EFFECT OF LINE THICKNESS CROSS-SECTIONAL GEOMETRY TO STRETCHABLE PRINTED CIRCUIT UNDER THERMAL PERFORMANCE

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A Project report submitted

in fulfilment of the requirements for the degree of

Bachelor of Mechanical Engineering with Honours

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2018

DECLARATION

I declare that this project report entitled “Effect of line thickness cross-sectional geometry of Stretchable Printed Circuit under thermal performance” is the result of my own work except as cited in the references.

Signature : ……

Name : ……

Date : ……

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in term of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Honours.

Signature : ……

Name : ……

Date : ……

DEDICATION

This report is dedicated to my beloved late father and my beloved mother,

Suhaimi Sulaiman and Fatimah Ismail.

ABSTRACT

The stretchable printed circuit are widely used days by days due to the physical characteristic that able to be bend and stretch. The stretchable printed circuit have been used in various field such as health, sport, industry and fashion. The research were done to find out the effect of ink thickness against the resistivity. Next, to find out the effect of temperature against the resistivity and the last one to find out the effect of strain applied against the resistivity. The samples were prepared with four different thicknesses (2, 4, 6 and 8 layers) where the layers was made using cellophane tape to create different thickness. The printing method used was screen printing method and the samples was measured using four point probe in the unit of Ω/sq. The samples were tested under three different condition where the first condition the sample will be measure under normal condition (room temperature – 32 ºC). The second condition, the sample were tested under various temperature (40, 60 and 100 ºC). The last condition the sample were tested in the room temperature under various strain applied (20, 40, 60 and 80 %), the Vernier caliper was used to apply the strain on the samples. Carbon was used as the conductive ink and thermal-polyurethane (TPU) was used as the substrate in this studies. The result of the study shows that when the ink thickness increase, the resistivity will decreased. As for the mechanical or strain test when the higher strain applied to the sample, the higher resistivity obtain by the sample.

ABSTRAK

Litar bercetak boleh regang digunakan dengan cara meluas hari demi hari kerana karakter fizikalnya yang mampu lentur dan regang. Litar bercerak boleh regang digunakan dalam pelbagai bidang seperti kesihatan, sukan, industri dan fesyen. Kajian ini dilakukan untuk mengetahui kesan ketebalan dakwat terhadap rintangan. Seterusnya, untuk mengetahui kesan suhu terhadap rintangan dan akhir sekali untuk mengetahui kesan ketegangan yang diberikan terhadap rintangan. Sampel disediakan dengan empat jenis ketebalan berbeza (2, 4, 6 dan 8 lapisan) dimana setiap lapisan dihasilkan dengan menggunakan pita selofan untuk menghasilkan ketebalan berbeza. Kaedah cetakan digunakan adalah kaedah cetakan skrin dan sampel diukur menggunakan prob empat mata didalam unit Ω/sq. Sampel akan diuji dibawah tiga kondisi berbeza dimana kondisi pertama sampel akan diukur didalam suhu bilik (32 ºC). Kondisi kedua, sampel akan diuji didalam pelbagai suhu (40, 60, 100 ºC). Kondisi terakhir, sampel akan diuji didalam suhu bilik dibawah pelbagai tegangan (20, 40, 60, 80 %) yang dikenakan padanya, dimana angkup vernier digunakan untuk meregangkan sampel. Karbon digunakan sebagai dakwat konduktif dan poliuretana termal digunakan sebagai substrat didalam kajian ini. Hasil kajian menunjukkan apabila semakin tebal dakwat, rintangan akan berkurangan Bagi ujian mekanikal atau ketegangan pula apabila semakin tinggi tegangan dikenakan pada sampel, semakin tinggi rintangan dihasilkan oleh sampel.

ACKNOWLEDGEMENTS

First of all I would like to take this opportunity to express my gratitude and thanks to my supervisor Dr. Mohd Zaid Bin Akop from Faculty of Mechanical Engineering, Universiti Teknikal Malaysia Melaka (UTeM) for his guidance, sincerity supervision, support and encouragement to ensure the project turned out to be a successful one.

I also would like to express my deepest gratitude to Siti Ashikin Binti Azli, Master student from the Faculty of Mechanical Engineering that always helping and giving advices to me in doing the task and experiment. The guidance and assistance in handling the equipments and machines provided was really helpful.

My sincere appreciation goes to my loving family who always supported and encouraged me by providing necessary support both financially and mentally whenever there was a need for it. Also special thanks to my friends Muhammad Zaim Bin Azmi, Nurul Syafika Binti Rozali, Nurul Hasanah Binti Sobri, Abdul Mueezz Bin Abdul Raheem and Muhammad Amin Bin Othman who always helps and sharing knowledge to me.

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LIST OF ABBREVIATIONS

PCB	Printed Circuit Board
SPC	Stretchable Printed Circuit
FR4	Fiber Glass
TPU	Thermoplastic polyurethanes / Thermal polyurethane
PWB	Printed Wiring Board
PDMS	Poly Dimethyl-Siloxane
PET	Polyethylene terephthalate
HTV	High Temperature Vulcanizing
LTV	Low Temperature vulcanizing
LSR	Liquid Silicone Rubber
CIJ	Continuous Inkjet
DoD	Drop on Demand
ASTM	American Society for Testing and Materials
MSDS	Material Safety Data Sheet

LIST OF SYMBOLS

s	=	spacing
mm	=	millimeter
cm	=	centimeter
m	=	meter
Rs	=	Sheet resistance
V	=	Voltage
I	=	Current
R	=	Resistance
Ω	=	Resistance
Ω/sq	=	Resistance per square

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CHAPTER 1

INTRODUCTION

1.1 Background of Research

The printed circuit board or PCB is a board that connecting electrical component together and actually make the device working and functioning correctly. The part of the PCB is consist of substrate, copper layer, soldermask and silk screen. The existence of the PCB really improve our technologies to another level.

But due to the restriction of the PCB which cannot be bend or stretch it make the PCB less favorable in small devices so there come the new technology which is stretchable printed circuit (SPC) or also known as stretchable printed ink. SPC is a circuit board that are made from combination of substrate but not same as the substrate used on PCB which is FR4 or also known as fiberglass or any solid component that are unbendable or stretchable and conductive ink

The substrate used is something flexible such as fabric, plastic and any flexible material that are suitable to be used, in this research the substrate used is thermoplastic polyurethanes or TPU which is bendable and stretchable. The conductive ink used is carbon and the ink will be printed above the substrate using screen printing method and the purpose of the ink is to conduct electricity through the stretchable printed circuit, this ink work as replacement of the copper layer in PCB.

After completing printing the conductive ink to the substrate, the substrate will be place inside oven for curing process. The last step after curing process is the testing process which is 4 point probe is used to measure the resistivity of the stretchable printed circuit board in unit of ohm/sq. The function of the SPC is same as normal printed circuit board but it is bendable and stretchable which make the SPC more versatile and can be use inside small devices or even in complicated shaped devices.

1.2 Problem Statement

The technology nowadays keep improving and more complex. In order to make something powerful yet small in size is becoming more and more difficult due to the restriction on printed circuit board (PCB) that not bendable and stretchable. But the PCB has evolved day by day and now the latest technology is stretchable printed circuit (SPC) which are bendable and stretchable. The substrate was made up using stretchable material such as fabric and plastic which allow the printed circuit board to become flexible and stretchable. With this two new features the use of the SPC made something impossible before to something possible, as can be seen the design of the television, phone and other gadget becoming more smaller and unique but the function of the device much better than before. This is due to the flexible and the stretchable properties of the SPC.

There are several problems that causing the limitation of SPC in the industries, such as the thermal properties, physical properties and electrical resistivity of the SPC. These problems will be study based on the parameter related, for example the effect of the temperature and strain to the conductive ink and substrate.

The effect of the line thickness cross-sectional to stretchable printed circuit under thermal performance will be covered in this research. There are different thickness of conductive ink was used to study the effect on resistivity and how to improve the quality of the SPC. The conductive ink and the substrate used in this study are carbon ink and thermal polyurethane (TPU) respectively.

1.3 Objective

The objective for this research are :

1. To study the effect of thickness of the ink to the resistance.
2. To study the effect of the temperature to the resistance.
3. To study the effect of the strain applied to the stretchable printed circuit to the resistance.

1.4 Scope of Study

The scope of study is listed as below :

1. Screen printing process to print the ink on the substrate.
2. Curing process to cured the samples.
3. 4 Point probe resistance test to measure the resistivity of the samples.
4. Mechanical and thermal testing of the specimens based on various temperature and strain.
5. Variable ink thickness (2 layers, 4 layers, 6 layers and 8 layers).

1.5 Planning and Execution

The research activities and progress for PSM 1 is been illustrates as Figure 1.1. The figure includes the flow and process of the research such as title selection, literature review, designing the experiment, formulation of samples, material characterization testing that consist of mechanical and thermal testing, data analysis, report writing then followed by report writing and report submission and the last one is PSM 1 seminar. In PSM 2 the research activities was continued. The new sample was prepared and used for the mechanical and thermal characterization test, followed by the data analysis process before compiling the final result in the report. The research activities present in PSM 2 was illustrated in the Figure 1.2.

WEEK ACTIVITIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Research Title Selection														
Literature review														
Design of experiment														
Formulation of sample														
Characterization testing • Mechanical • Thermal														
Data analysis														
Report writing														
Report submission														
PSM 1 Seminar														

Table 1.1 : Gantt Chart for PSM 1