Continuously Tunable Terahertz-wave Parametric Source based on Spectral Drill Cavity

Shin'ichiro Hayashi[1], Yoshiharu Urata[2], Seigo Ohno[3], Katsuhiko Miyamoto[4], and Norihiko Sekine[1]
[1]National Institute of Information and Communications Technology, Koganei, Tokyo, 184-8795 Japan
[2]PHLUXi, Inc., Chuo-ku, Tokyo, 104-0053 Japan
[3]Tohoku University, Sendai, 980-8578 Japan
[4]Chiba University, Chiba, 263-8522 Japan

***Abstract*—We propose continuously tunable terahertz-wave parametric source based on spectral drill cavity. When controlling of terahertz wave frequency by wavelength conversion using a nonlinear crystal, we have to control two laser beams. One is a frequency stabilized and intense pumping beam, and the other is a tunable seeding beam. We demonstrated an injection seeded optical parametric generator and amplifier as the pumping beam, a spectral drill cavity based ECDL as the seeding beam. Nonlinear wavelength conversion techniques are very promising for extending applied research into the terahertz region, and we expect that these will open up new research fields.**

I. Introduction

For more than two decades, there has been remarkable growth in the field of terahertz frequency science and engineering, which has become a vibrant, international, cross-disciplinary research activity [1]. Wavelength conversion in nonlinear optical materials is an effective method for generating (down-conversion) and detecting (up-conversion) terahertz waves owing to the high conversion efficiency, wide tunability, bandwidth, and room temperature operation. The large figure of merit of lithium niobate ($LiNbO_3$) makes this well-known nonlinear crystal ideal for such an application; terahertz wave parametric wavelength conversion between infrared and terahertz wave is realized by stimulated polariton scattering via transverse optical phonons [2, 3].

In this study, we propose continuously tunable terahertz-wave parametric source. The frequency stabilized pumping beam is generated by an injection-seeded PPLN (Periodically Poled Lithium Niobate) – OPG (Optical Parametric Generator) and a KTA (Potassium Titanyl Arsenate) – OPA (Optical Parametric Amplifier) pumped by a Nd:YAG (Neodymium doped Yttrium Aluminum Garnet) MOPA (Master Oscillator Power Amplifier) system. The frequency of terahertz-wave is controlled by the seeding beam using a "spectral drill" Fabry-Perot cavity including a geometric phase shifter [4].

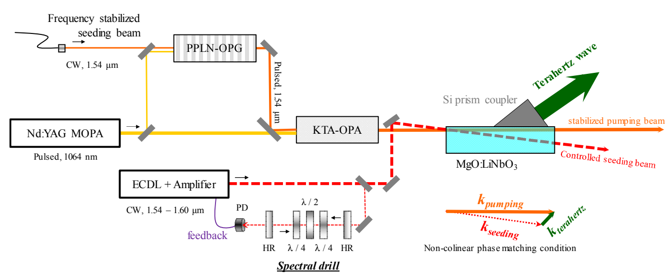

Fig. 1. Experimental apparatus.

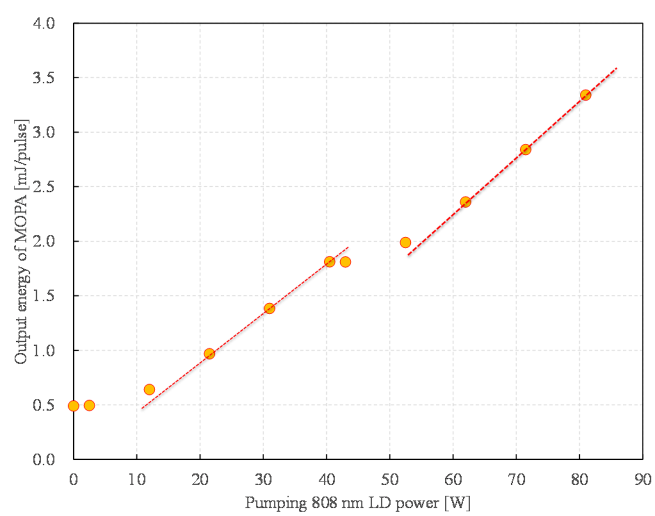

Fig. 2. Pumping 808 nm LD power dependence of the output energy of Nd:YAG based MOPA.

II. Experiment

In our experimental apparatus, shown in figure 1, the frequency stabilized pumping beam is generated using a 50 mm-long PPLN-OPG seeded by a stabilized laser beam (continuous wave, 1.539 μm) as traceable to the national standard. The generated pulses are amplified by a 20 mm-long KTA-OPA. These are pumped by a SLM Nd:YAG MOPA system. Figure 2 shows the pumping 808 nm LD power dependence of output energy of SLM 1064 nm beam. When the input energy from the master laser was 0.49 mJ/pulse, as the pumping 808 nm LD power increases, as the output energy of SLM 1064 nm also increases monotonically. When the pumping 808 nm LD power was 81 W, the maximum output energy of MOPA was about 3.3 mJ/pulse. Figure 3 shows the 1064 nm pumping energy dependence of output energy of frequency stabilized 1.5 μm beam when the seeding energy of 50 μJ/pulse. As the pumping 1064 nm energy increases, as the output energy of stabilized 1.5 μm energy also increases monotonically. When the pumping 1064 nm energy is 1.7 mJ/pulse, the maximum output 1.5 μm energy is about 0.35 mJ/pulse.

The seeding beam is monitored and controlled by using "spectral drill" resonator [4]. The resonator provides a continuous one-way sweep of the axis modes in a Fabry-Pérot cavity without sweeping the cavity mirror. The frequency of seeding beam is observed as intensity error signal. When the wavelength of seeding beam change from 1540 to 1600 nm, we can tune the wavelength of terahertz-wave between 40 and 3000 µm (corresponding frequency: 0.1 – 7.5 THz).

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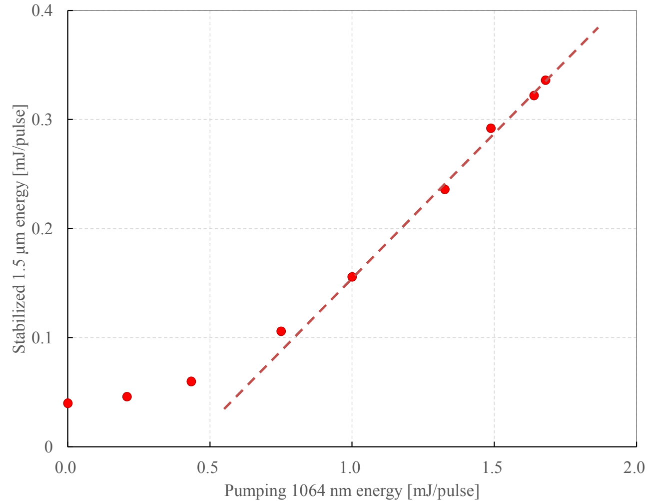

Fig. 3. Pumping 1064 nm energy dependence of output frequency stabilized 1.5 µm energy.