Temperature tuning of YCOB crystal for giant-pulse green micro-laser

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The current level of technologies enables to increase the application number were compact Nd:YAG passively Q-switched laser systems can be used. Currently one of demanding trend for such over MW-class systems expands to an engine ignition, mass spectroscopy and frequency conversion [1,2].

The previous result for second harmonic generation (SHG) of Nd^{3+}:YAG/Cr^{4+}:YAG microchip laser reached 85% by use of type I LBO crystal [3]. Because of the small temperature acceptance, this crystal has limitation where output energy of a laser is required to be stable over wide temperature range. The monoclinic rare-earth yttrium calcium oxyborate crystal $YCa_4O(BO_3)_3$ or YCOB has wide optical transparency, similar nonlinearity as LBO crystal and stable physical and chemical characteristics. Additionally, the excellent temperature acceptance of this crystal allows no degradation in second harmonic (SH) efficiency up to 120˚C [4].

In this work we compare the SHG efficiency for LBO and two YCOB crystals grown in Cz and Bridgman methods. Also temperature tuning of YCOB crystal was performed to obtain experimental data of temperature range within which conversion efficiency is strongly degraded.

The available output energy for frequency conversion after all optical elements reached 2.84 mJ. Combined with pulse duration 340 ps the maximum peak power reached 8.34 MW. Experiments with LBO crystal showed the maximum conversion efficiency of 73.5% by focusing lens 150 mm. In this case thee output energy and pulse duration were 1.7 mJ and 236 ps respectively. Both YCOB crystals showed highest conversion efficiency with focusing lens *f*=125 mm, when the fundamental beam diameter was 0.77 mm. For a Cz grown YCOB crystal the conversion efficiency reached 62.4% with the output energy and pulse duration 1.1 mJ and 228 ps, respectively. For the Bridgman grown YCOB crystal efficiency reached 70.4% with the output energy and pulse duration 1.14 mJ and 226 ps, respectively.

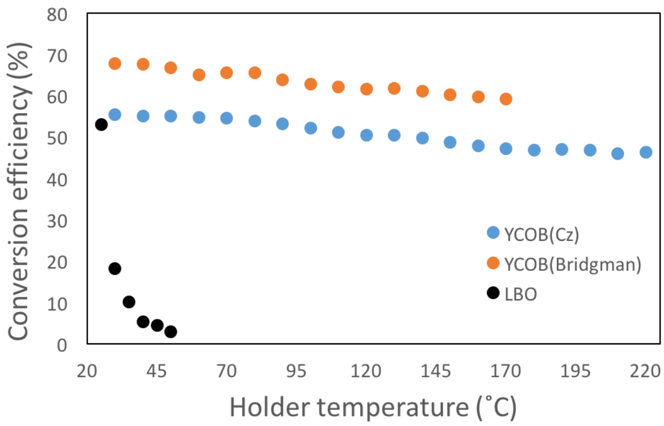

Figure 1. Temperature tuning of the YCOB and LBO crystals

Another experiment was performed to measure the temperature tuning of a YCOB crystal during long temperature range for the same fundamental energy of 1.8 mJ. The holder temperature changed from 25˚C to 220˚C for Cz grown crystal and up to 170˚C for the Bridgeman grown crystal. The difference in temperature range is because of crystals different aperture size and limited amount of heating power available. The slope for the crystal was -0.057%/˚C and -0.064%/˚C for the Cz and Bridgman grown crystals respectively (Fig. 1).

This work was funded by the C-PhoST (Consortium for Photon Science and Technology) and French National Research Agency, ANR, Programme Blanc International II - SIMI 4 - Physique (Blanc Inter II SIMI 4) 2011, under grant agreement ANR-11-IS04-0006.

References

[1] M. Tsunekane, T. Inohara, A. Ando, N. Kido, and K. Kanehara, "High Peak Power, Passively Q -switched Microlaser for Ignition of Engines," IEEE J. Quantum Electron. **46**(2), 277–284 (2010).

[2] R. Bhandari and T. Taira, "Palm-top size megawatt peak power ultraviolet microlaser," Opt. Eng. **52**(7), 076102 (2013).

[3] R. Bhandari and T. Taira, "> 6 MW peak power at 532 nm from passively Q-switched Nd:YAG/Cr4+:YAG microchip laser," Opt. Express **19**(20), 19135–19141 (2011).

[4] N. Umemura, M. Ando, K. Suzuki, E. Takaoka, K. Kato, M. Yoshimura, Y. Mori, and T. Sasaki, "Temperature-Insensitive Second-Harmonic Generation at 0.5321 μm in $YCa_4O(BO_3)_3$," Jpn. J. Appl. Phys. **42**(8), 5040–5042 (2003).