Cherenkov Phase Matched Ultrashort Terahertz Pulse Generation from Nonlinear Crystals

Kei Takeya[1], Tsubasa Minami[1], Ryo Yamazaki[1], Hirohisa Uchida[2], Kodo Kawase[1]

[1] Nagoya Univ., [2] Arkray Inc.
E-mail: takeya@nuee.nagoya-u.ac.jp

1. Introduction

Nonlinear optical (NLO) crystals are in common use to generate Terahertz (THz) waves. NLO crystals, such as 4-dimethylamino-N-metyl-4-stilbazolium tosylate (DAST), $LiNbO_3$, $LiTaO_3$, and GaAs, are used as effective THz sources based on their second-order nonlinearity. Various studies have been carried out on THz generation from NLO crystals using parametric processes, difference frequency generation, optical rectification, and coherent phonon emission. Effective THz generation, however, is suppressed by the high absorption coefficient of the NLO crystals. Because the refractive index of NLO crystals is different for optical and THz frequencies, the phase-matching conditions and the coherent length for optical rectification are issues for effective THz generation.

We have addressed these issues by developing a method for efficient THz-wave generation that is based on waveguide propagation with Cherenkov-type radiation using NLO crystal. This method has the following advantages: 1) many crystals can be used as THz-wave emitters; 2) It is not necessary to satisfy the phase matching condition inside crystal. ; and 3) THz wave generation is not suppressed by the absorption in the crystal [1]. We have demonstrated effective THz generation using $LiNbO_3$ waveguide crystal so far [2]. In this study we used other NLO crystals and achieved broadband THz generation.

2. Results

We used DAST, OH1 bulk crystal and OH1 waveguide crystals (thickness, 6.8 μm) in this study. The crystals were coupled to a spherical Si prism, which satisfied the Prism-coupled Cherenkov phase matching condition. The THz radiation emanated as spherical waves from each point of the crystals and was enhanced almost 50° from the pump-beam axis. We focused the pump beam on the surfaces of bulk crystals and edge face of waveguide OH1 crystal. The radiated THz pulses were observed by the method of time domain spectroscopy with photoconductive antenna.

The THz waveform was radiated from the waveguide illuminated by a 1560-nm pump pulse. The shape of obtained THz pulses from OH1 crystal is an ideal half-cycle. However, the shape from DAST crystal is complex waveform in time domain (Figure 1(a)). This is probably from the strong THz absorption of DAST crystal. Fig. 1(b) shows the corresponding spectrum obtained by Fourier transformation of the time-domain spectrum of DAST. The bandwidth of the spectrum was ~6 THz. Although the attenuation of the THz waves was observed at 1.1 THz due to the large absorption of the DAST crystal, the absorption seems like suppressed. This fact result from advantage of Cherenkov phase matching. We obtained THz-wave generation from NLO crystals with a wide tuning range.

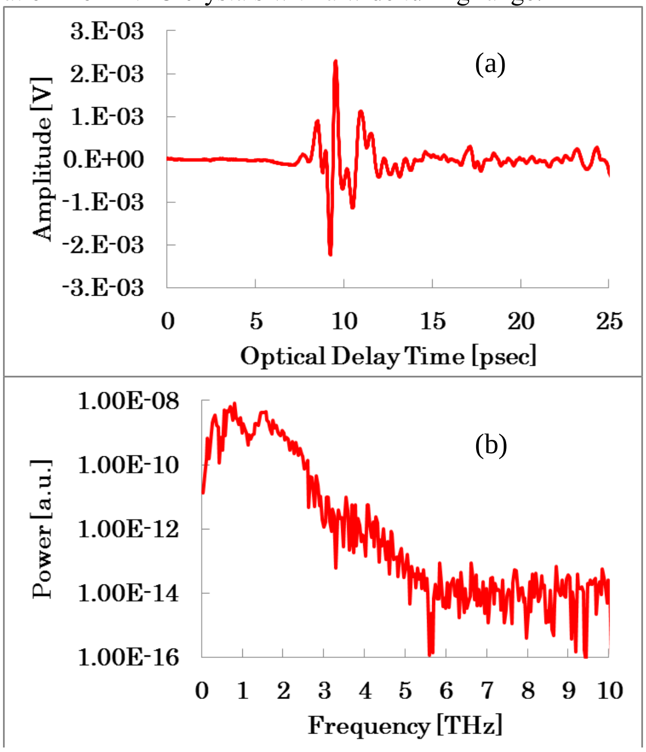

Figure 1 (a) Time domain waveform of THz pulse from the surface of DAST crystal illuminated by a 1560-nm pump pulse. (b) Frequency spectrum of generated THz wave.

3. Conclusions

We demonstrated THz wave generation from some nonlinear crystals using Cherenkov-phase matching method. Wide frequency THz wave generated from DAST and OH1 crystal illuminated by a 1560 nm pump pulses.

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References

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