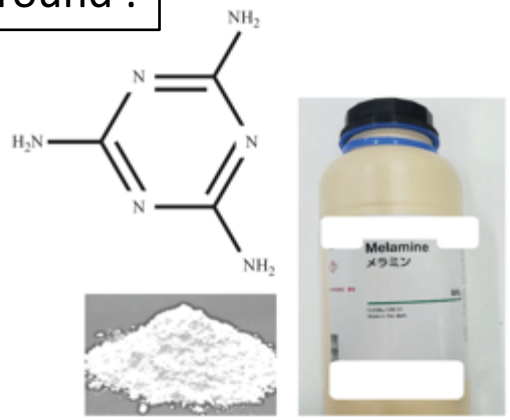
Project Title: 2.5D Technology-based Integrated Antenna Array mm-Wave System For Non-Invasive Food Safety Scanner (TIAS)

Background :



MELAMINE

to increase apparent protein content.

Food safety should be widely monitored and improved

- **50%** of dietary supplements are contaminated with melamine
- Found in **baby milk** in China, 2008; severe renal problems and kidney stones in infants.

Targets:

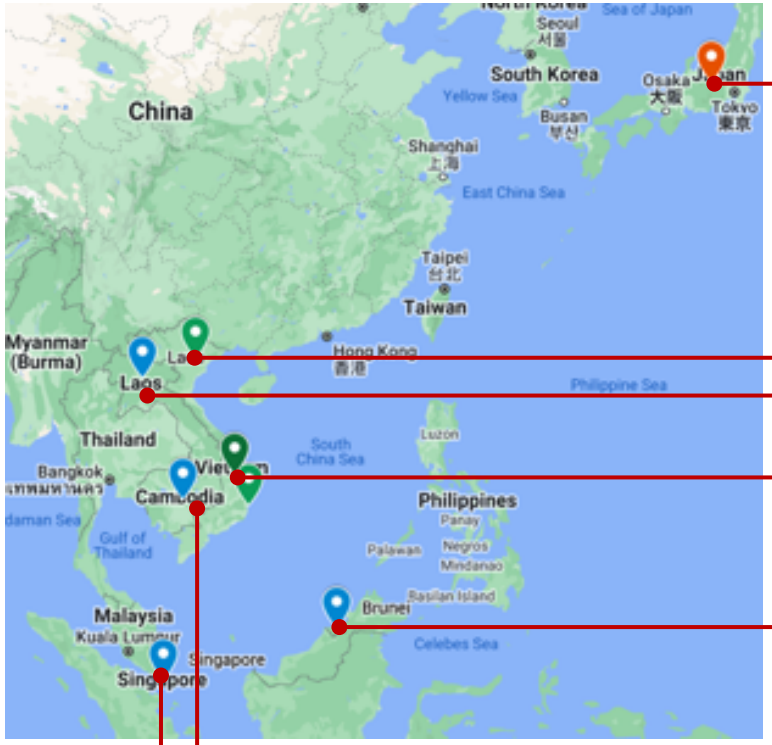
a portable and cost-effective **scanner** for real-time detection of contaminants in staple foods and/or animal feeds using non-invasive **mm-Wave sensing** with on-chip **antenna-array system**.

Speaker: **Dr. Tran Thi My Hanh, Nha Trang University, Vietnam (Project leader)**

Project Title: 2.5D Technology-based Integrated Antenna Array mm-Wave System For Non-Invasive Food Safety Scanner (TIAS)

Project Members :

Name /Position/Institution	Name /Position/Institution
Nguyen Ngoc Mai-Khanh /Assist. Prof./ The University of Tokyo, Japan	**Padapxay Sayakhot** /Deputy Director General/IICT, Laos
Tran Thi My-Hanh (Project Leader)/Vice-Director/Department Research Affairs, Nha-Trang University, Vietnam	**Aromhack Saysanasongkham** /Deputy Director/IICT, Laos
Pooja Shivanand Breh /Assist. Prof./Universiti Brunei Darussalam/Brunei Darussalam	**Bich-Yen Nguyen** /Senior Fellow, IEEE Fellow/Soitec, Singapore
Gong Xiao /Tenure Prof./National University of Singapore, Singapore	**Sopheakmanith Chhuon** /Researcher/Cambodia Academy Of Digital Technology (CADT), Cambodia
Vo Nguyen Quoc-Bao /Prof., Dean/PTIT, Vietnam	**Tetsuya Kawanishi** /Prof./Waseda University, Japan
Tran Ngọc Le/ Nha Trang University, Vietnam	

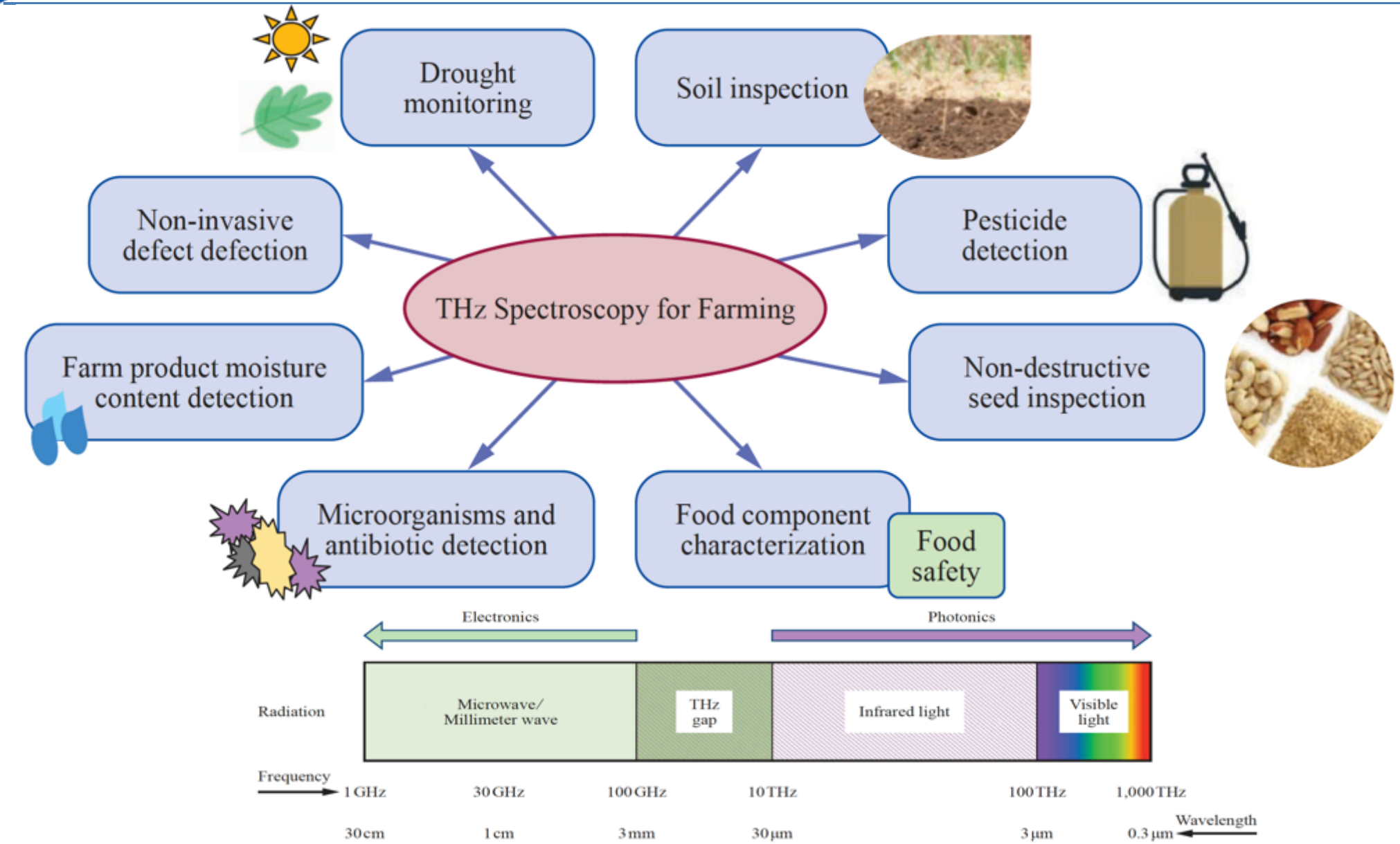


Project Duration :

2 years,
extended to Apr. 30, 2024

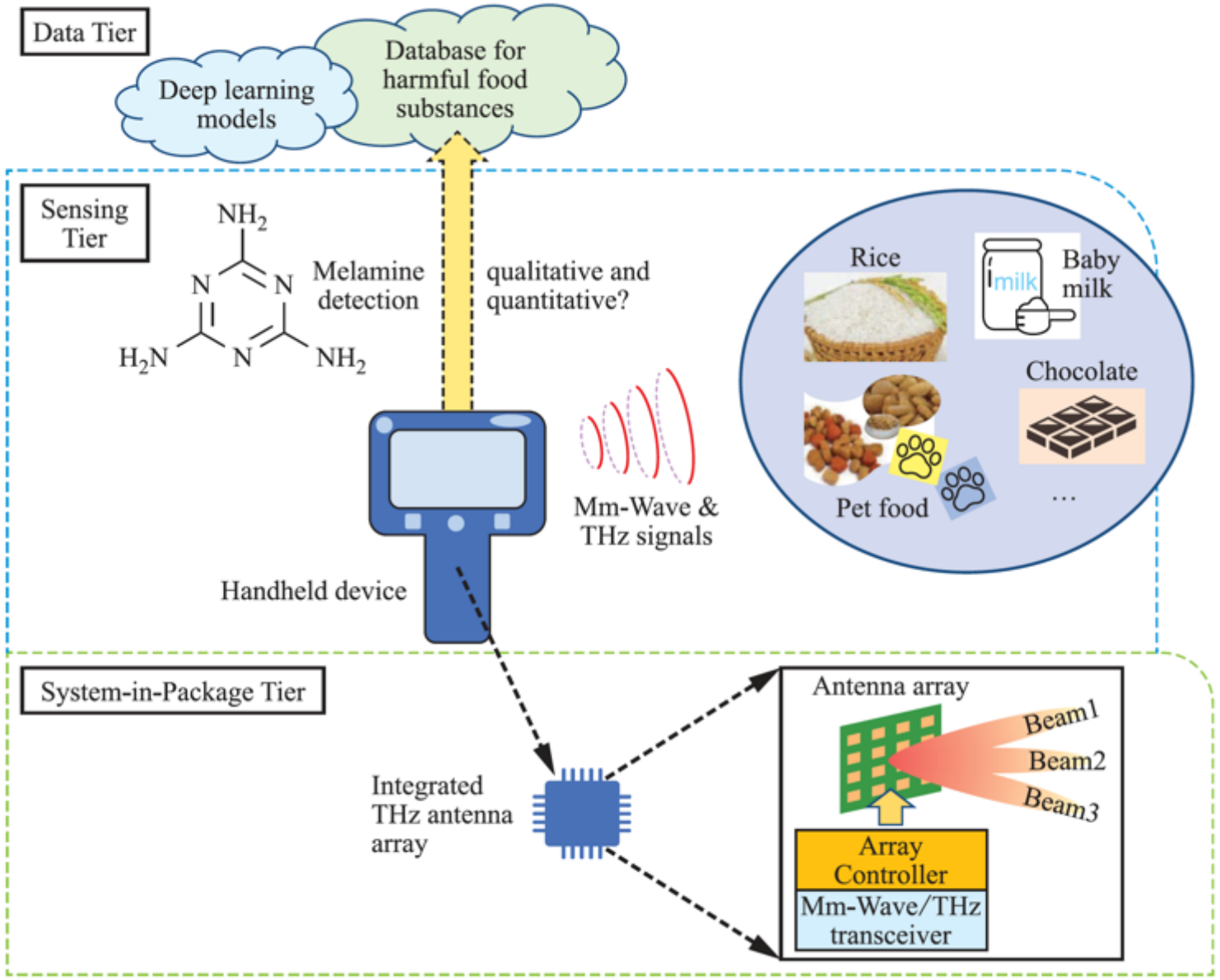
PTIT: Posts and Telecommnucations Institute of Technology; IICT: Institute of Information and Communication Technology

Various THz spectroscopy Applications for Farming



Proposed System and Applications

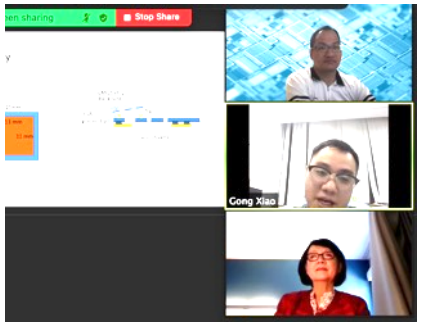
TIAS



Project Activities: TIAS Meetings

Kick-off meeting, May 2021, online

Group#1 meetings



Antenna chip fabrication

~6 times

Group#2 meetings

Chemical sample
Antenna design
Measurement

...

May 2021 — Antenna & chip fab.

Dec. — Collaborate with others: U.S and Belgium

Feb. 2022 — Field test/experiments: NTU, Vietnam and NICT, Japan

May

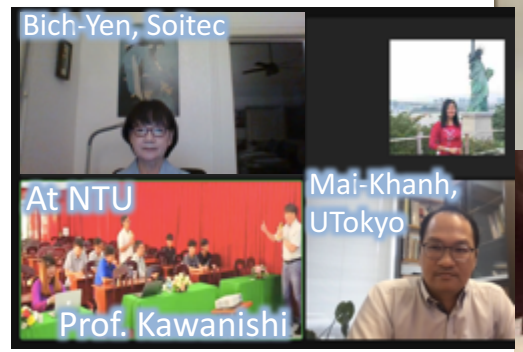
Sep. 2023 — Field test In-person meeting..

time

Project Activities: Field Test & Intl. Collaboration Expansion

1. Field Test:

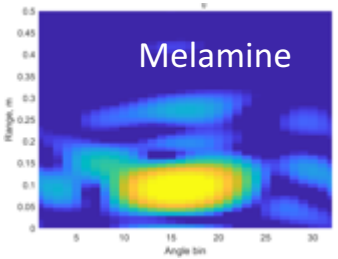
Places	Time	Content	Member
Vietnam, NTU	Apr. 2022	Analysis using chemical methods (HPLC method, FTIR method)	NTU Soitec UTokyo
Japan UTokyo Waseda Univ NICT	Apr. 2023	• Field test on chemical samples including milk/rice/melamine materials and their mixtures • Making milk/rice powder pellets for THz-based experiment • Jounal preparation	UTokyo NTU Waseda Univ.
Vietnam, NTU	Sep. 2023	• Prj. Review & Face-to-face meeting (1st)	NTU Waseda Univ. Soitec UTokyo

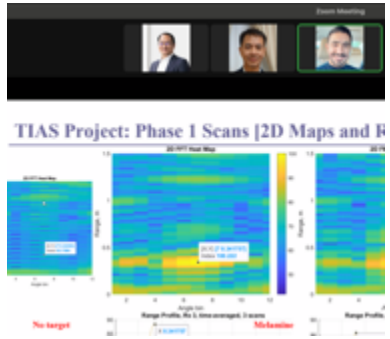


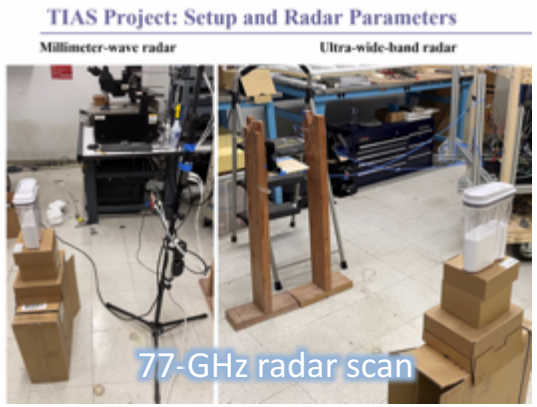
2. Intl. Collaboration Expansion

- UCDavis (U.S): 77GHz radar measurement
- UCLouvain (Belgium): chip design & fab.

Range-Angle Heat Map





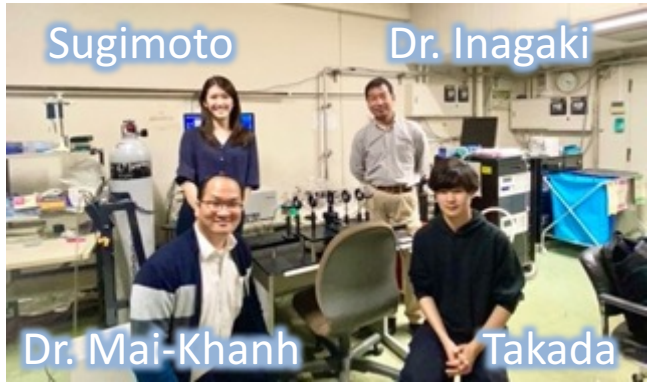


R&D results: Field Testing at NICT, Japan

- **Time**: Jun., Aug. 2022
- **Place**: UTokyo and NICT, Japan
- **Content:**
  - Sample preparation
  - THz/Mm-Wave measurements:
    - 220-330GHz; 330-500GHz
    - 0.1 – 3THz
- **Members:**

  Waseda Univ, UTokyo, & NICT

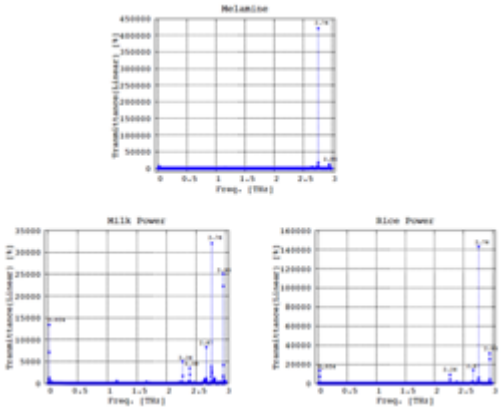
@UTokyo



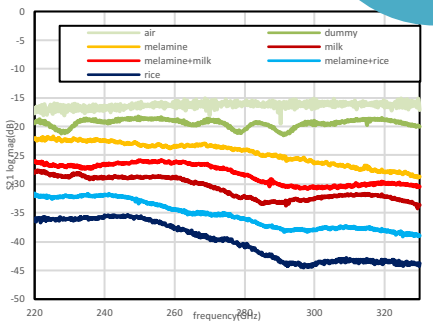
Sample Preparation @Clean-room UTokyo

THz/Mm-Wave Measurement: Waseda Univ + UTokyo + NICT

THz results

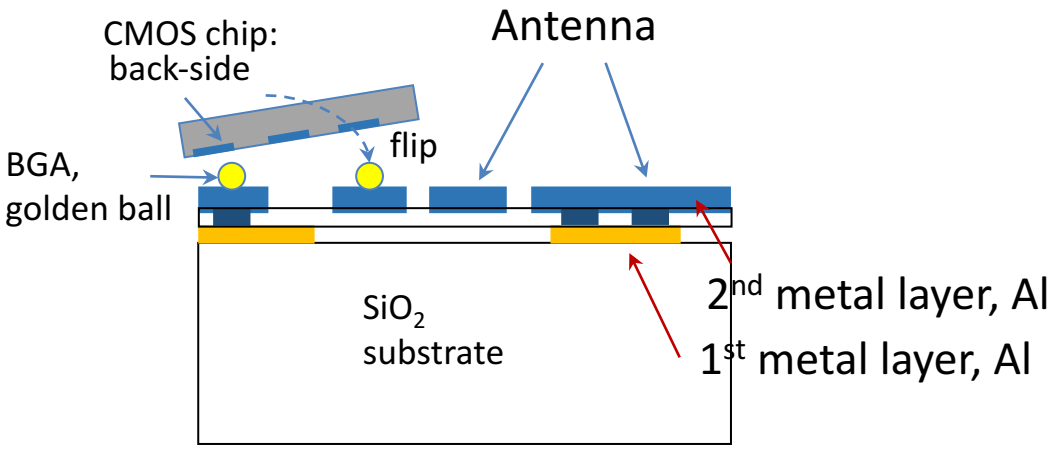


Mm-Wave results

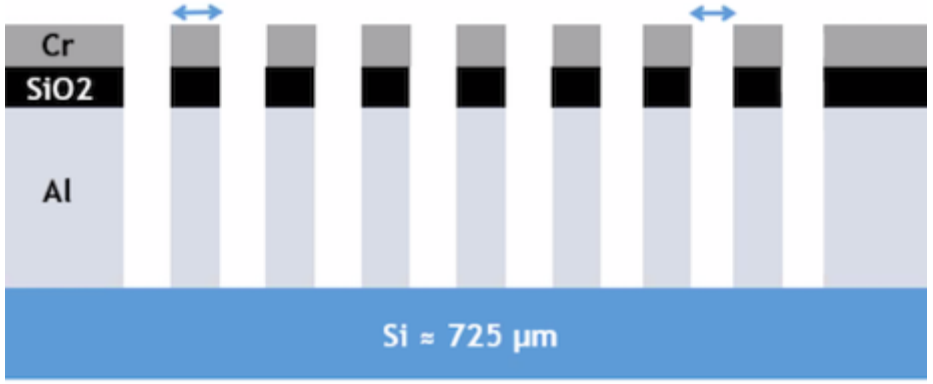


Samples of Melamine/ milk/rice/ mixtures

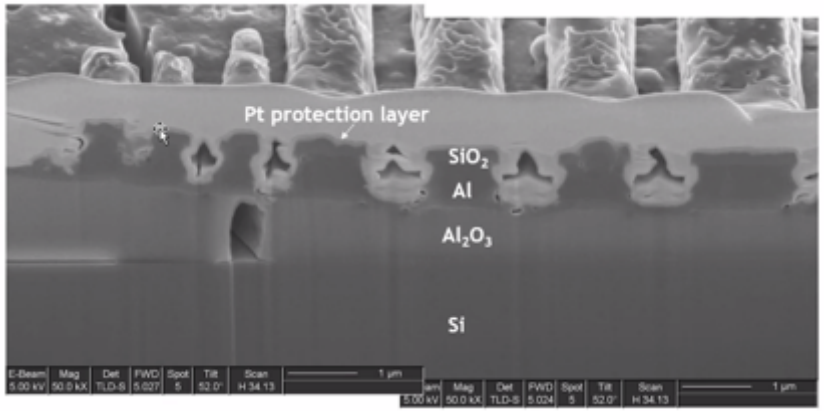
Antenna Chip Fabrication



1. Antenna design and fabrication team:
   - UTokyo, Soitec, NUS (Singapore)
2. Fabrication at Cleanroom NUS, Singapore
3. Issues:
   - Machine broken
   - Dried etching

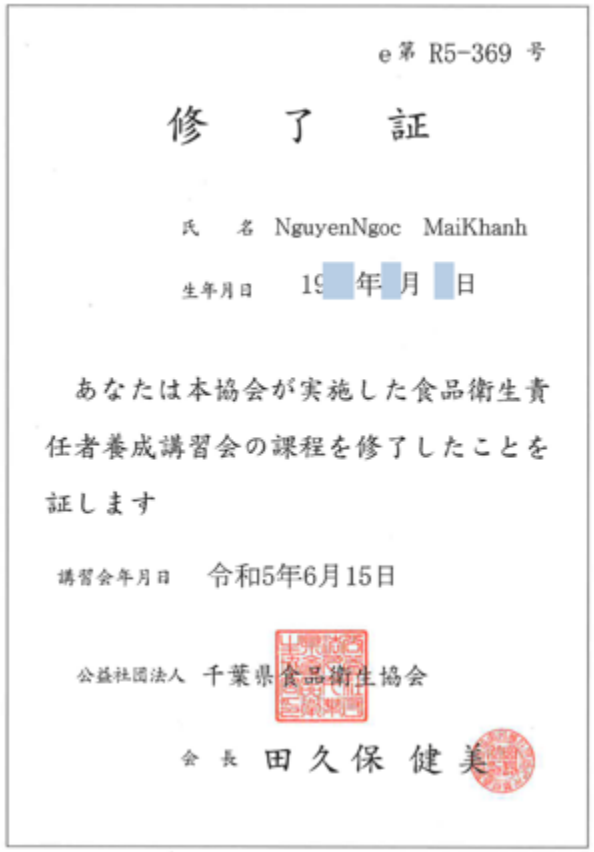


Note: Substrate Si for 1st trial, then SiO_2



Publication

Food safety course



e第 R5-369 号

修　了　証

氏　名　NguyenNgoc　MaiKhanh

生年月日　19　年　月　日

あなたは本協会が実施した食品衛生責任者養成講習会の課程を修了したことを証します

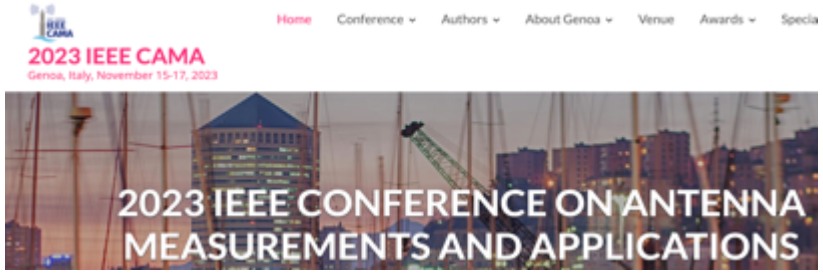
講習会年月日　令和5年6月15日

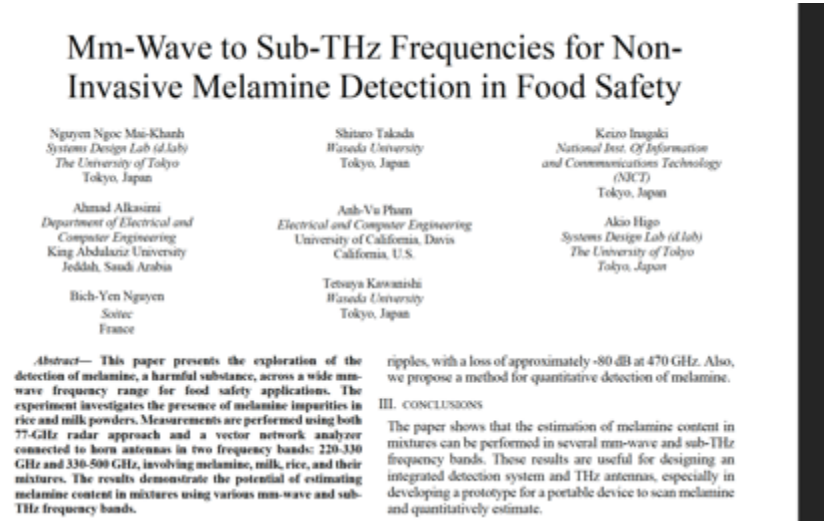
公益社団法人　千葉県食品衛生協会

会長　田久保　健美

Course fee: 10,000yen, self-support

IEEE Conference





Mm-Wave to Sub-THz Frequencies for Non-Invasive Melamine Detection in Food Safety

Nguyen Ngoc Mai-Khanh
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Soitec
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Waseda University
Tokyo, Japan

***Abstract*— This paper presents the exploration of the detection of melamine, a harmful substance, across a wide mm-wave frequency range for food safety applications. The experiment investigates the presence of melamine impurities in rice and milk powders. Measurements are performed using both 77-GHz radar approach and a vector network analyzer connected to horn antennas in two frequency bands: 220-330 GHz and 330-500 GHz, involving melamine, milk, rice, and their mixtures. The results demonstrate the potential of estimating melamine content in mixtures using various mm-wave and sub-THz frequency bands.**

ripples, with a loss of approximately -80 dB at 470 GHz. Also, we propose a method for quantitative detection of melamine.

III. CONCLUSIONS

The paper shows that the estimation of melamine content in mixtures can be performed in several mm-wave and sub-THz frequency bands. These results are useful for designing an integrated detection system and THz antennas, especially in developing a prototype for a portable device to scan melamine and quantitatively estimate.

Accepted, to be presented, Nov. 2023

Journal: IEICE Special Section

Abstract

Our project is to develop a portable and cost-effective scanner for real-time detection of foreign contaminants in agricultural staples and/or animal feed with a unique and novel mm-wave/THz sensing capability. This paper presents both qualitative and quantitative detection methods for the harmful substance melamine in a wide frequency range, from mm-wave to the THz range. Melamine has been illegally forcibly added to meals, including powdered milk or pet feed, in order to raise the protein level, one of the most crucial quality indicators. A method for quantitative detection of melamine is presented in this paper. Validation in both mm-wave and THz ranges is performed using experiments. The measurement results show that the estimation of melamine contentin mixtures can be performed in several mm-wave and THz frequency bands, including 220-330 GHz, 2 THz, 2.26 THz, and 4 THz. Especially the peak around 4 THz of melamine was found and to our knowledge this is the first study and THz measurement. To further evaluate the properties and response of melamine and its mixtures in the infrared spectrum and other chromatography, the quantitative determination of melamine was performed by both Fourier-transform infrared spectroscopy (FTIR) method and ultra-performance liquid chromatography (HPLC). These frequency bands of melamine property are useful for implementing a portable detection system with an integrated antenna array or THz pulse transceiver since the size of the components and the sampling resolution essentially depend on the operating frequency band or wavelength.

Keywords : Mm-wave, THz, food safety, melamine, detection, scanning, sensing, non-invasive, smart farming, integrated antenna, system-in-package

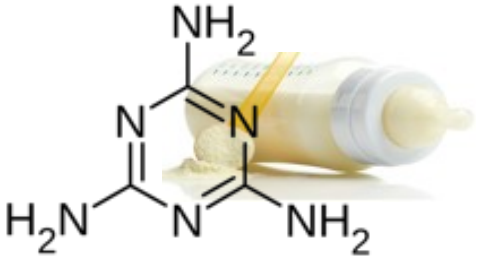
1. Introduction

manage their crop production using advanced technologies to increase the quantity and quality of agricultural

Published, Oct. 2023

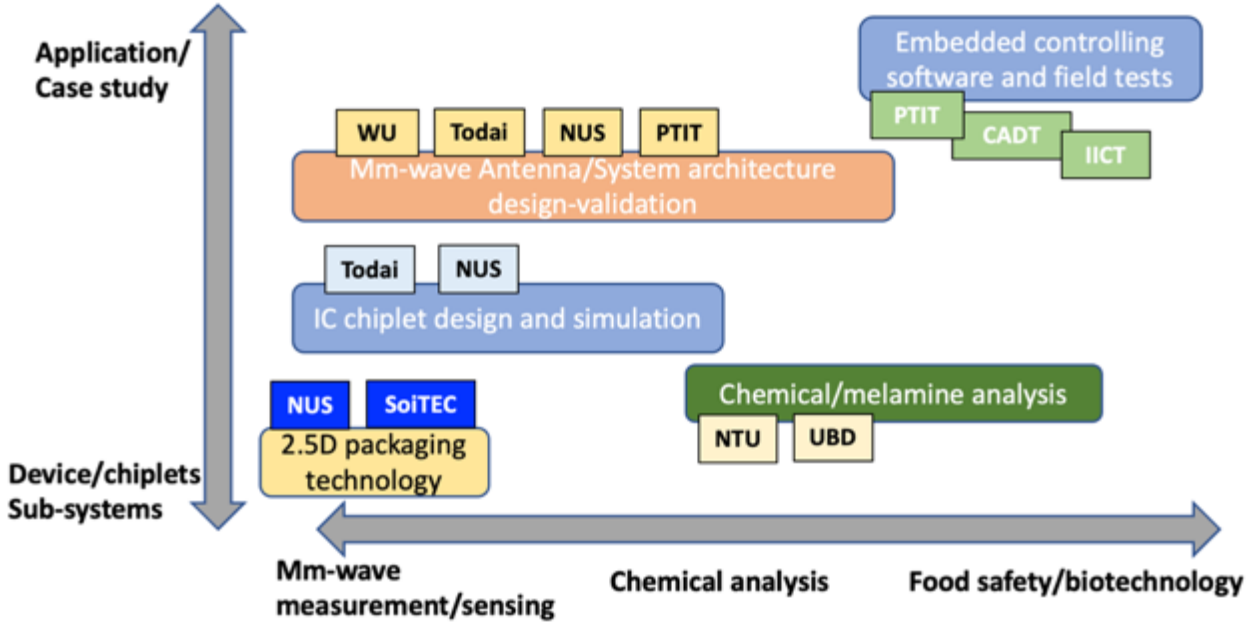
Societal Impact

1. **Broad Impact**: Research, Practice, Education
2. **Tech Advancement**: Enhancing Food Safety via Semiconductor Integration
3. **Global Connectivity**: Affordable mmW Systems for Developing Nations, Creating AIoT Library for mm-Wave/THz Sensing & Consumer Database



Next Plan

1. **Chip fabrication**:
   - On-glass **fabrication** : antenna design, chip fabrication
2. **Publication**



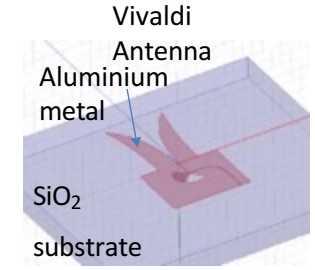
Conclusion

1. Scientific and technological

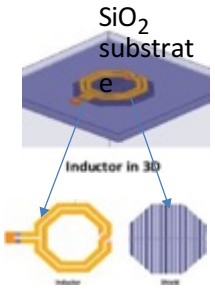
- Sucessfully designed an on-glass Vivaldi **antenna** for the purpose of sensing
- Melamine **sample** preparation

2. Experiment Results

- **Measurement** in 10 —500GHz and **THz** ranges
- **Infrared** spectrum and other chromatography
- Field test: Vietnam & Japan



Simulated Radiation Pattern 75GHz



90GHz

3. Antenna chip design & fabrication

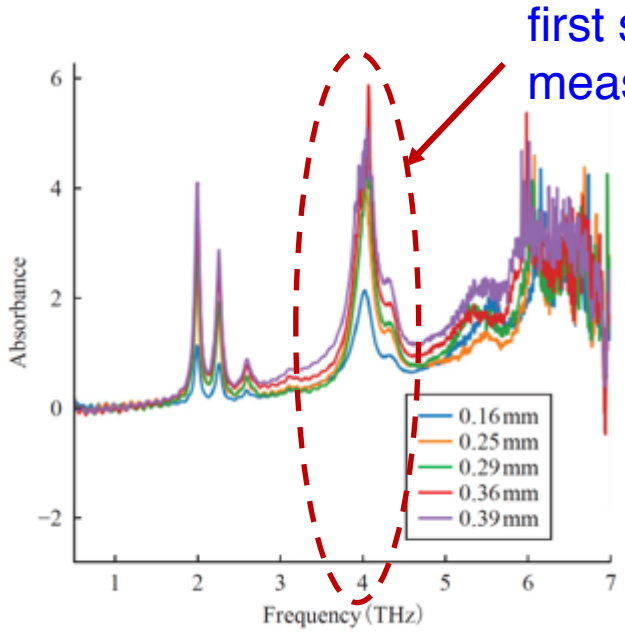
- Finish antenna design: slot and Vivaldi
- Fabrication: on-glass and 22nm FD-SOI

4. Publications

- IEEE conf. paper & IEICE journal

5. Intl' Collaboration

- UCDavis (U.S) and UCLouvain (Belgium)



Thank you for your support, collaboration, and attention!