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Research paper

Evaluation and protection of skin from cancer using conical dielectric probe

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Abstract

This present research paper proposes the usage of conical dielectric probe (CDP) for the identification, evaluation and protection of skin cancer. It is very easy to identify and cure skin tumors with the utilization of millimeter waves of size 95GHz or 35GHz called as dielectric probes. The response of this millimeter wave is very sensitive and reflective to water and so it is utilized in identifying the skin cancers. Such cancers have and parameter over that of healthy skin, and the probes spot cancers by recognizing these abnormal S-parameters utilizing COMSOL Multi physics software. Through experiment, evaluating the use of CDP and assure its protection as an optional for detecting the cancers of skin.

Keywords: *Dielectric Probe, Defective skin, COMSOL, Multi physics, Heta transfer module, RF module*

1. Introduction

The COMSOL Metaphysics will be a major platform for analysis of finite element, simulation software for multi physics. The COMSOL gives unified workflow and IDE for chemical, mechanical, electrical, and fluid provisions. Alive link for MATLAB and API for java might a chance to be utilized to manage the external software and have same utilized edited method[1].

The COMSOL holds an App Builder that might be utilized to progress the self-governing field- exact applications with tradition user-interface. Clients might utilize coping the devices or training. Particular offers might a chance to be included from the model or new offers might make presented by training and it holds a builder of physics to make a traditional physics interface available on COMSOL desktop. The COMSOL server [2] is the engine and software for successive training applications and the stage for handling their distribution and deployment. Client formed applications could be run in COMSOL server through Windows-installed client. Svante Littmarck and Farhad Saeidi start the COMSOL in July 1986 at the Royal Institute of Technology (KTH) in Stockholm, Sweden. Numerous components are accessible for COMSOL, characterized according to the application regions, namely Fluid, Mechanical, Electrical, Chemical, Interfacing, and Multipurpose [3].

II. Methodology

The reaction of a millimeter wave with frequencies of 35GHz and 95GHz is known to be delicate to content of water. This method utilizes a low-power 35GHz ka-band millimeter wave and its reflectivity to humidity for non-invasive cancer analysis. Since skin tumors hold more humidity over healthy skin, it prompts stronger reflections on this frequency band. Subsequently the probe identifies abnormalities in terms of S-parameters during the tumor areas. A circular waveguide at the dominant mode and conically decreased dielectric probe are rapidly analyzed, alongside the probe's radiation [4] characteristics, utilizing a 2D hub symmetric model. Temperature variety of the skin and the portion about necrotic tissue dissection would likewise perform too.

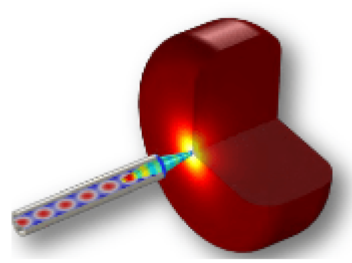

Figure.1. 3D Visualization of the 2D Ax symmetric model

III. Model Definition

The model contains of a tapered PTFE dielectric rod, a metallic circular waveguide, and a phantom of a skin chunk. The entire model is enclosed by an air domain which is truncated at its outermost shell with PML (perfectly matched layers) to absorb any radiation directly from the rod or reflected from the skin phantom.

One end of the waveguide is terminated with a circular port and excited using the dominant TE1m mode, where m is the azimuthal mode number of this 2D axisymmetric model [5] defined as 1 in the Electromagnetic Waves, Frequency Domain physics interface settings. The other end is connected to a tapered conical PTFE dielectric (εr = 2.1) rod. The shape of the rod is symmetrically tapered so the radius is increasing from the inside to the outside of the waveguide, then it is decreasing gradually for the impedance matching among the air domain and the waveguide. There is a ring structure in the middle to support the rod on the rim of the waveguide [6]. The tip of the rod is touching the skin phantom. The conductivity of the metallic waveguide is assumed to be high enough to neglect any loss and is modeled as PEC (perfect electric conductor). With the given radius of the waveguide and excited TE mode, the cutoff frequency is around 29.3 GHz, which is calculated by

$$f_{cm1} = \frac{c_0 p'_{nm}}{2\pi a}$$

where c0 is the speed of light, p′nm are the roots of the derivative of the Bessel functions Jn(x), m and n are the mode indices, and a is the radius of the waveguide. The value of p′ 11 is approximately1.841.

The operating frequency of the probe, 35 GHz, is higher than the waveguide cutoff frequency. The excited wave is propagating along the waveguide. The circular port boundary condition is placed on the interior boundary where the transmission characteristics and reflection characteristics are computed automatically in terms of S-parameters. The interior port boundary with PEC backing for one-way excitation requires the slit condition. The port orientation is identified to describe the inward direction for the S-parameter calculation. First, the electromagnetic properties of the model are analyzed without a phantom to check the design validity of the waveguide and dielectric rod. Then, complexity is added, first with a healthy phantom, then a phantom with a skin tumor [7].

Though the waveguide excited by low power is expected to be harmless, its effect on necrotic tissue is reviewed by studying Bio-heat Transfer as well as temperature, over a 10 minute period. The real part of the electric field Er excited from one end of the waveguide without a phantom is shown below. Its radiation pattern is visualized in the Modeling Instructions section.

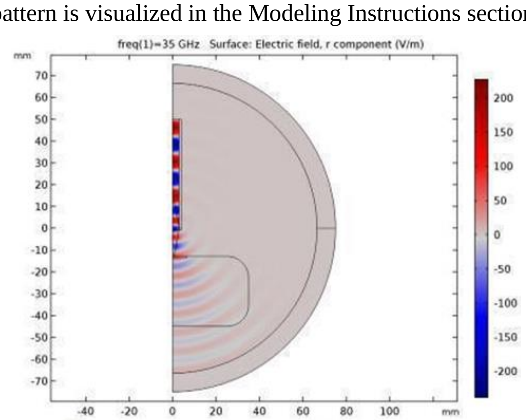

Figure.2. Wave propagation from the dielectric rod plotted with E

Temperature change on the surface of the phantom with the tumor is plotted as shown.

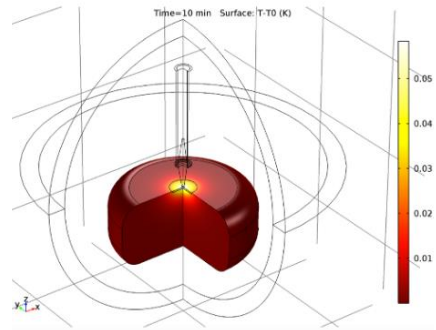

Figure.3. The temperature after 10 minutes

Since the input power from the waveguide port is low, 1mW, the temperature change is within 0.06° even after 10 minutes of millimeter wave exposure. The color difference shows the relatively hotter spot where the temperature is still very close to the initial temperature, 34 °C. Though the temperature analysis for the healthy phantom case is not included, it is easily expected that the temperature variation is less than the case with the tumor because the resistive loss should be lower due to the smaller imaginary part of the permittivity of the healthy skin [8]. So the visualized temperature profile is the worst-case scenario of temperature increase among all three cases [9]. The damaged tissue ratio is visualized in Figure 3. It shows that the effect of the low-power millimeter wave is negligible.

The computed S-parameters indicate more reflection when touching the skin with the tumor due to its higher moisture content, and they are approximately summarized below:

The electromagnetic material properties of skin and tumor at 35 GHz are approximated to show the feasibility of the S-parameter method by detecting the areas with higher moisture content. For any further research, extracting accurate data in the given frequency range is recommended.

IV. Implementation

In this model window now click 2D axis asymmetric and select physics tree to choose radio frequency of electromagnetic waves, frequency domain [EMW].
Click adds.
Click study.
Now select study tree to choose preset studies of frequency domain and then click done.
Global definitions
Now on the home toolbar click on parameters form setting windows then after locate the parameter section from the table and then enters following setting.

STUDY1
Step 1: frequency domain
From model window click step 1 as frequency domain and type f0 for setting the frequency.

Geometry1
In the Model Builder window, under Component 1 (comp1) click Geometry 1.

In the Settings window for Geometry, locate the Units section. From the Length unit list, choose mm.

Circle1 (c1)

On the Geometry toolbar, click the Primitives and select the Circle.

Now from the setting window circle locate size, shape and radius of text field and type 75.then from sector angle text field type 180 to locate the rotation angle section. Now type 270 to expand the layer section from the table for required settings

V. Results & Analysis

Far Field, 3D plot with actual parameters and respective s-parameters:

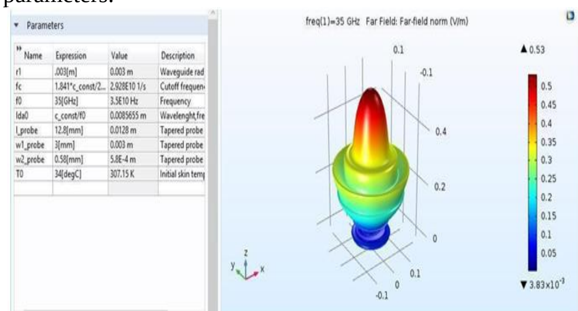

Figure.4. Comparison of actual parameters with low and high values and respective parameters.

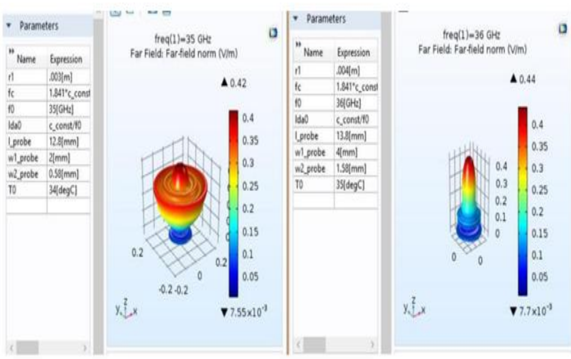

Figure.5. Tapered probe width 1 (Low Value)

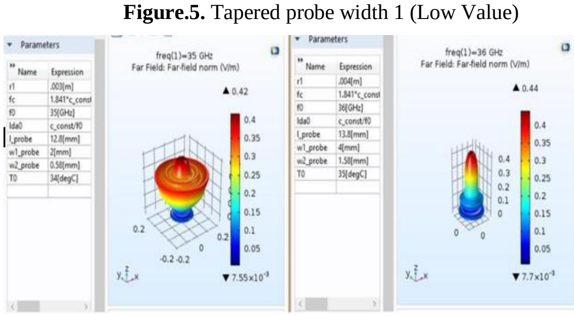

Figure.6. Here the actual parameters are compared with its low and high values of radius cut of frequency, length, tampered width-1, tampered width-2, temperature and S- Parameters

Conclusion

By analyzing various values of parameters, we observed that the variation in the actual parameters causes great effect on skin and the tissues can be damaged. The computed S- parameters indicate more reflection when touching the skin with the tumor due to its higher moisture content. The electromagnetic material properties of skin and tumor at 35 GHz are approximated to show the feasibility of the S-parameter method by detecting the areas with higher moisture content. Thus defected skin phantom are detected by the conical dielectric probe.

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