Time of flight measurements of polymer films by a terahertz chemical microscopy

T. Arisawa, H. Nino, K. Sakai, T. Kiwa, and K. Tsukada

Graduate School of Natural Science and Technology, Okayama University,
3-1-1 Tsushimanaka, Kitaku, Okayama 700-8530, Japan, pa2244w9@s.okayama-u.ac.jp

1. Introduction

A THz chemical microscope has been proposed to visualize the change in the surface potential on 'sensing plates' with a laser-excited THz method. [1], [2] Up to now, we have been demonstrated to map the surface potential shift on the sensing plate, which occurs by various kind of chemical reactions, such as ion penetration into polymers [3] immune reactions, and catalytic reactions.

TCM utilize sensing plate, on which sample solutions are prepared. By irradiating the femtosecond laser from the backside of the sensing plate, THz pulses radiate to the free space. Since the amplitude of the THz is proportional to the surface potential of the sensing plate, the surface potential map can be visualized by scanning the laser across the sensing plate. However, the waveforms or spectroscopic information of the THz pulses generated from the sensing plates have not been discussed yet.

Here, in order to measure the thickness of bio-related membranes, time of flight analysis was applied to the THz pulses from the sensing plate.

2. Experimental and result

Figure 1 shows the schematic of sensing plate with the sample film on it. The sensing plate consists of the SiO2 and Si films on the sapphire substrate. The thickness of Si film was approximately 1 μm, which is less than 1 % of the wavelength of THz. In order to evaluate the thickness of the sample films, the polymer films were stacked on the sensing plate surface. In this experiment, films made from polyvinylidene chloride were used as the samples. The thickness of the films was approximately 10μm. When the femtosecond laser introduced into the Si film, the THz pulses were generated and radiated. The some part of the THz pulses in amplitude was directly emitted to the free space, and the some part of the THz pulses was multi-reflected in the films and then emitted to the free space.

Figure 2 shows the THz waveforms obtained for the sample films with different number of stacks. The multiple peaks were observed after the first sharp peak at around 15 ps. Since the first peak was THz pulse emitted directly, the peak position was not shifted when the number of film stacks was changed. On the other hand, trail peaks were shifted by changing the number of film stacks.

This result suggests that the TCM can measure the films thickness of the films on the sensing plate by evaluating the peak shifts of trail peaks from the first peak position.

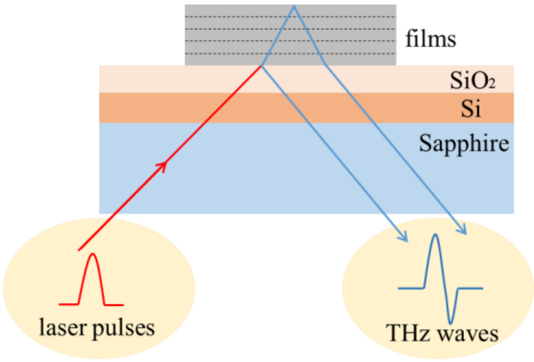

Fig. 1 Schematic of sensing plate and emitted THz waves.

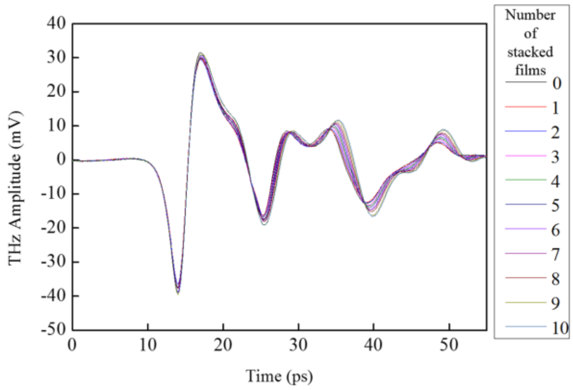

Fig. 2 THz waveforms for the polymer films with the different number of stacks on the sensing plate.

3. Summary

The time of flight analysis was applied to the TCM. While the first peak was not shift, the trail peaks were shifted with increasing the number of the film stacks on the sensing plate. This result suggests that TCM can be useful tool to measure the thickness of bio-related films such as human skins and cultivated cell sheets.

Acknowledgements

This study was partially supported by the Industry-Academia Collaborative R&D of the Japan Science and Technology Agency.

References

[1] T.Kiwa, et al., Appl. Opt, **47** (2008) 3324.
[2]T.Kiwa, et al., J. Appl. Phys. **46** (2007) 1052.
[3]K.Akimune, et al., Appl. Phys. Exp. **7** (2014) 122401-1.