Sonia Zappia

Multispectral electromagnetic diagnostics for quality control of food products

I year presentation

Tutor: Prof. Giuseppe Ruello co-Tutor: Dr. Lorenzo Crocco

Cycle: XXXV Year: 2019/2020

Outline

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2. Research activity
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- Main Topic
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My Background

M. Sc.	Ph.D.
Biomedical Engineering – February 5th 2019 Subject: **Magnetic Resonance Imaging** Prof. ***Giuseppe Ruello***	**Department of Electrical Engineering and Information Technology**, building 2, Via Claudio. **PhD start date**: 16/12/2020 **Scholarship type** : No scholarship Prof. **Giuseppe Ruello** Dr. **Lorenzo Crocco**

Research Activity - Introduction

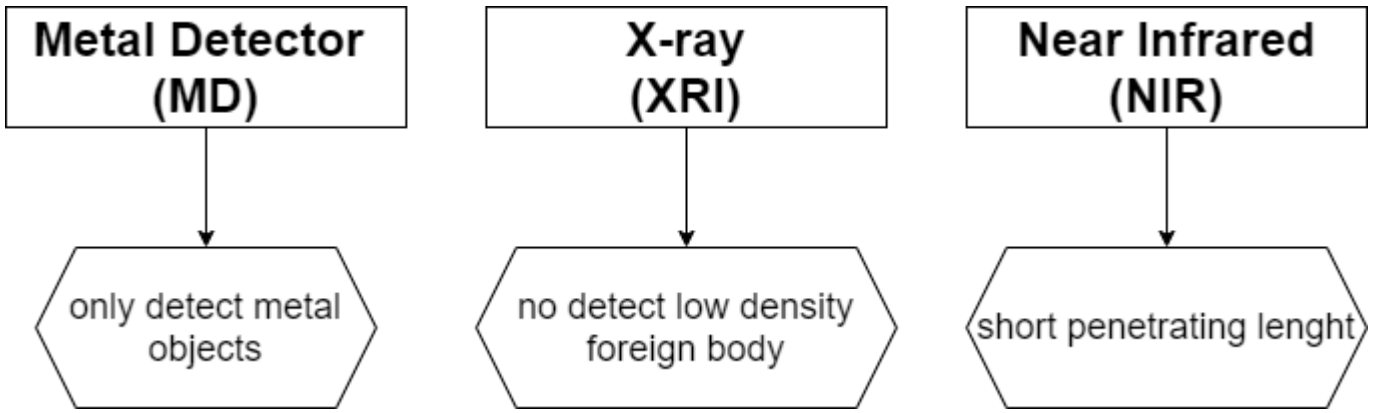
Quality control is of great importance in food industry, both for the evaluation of product characteristic and to avoid the occurrence of foreign body (FB) contamination and failure packaging.

Plastic Contamination

Metal Contamination

Packaging

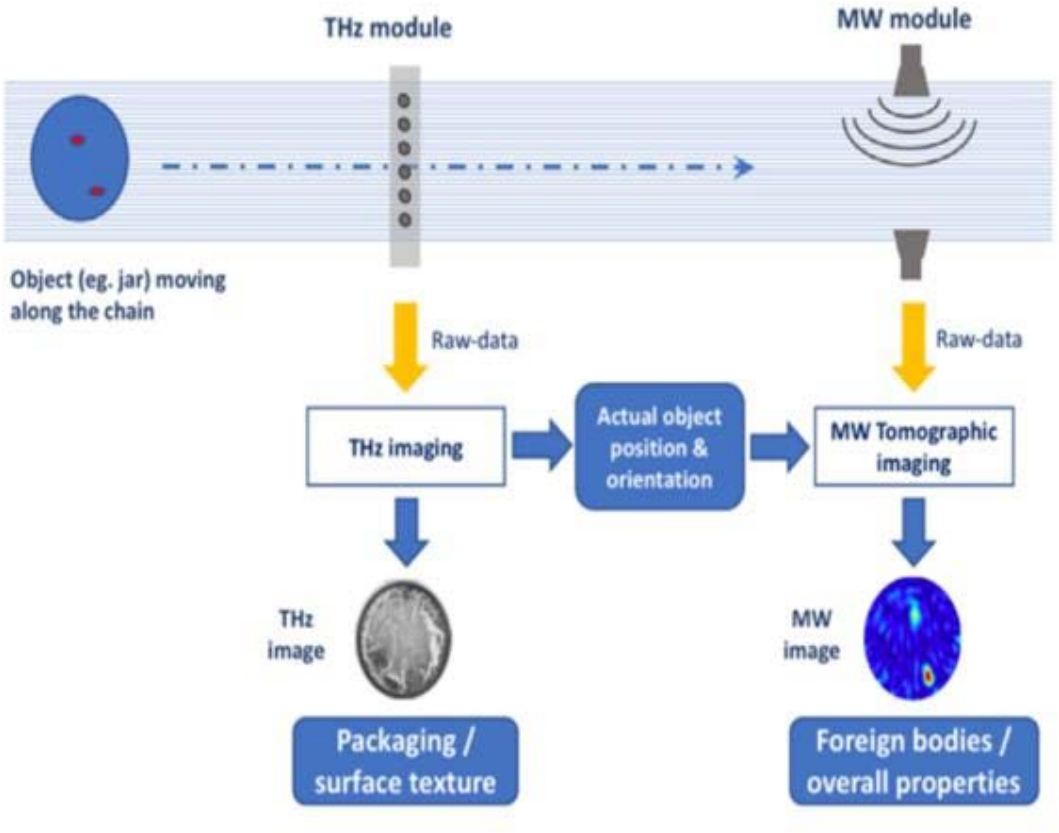
Currently Technologies Limitations:



Research Activity- Introduction

BEST - FOOD

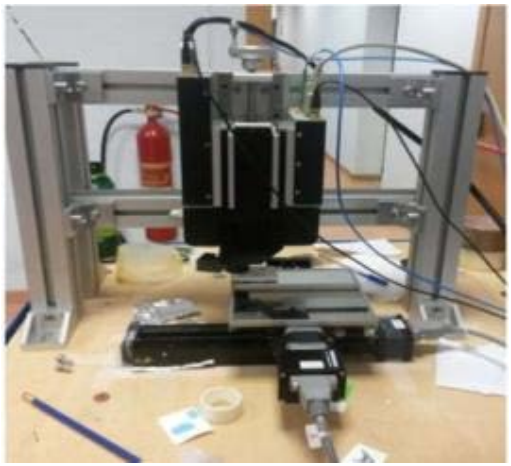
The **BEST-Food** project will develop and validate the feasibility of a novel in-line electromagnetic (EM) sensing technology for food inspection within the production chain. The synergic use of microwave (MW) and terahertz (THz) techniques will allow us to provide high resolution images and the detection of tiny defects in packaging and foreign body contamination in food product.



Main Topic : THz Imaging

My research was characterized by two principal activities:

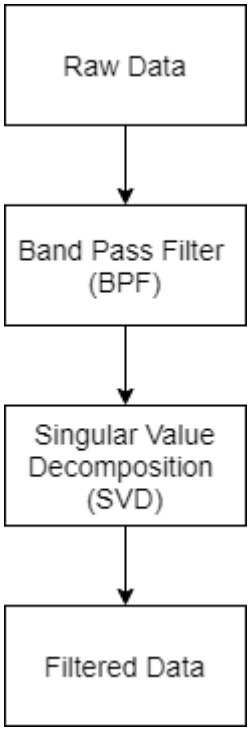
Experiments referred to non destructive testing of food samples carried out with the Fiber - Coupled Terahetz Time Domain (FiCO) system developed by Z-Omega and available at CNR-IREA



The FiCO system is equipped with an ad hoc designed imaging module, which allows an automatic planar scan. This module constraints to perform measurements in normal reflection mode.

Scan Length	50 ps
Scan Area	150 mm x 150 mm
Frequency Range	40 GHz - 1.16 THz
Resolution	120 μm
Operating Temperature	20° - 30°

Adoption of data processing strategy aimed to improve the imaging performance

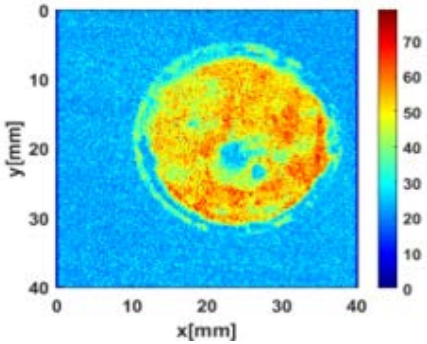


Case Studies and Results

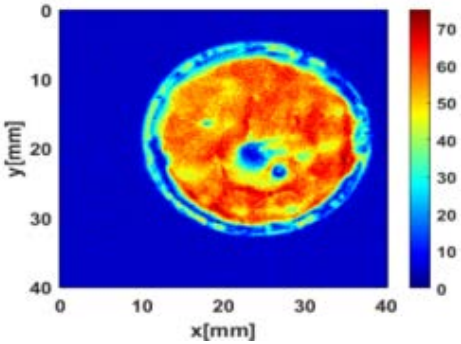
CHOCOLATE CREAM

FOREIGN BODY

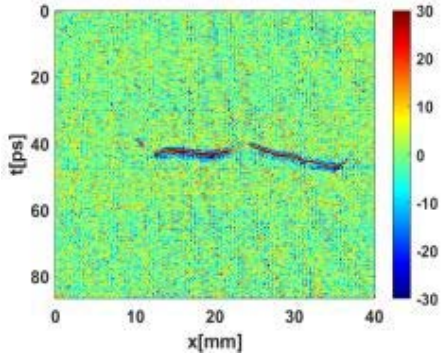
2D IMAGE : RAW DATA



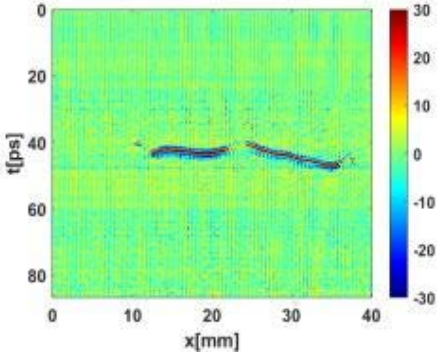
2D IMAGE : FILTERED DATA



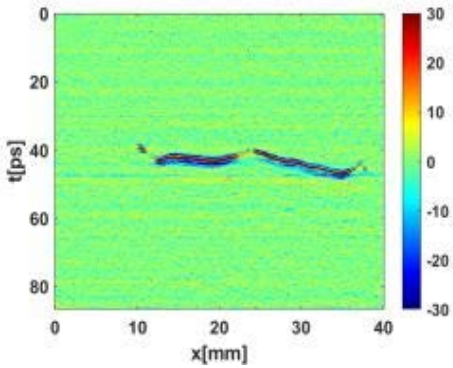
RAW DATA



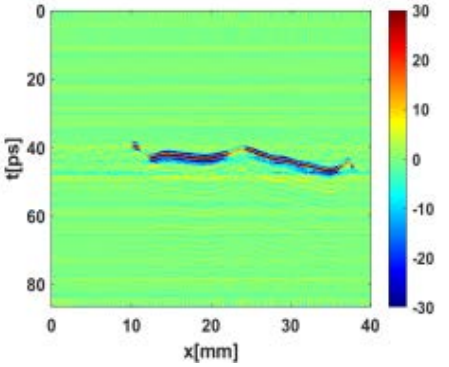
SVD DATA



BPF DATA



PROPOSED



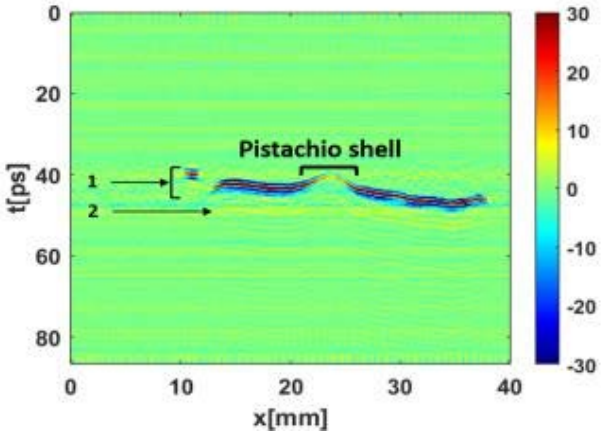
To quantitatively assess the effectiveness of the data processing, two indices are considered: the improvement factor (IF) and the Signal-to-Noise Ratio (SNR)

TABLE OF QUALITY INDICES

	IF(dB)	SNR_x(dB)	SNR_y(dB)
SVD	6.445	-0.277	-3.360
BPF	10.33	3.005	2.9004
Proposed	**15.68**	**9.132**	**7.384**

Case Studies and Results

The results indicate the ability of THz imaging to detect foreign body contamination.



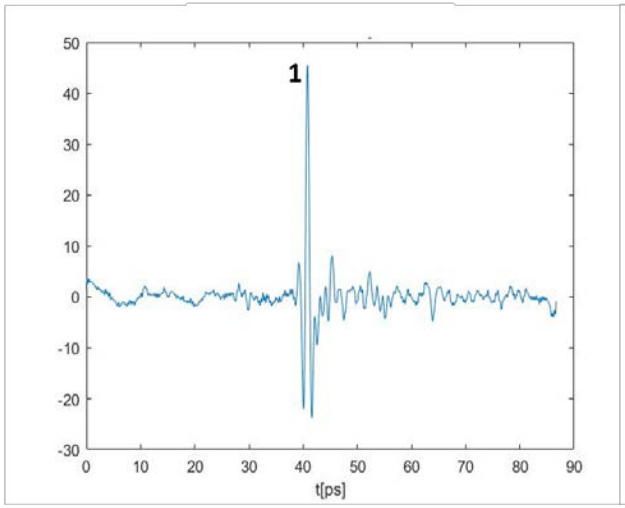
it is possible to distinguish two reflections due to occurrence of different materials:

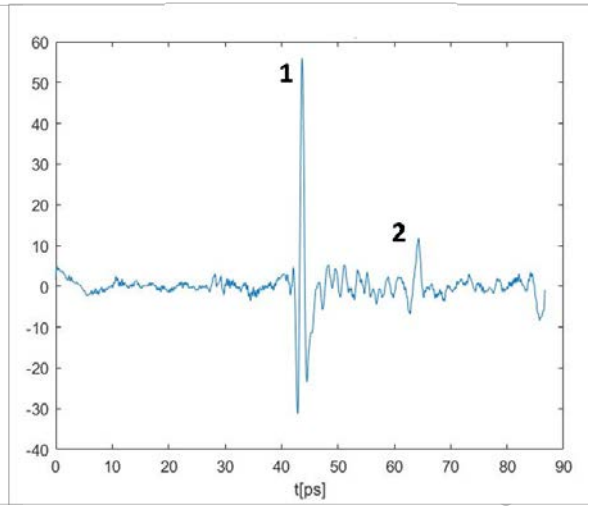
1. Air/chocolate interface
2. Chocolate/polystyrene interface

Taking into account the first reflection, one can note that the extent of the defect ranges from 20 mm to 25 mm.

it is interesting to observe the THz waveforms corresponding to two different points of the scan area for the sample below. The first point has been fixed in an area where only chocolate cream is present. On the contrary, the second waveform corresponds to an area where both chocolate cream and polystyrene are present.

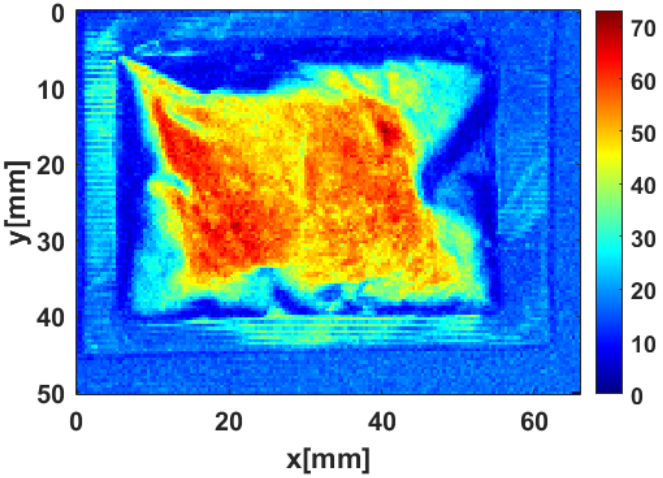
CHOCOLATE CREAM CONTAINING POLYSTYRENE

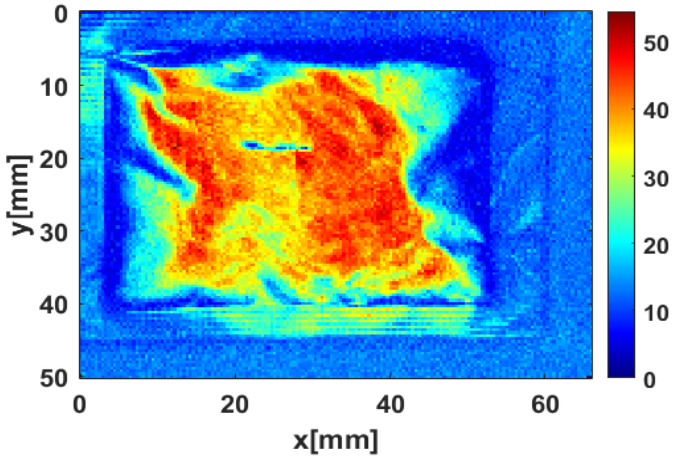




Case Studies and Results

The results indicate the ability of THz imaging to represent accurately the surface packaging defect.





Research activity: Overview

- ***Problem:***

  Evaluation of the Terahertz potential in detecting packaging and surface defects. Characterization of materials at THz. THz validation experiments. Solving an electromagnetic problem in a complex environment.

- ***Objective:***

  The aim is to take advantage of the synergic use of Terahertz and microwaves technologies in order to provide high resolution images and in-depth inspections for the development of an effective technology for food quality monitoring.

- ***Intended contribution (in perspective)***

- Electromagnetic characterization of the food samples at THz
- THz simplified scattering modeling of the studied scenario

Research Products

[P1]	S. Zappia, G. Ruello, L. Crocco – "Terahertz data processing for food quality inspection : preliminary results" accepted **conference paper** for the National Electromagnetism Meeting 2020 (RINEM 2020)
[P2]	R. Scapaticci, S. Zappia, I. Catapano, G. Ruello, G. Bellizzi, N. Pasquino, M. Cavagnano, S. Pisa, E. Piuzzi, F. Frezza, F. Vipiana, J. A. Tobon Vasquez, M. Ricci, L. Crocco – "Broadband Electromagnetic Sensing for Food Quality Control: A Preliminary Experimental Study" submitted **conference paper** for the 15th European Conference on Antennas and Propagation (Eucap 2021)

Summary of study activities

CYCLE XXXV

	Credits year 1							
	Estimated	1 bimonth	2 bimonth	3 bimonth	4 bimonth	5 bimonth	6 bimonth	Summary
Modules	20-40	**0**	3.3	2	5	3.6	9	**22.9**
Seminars	5-10	0	0.2	0.8	4.2	0	1.6	**6.8**
Research	10-35	0	6.5	8	1.2	6.4	5	**27.1**
	35-85	0	10	10.8	10.4	10	15.6	**56.8**

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Ad hoc PhD courses:

- Safety Critical Systems for Railway Traffic Management;
- Matlab Foundamentals;
- Innovation management, entrepreneurship and intellectual property;
- Machine Learning.

Courses attended borrowed from MSc curricula:

- Microwave and millimetre wave measurements.

Credits summary

	Credits year 1								Credits year 2								Credits year 3									
	Estimated	1 bimonth	2 bimonth	3 bimonth	4 bimonth	5 bimonth	6 bimonth	Summary	Estimated	1 bimonth	2 bimonth	3 bimonth	4 bimonth	5 bimonth	6 bimonth	Summary	Estimated	1 bimonth	2 bimonth	3 bimonth	4 bimonth	5 bimonth	6 bimonth	Summary	Total	Check
Modules	20-40	0	3.3	2	5	3.6	9	22.9	9	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	22.9	30-70
Seminars	5-10	0	0.2	0.8	4.2	0	1.6	6.8	6	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	6.8	10-30
Research	10-35	0	6.5	8	1.2	6.4	5	27.1	42	0	0	0	0	0	0	0	50	0	0	0	0	0	0	0	27.1	80-140
	35-85	0	10	10.8	10.4	10	15.6	56.8	35-75	0	0	0	0	0	0	0	40-80	0	0	0	0	0	0	0	56.8	180

THANK YOU FOR YOUR KIND ATTENTION