560 GHz terahertz wave generation using a soliton comb

Yu Tokizane[1], Naoya Kuse[1, 5], Kenji Nishimoto[2], Kaoru Minoshima[3, 4] and Takeshi Yasui[1, 2, 3]
[1]Institute of Post-LED Photonics, 770-8506, Tokushima, Japan, [2]Tokushima University, 770-8506, Tokushima, Japan, [3]JST ERATO MINOSHIMA IOS, 182-8585, Tokyo, Japan [4]University of Electro-Communications , 182-8585, Tokyo, Japan [5]PRESTO, 182-8585, Tokyo, Japan

***Abstract*—560 GHz THz-wave generation was demonstrated using micro soliton comb and photomixer. Infrared soliton comb was injected to wideband THz-wave UTC-PD, and output beam was measured by the Golay cell. Output wave had a transparency to the material and frequency of 557 GHz which was measured by the Fabry-Perot etalon.**

I. INTRODUCTION

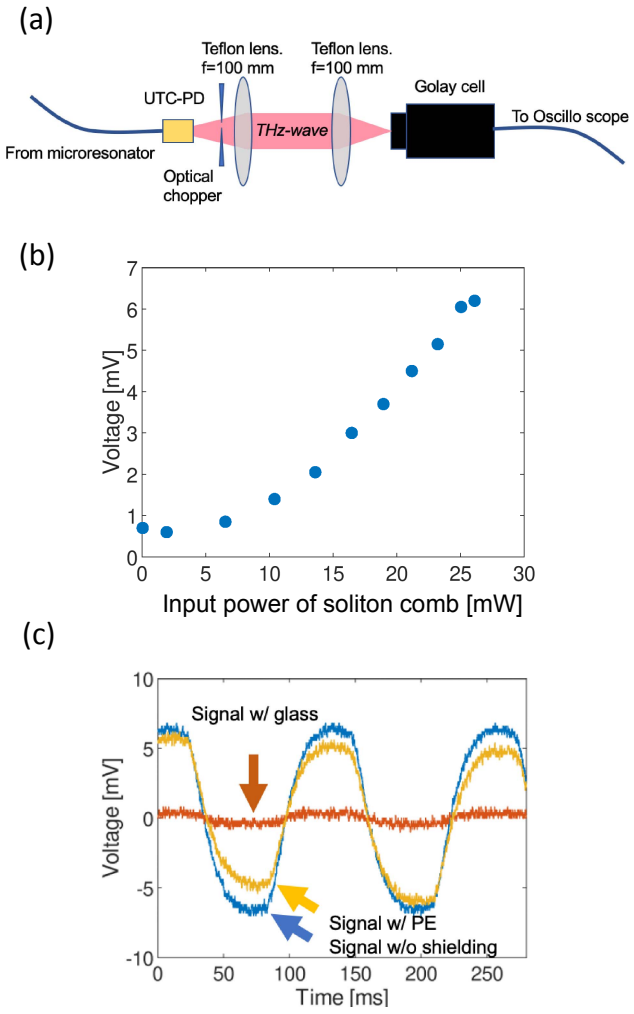
Terahertz (THz) waves are intermediate frequencies between light and radio waves which are able to be applied to security inspection, spectroscopic measurements, high-speed wireless communications, etc. because they have transparency, fingerprint spectra to some materials and high carrier frequency [1]. For these applications, a miniaturization and frequency stabilization of THz-wave sources are important. In recent years, the generation of THz-wave has been reported using a near-infrared micro soliton comb generated from a high Q-factor microcavity and a photomixer [2], which is expected as a compact and frequency-stable THz light source. However, the generation was only reported in frequency of 331 GHz. Further frequency scaling is important for the applications. In this report, we generated the THz-wave with 560 GHz using the soliton comb and a wideband photomixer.

II. RESULTS

The experimental setup is shown in Fig. 1(a). A soliton comb was generated from a micro-resonator designed for 560 GHz frequency interval, which was incident to the THz-wave photomixer using fiber optics. For the photomixer, the uni-traveling carrier photodiode (UTC-PD) was used whose operation frequency is wideband from 200 GHz to 650 GHz [3]. The output beam from the UTC-PD was collected on the Golay cell detector by a pair of Teflon lenses. Fig. 1(b) shows a relationship between the detected signal voltage and the power of the incident soliton comb to the UTC-PD. The signal voltage monotonically increases with respect to the incident power, which shows the energy of the soliton comb was converted to a THz-wave. To confirm the THz-wave generation, the signal was measured by shielding with a polyethylene plate or a glass plate (Fig. 1(c)). As a result, the generated wave transmitted through the polyethylene plate and was significantly attenuated by the glass plate, thus THz-wave generation was confirmed.

The frequency of the THz-wave was measured using the Fabry-Perot etalon consisting of a pair of high-resistivity silicon plate as a partially transmitted mirror [4]. When the etalon was inserted in the beam pass, periodic power modulation is measured with changing the cavity length. The transmittance of the etalon is described by the following equation.

$$T = \frac{1 - R^2}{(1 - R^2) + 4R\sin^2(\phi/2)} \quad (1)$$



(a) Experimental setup (b) Relationship between output signal and input power to the UTC-PD. (c) Measured signal of the Golay cell with or without blocking the THz-wave pass by the polyethylene or glass plate.

Here, R is reflectivity of the partially transmitted mirror and ϕ is the phase acquired when the light makes a round trip inside the cavity. When the ϕ equals to multiple of 2π, transmittance is maximum. Thus, difference of cavity lengths where intensity peak measured corresponds to half wavelength. Fig. 2 shows the transmitted power from Fabry-perot etalon by moving the translational stage and the least square fitting curve using eq. (1). A periodic intensity modulation was measured originated from the monochromatic wave input. The wavelength was 534 μm corresponding to the frequency of 561 GHz. A finesse of the etalon was measured to be 1.9 at cavity length of 2 mm. Corresponding bandwidth is 20 GHz, which is comparable to the resolution linewidth of the etalon (31 GHz) assuming the refractive index of Silicon mirror is 3.4. Thus, the linewidth of the source was not resolved in this experiment. To determine the linewidth of the THz-wave, the electric down-conversion with harmonic mixer [2] is required.

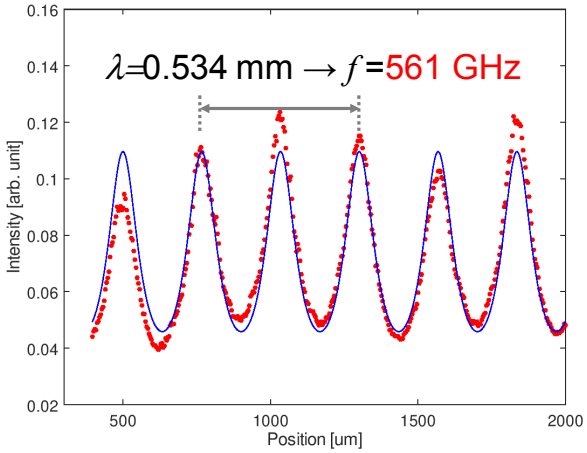


Fig. 2 Transmitted power from Fabry perot etalon with moving the translation stage. Red dots shows the measured power and blue lines shows the least square fitting curve from equation (1).

III. Summary

In this report, we generated the THz-wave using the soliton comb and a wideband photomixer. The energy conversion from soliton comb to the THz-wave was measured. The generated wave had a transparency to the polyethylene material and an absorption property for a glass plate. The frequency of the THz-wave was measured to be 557 GHz using the Fabry-Perot etalon. The

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