



## High efficient THz-TDS system using laser chaos and super focusing with metal V-grooved waveguides

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**Abstract**—Generation of a wide-range THz waves are investigated from a photoconductive antenna excited using a chaotic oscillation multimode semiconductor laser with optical delayed feedback by an external mirror. The properties of the generated THz wave are compared with those of a case excited by a CW steady state laser. The stable THz wave is obtained from the multimode-laser diode excited photoconductive antenna by using a laser chaos. For a high sensitive detection, a metal V-grooved waveguide (MVG) is also used. The 1.6 times signal is detected using MVG compared with conventional system using Si lens.

### 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(PA). But it is a high cost system. A multimode semiconductor laser is also used to excite the antenna(1-2). 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 also time series of THz wave is not stable since mode hops 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 a Metal V grooved Wave guide (MVG) is also used to detect the THz waves effectively in this paper.(Fig.1)



Fig.1 Metal V-grooved waveguide

### 2. Experimental Setup

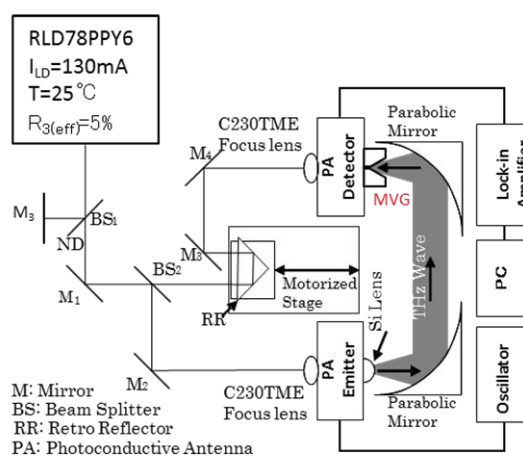


Fig.2 Experimental Setup

Experimental setup is shown in Fig.2. A semiconductor laser (780nm, ROHM, RLD78PPY6) is operated longitudinally multimode with a frequency interval of 43GHz between longitudinal modes without an external mirror ( $M_3$ ) under the condition of  $I_{op}$  (operation current)  $\leq 120$ mA. The output power is fed back into laser via the external mirror( $R_3$ ). Fed back rate is denoted by the effective reflectivity  $R_{3(eff)}$ . The emitter bowtie PA was applied with an AC voltage of 100 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. The photocurrent induced in the detector bowtie 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. Experimental Results

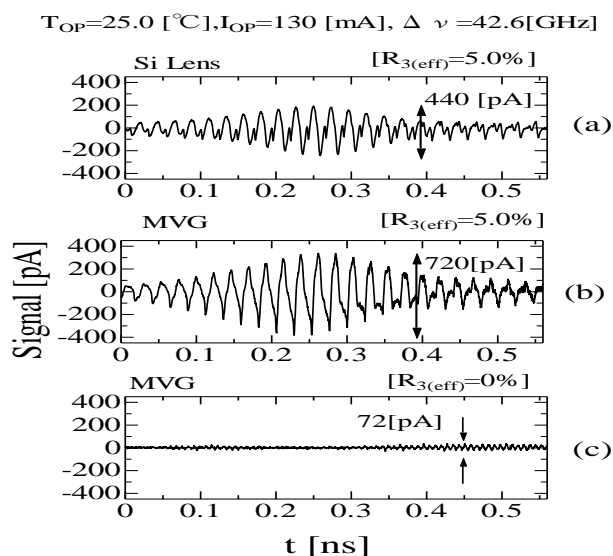


Fig.3 THz time series (a) Si lens,  $R_{3(eff)}=5\%$ , (b)  $R_{3(eff)}=5\%$ , (c) MVG,  $R_{3(eff)}=0\%$ .

The time series of generated THz wave are shown in Fig.3.  $R_{3(eff)}$  is fixed 5% in Fig.3(a) and (b). From top to bottom, THz waves are detected by using (a)Si lens, (b)MVG, and (C) MVG,  $R_{3(eff)}$  is 0%. Since the LT-grown substrate is opaque to 780nm laser light, the THz waves are irradiated from the back side of PA. However the THz waves are diffused in the substrate of PA, the 1.6 times signal is detected using MVG compared with conventional system using Si lens.

### 4. Conclusion

We demonstrated that the generated THz signals are stabilized and enhanced 10 times using laser chaos. And using MVG, the detected THz signals are enhanced 1.6 times owing the super focusing in the THz region.

### References

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