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Diode Laser Bar Beam Shaping Technique

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ABSTRACT

A high power diode bar has been focused to a spot of $<150\mu m$ diameter using a novel beam shaping technnique. The implications of this result for efficient end-pumping of solid-state lasers are discussed.

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SUMMARY

Due to their relative cheapness and wide commercial availability high power diode bars are becoming increasingly attractive as pump sources for high power solid-state lasers. Unfortunately, because of the highly elliptical output beam ($\sim 1\mu m \times 10mm$) and highly non-diffraction-limited nature of these devices, they cannot readily be focused into small, circular spots, which are suitable for efficient end-pumping of solid-state lasers. To date, many of the end-pumping schemes which have been employed with diode bars have either produced a rather large focused pump beam diameter (typically $\sim$1mm) [1],[2], or have employed relatively complex resonator designs (e.g. the tightly-folded resonator [3]).

In this paper we describe a simple beam-shaping technique [4] which allows the diode bar output to be focused into a circular spot of less than 200μm diameter with a low beam divergence, suitable for end-pumping solid-state lasers. The technique is depicted in Figs. 1 and 2, which show side and plan views respectively of the Multiple Reflection Beam

Shaper (MRBS). Laser output from a diode bar is first collected using a fibre collimating lens and subsequently imaged using a combination of cylindrical and spherical lenses (not shown). The light is then incident on the MRBS, which consists of two parallel, highly-reflecting, plane mirrors, separated by a short distance (~ 1.5mm) and offset, both vertically and horizontally, from one another as shown in Figs. 2(a) and (b). In crude terms, the action of the beam shaper is to effectively chop up the incident laser beam (in the non-diffraction-limited x-x plane) into a number of adjacent beams, and then to re-arrange the beams so that they emerge from the MRBS stacked on top of one another. For the purpose of this simplified explanation, the beam is arbitrarily chosen to consist of five parallel beams (1)-(5). Beam (1) is not incident on either mirror of the MRBS and is simply transmitted without any change in its position or direction. Beam (2) however, is incident on mirror B and is reflected on to mirror A, where it undergoes a second reflection and emerges from the MRBS parallel to beam (1), but is now displaced underneath it. Beams (3),(4) and (5) undergo similar multiple reflections at mirrors A and B and subsequently emerge from the MRBS stacked underneath beams (1) and (2). The overall result is that the M^2 value of the beam is decreased (from its value at the bar) in the x-z plane parallel to the diode junction and increased in the perpendicular (y-z) plane. The extent to which this occurs depends on the number of beams the diode output is chopped into by the MRBS. In our case the MRBS was configured to provide 12 beams to match the number of emitting regions from the diode bar we have used. Using a simple arrangement of orthogonal cylindrical lenses (not yet optimised), the emerging beam was then focused to an approximately circular spot with a diameter of 150μm, and with average spot diameters (over a 2.5mm path in air) of 250μm in the x-direction and 190μm in the y-direction. The transmission ($\sim$51%) of the pump optics was degraded by non-optimum lens coatings and by the present dielectric coatings in the MRBS (which limited its transmission to 70%). Preliminary results for simple, end-pumped, Nd:YAG laser (as shown in Fig. 1) confirm that low thresholds ($<$100mW) and high slope efficiencies ($\sim$40% with respect to incident pump power at the Nd:YAG rod) are achievable with a diffraction-limited TEM_{00} output. So far, 1.2W of output have been obtained for the maximum 7W of diode bar output. With further optimisation of the pump focusing optics and coatings, and a 20W diode bar, projections indicate $>$6W of output should be achievable. This technique should also be valuable for high gain amplifiers, for efficient operation on low gain laser transitions, and for efficient operation on quasi-three-level transitions, where an intense pump beam is required.

References

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[3] T.M. Baer, D.F. Head, P. Gooding, G.J. Kintz and S. Hutchinson, IEEE J. Quantum Electron. **28**, 1131 (1992).

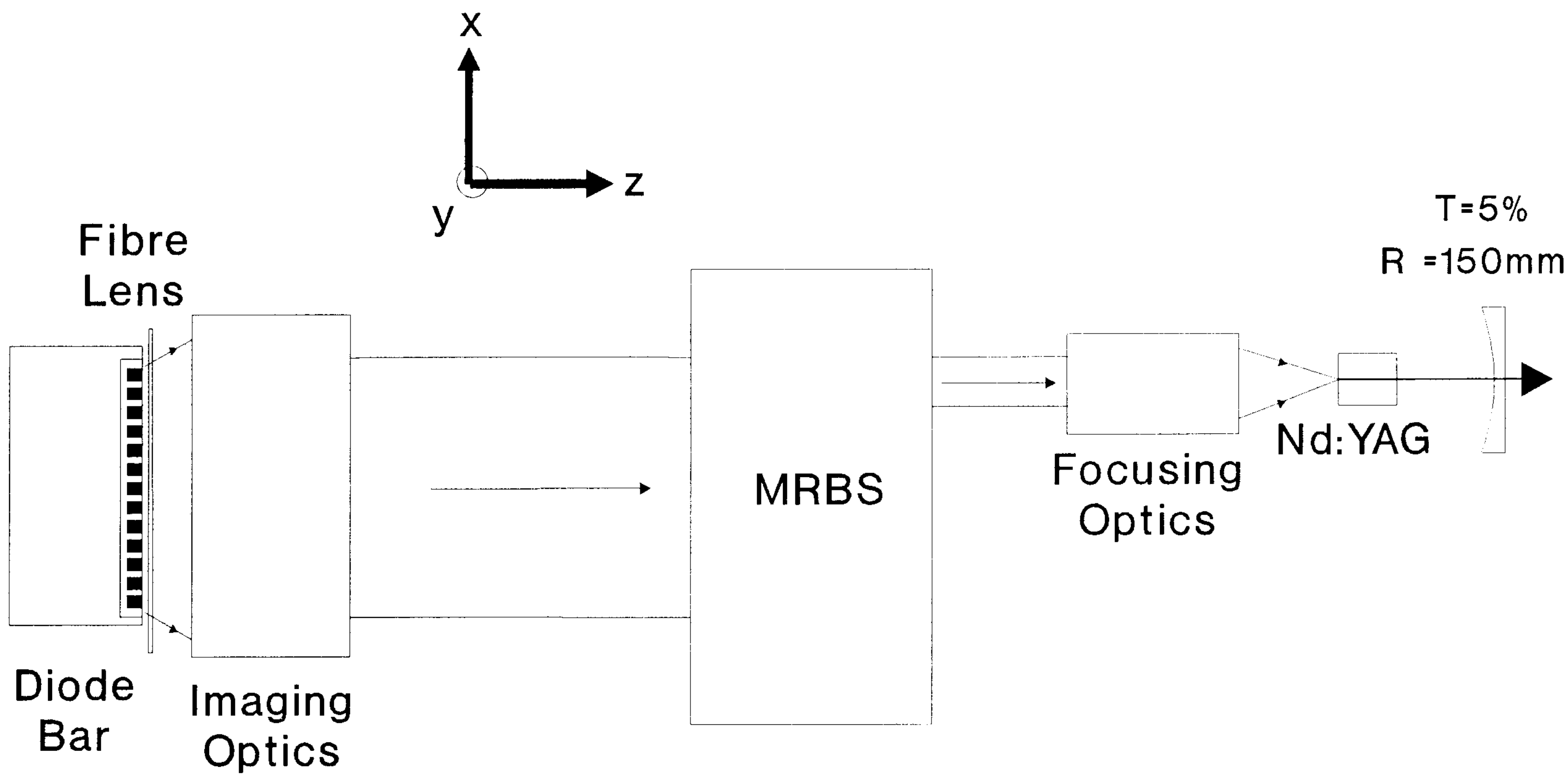
[4] W.A. Clarkson, A.B. Neilson and D.C. Hanna, United Kingdom Patent Application (November 1993).

W.A. Clarkson, A.B. Neilson and D.C. Hanna, "Diode Laser Bar Beam Shaping Technique."

Figure Captions

Fig. 1 Diode bar focusing scheme.

Fig. 2 Multiple Reflection Beam Shaper (MRBS); (a) side view and (b) plan view.


x
y
z
Fibre
Lens
Diode
Bar
Imaging
Optics
MRBS
Focusing
Optics
Nd:YAG
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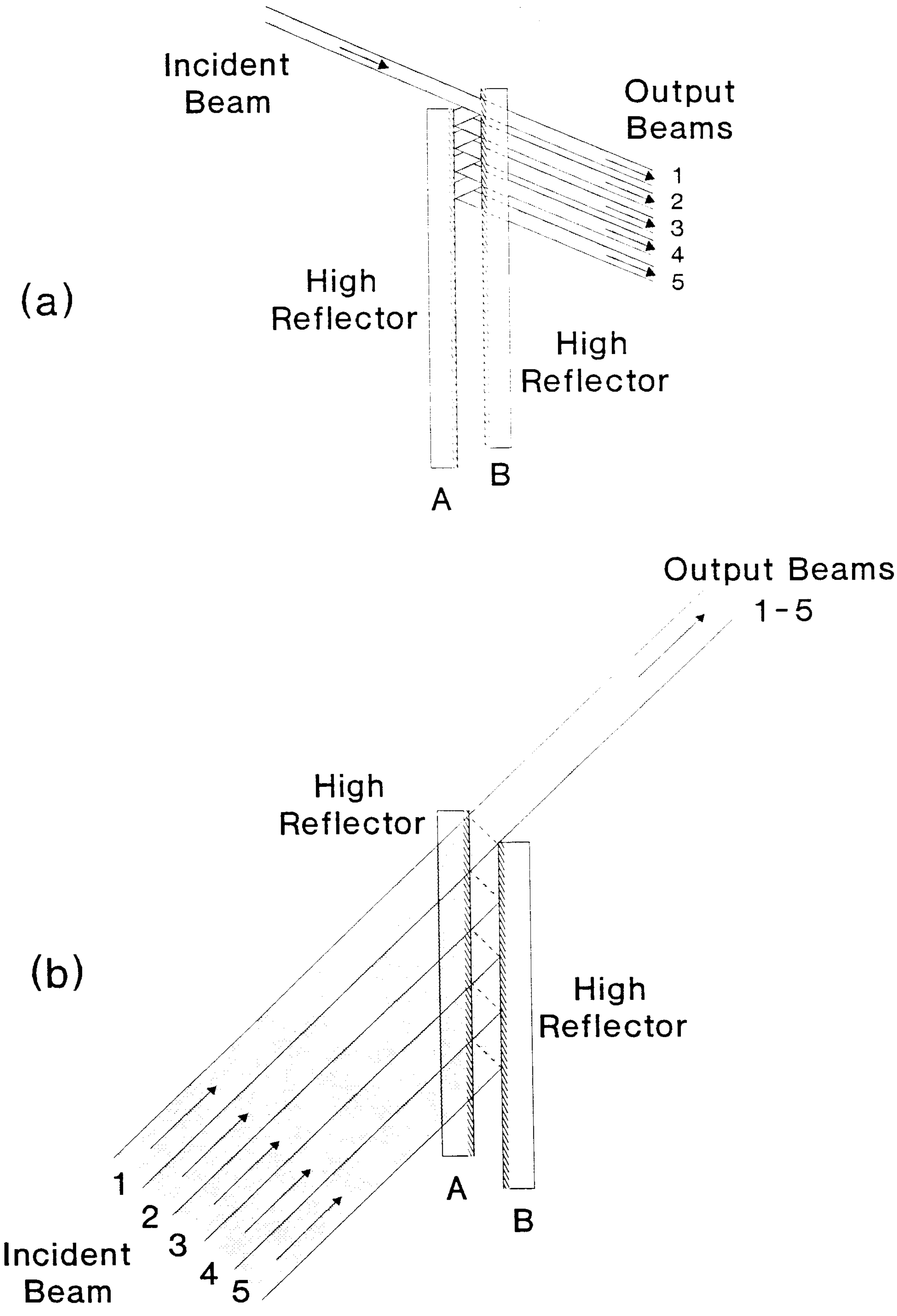
R =150mm



Incident Beam
Output Beams
1
2
3
4
5
High Reflector
High Reflector
A
B
(b)
Output Beams 1-5
High Reflector
High Reflector
A
B
1
2
3
4
5
Incident Beam