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Designed and Analyzing Different Conical Probes for Detecting Tumor in Skin

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Abstract: Skin cancer is a common type of cancer that emerges from the skin. The abnormal growth of cells can invade other parts of the body. These cells contain more moisture then they normal cell. The response to moisture of 35GHz frequency is need to detect the skin cancer. We proposed a conical dielectric probe with different radius design has 2mm probe, 3mm probe, 4mm probe and 5 mm probe antennas which are analyzed at 1W input power and various parameters like Electric Field (emw), temperature, Radiation Pattern, Resistive Losses, and damaged tissue are compared.
Keywords: Skin cancer, Millimeter-wave reflectometry, Dielectric probe.

I. INTRODUCTION

Skin cancer is a common type of cancer.[1] It is extended due to the development of abnormal growth of cells that emerges from the skin. [2] These cells can damage other parts of the body. The frequencies of 35 GHz and 95 GHz is known to be very sensitive to water content. By using these frequencies band we can detect the skin cancer. Since skin tumors contain more moisture than healthy skin, it leads to stronger reflections on this frequency band. Hence the dielectric probe can detects abnormalities.

II. MODEL DEFINITION

A circular waveguide at the dominant mode and a conically tapered dielectric probe are quickly analyzed, along with the probe's radiation characteristics, using a 2D axisymmetric design. various parameters like Electric Field (emw), temperature, Radiation Pattern, Resistive Losses, and damaged tissue are analyzed.
The design consists of a metallic circular waveguide, a tapered PTFE dielectric probe, and a part of skin chunk shown in Figure 1.

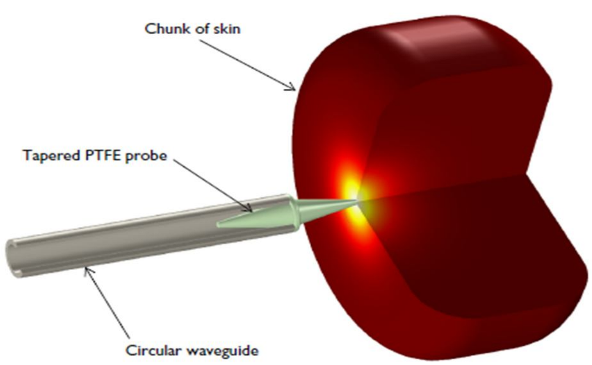

Figure 1: The probe consists of a circular waveguide and a tapered dielectric rod.

III. DESIGN PARAMETERS

The entire design is enclosed by an air domain which is truncated at its outermost shell with perfectly matched layers (PML) to absorb any radiation directly from the rod or reflected from the skin part. 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. The other end is connected to a tapered conical PTFE dielectric 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 between the waveguide and the air domain. There is a ring structure in the middle to support the rod on the rim of the waveguide. The tip of the rod is touching the skin part.

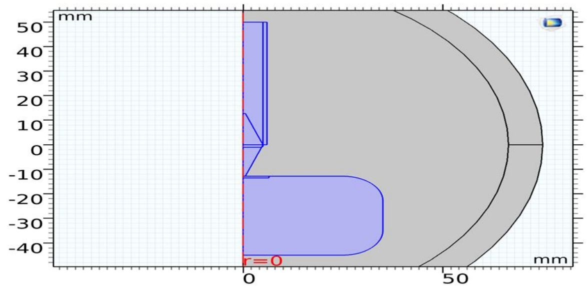

Figure 2: Model Geometry

Table 1: Parameters

Parameters		
Name	Value	Description
r1	0.002-0.005[m]	Waveguide radius
fc	1.841*c_const/2/pi/r1	Cutoff frequency
f0	35[GHz]	Frequency
lda0	c_const/f0	Wavelength, free space
l_probe	12.8[mm]	Tapered probe length
w1_probe	2-5[mm]	Tapered probe width1
w2_probe	0.58[mm]	Tapered probe width2
T0	34[degC]	Initial skin temperature

Radius of waveguide is varied from 2 to 5 mm operated at 35 GHz frequency, wavelength in free space can be calculated by speed of light by operating frequency.

Dielectric conical probe is of length 12.8mm with a radius of 2 to 5mm and at contact with skin has a width of 0.58mm.

EMW, Bioheat physics are applied on the design at 1mW input power at the other end of waveguide. The skin temperature is kept at 34deg C.

IV. RESULTS

The proposed design has 2mm probe, 3mm probe, 4mm probe and 5 mm probe antennas which are analyzed at 1W input power and various parameters like Electric Field (emw), temperature, Radiation Pattern, Resistive Losses, and damaged tissue are compared.

A. 2mm Probe

Parameters of the 2mm probe conical antenna are as follows:

1) Electric Field

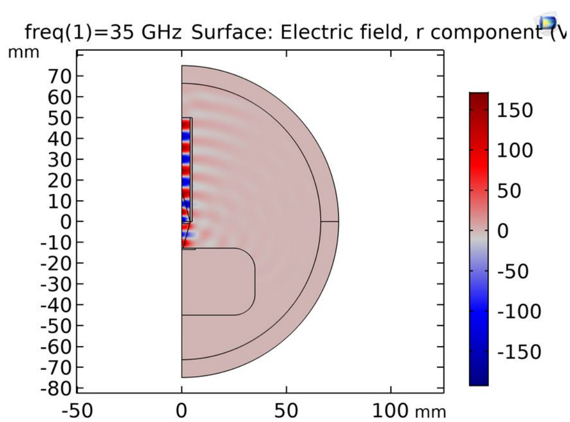

Figure 3: Electric field of 2mm probe antenna.

Figure 3 shows the electric field produced by the 2mm probe antenna during input power of 1 mW. The maximum value of electric field is given by 150 V/m which is nearly same for all the radius of the probe.

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2) Temperature

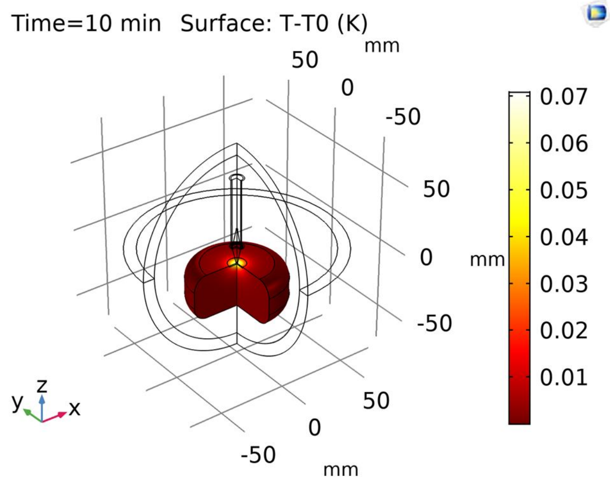

Figure 4: Temperature 2mm probe

The maximum temperature at center of tumor is 0.07K is produced at the tip of the probe which is connected to the skin. The yellow color is showing maximum temperature.

3) Damaged Tissue

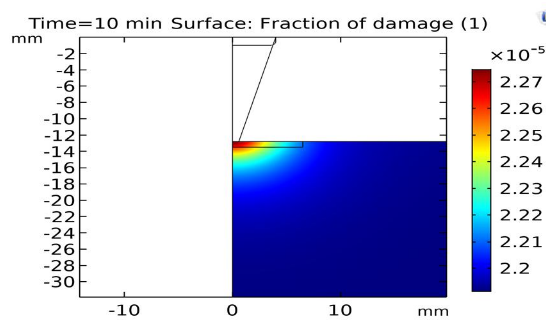

Figure 5: Dead Cells 2mm probe

Figure 5 shows the distribution of the heat source. Clearly the temperature field follows the heat-source distribution quite well. That is, near the antenna the heat source is strong, which leads to high temperatures which is sufficient to kill the tumor cells, while far from the antenna, the heat source is weaker and the blood manages to keep the tissue at normal body temperature. Red color shows the dead tissues on the surface of the skin.

4) Resistive loss

Resistive loss on tumor is shown in figure below.

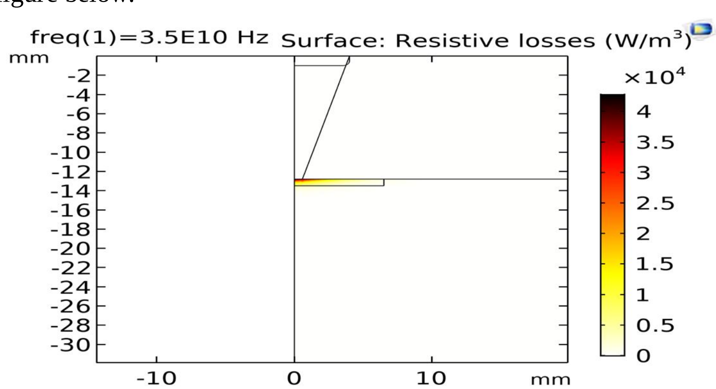

Figure 6: Resistive Loss for 2mm probe.

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5) 2D Radiation Pattern

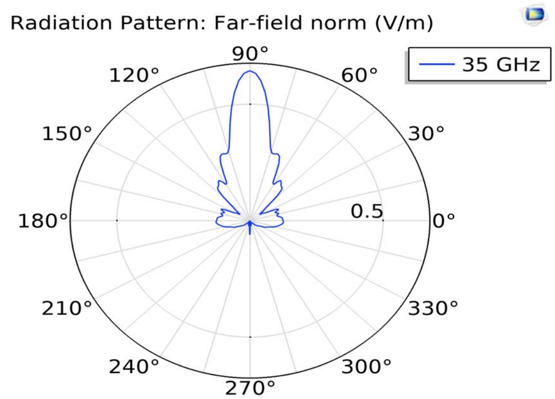

Figure 7: 2D radiation pattern of 2mm probe

The 2D radiation pattern of 2mm probe shows the radiation are very Sharpe and can penetrate more then 0.5mm. Radiation pattern is shape till 0.64mm can be seen in 3D plot.

6) 3D Radiation Pattern

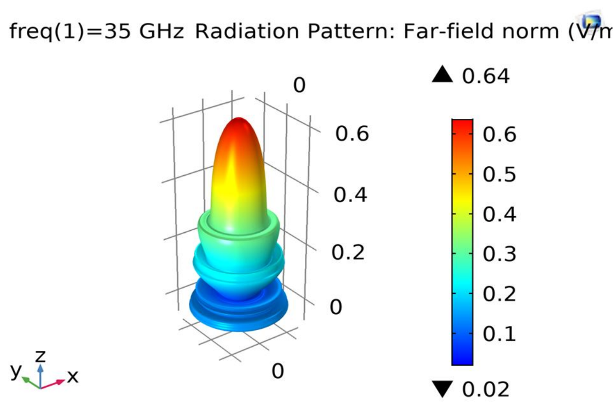

Figure 7: Radiation Pattern 3D of 2mm Probe

B. 3mm Probe

Parameters of the 3mm probe conical antenna are as follows:

1) 2D Radiation Pattern

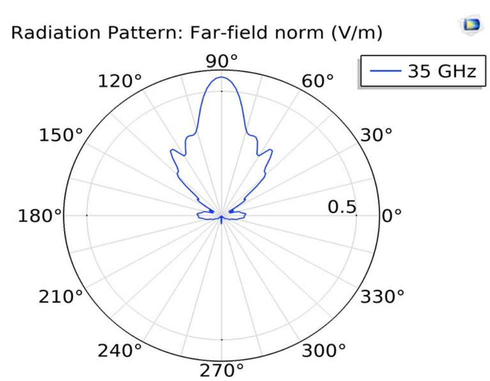

Figure 8: 2D radiation pattern of 2mm probe

The 2D radiation pattern of 3mm probe shows the radiation are Sharpe and wide at Centre, can penetrate more than 0.5mm. Radiation pattern is shape till 0.56mm can be seen in 3D plot. Which is less then 2mm probe.

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2) 3D Radiation Pattern

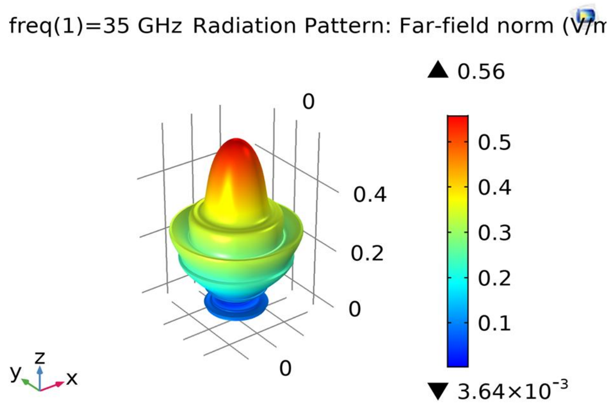

Figure 9: 3D Radiation pattern for 3mm probe

C. 4mm probe

Parameters of the 4mm probe conical antenna are as follows:

1) 2D Radiation Pattern

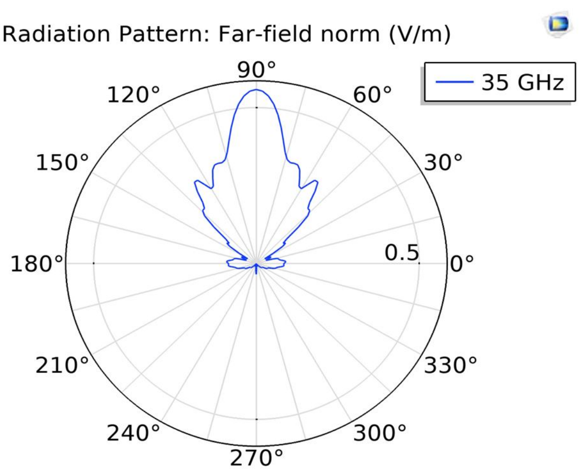

Figure 10: 2D radiation pattern of 4mm probe

The 2D radiation pattern of 4mm probe is almost same as 3mm probe.

2) 3D Radiation Pattern

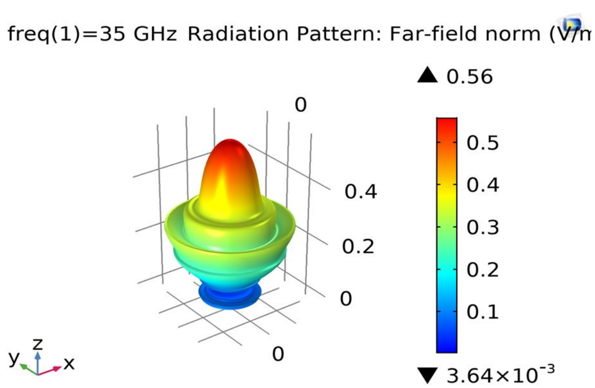

Figure 11: 3D Radiation Pattern

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D. 5mm Probe

Parameters of the 5mm probe conical antenna are as follows:

1) 2D Radiation Pattern

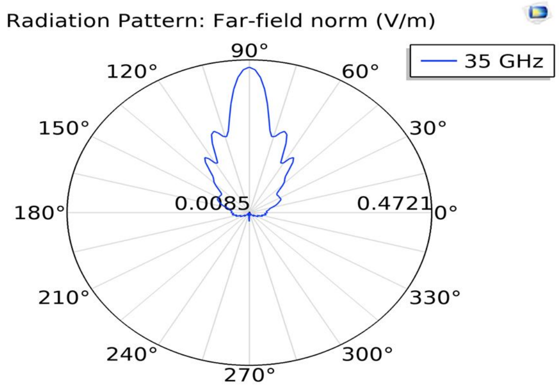

Figure 12: 2D radiation pattern of 5mm probe

The 2D radiation pattern of 5mm probe shows the radiation are not as Sharpe but wide at Centre, can penetrate 0.5mm. Radiation pattern is shape till 0.47mm can be seen in 3D plot. Which is less then 2mm,3mm and 4mm probe but it is wider then all of the other probes.

2) 3D Radiation Pattern

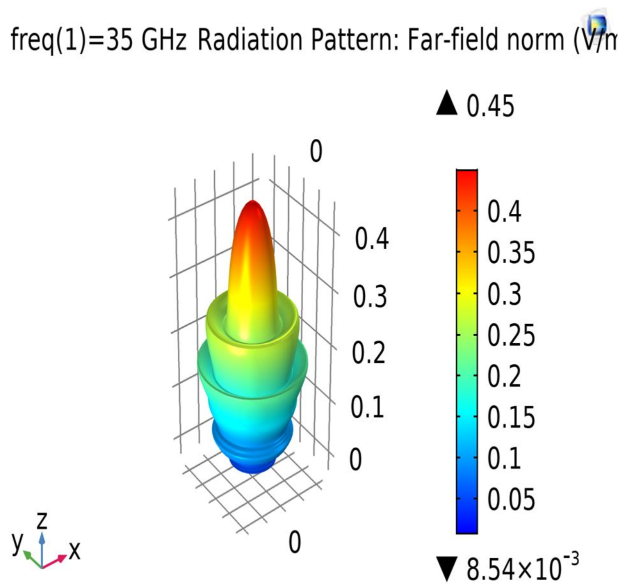

Figure 13: 3D Radiation Pattern 5mm probe

V. CONCLUSION

This model utilizes a low-power (1mW) 35 GHz Ka-band millimeter wave and its reflectivity to moisture for non-invasive cancer diagnosis. Since skin tumors contain more moisture than healthy skin, it leads to stronger reflections on this frequency band. By comparing radiation patterns of all the probes it can be concluded that 2mm conical probe has the sharpest pattern with depth of 0.64mm and is very fine, can be said best probe for deeper penetration of radiations, 3mm and 4mm probe is having depth of 0.56mm and little wider then 2mm probe, if the tumor is not so deep then this size of probes can be used. 5mm probe provide more wider width can cover more area on the surface of the skin but depth of it is very low. It can be concluded that the larger the radius of the probe more width radiation are achieved, if the radius is small the depth of the pattern is very large and can kill tumor till 0.64mm at a very low power of just 1mW.

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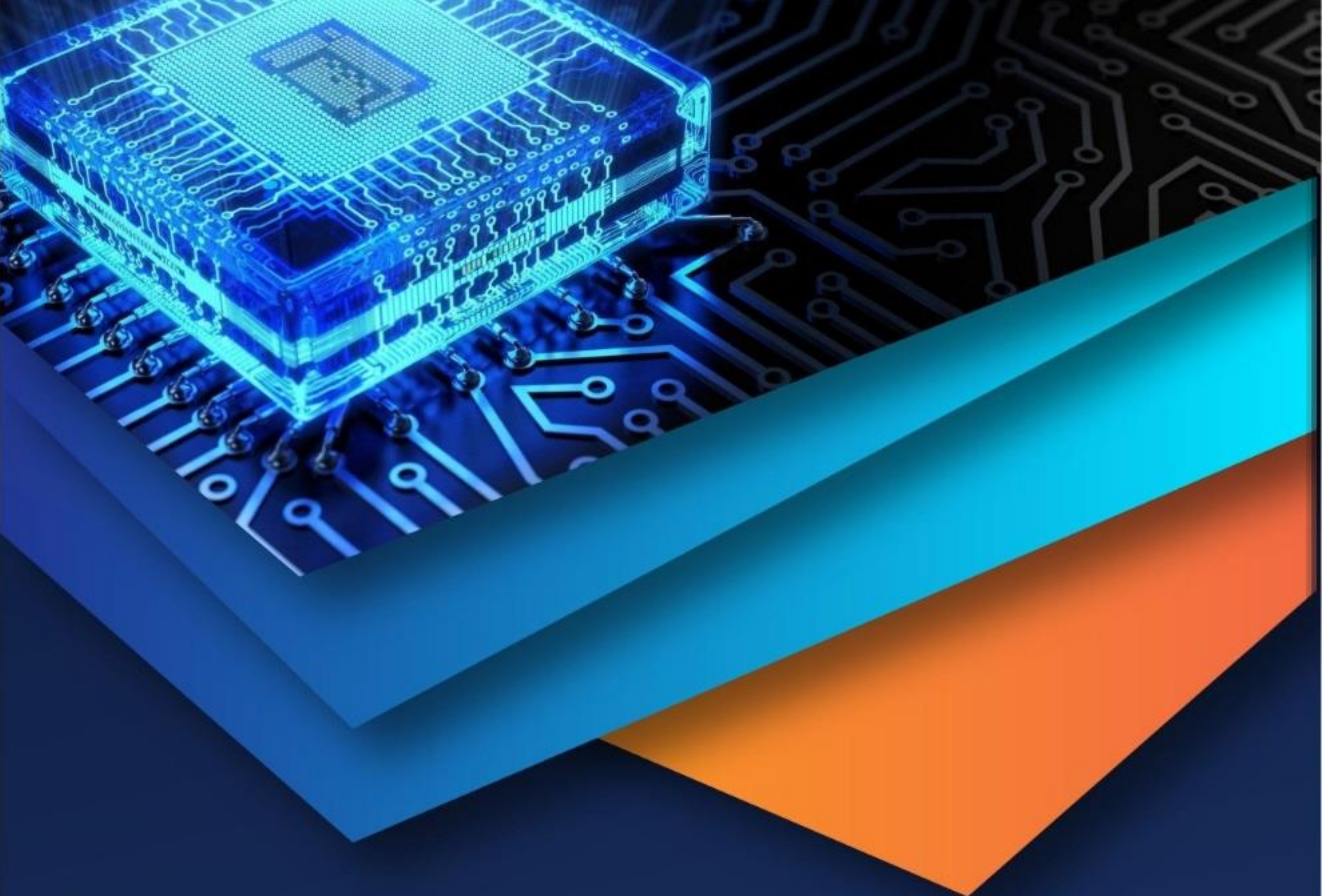

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