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Frequency tunable CW THz wave generation with Laser diode pumping

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Abstract:

Continuous-wave (CW) terahertz waves were generated via excitation of phonon polaritons in GaP. We investigated the phase matched angle frequency dependence of THz wave output power. We studied frequency–tunability of the CW THz wave.

1. Introduction

The Terahertz (THz) frequency region (100GHz to 10 THz) lies between radio and infrared regions and it has attracted significant interest due to number of potential applications. However pulsed THz waves have limited applications. CW THz waves can be used for carriers and modulators in telecommunications, and CW THz waves pumped using semiconductor lasers have a narrow line width of a MHz order. CW THz waves also have applications in high-resolution and high-speed THz spectroscopy, and imaging technologies, but only few CW THz sources have been developed so far. We have developed a widely frequency- tunable CW THz signal generator with laser diode (LD) pumping from GaP crystal and obtained high output power.

In 1963, Nishizawa predicted the generation of THz-waves from compound crystals via the excitation of phonons or molecular vibrations [1,2]. An electromagnetic wave with a frequency of 12.1 THz was generated from GaAs pumped by GaP Raman laser, at a power of 3 W [3,4]. Recently, wide-frequency-tunable high-power THz wave signals have been generated from GaP with Q-switched pulse pumping [5,6]. THz waves were generated using difference frequency generation (DFG) via the excitation of phonon-polaritons in GaP, which converts energy very efficiently, and the THz wave had a pulsed energy of 9 nJ/pulse (peak power of 1.5 W). Frequency-tunable CW THz-wave generation from GaP should be possible by enhancing the power density of the incident beams. This study describes the CW THz waves generation from GaP based on LD pumping as well as the frequency tunability.

2. Experimental

The pump and signal lasers are an external cavity laser diode (ECLD) and laser diode pumped Nd: YAG (1064 nm) laser respectively. The wavelength of ECLD can be varied from 1012 nm to 1080nm.The intensity of signal laser is amplified by using ytterbium-doped fiber amplifier (FA). The power from the ECLD and from FA was 0.24 and 3.6 W respectively. The incident beams were focused to spot sizes near the wavelength of THz waves on a GaP crystal. From the results of pulse pumping, the THz wave generated under the small angle phase-matching condition at each THz frequency should be tunable. Generated THz waves are detected by using Si bolometer cooled at 4.2 K. The bolometer signal is measured with a lock-in-amplifier.

3. Results and Discussion

Figure 1 shows the phase matching condition comparing that of theoretical and pulse pumping at 1 μm. At present the output power is in pW order. It is investigated that the THz power is likely proportional to square of the GaP crystal length ℓ, when the coherence length ℓ_{coh} is sufficiently larger than the crystal length [7].

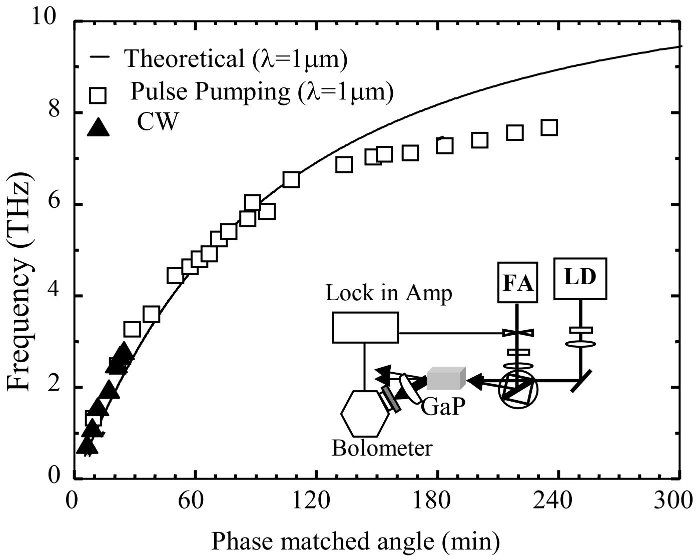

Fig. 1 Phase matching condition in GaP THz wave signal generator.

We investigated the phase matched angle dependence of the THz wave output power at various THz frequencies for different lengths of the GaP crystal. THz waves were generated over a range from 0.68 to 2.75 THz. CW THz power spectrum is obtained by piezo

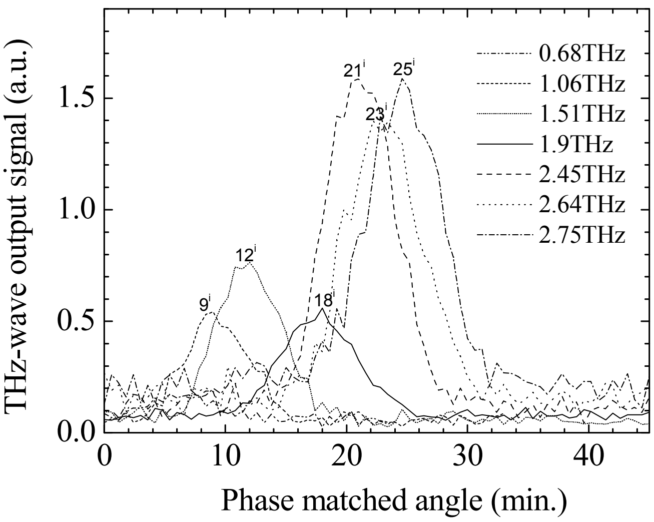

Fig. 2 CW THz-wave output power. GaP length is 10 mm

tuning the ECLD, in a wide range of THz frequencies.

4. Conclusion

Frequency-tunable CW THz wave generated with LD pumping based on the difference frequency generation via excitation of phonon polaritons in GaP. By tuning a small angle between pump and signal beam directions, a CW THz wave can generated in widely frequency range. The THz frequency of 0.2 to 7.5 THz can be swept widely with external cavity tuning and CW THz waves have very narrow line width of MHz. The generated output power can be enhanced by employing a longer GaP crystal with lower carrier density. CW THz power spectrum is studied by tuning ECLD, in a wide range of frequencies.

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