ADHESION INTEGRITY OF EPOXY PASTE ON THERMOPLASTIC POLYURETHANE(TPU)

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This report is submitted
in fulfillment of the requirement for the degree of
Bachelor of Mechanical Engineering

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DECLARATION

I declare that this project report entitled "Adhesion integrity of epoxy on thermoplastic polyurethane (TPU)" 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 (Structure & Materials).

Signature : ....

Name of Supervisor :..................................

Date : ....

DEDICATION

To my beloved father Tan Yong Lee and mother Toh Mei Mei.

ABSTRACT

This study aspires to have an analysis of carbon filled epoxy conductive ink printed on thermoplastic polyurethane (TPU). The objectives of this study are to evaluate the resistivity of different filler loading of conductive epoxy on TPU substrate, compare the resistivity of epoxy paste under tensile test, and observe the morphological microstructure between epoxy paste and TPU. Specifically, the parameters that were evaluated adhesion integrity which include of sheet resistivity, tensile test and morphological analysis. This project starts with printing of conductive ink on TPU and cured using an oven. In experiment, multimeter is used to measure the sheet resistance value of the sample in ohms-per-square. It can detect the resistivity of different percentage of ink loading. The highest average resistivity is detected in low percentage of ink loading while the lowest one is found in high percentage of ink loading. In tensile test, a self made machine is used to stretch the TPU to test conductivity of conductive ink.The resistivity increase as the conductive TPU stretch, the resisitance decreased. In morphological analysis, light microscope is used to visualize the microscopic image of carbon ink categorized by the electrical properties of the ink. Ink loading with high percentage of carbon particles has conductivity while low percentage has no conductivity. At low percentage, the microstructure image shows no appearance of carbon particles element while for high percentage; the image shows the content of filler loading. The future researchers can use different type of substrate or different materials of conductive ink in order to do the same analysis.

ABSTRAK

Kajian ini bercita-cita untuk menganalisis dakwat konduktif karbon yang mengandungi epoksi. Objektif kajian termasuk menilai berbeza konduktif karbon, berbanding resistiviti semasa ujian tagangan dan memperhati morfologi karbon mikrostrukrur yang cetak atas TPU. Secara khususnya, parameter yang dinilai terdiri daripada resistiviti, ujian tegangan dan analisis morfologi. Untuk mencapai analisis, prob empat titik digunakan untuk mengukur nilai rintangan lembaran sampel dalam ohms-per-kuadrat. Beberapa peratusan kandungan dakwat telah mengesan kehadiran resistiviti dan beberapa peratusan lagi tidak mengesan kehadiran resistivitas. Purata konduktiviti tertinggi dikesan dalam kandungan dakwat yang berperatusan tinggi manakala resistiviti yang paling tinggi didapati dalam kandungan dakwat yang berperatusanrendah. Dari segi tegangan, mesin mudah digunakan di mana sampel untek regang. Sementara itu, bagi sampel yang mengandungi peratusan pengisi tinggi mudah pecah. Dalam analisis morfologi, mikroskop cahaya digunakan untuk memvisualisasikan imej mikroskopik dakwat konduktif karbon yang dikategorikan oleh sifat-sifat elektrik dakwat. Kandungan dakwat dengan peratusan karbon yang lebih tinggi mempunyai kekonduksian manakala dakwat yang berperatusan rendah tidak mempunyai konduktiviti. Pada peratusan rendah, imej mikrostruktur tidak memperlihatkan unsur nanopartikel perak manakala peratusan yang tinggi; imej menunjukkan kandungan pengisi yang berkilau. Penyelidik masa depan boleh menggunakan jenis substrat yang berlainan atau bahan berlainan dalam dakwat konduktif untuk melakukan analisis yang sama.

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Thanks to my supervisor Dr. Ghazali bin Omar for giving me this opportunity to do final year project with him. He never hesitated to give me advice and guidance whenever I confronted problems. I am thankful for his patience and advice while leading me in this project.

I revere the patronage and moral support extended with love, by my parents whose passionate encouragement made it possible for me to complete this project and not to forget my late father who is always in my prayers.

I am deeply indebted to all concerned persons who cooperated with me in this regard for their valuable help in preparing this project. My joy knows no bounds in expressing my cordial gratitude to my friends as their keen interest and encouragement were a great help throughout the course of this project.

I humbly extend my thanks to all people that involved either directly or indirectly in order to complete this project.

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ρ	-	Resistivity
A	-	Cross-sectional area of the ink
L	-	Length of sample trace from end to end
R	-	Resistance
l	-	Length of line in mm
W	-	Width in mm
R_{SH}	-	Resistivity of the sheet in *Ohm/sq*, Ω */sq*
V	-	Voltage across the inner pins
I	-	Current between the outer pins
T_m	-	Melting point
E	-	Estimation of error
Ra	-	Average of roughness

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Recent few years, stretchable and flexible conductive products have attracted considerable attention for their potential applications in wearable electronics, smart textiles, soft robotics, and structural health monitoring. Numerous efforts put on development of high sensitive and stretchable sensor which can be compliant and sensitive to detect the process of body motions and work to monitor deformations (Chang,2015). Therefore, conductive epoxy paste with electrical stabilty and material under large strains should be considered.

Thermoplastic polyurethane (TPU) is a linear block copolymers with domains of varying length resulting in a polymer with both hard and soft domains with varying degrees of crystallization. TPU is widely used for properties like high abrasion resistance, high performance at low temperature, high shear strength, elasticity, transparency and oil and grease resistance.

Conductive epoxy used to form electrically conductive bond between dissimilar materials eliminating need for soldering. Polymer composite materials are perfect candidates as lossy media, since their conductivity can be improved by adding fillers(Valentini,2014). Good adhesion epoxy paste can minimize the stress risers at soft interfaces like TPU that develop during stretching and can avoid to substrate failure.

Instead of bulky and rigid wires, a stretchable conductive technology can be used to carry the electrical signals. The conductive ink is often screen printed onto TPU. Reliability is a concern in many applications due to stretching, compression and bending. Interface adhesion between printed materials like TPU and contacts (Au, Ag, Cu, Al, etc.) is important for print quality and reliability (Steven,2016). Conductive epoxy paste are regularly printed on plastic sheets like TPU. Poor electrical performance, mechanical strength, and adhesion integrity limits interest in printing technology for the semiconductor industry.

1.2 PROBLEM STATEMENT

Nowadays, the use of conductive polymer is become a trend of topic since it involved in a variety of applications in electronic devices, electronic packaging, military and health care industry.The bonding and joining between epoxy paste and TPU is an important issue. In this case, different filler loading is important because it will affect the electricity of object. Besides, stretchable conductive technology are widely used. The stretching of printed conductive adhesive will affect conductivity.

In this study will focus on promoting the adhesion integrity of epoxy paste on thermoplastic Polyurethane (TPU) by identify the effective adhesive material for TPU polymer because defect of printed conductive ink lead to failure of conductivity.

1.3 OBJECTIVE

The objectives of this project are as follows:

1. To evaluate the resistivity of different filler loading of conductive epoxy on TPU substrate
2. To compare the resistivity of epoxy paste under tensile test
3. To observe the morphological microstructure between epoxy paste and TPU

1.4 SCOPE OF PROJECT

The scopes of this project are include the preparation of conductive epoxy paste, printing of epoxy paste on TPU and undergo test on adhesion integrity of epoxy paste and TPU. To test resistivity and mechanical property of conductive epoxy paste, conductivity test, tensile test and observation are carried out.

1.5 THESIS CONTENT

The actions that need to be carried out to achieve the objectives in this project are listed below.

1. Literature review

Journals, articles, or any materials regarding the project will be reviewed.

2. Preparation of printing

Conductive epoxy paste prepared for printing on TPU which consist of polymer epoxy, conductive fillers, solvents and additives.

3. Printing

Print the conductive epoxy on TPU substrate respectively.

4. Testing of Epoxy Paste Printing

Do mechanical testing like tensile test . Besides, conductivity test to test whether there's any conductive electricity after tensile. Observe the adhesity of TPU and epoxy using light microscope.

5. Analysis

Analysis will be presented on the tensile test, bending test and conductivity test. Adhesity integrity between epoxy paste and TPU is analyse by tests.

6. Report writing

A report on this study will be written at the end of the project.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The sources from previous studies on TPU, conductive epoxy, methods of printing, heat treatment, material of substrates, method of mechanical testing and the conductive ink characterization are being presented with the sources from previous studies in this field.

2.2 CONDUCTIVE INK

According to Ilda Kazani, conductive inks have been used in many applications include electronics, computers and communications. PCBs (Printed circuit boards), RFID tags (Radio-frequency identification) or wiring boards are example of applications of conductive inks. Diverse technologies such as notably screen printing have been applied at the most. Primarily, conductive inks are composed of a filler, binder,solvent(s) and additives (Sughosh, 2013). The conductive fillers are what provide the conductive properties, while the binder provides the needed adhesion to the substrate and cohesion to each other. Thus, the conductivity of an ink depends upon the amount of filler loading, particle size of the fillers, percentage of binder used and continuity of the printed layer after printing and drying.

2.2.1 EPOXY

Epoxies are mixture of resin and hardener. Normally, epoxy resins are widely used in industrial applications due to their properties which include toughness, strong adhesion, chemical resistance and other specialized properties. The preferred epoxy resin for use with the present invention is a solid or liquid epoxy resin (YueXiao, 2000).

2.2.2 Metal-based materials

In 2007, Hye-Jin Cho state that the metal nanoparticles used in a conductive ink composition include one or more nanoparticles from a group consisting of silver (Ag), gold (Au), copper (Cu), nickel (Ni), palladium (Pd), platinum (Pt), and alloys thereof. f. The particle size of the metal nanooparticles may be 20 to 50 nm. According to Ilda Kazani, metals like copper, silver and gold are used in conductive inks. The conductive ink are made of a dispersion of metal particles and suitable resins in an organic or inorganic solvent. The less electrimigration property of copper make it a good candidate material but the unstable thermodynamical property in atmospheric conditions will lead to oxidation and deterioriate the conductivity (Park,2007). Compared to gold ink, silverbased ink is better option due to lower price.

2.2.2.1 Silver

According to Shangjie Chang state that silver nanowires have high optical and electrical properties. Thus, there are widely used in flexible devices. Mohammed Mohammed Ali stated in 2017 that silver nanowire which print on TPU substrate can maintain electrical conductivity for tensile strain ranging from 16%-30%. Normally, the viscous nature and good adhesion capabilities makes silver compatible with screen printing process. Besides, Wenfeng Shen stated that silver nanoparticles were easily stored without degeneration and can synthesized with epoxy in an aqueous phase in 2014. The inks printed on paper in different patterning techniques. The resulting high conductivity of the printed silver patterns makes it suitable in the fabrication of flexible electronic devices.

2.2.2.2 Copper

Michael Grouchko states in Journal of Materials Chemistry that copper nanoparticles widely used in inkjet printing of conductive patterns because it is a low-cost replacement for silver and gold nanoparticles which are currently used in . According to Park, B. K., copper is an excellent candidate material due to its lower cost and less electromigration effect than novel metals. The oxidation of copper can be happened spontaniously which lead to the failure of conductivity.

2.2.2.3 Carbon nanotube (CNT)

Li Li Zhang state that carbon-based materials include activated carbons (ACs) to carbon nanotubes (CNTs) are the most widely used due to their excellent physical and chemical properties.For example, carbon-based material have properties like low cost, different form of carbon, ease of processability, relatively inert electrochemistry, and controllable porosity.

2.2.3 Polymer

In 2015, Chen et al. reported that conductive polymers have been widely applied in various electronic devices such as light emitting displays and batteries. In regards of their organic nature, the adhesion between conductive polymer thin films and flexible plastic substrates and their mechanical stability are the best, mainly under bending conditions.

Among conductive polymers, poly(3,4-ethylenedioxythiophene) or PEDOT is considered as one of the most favourable technologically electrically conductive polymers as it has stable electrical conductivity and versatile processability.

2.3 METHODS OF PRINTING

According to Cian Nash, to achieve continuous metallic pattern in a different kind of substrates, the direct printing of metals is important technique. Conductive inks used in different application as conductive connectors printed on paper or substrates which have strict requirements in terms of performance and stability. The inks can be applied on a variety of substrates using different printing method to obtain the desired patterns. For example, coating techniques include spin, spray, curtain, casting, painting, knife-over-edge coating, doctor blading are the printing methods used in different situation.

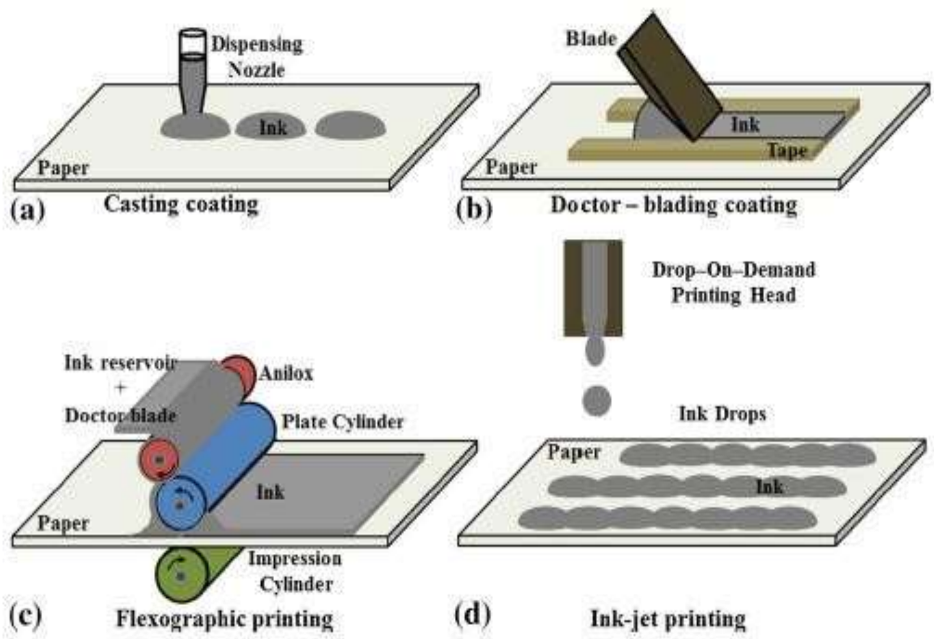

Figure 2.1 Methods of depositing the ink tracks

2.3.1 Doctor-blading

Paul D. Fleming III state that doctor blade is a printing method that removes the excess ink using blade. In the paper coating processes, doctor blading method are also used broadly. The doctor blade used to wipe the paste on the substrate with controlled adjustable angle.

According to Cian Nash, film formation that have 10 lm to 500 lm thickness range are allowed to use this printing method. Doctor blading method can minimized