

Passive Q-switching at 1.54 μm of a Er-Yb:GdCa₄O(BO₃)₃ Laser with a Co²⁺:MgAl₂O₄ Saturable Absorber

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Abstract: A train of Q-switched pulses is formed in a diode-pumped microchip laser consisting of an Er-Yb:GdCa₄O(BO₃)₃ active and a Co²⁺:MgAl₂O₄ passive elements. The pulses durations were in the range of 1.6-6 ns.

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1. Background

Er, Yb doped GdCa₄O(BO₃)₃ (GdCOB) crystal is one of the first efficient crystalline materials for 1.5 micrometer Er-Yb lasers [1]. Its main advantage over Er-Yb laser glasses is the higher thermal conductivity, while a disadvantage is the shorter upper laser level lifetime resulting in a high lasing threshold. Despite this high lasing threshold, the material exhibits high slope efficiency close to that of Er-Yb glasses. This has also been shown experimentally in the CW regime.

Nevertheless, most applications of miniature diode-pumped 1.5 μm lasers, such as range-finding and lidar, require Q-switched operation. For crystalline hosts, we have not been able to find any investigations of passive, Q-switched operation. For glass on the other hand, Co²⁺:MgAl₂O₄ (MALO or spinel) is well known to be an efficient passive Q-switching material (see, for example, [2]). Er-Yb:GdCOB shows emission spectrum in the 1.5 μm range rather similar to the the spectrum of Er ions in phosphate glasses. The values of the lasing cross-sections are also close.

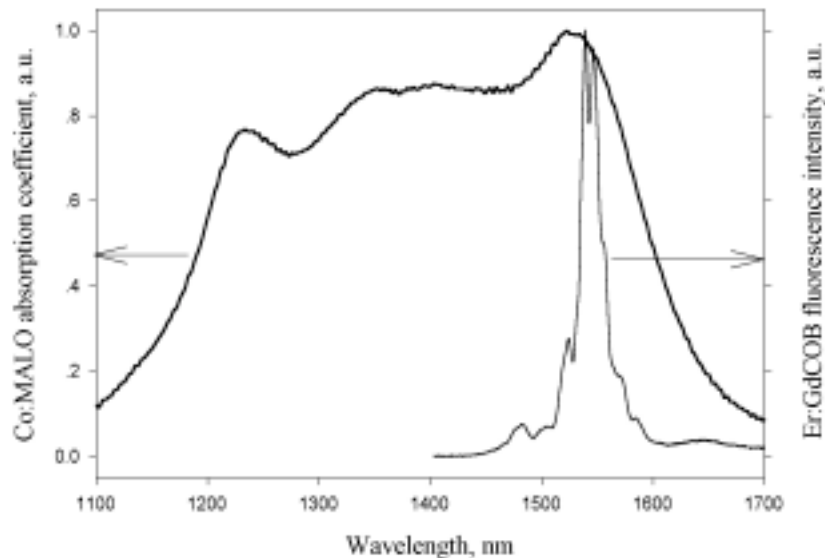


Fig. 1. The emission spectrum of Er-Yb doped GdCOB, and the absorption spectrum of MALO

As can be seen from the spectra, the MALO absorption spectrum peaks close to 1.54 μm , which is the natural Er lasing wavelength of Er-Yb:GdCOB. The value of Co²⁺ ions absorption cross section at this peak is about $3.5 \times 10^{-19} \text{ cm}^2$ that is more than a magnitude higher than the emission cross-section in GdCOB. Taking this into account one

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can expect that Co:MALO can be used for Q-switching Er-Yb:GdCOB lasers also.

2. Experiment.

The tests were held using a flat-parallel plate of Er-Yb:GdCOB crystal with a thickness of 2.4 mm and nominal dopants content of 38 % Yb and 2.5 % Er. As saturable absorber a 0.5mm thick MALO flat-parallel plate was used, giving a single-pass absorbance of 1.5% at the lasing wavelength 1.54 μm . The resonator mirrors (~100% and 98%) were deposited directly on the GdCOB and MALO crystals respectively. The other two facets of the active and passive elements had AR coatings and were immediately adjacent to each other in order to give as short cavity as possible. After assembling this optical pair no additional adjustment was needed to keep the laser resonator mirrors parallel.

The assembly was pumped by a system of seven laser diodes. The ~0.975 μm diodes radiation was focused into ~100 μm spot inside the GdCOB crystal. The overall power of the system reached 4-5 W, but only ~40% of this was absorbed in the laser crystal due to the narrow absorption line and some spread in the exact emission wavelengths of the diodes.

The described microchip laser emitted a train of Q-switched pulses each having 5-6 ns duration. This pulse duration is approximately equal to the duration achieved in Yb-Er:glass under the same conditions.

In a second experiment, using a MALO plate with 3 % single-pass absorbance the pulse duration dropped to approximately 1.6 ns. In all other aspects than the absorbance, the assembly was the same as in the experiments mentioned above. However, this system was pumped by a quasi-continuous wave 20 W laser diode focused in a ~200 μm spot. Unfortunately, the high peak power of these pulses burnt the partially reflective coating on the MALO.

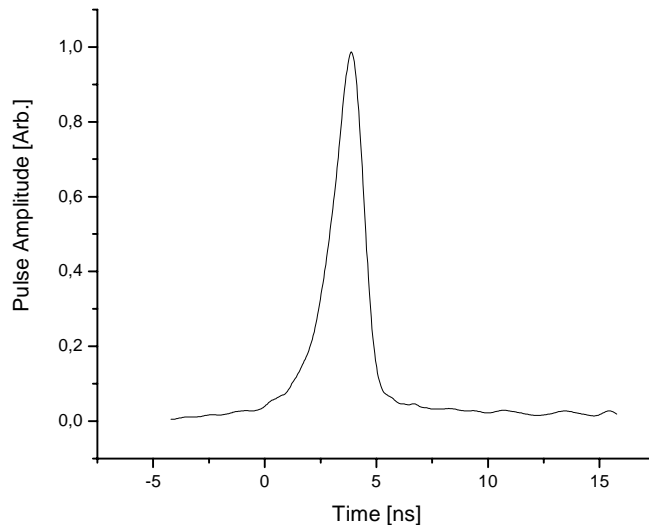


Fig. 2 The shape of a 1.6 ns pulse.

We believe that using the results obtained it is possible to create a high average power microchip laser yielding polarized (due to GdCOB crystal anisotropy) Q-switched pulses. This work is ongoing now.

3. References.

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