2011 International Conference on Biomedical Engineering and Technology
IPCBEE vol.11 (2011) © (2011) IACSIT Press, Singapore

Real-time monitoring Glucose by used Microwave Antenna apply to Biosensor

Sujitra Wiwatwithaya, Pattarapong Phasukkit+, Supan Tungjitkusolmun, Manas Sangworasilp and Chuchart Pintuviroj

Faculty of Engineering, King Mongkut's Institute of Technology Ladkrabang, Bangkok 10520, Thailand

Abstract. In this paper we investigate the electromagnetic field interaction with a glucose aqueous solution using a microwave antenna (U-shape) to evaluate the glucose concentration and vary temperature. The glucose concentration vary from 10-40 mg/ml compare with DI(de-ionized) water, the operating frequency of about 1-2.5GHz. The change of the glucose concentration is directly related to the change of the reflection coefficient due to electromagnetic interaction between the dielectric wave and the glucose aqueous solution. A glucose biosensor using microwave antenna(U-shape) provides a unique approach for glucose monitoring.

Keywords: Biosensor, microwave antenna, Finite Element Method .

1. Introduction

Glucose monitoring biosensors are devices used in clinical monitoring, biological research and in the food processing industry [1–6]. Glucose biosensors have been applied to a wide variety of analytical problems in medicine, drug discovery, the environment, food, security and defense. The potential growth in the world glucose biosensor industry is remarkable. Aqueous glucose solutions play a fundamental role in many chemical processes in a variety of chemical and biological systems. Sensitive monitoring for glucose concentration in water may become a useful tool for studying biological properties. Most sensors are based on electrochemical principles and employ enzymes for molecular recognition. The amperometric enzymatic principle is still of interest to many researchers because of its high selectivity to glucose. Amperometric enzyme electrodes hold a leading position among present glucose biosensor systems and have already found a large commercial market. [14]Glucose biosensors have taken several other forms, based on electrochemical, optical, piezoelectrical, thermal or mechanical principles [7–12].Recently, a number of mechanically based glucose biosensors based on the cantilever platform, have been demonstrated and found to respond specifically to the correct analyze over a wide concentration range. Commercial development of these devices has allowed measurement of glucose concentration with sufficient accuracy for some applications. However, the device is largely limited to monitoring patterns and trends and is invasive.Techniques with high sensitivity and efficiency for the detection of glucose concentration using a noninvasive technology are therefore of importance in biosensor construction. In order to better characterize the concentration of glucose concentration, we take advantage of the noninvasive evaluation capabilities of near-field interaction techniques using a microwave waveguide resonator biosensor [13–17]. An important ability of the microwave waveguide resonator biosensor is a new physical approach to noninvasive characterization of glucose aqueous solutions.

In this paper, we monitor the glucose concentration using a microwave dielectric resonator technique. The glucose biosensor operating frequency of about f = 1.9 GHz. The changes of glucose solution permittivity due to a change of concentration of the glucose were investigated by measuring the reflection

+ Corresponding author. Tel.: + 66-23264334
E-mail address: kppattar@kmitl.ac.th

coefficient return loss of the antenna. The change of the glucose concentration is directly related to the change of the reflection coefficient due the glucose solution.

2. Method

In this paper we develop antenna by used CNC machine to make strip antenna and application from PCB(Print Circuit Board) to made antenna like U-shape that open gap at the end of antenna

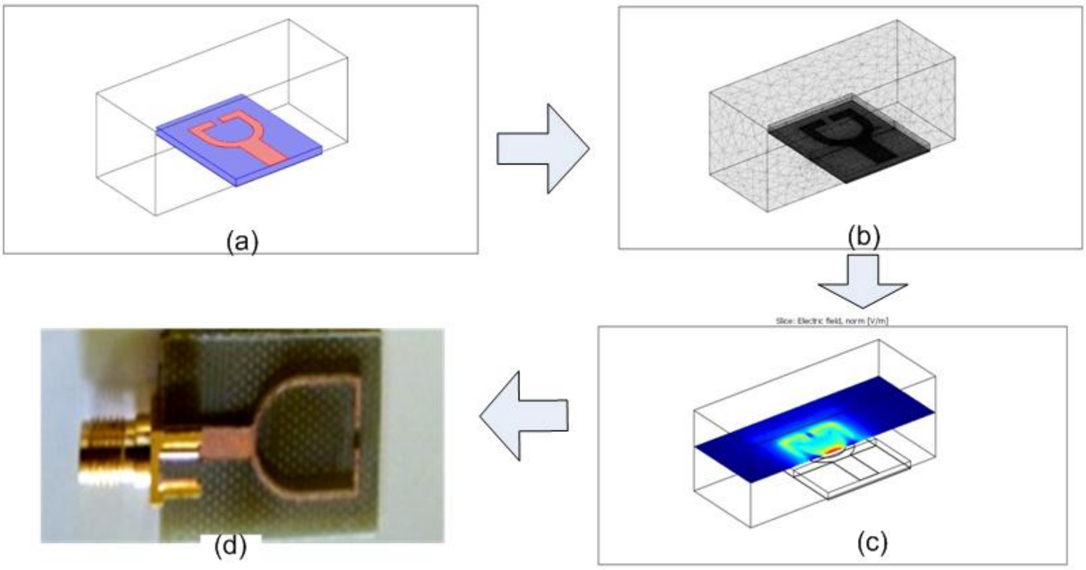

Fig.1 (a) CAD of U-shape antenna with glucose (b) Mesh of antenna with glucose (c)FEM simulation(E -field) (d) Real antenna

In figure show antenna structure that made by machine (CNC) we set resolution to high for made antenna that had dimension equal CAD drawing.

2.1. Theoretical background

In this paper we used were return loss for present maximum power transfer between antenna with glucose thus important parameter for measuring is return loss Return loss is a measure of VSWR (Voltage Standing Wave Ratio), expressed in decibels (db). The return-loss is caused due to impedance mismatch between two or more circuits And Reflection co-efficient equation present is

$$\Gamma = \left|\frac{1-VSWR}{1+VSWR}\right| \qquad (1)$$

Γ is the reflection coefficient that relate with complex impedance of antenna and complex impedance of media (substrate/glucose aqueous solution/air) that not present in this paper . In general the reflection coefficient present in term of dB(decibel) it can be written as

$$RL = -20\log|\Gamma| \qquad (2)$$

In this paper we show result of reflection coefficient is RL (return loss) by change glucose concentrations

2.2. Experiment set up

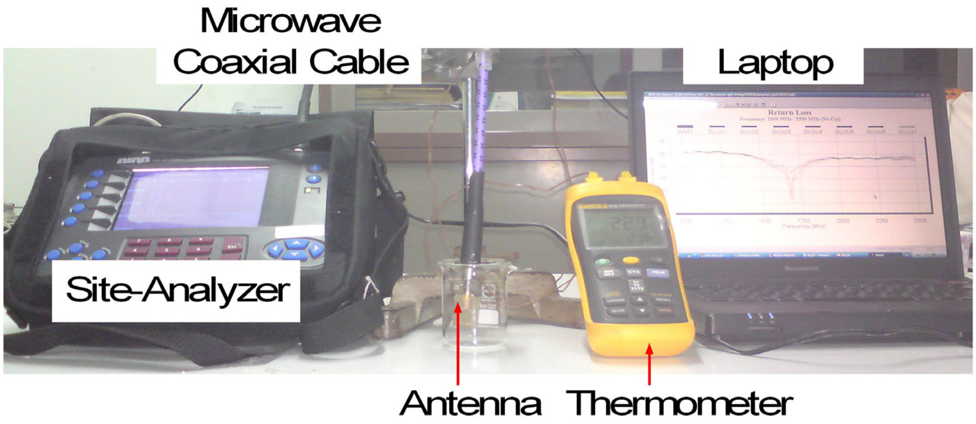

Fig. 2 Experimental set up

In Fig.2 show experiment set up system for experiment .Measurement of coefficient by used Site Analyzer (Brad Bird model SA600EX) connected with low loss coaxial cable, connector is N-type (measurement side) and SMA(3.5mm) male with antenna .Recording the result by Laptop connect via rs232 cable that had adapter convert rs232 to USB at the end ,this experiment we used thermometer monitor temperature (Fluke 54II)

2.3. Result

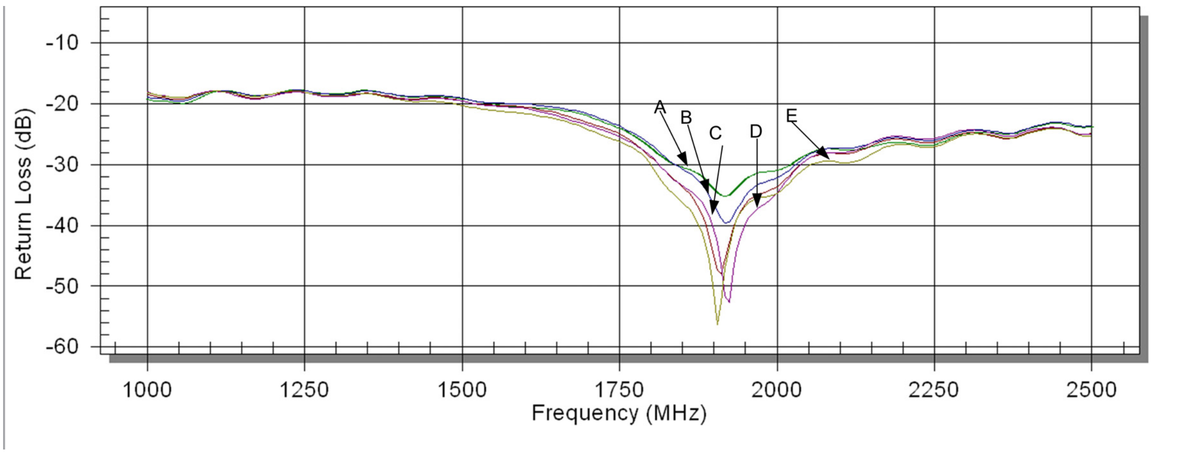

Fig.3 Measured Reflection coefficient (Return loss) A. DI water and different glucose concentrations: B. 10, C. 20, D.30 , E.40 mg/ml with glucose solution volume 40 ml.

In Fig.3 the level of reflection coefficient(return loss) related with glucose concentrates from the result that glucose that 40 mg/ml concentrations to get minimum value of return loss , thus it mean are the have maximum power transfer between antenna with glucose liquid and had little resonance frequency shipped (about 50Mhz)

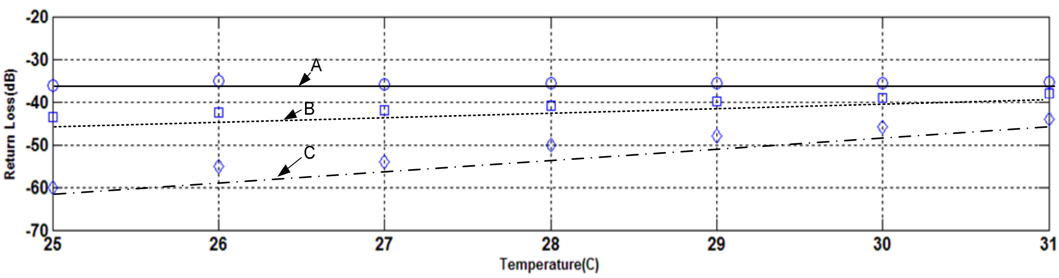

Fig.4 Measured Reflection coefficient (Return loss) dependences on temperature for glucose concentrations of A. DI water and different glucose concentrations: B. 10 and C.40 mg/ml with glucose solution volume 40 ml.

In Fig.4 Show the effect of temperature when used different glucose concentrations, from the result the value of return loss(RL) can be write in continues line for DI water the value of return loss(RL) is a little different when temperature change. When increased glucose concentration slope of line will increase related with glucose concentration.

Field distribution, In this paper we used finite element method(FEM) to computation electromagnetic distribution (Electric filed) in glucose the procedure to simulation electric filed in glucose that radiation from antenna by used Hi-end software (COMSOL Multiphysic v3.5a) ,as show in Fig.5, As the glucose concentration increased, the relative permittivity was increased .Insertion dept about 14.5 mm that optimum to clear the result for read.

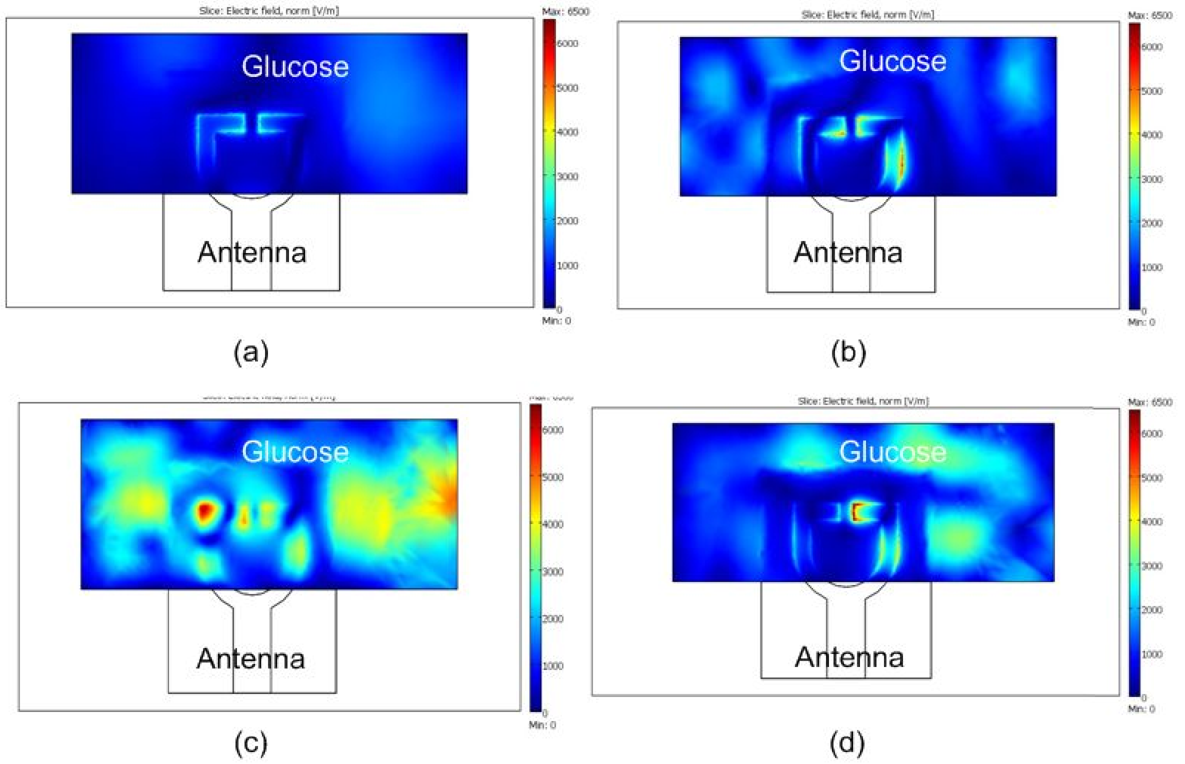

Fig.5 FEM simulation of electromagnetic field interaction between antenna(U-shape) and (a) DI water ,(b) 10 mg/ml (c) 20mg/ml and (d) 40 mg/ml glucose aqueous solutions

In Fig.5 show electromagnetic field interaction between antenna and DI water, glucose concentrations (10,20 and 40 mg/ml) that result present in color dark red for electric field high value and dark blue for electric field low value. For Di water had electric field distribution lowest when increased level of concentrations of glucose level of electric filed distribution will increased , thus electric field distribution related with glucose concentrations.

3. Conclusion

We demonstrated the measurement of aqueous glucose concentration using microwave antenna (U-Shape). The reflection coefficient (RL) is very sensitive to the concentration of glucose. These results clearly show sensitivity and usefulness of this microwave antenna for glucose biosensor.

4. References

[1] J. Wang, Electroanalysis 13 (2001) 983.

[2] N. Forrow, S. Bayliff, Biosens. Bioelectron. 21 (2005) 581.

[3] J. Homola, Anal. Bioanal. Chem. 377 (2003) 528.

[4] J. Newman, A. Turner, Biosens. Bioelectron. 20 (2005) 2435.

[5] A. Heller, Annu. Rev. Biomed. Eng. 1 (1999) 153.

[6] P. Leonard, S. Hearty, J. Brennan, L. Dunne, J. Quinn, T. Chakraborty, R. O'Kennedy, Enzyme Microb. Technol. 32 (2003) 3.

[7] J. McKee, B. Johnson, IEEE Trans. Inst. Meas. 49 (2000) 114.

[8] B. Choudhry, R. Shinar, J. Shinar, J. Appl. Phys. 96 (2004) 2949.

[9] A. Sharma, S. Annapoorni, B. Malhotra, Curr. Appl. Phys. 3 (2003) 239.

[10] A. Caduff, E. Hirt, Yu. Feldman, Z. Ali, L. Heinemann, Biosens. Bioelectron. 19 (2003) 209.

[11] A. Tura, S. Sbrignadello, S. Barison, S. Conti, G. Pacini, Biophys. Chem. 129 (2007) 235.

[12] F. Yin, K. Ryu, H. Shin, Y. Kwon, Curr. Appl. Phys. 7 (2007) 490.

[13] A. Subramanian, P. Oden, S. Kennel, K. Jacobson, R. Warmack, T. Thundat, M. Doktycz, Appl. Phys. Lett. 81 (2002) 385.

[14] M. Abu-Teir, M. Golosovsky, D. Davidov, A. Frenkel, H. Goldberg, Rev. Sci. Instrum. 72 (2001) 2073.

[15] B. Friedman, M. Gaspar, S. Kalachikov, K. Lee, R. Levicky, G. Shen, H. Yoo, J. Am. Chem. Soc. 127 (2005) 9666.

[16] A. Babajanyan, J. Kim, S. Kim, K. Lee, B. Friedman, Appl. Phys. Lett. 89 (2006) 183504.

[17] M. Tabib-Azar, J. Katz, S. Le Clair, IEEE Trans. Inst. Meas. 48 (1999) 1111.

[18] D. Pozar, Microwave Engineering, Addison-Wesley, New York, 1990, p. 65.

[19] W. Arnold, IEEE Trans. Ind. Appl. 37 (2001) 1468.

[20] D. Lide, Handbook of Chemistry and Physics, CRC Press, New York, 2004, pp. 6–16.