$GdCa_4O(BO_3)_3$ – an efficient crystalline host for Yb-Er doped 1.5 μm lasers

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Background: A high-power laser source in the 1.5 micron region is desirable for several applications. In surgery, the short absorption length in water enables delicate cutting and accurate coagulation of small amounts of tissue. For lidars and range-finders, the low absorbance in the Earth's atmosphere enables accuracy over longer distances. Furthermore, as 1.5 μm radiation is absorbed in the cornea of the eye it does not focus on the retina. This property makes it relatively eye-safe in contrast to e.g. 1 micron radiation.
The main problem in constructing a solid-state high-power laser source is the intense thermal load on the laser material. The ability of the material to handle the thermal load relies mainly on its' thermal conductivity. Until recently glass has been the by far most efficient host material for Yb-Er doped lasers in the 1.5 micron region. However, glass is well-known to have low thermal conductivity so for the construction of an efficient high-power laser it is necessary to find a crystalline host that is close to glass in efficiency. The $YCa_4O(BO_3)_3$ (YCOB) crystal is a very promising candidate that was presented two years ago. This poster presents the first succesful results using $GdCa_4O(BO_3)_3$ (GdCOB), a related crystal that is easier to manufacture due to a lower melting point.

Experiment and results: The GdCOB crystals were grown by the Czochralski method from a melt containing 38 at.% Yb and 2.5 at.% Er. The samples were polished flat-flat and the two opposite faces were coated to form a monolithic cavity with R = 97.9 % output coupling. Three different pump lasers were used; a pulsed diode laser, a cw diode laser and a Ti:sapphire laser. The input-output characteristics are shown in the figure. We believe the lower slope efficiency of the cw laser diode to be due to a non-optimal thermal lens. In the two other set-ups the thermal lens could be controlled.
The slope efficiency of 15 % is quite comparable to glass while the laser threshold is much higher. The high threshold is due to the low lifetime of the upper laser level, 1.2 ms in GdCOB compared to 6-8 ms in glass. However, in high power applications the higher thermal conductivity of the crystal could still result in higher output power before thermal fracture.
Q-switching has been achieved using $MgAl_2O_4$:Co as saturable absorber.
Future investigation will focus on finding the thermal limit to output power using more powerful pumping devices and optimising the important Q-switching regime.

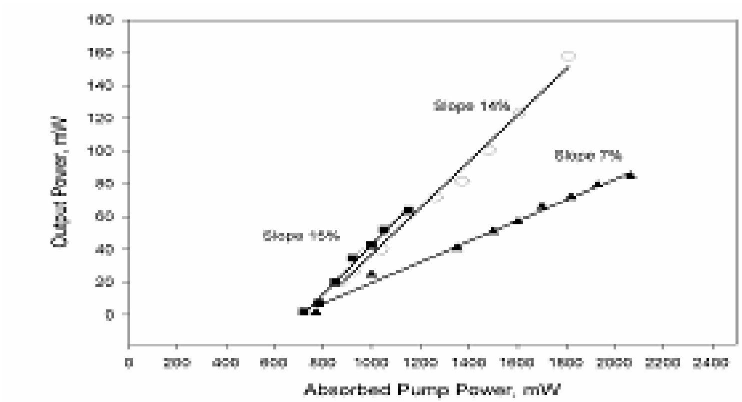

Figure: The input-output power characteristics of the different laser set-ups. Circles refer to pulsed diode pumping, triangles to cw diode pumping and squares to Ti:Sapphire pumping.