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中央大学 NII 大学共同利用機関法人 情報・システム研究機構 国立情報学研究所 National Institute of Informatics

February 19, 2025

Computer Vision Enhances the Potential of Ultrabroadband Imaging in Non-destructive Testing

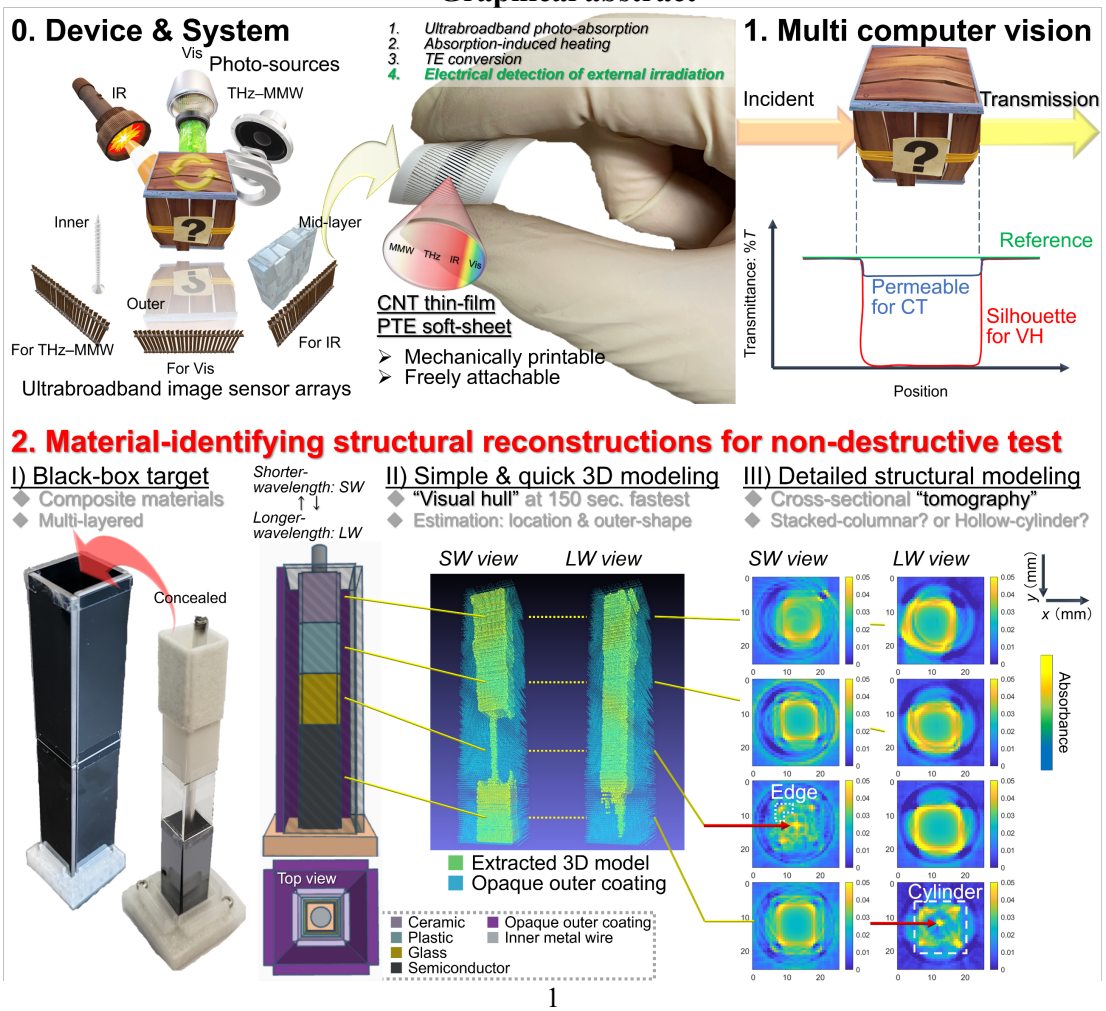
A New Approach Using Carbon nanotube tomography & visual-hull

Chuo University
National Institute of Informatics

Summary

Led by Assistant Prof. Kou Li, a research group in Chuo University (President: KAWAI Hisashi, Hachioji-shi, Tokyo, Japan), under a collaboration with National Institute of Informatics (Director-General: KUROHASHI Sadao, Chiyoda-ku, Tokyo, Japan), has developed a synergetic strategy among millimeter-wave–terahertz–infrared photo-monitoring and computer vision three-dimensional modelling toward ubiquitous non-destructive inspections, with a recent paper publication in *Advanced Materials Technologies*.

Graphical abstract



While non-destructive inspections of daily necessities and industrial products require material composition identifications and structural reconstructions of composite multi-layered three-dimensional (3D) objects, the development of analyzing systems that fully satisfy those performances is still insufficient. Particularly, synergetic combinations are urgently indispensable among non-destructive permeable inner material identifications with millimeter-wave (MMW)–terahertz (THz)–infrared (IR) photo-monitoring and computer-vision (CV)-driven 3D modelling. However, respective approaches on the above individual concept crucially regulate their use as planar image acquisition operations for the former (missing cross-sectional information) and visual light (Vis)-based outer views for the latter (lacking non-destructive permeability to inner structures).

To this end, this manuscript made the following significant contributions.

i) Integrating multi-wavelength MMW–IR monitoring functions into carbon nanotube (CNT) film photo-thermoelectric (PTE) imagers, which works in ultrabroadband ranges over conventional wide-band sensors at comparable sensitivities with those of existing narrow-band detectors in each region.

ii) Hybrid multi-CV operations among visual hull (VH) and Computed tomography (CT) with the CNT film PTE imager-based MMW–IR monitoring system as follows: speculating 3D spatial locations of each constituent material of targets by VH (shadow/silhouette-based vague views) as a first step of non-destructive inspections, then restores their detailed cross-sectional structures (e.g., columnar? or hollow?) by CT.

iii) Demonstrating material-identifying non-destructive structural reconstructions against multi-layered composite opaque 3D target objects by incorporating the aforementioned fundamental device and system preparations.

iv) Satisfying fundamental performances (1 mm resolution at 150 sec. for VH and 2 min. for CT) comparable to existing Vis-reconstruction methods by the presenting system, while the CNT film PTE imager fully functions over 1.15 mm–660 nm wavelength ranges beyond the above conventional CV approaches.

The paper was published online in the international scientific journal, *Advanced Materials Technologies* (February 15, 2025).

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