MW Peak Power UV laser by Fourth Harmonic Generation in $YAl_3(BO_3)_4$ crystal

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1. Introduction

In 2008, $YAl_3(BO_3)_4$ (YAB) was reported as new non-hygroscopic material with good d_{eff} (0.63 pm/V) and small walk-off (1.9°) which can be a good alternative to the two commercial crystals: the hygroscopic $CsLiB_6O_{10}$ (CLBO) or to the β-BaB_2O_4 (BBO; which presents large walk-off) for UV generation at 266 nm [1]. However, until now the UV peak power obtained with YAB was only limited to the kW range [2]. In this work, we demonstrate 1.6 MW peak power at 266 nm using YAB as nonlinear crystal.

2. Experimental setup

The main source at 1064 nm was a Q-switched Nd^{3+}:YAG/Cr^{4+}:YAG-based gain aperture of micro-MOPA (Master Oscillator Power Amplifier). The cavity was build using 1.1at-% Nd^{3+}:YAG crystal as gain medium, a Cr^{4+}:YAG crystal (T_0 = 40%) as saturable absorber and an output coupler (OC) mirror with 50% reflectivity and it was pumped by 808 nm laser diode. The gain aperture was a Nd^{3+}:YAG crystal pumped by another 808 nm laser diode. This system improves output energy to 4.5 mJ (792 ps pulse duration) and beam quality (M^2 from 2.5 to 1.1) by amplifying the fundamental TEM_{00} mode and not the higher order ones [3]. Green laser at 532 nm (3.3 mJ, 619 ps pulse duration) was obtained through second harmonic generation with a type I LiB_3O_5 (LBO) crystal (θ = 90° φ = 11.4°). The green beam was finally focused (φ = 250 µm) inside an uncoated 2.94 mm thick YAB crystal oriented for the FHG at 266 nm (θ = 66.6° φ = 0°) (Fig. 1-a).

3. Results and discussion

Up to 423 µJ were obtained at 266 nm (268 ps pulse duration), corresponding to 1.6 MW peak power with a power conversion efficiency η of 32 % as can be seen in Fig. 1-b. This peak power is one order of magnitude higher than the 240 kW previously reported for YAB [3]. However, regarding theoretical conversion efficiency calculations, higher conversion can be expected with YAB material in these conditions. The difference comes from linear absorption ($T_{crystal}$ = 44 % at 266 nm due to Fe^{3+} impurities) but also from two photon absorption phenomena as the saturation of η increase with the pumping intensity.

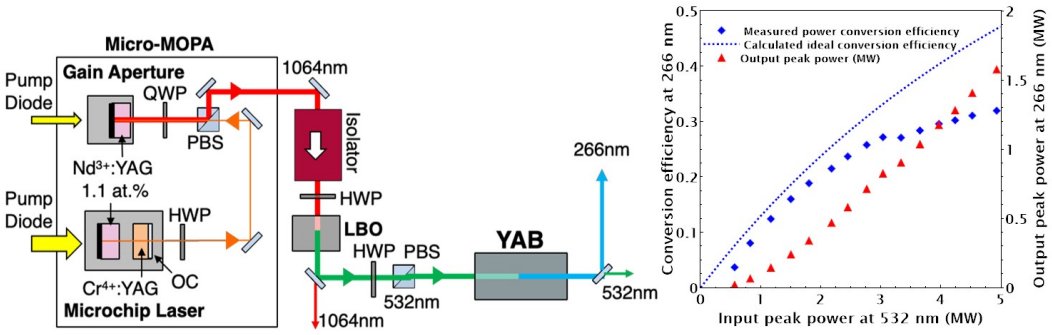

Fig. 1. Experimental setup UV light generation at 266 nm using YAB crystal (a) and obtained UV energy at 266 nm with corresponding power conversion efficiency.

4. Conclusion

Despite the limited transmission of the YAB crystal, up to 423 µJ of UV energy at 266 nm with 268 ps pulse duration were obtained by frequency conversion, corresponding to 1.6 MW peak power and 32% conversion efficiency. Further improvements are expected with the increasing of transmission at 266 nm through better growth control to open a path toward the use of longer crystals to reach >10 MW peak power. Also, two photon absorption in this material is under investigation.

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References

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