processor. This gained traction in the tech-related media.
- A story about a device that could lead to heart attack prevention co-created by Nirtek and InPAC, was featured on Channel 7, 9, 10 and the Herald Sun.
- InPAC got in front of NASA about working with them to help the space industry.
- Andy won the RMIT Award for Research Excellence (Technology) as the Early Career Researcher for Engineering.
- The world's fastest internet Nature Communications article became the top physics story of 2020.
- InPAC Industry Partner Advanced Navigation launched the world's first fully digital fibre optic gyroscope.
- Arnan received a Veski Study Melbourne Partnership to rapidly prototype photonics for ultrafast communications, satellites, sensors and bionics with Bionics Institute and Chalmers University of Technology in Sweden.
- RMIT was ranked as 85th in the world in optics.

Performance Against Targets

This section compares the Centre outcomes against the expectations set by the STEM College for RMIT Centres.

Create and maintain a vibrant, collegiate and stimulating intellectual environment in which researchers and research students are mentored, guided and supported to develop their careers.

Our team has fortnightly meetings that include different segments of focus. One element is to talk about prizes for career development. We have regular presentations where students and staff present a research update, and these are timed in the lead up to student milestone presentations to help them to prepare. Another element of these meetings is called 'Journal Club', which give staff and students the opportunity to analyse the latest academic literature.

Expectation 1: *Researchers within the Centre actively support, coach and mentor each other and their junior colleagues to achieve success in their research and career goals.*

Each of the teams within the Centre has their own regular set of meetings that they organise. This way Team Leaders have autonomy in finding the right structure to suit their leadership style.

Our Centre is trying to proactively find both industrial and academic opportunities for each of the teams to apply for. This serves two main purposes. Firstly, it gives each Team practice applying for grants. It also allows them to strategically identify high-profile papers for the team to pursue. We also ensure that the students are participants in this process.

Our PhD students are also encouraged to take up opportunities relevant to their individual skillset. For example, Siew Joo Beh has become CEO of InPAC-spinoff HatiSens, Sonya Palmer was elected a Fulbright Scholar and undertook five months of her PhD at The University of California, and Paramjeet Kaur begun at Ghent University in Belgium in an exchange program.

Expectation 2: *Number of female researchers in the Centre increases.*

We are proud of having a 50/50 gender balance in our HDR cohort, and we will continue to maintain that. A part of this that helps is our diversity in application areas. There are different gender balances in different research disciplines – for example biotechnology has a higher proportion of women compared to data communications.

However, we need to do better at the post-doctoral level, where we currently have 11 males and two females. There are several approaches we are taking to bolster this number at the management level.

Firstly, we will apply for grants that include funding for targeted recruitment (eg. ARC Centre of Excellence). However, we can't do targeted recruitment for all our projects – particularly industry projects – so we need to make sure we have enough funding for this kind of specialised recruitment.

Another method is to organise short project roles for recent PhD graduates, to target those who are promising female graduates. This approach worked for a number of female researchers at our Centre in 2021.

Another approach is proactively reaching out to female collaborators directly. We have found this approach to also be quite successful.

We need to plug into VC postdocs and VC fellowships that have a mandate for targeted recruitment. This will help us to ensure the resources are set aside for conducting female targeted recruitment.

Target 1: Panel of examiner forms submitted at third milestone and approved by SGR prior to all candidate submissions

Target 2: On time completion of milestones and submission of thesis.

Expectation 1: *Organisation of regular meetings.*

Our team has an InPAC-wide team meeting every fortnight, and each Team Leader organises a separate meeting with their PhD students. Each PhD student routinely presents at the InPAC team meeting in the lead up to a milestone presentation, giving them extra time to obtain feedback. These regular check-ins help students to work to their milestones.

Our goal is for HDR students to achieve their thesis submission within 3.5 years.

Expectation 2: *Workshops and/or seminars of the group.*

Each fortnightly meeting includes different segments, including project updates from staff and students and analysis of recent journal articles and media articles.

Expectation 3: *Creation of opportunities for HDR students to network including internship opportunities.*

Our team has applied for many grants that explicitly include internships, particularly with changes in the Research Training Scheme program that doubles the funding if an internship is involved.

Similarly, we have applied for many industry projects where we have explicitly said the industry partner must include an internship.

The whole philosophy of InPAC involves industry engagement, and most of the HDR students are inadvertently exposed to an industry partnership at some point during their PhD. Industry partners are also brought into our research at InPAC – pulling industry closer to the work students are doing.

Advance research in their specialist areas and develop both a national and international reputation for delivering excellent research outcomes.

Expectation 1: *Keep abreast of changes in the external environment and identify new opportunities both national and international.*

One traditional means of achieving this goal is via participation in national and international conferences, however COVID-19 has made this difficult. One way we have overcome this is by engaging with conferences virtually. Another approach has been to analyse our international peers' research in the external environment through the Journal Club segment in our fortnightly InPAC team meetings. This segment allows students and staff to analyse high profile publications and learn who the groups are internationally.

Target 1: New international partners/collaborators

Throughout COVID-19, we have been proactive in reaching out to international partners and collaborators. This is based on the assumption that it will be no more difficult to collaborate with us virtually than it would be to collaborate with other researchers in their local area. This has resulted in a significant increase in the number of international engagements. We have also emphasised funded engagements. In particular, we have focussed on European doctoral training centres (such as the Marie Curie COFUNDs ECLAUSION and REDI). We have laid the groundwork for further international engagements through the Marie Curie program and through the ARC Centre of Excellence scheme. This engagement approach is mutually beneficial, so our collaborators get funding out of it to maintain resources, excitement and momentum.

Our team has a lot of external collaborators all around the world (and locally), with connections in Europe, the US and China, to name a few. We have also built a profile in the media which has led to more invited talks at international conferences. A part of this strategy is to make sure that students have a paper in that conference and can be introduced by the invited speaker from InPAC.

Our Centre is heavily industry engaged, so we are proactively reaching out to industry partners around the world and doing customer interviews. These involve them telling us about what they are doing and what they need, so we have an idea of how we can help.

Target 2: Increase in publications with international co-authors

Most of our high-profile research is done with high-profile international partners, thanks to our existing networks overseas. Many of our InPAC team are also international, leading to our natural collaboration with international partners.

Through our growing presence on social media and in the media, we are deliberately emphasising our international papers, which then perpetuates further international partnerships.

Target 3: International research income growth of at least 10% per annum

Our focus is to apply for increasingly ambitious programs. For example, we have been scaling the Marie Curie program – starting with ECLAUSION (10 HDRs), scaling to REDI (44 HDRS) and laying the foundations for another program that is about 50% bigger than this again.

In parallel we are mentoring the next generation to do the same; team leaders and students will win their own grants and we will encourage them to apply for larger and larger funding.

However, in thinking about this scaling up, we will need administrative support.

Increase research income.

Expectation 1: *Establish a broad sustainable funding base that grows annually to support the Centre's research and goals.*

Target 1: Minimum 15% growth in total research income annually.

Our strategy at InPAC is to engage with industry starting with short term, modest funding, then quickly scaling to large scale collaborations. Our objective is to have three major projects running in parallel: one starting, one mid-term and one ending. We would classify a major project as about $3M (e.g., CRC-P). We do currently hold one CRC-P of this scale with Advanced Navigation and have a number of other candidates with whom we are submitting CRC-Ps in the coming rounds.

We have also applied for an ARC Centre of Excellence. This would provide a total of $35M from the ARC, of which RMIT would receive approximately $14M over seven years. This represents a major funding stream in its own right, but will also create a platform for other major initiatives in coming years.

Increase the quality and number of publications produced by Centre members and research students.

Target 1: At least 3 journal publications from each HDR candidate targeting Q1 outlets

Target 2: Centre outputs grow by a minimum of 15% per annum

Target 3: 75% of publications in Q1 journals.

Expectation 1: *Reinforce the culture of targeting high quality outputs*

At the beginning of each students' PhD journey, they work with their supervisors to map out four potential publications. Some students complete more than that, and we will try to extract those papers even after the students finish their PhDs. We also conceive their projects as three separate publications, with a publication plan to align to.

We encourage Postdocs to produce two first author publications a year, while participating in at least two others. We also ask the same of Team Leaders.

We are ramping up the quality of journals we publish in, for example, we have succeeded in co-publishing in Nature, Nature Photonics and Nature Communications. We have a pending publication in Science due in 2022 in which we are the lead. By showing that our team regularly publishes in these top-tier outlets, we are building a reputation and brand which will help us to achieve future publications in these outlets. We are also showing our team members what is possible and providing them a credible pathway to achieving similar levels of publication performance.

Establish, develop and broaden collaborations and partnerships with key external partners to create tangible impact and enhance the research environment of the Centre and build global engagement.

Target 1: 20% increase in industry funding annually

Target 2: New partnerships

Target 3: Evidence of efforts to broaden and strengthen partner relationships

Target 4: New research impact case studies.

We will aim for an increase of 20% in industry funding annually by working with our current clients to identify their problems. For example, a new project with optical communication components manufacturer Finisar began as a $20,000 project, and we articulated the trajectory of larger scale funding. The project has now risen to a $2M project. Our customer acquisition strategy is to always encourage our industry partners to think about projects at a large scale.

The Centre's Science Communicator uses the InPAC website to share our impact case studies which are shared on Twitter and LinkedIn. Four case studies were developed in 2021 and can be found on the InPAC case studies page.

Expectation 1: *Establishment of a significant multi-party externally funded Research Centre within five years (e.g. ARC Centre of Excellence (lead, or node)*

We currently have an application in its final stages for an ARC Centre of Excellence in Optical Microcombs for Breakthrough Science (COMBS). We have a 9 in 17 chance of this Centre succeeding.

Expectation 2: *ARC Industrial Transformation Research Hub or Training Centre*

Our recent recruit Sumeet Walia has already begun the process of preparing an ARC Industrial Transformation Research Hub in photonic sensors for different applications, however this will be for the 2023 round.

Expectation 3: *Cooperative Research Centre (lead or key participant)*

In our first year of operation as a Centre in 2020 we were awarded a $2.8 million Cooperative Research Centre Projects (CRC-P) grant with navigation system manufacturer Advanced Navigation.

We are actively working on two more of these (one in methane sensors and another with Finisar in data communications). Other opportunities are emerging in fibre sensors.

Expectation 4: *Industry funded research centre.*

With the establishment of the Breakthrough Victoria fund, there are new opportunities for commercialisation of our technology. One opportunity is emerging in ultra-high speed free space communications (e.g., to satellites with electro-optic systems). Long term, our strategy would be to have sufficient preliminary work to achieve Medical Research Future Fund support for commercial development of our biosensors and microfluidics devices for biomedical applications (however this would be in future years).

Expectation 5: *Active monitoring, tracking and recording of research impact and path to impact and the promotion of Centre research impact internally and externally.*

Using the RMIT Research Centre and Group Report Dashboard, we can track the amount of funding we receive from one year to the next.

To better understand our external promotion, we use Google Analytics to measure the amount of traffic going to the InPAC website (www.rmit.edu.au/inpac) each month.

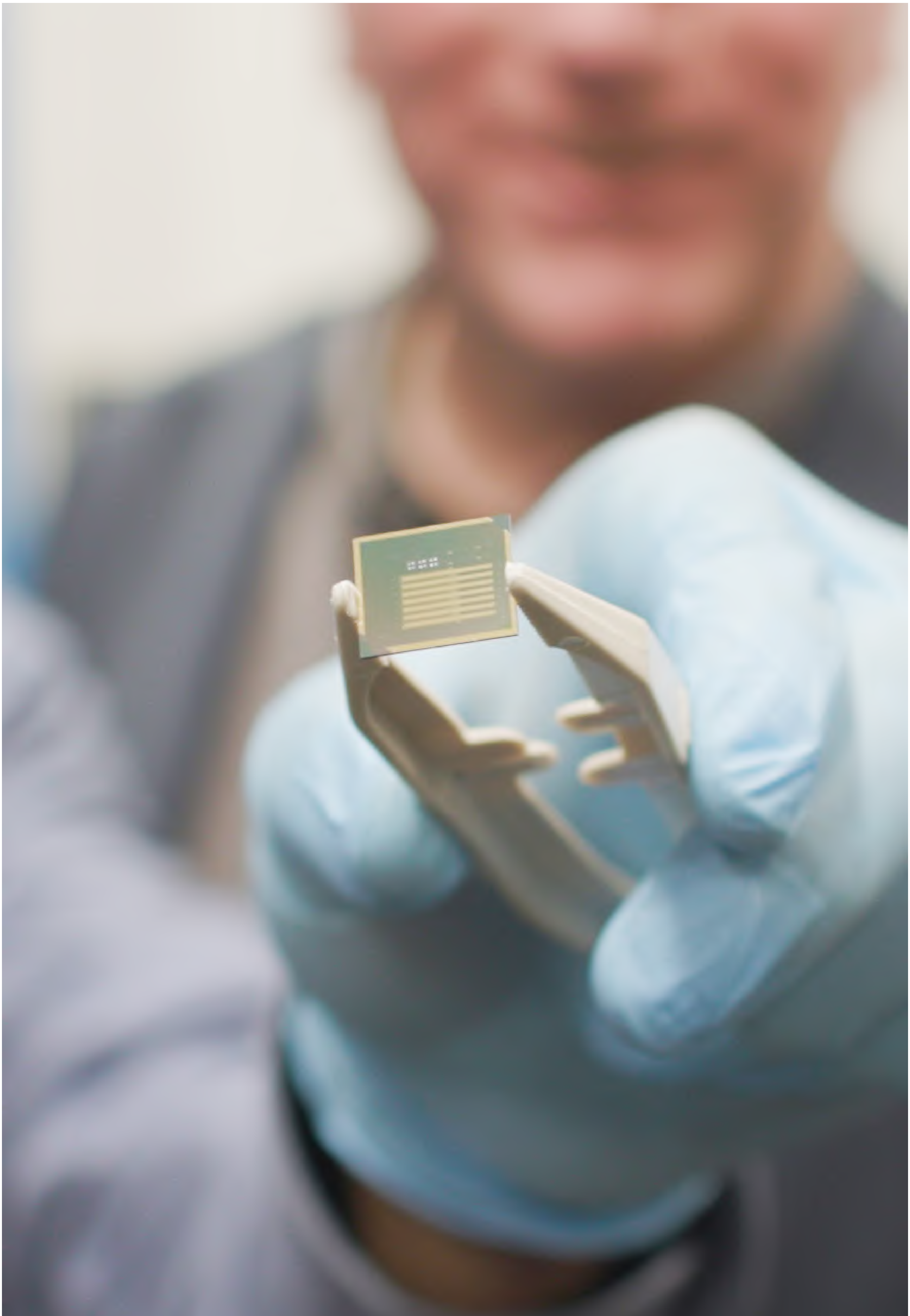
New InPAC case studies are housed on the case study webpage – these demonstrate our real-world impact and act as an advertising tool for future partners. They include testimonials from our project partners which is a way to gauge our research impact. Printed versions of these case studies are also disseminated to our laboratory visitors.

We also constantly evaluate engagement of our social media posts across our researchers' and Centre account and adjust accordingly. Our Science Communicator Rachael Vorwerk monitors the success of each post and offers advice to researchers to keep building their profile.

This section compares the Centre outcomes against the expectations set by the STEM College for RMIT Centres.

We'll be looking for an increase of 15% of all our performance measures for 2022.

Performance Measure	Target	2020 Outcome	2021 Outcome
Research Findings			
Number of research outputs			
Q1 Journal paper	20	28	35
Provisional patents	1	1	0
Quality of research outputs			
Journal paper with impact factor > 6	5	9	7
Post deadline presentations	0	0	0
Number of invited talks/papers/keynote lectures given at major international meetings	2	2	5
Number and nature of commentaries about the Centre's achievements			
Media releases	1	0	2
RMIT articles	1	3	1
Research Training and Professional Education			
Number of new HDR students			
PhD	5	5	6
Master	0	0	3
Number of HDR completions			
PhD	2	1	1
Master	0	0	0
Number of new postdoctoral researchers recruited	0	1	4
Number of Early Career Researchers (within five years of completing PhD)	3	3	7
Number of students mentored	15	20	20
International, National and Regional Links And Networks			
Number of international visitors and visiting fellows	3	4	0
Number of national and international workshops held/ organised by the Centre	1	0	0
Number of visits to overseas laboratories and facilities	3	0	0
End-User Links			
Number of government, industry and business community briefings	3	3	2
Currency of information on the Centre's website Number of unique visitors per month	Monthly 100	Monthly 220	Monthly 243
Number of public talks given by Centre staff	5	2	3
National Benefit			
Students in industry	1	1	1
Technology transfer	0	0	5
Industry/end-user collaboration	0	0	8

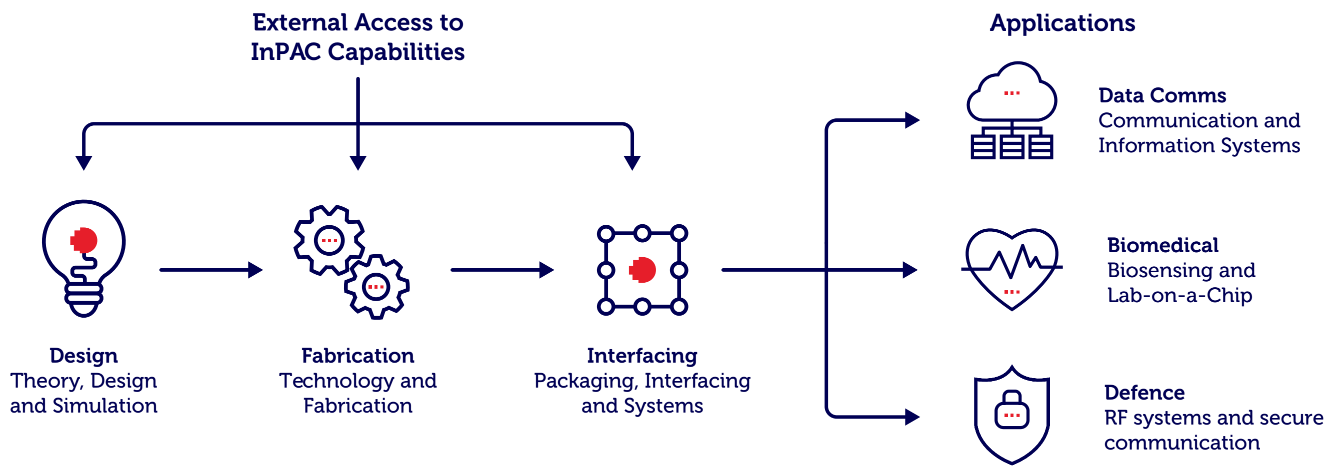


Key Research Areas

Our team at the Integrated Photonics and Applications Centre is made up of six teams that work with industry and academia to design, prototype and scale-up photonic chips to make new products.

The team has the capability to work with industry and research partners to think of new ideas, create chips, then test them in a real-world environment – all in a matter of weeks.

All our capabilities and expertise are concentrated at the RMIT Melbourne City campus, which enables us to rapidly advance photonic technologies, whilst ensuring this technology can be genuinely useful in the real world.



Steps to Designing an Integrated Photonic Chip

1. Theory

Our team is made up of academics that are constantly testing and publishing research – we draw on this in-house knowledge in every process.

2. Device Simulation

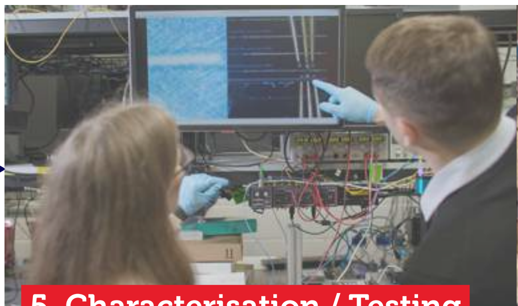
We use the IPKISS design framework to simulate all our chips to ensure all our designs are industry-compliant and scalable to mass manufacture.

3. Design

To make any design plug-in in with your existing systems, we draw from our library of tried-and-tested integrated photonics circuit components.

4. Fabrication

This phase involves printing the chips and testing that everything we've created performs in the way it was intended.

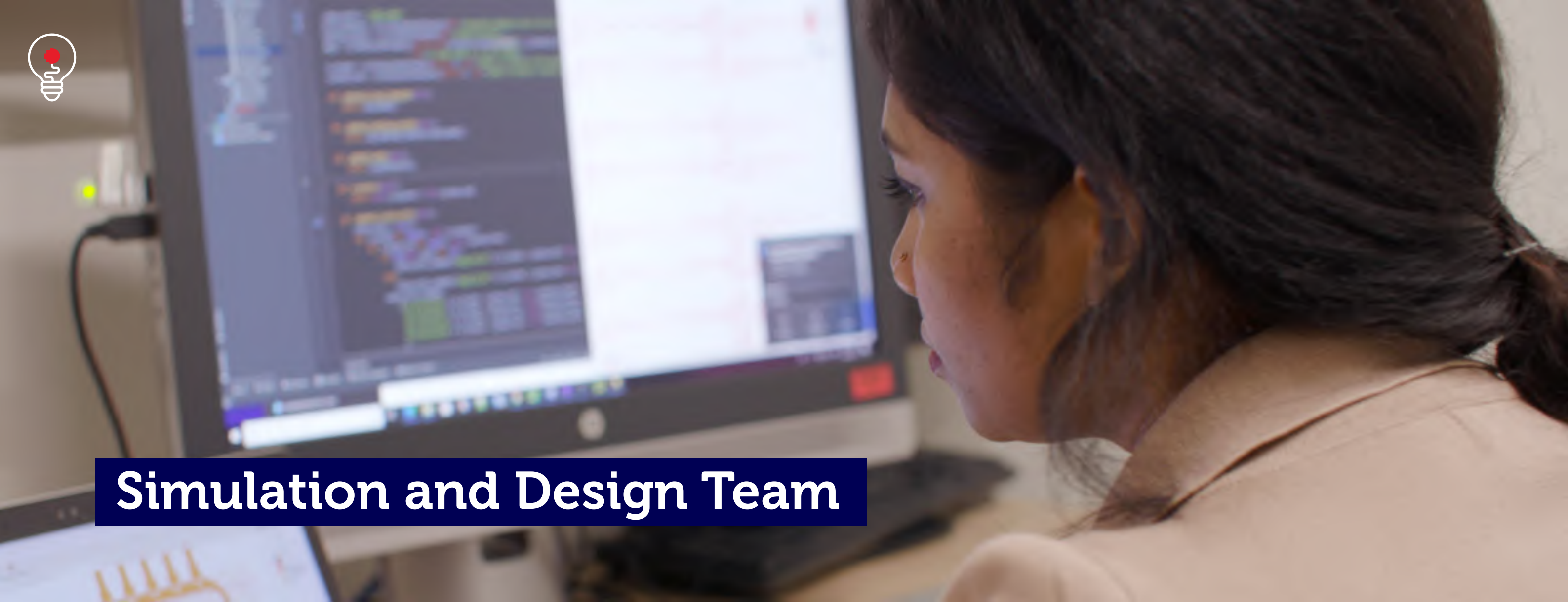


5. Characterisation / Testing

Once we have fabricated your chip, we do a number of tests to measure the performance of the chip to make sure it is behaving optimally.

6. Packaging

After the chip is performing optimally, we can create permanent electrical (wire bonding) and optical (fibre) interfaces to connect to any standard circuit boards.



Simulation and Design Team

As the design team, we understand that a complete integrated photonics design framework is crucial for success. We use the industry standard IPKISS design framework, which covers the complete circuit design flow process. Our partner Luceda Photonics created this software for the design, simulation and layout of photonic integrated circuits.

Designing for industry compliance and mass manufacture

To ensure that designs are industry-compliant and scalable to mass manufacture, we are continuing to develop many significant plug-ins for the IPKISS framework. These include direct interfaces and process design kits for a range of electron-beam lithography tools, automated characterisation tools, and a comprehensive electromagnetic simulation suite called REME.

Our goal is to create products for our users as scalable as possible, to ensure our designs fit into their existing systems. We also ensure that the chips we create will behave as intended, by designing and simulating our chips in the computer first before making them in the lab.

Research achievements

- We created a mature Silicon Photonics platform
- Translated our silicon photonic platform to Lithium Niobate on Insulator platforms to:
  - extend simulation tools to account for LiNbO3 unique properties
  - improve understanding of higher than usual loss on Lithium Niobate on Insulator rings
  - lithium niobate on Insulator Process Design Kits
- Interfacing IPKISS design with characterisation
- Haijin Huang was joint first author in a journal article
- Kokou Firmin Fiaboe submitted his first journal publication
- Tasneem Akther went through the first full Photonic Integrated Circuit design cycle
- Editors' pick for the Journal in Optics Express
- Involved in eight journal publications with InPAC and collaborators

New supercomputing facility to create photonics faster than ever before

With the launch of a dedicated RMIT Amazon Web Services (AWS) Cloud Supercomputing (RACE) Hub, RMIT researchers will be able to more easily process huge volumes of data in less time.

The Challenge

Finding computing that is powerful enough for our immense data sets

From simulating and visualising how to create a brain-like computer chip to understanding how light interacts with molecules, our researchers at the Integrated Photonics and Applications Centre rely heavily on high performance computing to carry out their work.

The unique challenge is that the team needs scalable computing infrastructure, or computing power, that can expand and contract when the task demands it. This is currently unavailable and as a result, dramatically slows down analysis.

Our Response

Partnering with RACE Hub to use the cutting-edge cloud technologies to unlock the value of data

To help with processing large data sets, RMIT has become the first Australian university to implement a dedicated commercial cloud supercomputing facility: RMIT Amazon Web Services (AWS) Cloud Supercomputing (RACE) Hub.

The RACE Hub will allow researchers and students within RMIT's industry hubs – including our Integrated Photonics and Applications Centre – to access scalable computing infrastructure.

The Results

Testing data-hungry processes to try to overload the system

Our Simulation and Design Team Leader, Thach Nguyen, is currently testing the RACE Hub platform by performing complex computing-hungry processes – like simulating and visualising the propagation of light on an integrated photonic chip – to try to overload the system to see if it works.

Direct access to the RACE Hub platform means that when he wants to design and simulate brain-like chips, or to create a chip which could break the record for the world's fastest internet, he can now run multiple processes all at once, with computing capability that will expand and scale as he needs it.

For the Integrated Photonics and Applications Centre, this new kind of efficient high performance computing capability creates a number of exciting applications including helping us to rapidly design and prototype chips faster than ever before to make our internet faster, helping drones more accurately inspect railway infrastructure, and building portable, handheld devices that could detect ovarian cancer more accurately.

RACE Hub is the collaboration between RMIT, Amazon Web Services and AARNet, and is supported by the Victorian Government Higher Education Investment Fund.

Read more about the partnership at
www.rmit.edu.au/news/all-news/2021/jul/aws-supercomputer

Fabrication Team

Our fabrication team works very closely with the simulation and design team to ensure that everything we fabricate performs in the way it was intended.

Research achievements

- We created prototypes for many users, including:
  - Industry end-users: Baraja, Bluglass and a US-based company
  - Academic users: Lanzhou University, Ghent University and the University of Sydney
  - InPAC users: Biomedical Applications Team, Defence and Precision Sensing Team, Data Communications Applications Team
- Silicon Niobate and Lithium Niobate on Insulator platform: waveguide propagation loss to ~0.25dB/cm
- Maintained silicon photonics platform
- Our team won the following fellowships and awards in 2021:
  - Dr Nitu Syed: McKenzie Postdoctoral Fellowship
  - Aditya Dubey: RMIT International Competitive PhD Scholarship
  - Sonya Palmer: Fulbright Fellowship
- Involved in 18 journal articles

Creating many fabrication platforms ready for many applications

The focus of our team is to fabricate integrated optics platforms for many different applications. The platforms include silicon photonic platform (Silicon and Silicon-Nitride), and hybrid integrated silicon photonic platform (Silicon + 2D materials, Silicon + Silicon-Nitride, and Silicon-Nitride + Lithium Niobate).

Our team also develop process design kits for different platforms, which make up a library of building blocks for end-users to create sophisticated photonic integrated circuits compatible with mass manufacturing standards.

Keeping up with the world's need for ever-faster internet

In collaboration with Lanzhou University in China, we created a commercially available chip capable of accurate and rapid data transfer to keep up with the world's demand for faster internet bandwidth and speed.

The Challenge

Keeping up with pressure on our internet infrastructure

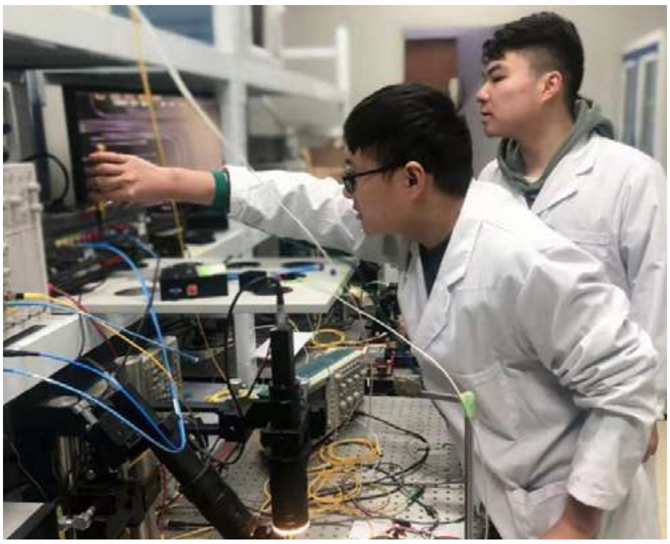
It's predicted that by 2022, the world's internet traffic will reach 4.8 zettabytes (or 700 billion Blu-ray discs). This puts more and more pressure on our internet infrastructure to carry more data, all with the need to consume less energy.

Our Response

Lessening the data burden with more robust infrastructure

In collaboration with researchers from Lanzhou University in China, we experimented with two novel approaches that could lessen the data burden on the optical networks that underpin our internet.

One approach is the combination of two powerful materials – silicon nitride and lithium niobate – to make fabrication easier and data transfer amounts larger. The other novel approach is multiplexing – a technique that allows rapid transmission of data along multiple channels at the same time.



Mr. Xu Han (right) and Mr. Yongheng Jiang (left) working in the lab at Lanzhou University.

The Results

Creating a commercially available chip capable of rapid data transfer

The team were able to create a commercially available chip, capable of accurate and rapid data transfer. This finding also appeared in an article on the front cover of the January 2022 edition of the Laser and Photonics Reviews journal.

This paves the way to keep up with our demand for ever-faster internet transmission to future-proof our infrastructure for years to come.

Read more about the research at
https://onlinelibrary.wiley.com/doi/10.1002/lpor.202270001

Biomedical Applications Team

Our team is made up of biomedical researchers, biotechnologists, chemists and engineers that work to advance diagnostics by offering advanced tests for early illness prediction.

Research achievements

- Successful NHMRC ideas grant worth $999,428, that will be conducted over three years for early diagnosis tools for ovarian cancer.
- Seven grants applications
- Eight active research projects
- Eight collaborative research projects with national and international partners and industry
- HatiSens was launched out of the Biomedical Applications Team at InPAC through the Medtech Actuator Program. The team received seed funding of $200K and presented at the MedTech Showcase.

The HatiSens team from L-R including Dr César Sanchez Huertas, Distinguished Professor Arnan Mitchell, Siew Joo Beh, Professor Karlheinz Peter, and Dr Markus Knoerzer.

Combining photonics and microfluidics to create on-the-spot diagnostic tests

Many procedures, from cancer diagnosis to even a COVID-test, require very manual laboratory procedures under supervision of specialists. To overcome these wait times and need for specialist knowledge, we are miniaturising equipment that normally takes up entire laboratory benches, onto a chip the size of a fingernail.

This is thanks to the combination of two research fields – ultrasensitive biosensors powered by light and complex microfluidics – that allow us to create ultrasensitive on-the-spot-diagnostic tests that have the potential to rapidly detect viral infections, allergies or diseases.

Detecting single cells and tiny molecules with ultrasensitive biosensors powered by light

We are looking to create robust and ultrasensitive photonic biosensors, capable of detecting the presence of single cells and molecules. In addition, we are creating multiplexed platforms that can perform different processes automatically in the same microchip. We intend to create this by experimenting with new microfluidic fabrication and signal processing approaches.

Creating a device for early detection of ovarian cancer

We're tackling the world's most lethal gynaecological cancer, to diagnose the disease even before symptoms arise.

The Challenge

Detecting a cancer that mimics the symptoms of other conditions

Every year ovarian cancer takes the life of a quarter of a million women worldwide, including 1,800 Australians. For every woman diagnosed with ovarian cancer, 70% will discover they are in an advanced state, and only 25% of these women will survive beyond five years.

The symptoms of ovarian cancer are commonly misdiagnosed as gastrointestinal or bowel problems, leading to these high rates of late diagnosis. There is also no early detection test for ovarian cancer. Currently, the only reliable diagnostic method is an invasive biopsy performed by a specialist that, when positive, is followed by intense chemotherapy with no time for recovery.

Our Response

Bridging disciplines to make ovarian cancer diagnosis more accurate and accessible

In November 2021, our team won a National Health and Medical Research Council (NHMRC) valued at $1M to create a more portable, inexpensive handheld device to more accurately detect ovarian cancer.

The team brings together engineering and biomedical experts at RMIT University, led by ovarian cancer specialist Magdalena Plebanski and integrated photonics specialist Arnan Mitchell.

The research team from L-R including: Dr April Kartikasari, Distinguished Professor Magdalena Plebanksi, Dr César Sanchez Huertas and Distinguished Professor Arnan Mitchell.

The Results and Current Progress

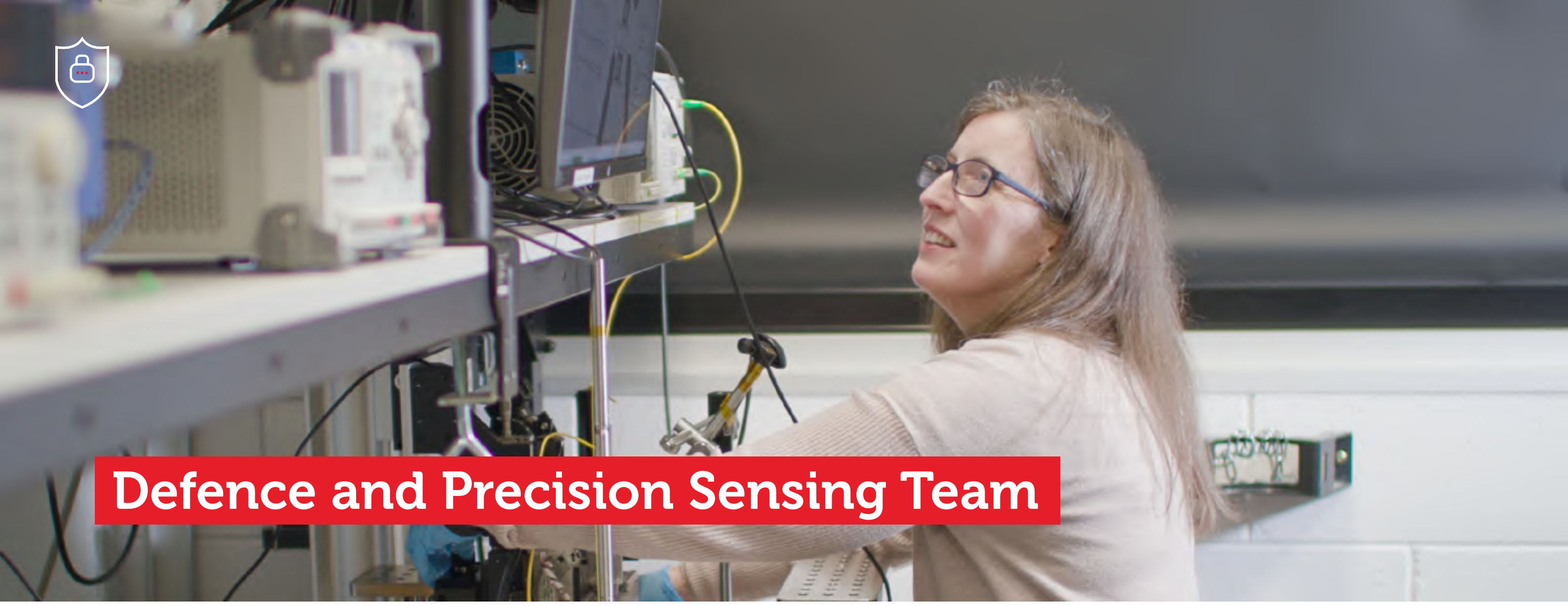
Developing a device that sees ovarian cancer before symptoms even start

Our team has discovered the biological markers present in patients with ovarian cancer, which appear years before symptoms even arise.

To be able to rapidly and accurately test for these ovarian cancer markers, the team are using two main approaches: photonic biosensors and microfluidics. Photonic biosensors contain up to 100 tiny sensors and use light to rapidly 'see' specific biomolecular markers – like those in ovarian cancer patients. Complex microfluidics are tiny automated filtration devices that can rapidly filter for cells or proteins in a tiny sample of blood.

We hope to create an accessible, reliable and cost-effective screening tool for ovarian cancer to be used by in-clinic GPs with these techniques. If successful, this research will save thousands of Australians' lives, with faster ovarian cancer diagnosis than ever before.

Read more about the research at
www.rmit.edu.au/news/all-news/2022/feb/ovarian-cancer-early-detection



Defence and Precision Sensing Team

Our team aims to engage with industry and defence agencies to provide integrated photonic solutions for more precise, accurate and compact sensors.

Creating smaller, more accurate sensors for growing industries

At InPAC we are investigating new photonic platforms like lithium niobate on insulator and silicon nitride and employing them for defence-related products. A special focus is set on energy efficient, compact, lightweight and robust (mechanical and electro-magnetic) solutions. The new photonic platforms will help to make sensors small enough to fit on drones for railway monitoring, satellites travelling at 11,000 kilometres per hour, and driverless vehicles for rapid decision-making.

Embedding sensors onto drones to monitor railway infrastructure health

In 2021, a focus area for our team is to fabricate the first chip prototypes for the Cooperative Research Centre Project to test more compact optical gyroscopes with our industry partner Advanced Navigation. This will also include increasing the maturity of the integrated photonic platform and focusing on technological challenges such as low loss optical interfaces.

PhD student Paramjeet Kaur at Ghent University, Belgium.

As part of this work, we will also hire two additional high-calibre research fellows and PhD students on the industry projects, which will help to grow our team in 2022.

Top five research achievements

- Cooperative Research Centre Project (CRC-P) came into full swing (most photonic integrated circuit components are ready)
- Advanced Navigation launches Boreas, the world's first fully digital fibre optic gyroscope in May 2021
- Started the ARC Linkage Project with Advanced Navigation (chip scale movement sensors)
- Luke Broadley demonstrated highly sensitive sensors for structural health monitoring in collaboration with Office of Naval Research Global (ONRG) and Defence Science and Technology (DST)
- PhD student Paramjeet Kaur is hosted at Ghent University for a year with Professor Gunther Roelkens to work on photodetector integration.
- Dr Andreas Frigg graduated from his PhD.

On-board navigation reference systems to explore deeper space

By using the most precise measurement devices on Earth – that measure the movement of atoms – our team is miniaturising on-board reference systems for more precise navigation for autonomous vehicles and deep space exploration.

The Challenge

Exploring deeper space needs less bulky equipment

The devices that help us to keep time in space are currently large – some as big as entire laboratory benches – and dependent on sending signals back to Earth to recalibrate where they are. This essentially keeps these timekeeping devices tethered to Earth.

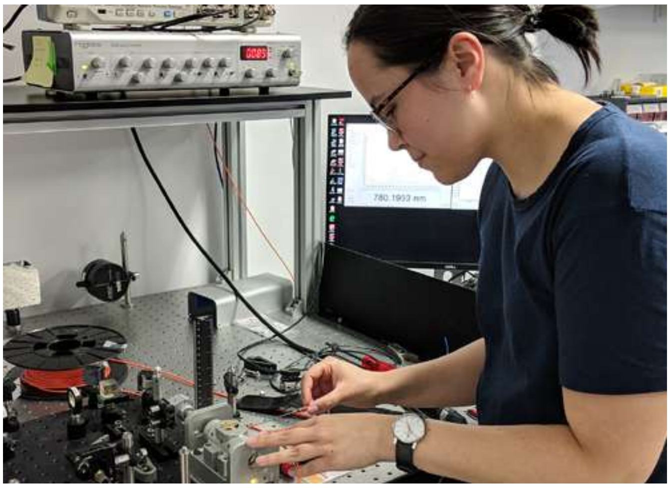
If we want to explore deeper space, we need to firstly miniaturise the pieces of equipment on board that help to keep time. This will also help spacecraft to measure their position in space, with a self-referencing system, rather than needing to send a signal back to Earth.

Our Response

Creating compact devices with the most sensitive measurement devices

To make deep space exploration more accurate, our team partnered with Melbourne-based laser manufacturers MOGLabs. Sonya Palmer, a PhD student at our Centre is working with MOGLabs to create measurement devices called quantum sensors that are the most accurate measuring device we have. These devices measure the world at the atomic level.

Quantum sensors are extremely sensitive measurement devices that exploit the properties of atoms to infer information. An atomic clock is a quantum sensor that measures the frequency of an electron transitioning between the energy levels of an atom and uses this to determine a reference for time.



Sonya Palmer in the labs of MOGLabs assembling a tuneable laser system for more compact measurement devices.

The Results and Current Progress

Collaborating to miniaturise atomic clocks that will fit onto spacecraft

In 2020, Sonya Palmer received a Fulbright Scholarship to go to the University of California with Professor John Bowers to miniaturise atomic clocks so they could potentially fit onto spacecraft. The scholarship aimed to create a highly specialised laser on a chip.

The aim going forward is to make these precise measuring devices smaller, but to also increase their functionality and impact. If we were able to put a precise optical atomic clock on board GPS satellites, we could increase the precision of their distance measurements to just centimetres – which could be used to land planes or navigate autonomous vehicles.

Miniaturised precise navigation systems will also allow us to venture deeper into space than ever before.

Read more about the research at
https://aip.scitation.org/doi/full/10.1063/5.0097880

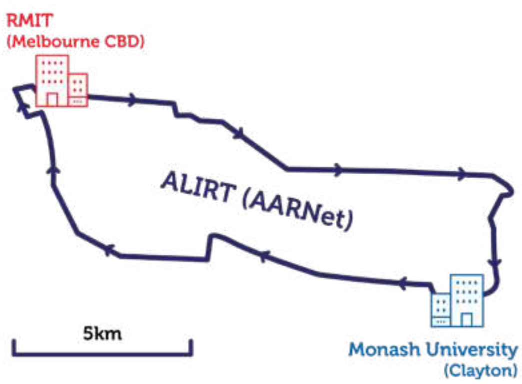
Data Communications Team

Our team explores how cutting-edge integrated photonics can achieve ultra-high speed data communications by exploiting new wavelength ranges, new advanced modulations formats and ultra-dense spatial and spectral multiplexing.

Increasing the bandwidth for faster internet for everyone

To achieve the ultimate internet data capacity over our optical fibre links, future communication systems will need to use the fully available bandwidth. A way to do this is with a device called a microcomb that creates a rainbow of infrared light allowing data to be transmitted on many frequencies of light at the same time, vastly increasing bandwidth.

To test these internet speeds, our team sends information around "real-world" fibre links, like those of Australia's National Broadband Network. InPAC hosts the Australian Lightwave Infrastructure Research Testbed (ALIRT)* – a unique 'dark fibre' facility provided by Australia's Academic Research Network (AARNet) – to allow collaborative research between institutes in Melbourne.



Research achievements

- Successful first stage application for Centre of Excellence (COMBS)
- Unsuccessful Future Fellowship and LIEF applications
- Two meaningful engagements with potential industry collaborators
- The Data Communications published seven papers:
  - One *Nature* (with Swinburne, photonic neural nets)
  - Two papers by Chawaphon (Park) Prayoonyong as first author (JLT and OpEx)
  - Others with non-InPAC authors

Breaking our world's fastest internet record and translating the results to industry

We are combining three key approaches to extend upon our record result from 2020 to pack even more data into our existing optical fibre infrastructure: new microcomb technologies, InPAC's state-of-the-art lithium niobate platform, and wavelength conversion technologies. This combination will bring us closer to translating our record results to industry, to grow capacity and extend the usable lifetime of systems like Australia's NBN.

*ALIRT is part of the InPAC laboratories linking RMIT and Monash University. The testbed was established under ARC Linkage Infrastructure and Equipment Funds LE170100160 as a collaboration between RMIT, Monash, Swinburne and AARNET. This project was supported by ARC Discovery Project 'Rainbows on Demand: coherent comb sources on a photonic chip' DP190102773.

Helping the world's fastest internet go where it's needed most

COVID-19 placed immense pressure on the world's data communications infrastructure as more people worked from home than ever before, demonstrating the need for faster internet speeds.

The Challenge

Ensuring that people in remote areas have access to high-speed internet

In 2020, our teams' chip that was a chip the size of a fingernail broke the world record for the fastest internet speed on a single optical chip at a speed of 39 Terabits per second, capable of downloading 1,000 high-definition movies in a single second.

Given that internet traffic is growing at 25% per year, these results were very promising. The next challenge is to open us internet access to everyone, and to get data to more places than before, including remote places like those struck by natural hazards or war.

There are two challenges remaining if we want to make higher-speed connections more accessible. Firstly, the remaining 80 components need to be miniaturised onto a chip so they can be easily installed anywhere in the world. And secondly, while our chip is already capable of transferring data at rapid data rates, it needs to also be efficient at operating at lower power to enable it to work in places where power is scarce. However, operating at low power introduces increased noise into the system, which can dramatically slow down internet speeds.

Our Response

Making high-speed internet accessible to all with an energy-efficient, easily deployed chip

To miniaturise these 80 components onto the same optical chip, our team needed a material capable of completing many functions at once. Our team investigated thin film lithium niobate, a material that is fast and allows a lot of components to work in unison on a single chip.

In making a more energy-efficient chip capable of maintaining high data transfer rates, our PhD student, Chawaphon (Park) Prayoonyong, explored how to reduce the impact of noise in the chip so that it remained efficient, while still maintaining the high data transfer rates.

The Results

One step closer to accessible internet for everyone through an ultra-high speed, compact and energy efficient transmitter

In 2021, the team at the Integrated Photonics and Applications Centre developed key components on the thin-film lithium niobate material, demonstrating high-speed modulators (devices for putting data on light) to make high-speed internet accessible to everyone. This technology will help to shrink an entire benchtop's worth of equipment onto a chip, so the chip could be easily installed into global internet infrastructure easily without the need for bulky equipment.

The team were able to address the second challenge of creating a chip efficient enough at operating at low power or when power is scarce, by reducing the amount of noise on the chip so the signal was clearer. The result was an energy-efficient chip capable of rapid-data transmission, which reduced the impact of noise by a factor of 10.

By overcoming these two challenges, the team is one step closer to making the world's fastest internet more accessible. With this, we'd be able to support higher-speed connections out to regional areas, or in new contexts like space. Space communications using microwaves (like our mobile phones do) could open up new connections in remote communities. This means that when lines are cut (due to natural disasters or war), there are still connections available. Optical communications have the potential to increase speeds of space communications by factors of 100 or more.

This means that the internet will be able to move to further distances with more reliability, all with small energy-efficient devices that can plug into any system. Our hope is that with this new device, high-speed internet will be cheaper and easier to install, making it more accessible to all.

Read more about the research at
https://ieeexplore.ieee.org/abstract/document/9488197

Media and Communication

The InPAC Science Communicator, Rachael Vorwerk, managed the Centre's media and communications strategy in 2021.

Objectives

The main objective was to build the Centre's profile and continue to grow InPAC's presence on social media and with the media.

Building the Centre's profile

- Four case studies were added to the InPAC website and promoted via the Centre's social media accounts and in print version for visitors to the InPAC lab.
- A photoshoot was conducted of the InPAC team on June 21st, 2021 to build a library of content for social media posts, Annual Reports, and future media releases.
- Throughout the year, InPAC team members built their web presence on social media and were featured on the Centre's social media channels.

Social Media

- The Centre continued to grow its LinkedIn page from 107 to 405.
- The InPAC Twitter account also increased its following from 225 followers to 330 followers.

Media

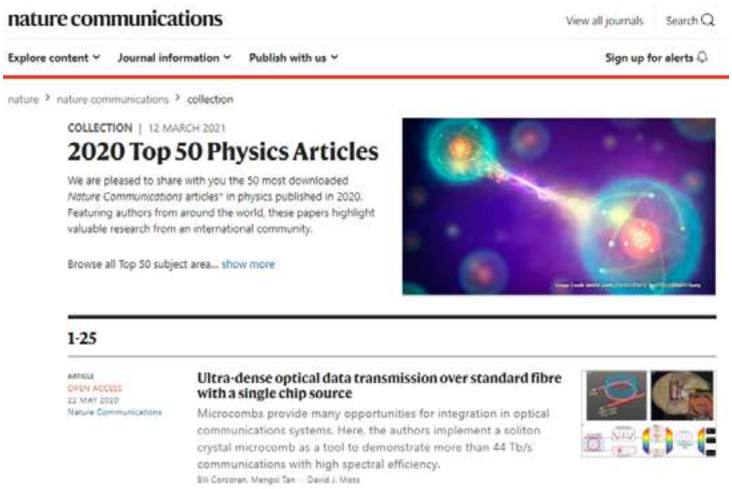
- In 2021 one RMIT media release was sent out, while two industry partners – Nirtek and Advanced Navigation – published media releases about collaborations with InPAC.

Outcomes

Australian researchers record world's fastest internet speed from a single optical chip | 22 May 2020

Researchers from Monash, RMIT and Swinburne universities have achieved the world's fastest internet data speed – enough to download 1,000 HD movies in a split second – using a single optical chip.

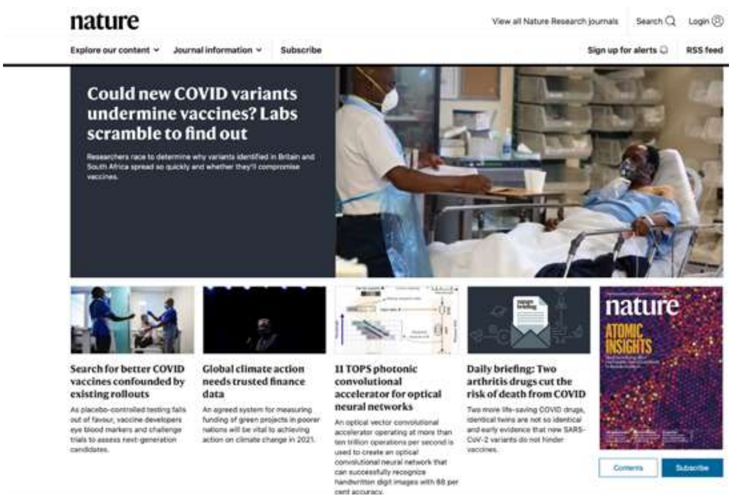
- The journal article was the 2020 top 50 Physics Articles in Nature Communications in 2021.



Researchers demonstrate world's fastest 'brain-like' processor | 7 January 2021

An international team led by Swinburne in collaboration with RMIT and Monash universities has demonstrated the world's fastest and most powerful optical neuromorphic processor for artificial intelligence.

- The world's fastest 'brain-like' processor Nature journal article was led by Swinburne University.
- Monash University and RMIT published separate articles, leading to published articles across 38 news outlets including Science Daily, Interesting Engineering and Tech Xplore.
- The story also featured on the homepage of *Nature*.

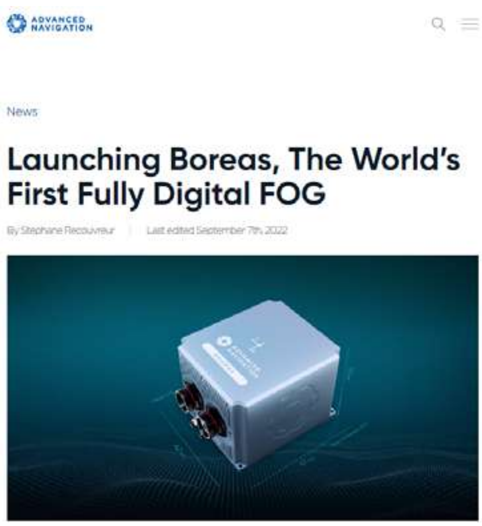


Start-up launches new laser tech to prevent heart attacks | 8 February 2021

A new Australian company called Nirtek is gearing up to develop and commercialise innovative technology that uses lasers to detect unstable coronary plaques, the leading cause of deadly heart attacks.

- Baker Heart and Diabetes Institute led the media release about a device to prevent heart attacks that was created with InPAC
- The media release led to segments in Nine News, Seven News, Channel 10 and the Herald Sun

Launching Boreas, the world's first fully digital fibre optic gyroscope | 26 May 2021



The Boreas is an ultra-high accuracy, strategic-grade inertial navigation system, offering a 40% reduction in size, weight, power, and cost relative to competing systems.

- Advanced Navigation led the media release
- InPAC printed optical components onto a tiny chip to make the digital fibre optic gyroscope more compact and reliable.

Other Highlights

- InPAC got in front of NASA, and shared a one-pager backgrounder with them about how our team can help the space industry.
- A video published on the InPAC Twitter account for National Science Week was watched more than 1,000 times.

Staff and Student Achievements

InPAC is proud to announce that in 2020/21 the students and staff of the Centre had several successful milestones:

PhD Completions

- **Dr. Andreas Frigg**

  Title: A low loss silicon nitride nanophotonic waveguide platform by reactive sputtering

  Photonic integrated circuits (PICS) underpin small and energy efficient devices for the telecommunication, data communications, sensing, LIDAR and quantum computing applications. Andreas' PhD investigated how to create photonic integrated circuits with a low-loss material called silicon nitride, while ensuring their compatibility with large existing fabrication foundries.

Awards and Prizes

- **Arnan Mitchell – Optica Fellow**

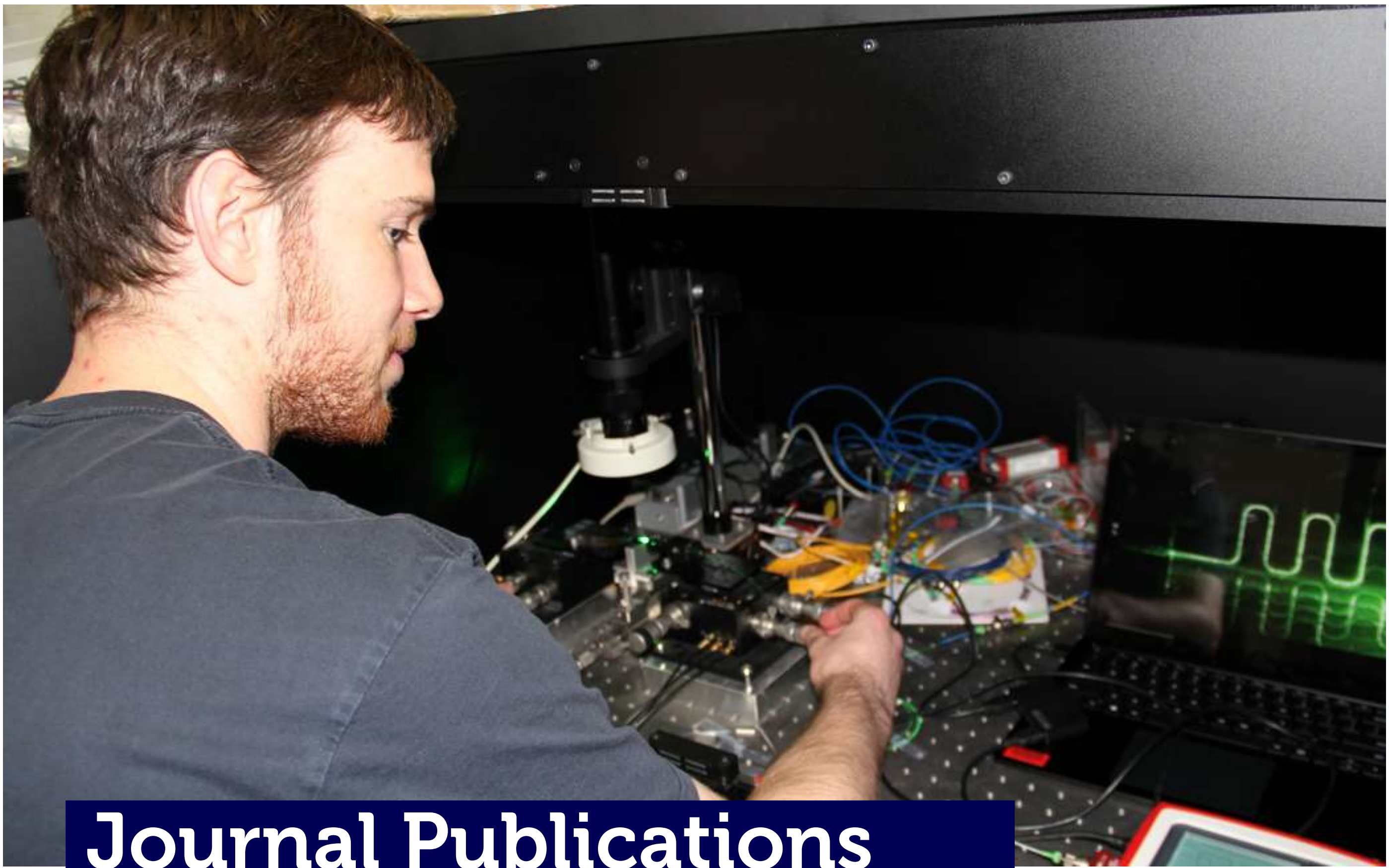
  Arnan was elected as a Fellow of Optica (formerly OSA, the Optical Society America). Arnan was recognised "for outstanding and sustained contributions to integrated photonics research, particularly in the lithium niobate platform".

- **Sonya Palmer – Fulbright Fellowship**

  Sonya visited the University of California in Santa Barbara for five months investigating integrated photonics and semiconductor lasers for satellites and more accurate medical equipment with Professor John Bowers' research group.

- **Nitu Syed: McKenzie Postdoctoral Fellowship**

  The Fellowships Program has been established to attract outstanding recent doctoral graduates to the University of Melbourne from around the world. The program aims to recruit new researchers who have the potential to build and lead interdisciplinary collaborative research activities inside and across Academic Divisions.



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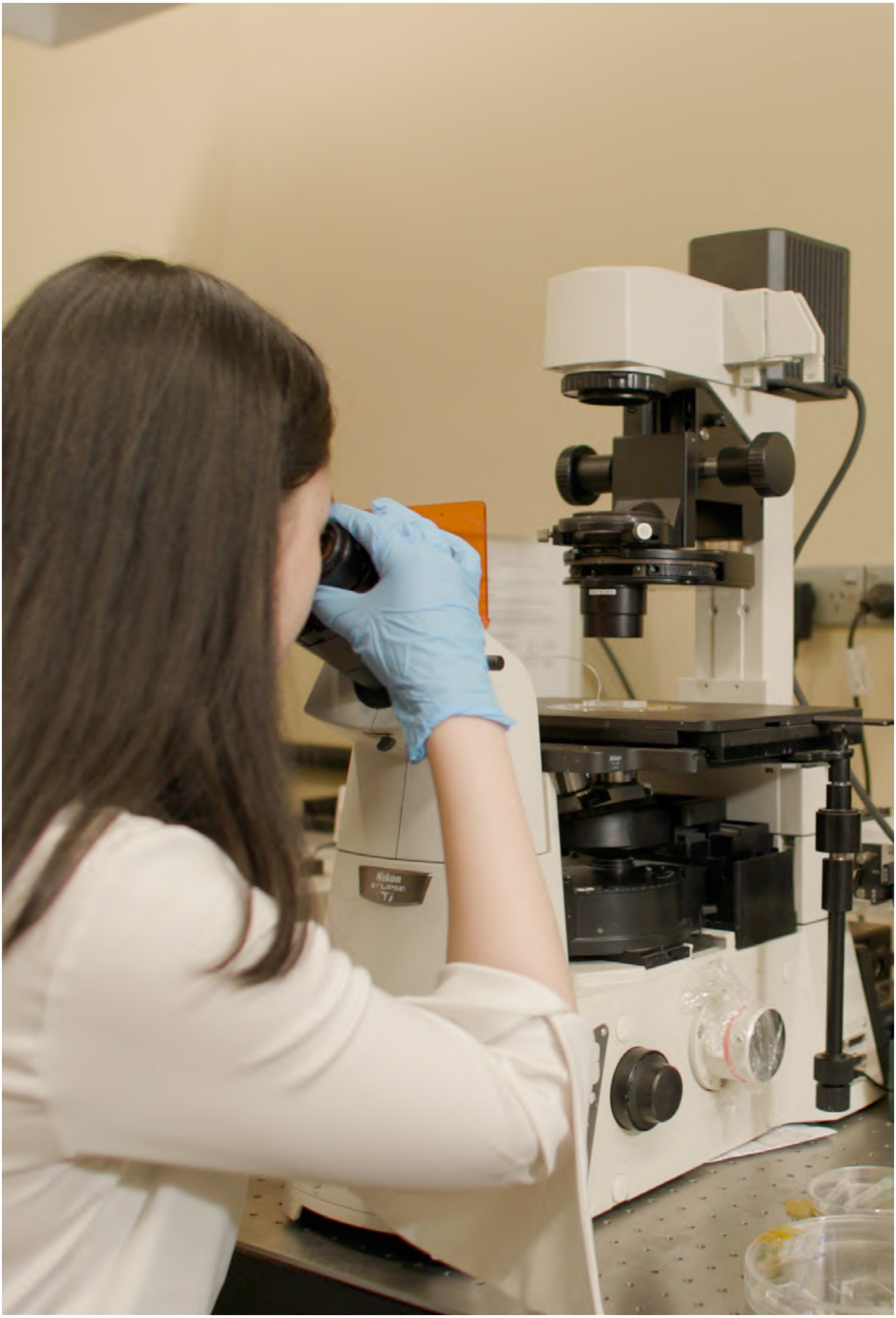
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