Physical and chemical composition optimization of CNT imagers for augmented reality non-destructive inspections

Ryoga Odawara[1*], Minami Yamamoto[1], Yukio Kawano[1, 2, 3], Yoshihiro Watanabe[4], Kou Li[1]
[1]*Faculty of Science and Engineering, Chuo University, Tokyo, 112-8551 (Japan)*
[2]*National Institute of Informatics, Tokyo, 101-8430 (Japan)*
[3]*Kanagawa institute of Industrial Science and Technology, Kanagawa, 213-0012 (Japan)*
[4]*School of Engineering, Tokyo Institute of Technology, Tokyo, 152-8550 (Japan)*
Corresponding Autor E-mail: a20.b5bw@g.chuo-u.ac.jp

1. Foreword

In the field of non-destructive inspection, ultra-broadband electromagnetic wave imaging measurements using carbon nanotube (CNT) film photo-thermal (PTE) sensors have been attracting attention in recent years[1]. This sensor can detect ultrabroadband photo-irradiation in infrared, THz, and millimetre waves regions at room temperature. Furthermore, the sensor has flexible characteristics. Therefore, the sensor has the potential to inspect for any shape. The vital matter of non-destructive inspections is speed and accuracy. In higher-speed operations, the integration time of signal readout is shorter. As a result, the normal mode noise increases. In addition, 2D integration of the sensor is necessary to realize higher-speed imaging rather than single elements or 1D integration setups. Therefore, it is essential to select device materials that can withstand the noise of higher-speed operations and integrate optical sensors in higher density for achieving superior performances of CNT film imagers. This study reports the physical and chemical composition optimization of CNT film broadband imagers beyond the speed-sensitivity trade-off for augmented reality non-destructive inspection.

2. Experiment and result

Fig. 1 shows a comparison of PTE images (target: metallic pattern marked as “10”) obtained by the CNT film PTE sensor. In the conventional study~~,~~ the noise in PTE images increased significantly as the operation speed became faster. This tradeoff between noise and speed is a critical problem for an image sensor. For this reason, this study adopts the high conductivity of the CNT film to solve this tradeoff. As a result, this study succeeds in decreasing the noise at higher-speed operation time. It turns out the CNT film utilized in this study can reduce noise more than that in the conventional study. Thus, the operation speed of the sensor is available at over five times faster than that of the conventional study.

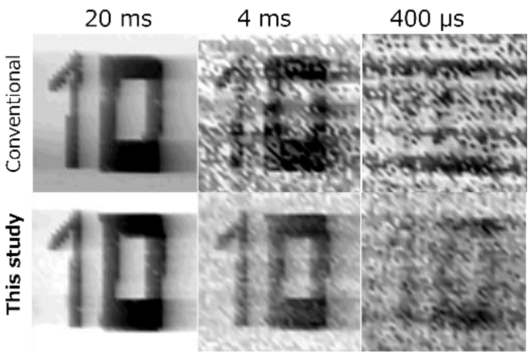

Fig. 1 Comparison of imaging results.

In Fig. 1, this work employed the single element CNT film PTE sensor for those images. Owing to the single-element configuration, the imaging time is extended. Hence, this study focused on the imager design of 2D integration to reduce imaging time. Fig. 2 shows the design of the CNT film imager and the imaging result with that device. This design succeeds in an 8×8 integration by the original design. Image sensor pixels consist of the interface portion between CNT films and electrodes. As shown in Fig. 2, the successful integration of pixels maintained 2.4 mm spacing. The CNT solution printing technique produced this design. This imager achieved five times shorter imaging time rather than that of the single element.

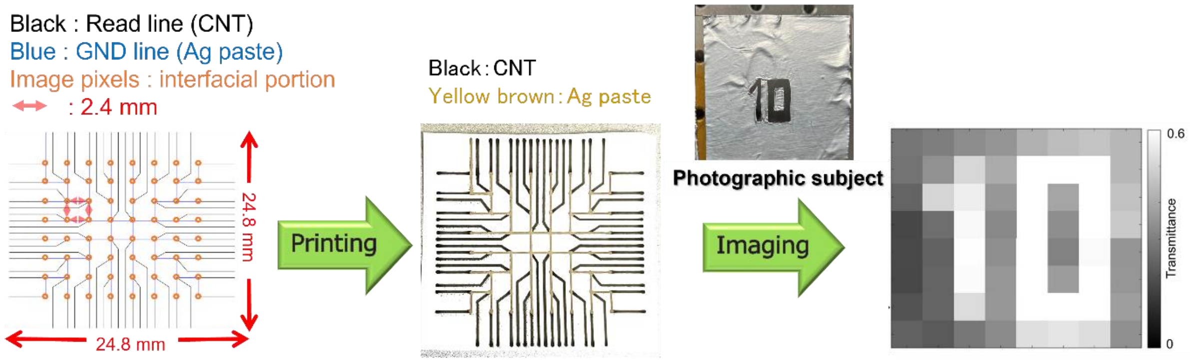

Fig. 2 Design of the CNT film imager and imaging result by that camera

[1] K. Li, *et. al.*, *Adv. Mater. Interface*, **2023**, 10, 2300528.