A high power, high slope efficiency, laser-diode-pumped continuous wave Nd:glass laser

D.W. Hughes, C.A. Bailey, J.R.M. Barr, M.W. Phillips and D.C. Hanna,
Optoelectronic Research Centre,
Department of Physics
Southampton University,
Southampton,
SO9 5NH

Summary

It has recently been shown[1,2] that picosecond pulses may be readily obtained by the active mode-locking of the laser-diode-pumped Nd:glass laser. Sub-picosecond pulses have been obtained from a Nd:glass laser pumped by a krypton ion laser[3] using the technique of self-starting additive pulse mode-locking[4]. The existence of an intensity dependent threshold[5] for the onset of self-starting APM indicates the need for the development of high power, high slope efficiency laser-diode-pumped Nd:glass lasers if self-starting APM is to be achieved in this system. In this paper, we report the operation of a Nd:glass laser pumped by three single stripe laser diodes, which yielded an output power of 360 mW with a slope efficiency of 32%. This performance is shown to be similar to that obtained using an argon ion laser-pumped Ti:sapphire laser as the pump source.

The laser diodes used were 500 mW single broad stripe (40μm) devices (STC LQ-(P)-05). These were held on copper mounts, and their wavelength temperature tuned using a Peltier cooler to ensure maximum absorption (95%) in the active medium. The output from the diodes was collimated using a 6.5 mm focal length lens and a prism beam expander. The laser cavity used was a standard 3-mirror astigmatically compensating cavity, with 5% output coupling. The active medium was a 2.4 mm thick, 10 mm diameter disc of Schott LG760 phosphate glass with 4% wt. Nd^{3+} doping, which was placed at the focus of the cavity at Brewster's angle. This doping level was low enough to ensure that the output from two laser diodes could be polarization combined to pump the Nd:glass laser without the glass melting. The glass was held between two copper plates, with a thin layer (100μm) of indium between the glass and the copper for good thermal contact. This significantly reduced the deleterious effects of thermally induced birefringence[6].

The output from two of the laser diodes (diodes 1 and 2) was polarization combined, and was used to pump the glass laser through the cavity rear mirror using a 3.2 cm lens. An output power of approximately 250 mW was obtained with a slope efficiency of 32%. The absorbed pump power threshold was 55 mW. This is a significant improvement over previously reported slope efficiencies (typically 10-12%) from Nd:glass lasers pumped with laser diode arrays[1,2]. A third laser diode (diode 3) was used to pump the glass laser through the cavity turning mirror. The collimating arrangement was identical to that of the other two laser diodes. A x2 telescope had to be used to expand the collimated output from diode 3 in order to achieve single transverse mode (TEM_{00}) operation of the Nd:glass laser when pumped by diode 3 alone. The output from diode 3 was focussed through the turning mirror using a 7.5 cm lens. With all three laser diodes pumping, a maximum output of 360 mW was obtained for 1.25 W absorbed. Combining a fourth laser diode with diode 3 should yield output powers comfortably in excess of 400 mW. Output powers of this magnitude should be sufficient to initiate self-starting APM operation.

When the Ti:sapphire laser was used as the pump source, an identical Nd:glass laser cavity was used. The output from the Ti:sapphire laser was split into two in order to pump the Nd:glass laser both through the cavity rear mirror and the turning mirror. This was done so that up to 2 W of pump power could be used without causing the glass to damage (it was found when pumping with the Ti:sapphire laser that thermal damage occurred to the glass at a pump power of approximately 1 W, when the glass was pumped from one direction only). For 5% output coupling, the threshold pump power was 57 mW absorbed, and the slope efficiency was 30%. The slope efficiency decreased slightly as the pump power was increased above 1.25 W due to thermally induced birefringence. The maximum output power obtained was 400 mW for an absorbed pump power of 1.65 W. The similarity between the Nd:glass laser performance for the two different pumping sources is particularly significant when the much cleaner Gaussian TEM_{00} output available from the Ti:sapphire laser is considered.

Detailed performance characteristics of this laser will be presented, and self starting APM operation will be discussed.

References

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