Multi-layered 3D imaging with CNTs broadband photo-sensors

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1. Introduction

Non-destructive testing technology is indispensable in the industry. In addition, demand for high-precision internal inspections of 3D-structured objects is increasing, and inspection techniques using electromagnetic waves attracts significant attention. Although conventional non-destructive inspection utilizes X-ray, their hazardous configurations associated with invasiveness need to be addressed. On the other hand, photo-sensing in broadband ranging from infrared (IR) to millimeter-waves (MMW), which non-invasively exhibits high transmittance, potentially solves the above problem. In these bands, CNT films are well known for their highly efficient absorption[1]. Herein, this study utilizes CNTs photo-thermal broadband sensors for IR–MMW imaging of three-dimensional objects. As a result, the combination of the multi-wavelengths imaging and typical silhouette-based 3D reconstruction techniques[2] enables non-destructive inspection of multi-layered objects.

2. Result

Fig.1a shows the multi-layered object used in this work. The target object consists of a metallic bar in the center, an inner plastic container around the bar, and an opaque wall at the outside. In addition, glass and silicon boards locate between the plastic container and the opaque wall (Figs. 1b–c presents each sectional view). Directions (1) and (2) in the figure are perpendicular to the glass and silicon faces. The use of near-IR (NIR) irradiation and the CNTs photo-sensor enables non-destructive transmissive imaging of the object. Figs.1d–e shows the obtained images from two different viewing directions. The plastic container is visible in the image obtained from the direction (1), as the NIR irradiation exhibits transparency to the outer wall and the glass. On the other hand, the image obtained from direction (2) does not visualize the plastic container, as the silicon is invisible to the NIR irradiation.

The use of images with different appearances such as the above enables simple 3D reconstruction of the target. Furthermore, the CNTs sensor functions in broadband imaging. Multi-layer 3D reconstruction of the object, employing multiple images obtained by sensing with visible light, IR, terahertz waves, and MMW will be reported at the workshop.

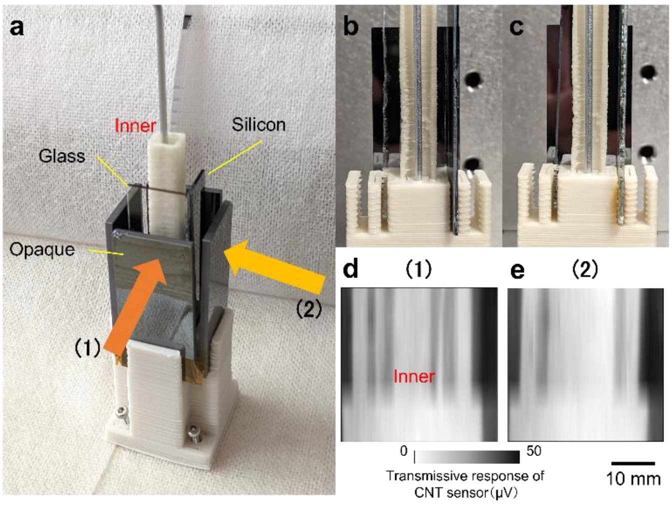

Fig.1. a, Photograph of the multilayered object to be examined. **b,** Cross sectional view from direction (1) in (**a**). **c,** Cross sectional view from direction (2) in (**a**). Near-infrared imaging with CNTs sensor non-destructively obtains **d,** image from direction (1) in (**a**), and **e,** image from direction (2) in (**a**).

3. References

[1] K. Li, et al. Nature Communications, 12, 3009 (2021).

[2] A. Y. Mulayim, U. Yilmaz and V. Atalay, IEEE Transactions on Systems, Man, and Cybernetics, Part B, vol. 33, no. 4, 582-591 (2003)