

Institute for Photonics & Advanced Sensing (IPAS) Lasers & Nonlinear Optics

Theme Leaders



A/Prof David Lancaster

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; low cost; 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.



Fibre & Planar Waveguide Lasers

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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*, described in the *Optical Materials & Structures* flyer 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 being 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 1.9 μ m. 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.