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Room-temperature continuous-wave Er^{3+}:$LiLuF_4$ upconversion laser at 552 nm

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Summary

Upconversion lasers need host materials with low effective phonon energies to minimize the non-radiative decay rates of the rare-earth dopant excited energy levels involved in the multi-step pumping process. Fluoride crystals like $LiYF_4$ indeed show low effective phonon energies as compared to oxide materials and can be grown by the Czochralski method. Er^{3+}:$LiYF_4$ room-temperature continuous-wave upconversion lasers emitting in the green spectral region have successfully been demonstrated for the first time in our laboratory [1]. Efficient excitation of the green emitting $^4S_{3/2}$ level was achieved by pumping at 810nm or 970nm, where semiconductor laser diodes are commercially available. Therefore, the realization of an all-solid-state erbium-doped fluoride-crystal upconversion laser can be envisaged.

$LiYF_4$ melts incongruently leaving a non-stoichiometric melt in the crucible while gradually enriching the LiF phase during Czochralski growth. Quite generally, this behaviour leads to low growth rates and a low efficiency regarding the melt-to-crystal conversion. $LiLuF_4$ is isomorphic to $LiYF_4$ and, in contrast, melts congruently and can be stoichiometrically Czochralski grown. Therefore, rare-earth-doped $LiLuF_4$ crystals have been investigated for their lasing potential. To the best of our knowledge, Nd^{3+} is the only rare-earth dopant that has reportedly shown continuous-wave laser operation in the $LiLuF_4$ matrix to date [2].

We report on the Czochralski growth of Er^{3+}(1%):$LiLuF_4$. Spectroscopic investigations revealed absorption coefficients of $0.06cm^{-1}$ and $0.28cm^{-1}$ (π-polarization) at 810nm and 974nm, respectively, a peak emission cross section of $1.2\times10^{-20}cm^2$ at 552nm (π-polarization), and a lifetime of 394μs of the green emitting Er^{3+} $^4S_{3/2}$ level. Excited-state absorption measurements are currently in progress.

Room-temperature continuous-wave lasing at 552 nm was demonstrated under $Ti:Al_2O_3$ pumping at either 810nm or 974nm. Maximum output power of 72mW (cf. Fig. 1) was obtained in a nearly concentric resonator with the pump source tuned to 974nm. At this output power level, the incident pump power was 2.5W corresponding to 450mW of absorbed power.

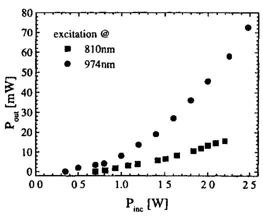

Figure 1: Input-output characteristics of Er^{3+}(1%):$LiLuF_4$. Output coupling was 1.4%.

[1] F. Heine, E. Heumann, T. Danger, T. Schweizer, G. Huber, and B. H. T. Chai: Appl. Phys. Lett. **65** (4), 383 (1994)

[2] A. A. Kaminskii, K. Ueda, and N. Uehara: Jpn. J. Appl. Phys. **32** pt. 2 (4B), 586 (1993)

11.45 CTuF4

High Power and High Energy Self-frequency Doubling Nd^{3+}-doped YCOB Lasers

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The development of high power diode-pumped and flashlamp-pumped self-frequency doubling (SFD) lasers, such as Nd:YCOB [1], may be an attractive alternative to lasers incorporating intra-cavity doubling with a separate nonlinear crystals. Several SFD lasers have shown efficient frequency doubling into the green [1-2]. The use of intracavity doubling in cw diode-pumped systems is of interest for efficient visible laser sources Flashlamp-pumped intra-cavity doubled systems will allow for smooth long-pulse SFD laser systems suitable for a number of medical applications. Here we report our latest developments in high power , diode-pumped cw visible SFD laser systems and in flashlamp-pumped systems incorporating SFD crystals such as Nd:YCOB.

We have previously shown efficient laser action and SFD operation of Nd:YCOB using diode-pumping from a single 100 μm emitter [1]. Over 60 mW of green radiation was obtained using a linear hemispherical resonator and more than 350 mW of 1060 nm laser light was obtained using a 2% output coupler.

To scale SFD radiation to higher powers, we have used a Polaroid Polychrome Laser system consisting of multiple single emitters, collimated and microlensed to reduce the beam divergence. The diode system was capable of producing more than 6 3 W of collimated radiation at 812 nm. When focused, the diode system could obtain spot sizes on the order of ~ 200 μm. A hemispherical laser cavity was used consisting of a flat high reflector and a 10-cm radius of curvature output coupler. The 3 x 3 x 5 mm long Nd:YCOB crystal was coated with a triple-band anti-reflection coating and mounted on a cooled copper block next to the high reflector Figure 1 shows the fundamental output power for the one and two-percent output coupler for different numbers of diode pump modules. The fundamental output power exceeded 1 3 W for 3.4 W of absorbed pump power Green self-frequency doubled output powers of over 85 mW were obtained. The conditions needed for scaling Nd:YCOB SFD lasers to higher powers will be discussed.

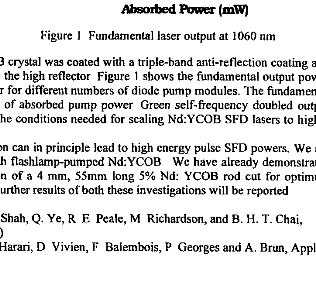

Figure 1 Fundamental laser output at 1060 nm

Flashlamp-pumped laser operation can in principle lead to high energy pulse SFD powers. We are currently investigating SFD operation with flashlamp-pumped Nd:YCOB We have already demonstrated both free-lasing and Q-switched operation of a 4 mm, 55mm long 5% Nd: YCOB rod cut for optimum phase-matched conditions of 1060 nm. Further results of both these investigations will be reported

[1] J. M. Eichenholz, D. A. Hammons, L Shah, Q. Ye, R E Peale, M Richardson, and B. H. T. Chai, Appl. Phys Lett., **74**, 1954 (1999)

[2] F. Mougel, F. Augé, G Aka, A. Kahn-Harari, D Vivien, F Balembois, P Georges and A. Brun, Appl. Phys. B, **67**, 533 (1998).