Gain Measurement of Stimulated Phonon-Polariton Scattering in $MgO:LiNbO_3$ for High-Peak-Power Terahertz-Wave Parametric Generation

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1. Introduction

Injection-seeded terahertz (THz)-wave parametric generators (is-TPGs) based on stimulated phonon-polariton scattering in $MgO:LiNbO_3$ crystal are now well established as practical and widely-tunable sources of high-peak-power THz-wave radiation [1]. One of the key characteristics of these THz-wave sources is the parametric gain coefficient in $MgO:LiNbO_3$ crystals. Theoretically, the gain coefficient has been studied by using the physical parameters of A_1-symmetry mode at 248 cm^{-1} [2]. However, the absolute gain characterization still remains as an unsolved issue because no measurement has succeeded so far in directly determining the gain coefficient of stimulated phonon-polartion scattering.

In this study, therefore, we demonstrate a direct measurement scheme for parametric gain characterization of stimulated phonon-polartion scattering in $MgO:LiNbO_3$ crystal. By measuring the THz-wave output from $MgO:LiNbO_3$ crystal as a function of crystal length, the gain coefficient has been determined.

2. Experiment

To measure the THz-wave output as a function of crystal length, we used the surface-coupling configuration based on trapezoidal $MgO:LiNbO_3$ crystal. In this configuration, coupling angle of THz waves is perpendicular to the surface of trapezoidal $MgO:LiNbO_3$ crystal [3]. At this surface, both pump and idler waves experience total internal reflection. As a result, effective crystal length, which is defined by the distance between pump-incident position and total-reflection position, is continuously variable by translating the crystal positon as indicated by the dashed arrow in the inset of Fig. 1. Consequently, this configuration enables us to measure the crystal-length dependence of THz-wave output in is-TPG without changing the size of $MgO:LiNbO_3$ crystal.

Figure 1 shows the measured THz-wave output as a function of crystal length. The crystal length was varied in the range from 1.5 cm up to 3.8 cm. In this experiment, the pumping intensity at full-width at half-maximum (FWHM) was fixed at 1.25 GW/cm^2 because the gain coefficient is expressed as a function of THz-wave frequency and pumping intensity [2]. From this measurement, the gain coefficient of stimulated phonon-polartion scattering in $MgO:LiNbO_3$ crystal was determined by taking the natural log of normalized THz-wave output. Because the THz-wave output increased exponentially as crystal length increased, we can evaluate the slope efficiency as shown by the dashed line. This slope efficiency corresponds to exactly to the gain coefficient for THz-wave parametric generation. The gain coefficient at 2.3 THz was determined to be 5.07 cm^{-1} at the fixed pumping intensity of 1.25 GW/cm^2.

3. Conclusion

We have demonstrated the gain measurement of stimulated phonon-polartion scattering in $MgO:LiNbO_3$ crystal by using the surface-coupling configuration. This scheme is applicable not only for $MgO:LiNbO_3$ crystal but also for other crystals.

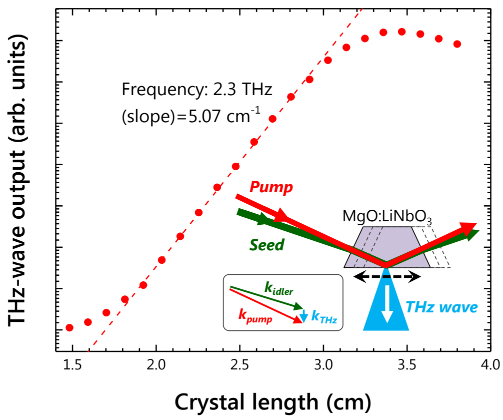

Fig. 1. Measured THz-wave output as a function of crystal length at the pumping intensity of 1.25 GW/cm^2. Inset shows the schematic experimental setup for gain measurement.

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