Tunable Terahertz Generation in Periodically Poled Structures Using Femtosecond Laser Pulses

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***Abstract*—Terahertz generations were demonstrated in periodically poled lithium niobate and lithium tantalate crystals around 1-2 THz. Different forward and backward terahertz radiations are possible in periodically poled structures via difference frequency generation within the ultra-broad pump laser. The generated THz pulses could be controlled by the quasi-phase matching structures.**

I. INTRODUCTION

The development of terahertz (THz) radiation sources has considerable interest in spectroscopy, imaging, medical diagnostics, gas sensing, and astronomy. A common way to generate coherent THz waves is to utilize the optical rectification in an electro-optic crystal using a fs laser pulse. For efficient single-cycle THz generation, group velocities of the optical and the THz pulses should be matched in the medium. It is accomplished in only a few crystals such as ZnTe or GaP around wavelength of 800 nm [1]. An alternative approach for the tunable narrow-band THz generation with multi-cycles or arbitrary waveforms by the optical rectification was demonstrated using periodically poled nonlinear crystals [2]. In this work, we present a forward and backward THz generation by difference frequency generation (DFG), which allows the generation of narrow-band and multi-cycles THz waveforms. The main idea is to utilize the group velocity mismatch between the optical and THz waves in periodically poled lithium niobate (PPLN) and stoichiometric lithium tantalate (PPSLT) crystals. The optical and generated THz pulses will be separated after a walk-off length and then the optical pulse will lead the THz pulse by the optical pulse duration τ. If the periodically poled domain length is comparable to the walk-off length, each domain contributes to the THz radiation independently. Because of the periodic reversed sign of the nonlinearity at each domain, the generated THz waves also have reversed wave forms alternatively. As a result, the form of THz wave is corresponding to the structure of the periodically poled domains.

II. EXPERIMENTAL RESULTS

As a pump source, a Ti: sapphire oscillator system with about 190 fs and the center wavelength of 800 nm was utilized. For the tunable THz generation, PPLN and PPSLT crystals with several quasi-phase matching (QPM) periods were fabricated by the electrical field poling method [4]. For the THz detection, a photoconductive dipole antenna was used [5]. Fig. 1 shows the typical backward THz generation at 2-mm long PPLN and PPSLT crystals with QPM period of 30.2 μm and 60 μm, respectively, at room temperature. The coherent THz radiations around 1.3 THz of PPLN and PPSLT crystals have good agreement with the calculation results using the material dispersion. The generated THz frequency is tunable as a function of the QPM period as shown before [3]. The PPSLT crystal is much better than the PPLN crystal for tunable THz generation owing to the larger clear aperture.

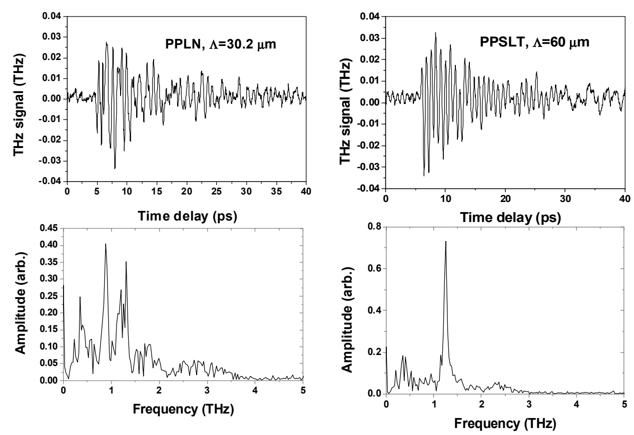

Fig.1. Measured THz waveforms (top) generated from the PPLN and PPSLT crystals in time domain and the corresponding Fourier transformed spectra (bottom).

From the analysis of the generated THz multi-cycles, moreover, we could image the poled domains of the crystals without destructing them. However, the multi-cycles signal intensities were gradually decreased because of the THz absorption. To reduce the THz absorption at the poled crystals, experiments at low temperature are going on. We will give a full detail of the results.

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978-1-4244-2120-6/08/$25.00 ©IEEE.