Chief Investigator Profiles

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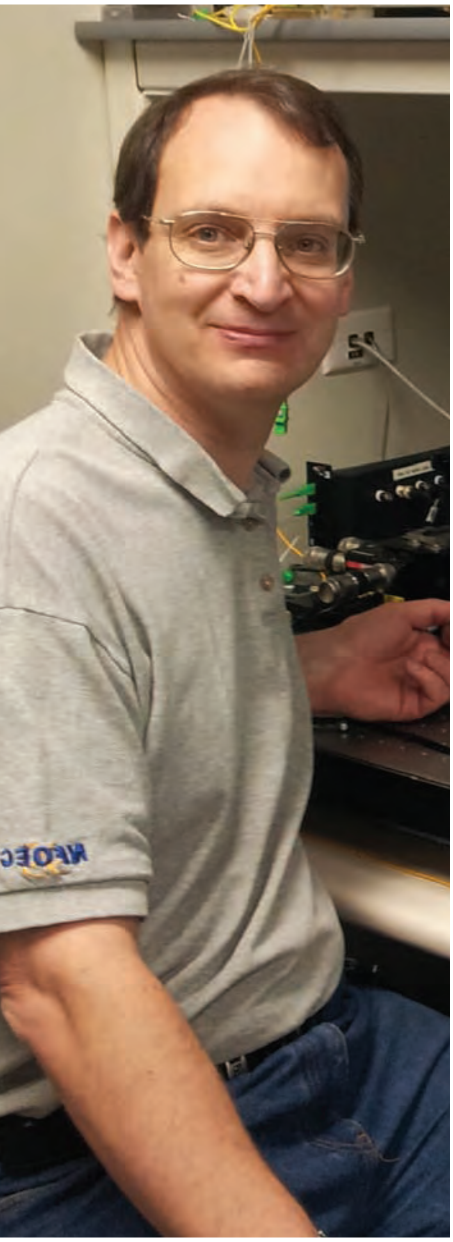
Steve Madden



Associate Professor Madden currently leads research on chalcogenide, tellurite, and polysiloxane integrated optical devices at the Laser Physics Centre, ANU. His research career in fibre & integrated optics spans the period from 1984 to the present in start-ups, multi-nationals, and academia covering a diverse range of areas including liquid crystals, seven different materials systems for planar devices, all-fibre devices, flip-chip hybrid integration, fibre and planar Bragg gratings and devices, planar tunable lasers, optical transmission systems and all optical networking, and non-linear effects in SOAs and planar waveguide devices. The spectrum of work has covered fundamental science through to putting new high technology products into volume production and out onto the market.

Key Areas of Research Contribution

A/Prof Madden's research interests include fibre and integrated optics, planar waveguides, optical transmission systems, optical switching, MIR light generation and processing with integrated optics, semiconductor processing methodology, liquid crystals, optical polymers, tellurite and chalcogenide glasses and devices.

2011 Achievements

The major ANU team achievements for 2011 were centred on the core enabling demonstrations for several of the CUDOS flagship projects. The highest profile results were the realisation of low coupling loss chalcogenide circuits, propagation loss compensation, and MIR chalcogenide devices.

The chalcogenide nonlinear chips fabricated at ANU have been used in many previous CUDOS experiments to demonstrate groundbreaking all optical processing functions. However, coupling light in and out of the very small waveguides requires special lensed-tip fibres to focus the light to a much smaller spot than that of standard optical fibre. This results in significant insertion loss of typically 5dB per end for the waveguide devices and undesirable back reflections from the chip facets. These losses and reflections have now become a major limitation for future advanced research into all optical processing and a solution is required.

The ANU team pursued the development of vertical film taper coupling devices to take the light from a high index, very small chalcogenide waveguide into a much larger and lower index waveguide that is compatible with standard high numerical aperture optical fibres. As the waveguide is index- matched to the fibre, reflections are eliminated and by careful choice of the waveguide size very low coupling losses can be achieved. After much research the ANU team demonstrated a coupling loss per end to Nufern UHNA-3 fibre of <0.4dB per end using the vertical tapers over more than 500nm of optical bandwidth. When implemented early in 2012 with the "standard" type of nonlinear chalcogenide devices used previously, these results are expected to dramatically enhance the nonlinear processing capability in the Terabit per second Optical Communications and Quantum Integrated Photonics flagship projects as the device performance scales supra-linearly with coupling loss.

As research progresses it is also becoming clear that even lower chalcogenide waveguide propagation losses are needed to excite nonlinearities required for functions such as phase sensitive or Raman amplification. Given that losses are currently at world best levels at the 0.2-0.3dB/cm level, and given the very high index contrast of the waveguides, this is not a straightforward task. The ANU group commenced using the newly commissioned optical lithography stepper at Bandwidth Foundry in Sydney to reduce sidewall roughness, but waveguides that are effectively lossless would appear to be the most appropriate implementation. To achieve this they researched a dispersion-optimised hybrid waveguide where the chalcogenide waveguide sits on top of a Tellurium Dioxide cladding that is Erbium doped to provide a small amount of optical gain in the 1550nm band, thereby compensating the propagation losses.

Initial results have been promising. The team demonstrated reduction in loss with low power pumping of the Erbium, and they expect full loss cancellation once the devices are optimised and they can apply full pumping to the waveguides later in 2012. Attaining this under normal operational conditions will have a tremendous impact on the nonlinear processes as true exponential growth of the nonlinear products could be enabled leading to conversion efficiencies that enable a whole new set of applications.

In 2011 Centre researchers commenced the new Mid Infrared (MIR) flagship project. Working in the MIR is much harder and more complicated than in the telecom bands and requires the development and commissioning of a dedicated MIR nonlinear test system. This comprises a high average power 7ps pulse source operating in the 3.4 micrometre band, a fully achromatic waveguide coupling system, and a 1.5-5.5 micrometre Indium Antimonide camera system for visualisation. The system is now fully operational. The researchers also fabricated the first dispersion optimised chalcogenide waveguides aimed at MIR supercontinuum generation during the year, based on a chalcogenide waveguide atop a Tellurium Dioxide cladding. Although the fabrication was successful, further work is needed in 2012 to reduce the OH absorption in the Tellurium dioxide to optimise the performance and generate broadband MIR light for the first time.