DEVELOPMENT OF REFLECTANCE INTENSITY BASED MICROCONTROLLER FOR FIBRE COMPACTNESS ANALYSIS

by

ONG TEE SAY
(1130110613)

A thesis submitted in fulfillment of the requirements for the degree of Master of Science (Microelectronic Engineering)

School of Microelectronic Engineering
UNIVERSITI MALAYSIA PERLIS

2013

DECLARATION OF THESIS

Authors' full name	:	ONG TEE SAY
Date of Birth	:	27 JULY 1987
Title	:	DEVELOPMENT OF REFLECTANCE INTENSITY BASED MICROCONTROLLER FOR FIBRE COMPACTNESS ANALYSIS
Academic Session	:	2011 – 2013

I hereby declare that the thesis becomes the property of Universiti Malaysia Perlis (UniMAP) and to be placed at the library of UniMAP. This thesis is classified as:

☐ **CONFIDENTIAL** (Contains confidential information under the Official Secret Act 1972)*

☐ **RESTRICTED** (Contains restricted information as specified by the organization where research was done)*

☐ **OPEN ACCESS** I agree that my thesis is to be made immediately available as hard copy or on-line open access (full text)

I, the author, give permission to the UniMAP to reproduce the thesis in whole or in part for the purpose of research or academic exchange only (except during a period of ___ years, if so requested above).

Certified by:

____________________ ____________________

SIGNATURE **SIGNATURE OF SUPERVISOR**

ONG TEE SAY **ASSOC PROF DR ZALIMAN SAULI**

870727-10-5233 **NAME OF SUPERVISOR**

Date: ______________ Date: ____________

GRADUATE SCHOOL

UNIVERSITI MALAYSIA PERLIS

PERMISSION TO USE

In presenting this thesis in fulfillment of a post graduate degree from Universiti Malaysia Perlis, I agree that permission for copying of this thesis in any manner, in whole or in part, for scholarly purposes may be granted by my supervisor or, in their absence, by Dean of the Graduate School. It is understood that any copying or publication or use of this thesis or parts thereof for financial gain shall not be allowed without my supervisor's written permission. It is also understood that due recognition shall be given to me and to Universiti Malaysia Perlis for any scholarly use which may be made of any material from my thesis.

Requests for permission to copy or make other use of material in whole or in part of this thesis are to be addressed to:

Dean of Centre for Graduate Studies

Universiti Malaysia Perlis

No. 112 & 114, Tingkat 1, Blok A, Taman Pertiwi Indah

Jalan Kangar-Alor Setar, Seriab

01000 Kangar

Perlis Indera Kayangan

Malaysia.

ACKNOWLEDGEMENT

First of all, I would like to express my sincere gratitude to my project advisor Assoc. Prof. Dr. Zaliman Sauli and Dr. Vithyacharan Retnasamy for the continuous support of my Master study and research. I am deeply appreciated to them for their precious time, patience, motivation, enthusiasm and guidance throughout the implemented of this project and writing this thesis.

I am also very grateful to my mentors Mr. Wan Mokhdzani, Mr. Steven Taniselass, Mr. Hafiz, Mr. Ruhaizi and Mrs Hafizah for their valuable input, insightful comments and moral support throughout the course of my studies.

My sincere thanks also go to Dean and all the staffs and PLV from School of Microelectronic for their unconditional support and facility. I also would like to thank the Ministry of Higher Education of Malaysia, Vice Chancellor of UniMAP and the Research and Development Unit of UniMAP for their financial support of my postgraduate study.

I am thankful to my colleagues and friends. The time spend together will never be forgotten. In no particular order, thanks are deserved to Moganraj, Rajendaran, Shakirina, Yee Chin, Kang Nan, Wei Jer, Izatul, Aaron and many more for their support in the various stages of the study.

Last but not the least, I would like to thank all my family members especially my parents Mr Ong Chow Jing and Mrs. Lee Yian Chan for giving all the support I needed during my study especially in completing this project. Their support gives inspiration to me to get through all the hindrance. Finally, thanks a lot to everyone that has directly or indirectly helped me to get through in making this project finish properly.

TABLE OF CONTENTS

PAGES

LIST OF TABLES

LIST OF FIGURES

FIGURE **PAGE**

LIST OF ABBREVIATIONS

VIS/NIR	Visible and Near Infrared
LCD	Liquid Crystal Display
PIC	Peripheral Interface Controller
KCL	Kirchhoff's Current Law
ADC	Analog-to-Digital
SEM	Scanning Electron Microscope
TEM	Transmission Electron Microscope

LIST OF SYMBOLS

°	Degree
R	Resistance
V	Voltage
I	Current
θ	Theta

Pembangunan Mikropengawal Berdasarkan Keamatan Pantulan Untuk Analisis Kepadatan Gentian

ABSTRAK

Kualiti adalah salah satu elemen yang penting dalam kehidupan manusia. Semua industri berasaskan perubatan, elektronik, automotif, penerbangan, tekstil, makanan, kayu-kayan, kertas dan sebagainya mempunyai elemen kawalan kualiti dalam kedua-dua proses pengeluaran dan pembuatan. Pengukuran kualiti permukaan adalah satu proses di industri untuk memeriksa permukaan bahan. Salah satu kaedah untuk menentukan kualiti permukaan adalah dengan mengukur kepadatan gentian dan susunannya. Pada masa ini, peralatan yang digunakan untuk memeriksa kepadatan gentian dan susunannya di permukaan bahan adalah mikroskop optik, spektrofotometer VIS/NIR, mikroskop elektron imbasan (SEM) dan mikroskop penghantaran elektron (TEM). Walau bagaimana pun, semua alat ini adalah mahal. Justeru itu, wujud keperluan untuk satu kaedah yang mudah, murah dan cepat untuk menentukan kualiti permukaan barangan di bahagian pengeluaran sebelum dipasarkan kepada pengguna. Dalam kajian ini, satu prototaip mikropengawal ringkas dan berkos rendah untuk mengukur keamatan pantulan cahaya telah direka dan dibikin untuk membezakan pelbagai susunan dan kepadatan gentian dengan menggunakan laser dan prinsip pantulan. Isyarat yang dikesan oleh fotodiod akan ditukar kepada voltan yang mempunyai hubungkait dengan kualiti permukaan sampel. Lingkungan projek ini hanya memberi tumpuan kepada pembezaan ketumpatan kertas yang tinggi dan rendah. Prototaip ini telah diuji dengan ketumpatan kertas yang tinggi diwakili oleh kertas cetak biasa 70 g/m^2, 80 g/m^2 serta 100 g/m^2 dan ketumpatan kertas yang rendah diwakili oleh kertas tisu yang mempunyai tiga, dua dan satu lapisan. Keputusan siasatan telah menunjukkan bahawa kertas cetak 100 g/m^2 mempamerkan keluaran voltan yang paling tinggi berbanding dengan kertas cetak 80 g/m^2 dan 70 g/m^2. Ini adalah kerana susunan gentian yang lebih padat pada kertas yang berketumpatan tinggi menunjukkan tahap keamatan pantulan cahaya yang lebih tinggi. Bagi ketumpatan kertas yang rendah, keputusan telah menunjukkan bilangan lapisan kertas tisu mempengaruhi pemantulan cahaya dengan ketara. Ketumpatan kertas tisu yang tinggi dengan bilangan lapisan tinggi menunjukkan keluaran voltan lebih tinggi berbanding dengan bilangan lapisan kertas tisu rendah. Kaedah pemerhatian di mikroskop menyokong analisis pantulan itu. Pengukuran dilakukan dengan menggunakan spektrofotometer UV lambda 950 mempunyai keputusan yang serupa dengan prototaip ringkas, seterusnya mengesahkan analisis pantulan yang diperolehi daripada prototaip tersebut. Menerusi kajian ini, prototaip ringkas ini telah didapati berjaya membezakan pelbagai susunan dan kepadatan gentian di dalam beberapa jenis permukaan bahan dengan menggunakan konsep pantulan permukaan. Prototaip ini berpotensi untuk diperluaskan penggunaannya untuk gentian bahan yang lain.

Development of Reflectance Intensity Based Microcontroller For Fibre Compactness Analysis

ABSTRACT

Quality is an integral element in human life. All industries ranging from medical, electronic, automotive, aviation, textile, food, to wood and paper possess some sort of quality control element in both the output and manufacturing process. Surface quality measurement is a process in the industry to investigate the surface of a material. One method in determining the surface quality is by measuring its fibre compactness and arrangement. Currently, equipments used to examine the fibre compactness and arrangement on the surface of a material includes optical microscope, VIS/NIR spectrophotometer, scanning electron microscope (SEM) and transmission electron microscope (TEM). However, all of these equipments are costly. Therefore, there is a need for a simple and cheap method to quickly determine the surface quality of products before it is marketed to consumers. In this research, a simple, low cost prototype of microcontroller to measure reflectance intensity were designed and fabricated to differentiate various fibre arrangement and compactness by using laser and principle of reflection. The signal detected by photodiodes was converted into a voltage which can then be correlated with the surface quality of the sample. The scope of this project focused on the differentiation of high and low density paper. The prototype was tested on high density paper, represented by 70 g/m^2, 80 g/m^2, and 100 g/m^2 common printing paper and low density paper, represented by three, two and one ply facial tissue paper. Measurement results showed that 100 g/m^2 printing paper exhibited a higher reflected voltage output compared to 80 g/m^2 and 70 g/m^2 printing papers. This is because the denser fibre arrangement in the higher density paper results in higher reflectance intensity. As for the low density papers, results showed that the number of ply of the tissue paper significantly influences the light reflectivity. The high density tissue paper with a higher number of ply showed higher voltage output compared to lower ply tissue paper. Microscope observation method supports the reflectance analysis. Measurement done by UV lambda 950 spectrophotometer produce similar observations, hence validate the reflectance analysis. From this research, it was found that the prototype able to successfully differentiate various fibre arrangement and compactness on several material surfaces using surface reflection. This prototype has the potential to be further extended its usage to other fibre materials.

CHAPTER 1

INTRODUCTION

1.1 Overview

Quality is an important element in every aspect of human life. It is a discipline and practice that needs to be always embraced and carried out for long-term survival (Fryman, 2002). The term quality in business context can be classified under three categories; quality management, quality assurance, and quality control. The basis of quality in management, assurance and control are:

i. Quality management are organizational controlling activities that increase and optimize administrative and procedural systems with the aim to ensure their products meet specifications.
ii. Quality assurance assures that the product or service which will fulfill the expectations of customers.
iii. Quality control is the process to ensure outcome of the product achieve set standards.

Quality can be viewed as an absence of mistakes or a degree of perfection. It is a condition or fitness for purpose that may be understood differently by different people (Shewfelt, 1999). Quality is essential in various fields such as engineering, manufacturing, medicine and education as a system to improve performance.

In the industry, it is important to have a good method for measuring quality to ensure each product achieve acceptable standards. Quality can be measured qualitatively or quantitatively. Quantitative measurement is based on measuring quantifiable data in some way. These observations and measurements are used as reference or objective and repeated by other researchers. On the other hand, qualitative measurement is analysed on the perspectives or hunches regarding the subject to be investigated and studying human behaviour, for example the disciplines in school, the hygiene level of a house or the mood or look of a person (Charoenruk, n.d).

Surface quality measurement is an integral part for most industries in the world. Many industries such as the fruit, textile and wood pulp, automotive, and semiconductor industries have stringent surface quality control of the product. In steel industries, quality is measured based on surface roughness of the steel. Qualitative measurement are mostly used in describing the phenomenon or appearance of the situation.

In fruit industries, surface quality measurement is an important process and essential to inspect the surface quality of fruits before delivering it to customers. The surface measurement information provides characteristics of the fruit surface such as its freshness and ripeness. Quality measurement is a way to control and ensure the product meet certain specifications and requirements. Besides that, surface quality measurement is an essential process for most industries to rate and distinguish the grade of their products.

In the textile and wood pulp industry, surface quality measurement is important to classify the grade of the fibre as high or low quality. It is determined by considering the pulp’s tensile strength, viscosity, cleanliness and brightness (Foelkel, 2007). The wood pulp industry manufactures paper which can be categorized in accordance to the quality of the fibre used. Thus, the quality measurement is essential for the wood pulp industry to evaluate and differentiate the various types of paper which are commercially available in the market.

1.2 Problem Statement

Fibre is the basic component in all textiles and it comprises of long and narrow hairlike components originating either from plant or animal tissue (Terms, 1997). Surface quality measurement is a process to investigate the surface of a material. Twenty years ago, the surface quality of fibre texture was measured from the personal estimation by an expert and it can be quite subjective (Sommerville, 2002). There are no specific standards to evaluate the textile fibre quality in a quantitative manner (Neitzel, Blinzler, Edelmann, & Hoecker, 2000).

One of the method to determine surface quality of a material is by measuring its fibre compactness and arrangement. Currently, equipment used to examine the fibre compactness and arrangement on the surface of a material includes the optical microscope, VIS/NIR spectrophotometer, scanning electron microscope (SEM), and transmission electron microscope (TEM). However, all of these equipments are expensive and are not suitable for use outside a laboratory.

Hence, a simple and lost cost quantitative measuring tool needs to be designed and fabricated. To the best of the author's knowledge, no work has been done to fabricate a simple and cost effective device to check the fibre compactness and arrangement.

1.3 Objectives of this Research

The main objective of this research is to develop a microcontroller based tester to manipulate a laser to analyze the fibre compactness and arrangement. This tester must be able to test the arrangement of different fibers and differentiate them with an measurable output. The listed sub-objectives below facilitate achieving the main objective:

i. To design, fabricate and assemble a ptototype tester. In order to achieve this, three parts of the prototype need to be completed; the light box, receiver and emitter circuit. The light box must have minimal or zero light pollution. In addition, the best physical arrangement and position of laser and photodiodes need to be determined with respect to the specimen placement location. The last piece of the prototype will be the receiver circuit. The choice of photodiode is important to differentiate the light to be absorbed.

ii. Calibration and testing the prototype would be the final element of this work.

1.4 Research Scope

The work scope revolves around designing and fabricating a functional prototype microcontroller based tester which would be used to test fibre arrangements. The fibres to be tested in this work will be limited to printing paper and tissue paper, which are designated as high and low density papers, respectively.

1.5 Research Approach

This project has a two-pronged approach prior to embarking on this project, also a detailed literature review needs to be done. The first pronge will be the microcontroller circuit. Here in this section, there are two parts; the intensity receiver analyzer and emitter circuit.

The second pronge is to design and assemble the reflectivity test, which will be refered to as the light box from now on. For specimen testing, the emitter circuit and photodiode arrangement need to be specified.

1.6 Thesis Organization

This thesis is divided into five chapters. Chapter 1 provides the introduction and a brief overview on the project. It also contains the problem statement, objectives, research scope and approach.

Chapter 2 (Literature Review) presents previous work done by past researchers, it contains the prediction of produce quality, soil properties, hematology analysis and behaviour of unreinforced polyamide 6. Currently available equipment in the market for checking fibre arrangement and compactness are also reviewed.

The method for setting up the system to analyse fibre arrangement is discussed in Chapter 3 (Research Methodology). It is divided into two categories; the hardware and the software. The hardware part consists of the fabrication of the light box, receiving circuit and transmitting circuit. The software part consists of the PIC microcontroller programming step which is briefly discussed. The testing procedure is also discussed in this chapter.

Chapter 4 provides the discussion on the calibration and testing of the lab module tester. The experimental results of the lab module tester discussed the quantitative data The optical microscope observation of the tested specimen is also explained in this chapter.

The conclusion of the research is discussed in Chapter 5 (Conclusion). The suggestion for the future recommendations and the research summary is briefly discussed.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter provides an overview on the behavior on fibres and light. It also reviews past studies that utilized light as a manipulator to analyze and distinguish quality and characteristic of the surface material. Previous investigations using light for other applications are also discussed. Finally, literature on fibre compactness and arrangement on surface material was reviewed as well.

2.2 An Overview of Fibre

In general, fibre can classified into three categories, natural, synthetic, and wood. Natural fibres are a new generation of reinforcements as well as supplements for polymer based materials (Ho et al., 2012). Figure 2.1 illustrates the structure of a cotton fibre which is anatural fibre. Man-made fibre such as synthentic fibre are low cost and mass produced. Synthetic fibres are made of polymers, which are mainly obtained from petroleum (Sahgal, A. C. & Sahgal, M., 2009). Examples of man made fibre are acrylic, polyester and elastane (Bledzki, Sperber, & Faruk, 2002). Wood fibres are obtained from cellulosic elements which are collected from trees. Classification of fibres are shown in Figure 2.2.

In the paper industry, wood fibre is the main component to produce paper. The main composition of wood are cellulose, lignin, and easily extractable substances such as carbohydrates and aromatic oils. The pulp is a product that underwent a process to separate the cellulose fibres from wood or waste paper. Cellulose, $(C_6H_{10}O_5)_n$ is mixed with other substances to produce paper. The substance like lignin will be removed as the paper with high lignin content will yellow quickly when exposed to light. Pulp can be produced mechanically or chemically. The mechanical pulping method involves grinding and pressing the wood to split the fibres into finer ones. Mechanical pulping is a very efficient technique as up to 95% of the dry weight of the wood can be changed into pulp. The chemical pulping involves using a chemical or water solution to dissolve the lignin and split the fibres in the wood. The paper made from chemical pulp has higher resistance to color change because of the absence of lignin (Wood, 2012).

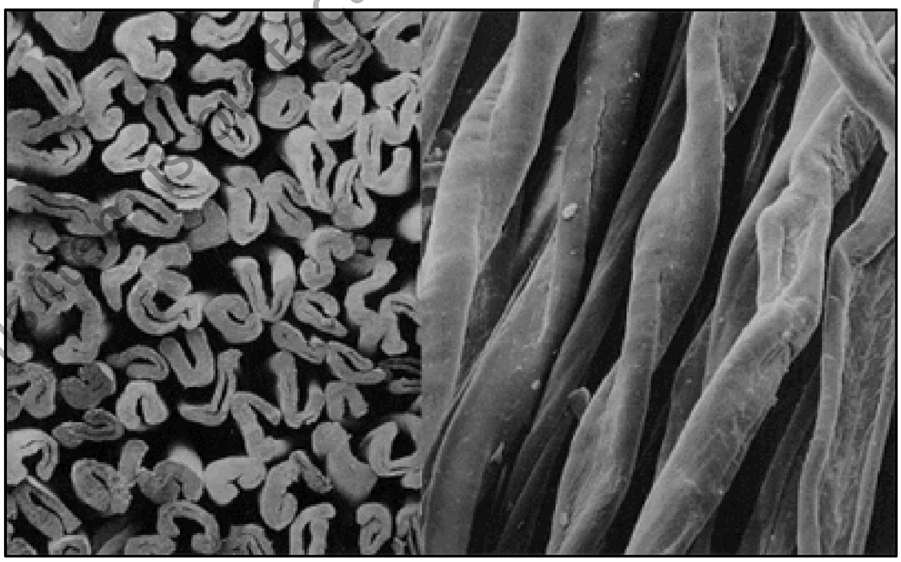

Figure 2.1: Cotton fibre view under microscope (Fibres, 2009)

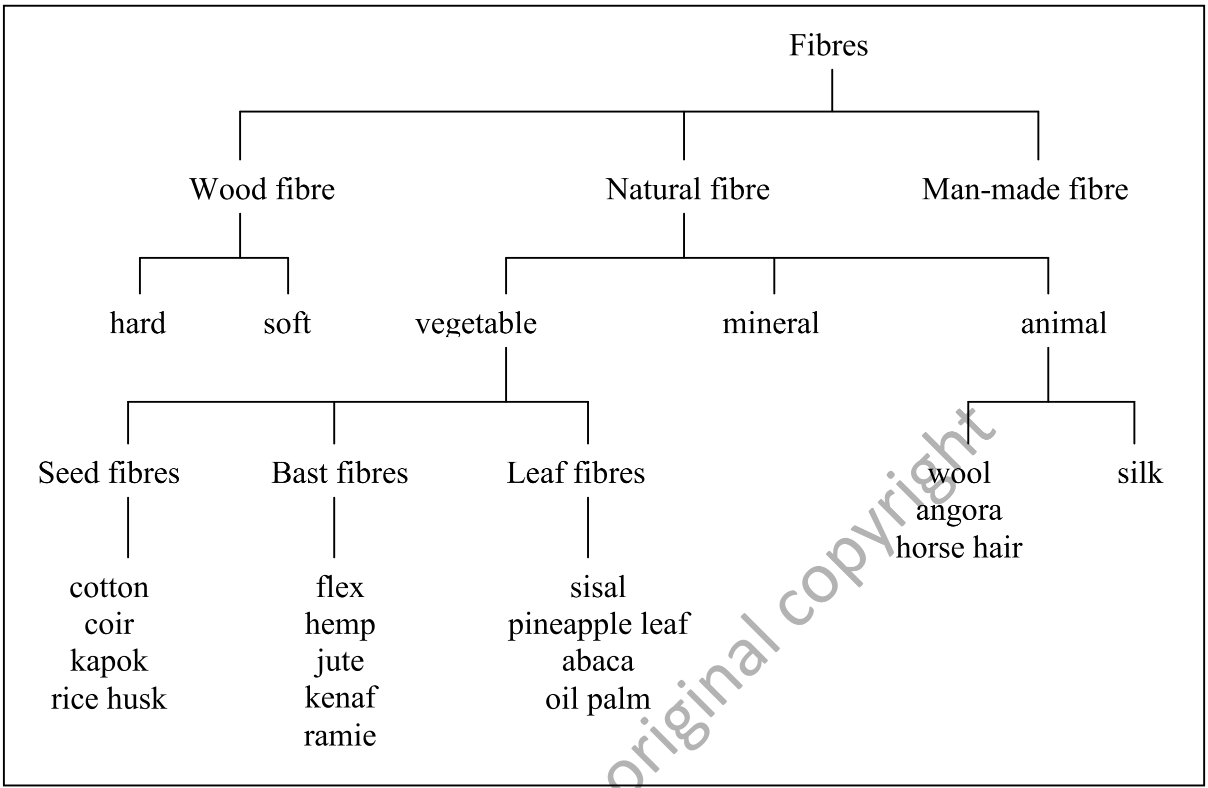

Figure 2.2: The classification of fibres (Bledzki et al., 2002)

2.3 Light Behaviour and Concept

Light is an electromagnetic radiation that is visible to the human eye in the wavelength range of 400 nm to 700 nm (Coon & Mitterer, 2008; Myron. Yanoff et al., 2009). The wavelength of visible light is in between the ultraviolet wavelength and the near infrared wavelength. Reflection happens when the radiation incidents a surface or any boundary that does not absorb it. The radiation then bounces off the surface at an angle. As an example, when a laser is pointed onto a mirror at an angle x° from the normal, then the reflection of the laser point can then viewed on an opaque surface at degree -x°. The colour of the wavelengths is shown in Table 2.1.

Table 2.1: The colour and wavelengths (Tilley, 2012)

COLOUR	WAVELENGTH (λ in nm)
Ultraviolet	350
Violet	400
Blue	450
Blue-green	500
Green	525
Yellow-green	550
Yellow	580
Orange	600
Orange-red	650
Deep red	700
Infrared	750

There are two types reflection of light which are the specular reflection and diffuse reflection. The incident ray and reflected rays are parallel to each other and it is known as specular reflection. Specular reflection happens when the light reflected from smooth surfaces, examples from the mirror. When the reflected rays are scattered in varying directions it is known as diffuse reflection. The diffuse reflection is the reflection light from any rough surfaces, for example, rays reflected from the rusty steel (Shipman, Wilson, Todd, & Higgins Jr, 2012). The illustration and photograph of the specular reflection and diffuse reflection is shown in Figure 2.3.