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CTuM71

Diode-pumped cw laser around 1.54 μm using Yb, Er-doped silico-boro-phosphate glass

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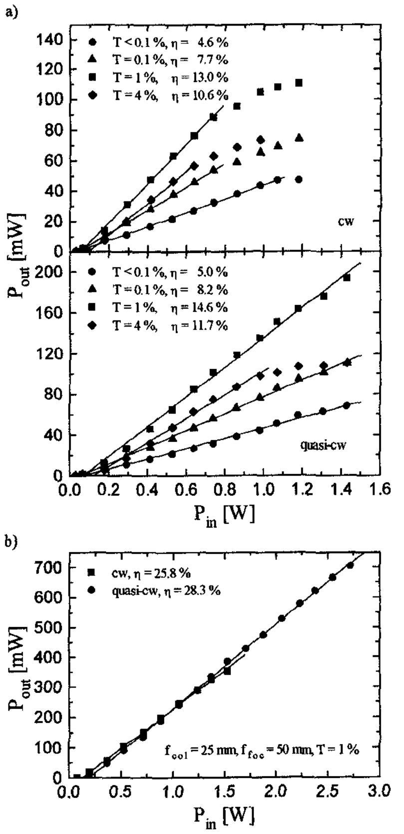
Erbium lasers in the eye-safe region around 1.55-μm wavelength exhibit many applications such as measuring techniques, LIDAR systems, and data transfer via glass fibers. The highest slope efficiencies of an Er 1.55-μm laser have been reported for an Yb, Er-doped glass.[1] In the present work the laser properties of Yb, Er-doped silico-boro-phosphate glasses containing high Yb concentrations were investigated under longitudinal diode pumping. These glasses were already used for transverse diode excitation.[2] Laser action of similar glasses has also been reported for longitudinal pumping, but only with low output power.[3]

During the laser experiments summarized in Table 1 the glasses were pumped around 970 nm wavelength with two InGaAs laser diodes coupled with a polarizing beam splitter. A hemispheric resonator with an output mirror of $r = -5$ cm radius of curvature was used. In the case of quasi-cw (qcw) pumping, the pump light was chopped with 32 Hz and a duty cycle of 50%, so the average power was half the quasi-cw power. The emission wavelength varied between 1.53 μm and 1.57 μm. The highest output powers were obtained with a transmission of the output mirror of $T = 1\%$ [Fig. 1(a)]. The glasses exhibited thermal problems, and the surfaces were damaged at high pump powers.

The 2-mm-long $Yb(4 \cdot 10^{21} cm^{-3})$, $Er(5 \cdot 10^{19} cm^{-3})$:glass was also pumped with a 3.7-W pigtail laser diode. The diameter of the fiber was 100 μm. Using collimating and focusing lenses of $f_{col} = 25$ mm and $f_{foc} = 50$ mm, hence an enlarged pump focus, the maximum cw and quasi-cw (duty cycle 50%) output powers and slope efficiencies were $P_{out,cw} = 353$ mW, $P_{out,qcw} = 706$ mW, $\eta_{cw} = 25.8\%$, and $\eta_{qcw} = 28.3\%$ [Fig. 1(b)].



CTuM71 Fig. 1. Laser characteristics of the 2-mm-long $Yb(4 \cdot 10^{21} cm^{-3})$, $Er(5 \cdot 10^{19} cm^{-3})$: glass in the cw and quasi-cw mode when pumping with a) the polarization-coupled laser diodes (f = 3 cm) and b) the pigtail laser diode.

In further experiments the cooling as well as the Yb and Er concentrations have to be optimized for an improvement of the laser performance. In addition, the damage threshold should be increased in order to allow higher pump levels.

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CTuM71 Table 1. Results of the Laser Experiments on Yb, Er-doped Silico-boro-phosphate Glasses with $4 \cdot 10^{21} cm^{-3}$ Yb

Er concentration [cm^{-3}]			$3 \cdot 10^{19}$	$5 \cdot 10^{19}$	$3 \cdot 10^{19}$	$5 \cdot 10^{19}$
d [mm]	f [cm]	mode	P_{thr}[mW](HR)		P_{out}[mW](T = 1%)	
2	2	cw	10	28	72.7	115.0
		qcw	10	31	132.3	177.0
	3	cw	15	26	92.1	110.2
		qcw	15	26	124.0	194.0
4	2	cw	44	80	73.6	90.3
		qcw	49	97	79.7	106.0
	3	cw	41	52	89.5	120.6
		qcw	44	52	103.6	154.3

CTuM72

V:YAG as passive *Q*-switch at 1342 nm and 1064 nm

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Passive Q-switching has provided a very successful, compact, means of generating short, high intensity pulses. Many of the saturable absorbers used have been based on materials doped with the Cr^{4+} ion, in particular Cr:YAG, which has yielded pulses of 600-ps duration and peak power in excess of 28 kW, in a microchip geometry with Nd:YAG.[1] The saturable absorption of the Cr^{4+} ion falls off beyond 1.1 μm, restricting its application to wavelengths shorter than this. More recently the use of multiple quantum well semiconductor devices has produced ultrashort pulses, 230 ps at 1342 nm and 56 ps at 1064 nm using $Nd:YVO_4$ in a microchip format.[2,3] These SESAM devices however have high loss, giving low pulse energies, and their low damage threshold limits their scalability.

Here we believe we report the first use of V:YAG as a passive *Q*-switch for a diode-pumped Nd^{3+} laser at 1 μm and 1.3 μm. Previous investigations of the dynamics of the excited states and saturation of V:YAG showed that this crystal can be successfully used as a saturable absorber for pulsed lasers operating in the red and infrared spectral regions.[4,5] The V:YAG crystal used for our work was a 3-mm-long cylinder, with a V^{3+} doping concentration of 2×10^{20} atoms/cm^3 and had a wedge of 4 mrad between the crystal faces. The crystal carried a broadband AR coating. The small signal transmission of the crystal was 95.5% at 1064 nm and 92.2% at 1342 nm with less than 1% reflection from the coatings.

The 1342-nm laser consisted of a 1%-doped $3 \times 3 \times 0.5$ mm piece of $Nd:YVO_4$ coated HR/AR at 1342 nm, an air gap of 0.5 mm, the V:YAG crystal, and a discrete output coupler, giving a total cavity length of 4 mm. The 1064-nm laser used for its gain material a 3%-doped $3 \times 3 \times 0.5$ mm crystal of $Nd:YVO_4$ coated HR/AR at 1064 nm as the gain material and suitable discrete output couplers. A 2-W laser diode was used to pump this arrangement through a 8-mm collimating lens and 8-mm focussing lens. No attempt was made to shape the diode beam to optimize coupling or to double pass the pump light through the gain crystals.

At 1064 nm the relatively low loss of the satu-