EFFECT OF TYPE OF SUBSTRATES TO CONDUCTIVE INK UNDER THERMAL PERFORMANCE

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A report submitted

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DECLARATION

I declare that this project report entitled “Effect of type of substrates to conductive ink 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 terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Honours.

Signature	: ……………………..
Supervisor's Name	:……………………....
Date	: ……………………..

DEDICATION

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

Azmi bin Saad and Zaitun binti Ibrahim

ABSTRACT

This research project were done to investigate the effect of type of substrates to conductive ink under thermal performance. Two type of substrates were use which is Thermoplastic Polyurethanes (TPU) and Polyethylene Terephthalate (PET) were considered to be use in this research project. Carbon conductive ink from company *Bare Conductive* were used to be printed on the substrates using screen printing method. Instead of conventional method of screen printing method which use mesh as ink template, two tape were tape parallel to each other with the gap of 3 mm to create the ink template. The consistency of the ink printed where considered before continue with the resistivity test of the substrate. The conductive ink were printed for both TPU and PET substrates to be use for the resistivity test & surface roughness test. The electrical resistivity were tested using four-point probe from Jandel's RM3000 test unit, with using ASTM F390-98 as guideline. In terms of the substrate's resistivity, it can be conclude that the TPU resistivity is much lower than PET resistivity where TPU at room temperature have 149.2 Ω/sq while PET have 370.8 Ω/sq at room temperature which is twice the amount of TPU. For the resistance against temperature's result, the resistivity of the conductive ink on both substrates will decrease as the temperature applied to the conductive ink increase where at 100°C, TPU resistivity drop till 52.8 Ω/sq while PET resistivity at 100°C is 102.3 Ω/sq. The surface roughness of both of the substrates and the conductive ink will also decrease when the temperature applied increase where for TPU the mean surface roughness are 2.958μm at room temperature and drop to 1.17μm at 100°C while PET's mean surface roughness for room temperature are 1.921μm and drop to 1.332μm for 100°C. For the adhesion test, a new batch of TPU and PET samples were made to be conduct for this test. The test were conducted using ASTM D3359 as guideline. For the adhere test, the conductive ink appear to be easily detached from the TPU substrates compare to PET and the same results occurred as the temperature increase. However this result seems to be contradicted to the fact that higher surface roughness give better adhesion. Therefor, it can also be conclude that this conductive ink are not suitable as it is very easily detach from the substrates.

ABSTRAK

Projek penyelidikan ini dilakukan bagi menyiasat kesan jenis-jenis substrat kepada dakwat konduktif dibawah prestasi termal. Dua jenis substrat telah digunakan iaitu Poliuretana Termoplastik (TPU) dan Polietilena Tereftalat (PET) telah dipertimbangkan bagi digunakan didlam projek penyelidikan ini. Dakwat konduktif karbon daripada syarikat Bare Conductive telah digunakan untuk dicetak pada substrat mengunakan kaedah percetakan skrin. Daripada mengunakan kaedah konventional percetakan skrin iaitu mengunakan jerat sebagai templat dakwat, dua pita di pita selari sesamanya berjurangkan 3 mm untuk dibuat ruang sebagai templat dakwat. Konsistensi dakwat dicetak telah dipertimbangkan sebelum meneruskan ke ujian rintangan kepada substrat. Dakwat konduktif ini telah dicetak pada kedua-dua substrat TPU dan PET untuk kegunaan ujian rintangan dan ujian kekasaran permukaan. Rintangan elektrik telah diuji menggunakan prob empat titik daripada Jandel RM3000 unit ujikaji, dengan mengunakan ASTM F390-98 sebagai garis panduan. Dari segi rintangan substrat, ia boleh dirumuskan bahawa tahap rintangan TPU lebih rendah berbanding tahap rintangan PET dimana di suhu bilik, TPU mempunyai rintangan sebanyak 149.2 Ω/sq dan PET pula 370.8 Ω/sq iaitu dua kali ganda lebih banyak berbanding TPU. Untuk keputusan rintangan terhadap suhu, rintangan dakwat konduktif pada kedua-dua substrat akan berkurangan jika suhu yang dikenakan kepada substrat bertambah dimana di suhu 100°C, rintangan pada TPU menurun ke 52.8 Ω/sq dan PET pul menurun ke 102.3 Ω/sq. Kekasaran permukaan kedua-dua substrat dan dakwat konduktif juga akan berkurang apabila suhu yang dikenakan bertambah dimana untuk TPU purata kakasaran permukaan adalah 2.958µm untuk suhu bilik dan menurun ke 1.17µm pada suhu 100°C manakala purata kekasaran permukaan bagi PET di suhu bilik adalah 1.921µm dan menurun ke 1.332µm ke 100°C. Untuk ujian kelekatan, kumpulan sampel TPU dan PET yang baru telah dihasilkan untuk digunakan di ujian ini. Ujian ini telah dijalankan mengunakan ASTM D3359 sebagai garis panduan. Untuk ujian kelekatan, dakwat konduktif didapati mudah untuk tercabut daripada substrat TPU berbanding substrat PET dan hasil yang sama juga berlaku apabila suhu ditambah. Namun keputusan ini kelihatan bercanggah dengan fakta dimana kekasaran permukaan yang tinggi mampu memberikan kelikatan yang lebih baik. Oleh itu ianya boleh dikonklusikan bahawa dakwat konduktif ini adalah tidak bersesuaian untuk kegunaan kerana ianya mudah untuk tercabut daripada substrat.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVATIONS

FEC	Flexible electric circuit
PCB	Flexible electric circuit
TPU	Thermoplastic polyurethanes
PET	Polyethylene terephthalate
IoT	Internet of things
CNT	Carbon nanotubes
SPC	Stretchable printed circuit
EMF	Electromotive force
Ag-MWNT	Silver multi-walled carbon nanotubes
AFM	Atomic force microscope
SP	Nano Silica Particle
RMS	Root mean square roughness
RA	Mean roughness
$(Mg_3Ca(CO_3)_4)$	Huntite/hydromagnesite mineral
TGA	Thermogravimetric analysis
DSC	Differential scanning calorimetry
Tg	Glass transition temperature

DBD	Dielectric barrier discharge
ASTM	American Society of Testing and Material

LIST OF SYMBOLS

°C	=	Celsius
V	=	Volt
A	=	Ampere
Ω/sq	=	Ohm per sheet square
σ	=	Conductivity
ρ	=	Volume resistivity
mm	=	Millimeter
μm	=	Micrometer
ℓ	=	Sample range length

CHAPTER I

INTRODUCTION

1.1 Background

Flexible electric circuit (FEC) or flexible circuit board is an revolutionized technology for printed circuit board (PCB) where its serve the same purpose which is connect electrical and mechanical component into a device. For PCB, it have a solid substrate property while the FEC have a flexible substrate property. This difference is one of the main point of interest in FEC as it can lead to creation of device or machine which is flexible to do a certain task.

The study on the FEC were conduct by many researcher which consist of combination of varies material of substrates, various combination of filler, binder and solvent to create a conductive ink, the thickness of the conductive ink as well as the width of the conductive ink as well. Not only the combination of filler, binder and solvent to create conductive ink will give a various kind of results data, the combination of substrates and conductive ink as well can give different data for its properties and reaction between the combination make it that there are million possibilities for the data to obtain.

In this study, the type of substrates used where compared between Thermoplastic Polyurethane (TPU) into Polyethylene terephthalate (PET). Both type of substrates will undergo the same experiment which is experiment test in room temperature and designed temperature of 40°C, 60°C and 100°C on both substrates and the ink, adhesion test, surface roughness test and the resistivity measuring of the conductive ink.

1.2 Problem statement

In the industry, the PCB were commonly use in making product. However there are a lot of limitation of PCB which searching for new alternative have been the aim of researcher to research for the new method for the electric circuit. Firstly the limitation of the size of the PCB where it is very hard to store. Bigger PCB mean that there are a lot of components can be attach to the board. However, bigger PCB mean bigger board and this will make it hard to transport or store. FEC reduce this problem where FEC can be reshape which it can be fold to reduce the area to store.

FEC usage is also new in the industry. Its combination between various substrates as well as various conductive ink are potential to have thousands of variety. Therefore there are lack of information and data of the usage of the FEC. This research also include the temperature effect on the combination of carbon conductive ink with TPU and PET substrate.

1.3 Objectives

The objectives of the study is to:

1) To analyst the resistivity of TPU and PET substrates with carbon conductive ink.
2) To compare the resistivity of both TPU and PET sample when different range of temperature applied on the sample.
3) To compare the surface condition of the TPU and PET sample before and after the temperature applied on the sample.
4) To analyst the adhesion capability of the carbon conductive ink on both TPU and PET sample with and without the temperature applied on the sample.

1.4 Scope of project

The scope of this study are to :

1) Make a comparison on the behavior of the substrates and ink when on temperature test of 40°C, 60°C and 100°C.
2) Make a study on the TPU and PET sample surface condition before and after the temperature test.
3) Make comparison on adhesion test result of the TPU and PET sample with no temperature applied and 100°C temperature applied samples.