Pump Wavelength Free Broadband Terahertz Generation via Nonlinear Optical Crystal

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1. Introduction

The light source is one of the most important things for a study of the light. With respect to the Terahertz (THz) generation using femtosecond laser pulse, photoconductive antenna (PCA) and nonlinear optical crystals are popular as light sources. For a strong THz emission, nonlinear optical crystals are more suitable rather than the PCA, because the generated THz power is proportional to the square of pump laser power and the nonlinear optical crystals have a high laser damage threshold.

When we use nonlinear optical crystals to generate THz waves, choosing the wavelength of the pump beam is an important factor. In case of organic crystal DAST, we need to use a wavelength of around 1600 nm to generate broadband THz waves. However, the output power of the laser pulses which have a wavelength of 1600 nm is not strong in generally. If we can use various wavelengths on THz waves generation from nonlinear optical crystals, we can achieve stronger THz emission. In this study, to clear this problem, we employed Cherenkov phase matching (Fig. 1) THz generation with nonlinear optical crystal.

2. Experiments and Results

We employed Prism coupled Cherenkov phase matching with $LiNbO_3$ crystal. The femtosecond laser we used is HFX 400 (IMRA) which enable to generate femtosecond laser pulses of two wavelengths simultaneously. The pump pulses are introduced in the $LiNbO_3$ crystal and propagate inside the crystal, then the pulses generate THz waves from the crystal due to optical rectification and make THz wave-front along the Cherenkov angle.

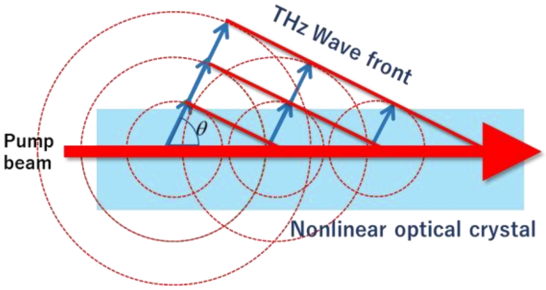

Fig. 1. Diagram of Cherenkov phase matching.

The method of detection of THz waves is based on terahertz time domain spectroscopy. A time domain waveform was observed by using photoconductive antenna and time delay line.

The THz output from the crystal pumped by femtosecond pulses with wavelength of 1560 nm and 805 nm are shown in Fig. 2. Pump pulses of each wavelength generate THz output with dynamic range over 50 dB and broadband THz wave beyond 6 THz. Moreover, the output THz power is proportional to the square of the pump power for each wavelength. These facts show that one can generate broadband THz waves without limitation of the wavelength of pump laser using Cherenkov phase matching.

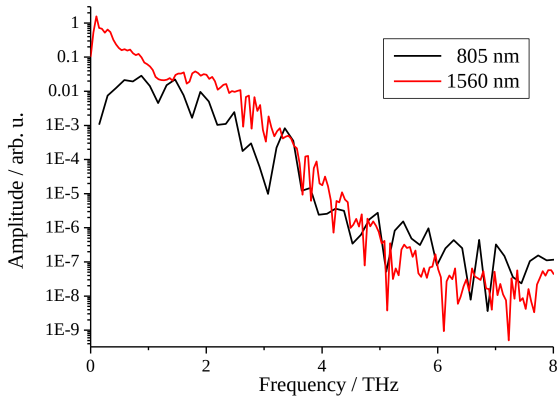

Fig 2. THz spectra generated with 805 nm (black) and 1560 nm (red) pump wavelengths.

3. Conclusions

Although the selection of the wavelength of the pump beam is an issue with regard to the THz generation using nonlinear optical crystals excited by a femtosecond laser pulses, we demonstrated that Cherenkov phase matching can clear the issue. Using even two different wavelengths of femtosecond laser, $LiNbO_3$ crystal generates broadband THz waves.

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