

Industry Focus

DSTG has recognised the need for commercialised high-powered lasers in Australia.

Enabling scalable, high-powered lasers in Australia

Professor David Lancaster from the University of South Australia and Dr Dmitrii Stepanov from the Defence Science and Technology Group speak to Alexandra Cooper about a new project to develop cost effective components for the next generation of high-powered lasers.

USED for a wide range of applications within the manufacturing sector, laser technology has been recognised by the Defence Science and Technology Group (DSTG) as a disruptive technology that is greatly needed in Australia, and as a precise method for cutting, marking and 3D printing among others. However, it typically has been an expensive tool to develop and commercialise, which has left Australia in the dust in terms of global competitiveness.

The University of South Australia, in partnership with the University of Adelaide, has embarked on a new \$1.8 million project that is

developing unique manufacturing platforms for producing reliable, affordable, miniature and integrated optical components. The goal is to underpin commercialised, next-generation high-powered lasers built in Australia.

Funded under the Next Generation Technologies Fund by the DSTG, the aim is to link the university-led science and technology with Australian Defence needs, and align with plans to bolster Australia's sovereign Directed Energy (DE) capabilities.

Instigated through the DE science and technology network of university and industry partners, the project

will help build an ecosystem of laser technology throughout Australia, especially in manufacturing and defence.

EOS Professorial chair in Laser Physics, David Lancaster, leads the Laser Physics and Photonics Devices Laboratories at the University of South Australia. He has a 30-year track record in high-powered laser research and development, including 10 years as a senior research scientist at DSTG, where he initiated and led a program to develop local capability in high-powered fibre lasers.

"My research has aligned quite well with Defence over a few years, as my work is relevant to laser

development for atmospheric transmission applications," Lancaster said. "We've developed some unique technology and approaches that complements Defence's work."

This three-year project is focused on enabling the low-cost production of high-powered lasers by developing the deeper, underlying CNC-based (computerised numerical control) manufacturing process.

"In designing and assembling a laser that harnesses 10kW of power, transmitted through an optical fibre which is thinner than a human hair, you've got to have a lot of confidence in the underlying technology," Lancaster said. "That amount of

strands of hair that must withstand intense heat loads and extreme electric fields.”

Using an ultra-fast laser direct-write manufacturing process, the 3D chip lasers are fabricated into a specialist glass that the University of Adelaide's Institute for Photonics and Advanced Sensors has been developing for the past 12 years. This fluoride based glass is highly pure, has been optimised to allow laser written structures to be printed into it and can be “doped” with various rare earth laser active elements. In this work the dopants are thulium and holmium which lase in the infrared.

“This technology is unique in terms of performance – the prototype miniature lasers that the university produced have surprisingly high power,” DSTG's senior laser physicist from the Weapons and Combat Systems Division, Dr Dmitrii Stepanov said. “That makes things simpler when you're trying to scale up the power because in amplifying the light from these chips to kW levels, you can use a reduced number of amplification stages.”

Another advantage of the technology is that the high output can be achieved with very low size, weight and consumed power (SWaP) of the laser chip prototypes.

“We're working at the scale of the wavelength of light,” Lancaster said. “We're using lasers to make submicron modifications to realise lasers inside host glass, and that's our unique approach in building these tiny micro lasers.”

According to Stepanov, it is also highly customisable.

“The enabling manufacturing technology can be used as a platform for a number of different uses,” Stepanov said. “It is material agnostic and can process any glass material in a highly customisable way, with the ability to produce a

range of different fibre or waveguide devices.”

The University of South Australia's unique manufacturing processes that are used to develop the components will also ensure inherently safer systems than most of the common industrial lasers that are currently on the market.

“It's important to clearly understand the risks and the danger due to the high power,” Lancaster said. “You're worried about stray reflections and worried about destroying the system as well, because at the end of the day these are not low-cost systems. So you really want to be both protecting yourself and anybody else around, protect the building and also protect the laser.”

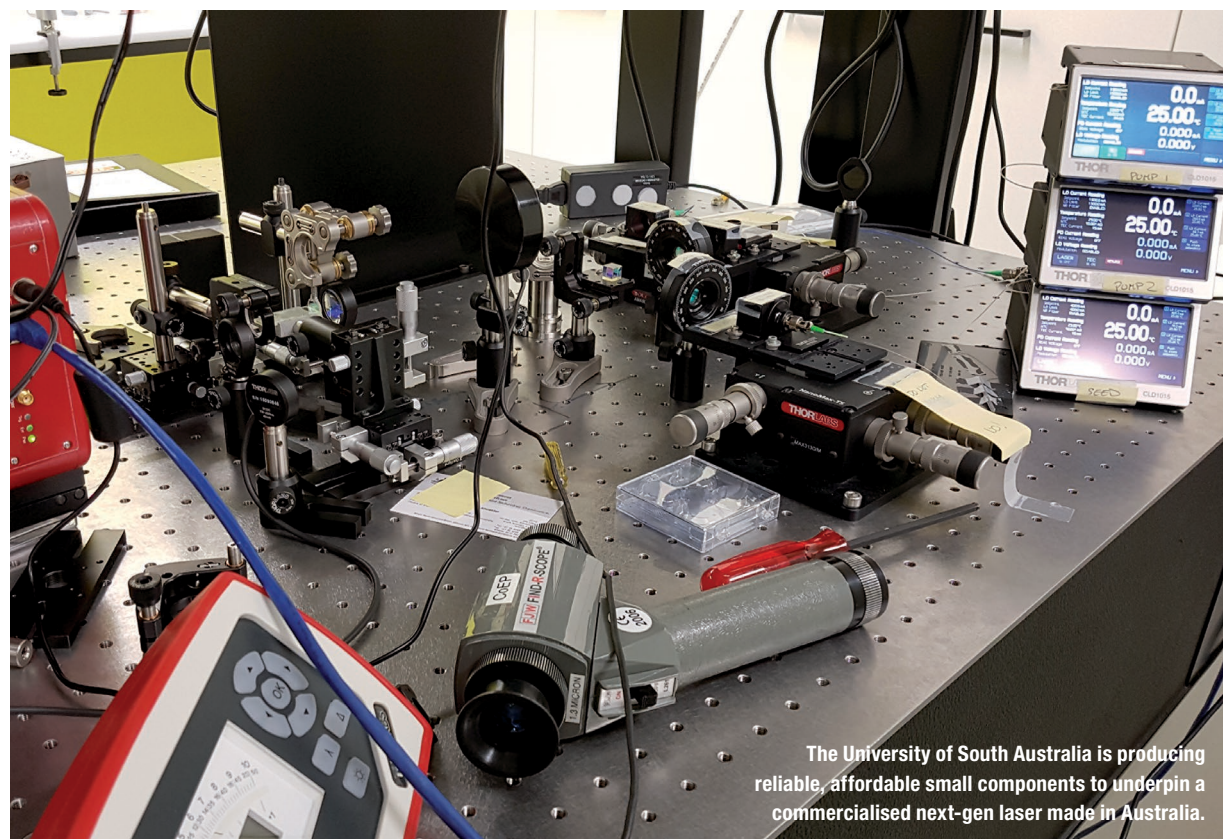


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power allows you to start cutting pretty well arbitrary thicknesses of steel. What we're developing are manufacturing processes and device architectures to make components that are capable of handling this sort of power.”

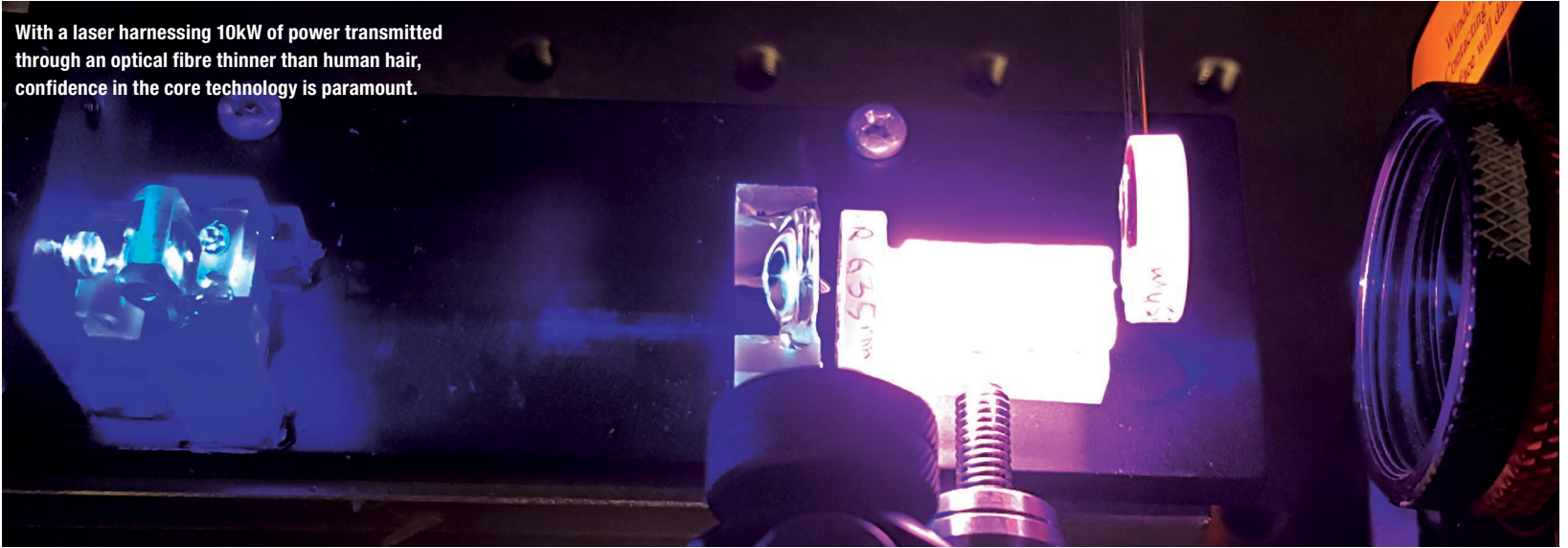
This requires the components themselves to be quite small and durable, Lancaster explains.

“A lot of what we're trying to do here is develop very reliable, small componentry that underpins these bigger systems because the bigger systems are made up of arrays of very small lasers,” Lancaster said. “We'll be building these lasers out of components that are thinner than



The University of South Australia is producing reliable, affordable small components to underpin a commercialised next-gen laser made in Australia.

With a laser harnessing 10kW of power transmitted through an optical fibre thinner than human hair, confidence in the core technology is paramount.



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Our approach is to develop manufacturing processes based on a reasonable capital outlay, but then to produce these modules in bulk so that they can be produced cost effectively once you've accounted for your capital costs.

Carbon dioxide lasers are the most common industrial lasers that are currently available. While this long infrared laser is safer for the user (as it doesn't transmit to the retina), it is an older technology which does not deliver the necessary concentration of power that is required in many manufacturing processes.

"One of the biggest issues with lasers is the scatter of the beam from where it is incident," Lancaster said. "We've developed a novel, very compact laser while working in an interesting spectral region – the infrared region. It's a waveband that is ideal for transmitting through the atmosphere and it's also a wavelength that's considered more 'eye-safe,' as it doesn't transmit through to the sensitive retina in the back of the eye."

The intention for the project is to develop the manufacturing technology capable of producing lower cost modules, which will enable an Australian manufacturer to build the end product in a cost effective way.

"Our approach is to develop manufacturing processes based on a reasonable capital outlay, but then to produce these modules in bulk so that they can be produced cost effectively once you've accounted for your capital costs," Lancaster said. "By the end of the project, we're hoping to invite opportunities for potential companies in Australia."

In moving up several types of technology to a more mature technology readiness level (TRL), the aim is for the technology to be spun out through either an Australian start-up or SME that can begin assembling it into prototypes.

The project will also help to increase Australia's sovereign manufacturing capabilities. This is something that Lancaster has struggled with over the years.

"Something I've grappled with in Australia for a long time is how to get the technology out of a university and into manufacturing. It's always challenging, because there's always risk and there's always a lot of dollars involved – and that combination is a difficult sell," he

said. "The manufacturers who are using these lasers as tools for 3D laser manufacturing, metal cutting or welding don't need to understand the tools; they just need the tools to be mature, turnkey systems. And at this stage that doesn't exist in Australia."

"We're hoping, through this significant project with DSTG, to get to the stage where the risk is reduced and we have some fairly mature manufacturing processes."

This is one of the reasons why DSTG is seeking to develop the underlying layer of expertise that enables these turnkey systems to be made, to build sovereign manufacturing capability in Australia.

"By building a sovereign industry with a competitive technology, ultimately the company who commercialises the lasers won't need a government investment but will be able to sustain the growth themselves," Stepanov said. "In turn, this will help to essentially increase the laser industry capability in the country."

Building this capability domestically will also mean that the end user in Australia will have improved accessibility for services such as maintenance and troubleshooting.

"Currently all the commercial lasers are overseas, so if manufacturers have any issues or need any service they are on their

own," Lancaster said. "Particularly in light of COVID-19, there's no laser service engineers who are able to visit from overseas."

Along with this, there are multiple competitive advantages involved in developing this laser.

"The proposal was focused on developing manufacturing technology and giving both cost and performance advantage to the potential industry partner, because the technology is scalable to high volumes and can operate at a high speed," Stepanov said.

"Also, while the University of South Australia does have a significant leading edge with their prototype manufacturing technology, the benefit of this particular project is that it capitalises on their already existing intellectual property (IP) and creates a new critical IP, which will help them maintain that competitive edge."

Lancaster believes that the wide use of laser technology is the future of Australian manufacturing; the challenge for laser manufacturers lies in deciding how they can compete in this space on a global stage.

"It's non-contact, there's no wearable parts and it's clean – that's one of the biggest things, as there's no contaminants from using pure energy in manufacturing," Lancaster said. "It's an exciting opportunity for Australia. We'll just have to push hard and see if we can get a foot in the door." **M**

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