The rising power of fibre laser technology

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Abstract: We review progress in the development of cladding-pumped fibre laser technology which now provides a practical route to compact and efficient active fibre devices with high beam-quality and output-powers up to the kilowatt-level. The technology can also be used to obtain high-quality pulsed performance over broad parameter ranges.

During the past few years tremendous increases in the output powers that can be reached using fibre laser technology have been achieved. Perhaps this growth in performance is best appreciated by plotting the highest reported output powers from fibre lasers operating on a single spatial mode (SM) at wavelengths around 1 μm as a function of year, as shown in Fig.1. As can be seen the progress has been explosive and we are now rapidly approaching the kW level for SM beams [1,2,3]. Indeed the kW level has already been surpassed in the slightly Multi-Mode (MM) regime [4]. To date most high power fibre laser work has focused on the Yb-doped system operating around 1 μm, mainly because of the high efficiency (typically >80%), and the availability of high power semiconductor pump sources at the required pump wavelength of 915 and 976nm. However, high-power fibre lasers operating in the eye-safe region (1.5 – 2 μm) are also now attracting a lot of attention for use in important free-space applications such as remote optical sensing, range-finding, and free-space optical communications. Eye-safe lasers are significantly less efficient than Yb-doped fibre lasers at 1.1 μm. Nevertheless output powers in excess of 100 W have been reported recently at 1.57 μm from an erbium-ytterbium co-doped fibre laser [5].

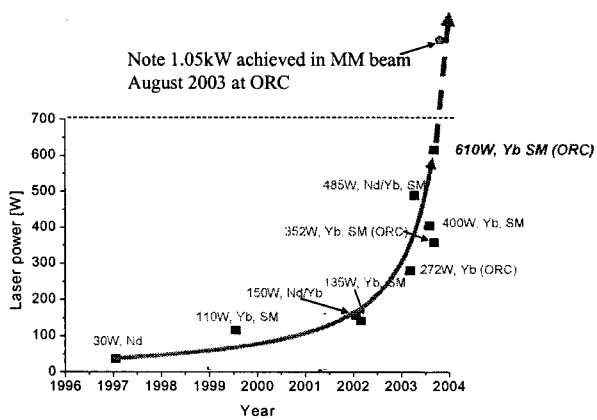

Figure 5 The steadily increasing rise in reported output power for single transverse mode fibre lasers operating in the important 1 im spectral region. Similarly rapid rates of improvement have been achieved for many other aspects of laser performance e.g. Q-switched pulse energies, single frequency MOPA powers etc.

By far the majority of cladding-pumped fibre laser work previously reported has concerned continuous-wave laser performance; however it is to be appreciated that fibre technology has much to offer for pulsed laser applications also. For example, by incorporating additional elements into fibre cavities, such as acousto/electro-optic modulators, it is possible to either Q-switch or mode-lock cladding pump fibre lasers to obtain operation in the nanosecond, and pico/femto second regimes respectively. When designing pulsed fibre laser systems it is important to realize that the high gain-efficiency of active fibres generally leads to relatively poor energy storage, which can be a problem for pulsed operation. However, the development of strategically doped large-core fibres have been used to generate mJ-level pulses at 1.6 μm [6] and multi-mJ pulses at 1.1 μm [7] and is now sufficient for many pulsed laser applications.

In summary, fibre laser are now competitive in performance terms to the more conventional bulk and disk high power laser systems and there is great potential for still further increases in output power - indeed a 10kW fibre laser seems entirely feasible although clearly many technological challenges still remain ahead before such high power systems are reliably achieved and successfully commercialized.

References

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