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Thermal effects in single pass SHG with focused beams

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Compact and efficient green laser light sources have numerous applications such as laser displays, material processing, biological investigations, eye surgery, and scientific research such as quantum optics. Due to high optical nonlinearity and noncritical phase matching capability, the quasi-phase-matching (QPM) technique has been an attractive method to obtain an efficient interaction of lights [1]. The main obstacle to high-power operation is thermal effects such as thermal dephasing (longitudinal) and thermal lensing (transversal), which come from a temperature gradient in QPM crystals owing to absorption of light [2]. In presentation, thermal effects with a focused beam, heat capacity of wavelength conversion module and characterization method of thermal effect in high-power wavelength conversion will be discussed in detail.

Wavefront aberration by thermal lensing can be deduced by observing the size of transmitted first harmonic (FH) beam at a screen. We used a FH beam with a waist of 30 μm in a 20 mm long PPMgSLT crystal. Figure 1 shows the measured SH power and the FH beam size versus the temperature change for a front focusing close to the input surface at a FH power of 35 W. The FH beam size clearly depends on the SH power. Thermal lensing effect is more sensitive to SH power because of a higher absorption coefficient (~ one order) and smaller beam size of SH than that of FH, and ~ 3 times larger value of Δn/ΔT at a green SH than that at FH in Mg:SLT crystal.

In order to separate thermal lensing effect by FH and SH waves, first, FH beam size was measured at a higher temperature of 70°C than QPM temperature, in which the SH power is negligible (below 4 mW). Figure 2 shows the measured FH beam size at a screen for three different focusing positions. In the case of center focusing in the crystal length, the beam size is increased as increasing the FH power. Because the value of Δn/ΔT is positive in MgSLT, the thermal lens works as a convex lens. Therefore, the increase in the beam size means that the contribution of thermal lensing effect from the input surface to the focal plane is higher than that from the focal plane to the output surface. On the other hand, the FH beam size is almost kept in the power change in the case of front focusing.

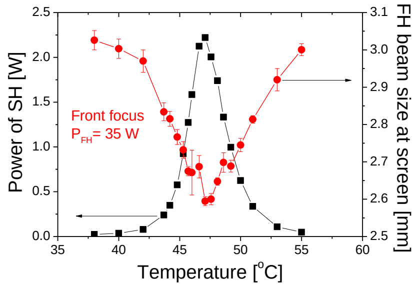

Fig.1. SH power and FH beam size in temperature tuning for front focus at FH power of 35 W.

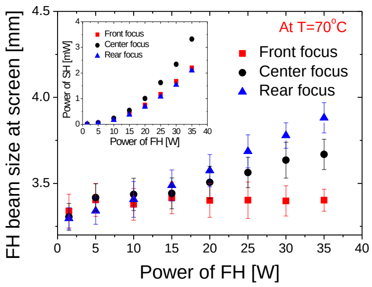

Fig.2. FH beam size at a screen versus FH power without SHG.

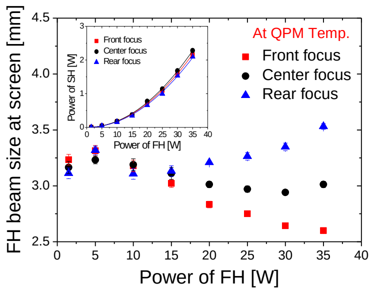

Fig.3. FH beam size at a screen versus FH power with SHG.

Fig. 3 shows the measured FH beam size at QPM temperature. Owing to the thermal lensing effect by SH, the FH beam size is first decreased at a screen, and then increased as growing SH power. This behavior can be attributed to the positional change of the thermal lens. The thermal lens by SH moves from output side to input side as growing SH power. In the case of rear focus, the thermal lens reaches the focal plane at lower SH power. These works are partially supported by JST-CREST.

References

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