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Characterization of 8 mol% Mg-doped congruent $LiTaO_3$ crystal for high-energy quasi-phase matching device

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Quasi-phase matching (QPM) technique have realized an efficient and various types of nonlinear wavelength conversion by using a desired nonlinear coefficient in arbitrary wavelength by specially designed crystal structure. Ferroelectric crystals such as $LiNbO_3$ (LN) and $LiTaO_3$ (LT) have been reported for major materials of the QPM device from visible to mid infrared (MIR) wavelength region. In last several years, we have reported a large-aperture QPM device using a Mg-doped congruent LN (MgLN) for high-power/energy operation, and demonstrated a highly efficient and high-energy optical parametric oscillation with > 0.5 J output energy by a 10-mm-thick periodically poled MgLN (PPMgLN) [1]. As increasing of both conversion efficiency and handling power/energy in PPMgLN device, crystal damage have become severe problem, which needed to find another choice for the QPM material. Compared to LN-type crystals, LT-type crystals have relatively wide transparent range, small absorption, and high thermal conductivity, although their nonlinear coefficients are low, which are suitable for high-power/energy QPM devices. LT crystal with Mg-doped stoichiometric composition, grown by double crucible Czochralski or vapor phase epitaxy method, have been already reported [2]. In this study, we focus on the Mg-doped congruent LT (MgLT) grown by conventional Czochralski method. An increase of Mg doping can basically improve various properties for the QPM device, though high-quality crystal growth become difficult. Here we focus on the characterization of 8 mol% MgLT (Mg8LT), and compare with low Mg-doped MgLTs [3] and 5 mol% MgLN.

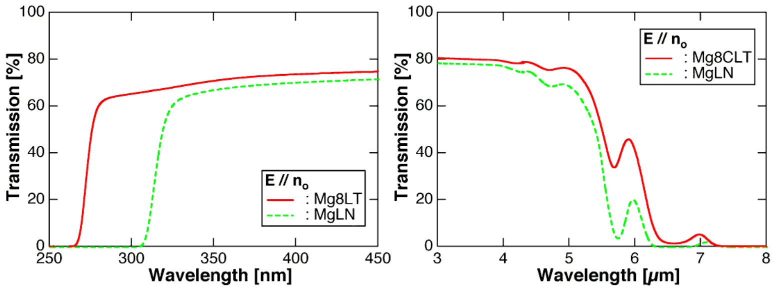

Fig. 1 Transmission of Mg8LT & MgLN in (a) UV and (b) Mid-IR range.

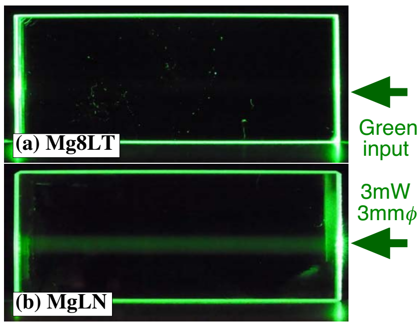

Fig. 2 Scattering of green light in (a) Mg8LT, (b) MgLN.

Transmission characteristics of Mg8LT and MgLN in UV and MIR region are compared in Fig.1. Also, green light (3 mW, 3 mm diameter) scatterings are also shown in Fig.2. Both results showed that Mg8LT has favorable properties for high-power/energy operation of wide transmission in UV region and small scattering loss against green light.

For realizing a QPM device using MgLT, its coercive field E_c, to invert the crystal polarization, is important, though it is much sensitive to the crystal quality and the amount of Mg doping. E_c of Mg8LT, measured by REFVR method (S = 1 kV/mm-s) [3] at various temperature, are shown in Fig. 3. The E_c at room temperature and 150°C were measured to 2.2±0.6 kV/mm and 1.2±0.1 kV/mm. Figure 4 presents a summary of our E_c measurement for MgLT with various Mg doping. Although there are some discontinuity between old [3] and new datas by difference of crystal-growth condition, decreasing of E_c on increasing Mg doping could be measured.

MgLT is a promising crystal instead of MgLN for future higher-power/energy QPM device, and we will continue its evaluation for realizing an actual periodically poled MgLT device.

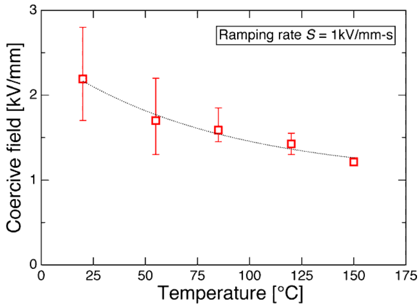

Fig. 3 Coercive field of Mg8LT.

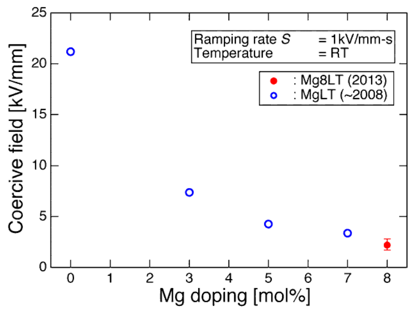

Fig. 4 Coercive field of old and new MgLT.

Ref [1] H. Ishizuki and T. Taira, Opt. Express **20**, 20002 (2012).
[2] S. V. Tovstonog, S. Kurimura, and K. Kitamura, Appl. Phys. Lett. **90**, 05115 (2007).
[3] H. Ishizuki and T. Taira, Opt. Express **18**, 253 (2010).