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Quasi-three-level laser operation of Yb:YAG waveguides

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The main advantage of using waveguides in laser systems is that they produce high pump intensities over long interaction lengths for low input pump powers. This should lead to lower thresholds and more efficient lasers. Often though extra loss due to waveguide propagation reduces the benefits of this confinement. However in three-level and quasi-three-level laser systems there already exists absorption loss at the laser wavelength due to thermal population of the lower laser level. Any added waveguide propagation loss will therefore not have such a significant effect on laser performance. An example of such a laser system is Yb:YAG where 4% of the total population resides in the lower laser level. For a 6.5 at.% doped sample this is roughly equivalent to a propagation loss of 2.5db/cm which for the guides discussed here is the main contribution to the loss. The laser performance of Yb:YAG has been measured in planar waveguides made by two methods - ion-implantation and epitaxial growth.

An ion-implanted Yb:YAG guide was fabricated by implanting He^+ ions with energies up to 2.65MeV into the crystal face. This produced a guide with losses of ~2dB/cm which produced a laser spot size of 2.5μm in the guided direction. Using HR mirrors this lased with an absorbed power threshold of 30mW. A slope efficiency of 19% and a threshold of 75mW was obtained when one mirror was replaced with an 83% reflectivity output coupler. Improvement of these results could be made by moving to a channel geometry as has been successfully demonstrated in ion-implanted Nd:YAG.

Planar guides have also been fabricated by liquid phase epitaxial growth of a 6μm Yb,Ga,Lu:YAG layer on top of a pure YAG substrate. These have much lower loss (~0.2dB/cm) than the ion-implanted guides and therefore the guide loss makes very little difference to the laser performance. With an 83% reflectivity output coupler the threshold is 14mW and the slope efficiency 28%. This compares very favourably to similar bulk experiments. Again the move to a channel would further enhance the laser performance. Methods for doing this are currently under investigation.