COST-STSM-TD1301-180716-080590 Scientific Report

STSM Topic: A study of the biological tissues dielectric properties

STSM Applicant: Irina Alborova, Bauman Moscow State Technical University, Moscow (RU), alborova@inbox.ru

Host: Charles V Sammut, University of Malta, Msida (MT), charles.v.sammut@um.edu.mt

Period: from 21-11-2016 to 05-12-2016

(i) Abstract

Dielectric properties are the most important parameters determining energy deposition when biological tissues are exposed to radio frequency and microwave fields. Energy absorption is determined by the specific absorption rate (SAR). SAR distributions can be computed accurately only if the complex relative permittivity of the target tissue is known to a sufficiently high accuracy. Presently there is a lack of data on the dielectric properties of biological tissues at high frequencies. This work describes the measurements of ex-vivo dielectric properties of fat tissue and their correlation to preserved samples. The temperature variability of the dielectric properties of fat from 21°C up to 37°C is shown. During the experiments an open-ended coaxial probe technique and a vector network analyzer (Rohde&Schwarz ZVA-50) with a dielectric measurement kit (85070E Agilent Dielectric Probe kit) for measurement of the complex reflection coefficient S11 parameters were used. The frequency band examined was from 1 GHz up to 20 GHz. The measurement system is controlled by a PC and the measured data is recorded for the given number of frequencies. The complex reflection coefficient (S11 parameter) is converted to complex permittivity (ε) utilizing the Agilent software 85070E. A one-pole Cole-Cole model was used to fit the measured data as a function of frequency and the dispersion parameters.

(ii) Purpose of the STSM

This work plan will involve work packages where the applicant will perform preliminary investigations on the individual and temporal variability of the animal adipose dielectric properties in different frequency range, working closely with Dr. Lourdes Farrugia and Dr. Charles Sammut at the University of Malta.

These studies are part of work investigating the possibilities/limitations of microwave imaging technique in detecting the dielectric inhomogeneous inclusions in the biological tissues.

The applicant will be involved in the investigation of the following:

Sample holders for biological tissues: The applicant will investigate the most appropriate sample containers.

Sample volume: The investigation of optimal sample volume for biological tissue collection such that all reflections are only due to the material under test (MUT).

Frequency range: A literature review of current data together with applications where this data can be relevant will be used to establish an optimal frequency range for the measurements.

The method of measurements: The applicant will become familiar with the sequence of the dielectric properties measurement.

Individual variability: Investigation of individual and temporal variability of respective dielectric properties.

(iii) Description of the work carried out during the STSM

During the STSM-program a procedure was proposed to determine the dielectric properties of the biological tissues which also; minimised the impact of the measurement method on the result. This research was conducted at the University of Malta (Msida, Malta), in the Electromagnetics Laboratory using a vector network analyzer (Rohde & Schwarz) and the reflection method using an open-ended coaxial probe (Slim probe from Keysight Technologies).

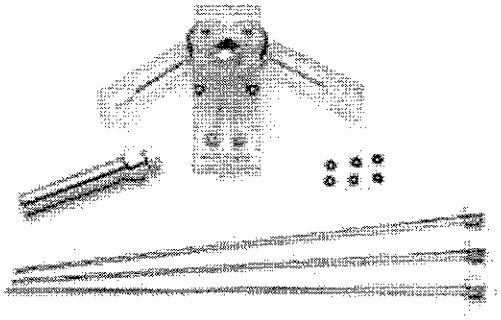

Fig. 1. Coaxial probe

The necessary steps taken to obtain successful and repeatable measurements of the electromagnetic field strength E using the coaxial probe were:

1. to immobilize probe cable and eliminate the possibility of bending the cable, the probe, and the torsion nuts electrical connectors;
2. use a sample with a thickness of 10 mm diameter and 20 mm larger than the diameter of the probe.

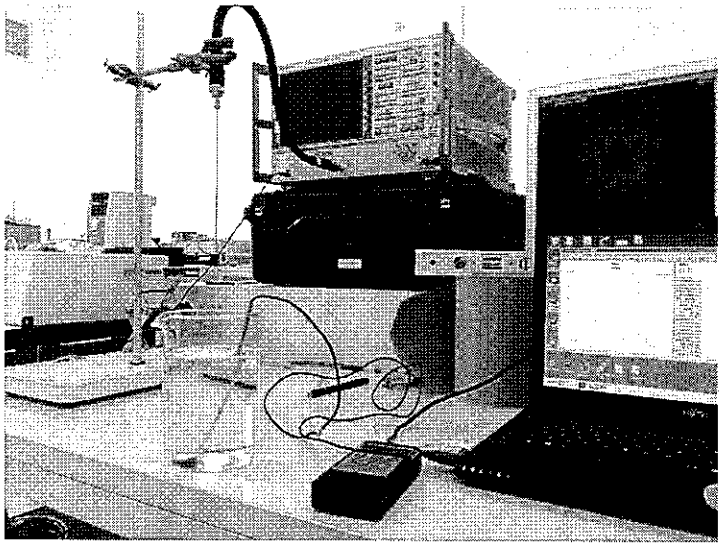

Fig. 2. Measurement setup

Before the measurement it is necessary:

1. setup the measurement parameters (frequency, number of measurement points in the frequency range, the calibration parameters);
2. to calibrate. During the calibration, make sure that at the end of the probe there are no air bubbles.

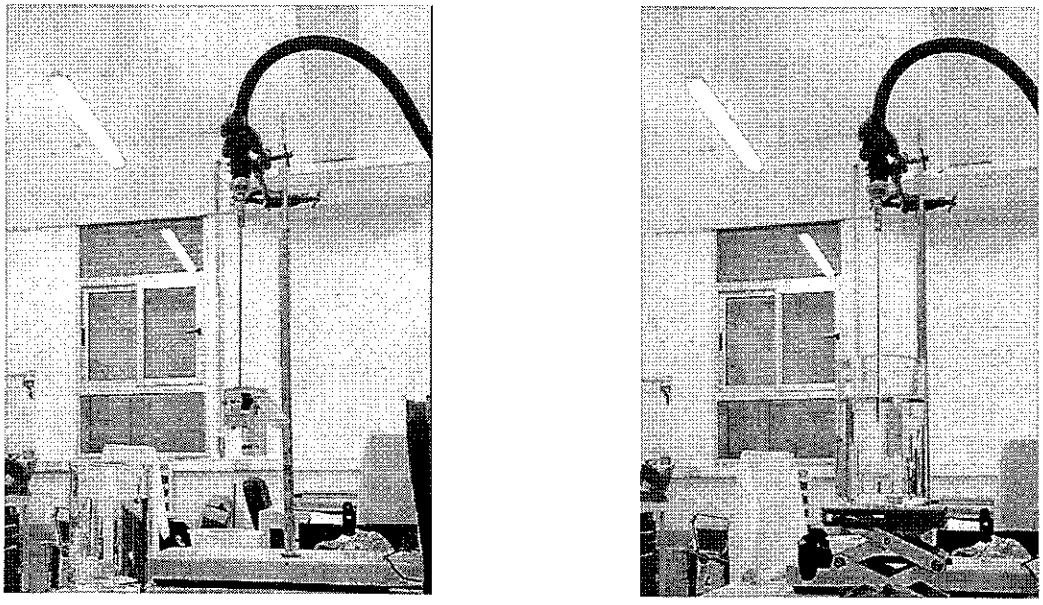

Fig. 3. Calibration pocedure

After calibration, it is important to ensure that the probe is cleaned and wiped dry and then it is possible to conduct experiments.

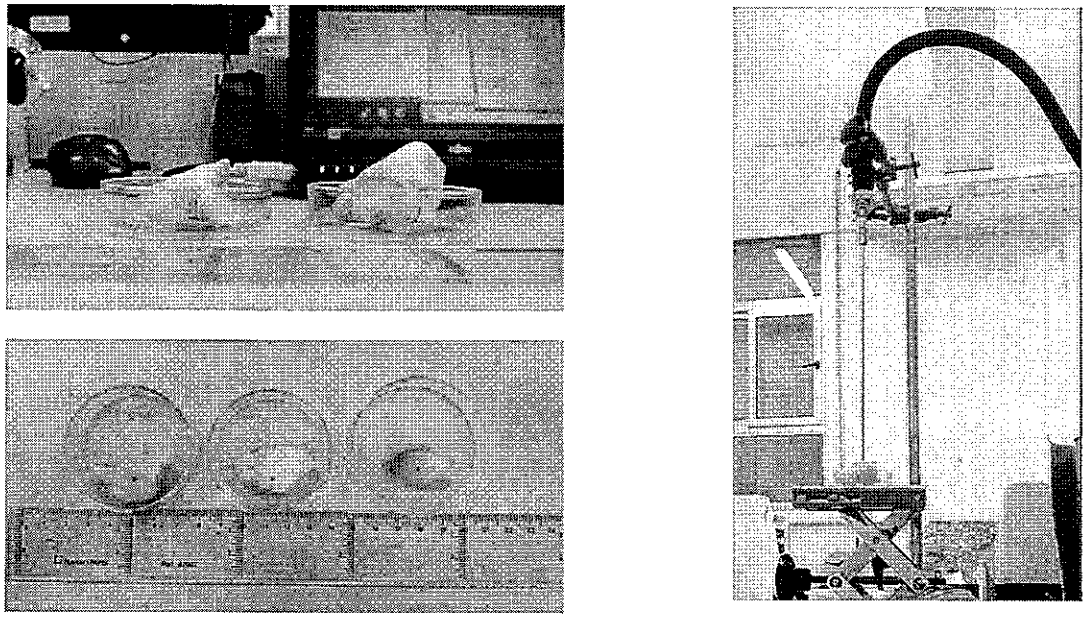

Fig. 4. Measurements of an adipose tissue samples

Results of the experiments were obtained and presented in the form of graphs. Figure 5 present the results of temperature variation.

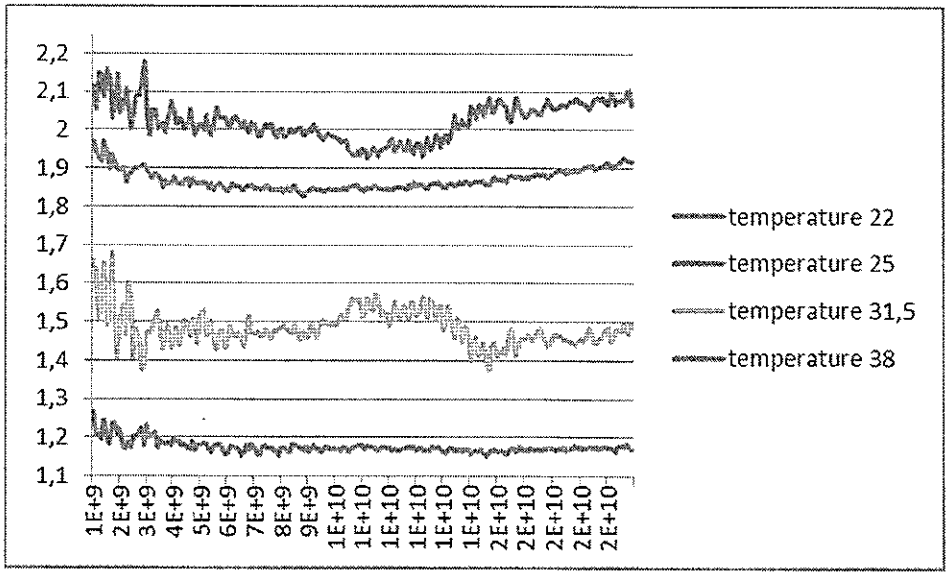

Fig. 5. Experimental results of temperature variation [label the axis of the graph]

During the STSM-program it was shown the differences between the normal and fixed fat tissue (fig. 6). Include a dscription of how you fixed the sample

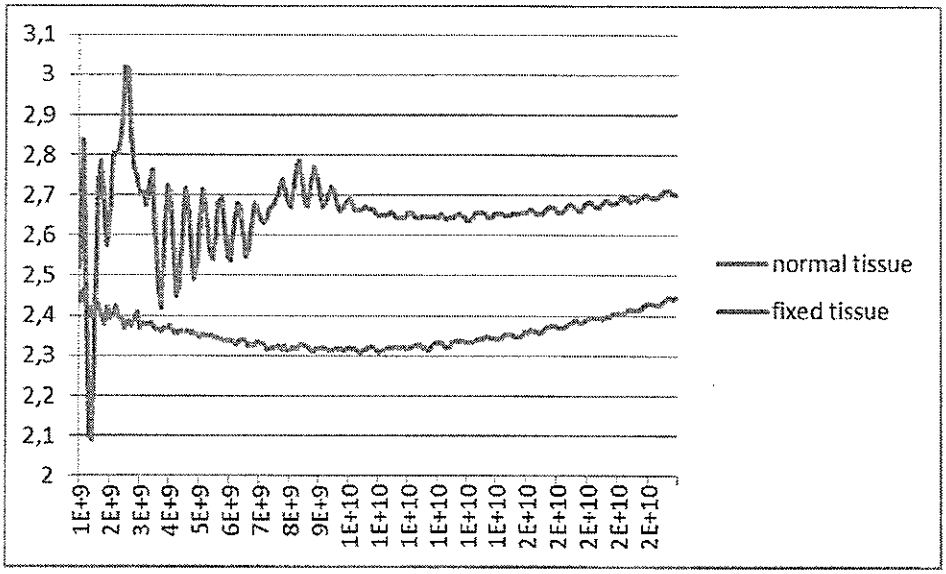

Fig. 6. Experimental results of the differences between the normal and fixed fat tissue

(iv) Description of the main results obtained

During the 2 weeks I gained good experience in measurement of dielectric properties. I learnt about sample holders for biological tissues, optimal sample volume for biological tissue and the methods of measurements. With help of Julian Bonello, Dr Lourdes Farrugia and Professor Charles V. Sammut I learned how to measure the dielectric properties of biological tissues, conducted measurements using a vector network analyzer (Rohde&Schwarz ZVA-50) and a dielectric measurement kit (85070E Agilent Dielectric Probe kit). This will help me in my further research to realise the possibilities of detecting the dielectric inhomogeneous inclusions in the biological tissues by using the radar aids.

I am really thankful to COST Action for providing me with the opportunity to learn new things and to acquiring new knowledge and skills.

(v) Future collaboration with host institution (if applicable)

(vi) Foreseen publications/articles resulting or to result from the STSM (if applicable)

Irina L. Alborova, Julian Bonello, Lourdes Farrugia, Charles V. Sammut, and Lesya N. Anishchenko «A Study of the Dielectric Properties of Biological Tissues: Ex-vivo vs Preserved Samples». Progress in Electromagnetics Research Symposium (PIERS) (22-25 May 2017, St. Petersburg, Russia).

(vii) Confirmation of the host of the successful execution of the STSM

We confirm that Irina Alborova from Bauman Moscow State Technical University worked in the Electromagnetics Laboratory at University of Malta from 21-11-2016 to 05-12-2016.

The visit has been successful and the results are described in this report, which I confirm.

Prof. Charles V Sammut, University of Malta, Msida (MT)

Dr. Lourdes Farrugia, University of Malta, Msida (MT)