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Low threshold 1.64 μm operation of a Yb,Er:YAG waveguide laser

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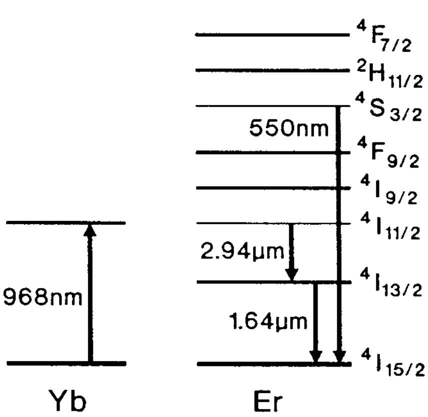
Er^{3+}-doped $Y_3Al_5O_{12}$ (YAG) is an interesting system with several useful laser transitions. Laser operation has previously been demonstrated on the 1.6 μm, 2.94 μm, and 561 nm shown in the level diagram of Fig. 1.[1-3] Co-doping with Yb^{3+} allows these transitions to be pumped on the strong, diode compatible absorptions at 940 and 970 nm. Low-loss YAG waveguides grown by liquid-phase epitaxy have operated as low threshold lasers in Nd^{3+4} and Yb^{3+}-doped systems. In the present work we have investigated the laser performance at 1.6 μm of Yb,Er codoped YAG epilayers grown on an undoped YAG substrate.

Samples were prepared using a liquid-phase epitaxial growth process described previously.[4] The active layer was 10 μm thick and contained 6 at.% Yb and ~0.5 at.% Er. On top of this active layer a further YAG cladding layer was grown to reduce the waveguide propagation losses.

To test the laser performance, a 1.8 mm length of waveguide was pumped by a Ti:sapphire laser on the strong 968 nm Yb absorption. With mirrors that were highly reflecting at 1.6 μm butted to the polished waveguide end faces, the guide was found to lase at 1.6 μm, with a threshold power of 24 mW incident on the input mirror. Taking into account the mirror transmissions and measuring the unabsorbed pump power, the absorbed power threshold was calculated to be 15 mW. When the laser was tested with a 1% transmitting output coupler, the absorbed power threshold rose to 70 mW and the slope efficiency was about 2%. A further small increase in output coupling caused the threshold to rise significantly and the slope efficiency to decrease, suggesting that strong upconversion was taking place in the crystal. This is consistent with previous experiments that suggest that Yb co-doping increases the amount of upconversion.[5]

The low threshold observed for 1.64 μm operation of the waveguide indicates that propagation losses are low, encouraging the hope that the low gain 2.94 μm and green upconversion transitions might operate efficiently in this material. Since the fabrication process offers good control over composition the doping levels could readily be optimized for either transition. Current efforts are devoted to making a low-loss channel waveguides, with guidance in two dimensions, in these materials. In principle a further threshold reduction by roughly an order of magnitude is possible in a channel waveguide.



CMF4 **Fig. 1.** Energy levels and transitions in Yb,Er:YAG.

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