ABN

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Novel Beam Shaping Technique For High Power Diode Bars

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ABSTRACT

Using a novel beam shaping technique, a diode bar output has been focused to a spot of 150μm diameter. Preliminary results for efficient end-pumping of a Nd:YAG laser are reported.

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SUMMARY

High power, cw, diode bars are becoming increasingly attractive as a pump source for high power solid-state lasers, due to their relative cheapness and wide commercial availability. Unfortunately, the highly elliptical output beam ($\sim 1\mu m \times 10mm$) has rendered these devices difficult to use efficiently in end-pumped configurations, and as a consequence their true potential has yet to be fully realised. 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 to spot of less than 200μm diameter with a relatively low beam divergence, suitable for end-pumping solid-state lasers. The technique is shown in

W.A. Clarkson, A.B. Neilson and D.C. Hanna, "Novel Beam Shaping Technique For High Power Diode Bars."

Figs. 1 and 2. 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. The light is then incident on the Multiple Reflection Beam Shaper (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), where the principle of operation is shown schematically. Light incident on the MRBS can be considered to be made up of many parallel beams. The number of beams is dictated by the separation of the mirrors and by the total width of the incident beam. For the purpose of this simplified explanation, the beam is considered to be made up 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 from it in the orthogonal direction to its original displacement. 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 bar 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. 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 (~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 (~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 and efficient operation on low gain laser transitions.

References

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W.A. Clarkson, A.B. Neilson and D.C. Hanna, "Novel Beam Shaping Technique For High Power Diode Bars."

Figure Captions

Fig. 1 Diode bar focusing scheme.

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

Fig. 1

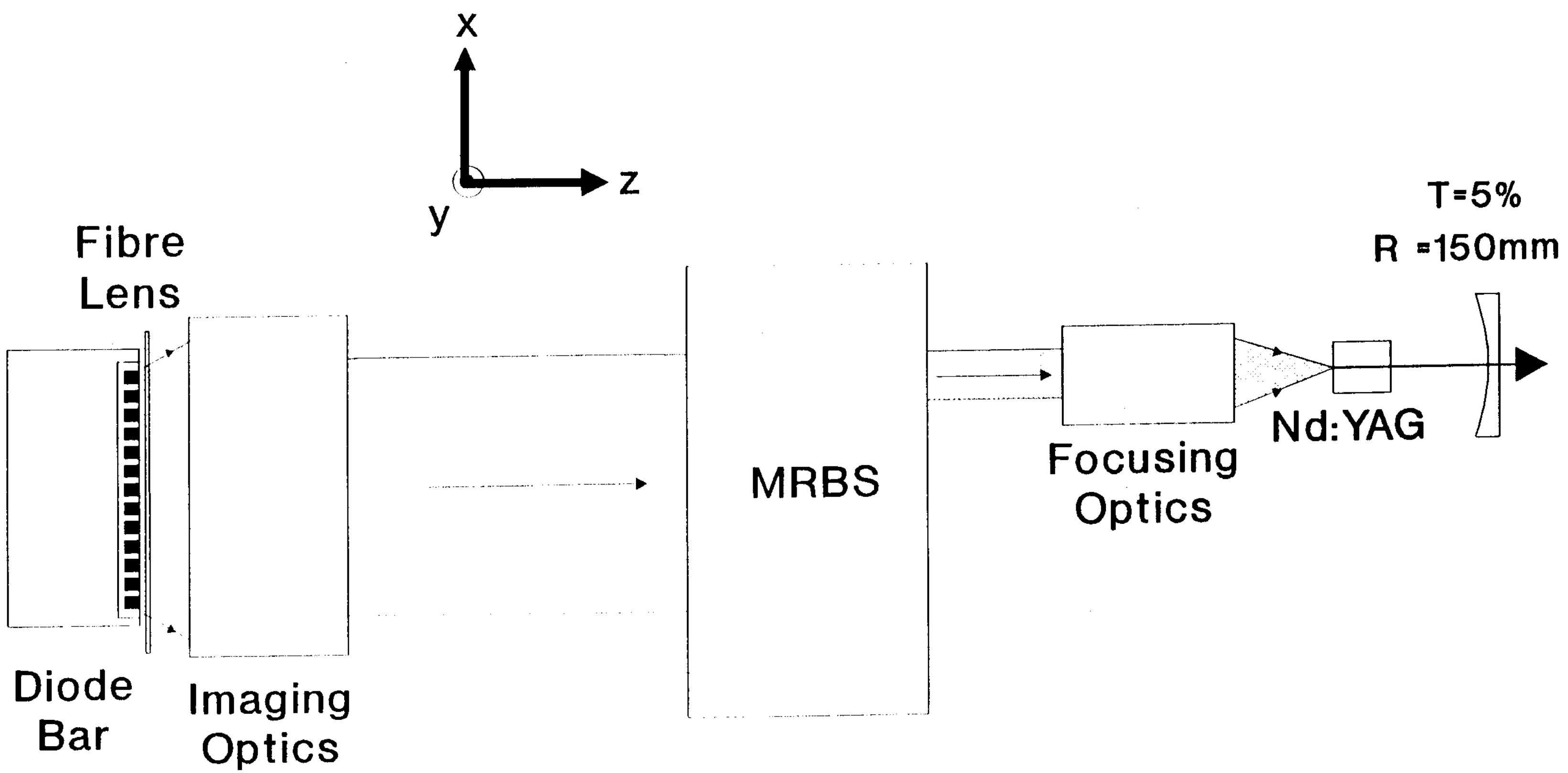
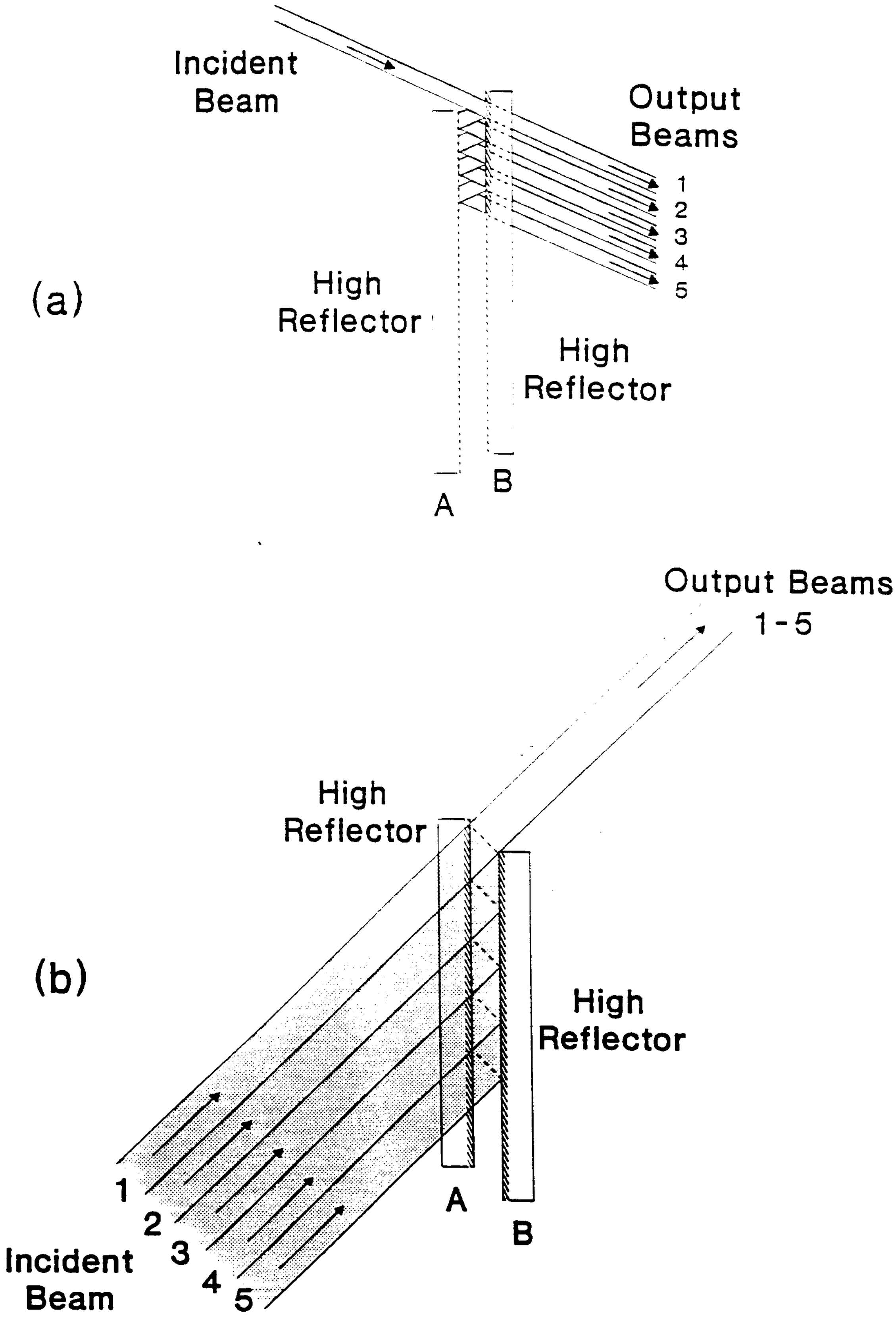

x
z
y
Fibre
Lens
Diode
Bar
Imaging
Optics
MRBS
Focusing
Optics
Nd:YAG
T=5%
R =150mm

Fig. 2



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