論文 / 著書情報
Article / Book Information

題目(和文)	全方位非破壊検査に向けたテラヘルツ帯フレキシブル撮像デバイスの研究
Title(English)	A Study on a Flexible Terahertz Camera for Omnidirectional Non-Destructive Inspections
著者(和文)	鈴木大地
Author(English)	Daichi Suzuki
出典(和文)	学位:博士(工学), 学位授与機関:東京工業大学, 報告番号:甲第10797号, 授与年月日:2018年3月26日, 学位の種別:課程博士, 審査員:河野 行雄,波多野 睦子,宮本 恭幸,小寺 哲夫,鈴木 左文,尾辻 泰一
Citation(English)	Degree:Doctor (Engineering), Conferring organization: Tokyo Institute of Technology, Report number:甲第10797号, Conferred date:2018/3/26, Degree Type:Course doctor, Examiner:,,,,,
学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

専攻： Department of	電子物理工学　専攻	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of　（　工学　）
学生氏名： Student's Name	鈴木　大地	指導教員（主）： Academic Supervisor(main)	河野　行雄
		指導教員（副）： Academic Supervisor(sub)	

要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Visualization techniques via terahertz (THz) frequency waves have a great potential for the use in powerful non-invasive inspection methods due to their unique abilities of high penetration and fingerprint spectra of molecules. Most real objects have various three-dimensional curvatures; however, conventional THz imaging technologies are mainly limited to flat samples, hampering accurate measurements of such objects. In order to overcome this difficulty, in this research, I developed a wideband, flexible and portable THz camera based on an array of carbon nanotube (CNT) THz detectors.

I first explored detection mechanisms and materials for flexible THz camera. Owing to the advantages of broadband and high sensitive THz detection under the room temperature, we focused on the CNT film THz detector based in the photothermoelectric effect and fabricated a flexible THz detector. According to the Seebeck effect, we found that the large temperature gradient inside the CNT film improves the detector sensitivity. Through thermal analysis via both simulations and experiments, I optimized the thermoelectric device design in terms of device shape (film thickness and channel width), electrodes, thermal transport, and Fermi level. The presented experimental results were well consistent with the thermal conduction theory, leading to enhancement in detection performance such as sensitivity, noise equivalent power (NEP), and detection speed. At the moment, the NEP value and the detection speed reach 20 $pW/Hz^{1/2}$ and 5 ms respectively.

In the following chapter I integrated many CNT detectors into a flexible THz imagers. For device miniaturization, I encountered problems of signal cancellation between source and drain electrode edges and low spatial resolution. I overcame these difficulties by utilizing different electrode materials and eliminating undesired signals via THz wave penetration, and miniaturized one pixel size in micrometer scale. Additionally, I developed a self-aligned filtration process for the fabrication of microscale CNT film arrays while keeping their free-standing structure, which can avoid the deterioration of THz response caused by thermal diffusion. This is also important in making two-dimensional matrix detector arrays by fabricating lead electrodes on both front and rear sides of the CNT film without complicated fabrication process. By applying all the techniques developed in my study, I successfully fabricated a flexible THz camera.

In order to put THz imaging applications into practical use in industry, the development

of measurement systems are required along with the studies of basic THz components such as emitters and detectors. In the last part of my dissertation, I applied the flexible THz imagers to the development of a bendable, easy handling, high speed, and multi-view inspection system. As a first step to establish future scanning systems, I measured the THz reflection images from the several objects by using flexible THz imagers. The series of the experimental results indicate that we can obtain the information about not only the existence of cracks but also the surface shape of the materials by the THz reflection signals.

A series of results demonstrated that the flexible THz imagers can be easily applied to curved samples without complicated optical components or systems. This advantage over existing THz imaging technologies is expected to expand the usability of non-destructive inspections in industrial fields. The presented flexible THz cameras and systems will thus open a new path to non-invasive inspection systems based on THz imaging.