CNT film photo scanner for in-line pharma agent pills imaging in infrared–terahertz bands

Miki Kubota[1*], Yuya Kinoshita[1], Yuto Matsuzaki[1], Minami Yamamoto[1], Leo Takai[1], Yukio Kawano[1–3], Kou Li[1]

[1] *Chuo University, 1-13-27 Kasuga, Bunkyo-ku, Tokyo, 112-8551, Japan*
[2] *National Institute of Informatics, 2-1-2 Hitotsubashi, Chiyoda-ku, Tokyo, 101-8430, Japan*
[3] *Kanagawa institute of Industrial Science and Technology, 3-2-1, Sakado, Takatsu-ku, Kawasaki-shi, Kanagawa, 213-0012, Japan*
a20.7c7e@g.chuo-u.ac.jp

1. Introduction

Pharmaceuticals are essential in modern society, and high-quality management is essential. Therefore, it is desirable to conduct full and detailed inspections in the manufacturing process. However, such an inspection system is still insufficient, which potentially causes the supply of defective products. The above situation indicates that establishing additional inspection methods is indispensable. In recent years, the demand for non-destructive inspection has grown, not only for pharmaceuticals. In every inspection method, optical measurements in infrared (IR) and terahertz (THz) bands have gathered attention as transmissive properties of materials differ with wavelength and composition [1, 2]. Regarding photo-detection, carbon nanotubes (CNT) film is also adequate in the above ultrabroad IR–THz bands with the photo-thermoelectric (PTE) effect [3, 4]. To this end, this work integrated IR–THz multi-wavelength imaging systems to the line with the CNT film photo scanner and performed imaging measurements of the pharma agent pills (Fig. 1a).

2. Experiment

This work constructed an in-line transmissive imaging system with multi-wavelength irradiation: short wavelength infrared (SWIR, λ - 4.33 μm), long wavelength infrared (LWIR, λ - 6.33 μm), and sub-THz (λ - 909 μm). Fig. 1b shows the presenting CNT film imager and its function. The PTE response of the pixel differs with external photo-irradiation intensity. This device detects the optical transmissive signal to the target under a one-axis scan imaging.

3. Results

Fig. 1c shows the multi-wavelength imaging results of sedative pills containing plastic, glass, and metal inside. In a monochrome color scale, the darker and brighter range refers to the higher and lower intensity of the transmissive PTE responses. The local reduction of the transmittance in the pill corresponds to the foreign substance, which is visually indistinguishable. The above PTE image indicates that the two-wavelength irradiation of SWIR and LWIR visualises the plastic. Then, the obtained result detects the glass with LWIR irradiation. Finally, all three-wavelength irradiation in this work visualizes the metal. These tendencies that visibilities differ with irradiation bands reflect broad changes in transmittance of the various materials with composition and wavelength in IR–THz regions. The above situation leads to composition identification of foreign substances by combining the database of material and transmittance in IR–THz bands. In this way, this work focused on optical properties in IR–THz bands and demonstrated a basic system for pharma inspection with the CNT film photo scanner.

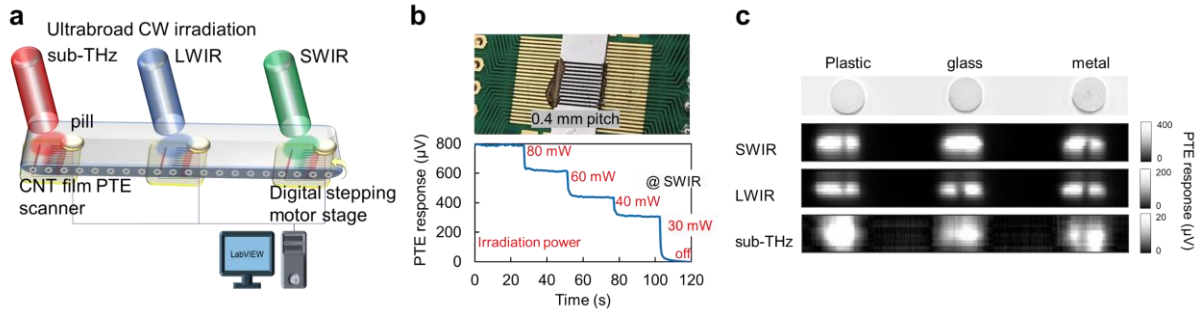

Fig. 1. a, In-line multi-wavelength imaging system in this work. b, CNT film photo scanner and its change in PTE response with external photo-irradiation intensity. c, Material composition identification of the samples with different concealed foreign substances.

4. References

[1] K. Li, *et al*. Advanced Optical Materials, early view (2023)
[2] K. Li, *et al*. Micromachines, **14**, 1, 61 (2023)
[3] D. Suzuki, *et al*. Sensors and Actuators A: Physical, 354 (2023)
[4] T. Araki, *et al*. Advanced Materials, early view (2023)