*2012 4th International Conference on Bioinformatics and Biomedical Technology*
*IPCBEE vol.29 (2012) © (2012) IACSIT Press, Singapore*

# Finite Element Analysis Approach For Investigation of Breast Cancer Detection Using Microwave Radiation

K. Mathuphhot[1+], A. Sanpanich[1,2], P. Phasukkit[1], S. Tungjitkusolmun[1] and C. Pintavirooj[1]

[1]Faculty of Engineering, King Mongkut's Institute of Technology Ladkrabang, Bangkok, THAILAND.
[2]Biomedical Instrumentation Center, Institute of Molecular Biosciences, Mahidol University, NakhonPathom, THAILAND.

**Abstract.** One of the main problem which threatening health in middle-aged women around the world is breast cancer. Not only a physical painfulnessbut also including her own family and victim relatives who suffering from this unavoidable pity fate.To detect those cancerous tumors as in an earlier stage as possible seem to be the best way to handle with this hazard.Besides from x-rays mammography and a conventional diagnostic ultrasound, microwaveradiation tomography technique is a promising method to investigate any abnormality forming in her mammalian gland. In this paper, we propose a simulation of microwave radiation using a finite element method (FEM)of our modified imaging setup system for female breast cancer diagnosis. By using FEM, we compared a design of antenna with two structure dipoles as a vertical polarization and horizontalpolarization. 900 MHz and 2.45 GHz also performed comparatively in term of wave penetration. The promising results show a propagation of electric field in nonhomogenous breast phantom model and encourage us to develop a real imaging setup system in the future.

**Keywords:** breast cancer detection, microwave radiation, finite element method

## 1. Introduction

Cancerous cell in mammalian gland or breast cancer is one of the major health hazards to woman for a long time ago. This fatal cancer is commonly found in middle-aged women all over the world especially in the western country. This harmful phenomenon in her gland is still increased dramatically every year.Many factors were claimed as an existing cause such as foods, contamination, life style and also unidentified cases. Following with many impacts to a quality of life of her owns and also her relative family [1]. It was known that to detect any abnormality region in an earlier state or in a benign state as soon as possible is the best suitable way to handle with this problem. A conventional method which widely accepts as a gold standard to investigate this threat is X-rays breast compression imaging or a mammography which it is also recommended to perform annually. This technique seems to be an efficient solution, however an implicit risk from an accumulated radiation dose is an unavoidable factfrom this classical manipulation. Furthermore, this investigation is not suitable for young women who her glandular tissue still growing. Diagnosis using conventional B scan ultrasound is also popular and widely usedas a screening test due to its safety and its advantage for soft tissue or living organ imaging. In spite of this, the image obtains from an echo ultrasound or reflecting pulse is only show a shape or boundaries of a reflecting tissue or organ not a local property of it. A quantitative image from this technique is still quite complicating due to lack of physical parameters from their projection data [2,3]. Using microwave radiation is an another effective modality to image breast tissue. The electrical properties as conductivity, permittivity or dielectric parameters of interesting tissue are used to pathologicalidentify between normal breast cell and tumoral tissue through those contrast distribution maps[4].The sensitivity, specificity and ability to detect a small size of malignant tumor encourage this health

[+] Corresponding author. Tel.:
*E-mail address*: kppattar@kmitl.ac.th

examination promising for medical diagnosis purpose.Many researchers try to present their modified detection and imaging setup systems with this alternative microwave imaging [5-8]. Due to a propagation phenomenon of an electromagnetic microwave radiation, a design of radiation antenna probe and also receiver plays an important role in this technique. The interesting works described above were mostly investigated in numerical simulation method as a preliminary implementation firstand then following by real experiment validation.

In this research work, we present apropagation of microwave radiation in simple phantom model of normal breast tissue and breast tissue with tumoral region by using a full 3D finite element method (FEM). The implementation was compared with 2 main designing structures of antenna probe as a vertical polarization shapeand horizontal polarization shapein which placed beside each other as anactive and passiveapplicator. 900 MHz and 2.45 GHz were selected as aradiationmicrowave frequency. The simulation output not only shows a promising result of electric field, magnetic field and vector power flow propagation through the breast tissue phantom model but also encourage us to validate with our experimental setup imaging system in near future.

This paper is presented as following. An introduction and microwave propagation concept is presented in section 1 and 2 respectively. The implementation of finite element method in breast phantom is in section 3. Section 4 is our simulation results while discussion and conclusion is proposed in section 5.

## 2. Microwave Propagation in Breast Tissue Phantom Model

Due to a FEM of RF module, governing equation of microwave propagation in this simulation 3D space geometry is respected asdefinedin (1), the Helmholtz equation for electromagnetic wave.

$$\nabla \times (\mu^{-1} \nabla \times \boldsymbol{E}) - k_0^2 \varepsilon_r \boldsymbol{E} = 0 \tag{1}$$

where $\boldsymbol{E}$ is an electric field $\left(\frac{V}{m}\right)$

$\mu$ is a relative permeability$\left(\frac{H}{m}\right)$

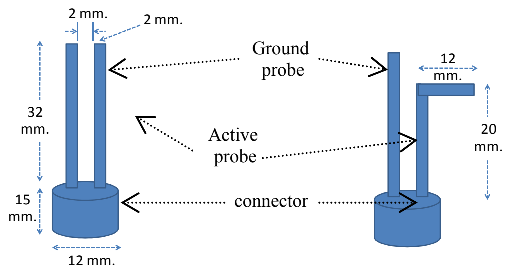
$\varepsilon_r$ is arelative permittivity$\left(\frac{F}{m}\right)$

$k_0$ is a wave number for free space

## 3. Simulation Concept

As a preliminary, female breast phantom model in this investigation is designed as a simple model as possible. Normal breast tissue is modeled as the outer region with dimension about 5×5 centimeters in length and width and 0.5 centimeter in depth. Tumoral cell was located at the center with dimension about 1 centimeter in cubic size. Table I shows two main dielectric properties of breast phantom in this simulation. Permittivity (ε) and conductivity (σ) of normal breast tissue is 9, 0.4 and for tumor is 50, 4 in $F \cdot m^{-1}$ and $S \cdot m^{-1}$unit, respectively [6]. Our preliminary implementations intently focusona radiating antenna design. Two structures of antenna were designed as shown in Fig. 1. One is a vertical polarization structure and another one is in a horizontal polarization structure. These antennas were placed beside each other as an active and passive applicator with a distance between each applicator is about 3 centimeter. Grounding strip probe also fixed laterally to beam direction of electromagnetic wave. These applicators were mounted on a 5×5 centimeters common epoxy board with having SMA 3.5 millimeter type as a connector.In our simulation, this radiating system supposes to attach on breast phantom described above.Figure 2 shows the alignment of both antennas.

Our microwave simulation was performedin 3 cases of antenna alignment as shown in Table II while a radiating frequency is selected as 900 MHz and 2.45 GHz at 2 Watts of ideal output powerwith respect to a specific absorption rate (SAR) and an industrial, scientific and medical (ISM) radio bands. The propagation of electric field, magnetic field and power flow of each case was analyzed by using FEMof COMSOL Multiphysics (version 3.5a)solver in RF module.Basic condition of FEM meshing refinementwas selected as an automatic initial mesh of triangular mesh shape and an amount of mesh was about 15,000-22,000.This simulation was operated on a personal computer with CPU Core Quad 2.50 GHzunder 64 bits Microsoft Window 7 platformand 4 GB of RAM memory.




1(a) Vertical polarization 1(b) Horizontal polarization

Fig. 1: Antennastructure.

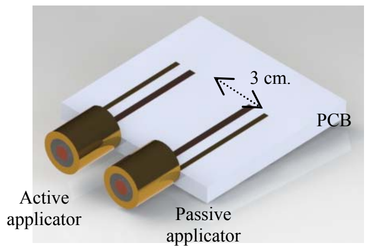



Fig. 2: Antennaconfiguration.

Table 1. Dielectric Properties Of Breast Tissue

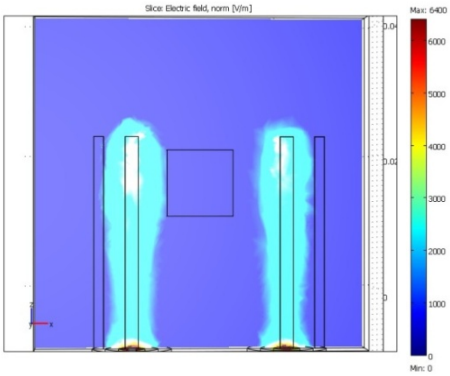
| Tissue | Permittivity,ε $(\frac{F}{m})$ | Conductivity,σ $(\frac{S}{m})$ |
|---|---|---|
| **glandular tissue** | 9 | 0.4 |
| **tumor** | 50 | 4 |

Table 2. Antenna Alignment

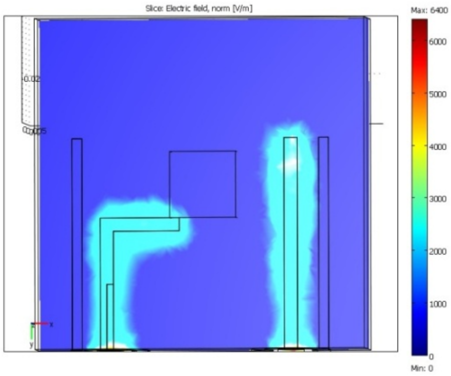
| | Active antenna | Passive antenna |
|---|---|---|
| **case I** | Vertical | Vertical |
| **case II** | Horizontal | Vertical |
| **case III** | Horizontal | Horizontal |

## 4. Simulation Results

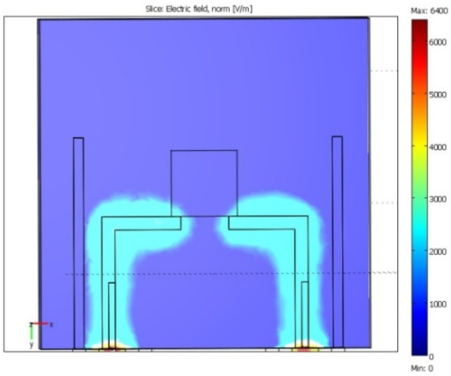
Simulation results of this study are comparatively shown in Fig. 3-6. for frequency 900 MHz, 2.45 GHz and for case I,II,III followingas in Table II.




3(a) vertical-vertical alignment



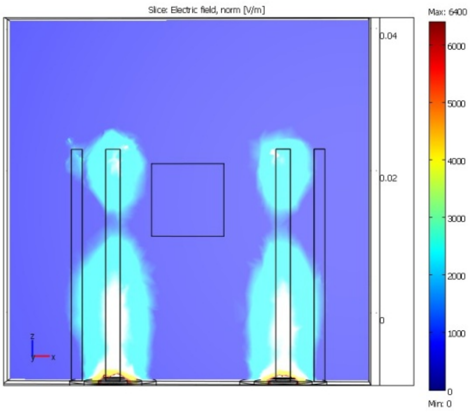

3(b) horizontal-vertical alignment



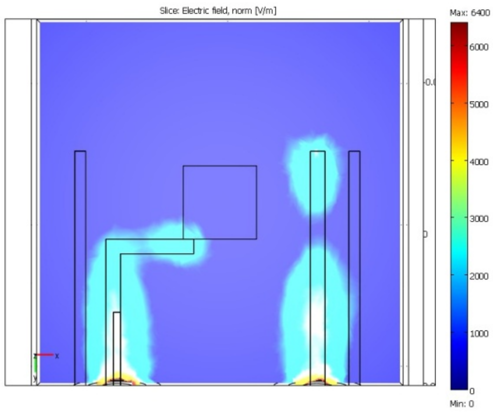

3(c) horizontal-horizontal alignment

Fig. 3: Electric field propagation at 900 MHz frequency in breast phantommodel with tumor region.

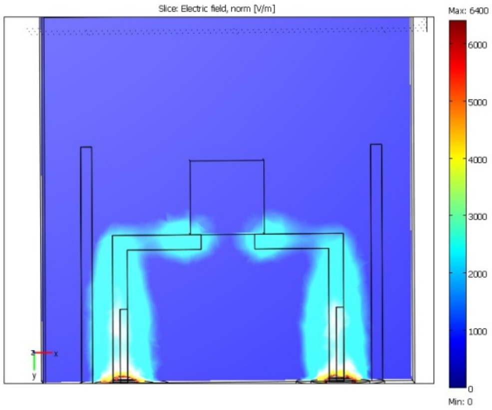
Figure 3 and 4 shows a propagation of electric field in breast phantom with tumor region inside for three antenna alignments at frequency 900 MHz and 2.4 GHz. All these 2D plane propagation images were sliced at half-height position of tumor region.




4(a) vertical-vertical alignment




4(b) horizontal-vertical alignment



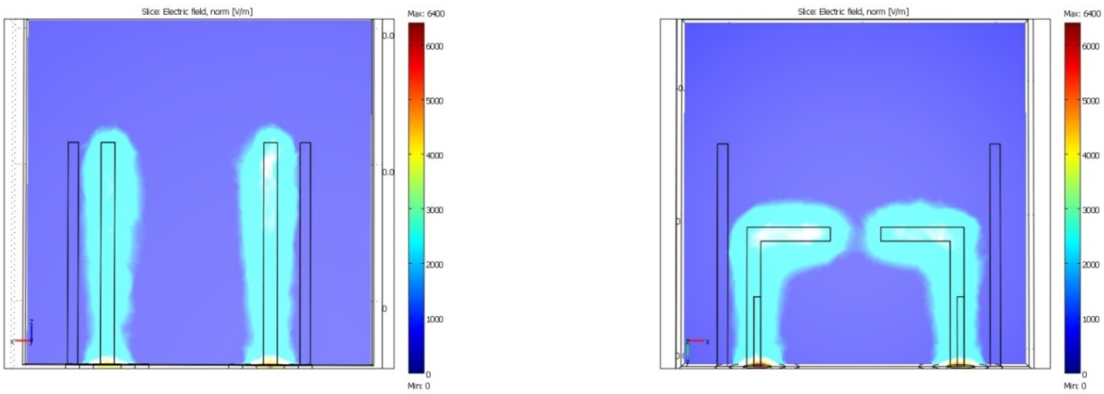

4(c) horizontal-horizontal alignment

Fig. 4: Electric field propagation at 2.45 GHz frequency inbreast phantom model with tumor region.

Figure 5 and 6 shows a propagation of electric field in breast phantom without any tumor region inside for two antenna alignments at frequency 900 MHz and 2.4 GHz.

## 5. Discussion And Conclusion

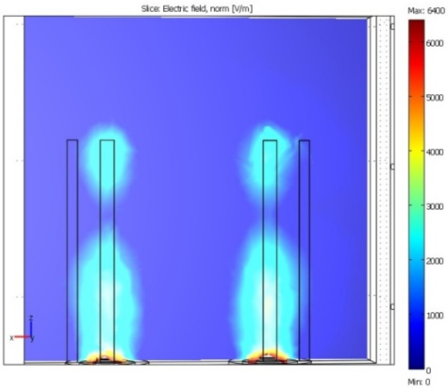
By using FEM, we demonstrate a microwave propagation of electric field into simple breast tissue phantom model. The simulation was compared between two radiation wave frequencies, 900 MHz and 2.45 GHz. Two structures with three configurations of antenna were studied as preliminary investigation in non-homogeneous breast phantom model. The microwave propagation obtained from this simulation provides us a useful pattern for a further implementation. Our long-term target goal is to develop a simple microwave tomography for enhancement in general breast cancer screening detection. The practical scanning image system and also breast phantom model is still modified and developing to verify and evaluate these results in which a real experimental setup system should be performed in near future.



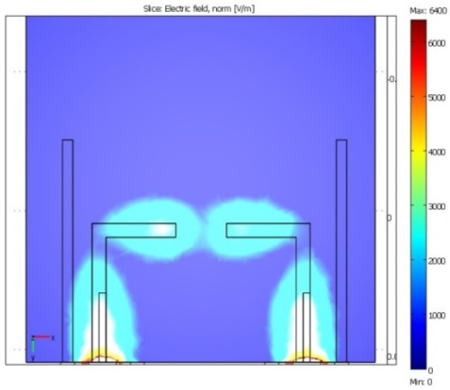

5(a) vertical-vertical alignment

5(b) horizontal-horizontal alignment

Fig. 5: Electric field propagation at 900 MHz frequency in breast phantom model.




6(a) vertical-vertical alignment




6(b) horizontal-horizontal alignment

Fig. 6: Electric field propagation at 2.45 GHz frequency in breast phantom model.

# 6. References

[1] C.M. Sehgal, S.P. Weinstein, P.H. Arger and E.F. Conant, “A Review of Breast Ultrasound”, *J Mammary Gland Biol Neoplasia*, vol.11, pp.113-123, 2006.

[2] C. Kak and M. Slaney, Principles of Computerized Tomographic Imaging. *New York: Institute of Electrical and Electronics Engineers,* 1988.

[3] W.R. Hendee and E. R. Ritenour, “Medical Imaging Physics”, 4th edition, *Wiley-Liss, New York,*2002.

[4] E.C. Fear, P.M. Meaney and M.A. Stuchly, “Microwaves for breast cancer detection?”, *IEEE Potentails,* vol. 22, pp. 12-18, 2003.

[5] V. Zhurbenkok. , “Challenges in the Design of Microwave Imaging Systems for Breast Cancer Detection,” *Adv Electr Comput En,* vol.11, pp.91-96, 2011.

[6] E. C. Fear and M. A. Stuchly, “Microwave Detection of Breast Cancer,” *IEEE T Micro Theory,* vol.48, pp. 1854-1863 ,2000.

[7] X. Xiao and T. Kikkawa, “Study on the Breast Cancer Detection by UWB Breast Cancer Detection*,” ICMMT2008 Proceedings, Nanjing.*

[8] R. Firoozabadi and E. L. Miller, “Finite Element Modeling of Electromagnetic Scattering for Microwave Breast Cancer Detection”*COMSOL Conference 2010, Boston*