CTuK53

Novel erbium-doped crystal saturable absorber *Q*-switches for the Er:glass laser

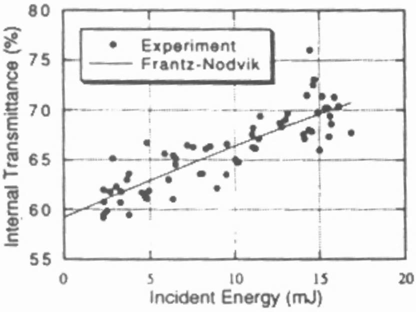
M. B. Camargo, R. D. Stultz,*
M. Birnbaum, K. Spariosu, *Center for Laser Studies, University of Southern California, DRB 17, University Park, Los Angeles, California 90089-1112*

Er:glass lasers are useful for a large number of applications because they emit in a narrow eye-safe region around 1.53 μm. For many of these applications a *Q*-switched pulse is required. Active *Q*-switches increase the complexity and the cost of the system. Passive *Q*-switches such as saturable absorbers remain the simplest and cheapest method.[1-4]

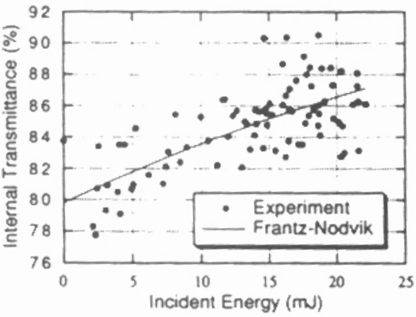
In this paper we report the first passive *Q*-switching of the Er^{3+}:glass laser at 1.53 μm using $Er^{3+}:CaF_2$ as an intracavity saturable absorber. *Q*-switched pulses of 69 ns (FWHM) and 11 mJ were obtained using an uncoated 1-mm-thick *Q*-switch sample in a 17.5-cm-long resonator cavity along with a 3 × 50 mm QE-7S (Kigre) Er:glass laser rod. Saturable absorber *Q*-switching of Er:glass has previously[5] been obtained using $Er:Ca_5(PO_4)_3F$ (or Er:FAP); however, new results for this material, as well as a comparison to $Er:CaF_2$ are presented here. We achieved *Q*-switch pulses of 27 mJ, 47 ns using an AR-coated Er:FAP crystal, repre-

CTuK53 Table 1. Summary of Er:CaF, and Er:FAP Q-switch Results

Q-switch	Q-switch thickness (mm)	Er:glass laser rod	Resonator length/intracavity lens focal length	Output mirror reflectivity (%)	Output Energy (mJ)	Threshold (J)	Q-switch pulse width (nsec)
(3.5%)Er:CaF_2	1.1	(QE-7) 3 x 76 mm	41 cm/ +15 cm	88 (flat)	2.3	53	233
(3.5%)Er:CaF_2	1.1	(QE-7S) 3 x 50 mm	21 cm/+7.6 cm	88 (flat)	3.3	205	129
(2.0%)Er:CaF_2	1.0	(QE-7S) 3 x 50 mm	17.5 cm/+5 cm	94 (2.5 cm curv.)	11	51	69
(2.0%)Er:CaF_2	1.0	(QE-7S) 3 x 50 mm	21 cm/+5 & -2.5 cm (intracav. telescope)	94 (flat)	1.6	39	400
(1%)Er:(1%)Yb: FAP(uncoated)	4.0	(QE-7S) 3 x 50 mm	17.5 cm/+5 cm	80 (2.5 cm curv.)	15	135	43
(1%)Er:(1%)Yb: FAP(coated)	4.5	(QE-7S) 3 x 50 mm	17.5 cm/+5 cm	94 (2.5 cm curv.)	27	44	47



CTuK53 Fig. 1. Bleaching data of (2%) Er:CaF_2 at 1.543 μm. Solid curve is from modified Frantz-Nodvik equation for saturation fluence of 9.2 J/cm².



CTuK53 Fig. 2. Bleaching data of (1%)Er:(1%)Yb:FAP at 1.543 μm. Solid curve is from modified Frantz-Nodvik equation for saturation fluence of 9.8 J/cm².

senting a significant improvement over the previously reported results (6 mJ, 83 ns).[5]

Our saturable absorber Q-switching results were obtained using several Er:glass resonator cavity configurations, summarized in Table 1. All the Q-switch crystals were cut and polished with flat, parallel surfaces. The Q-switches were aligned parallel to the cavity mirrors. The Er:FAP crystals (uniaxial) were cut with the c-axis parallel to the polished surfaces (E//c absorption band is higher and broader than E//a).

Q-switching with Er:FAP typically resulted in one very short pulse (Q-switched), followed by several free-running spikes of much lower peak power.[5] The Er:CaF_2 Q-switches did not exhibit the free-running spikes but instead when the pumping energy was increased, we observed what seemed to be repetitive Q-switching.

The absorption cross-sections for both Er:CaF_2 and Er:FAP were determined by bleaching the crystals using a Raman-shifted Nd:YAG laser at 1.543 μm with a pulsewidth of 15 ns. We measured 1.543 μm saturation fluences (Figs. 1 and 2) of 9.2 J/cm² for Er:CaF_2 and 9.8 J/cm² for Er:FAP (E//c). These correspond to cross-sections of 1.41×10^{-20} cm² and 1.32×10^{-20} cm² (E//c) for Er:CaF_2 and Er:FAP, respectively. Using the absorption spectra for both materials, we corrected the cross-sections to 1.29×10^{-20} cm² and 1.43×10^{-20} cm² (E//c), respectively, for the Er:glass wavelength of 1.533 μm. Theoretical modeling of the Q-switched pulses showed good agreement with the results summarized in Table 1.

Also with Hughes Aircraft Company, El Segundo, California 90245

1. D. W. Anthon, T. J. Pier, Sol. Stat. Lasers III, SPIE **1627**, 8 (1992).
2. S. E. Sverkov, B. I. Denker, V. V. Osiko, Yu. E. Sverkov, Sol. Stat. Lasers III, SPIE **1627**, 42 (1992).
3. H. S. Keeter, D. S. Dewald, M. A. Woodall, Sol. Stat. Lasers III, SPIE **1627**, 21 (1992).
4. S. J. Hamlin, J. D. Myers, M. J. Myers, Eyesafe Lasers: Comp., System., and Applic., SPIE **1419**, 100 (1991).
5. K. Spariosu, R. D. Stultz, M. Birnbaum, T. H. Allik, J. A. Hutchinson, Appl. Phys. Lett. **62**, 2763 (1993).

CTuK54

High-gain, diode-laser-pumped Nd:YVO_4 slab amplifier

J. E. Bernard, E. McCullough, A. J. Alcock, *Institute for Microstructural Sciences, National Research Council, Ottawa, Ontario, Canada K1A 0R6*

We have previously reported[1] a novel, diode-laser, side-pumped Nd:YVO_4 slab laser oscillator with high optical to optical conversion efficiency. This oscillator design uses a laser material such as Nd:YVO_4 which absorbs strongly at the pump wavelength so the laser gain is confined to a thin region next to the flat pump face. Good spatial overlap between the pumped volume and the laser mode is obtained by arranging the cavity optics so that the laser mode makes a single, grazing-incidence, total internal reflection from the pump face and therefore remains in the region of highest gain throughout its passage through the laser material. Because of the single reflection,