Real-time, Terahertz Impulse Radar Based on Asynchronous Optical Sampling

Takeshi Yasui, Yasuhiro Kabetani, Shuko Yokoyama, and Tsutomu Araki
Graduate School of Engineering Science, Osaka University, Toyonaka, Osaka 560-8531, Japan

***Abstract*—We propose real-time THz impulse radar based on time-of-flight measurement of a pulsed THz wave. Combined use of the THz impulse radar with asynchronous optical sampling technique can achieve a real-time distance measurement of a moving and/or distant object because it requires no mechanical stages for time delay. The achieved precision of the THz impulse radar was 550 µm to an object at a distance of 1 m.**

I. Introduction

RADAR (radio detection and ranging) technique has a wide variety of applications in military and commercial fields. Recently, commercial radar plays an important role in the field of automobile driving such as adaptive cruise control systems for driving assistant and collision mitigation systems for safe driving support. Automobile radar using an infrared laser light provides precise distance measurement, however, this method is affected by light scattering caused by bad weathers (rain, snow, and fog) and contaminated surface of a target. On the other hand, automobile radar using millimeter wave can be used under bad weathers and applied to contaminated surface of the target whereas the precision of distance measurement is relatively low. In this way, the conventional methods of automobile radar have their own merits and demerits. If merits of both methods are combined with each other, ideal automobile radar will be achieved. One possibility to combine merits of both methods is use of THz wave as a radar wave because THz wave lies at a boundary between infrared light and millimeter wave, and possesses both characteristics of them. In this paper, we proposed real-time THz impulse radar by combination of time-of-flight measurement of THz pulse and asynchronous optical sampling, namely AOS-THz-TOF radar.

II. Experimental setup

We modified a transmission setup for AOS-THz-TDS [1] into a reflection setup for AOS-THz-TOF radar. The experimental setup is shown in Fig. 1. We used two mode-locked Ti:Sapphire lasers for generation and detection of THz pulse. The mode-locked frequencies of the two lasers (f_1 = 81.8 MHz, f_2 = 81.8 MHz + 10 Hz) and the difference frequency between them ($\Delta f = f_2 - f_1$ =10Hz) are well stabilized by a laser control system. Portions of the two laser lights are fed into a SFG (sum-frequency-generation) cross-correlator using a nonlinear optical crystal, and the resulting SFG signal is used for time origin for AOS measurement. Residual of the two laser lights are incident on to photoconductive antennas (PCA) for THz generation and detection, respectively. The THz pulse radiating from a THz-PCA emitter is collimated by an off-axis parabolic mirror, and then directed to a target object at a distance of 1 m by a mirror. Reflected and/or scattered THz pulse at surface of the object is collected and focused onto a THz-PCA detector by another off-axis parabolic mirror. After passing through a high-gain current preamplifier, the signal is measured at a scan rate of Δf with a fast digitizer triggered by the time origin signal from the SFG cross-correlator.

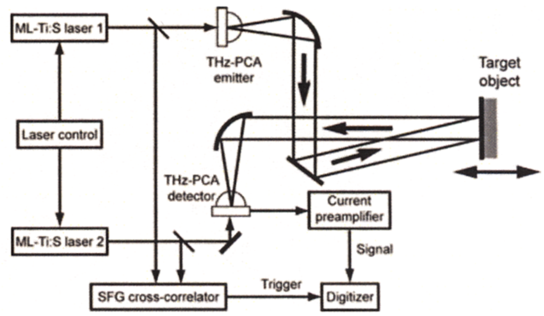

Fig. 1. Experimental setup.

III. Results

To evaluate precision of AOS-THz-TOF radar, we measured displacement of a target object (Al plate) while moving it by a translation stage. Figure 2 shows a relationship between stage displacement and measured displacement. One can confirm a linear relationship between them. Error between stage displacement and measured displacement is also shown in Fig. 1. When we defined mean of the error as measurement precision, the measurement precision of the presented method was 550µm within a displacement range of 20 cm.

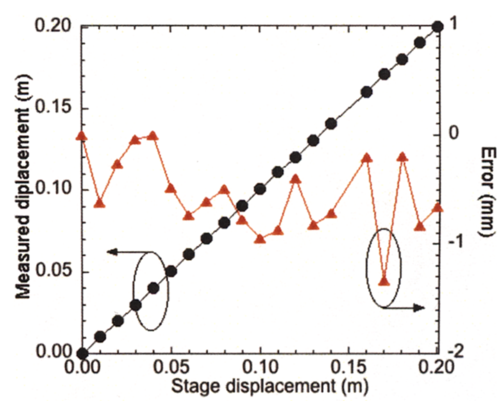

Fig. 2. Relationship between stage displacement and measured displacement.

References

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