 https://doi.org/10.1051/epjconf/202024306003

Infrared and self-frequency-doubling emission characteristics of diode-pumped Nd:LGSB laser crystal

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Visible laser sources are attractive for various applications, such as laser display, information storage, optical communications, or in medicine. In addition, a self-frequency-doubling (SFD) laser can be incorporated in a chip device, bringing advantages like stability, efficiency, low cost, compactness and simplicity. Different Yb^{3+}- and Nd^{3+}-doped bifunctional crystals have been developed [1], including Yb:YCOB [2], Nd:GdCOB [3], Nd:NLBO [4], or Nd:CTGS and Nd:STGS [5,6]. The need for efficient SFD laser devices justifies the high interest for discovering novel bifunctional materials with enhanced performances [7]. In this work, we report on infrared laser emission and first SFD results at 531 nm achieved with a 2.3-at.% Nd:LGSB bifunctional crystal, grown by the Czochralski method in our laboratory.

The laser medium was a 2.3-at.% Nd:LGSB negative uniaxial crystal, uncoated, with a thickness of 5.7 mm; it was cut for type I phase matching condition (θ= 35.3°, φ= 60°) at room temperature. The crystal was fixed in a copper mount whose temperature was carefully controlled, in order to ensure proper cooling during lasing, while keeping the phase matching condition for SFD. The optical resonator (Fig. 1) was a short (10-mm length) plane-concave configuration. The plane pump mirror (HRM) was coated high transmission (HT, T> 98%) at the 807-nm pump wavelength (λ_p) and high reflectivity (HR, R> 99.9%) at both fundamental (λ_ω= 1062 nm) and green ($\lambda_{2\omega}$= 531 nm) laser wavelengths. The concave out-coupling mirror (OCM) had a radius ρ= 100 mm. The pump (at λ_p= 807 nm) was done with a fiber-coupled diode laser, whose fiber end (100-µm core diameter, NA= 0.22) was imaged into Nd:LGSB with a 1:1 optical system made of two aspherical lenses.

The laser emission at λ_ω= 1062 nm was evaluated first, using OCM with different transmissions, T. The best performance was recorded for an OCM having T= 0.05. As shown in Fig. 2a), the Nd:LGSB crystal yielded 1.55 W output power (P_{out}) at 4.5-W absorbed pump power (P_{abs}); the slope efficiency, with respect to P_{abs}, was η_{sa}= 0.42. Saturation of P_{out} was observed for P_{abs} exceeding 3.9 W, indicating thermal effects in Nd:LGSB.

For the generation of green light by SFD, an OCM coated HR (R> 99.9% at 1062 nm) and HT (T> 95% at 531 nm) was used. The green output power reached P_{out}= 13.2 mW for P_{abs}= 4.31 W at 807 nm [Fig. 2b)]. The spectrum was centred at $\lambda_{2\omega}$= 531 nm, having a bandwidth (FWHM definition) of 1.3 nm.

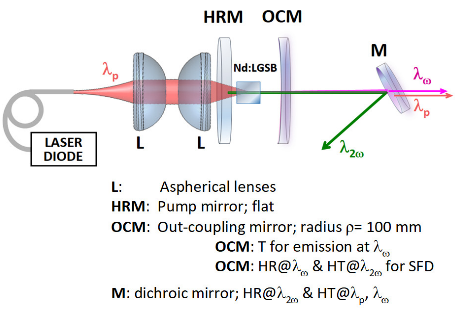

Fig. 1 The experimental set-up, general view.

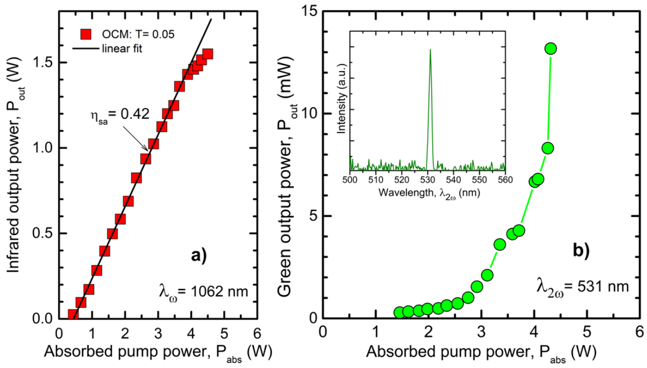

Fig. 2 Output power vs. aborbed pump power for emission at **a)** λ_ω= 1062 nm and **b)** SFD at $\lambda_{2\omega}$= 531 nm. Inset shows the emission spectrum at 531 nm.

In conclusion, we report on first SFD experiments performed on Nd:LGSB bifunctional laser crystal, from which 13.2 mW output power of green light at 531 nm was obtained. The results compare well with previous reports on other Nd-based bifunctional media [4-6]. Improved SFD performances are expected by optimizing the Nd:LGSB medium characteristics (doping level and length), by coating the crystal, as well as by designing a new laser resonator.

Financing: Projects 119/2017, PN-III-P4-ID-PCE-2016-0853 and NUCLEU 16N/2019, Ministry of Research and Innovation, Romania.

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