# Development of LYSB and Yb-doped LYSB crystals as new candidates for the next generation of nonlinear optical and/or laser crystals

Greculeasa M[1,2]*, Broasca A[1,2], Voicu F[1], Stanciu G[1], Hau S[1], Gheorghe C[1], Croitoru G[1], Pavel N[1], Gheorghe L[1]
*Greculeasa M: madalin.greculeasa@inflpr.ro
1 National Institute for Laser, Plasma and Radiation Physics, ECS Laboratory, Romania
2 Doctoral School of Physics, University of Bucharest, Faculty of Physics, Romania

Nowadays, solid-state lasers with emission in the visible (VIS) range are used in a wide variety of applications. Currently, they are limited to those based on the $Pr^{3+}$ ion and to tunable lasers which cover a narrow domain of laser emission wavelengths in the VIS range. An alternative method to obtain VIS coherent radiation sources consists of frequency conversion of actually known solid-state laser emission using suitable nonlinear optical (NLO) crystals. Thus, laser radiation in the green spectral range can be obtained by second harmonic generation (SHG) of solid-state lasers emitting in the 1 µm range. Also, a more compact laser system can be obtained by self-frequency doubling (SFD) processes, using a bifunctional crystal that combines both the active laser medium and the nonlinear frequency conversion medium in one crystal. For this purpose, incongruent melting $La_xY_ySc_{4-x-y}(BO_3)_4$ - LYSB and 4 at.% Yb-doped $La_xY_ySc_{4-x-y}(BO_3)_4$ - LYSB:Yb (4 at.%) crystals were successfully grown by the Czochralski method [1], for the first time according to our knowledge, and investigated as new candidates for the next generation of efficient NLO and/or laser crystals. The grown crystals are shown in Fig. 1.

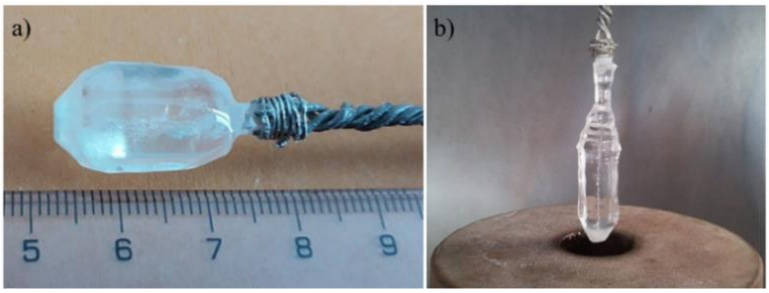


Fig. 1. Czochralski-grown crystals: LYSB (a) and Yb:LYSB (b).

High-quality crystals with dimensions of about 12 mm in diameter and 25 mm in length were grown along the ⟨0 0 1⟩ direction (parallel to the crystallographic ***c***-axis) using optimized pulling and rotation rates of 2 mm/h and 8 - 10 rpm, respectively. Taking into account the incongruent melting of LYSB and Yb:LYSB (4 at.%) crystals, their starting melt compositions were also optimized and a special thermal setup was engineered to avoid the constitutional supercooling phenomenon. In terms of NLO properties, both crystals possess remarkable properties specific to huntite-type crystals. The laser performances of LYSB:Yb (4 at.%) crystal prove its favorable intrinsic properties to generate laser emission in the 1 µm range with high efficiency. The highly efficient laser emission at ~ 1028 nm (slope efficiency over 0.60), together with good NLO characteristics to convert its own emission into emission at ~ 514 nm via SHG, make the LYSB:Yb (4 at.%) crystal a very promising active medium to be used in SFD configuration.

**Funding**
Program NUCLEU-LAPLAS VII/30N/2023 and project PCE 49/2021 (PN-III-P4-ID-PCE-2020-2203), Romanian Ministry of Research, Innovation and Digitization.

**References**
[1] Broasca A et al. Pure and Yb-doped $La_xY_ySc_{4-x-y}(BO_3)_4$ crystals: a review of recent advances. Crystals. 2023;13(12):169.