Proximity-Coupled, Diode-Bar-Pumped, Waveguide Laser

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Abstract

A simple and compact, side-pumped, waveguide laser is demonstrated by proximity coupling a 10W diode-bar to a contact-bonded, Nd:YAG waveguide.

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Summary

Recent work on high-power, planar-waveguide lasers[1-3] has been motivated by the fact that the planar geometry is ideal for thermal management and well-matched to that of diode-bar pump lasers, previously allowing simple cylindrical lens coupling[2,3]. Here we report in-plane, proximity-coupling of a diode-bar to a planar waveguide with no intervening optics. This simple and highly-compact coupling arrangement is shown to be suitable for side-pumped lasers based on high-numerical-aperture (NA), contact-bonded, waveguides.

For this initial demonstration we used a 10W diode-bar from Jenoptik. The fast-axis divergence was calculated by measuring the intensity profile at a known distance from the diode, and determining the spot size from the second moment. The divergence, θ, was found to be 0.47 radians, corresponding to an NA of 0.45. The planar guide used in these experiments consists of an 8μm-thick, Nd:YAG core contact-bonded to a Sapphire substrate, giving an NA approximately equal to that required to confine the pump beam, as shown schematically in figure 1. The waveguide was cut and end-polished to a length of 18mm, considerably larger than the

10mm emitting dimension of the diode-bar, and a width of ~2mm.

The diode and waveguide, with water-cooled heatsinks, were both mounted on precision manipulators and their separation was monitored using a microscope placed directly above them. As the guide and diode were gradually brought together measurement of their separation, optimisation of the fluorescence signal, and observation of the diffraction pattern of unabsorbed pump after the waveguide, were all used to achieve optimum orientation and positioning. Although physical contact was made, observation of the diode under a microscope suggested that the actual emitters were slightly recessed from the plane of contact by a distance of ~9μm. Figure 2 shows the observed increase in fluorescence with decreasing separation and figure 3 shows a picture of one end of the diode and waveguide observed through the microscope. By measuring the total power (launched and not launched) after the waveguide and comparing it to the incident power, we calculated the product of single-pass absorption efficiency (over 2mm) and launch efficiency to be 45%. The absorption length for the optimally-tuned diode is around 3mm, thus implying a very high launch efficiency, ~90%, a value consistent with an 8μm guide at a minimum separation from the emitters of 9μm.

A side-pumped laser was then constructed around this efficient and compact coupling system by placing an HR 1.064μm mirror on one end-face and a 23% output coupler on the other. A pump mirror was also used to double-pass the pump light through the waveguide. For 6W of incident power, initial results have produced over 0.5W of waveguide-laser output. However some of this output was in directions implying that internal reflection off the polished side-faces was allowing various different lasing paths within the waveguide. Further optimisation will aim towards unstable resonator design, with deliberate suppression of side-wall reflections.

References

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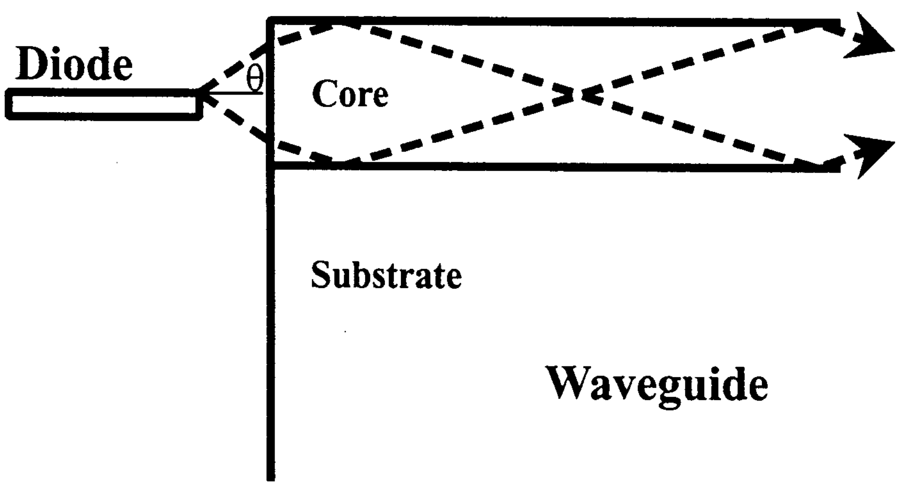
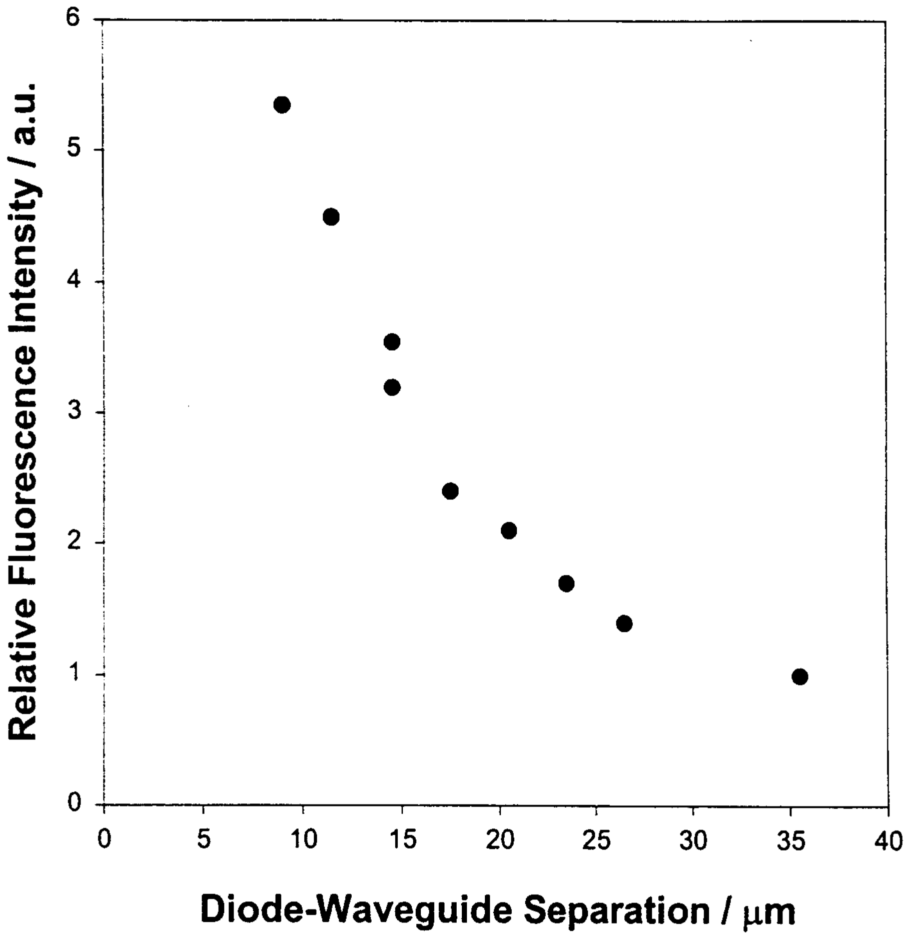
Figure Captions

Fig. 1 Schematic diagram of proximity-coupling.

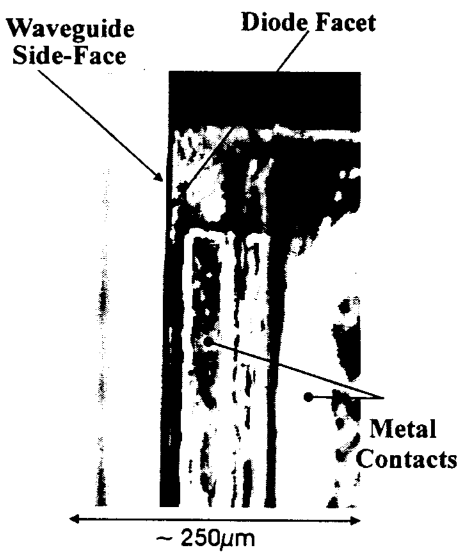
Fig. 2 Fluorescence intensity versus diode to waveguide separation.

Fig. 3 Microscope picture showing the plan view of the proximity-coupled diode and waveguide.


Diode
θ
Core
Substrate
Waveguide



Relative Fluorescence Intensity / a.u.
0
1
2
3
4
5
6
0
5
10
15
20
25
30
35
40
Diode-Waveguide Separation / µm


Waveguide
Side-Face
Diode Facet
Metal
Contacts
~ 250μm