THz Frequency Comb for Precise Frequency Measurement of Continuous-Wave Terahertz Radiation

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***Abstract*—We demonstrated a frequency measurement of CW-THz wave referring to THz frequency comb. Effectiveness of the proposed method is demonstrated by measurement of sub-THz test sources. The achieved precision of frequency measurement was $2.0*10^{-11}$.**

I. Introduction And Background

OPTICAL frequency comb generated by a mode-locked femtosecond laser has emerged as a new mode for optical frequency metrology [1]. Since the frequency comb structure can be used as a precise ruler in the frequency domain, such combs have received a lot of interest as a metrological tool in the ultraviolet through the mid-infrared region. Recently, the concept of a frequency comb has been extended to the THz region using a stabilized fs mode-locked laser in combination with a photoconductive antenna (PCA) [2]. When the optical comb is incident to a PCA for THz detection, THz comb of photocarrier (PC-THz comb) is induced in the PCA. Since the PC-THz comb possesses attractive features for THz frequency metrology, including excellent accuracy and stability, broadband selectivity, ultra-narrow linewidth, and exact multiplication, the PCA having the PC-THz comb can be used as a THz detector having a precise ruler of THz frequency. In this paper, we demonstrate determination of the absolute frequency of a sub-THz CW test source based on THz comb, namely THz spectrum analyzer [3, 4].

II. Results

First, we measured the spectral shape of CW-THz wave (tuning range = 75-110 GHz, output power = 2.5 mW, linewidth < 0.6 Hz) radiated from an active frequency multiplier chain (multiplication factor = 6) combined with a frequency synthesizer (tuning range = 12.5-18.33 GHz) and a rubidium (Rb) frequency standard (accuracy = 5×10^{-11} and stability = 2×10^{-11} at 1s). Frequency spacing of the PC-THz comb is beforehand stabilized by phase-locking the mode-locked frequency of the fiber laser to the Rb frequency standard. Figure 1(a) shows the spectrum of the f_b beat signal (RBW = 1Hz and sweep time = 2.3 s) when the output frequency of the CW source is set at 99,007,200,000 Hz. The linewidth of the beat signal was only 1.35 Hz, indicating the narrow linewidth of THz comb mode.

Second, we measured 140-GHz CW-THz wave generated by photomixing of two near-infrared CW laser phase-locked to dual optical comb, respectively [5]. Figure 1(b) shows the spectrum of the fb beat signal. The linewidth of the CW-THz radiation was 631 kHz when a Gaussian function was fitted to the spectral shape. Since the linewidth of the comb mode is much narrower than that of the beat signal, the spectrum reflects the spectral characteristics of this CW-THz source.

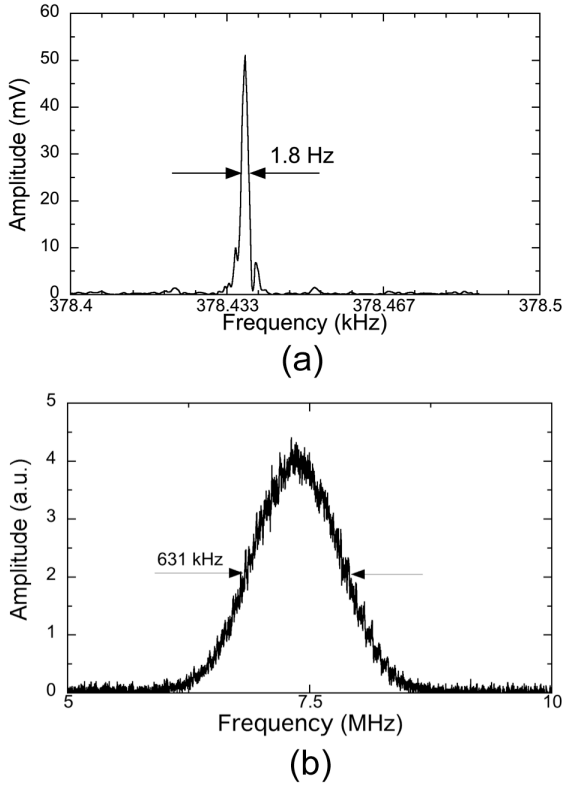

Fig. 1. Spectrum of f_b beat signal. (a) 99-GHz active frequency multiplier chain and (b) 140-GHz photomixing source.

References

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