Pulsed fibre laser and amplifier systems.

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Tremendous progress has been made over recent years in the development of high-power fibre laser systems. Gone are the days when fibre lasers were perceived as an irrelevant curiosity offering interesting performance features but always at a power level that seemed inadequate for all but a few niche applications. Improvements in high-power, high-brightness multi-mode pump lasers, coupled with the development of cladding-pumped laser technology, have changed that view. It is now widely appreciated that the excellent heat dissipation characteristics of fibre along with the high efficiencies (often greater than 80%), actually make fibre lasers a front runner for many high power laser applications and in particular those that require the generation of high average power continuous-wave radiation. Average power levels of 110W have already been reported for a fibre laser and there is significant potential for scaling the power levels still higher.

Whilst such arguments have proved compelling from the continuous wave laser perspective the suitability of fibre based systems for pulsed laser and amplifier systems is less obvious. In a conventional single-mode fibre light is confined within a mode with a characteristic diameter of order 5-10μm. This limits the energy storage of the medium and compromises laser operation for applications, such as Q-switching, which critically depend on this. Furthermore, fibres are inherently nonlinear and the tight mode confinement limits the pulse peak powers that can be reliably generated, or transmitted, through the system. Fortunately however it is possible to reduce the impact of such limitations by using advanced large mode-area single-mode fibre designs, or by going to multi-mode cores which offer even larger mode-areas. The key to successfully using the later is to manage the mode-selection and mode-coupling issues that naturally arise in order to ensure good spatial mode-quality output. Using such an approach it is possible to increase by more than two orders of magnitude the pulse energies attainable from both fibre laser, and seeded MOPA systems. For example we recently achieved ~8mJ pulses from a Q-switched fiber laser thereby opening up the possibility of using such sources for applications such as LIDAR that were previously considered incompatible with the pulse energies achievable with fibre technology. Moreover using techniques such as fibre based chirped pulse amplification it is possible to construct femtosecond pulse sources operating at several hundred μJ pulse energies and at multi-watt average power levels. Such sources are suited to a range of applications ranging from scientific research through to materials processing.

In this presentation we review the latest advances in pulsed fibre laser and amplifier systems operating from the nanosecond to femtosecond regime. We discuss a number of the key application areas for such technology and conclude by making predictions for future research directions and ultimate performance limits.