ISLA (287732) 18M publishable summary

www.isla-project.eu

Project context and objectives
Fibre lasers have already had a major impact in the marketplace for laser products. Their small size, flexibility and high power has proved highly desirable and the range of applications is growing all the time, ranging from sensing and measurement to cutting and marking. Most fibre lasers operate at around 1 µm because there are high power pump diodes and an array of technology building blocks developed for erbium-doped fibre amplifiers (EDFAs) which make this a convenient and low cost route to fibre laser sources.

The ISLA consortium believes that fibre lasers emitting radiation at around 2 µm will have an increasingly important role to play in this rapidly expanding market. Two micron fibre lasers offer a clear route to higher power fibre lasers and can be built using established silica fibre technology. The ISLA project will develop an integrated modular common platform of fibre and components to support high power CW SM, Q-switched pulsed and sub-ps pulsed lasers. The prototypes will be tested in two key industrial applications: transparent plastic cutting and PV cell scribing.

In this summary, the key elements of the project are briefly reviewed and the objectives defined. Readers wishing to know more about the project are invited to join the ISLA Advisory Group, which offers an opportunity to help direct the development work and to identify and develop new applications with the consortium. Please see the project website (www.isla-project.eu) for details.

ISLA will tackle the following technical areas:

Rare-earth-doped fibres
ISLA will optimise the core composition to enhance the cross-relaxation process in Tm-doped silica fibres to realise efficiencies close to the theoretical limit. This will require a carefully tailored host core composition to allow the incorporation of a high concentration of rare earth ions and to avoid unwanted parasitic spectroscopic processes.

ISLA will also optimise Ho-doped silica fibres for in-band pumped Ho fibre lasers. A family of compatible fibres will be developed in SM, PM and photo-sensitive variants to provide a broad platform for integrated ISLA devices operating in CW and pulsed modes.

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Fibre-coupled isolators
The weak Verdet constant and high loss of traditional optical isolator materials (e.g. TGG; terbium gallium garnet, BIG; bismuth iron garnet) at 2 µm make isolators a critical component for 2 µm lasers. ISLA will explore newly available materials and new disruptive designs to provide fibre-coupled prototype isolators in the 2 µm region.

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Fibre-coupled modulators
ISLA will develop modulator devices as part of the integrated platform, so that these devices may be combined with other components to simplify design and improve performance. These will include a specialised acousto-optic tunable filter (AOTF) for laser tuning with greatly reduced sidelobes, and several AO modulators for operation at various power levels.

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Nanocarbon-based modelockers
Nanocarbon-based composites offer an exciting disruptive technology for saturable absorber modelockers which may be made using low cost laboratory techniques. These devices offer considerable advantages over SESAMs (semiconductor saturable absorber mirrors), the preferred modelocker technology at 1 µm, e.g. a much broader tuning range, large absorption cross-section, and fast time constants to support sub-picosecond pulse formation.

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Fibre-coupled bulk optic components
Using both commercially available fibres and the fibres developed in the project, a set of fused fibre components optimised for the ISLA fibre lasers will be developed for single-mode (SM), multimode (MM) and polarisation maintaining (PM) fibres. These fused components will be developed to provide system elements (e.g. taps, WDMs) as well as high power pump combiners (e.g. 19×1 combiners, 6+1×1 combiners etc.) as an integral part of an integrated common platform.

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Laser pump diodes
Diodes in the 79x nm range generally suffer from reduced performance and lifetime compared with longer wavelength diodes such as 808 nm or those in the 9xx nm range. The main reason is the higher photon energy leading to increased carrier leakage resulting in high threshold currents and lower efficiency. To overcome these issues, wide bandgap materials containing high amounts of aluminum are required but these result in relatively low brightness pump sources and integration of gratings is difficult compared with the well-established processes for InP devices.

In the ISLA project several novel techniques will be investigated at Oclaro to improve the threshold currents and efficiency of laser diodes at 79x nm. Power levels of 4 W and higher from 100 µm stripe width are expected during the project; twice that of reported devices to date.

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Main results to date

Rare-earth doped fibres for high power 2 µm lasers
High power operation of thulium and holmium doped fibre lasers in the 2 µm wavelength regime requires optical fibres that are highly efficient and that can withstand very high pump power. Careful tailoring of the fibre core composition and design to minimise core propagation loss and maximise gain is crucial. In thulium and holmium fibre lasers operating in the 2 µm region the main source of unwanted absorption within the core is due to OH ions which enter the fabrication process in the form of water.

ISLA fibres are drawn from a preform of glass produced via modified chemical vapour deposition and solution doping. OH ions can become incorporated into the core of the doped glass via H_2O contamination of the doping solution as well as contamination of the source gases followed by thermal diffusion.

ORC Southampton has been optimising the fabrication process of the thulium-doped optical fibres to minimise this OH contamination by strict control of source materials as well as introducing chlorine drying stages and chlorine flow during the fabrication process. This chlorine acts to remove OH and H_2O converting them into HCl and O_2 which are then removed by gas flow.

Through optimisation of the chlorine drying process and source materials the ORC has reduced OH contamination in its fibres to ~0.1 ppm. The result is very low loss fibre that will form the bedrock of efficient 2 µm fibre lasers to be developed as part of the ISLA project.

Optimising the dopant concentration in order to maximise the efficiency of the ISLA thulium fibre lasers is underway as well as production of the first of the ISLA holmium doped fibres.

Fused fibre components for 2 µm
Through ISLA, G&H has developed its power combiner technology to cover the 2 µm operating window. These devices provide a high efficiency means of combining radiation from several multimode (MM) sources (e.g. pump diodes) into a single fibre; a key requirement for high power fibre lasers.

G&H proprietary manufacturing techniques allow the precise fusion of input fibres around a central signal feed-through fibre and a dual-clad output fibre providing high coupling efficiency over a wide pump wavelength range. The technology extends to large mode area (LMA) signal feed-through fibres, dual-clad output fibres and a variety of port counts and configurations.

A range of other fused devices have also been developed for 2 µm applications through advances in the ISLA project, including side-coupled power combiners with polarisation maintaining (PM) signal feed-through. These devices provide the combination of MM pump fibres with a PM signal feed-through and a PM dual-clad output

High power 2 µm pump combiners
G&H has fabricated high power 7x1 pump combiners for high power thulium fibre lasers. These components will be used in the ISLA demonstration lasers to combine the high power 79x nm pump diodes from Oclaro.

Due to the intense power levels the thermal management of these fibre-based components needs to be very carefully modelled, and G&H has developed a new package for ISLA. Devices are currently under-going testing at up to 2.1 kW of pump power.

Faraday rotator materials for 2 µm
Most optical isolators utilise the Faraday Effect which is the rotation of the plane of polarisation of a light wave as it propagates through a medium subjected to a magnetic field parallel to the direction of propagation. The Faraday effect is particularly unusual because it is non-reciprocal. Thus if light passes a magneto-optical medium (a Faraday rotator) twice in opposite directions, the Faraday rotation does not cancel, but doubles. This non-reciprocal behaviour gives the basis for optical isolator components which function as one-way optical valves or diodes.

Several potential Faraday rotator materials for 2 µm isolators have been characterised by researchers at G&H. Some of the materials show great promise, producing rotations several times larger than isolator materials commonly used at 1 µm, such as terbium gallium garnet (TGG). These new materials offer greatly increased rotation in the two micron spectral region. Furthermore, these materials have also been shown to have high transmission and damage thresholds.

Expected results and impact
The component and fibre developments made in the ISLA project will be integrated in three demonstration lasers:

Demo laser 1
500 W CW Ho-doped fibre laser for the cutting of selected transparent plastics (without addition of any dyes or additives). The performance will be compared directly with a similar power 1 µm reference laser.

Demo laser 2
20 W 10 mJ Ho-doped Q-switched fibre laser; its performance will be demonstrated in the scribing of thin film PV panels. Higher scribing speed will be demonstrated for the ISLA 2 µm fibre laser compared with a 1µm reference.

Demo laser 3
100W ps Ho-doped MOPA will explore the potential for scaling short pulse fibre sources in the 2 µm wavelength regime to much higher power levels.

Results of this work will be reported in the ISLA newsletters and on the website.