1.5W Diode-Pumped Monolithic Planar Waveguide Laser

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Abstract

We describe a compact and efficient Nd:YAG waveguide laser pumped by a diode-bar. An output of 1.5W is obtained for 6W incident power, with significant brightness enhancement.

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Diode bars are now being widely employed as pump sources for solid state lasers. However, their output is highly elliptical with one axis being typically >1000X diffraction limited. This makes it difficult to use them for longitudinal pumping where small-diameter circular beams are normally required. Here we report the longitudinal pumping of a planar waveguide laser by a diode bar. The planar waveguide has the advantage of being compatible with the elliptical nature of the diode beam, simplifying the focussing requirements and leading to a very compact laser source. The guidance of the pump and signal radiations also leads to a very good spatial overlap, and consequently efficient operation, without the need for careful resonator alignment.

Figure 1 shows the experimental set-up used in these experiments. The diode-bar was collimated in the vertical direction to a beam diameter of 325μm with a fibre lens. The M^2 values of the beam after the fibre lens were found to be 2.4 and ~3000 in the vertical and horizontal axes respectively. Focussing in the vertical plane was achieved by expanding the beam with a cylindrical lens telescope and finally focussing into the waveguide with a 6.25mm focal length cylindrical lens. Focussing in the horizontal (non-guided) plane was achieved with a single 19mm focal length cylindrical lens. This lens array produced a 25μm by ~1mm (radius) line focus with a maximum power of 6W. The lenses are all glued permanently in position and so very little alignment is required in the final system.

The planar waveguide used was grown by liquid-phase epitaxy and consisted of an 80μm thick Nd:YAG core with YAG substrate and cladding layers. The end-faces were cut and polished plane and parallel to give a cavity length of 5mm. The faces were coated, forming the laser cavity, with a nominally high reflector at one end and a 5% output coupler at the other. Figure 2 shows the laser performance obtained with this waveguide. A 39% slope efficiency with respect to incident power was obtained with a maximum output power of 1.5W. With the guide aligned for maximum power the output was observed with a CCD camera to consist of 3 lobes in the guided direction and single-lobed (although not smooth) in the other direction. M^2 values of 5.2 and 89 were found in the guided and non-guided planes. It was found that with a small vertical adjustment the output appears single lobed in both directions and the M^2 values are reduced to 3.6 and 72. Under these circumstances the output power is reduced to 1.2W. This is a more than 5-fold increase in brightness compared to the incident pump beam.

Future work will concentrate on improving the focussing lens array via the use of fibre lenses, to allow smaller guides, which support a smaller number of modes, to be used. Combining this with tighter focussing in the non-guiding plane should lead to further significant improvements in the M^2 values.

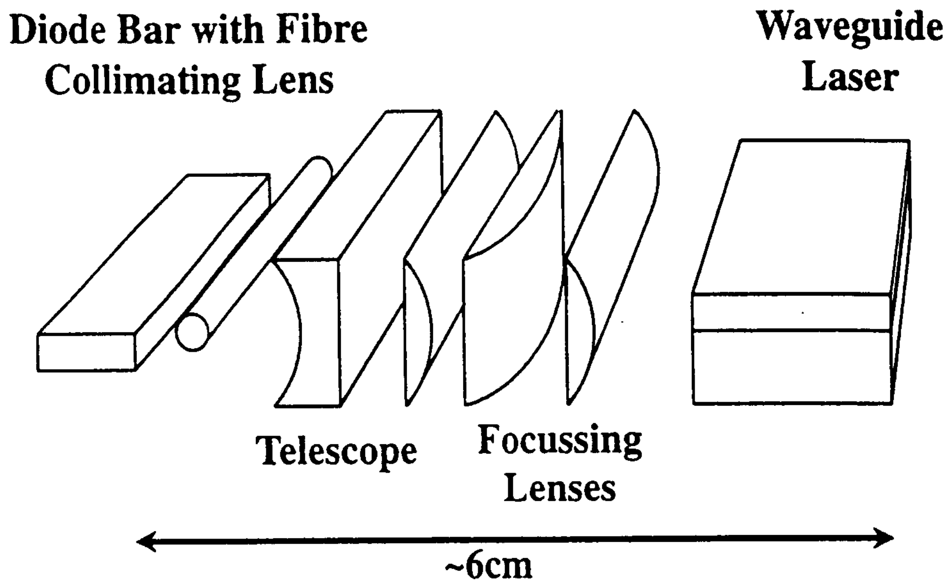

Fig.1 Schematic representation of the diode-bar pumped waveguide laser.

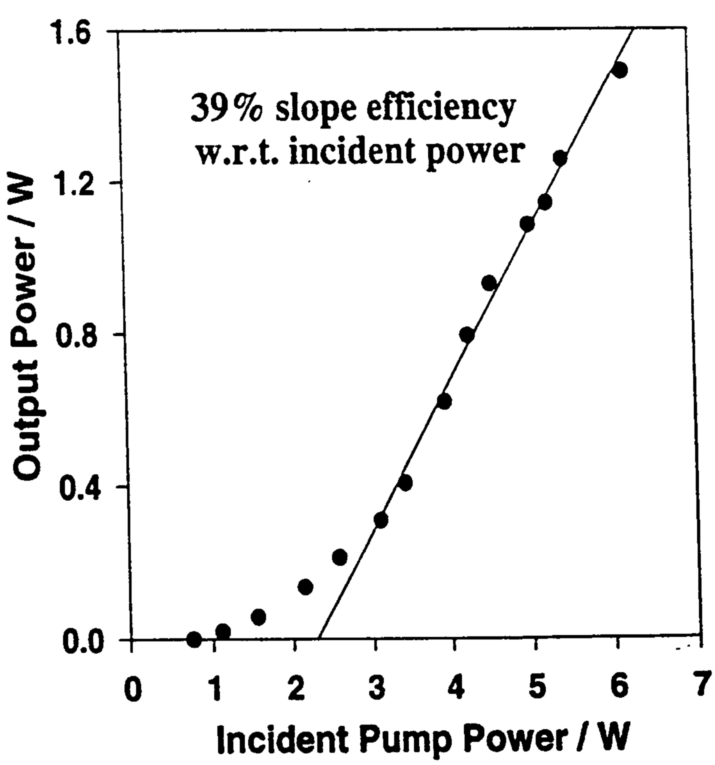

Fig.2 Output power against incident pump power for the waveguide laser.