12:00noon

CFJ7 Ion-implanted, quasi-three-level, Yb:YAG waveguide lasers

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Yb:YAG has many advantages compared to the widely used Nd:YAG system. These include closer pump and laser wavelengths, leading to a more efficient transfer of energy from the pump to laser photons and less thermal loading of the gain medium. Excited state absorption, upconversion, and concentration quenching are also reduced because of the fact that there is only one excited 4f manifold. Efficient, room-temperature operation of a bulk Yb:YAG laser at 1.03 μm has recently been reported[1] showing that the broad absorption bands are well suited to diode pumping.

The main drawbacks associated with the Yb:YAG system are its quasi-three-level nature and its low emission cross section (σ_e is ~20 times lower than Nd:YAG), leading to a higher laser threshold than for Nd:YAG. However, the use of a waveguide geometry enables the high intensity required to reach threshold to be achieved at modest pump powers. The fact that such waveguides have an additional propagation loss need not be so significant for (quasi-) three-level systems as a result of the presence of loss caused by absorption from the lower laser level. Here we report results using a planar ion-implanted waveguide in Yb:YAG.

The waveguide was created by implanting He^+ ions through a polished surface of the 6.5 at.%-doped Yb:YAG crystal. The single-mode, planar waveguide formed at the surface had propagation losses of ~2 dB/cm and a guided spot size ($1/e^2$ half-width of intensity) of ~2.5 μm for propagation wavelengths of 1 μm. The planar waveguide was cut and polished to a length of 1.65 mm, corresponding to one absorption length for the bulk material. The laser cavity was formed by simply butting high reflectivity mirrors against the polished end-faces. Using a $Ti:Al_2O_3$ pump laser tuned to 941 nm, coupled into the waveguide with a microscope objective, laser action was observed at an absorbed power threshold of 30 mW. With an 83% output coupler the threshold rose to 74 mW and a 19% output slope efficiency was obtained. These results are broadly in line with the bulk experiments of Ref. 1, the main difference being the lower slope efficiency for the waveguide laser caused by the extra propagation losses.

Work is currently underway to fabricate channel waveguides. The fabrication techniques for such guides have already been established for Nd:YAG.[2] Based on the Nd:YAG results threshold reductions of at least 1 order of magnitude can be expected for the Yb:YAG channels, because of the reduced spot sizes. Furthermore, improved slope efficiency is expected because of improved signal/pump overlap and the ability to work with higher output transmissions. Results obtained for the channel waveguides will be reported.

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1. P. Lacovara, H. K. Choi, C. A. Wang, R. L. Aggarwal, T. Y. Fan, Opt. Lett. **16**, 1089 (1991).
2. A. C. Large, S. J. Field, D. C. Hanna, D. P. Shepherd, A. C. Tropper, P. J. Chandler, P. D. Townsend, L. Zhang, in 1992 *Conference on Lasers and Electro-Optics* Vol. 12, OSA Technical Digest Series (Optical Society of America, Washington, D.C., 1992) pp. 242-244.