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Infrared Wavelength Tunability in Yb:YCOB

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Ytterbium-based laser systems have demonstrated promise as alternatives to neodymium-laser systems in high power laser applications. Ytterbium systems are particularly well suited for diode pumping and have previously demonstrated wavelength tunability when doped into YAG [1-6]. Here we summarize our experiments with ytterbium doped into a new laser host material, $YCa_4B_3O_{10}$ (YCOB), which provides at least 70nm of wavelength tunability.

Ytterbium is an attractive dopant ion for tunable lasers because it has a wide range of *4f*-*4f* vibrational transitions, which result in broad-band spontaneous emission. In the past, the usefulness of ytterbium has been limited by the fact that there are no excited manifolds accessible beyond the *4f* manifold at 10,000cm^{-1}, therefore flashlamp pumping is inefficient [3]. However, ytterbium is ideal for diode pumping because it has a broad absorption band, which reduces the temperature control requirements on diode output wavelength [4]. Furthermore, the lack of higher energy levels is an advantage for diode pumping because it eliminates energy loss due to excited-state absorption and upconversion [3]. Another advantage of ytterbium is that its atomic radius is very close to that of yttrium, thus when ytterbium replaces yttrium, as in the case of Yb:YAG, there is virtually no latice mismatch and consequently no concentration quenching [3]. The broad spectral emmision of ytterbium allows for 80nm of wavelength tunability [4] and has generated femtosecond pulses [7] in YAG.

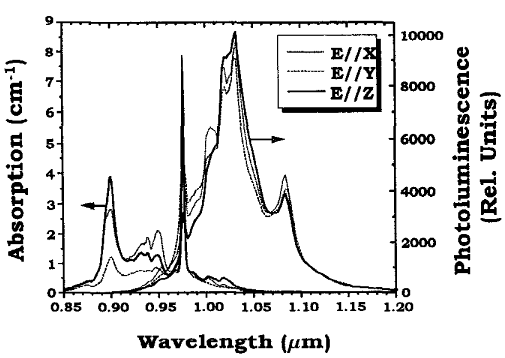

Figure 1: Polarized absorption and emmision spectra of Yb:YCOB.

YCOB is a member of a new class of calcium oxyborate cyrstals that demonstrate great promise as a laser host material. Similar to YAG, large YCOB boules with excellent optical, thermal and mechanical properties can be grown in a short time via Czochralski pulling. As in Yb:YAG, high dopant concentrations can be achieved without concentration quenching. Yb:YCOB has a broad

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emmision band (Fig 1) allowing for wide wavelength tunability. Unlike Yb:YAG, Yb:YCOB has a very long excited-state lifetime of 2 to 3ms, depending on dopant concentration [4].

Furthermore, YCOB is a good nonlinear crystal [8], and it has recently been demonstrated that Nd:YCOB [9], and Yb:YCOB [10] are capable of self-frequency doubling. Consequently, the large tunability of ytterbium and the nonlinear characteristics of YCOB make Yb:YCOB a potential tunable laser source in the green as well as the infrared.

In these experiments, we used a 10mm long Brewster/Brewster cut crystal with 10% ytterbium concentration in a standard X-cavity configuration pumped by a Ti:Sapphire laser tuned to 900nm with a maximum power of ~1.4W. Using a 2% output coupler, the cavity was optimized for a minimum threshold of 184mW absorbed pump power. CW output power as a function of absorbed pump power had a slope efficiency of 24%, with a maximum output power of 150mW. Tuning was accomplished by inserting a single plate birefringent filter into the cavity. The additional intracavity loss reduced the maximum output power to 120mW. Fig. 2 shows the output power as a function of wavelength, with 70nm of wavelength tunability centered at 1050nm.

In conclusion, we show that Yb:YCOB has a comparable tuning range to Yb:YAG [2]. This combined with YCOB's good thermal and mechanical properties make it attractive for use in high power and high repetition rate ultrashort pulse laser systems. Although these experiments are preliminary, Yb:YCOB shows great promise as an inexpensive, rugged, and compact diode pumped, tunable and/or modelocked laser material for applications in the infrared, and extension to visible wavelengths by virtue of self-frequency doubling.

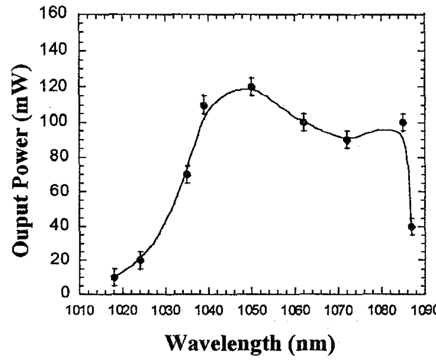

Figure 2: Laser output power as a function of laser wavelength.

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