Birefringence dispersion management of langasite nonlinear crystals for the improvement of mid-infrared amplification

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Nonlinear optical crystals generally hold the intrinsical contradiction between the laser damage threshold and transmission range, which restricts development of the high-power and large-energy mid-infrared (mid-IR) lasers, especially the mid-IR optical parametric chirped-pulse amplification (OPCPA) system [1]. The langasite crystal was identified as a promising candidate for the 4–6 μm terawatt-class OPCPA system, but suffers the relatively low effective nonlinear coefficient (d_{eff}) [2]. Herein, a birefringence dispersion management strategy is originally developed and applied for the d_{eff} improvement of langasite crystals based on their structural symmetry, as shown in Fig.1. A series of $La_3(Nb_{1-x}Ta_x)_{0.5}Ga_{5.5}O_{14}$ ($LGNT_x$) solid-solution crystals (x = Ta/(Ta+Nb) = 0.17, 0.40, 0.51, 0.77 and 0.95) were theoretically designed and grown for the first time. By characterization of the crystals, the $LGNT_{0.40}$ crystal was experimentally confirmed with largest d_{eff} by implementing a data-driven routine, which is 1.7 times improvement compared with that of the well-known $La_3Nb_{0.5}Ga_{5.5}O_{14}$ (LGN) crystal, and the 2.9 times of theoretical enhancement in the amplification efficiency of the OPCPA system. These results do not only provide a kind of candidate for the ultra-intense mid-IR lasers but demonstrate a feasible strategy for managing the birefringence dispersion applied in the optics, including polarization regulation, beam splitting, wave plates, etc. [3]

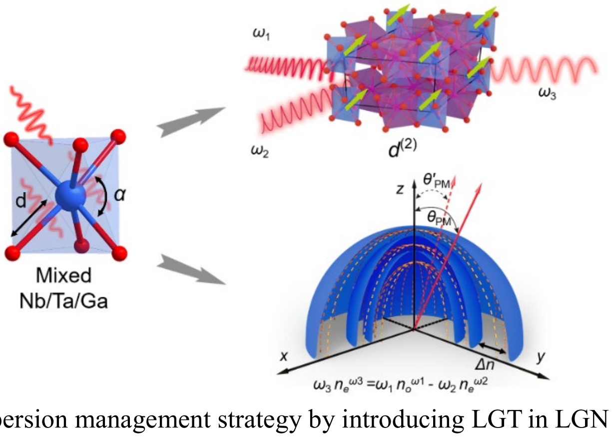

Fig.1 The birefringence dispersion management strategy by introducing LGT in LGN to regulate the (BO_6) polyhedron is implemented for optimizing the crystal structure and finally improving d_{eff}.

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