



Faculty of Electronic & Computer Engineering

**A NEW TECHNIQUE TO DESIGN COATING STRUCTURE FOR
ENERGY SAVING GLASS USING THE GENETIC ALGORITHM**

Farah Ayuni Binti Azmin

Master of Science in Electronic Engineering

2016

**A NEW TECHNIQUE TO DESIGN COATING STRUCTURE FOR ENERGY
SAVING GLASS USING THE GENETIC ALGORITHM**

FARAH AYUNI BINTI AZMIN

**A thesis submitted
in fulfillment of the requirements for the degree of Master of Science in Electronic
Engineering**

Faculty of Electronic & Computer Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2016

DECLARATION

I declare that this thesis entitled “A New Technique to Design Coating Structure for Energy Saving Glass Using the Genetic Algorithm” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :.....

Name :.....

Date :.....

APPROVAL

I hereby declare that I have read this thesis and my opinion this thesis is sufficient in term of scope and quality for the award of Master of Science in Electronic Engineering.

Signature :

Supervisor Name :

Date :

DEDICATION

To my beloved husband, mother and father, mother and father-in-law, and Sofea Azzahra.

ABSTRACT

Energy saving glass is a specially coated glass with metallic-oxide coating that helps save energy by reflecting heat from the sun in the infrared region. Properties of an energy saving glass reflect the heat of infrared radiation while allowing visible white light to pass through the glass. Due to the presence of this metallic coating, some amount of useful radio frequency (RF) or microwave signals are attenuated. Magnitude for some wireless communication signals such as mobile phones (GSM, UMTS and 3G), global positioning system (GPS), wireless network (Wi-Fi), wireless broadband (WiMAX, LTE) are weakened. This limits the efficiency of the energy saving glass function in the wireless communication of microwave signals. In order to overcome this problem, currently there are three solutions; the first solution is to etch a structured design shape on the coated side of the glass, the second solution is by using different types of materials at the fabrication stage of energy saving glass process, and lastly, the common practice to address the signal attenuation is by employing numerous repeaters to improve signals. However, by changing materials during fabrication and having additional repeaters will incur extra cost through many aspects. Therefore this research focuses on the first solution that is to remove a portion of a structured design shape on the coated side of the glass. Currently, the shape is in the regular symmetrical forms such as square, triangle, circle, pentagon, rectangle, and octagon. This research proposed a modified regular shape which is based on the best selected regular shape, modified using genetic algorithm on the central processing unit (CPU). Genetic algorithm is a method which is easily transferred to the existing simulations and models. In order to evaluate the proposed approach, two different regular shapes are selected namely the Modified Single Square Loop (MSSL) and Single Square Loop (SSL). After modifying these shapes using the Genetic algorithm and Parallel Genetic algorithm, the outputs are simulated in the Computer Simulation Technology (CST) simulation software. Result shows that SSL with 10% coated part results -29.3044dB of return loss.

ABSTRAK

Kaca penjimatan tenaga adalah merupakan sejenis kaca yang disalut khas dengan lapisan logam-oksidasi yang membantu menjimatkan tenaga dengan memantulkan haba daripada matahari dalam lingkungan inframerah (IR). Sifat penjimatan tenaga bagi kaca ini memantulkan haba sinaran inframerah sementara cahaya putih dibolehkan melaluinya. Dengan kehadiran lapisan logam ini, beberapa jumlah frekuensi radio (RF) atau isyarat gelombang mikro menjadi lemah. Magnitud untuk beberapa isyarat komunikasi tanpa wayar seperti telefon bimbit (GSM, UMTS dan 3G), sistem kedudukan global (GPS), rangkaian tanpa wayar (Wi-Fi), jalur lebar tanpa wayar (WiMAX, LTE) juga lemah. Ini menghadkan kecekapan fungsi kaca penjimatan tenaga ini dalam komunikasi tanpa wayar bagi isyarat gelombang mikro. Bagi mengatasi masalah ini, terdapat tiga jenis penyelesaian; penyelesaian pertama adalah untuk menggores reka bentuk berstruktur di bahagian bersalut kaca, penyelesaian kedua adalah dengan menggunakan pelbagai jenis bahan-bahan pada peringkat fabrikasi penjimatan tenaga dalam proses pembuatan kaca, dan akhir sekali, praktis biasa untuk menangani masalah isyarat menjadi lemah adalah dengan menggunakan banyak pengulang untuk meningkatkan isyarat. Walau bagaimanapun, dengan menukar bahan semasa fabrikasi dan mempunyai pengulang tambahan akan melibatkan kos tambahan melalui pelbagai aspek. Oleh itu kajian ini memberi tumpuan kepada penyelesaian pertama iaitu untuk membuang sebahagian kaca dalam reka bentuk berstruktur di bahagian sebelah bersalut kaca. Pada masa ini, bentuk yg wujud hanya dalam bentuk simetri biasa seperti empat persegi, segitiga, bulatan, pentagon, segi empat tepat, dan oktagon. Kajian ini mencadangkan supaya bentuk diubahsuai berdasarkan bentuk biasa yang terbaik, ia diubah suai menggunakan algoritma genetik pada unit pemprosesan pusat (CPU). Algoritma genetik adalah satu kaedah yang mudah dipindahkan kepada simulasi dan model yang sedia ada. Dalam usaha untuk menilai pendekatan yang dicadangkan, dua bentuk biasa yang berbeza dipilih iaitu Modified Square Single Loop (MSSL) dan Single Square Loop (SSL). Selepas mengubah suai bentuk ini menggunakan algoritma genetik dan algoritma genetik selari, output disimulasikan dalam perisian simulasi Computer Simulation Technology (CST). Keputusan menunjukkan bahawa SSL dengan 10% bahagian bersalut hasil -29.3044dB kehilangan balasan.

ACKNOWLEDGEMENTS

First of all, I would like to thank Allah Almighty, Most Gracious, and Most Merciful, who made me capable to complete this thesis throughout the years. My greatest indebtedness is to my mother, my father, family and friends for their patience, inspiration, continuous encouragement and thoughtful advice throughout my years as a research master student. I would like to express my appreciation to Mr. Fauzi bin Mohd Johar who had guided me throughout the research for his advice that had greatly improved my knowledge on algorithms and applications of energy saving glass.

I am also very thankful to Prof. Dato' Dr. Mohammad Kadim Bin Suaidi for his generous help, advises and motivation. Without their continued moral support and concern, this thesis would have not been presented here. I am also very thankful to this research project principal Prof. Madya Dr. Badrul Hisham Ahmad and contributing lecturer Mr. Zoinol Abidin bin Mohamad for their moral support and concern throughout the research.

I am in debt and owe great thanks to Dr. Abdul Samad bin Shibghatullah and many other lecturers from Faculty of Information and Communication Technology, UTeM who have helped into understanding of Artificial Intelligence- Genetic Algorithm, my main method for this research. I would also like to extend my gratitude to Center of Graduate Studies (CGS) of Universiti Teknikal Malaysia Melaka (UTeM), for their funding support for my studies under Zamalah Scheme.

TABLE OF CONTENTS

	PAGE
DECLARATION	
DEDICATION	
ABSTRACT	i
ABSTRAK	ii
ACKNOWLEDGEMENTS	
TABLE OF CONTENTS	iv
LIST OF TABLES	vii
LIST OF FIGURES	viii
LIST OF ABBREVIATIONS	xi
LIST OF PUBLICATIONS	xiii
CHAPTER	1
1. INTRODUCTION	
1.1 Background	1
1.2 Problem Statement	2
1.2.1 Current Solution to Energy Saving Glass Problem	3
1.3 Objectives	7
1.4 Methodology	7
1.5 Organization of Thesis	9
2. LITERATURE REVIEW	11
2.1 Introduction	11
2.1.1 Chapter Objectives	11
2.1.2 Chapter Outline	11
2.2 Energy Saving Glass	12
2.2.1 Types of Energy Saving Glass	13
2.2.2 Signal in Energy Saving Glass	14
2.2.3 Applications of the Energy Saving Glass	15
2.3 Current Approaches to Reduce Losses in Energy Saving Glass	17
2.3.1 Coating Shape Design using FSS	17
2.3.2 Type of Coating	19
2.3.3 Use of Repeater	21
2.4 Limitations to Current Approaches	22
2.4.1 Optimum Coating Design Structure	22
2.4.2 Types of Coating	25
2.4.3 Use of Repeater	25
2.5 Genetic Algorithm Optimization	26
2.5.1 Genetic Operations	27
2.5.1.1 Selection	28
2.5.1.1.1 Roulette Wheel Selection	28
2.5.1.1.2 Rank Selection	29
2.5.1.1.3 Tournament Selection	30
2.5.1.1.4 Elitism	30
2.5.1.2 Crossover	31
2.5.1.3 Mutation	32

2.6	Summary	33
3.	THE PROPOSED APPROACH USING GENETIC ALGORITHM	34
3.1	Introduction	34
3.1.1	Chapter Objectives	34
3.1.2	Chapter Outline	35
3.2	The Proposed Approach with Genetic Algorithms	35
3.2.1	Select the Best Regular Shape	37
3.2.2	Pixelated and Bit Representation	40
3.2.2.1	Pixilation of a Single Square Loop design	40
3.2.2.2	Pixilation of MSSL generated design shape	41
3.2.3	Application of the Genetic Algorithm Optimization	41
3.2.3.1	Generating population	42
3.2.3.2	Fitness function	43
3.2.3.3	Selection process	46
3.2.3.4	Crossover operation	47
3.2.3.5	Mutation operation	49
3.2.4	Design and Test	50
3.3	Summary	51
4.	GENETIC ALGORITHM ON CENTRAL PROCESSING UNIT (CPU) - RESULTS AND ANALYSIS	52
4.1	Introduction	52
4.1.1	Chapter Objective	53
4.1.2	Chapter Outline	53
4.2	Process of Genetic Algorithm in CPU	55
4.2.1	Choose an Existing Shape	56
4.2.2	Modify Shape into Grids	56
4.2.3	Chromosome Encoding	58
4.2.4	Generate Initial Population	58
4.2.5	Genetic Algorithm Operation	59
4.2.6	Chromosome Decoding	62
4.2.7	Verification of Design in Transmission and Return Loss	62
4.2.8	Design Condition	64
4.3	Numbers of Simulation	65
4.4	Parameters Setting for the simulations	67
4.5	Simulation Results and Analysis	68
4.5.1	MSSL Results and Analysis	68
4.5.2	SSL Results and Analysis	78
4.6	Results Analysis	87
4.7	Summary and Conclusion	88
5.	CONCLUSION AND RECOMMENDATION	89
5.1	Introduction	89
5.2	Summary	90
5.2.1	Chapter One	91
5.2.2	Chapter Two	92
5.2.3	Chapter Three	92
5.2.4	Chapter Four	93

5.3	Summaries of Contributions	94
5.4	Limitations of research	94
5.5	Recommendation	95
REFERENCES		98
APPENDICES I		110
APPENDICES II		114
APPENDICES III		136

LIST OF TABLES

TABLE	TITLE	PAGE
4.1	Pseudo code of genetic algorithm with rules to crossover and mutation	59
4.2	Parameter use in CST for designing MSSL-Coated, MSSL-Uncoated, SSL - Coated and SSL-Uncoated.	68
4.3	Result of coated and uncoated side of MSSL design shape	77
4.4	Results comparison between the original and modified MSSL	78
4.5	Result of coated and uncoated side for SSL design shape	86
4.6	Results comparison between the original and modified SSL	87
5.1	Example of bit zero in a string and its given accumulated point	144
5.2	Return loss, transmission and % of transmission for MSSL-Coated (5%,10% and 15%)	158
5.3	Return loss, transmission and % of transmission for MSSL-Uncoated (5%,10% and 15%)	158
5.4	Return loss, transmission and % of transmission for SSL- Coated (5%,10% and 15%)	165
5.5	Return loss, transmission and % of transmission for SSL- Uncoated (5%,10% and 15%)	165

LIST OF FIGURES

FIGURE	TITLE	PAGE
2.1	The illustration of the inside and outside of an energy saving glass.	
2.2	Illustration of the energy saving technique	
2.3	Regular shapes of existing coating	
2.4	The double regular shapes	
2.5	Diagram of the use of a repeater.	
2.6	Circular loop design shape Rafique et al. (2011)	
2.7	Double rectangular design shape (Kiani <i>et al.</i> , 2010).	
2.8	A cross dipole shape dimension (Kiani <i>et al.</i> , 2010),	
2.9	Various popular crossover diagram.	
2.10	Mutation occur after crossover	
3.1	Genetic algorithm-based optimization flowchart	
3.2	A square loop design	
3.3	Pre-existing FSS design generated by Modified Single Square Loop (MSSL)	
3.4	Pixelated MSSL generated design shape	
3.5	Various popular crossover diagram	
3.6	Flow chart of CPU and GPU related task	
3.7	The structure of work result objective and comparison objective based on the proposed approach.	
4.1	Flow chart of design using genetic algorithm process	
4.2	Gridded MSSL design shape	
4.3	Gridded SSL design shape	
4.4	Example of a 100-bits chromosomes.	
4.5	Example of S11 and S21 results in CST	
4.6	Practical representation of transmitted signal	

- 4.7 Work of experiment on MSSL design shape
- 4.8 Work of experiment on SSL design shape
- 4.9 Original initial population generated by MSSL.
- 4.10 Result of return loss (S11)
- 4.11 Result of transmission coefficient (S21)
- 4.12 Modified MSSL design on coated part at randomly 5%
- 4.13 Modified MSSL design on coated part at randomly 10%
- 4.14 Modified MSSL design on coated part at randomly 15%
- 4.15 Modified MSSL design in uncoated part at randomly 5%
- 4.16 Modified MSSL design in uncoated part at randomly 10%
- 4.17 Modified MSSL design in uncoated part at randomly 15%
- 4.18 Initial design of FSS before modification using genetic algorithm
- 4.19 Modified SSL design on coated part at randomly 5%
- 4.20 Modified SSL design on coated part at randomly 10%
- 4.21 Modified SSL design on coated part at randomly 15%
- 4.22 Modified SSL design on uncoated part at randomly 5%
- 4.23 Modified SSL design on uncoated part at randomly 10%
- 4.24 Modified SSL design on uncoated part at randomly 15%
- 5.1 Main flow chart
- 5.2 Flow chart of design using genetic algorithm process
- 5.3 Generate chromosome flowchart
- 5.4 Crossover operation flowchart
- 5.5 Mutation operation flowchart
- 5.6 Number of experiments for MSSL
- 5.7 Number of experiments for SSL
- 5.8 Results for MSSL-Coated 5%
- 5.9 Results for MSSL-Coated 10%
- 5.10 Results for MSSL-Coated 15%
- 5.11 Results for MSSL-Uncoated 5%
- 5.12 Results for MSSL-Uncoated 10%
- 5.13 Results for MSSL-Uncoated 15%
- 5.14 Results for SSL-Coated 5%
- 5.15 Results for SSL-Coated 10%
- 5.16 Results for SSL-Coated 15%

ERROR! BOOKMARK NOT

- 5.17 Results for SSL-Uncoated 5%
- 5.18 Results for SSL-Uncoated 10%
- 5.19 Results for SSL-Uncoated 15%

LIST OF ABBREVIATIONS

ACO	-	Ant Colony Optimization
ALU	-	Arithmetic Logic Unit
CPU	-	Central Processing Unit
CST	-	Computer Simulation Technology
CT	-	Coated
CUDA	-	Compute Unified Device Architecture
CVD	-	Chemical Vapour Deposition
FDM	-	Finite Difference Method
FDTD	-	Finite Difference Time Domain
FEM	-	Finite Element Method
FSS	-	Frequency Selective Surfaces
GP	-	Genetic Programming
GPGPU	-	General Purpose Graphics Processing Unit
GPS	-	Global Positioning System
GPU	-	Graphic Processing Unit
GSM	-	Global System Mobile
IR	-	Infrared
ISM	-	Industrial, Scientific And Medical Bands
MSSL	-	Modified Single Square Loop
PSO	-	Particle Swarm Optimization

RWS	-	Roulette Wheel Selection
SSL	-	Single Square Loop
TS	-	Tournament Selection
UCT	-	Uncoated
UV	-	Ultraviolet

LIST OF PUBLICATIONS

1. F. M. Johar, F. A. Azmin, M. K. Suaidi, A. S. Shibghatullah, B. H. Ahmad, S. N. Salleh, M. Z. A. Abd Aziz, M. Md Shukor, "Application of Genetic Algorithm to the Design Optimization of Complex Energy Saving Glass Coating Structure" Journal of Physics (IOP) on International Conference of Mathematics, Physics and Chemistry, ScieTech 2014 (Scopus)
2. M.M. Ismail, M.A. Meor Said, M.A. Othman, M. H. Misran, H.A. Sulaiman, F.A.Azmin, "Buried vs. Ridge Optical Waveguide Modeling for Light Trapping into Optical Fiber" International Journal of Engineering and Innovative Technology (IJEIT) Vol 2, Issue 1, July 2012.
3. F. M. Johar, F. A. Azmin, M. K. Suaidi, A. S. Shibghatullah, B. H. Ahmad, S. N. Salleh, M. Z. A. Abd Aziz, M. Md Shukor, "A Review of Genetic Algorithms and Parallel Genetic Algorithms on Graphics Processing Unit (GPU)" International Conference on Control System, Computing and Engineering (ICCSCE 2013), Park Royal Penang, Malaysia on 29-30 November 2013. (IEEE)
4. F. M. Johar, F. A. Azmin, M. K. Suaidi, A. S. Shibghatullah, B. H. Ahmad, S. N. Salleh, M. Z. A. Abd Aziz, M. Md Shukor, "Application of Genetic Algorithm to the Design Optimization of Complex Energy Saving Glass Coating Structure" International Conference of Mathematics, Physics and Chemistry, ScieTech 2014, Jakarta 13-14 January 2014. (Scopus)
5. Fauzi Mohd Johar, Farah Ayuni Azmin, Abdul Samad Shibghatullah, Mohamad Kadim Suaidi, Badrul Hisham Ahmad, Siti Nadzirah Salleh, Mohamad Zoinol Abidin Abd Aziz, Mahfuzah Md Shukor, Liew Voon Bin, Wong Wei Yang, "Application of Genetic Algorithm for the Optimization of Energy Saving Glass Coating Structure Design" International Conference on Internet Service Technology and Information Engineering 2014 (ISTIE 2014) Bali Dynasty Resort, Bali Indonesia on 31 May 2014 to 1 June 2014. (Scopus) 012018.

6. Farah Ayuni Azmin, Abdul Samad Shibghatullah, Fauzi Mohd Johar , Mohammad Kadim Bin Suaidi, Badrul Hisham Ahmad, Siti Nadzirah Salleh, Mohd Zoinol Abidin Abdul Aziz, Mahfuzah Md. Shukor, “Single Square Loop Design Approach using GA-based Frequency Selective Surface For Energy Saving Glass Coating Structure” Journal of Theoretical and Applied Information Technology (JATIT), 31st May 2015 -- Vol. 75. No. 3 – 2015.

CHAPTER 1

INTRODUCTION

1.1 Background

Nowadays, energy saving glass has become very popular in modern buildings and vehicles. It was proven to be very useful to maintain the temperature level inside a building or vehicle using the energy saving glass. This technology falls under the green technology category for it helps to contribute in saving the energy in a building or vehicles. It was in the late 1980s, when energy saving glass or low emissivity glass first began to contribute to energy saving through the window of a modern building design. It works by applying a very thin metallic oxide (e.g. silver oxide or tin oxide) on one side of the glass. It consists of multiple layers of metal and metallic oxides placed on the glass through a sputtering process in a special room called the vacuum chamber. A uniform thin (0.3-0.4 micron) layer of pyrolytic coating (hard coating) or metal oxide (soft coating) is fabricated on the glass substrate.

There are different processes available to fabricate these coatings, for example, a chemical vapour deposition (CVD) method. These windows are then capable to attenuate infrared frequencies while passing the ultraviolet band of the spectrum, due to the presence of this coating. Thermal insulation is maintained at an excellent level in a room that employs energy saving window while one can still easily see through the glass window without knowing the existence of this special coating. This shows that at room temperature, the coating layer is able to transmit visible white light while infrared radiations are reflected. This is due to the property of the energy saving glass.

IR insulation is thus achieved, when the energy saving glass is proven to be very helpful in saving electricity bills when buildings that incorporate this specially coated glass are warmer in winter and cooler during summer (Kiani *et. al.*, 2008). The following section presents the background of the research with the introduction of the problem as well as solutions to overcome the problem associated.

1.2 Problem Statement

There is one common drawback associated with these glass windows, in spite of being energy efficient in saving the electricity bills. Due to the presence of the metallic oxide coating, useful RF/microwave signals such as mobile phones, Wi-Fi, security and personal communication signals are attenuated. Useful signals in the wireless communication systems such as global positioning system (GPS), mobile communication system (GSM, UMTS, 3G), wireless network (Wi-Fi) and wireless broadband (WiMax, LTE) are also attenuated due to the metal-oxide coating on the energy saving glass (Sohail *et al.*, 2011).

This limits the efficiency of the energy saving glass function in the wireless communication of microwave signals. In addition, the functional aspect of an energy saving glass is limited when most wireless communication signals are attenuated through the use of low-E glass. Wireless Local Area Network (WLAN) signals operating at 2.45 GHz and 5.25GHz are also attenuated. However, in terms of wireless security, this contributes to the advantage in security. A study (Sohail *et al.*, 2011) proved that the attenuation of GSM, GPS, UMTS, 3G, Wi-Fi signal leads to poor communication inside the building. Thus, the transmission is very low.

In order to overcome this problem, there are three solutions proposed to selectively improve the transmission of signal. The first solution is to etch a structured design shape on the coated side of the glass. There are regular and irregular shapes. It can be symmetrical and asymmetrical depending on the geometry constructions. However, according to the current work (Kiani, Olsson, Karlsson, & Esselle, 2010) using the Frequency Selective Surfaces (FSS), shapes that are symmetrical, are periodically arranged as patch elements or apertures. FSS is a periodic structure that works as a filter. Patches exhibit nearly the total reflection of signals, while an aperture refers to nearly the total transmission of signals.

The second available method used to develop an energy saving glass is through the type of coating used during the fabrication process. There are two different coating types available, (Ullah, 2012; Ullah, Zhao, & Habibi, 2011) which are hard and soft coating layers. Each has their own goods that benefit one another. Third method, the common practice to address the signal attenuation is by employing numerous repeaters to improve signals. However, establishing and operating additional repeaters will incur extra cost and electricity usage.

1.2.1 Current Solution to Energy Saving Glass Problem

There are three types of solutions found suitable to overcome the drawbacks with energy saving glass. The first proposed solution for this problem is to selectively improve the transmission of RF / microwave signals by etching a bandpass FSS on the coated side of the energy saving glass (Kiani *et al.*, 2010). The coating on the energy saving glass is usually etched in regular shapes.

There are some popular geometry shapes usually coated on the energy saving glass, such as cross dipole, circular loop, hexagon and square loop (Kianni, 2009). This structured coating works as a filter where the coated part will reflect IR while the etched part is left where the transmissions are allowed to pass through. Hence, the bigger the size of the coating the greater the signals and heat will be reflected.

This coating design structure is believed to have some effects on the transmission of signal, passing through this energy saving glass. Based on previous study, the coating design structure can be divided into three different categories. They are regular, modified regular and irregular shapes. Regular shapes can be referred as symmetrical shapes. There are a lot of regular shape designs such as square, triangle, circle, pentagon, rectangle, octagon and many more. Modified regular shapes as the name reflects, referred to shapes that are constructed from regular shapes. Irregular shapes are represented by a construction of shapes that are totally new and being randomly shaped. They are also not symmetrical. In other word, it is a complex design of shapes.

The second solution to this drawback can be solved during the fabrication process, where different types of materials are used at an early stage of energy saving glass process. Amongst the different coating types available are hard coating types. They are more robust and easier to handle. On the other hand, soft coating type provides higher IR attenuation but is easily broken if not handled with care. This is due to the soft metal oxide coating layer that is fabricated using either the sputtering process or CVD.

According to Ullah et al. (2011), hard coating layers attenuate up to 200dB within the same frequency band while soft coating could result in a 30dB attenuation (Suncool TM) within the RF microwave range. Another common practice to overcome the signal attenuation is by setting up a number of repeater amounts to enhance the useful signals.

However, installing and operating these additional repeaters are inefficient in terms of cost and consume more electricity. Furthermore this requires huge amount of works in money and manpower. These drawbacks will limit the efficiency of an energy saving glass function in terms of wireless communication. In order to optimize energy saving glass implementation in supporting the green technology, the work has to be environment-safe compliance. The current pattern of solution in overcoming the drawback with energy saving glass is by employing the regular shape patterns.

Results showed that the improvement in attenuation is at least at 25dB to 30dB. According to this situation, it can be assumed that the attenuation of signals with energy saving glass involves the use of low-e glass. Recently, a study also attested that the transmission of signals improved when at least 10% of metallic coating was removed, and the transmission loss of cross dipole for instance results around 25dB (Kianni *et al.*, 2011). As the size of the etched part coating gets bigger, the better the efficiency of the transmission signals. The smartest way to deal with this problem is by introducing a modified regular shape of coating. Other study using the regular shapes of cross-dipole for example, showed transmission loss at 25-30dB (G. I. Kianni, 2011).

It is positive that the shape of the coating represents most of the percentage of the coated area of an energy saving glass which contributes to the attenuation of useful signals. Until today, the coating of an energy saving glass still uses regular shapes as the structure of the low-e glass coating. Based on the study above, introducing a new modified regular shape of coating with less percentage of coating area is one of the ideas that may improve the efficiency of the microwave signal transmission. Currently there are two issues in proposing a modified regular shape. First, it is difficult to implement since a modified regular shape involves small pixels and it is complicated to optimize every single pixel.