Two-dimensional high-yield printable integration of carbon nanotube photo-thermal pixels for realtime, large-area, and broadband non-destructive testing camera applications

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1. Introduction

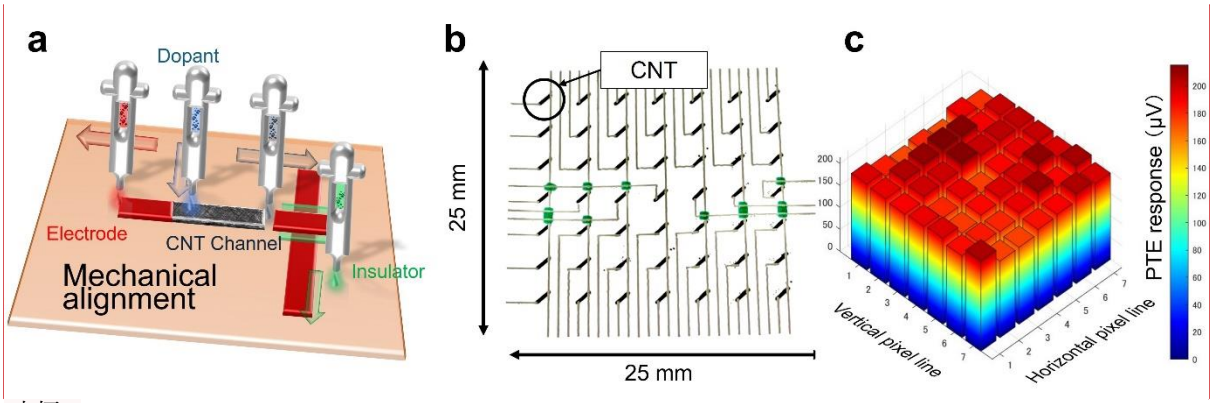
This study aims to develop a photo-thermoelectric broadband imaging camera sheet and apply it to non-destructive testing technology by taking advantage of the optical and mechanical properties of carbon nanotube (CNT) thin films [1]. The presenting device has ultra-broadband absorption properties and flexibility compared to existing solid-state detectors. The principle of this device is the photo-thermoelectric effect (PTE). First, certain electromagnetic waves irradiated on CNTs are absorbed into local heating. Then, heat generates the electromotive force by the Seebeck effect. This work employed a desktop auto dispenser (available in uncooled atmospheric conditions) to print the entire structure on a flexible/stretchable thin substrate for fabricating the above imaging sheet. This study succeeded in developing a high yield photo-thermoelectric 2D camera device and real-time, large area, and broadband non-destructive imaging by mechanical alignment of each pixel.

2. Method

This study employed the mechanical auto dispenser (Fig. 1a) as the printing equipment. All materials used, including electrodes and insulators, are in ink form. The device materials used are SWCNTs and n-type chemical carrier dopants (for forming pn junctions). These liquid materials show high compatibility with existing printing technology, and the dispenser enables high-yield micro-integration and three-dimensional wiring structures, leading to the realization of a two-dimensional camera sheet.

3. Results and Discussion

Figure. 1b illustrates the fabricated 2D camera sheet in this study. This camera sheet has 49 pixels. The n-type dopant applies to the upper right half of the CNT film. This camera sheet uses the PTE effect as its operating principle [2]. The device is able to perform ultra-broadband optical detection with low noise at room temperature due to the PTE operation of the CNT film. Measurement of the PTE response value by irradiating a near-infrared laser (λ=1.55 μm) at the pn junction of each pixel showed that this camera device is high yield (Figure. 1c). This represents that the camera printing is highly accurate.



[李恒1]

Fig. 1a. In-line multi-wavelength imaging system in this work. b. The black lines are CNTs with n-type doping in the upper right. c. PTE response of each element.

4. References[李恒2]

[1] K. Li, et al., *Nature Communications*, 12, 3009 (2021).
[2] K. Li, et al., *Science Advances*, 8, 19, eabm4349 (2022).