Submitted to QE-12

High power diode-bar-pumped Nd:YAG laser at 946nm

W.A. Clarkson, R.L. Koch, K.I. Martin and D.C. Hanna
Optoelectronics Research Centre
University of Southampton
Southampton, SO17 1BJ

Diode-pumped Nd:YAG lasers operating at ~946nm are potentially attractive sources since they can be frequency-doubled to the blue. However, efficient lasing on the 946nm transition is considerably more difficult to achieve than on the more familiar 1.064μm transition. This is partly due to its quasi-three-level nature which results in a significant reabsorption loss which (at room temperature) is ~0.8%/mm for a 1% Nd doped YAG rod. The main problem however, with the 946nm line, is its small stimulated emission cross-section which is ~9 times smaller than for the 1.064μm line [1],[2]. As a result, 946nm Nd:YAG lasers have a threshold which is at least a factor of 9 times higher than for a comparable 1.064μm laser.

The solution to this problem has been to use resonators which support a much smaller laser mode size and to use diode pump sources with good enough beam quality to allow their focusing to match this mode size. Efficient diode-pumped 946nm Nd:YAG lasers have therefore been restricted in cw power to less than 0.3W [3] since only the lower power diodes have provided adequate pump beam quality. Higher power diode lasers have highly elongated emitting regions, which has made it difficult to achieve the tight focusing required by low gain lasers.

This situation has now been changed as a result of a new beam shaping technique that we have recently reported [4], which allows the output beam from a high power diode bar to be re-configured with nearly equal M^2 values for orthogonal planes, but without a significant reduction in brightness. In this paper we report the use of this technique to allow efficient end-pumping of a 946nm Nd:YAG laser by a 20W diode bar. The beam shaper is of extremely simple

W.A. Clarkson, R.L. Koch, K.I. Martin and D.C. Hanna, "High Power 946nm Nd:YAG Laser......"

construction, since it consists of only two high reflectivity mirrors which are separated from each other by a small distance and aligned approximately parallel to each other. The action of the beam shaper is to effectively chop-up the incident beam from the diode bar into a number of adjacent beams and re-arrange their relative positions so that they emerge from the beam shaper stacked underneath each other. In this way the relative M^2 values for orthogonal planes can be adjusted as required, and if necessary made approximately equal. For this experiment we arranged for the focused beam to have to spot sizes of ~300μm by ~360μm with M^2 values for orthogonal planes of ~70 and ~100 respectively. The Nd:YAG laser design used was a simple folded-cavity with mirror reflectivities chosen to suppress laser oscillation at 1.06μm, and a convex input mirror to compensate for thermal lensing in the 5mm long laser rod, which was mounted in a water cooled heat sink and maintained at a temperature of ~10°C. Using this arrangement and an output coupler with a 2% transmission, ~2.3W of TEM_{00} output at 946nm was obtained for 12.7W of pump incident on the laser rod. Operation at the maximum incident pump power of 14.4W resulted in a 946nm output of approximately 2.6W but with some what worse beam quality due to thermal lensing. The results of efforts aimed at further optimisation of the cavity design and pump optics will be reported.

References

[1] W. P. risk and W. Lenth, Opt. Lett. **12**, 993 (1987).

[2] T. Y. Fan and R. L. Byer, IEEE J. Quantum Electron. **23**, 605 (1987).

[2] G. Hollemann, E. Peik and H. Walther, Opt. Lett. **19**, 192 (1994).

[3] W. A. Clarkson, A. B. Neilson and D. C. Hanna, Conference on Lasers and Electro-Optics, vol. 8, OSA Technical Digest Series (Optical Society of America, Washington, DC, 1994), p.360.