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Vol. 1 pp. 660-661
Publication Date: 2014/03/17
Online ISSN: 2188-5079

2012 International Symposium on Nonlinear Theory and its Applications
NOLTA2012, Palma, Majorca, Spain, October 22-26, 2012

Generation of a stable and wide range THz wave using an optical fiber and laser chaos

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Abstract– Generation of a wide-range THz wave from a photoconductive antenna excited by a multimode semiconductor chaotic oscillation laser with an optical delayed feedback using an external mirror is investigated. An optical fiber is also used for easy alignment. The properties of the generated THz wave are compared with those of generated THz wave by using a CW steady state laser.

1. Introduction

Generation of a stable wide-range THz Wave using a chaotic oscillation in a multimode semiconductor laser with an optical delayed feedback by the external mirror is investigated. A mode-locked Ti:sapphire laser is frequently used to excite the Voltage-biased photoconductive antenna. But it is a high cost system. A multimode semiconductor laser is also used to excite the antenna [1]-[4]. This system is cheap but a spectrum of generated THz wave is essentially line spectrum with a frequency interval between longitudinal modes of a semiconductor laser and THz spectrum is limited below 0.5THz. And also time series of THz wave is not stable since mode hopes in multimode semiconductor lasers suddenly occur.

We propose to use a chaotic oscillation of a semiconductor laser in order to obtain stable cheap continuously wide range THz wave. And an optical fiber is also used for easy alignment in this paper.

2. Experimental Setup

Experimental setup is shown in Fig.1. A semiconductor laser (780nm, ROHM, RLD78PPY6) is operated longitudinally multimode with a frequency interval of 43GHz between longitudinal modes without an external mirror (R_{ex}) under the condition of I_{op} （operation current）≦120mA. But in the case of I_{op}>120mA, this laser is operated longitudinally single mode. The output

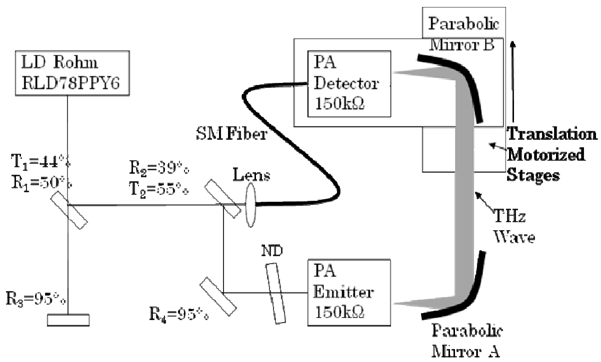

Fig. 1 Experimental Setup using an optical fiber

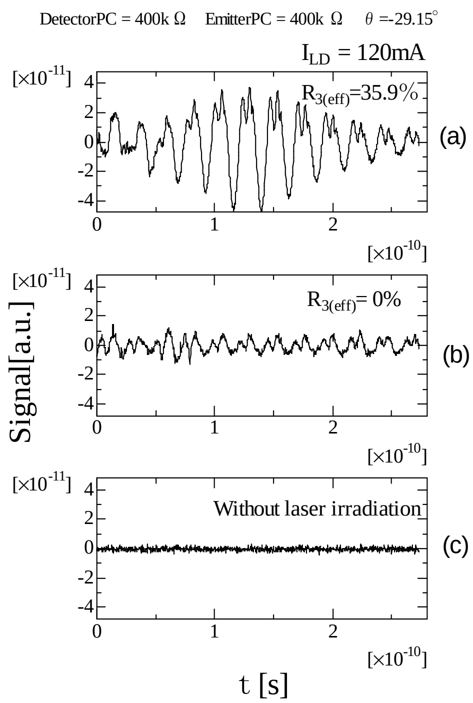

Fig.2 Time series of the THz waves

power is fed back into laser via the external mirror. Fed back rate is denoted by the effective reflectivity ($R_{3(eff)}=T^2R_3$), where T is the transmission coefficient of BS_1. The emitter PA was applied with an ac voltage of 20 Vpp with a frequency of 40 kHz for lock-in detection. The sub-THz radiation which traveled in free space was focused on the detector PA. In order to easy alignment, an optical fiber is also used for irradiating laser output power to the detector photoconductive antenna (PA).The photocurrent induced in the detector PA was detected by the lock-in amplifier with a time constant of 300 ms. The signal is obtained as a function of the delay time is a cross correlation between the sub-THz wave electric field and the exciting laser intensity.

3. Results

The time series of generated THz wave are shown in Fig.2. From top to bottom $R_{3(eff)}$ is (a)35.9% and (b)0% . Noise level is shown in Fig.2(c) in which laser output power is not irradiated to the photoconductive antenna. The output power of laser is fluctuate with a optical delayed feedback and the generated THz wave is stable as is shown Fig.2(a). Otherwise the generate THz wave is not stable in the case of a CW steady state laser excitation of photoconductive antenna as is shown in Fig.2(b).

The noise level of this system is given in Fig.2(c), in which the emitter photoconductive antenna is not irradiated by the laser output power.

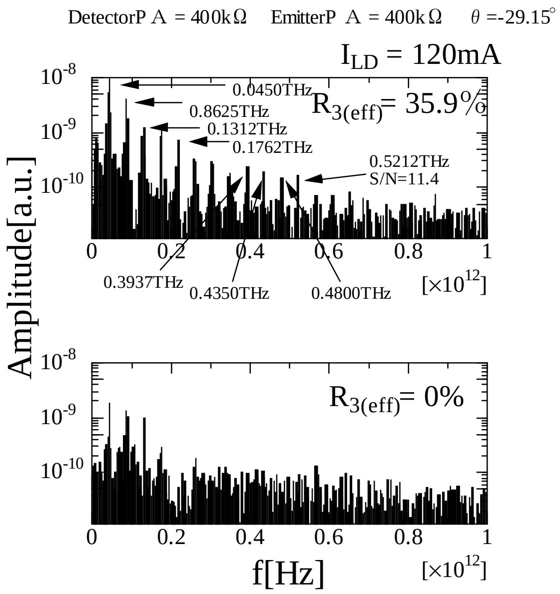

Fig.3 THz spectra

The THz spectra are shown in Fig.3, in which I_{op} is fixed at 120[mA]. The laser is operated multimode longitudinally without external mirror and THz wave is obtained under CW laser operation (R_{3eff}=0%). In this case the THz spectrum is limited under 0.4 THz and the THz signal (a current of photoconductive antenna) is not stable. As the feedback rate is larger, the laser spectrum is broadened and a laser oscillates chaotically. In the case of $R_{3(eff)}$ is 35.9% (in a chaotic oscillation region of a laser), the higher frequency THz spectrum above 0.5THz is obtained and an amplitude is also stronger than that of CW laser .

3. Conclusion

A stable and wide range THz wave is generated using a laser chaos. Optical alignment is also easy using an optical fiber.

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