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HIGH POWER SINGLE FREQUENCY OPERATION AND EFFICIENT INTRACAVITY FREQUENCY DOUBLING OF A Nd:YAG RING LASER PUMPED BY A DIODE BAR

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Scaling single-frequency and visible intracavity-frequency-doubled diode-pumped solid-state lasers to multi-watt power levels is an area in which has attracted a great deal of interest due to the many potential applications of such sources. Ideally this should be achieved with the high overall efficiencies that have been such a notable feature of many lower power diode-pumped solid-state lasers [1]. However, power scaling of the diode array pump lasers has led to output beams which are characteristically very asymmetric with M^2 beam quality factors for orthogonal planes which typically differ by a factor of more than a 1000. This has rendered these devices very difficult to focus to small spot sizes and to use efficiently in end-pumped configurations.

Recently, a new beam shaping technique has been developed [2], which allows the output from non-diffraction-limited sources, such as diode bars to be focused into a nearly circular spot of much higher brightness than is currently available from fibre-coupled bars, and therefore should allow much greater flexibility in the design and mode of operation of multi-watt, end-pumped solid-state lasers.

In this paper we report a demonstration of efficient single-frequency and intracavity frequency-doubled operation of Nd:YAG ring laser end-pumped by the re-shaped and focused output from a diode bar. The use of a ring configuration is not only attractive for the ease with which single frequency operation can be achieved, but also, at high pump powers, it has the advantages of reducing the effect of thermally-induced lens aberrations and stress-birefringence, compared to a standing-wave laser, since there is only a single-pass of the gain medium for each round-trip. The ring resonator design we have used is a simple figure-of-eight ring cavity with a TGG Faraday rotator and half-wave plate to enforce unidirectional lasing. The Nd:YAG rod was end-pumped by a 20W cw diode bar, which was re-shaped by two high reflecting plane mirrors [2], and focused to an approximately circular spot of radius 290μm, with a far-field beam divergence (full width in air) of ≈6°. For the maximum available pump power of 14.4W incident on the Nd:YAG rod, a single-frequency output of 5W at 1.064μm was obtained. Intracavity frequency doubling was achieved using a similar cavity design with a 15mm long KTP crystal which was cut for type II phase matching, with the special orientation for compensation of Poynting vector walk-off of the fundamental polarisations [3]. For the maximum incident pump power of 14.4W, a cw single-frequency output of approximately 3W at 532nm was obtained. This output power limit was significantly less than expected on the basis of known cavity losses, and is in fact a result of the fundamental beam choosing a misaligned feedback path so as to avoid the high nonlinear conversion loss. The prospects for further increases in both the 532nm and 1.064μm single-frequency output powers by optimising the pump optics and by improving the ring resonator design will be discussed.

References

[1] J. L. Nightingale and J. K. Johnson, Conference on Compact Blue-Green Lasers, OSA Technical Digest Series (Optical Society of America, Washington, DC, 1994), paper PD6.

[2] 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.

[3] J. Nightingale, Conference on Advanced Solid-State Lasers and Compact Blue-Green Lasers, vol. 2, OSA Technical Digest Series (Optical Society of America, Washington, DC, 1993), p.443.