주기적으로 분극반전된 stoichiometric lithium tantalate를 이용한 안정된 고출력 녹색광생성

Stable high-power green light generation with thermally conductive periodically-poled stoichiometric lithium tantalate

유난이, Sunao Kurimura, Yoshiyuki Nomura and Kenji Kitamura
National Institute for Materials Science,1-1, Namiki, Tsukuba, 305-0044, Japan
YU.Nanei@nims.go.jp

A high-power green light has been used at various application fields such as an effective tool in processing high-reflectivity materials, in medical equipment, as a compact pump source of Ti:sapphire lasers instead of a Ar-ion laser, and laser displays. For an efficient green light generation, a quasi-phase matching (QPM) technique in the lithium niobate family has been widely used. In 1997, Miller *et al.* have demonstrated a CW green light of 2.7 W [1] using a 53-mm-long periodically poled lithium niobate (PPLN) at a high temperature (~ 200°C) because of photorefraction at room temperature operation. Recently, Mizuuchi *et al.* have reported on a CW green generation of 1.03 W using a periodically poled $MgO:LiNbO_3$ by considering of high resistance against photorefractive damage [2]. Popov *et al.* have also reported on a 6 W green light [3] with a seeded high power ytterbium fiber amplifier using a periodically poled KTP (PPKTP) crystal.

However, we still have difficulties such as photo induced damage, and thermal dephasing for practical applications. On the other hand, we have developed stoichiometric lithium tantalate (SLT) with a high nonlinearity and an order of magnitude lower coercive field than congruent lithium niobate and tantalate. These features are attractive for high-power wavelength conversion with large-aperture QPM devices.

In this work, we fabricated a uniform PP structure with a high domain aspect ratio and stable green light generation of 4.4 W at 532nm with an uncoated 10.2-mm-long PP 1.0 mol% MgO-doped SLT (PPMgSLT) at room temperature without photorefraction. Moreover, the PPMgSLT crystal requires temperature adjustment as small as 0.5°C at the maximum fundamental input power of 11 W because of its higher thermal conductivity than PPKTP [4].

We fabricated PP structures with a QPM period from 7.8 to 8.0 um in 1-mm-thick PPMgSLT. A metal electrode was deposited on a patterned photoresist film on the +Z surface of a 2-inch diameter wafer. An electric field with pulse duration of 40 ms was applied at 1.4 kV/mm, and a PP structure was obtained with a high domain aspect ratio (depth/width) of 250. A $Nd:YVO_4$ laser was operated at a repetition rate of 50 kHz with a 15 ns pulse width, which oscillates in single longitudinal mode with $M^2 \sim 1.2$. The fundamental beam was focused to 0.36 mm in diameter using a lens. To estimate the periodic uniformity of the PP structure, we measured second harmoinc (SH) intensity as a function of temperature. The temperature bandwidth of 3.2°C in Fig. 1 agrees well with the theoretical value of 3.26 °C using the reported Sellmeier equation [5], indicating an excellent uniformity along the device length. A maximum SHG power of 4.4 W with a peak power density of 6.6 MW/cm^2 was obtained by 11 W pumping without photorefraction at 33 °C as shown in Fig. 2. A stable output power and good beam profile of 532 nm was observed during the whole experimental time (more than 35 hours).

Although KTP yielded a similar average power at room temperature as previously reported [3], the temperature shift of the phase matching point was reported to be 2 to 3°C because of the thermal effect at a high input power. However, in this study, the crystal required a temperature shift as small as 0.5°C, indicating higher heat dissipation than that in KTP crystals. The absence of photorefraction, detrimental thermal lensing and insignificant roll-off of the SH efficiency curve suggests that further power scaling should be possible.

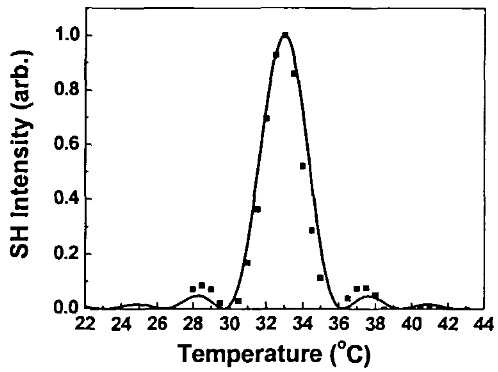

Fig.1 SH intensity vs.temperature at QPM period of 8.0 um.

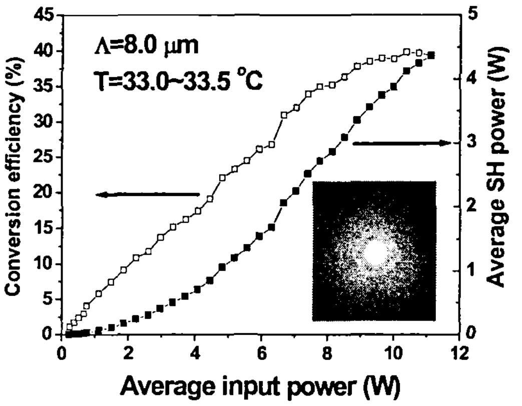

Fig.2 SH output power vs. input power.

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