View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by Elsevier - Publisher Connector

Available online at www.sciencedirect.com
ScienceDirect
Procedia - Social and Behavioral Sciences 195 (2015) 2905 – 2911
Procedia Social and Behavioral Sciences

World Conference on Technology, Innovation and Entrepreneurship

A Microstrip Patch Antenna Design for Breast Cancer Detection

Rabia Çalışkan[a,*], S. Sinan Gültekin[a], Dilek Uzer[a], Özgür Dündar[b]

[a]*Selcuk University, Faculty of Engineering, Electrical and Electronic Engineering Department, Konya 42250, Turkey*
[b]*Necmettin Erbakan University, Konya 42355, Turkey*

Abstract

Breast cancer affects many women and has fatal conclusions if it does not cure correctly. Early diagnosis is the most important parameter to detect and interfere with cancer tissue. Some of methods for breast cancer detection are X-ray mammography, MRI and ultrasound. However, they have some limitations. For example; between 4 and 34 % of all breast cancers are missed because of poor malignant/benign cancer tissue contrast. Microwave imaging to detect breast cancer is a promising method and there are many works in this area. All materials have different permittivity and conductivity. In this work, a 3D breast structure has different permittivity and conductivity is modelled in HFSS by using Finite Element Method (FEM) to solve electromagnetic field values and a microstrip patch antenna operating at 2.45 GHz is designed and substrate material is FR4 ($\varepsilon_r = 4.4$ F/m). Slotting on microstrip patch and modifying ground plane, imaging quality is increased. About this, electric field, magnetic field distribution and current density on the antenna are evaluated.

© 2015 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
Peer-review under responsibility of Istanbul Univeristy.

Keywords: Microstrip patch antenna, breast cancer, cancer detection, HFSS ;

1. Introduction

In according to cancer incidence statistics in 2012, 14.1 million people were diagnosed with cancer worldwide and 8.2 million people died from cancer. In Turkey, 97.000 men, 62.000 women and overall 159.000 people were diagnosed with cancer every year (Turkey Public Health Agency, 2012). There are many factors to affect this such as life-style, foods, contamination, stress and undefined things. Breast cancer type is the most common cancer type

* Corresponding author. Tel.: +90 0332 223 21 70 fax:+90 332 241 06 35.
E-mail address: rabiacaliskan@selcuk.edu.tr

1877-0428 © 2015 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
Peer-review under responsibility of Istanbul Univeristy.
doi:10.1016/j.sbspro.2015.06.418

among women. A lot of women suffer from this disease in the worldwide and have many unreturned problems because of not to diagnose early. The most important process before healing is early diagnosis. Early diagnosis has vital importance is reason to return life for many sufferers.

There are many methods to detect breast cancer such as X-ray mammography, ultrasound, tomography and MRI. However, they have some negative and undesired sides. Especially for younger women, these methods are not preferred because of ionized radiation. So, microwave imaging techniques are developed. Microwave imaging method for early diagnosis is rather interested and promising. Microwave imaging has more advantages such as low cost, more safety and easier availability. The working principle of microwave imaging techniques is based on the dielectric contrast between the malignant tumor tissues and the healthy ones (Wang & Huang, 2012). The electrical properties as conductivity, permittivity or dielectric parameters of interesting tissue are used to pathological identify between normal breast cell and malignant tumor tissue through those contrast distribution maps (Sanpanich, Phasukkit, Tungjitkusolmun, & Pintavirooj, 2011). The basic idea of using microwave imaging system for breast cancer detection is to transmit electromagnetic waves from a transmitting antenna to the breast and receive the scattered waves at a receiving antenna (Mahalakshmi & Jeyakumar, 2012). Differences between electric field and magnetic field are important to identify cancerous tissue's position and volume etc. Thus, antenna choice plays an important role. Although there are several antenna kinds like horn, dipole, monopole etc., micro strip antenna has more advantages such as small structure, low cost, lightness and availability. To predict and optimize a radiating pattern of electromagnetic wave emitted from each antenna into tissue volume still be a key factor in microwave antenna system design especially both 2D plane and 3D space (Sanpanich, Phasukkit, Tungjitkusolmun, & Pintavirooj, 2011). There are lots of works for breast cancer detection about microwave imaging in literature. A study was investigated to detect breast cancer about microwave imaging (Sanpanich, Phasukkit, Tungjitkusolmun, & Pintavirooj, 2011). To detect cancerous breast tissue, (Wang & Huang, 2012) designed a MIMO antenna structure and evaluated microwave imaging results. To obtain microwave imaging by radiating into breast tissue, a single layer micro strip patch antenna structure was designed (Mahalakshmi & Jeyakumar, 2012).

In this paper, inset fed antenna structure as a rectangular microstrip patch antenna is used for the purpose of microwave imaging over detecting cancerous tissue into breast structure and so, a simple 3D breast structure is modelled to define cancerous tissue. 3D breast structure is designed by inspiring from the reference (Sanpanich, Phasukkit, Tungjitkusolmun, & Pintavirooj, 2011). All simulations are implemented in HFSS by using Finite Element Method (FEM). ISM band which is used commonly is preferred for investigation. In this work, better simulation results are obtained by modifying ground plane and slotting on microstrip patch. The antenna structure operating at 2.45 GHz is placed under breast skin and differences between electromagnetic field values according to simulations results are evaluated via graphics. Section 2 explains basic antenna design, section 4 and 5 explain simulation & results and conclusion, respectively.

2. Basic Breast Structure

Female breast structure in this work is modelled as a basic breast structure which is shown in Fig. 1. The dimensions of normal breast tissue are selected as "65.4x88.99x80 mm^{3}". The dimensions of breast skin are selected as "65.4x88.99x1 mm^{3}" and breast skin is placed under the normal breast tissue. Cancerous breast tissue is modelled as a spherical structure and is placed into the normal breast tissue. Its radius is selected 20 mm for simulations. In general, an interaction of microwave propagation in body living tissue concerned with an electrical field is respected to two main dielectric properties as permittivity (ε) and conductivity (σ) (Sanpanich, Phasukkit, Tungjitkusolmun, & Pintavirooj, 2011). Permittivity and conductivity change from materials to materials and these changes are used to evaluate electric field and magnetic field values in the different structures. Structures have different permittivity and conductivity values have different electromagnetic field values. This parameter plays an important role to detect cancerous tissue. Table 1 shows that permittivity and conductivity values of basic breast structure (Sanpanich, Phasukkit, Tungjitkusolmun, & Pintavirooj, 2011). Permittivity and conductivity values of cancerous breast tissue are 50 (F/m) and 4 (S/m) while permittivity and conductivity values of normal breast tissue are 9 (F/m) and 0.4 (S/m), respectively.

3. Basic Antenna Design

In this work, inset fed antenna structure as a rectangular microstrip patch antenna is used. Fig. 2. shows proposed antenna structure and the names of its dimensions. FR4 (ε_r = 4.4 F/m) is used as substrate material. Substrate dimension x is 65.4 mm, y is 88.99 mm and substrate thickness is 1.588 mm. Patch dimension x is 37.26 mm, y is 28.83 mm. Inset distance and inset gap are 9.574 mm and 1.518 mm, respectively. Feed length is 27.958 mm and feed width is 3.036 mm. The proposed antenna is placed under the breast structure, which is shown in Fig. 3. According to design in Fig. 3., simulations are implemented.

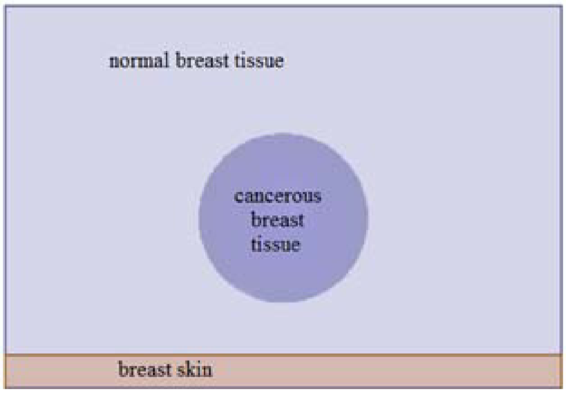

Fig. 1. basic 3D breast structure

Table 1. Dielectric and conductivity values of breast tissue

Tissue type	Dielectric (ε)	Conductivity(σ)
Normal breast tissue	9	0.4
Breast skin	36	4
Cancerous breast skin	50	4

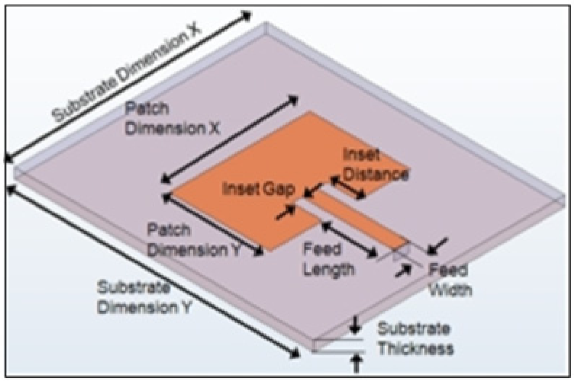

Fig. 2. proposed antenna structure

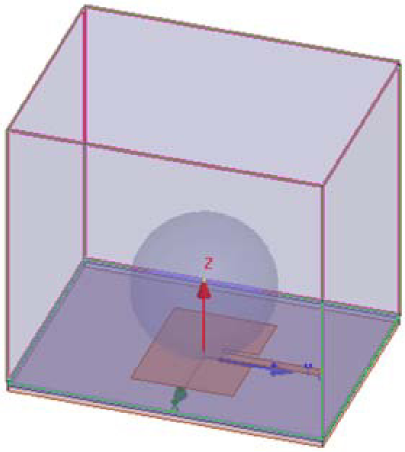

Fig. 3. design with proposed antenna and breast structure

4. Simulation & Results

In this work, by investigating electromagnetic field values over the breast tissue with tumor and without tumor, evaluations are presented. There are total five antenna structures, by modifying ground plane and slotting on microstrip patch. As shown in Fig. 3., for each antenna structure, breast tissue with tumor and without tumor is simulated. Table 2 shows electric field, magnetic field and current density maximum values into the breast tissue of simulation results. Depending on each theta angle that varies from -180° to 180° for phi = 0°, data table of radiation pattern about electric field values into breast structure with tumor and without tumor is obtained. The values are used to obtain graphics. The graphics are evaluated to detect tumor.

Fig. 4. (a) shows the first antenna structure that has no parameter changes. Fig. 4. (b) shows graphic which presents differences between electric field values into breast tissue with tumor and without tumor. Red line on the graphic represents electric field values into breast structure without tumor. Blue line on the graphic represents electric field values into breast structure with tumor. Differences between electric field values as breast tissue with tumor and without tumor are rather important. Circles on the graphic indicate clear differences between simulation results with tumor and without tumor.

Fig. 5. (a) shows the second antenna structure which has modified ground plane. Dimensions of modified ground plane are 65.4 mm for x axis and 48 mm for y axis. New ground plane is placed underneath microstrip patch exactly. Fig. 5. (b) shows graphic that presents differences between electric field values into breast tissue with tumor and without tumor. As shown in the graphic, changes of electric field values pointed out with circles are important factor to determine incidence of tumor.

Fig. 6. (a) shows the third antenna structure that has the same modified ground plane and a rectangular slot on microstrip patch. Dimensions of the rectangular slot are 17.26 mm for x axis and 11.256 mm for y axis. Position of the slot is determined by getting 10 mm distance both right and left of patch for x axis and for y axis 4 mm distance both top and bottom of patch. Fig. 6. (b) shows graphic that presents differences between electric field values into breast tissue with tumor and without tumor. Circles on the graphic point alterations between electric field values and this is an important situation to decide whether there is tumor into breast tissue or.

Fig. 7. (a) shows the fourth antenna structure which has the same modified ground plane and a I-shape slot on microstrip patch. Dimensions of I-shape slot are 17.26 mm for x axis and 1.256 mm for y axis. Position of the slot is selected by getting 10 mm distance both right and left of patch for x axis and for y axis 9 mm distance both top and

bottom of patch. Fig. 7. (b) shows graphic that presents differences between electric field values into breast tissue with tumor and without tumor. As shown in the graphic, differences between electric field values remarked with circles are important key role to decide incidence of tumor.

Fig. 8. (a) shows the fifth antenna structure that is designed by slotting on the same modified ground plane. Dimensions of rectangular slot are 6.072 mm for x axis and 9.574 mm for y axis. Position of the slot is determined to work out at inset distances. Fig. 8. (b) shows graphic that presents differences between electric field values into breast tissue with tumor and without tumor. Differences between electric field values are indicated to draw circles.

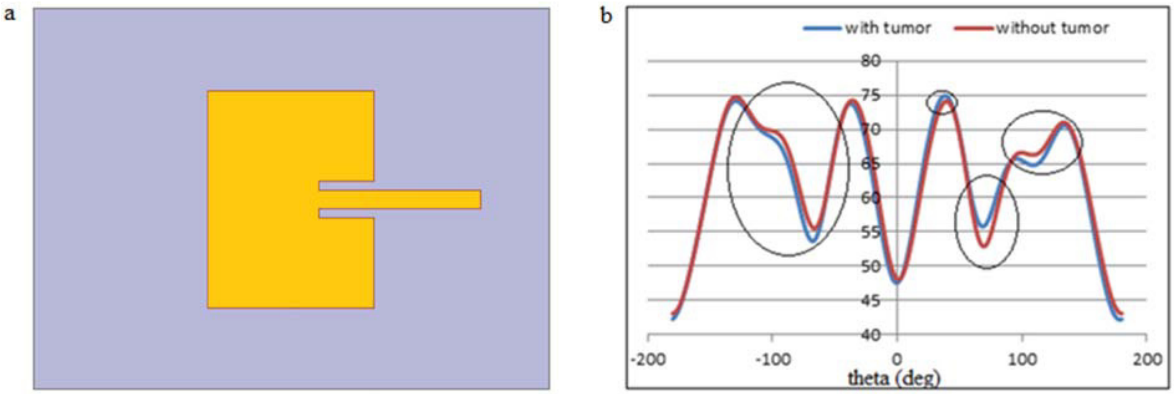

Fig. 4. (a) first antenna structure;
(b) graphic of electric field distribution between breast tissue with tumor and without tumor

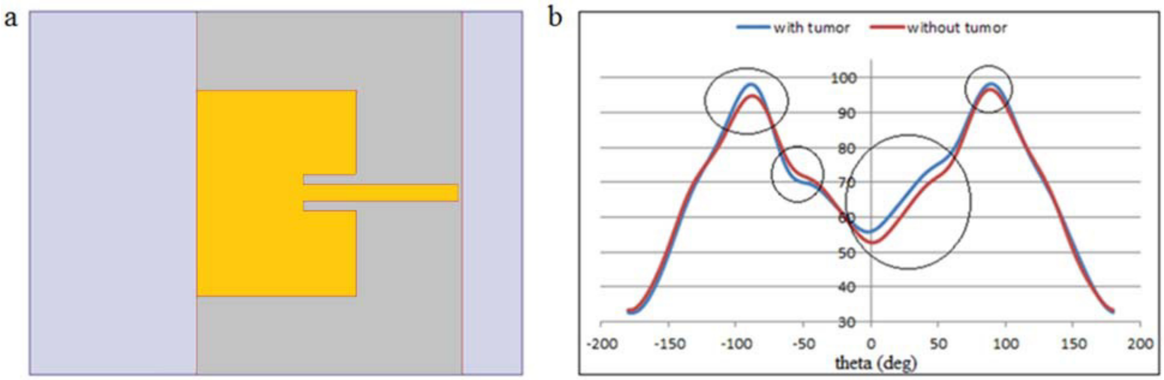

Fig. 5. (a) second antenna structure (modified ground plane);
(b) graphic of electric field distribution between breast tissue with tumor and without tumor

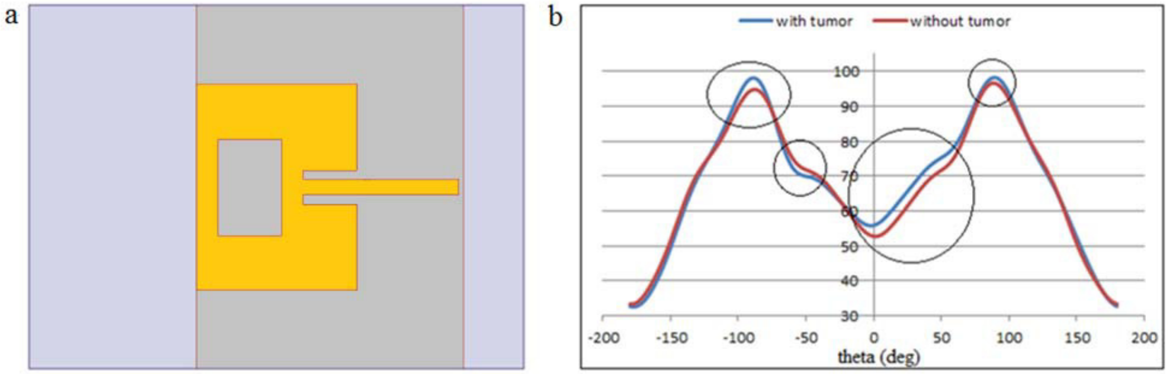

Fig. 6. (a) third antenna structure (modified ground plane);
(b) graphic of electric field distribution between breast tissue with tumor and without tumor

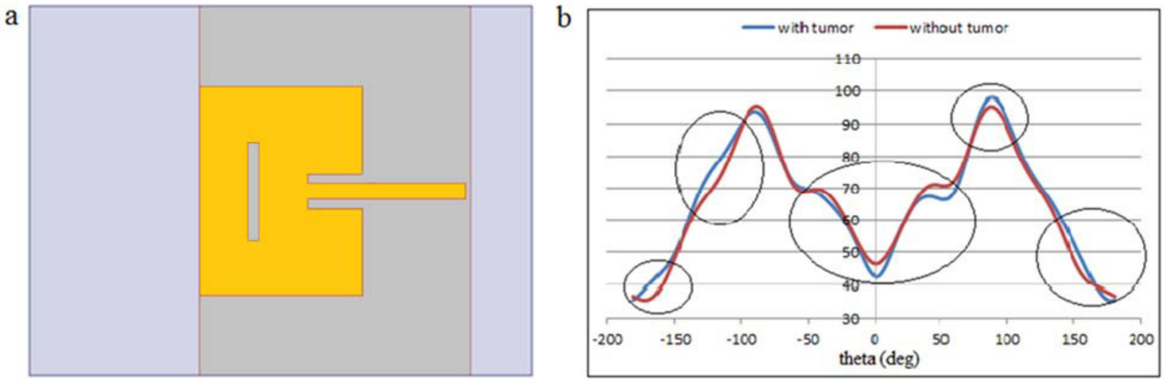

Fig. 7. (a) fourth antenna structure (modified ground plane);
(b) electric field distribution graphic between breast tissue with tumor and without tumor

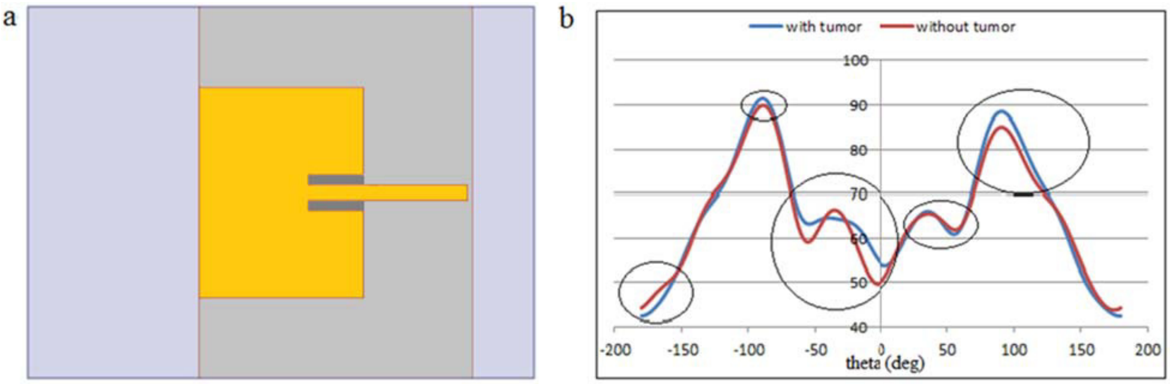

Fig. 8. (a) fifth antenna structure (modified ground plane);
(b) graphic of electric field distribution between breast tissue with tumor and without tumor

Table 2. Obtained electric field, magnetic field and current density values according to each antenna structure

Antenna Structure Name	Max E Field	(V/m)	Max H Field	(A/m)	Max J	(A/m^2)
	With tumor	Without tumor	With tumor	Without tumor	With tumor	Without tumor
First	215.52	216.46	0.88393	0.87558	86.208	86.582
Second	168.87	169.43	0.7916	0.78838	67.547	67.774
Third	156.57	154.02	0.81422	0.83469	62.629	61.606
Fourth	**137.36**	**170.38**	**0.786**	**0.84634**	**54.946**	**68.15**
Fifth	165.04	154.56	0.76633	0.78827	66.017	61.825

Table 2 shows electric field, magnetic field and current density maximum values for each antenna structure designed as with tumor and without tumor. Differences between values of breast structure with tumor and without tumor are clearly shown in Table 2. As the antenna structure changes, electromagnetic field values into breast structure have certain alterations. Considering these alternations, incidence of tumor in the breast structure can be detected. Also, changes between results obtained highly increase together with exchanging antenna structures.

5. Conclusion

In this paper, it is studied that inset fed rectangular microstrip antenna structures are investigated to provide microwave imaging with a view to diagnose breast cancer early. The antenna structure operating at 2.45 GHz are simulated with basic 3D breast structure. Different antenna designs are evaluated by modifying ground plane and slotting on microstrip patch. Conclusion of work, for the fourth antenna structure, electric field, magnetic field and current density values in the situation of breast structure with tumor are 137.36 V/m, 0.786 A/m ve 54.946 A/m^2 respectively, while the values in the situation of breast structure without tumor 170.38 V/m, 0.84634 A/m ve 68.15 A/m^2, respectively.

It can be said that this work obtains better results when compared to works in literature. Depending on simulation results and graphical observation, the fourth antenna structure provides the best detection for breast cancer.

References

Mahalakshmi, N., & Jeyakumar, V. (2012, July). Design and development of single layer microstrip patch antenna for breast cancer detection. *Bonfring International Journal of Research in Communication Engineering*, 14-18.

Sanpanich, A., Phasukkit, P., Tungjitkusolmun, S., & Pintavirooj, C. (2011). Basic investigation of breast cancer detection in early stage using Microwave Radiation: Finite Element Analysis Approach. *The 2011 Biomedical Engineering International Conference (BMEiCON-2011)*, (s. 212-125).

Singh, P. K., Tripathi, S. K., Sharma, R., & Kumar, A. (2013). Design & simulation of microstrip antenna for cancer diagnosis. *International Journal of Scientific & Engineering Research*, 1821-1824.

Y, M., & Jeyanthi, D. (2014, March). Design of a novel microstrip patch antenna for microwave imaging systems. *International Journal of Engineering and Technical Research (IJETR)*, 119-123.

Zhang, H., El-Rayis, A., Haridas, N., Noordin, N., Erdogan, A., & Arslan, T. (2011). A smart antenna array for brain cancer detection. *2011 Loughborough Antennas & Propagation Conference*, (s. 1-4). Loughborough.

Karlı, R., & Ammor, H. (2014, May). Miniaturized UWB microstrip antenna with T-slot for detecting malignant tumors by microwave imaging. *INTERNATIONAL JOURNAL OF MICROWAVE AND OPTICAL TECHNOLOGY*, 214-220.

Klemm, M., Craddock, I., Preece, A., & Leender, J. (2008). Evaluation of a hemi-spherical wideband antenna array for breast cancer imaging. *RADIO SCIENCE*, 1-15.

Wang, L., & Huang, B. (2012). Design of Ultra-Wideband MIMO antenna for breast tumor detection. *International Journal of Antennas and Propagation* , 1-7.

Turkey Public Health Agency. (2012). Ministry of Health: http://kanser.gov.tr/Dosya/ca_istatistik/Turkiye_Kanser_istatistikleri.pdf is obtained.

(2012). Cancer Research UK: http://www.cancerresearchuk.org/ is obtained.