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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

TIN ELECTRODEPOSITION ON CU SUBSTRATE FOR FLEXIBLE CONNECTOR INDUSTRIES

Submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Hons.)

by

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DECLARATION

I hereby, declared this report entitled "Tin Electrodeposition on Cu Substrate for Flexible Connector Industries" is the results of my own research except as cited in reference.

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Date : 7/9/2020

APPROVAL

The report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Hons.).

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ABSTRAK

Tembaga kebiasaannya digunakan sebagai konduktor elektrik kerana mempunyai tahap konduktor yang tinggi dan murah jika dibandingkan dengan perak dan emas. Walau bagaimanapun, disebabkan kurangnya tahap ketahanan terhadap kakisan dan pengoksidaan terhadap air, tembaga perlu disalutkan. Salutan timah digunakan sebagai penghalang kakisan agar tembaga tidak mengalami kakisan, lantas mengekalkan kekonduksiannnya. Disebabkan oleh kecekapan dan mudah dihasilkan secara besar-besaran, penyaduran timah terhadap tembaga sering digunakan. Kualiti terhadap salutan tembaga, bergantung sepenuhnya terhadap prosedur parameter penyaduran timah, contohnya seperti ketumpatan arus. Kaedah penyaduran timah telah ditetapakan oleh pembekal. Ketumpatan arus memainkan peranan penting terhadap kesan kepada mikrostruktur salutan tembaga, kekerasan dan kadar pemendapan. Oleh itu, siasatan perlu dilakukan terhadapnya. Penyaduran timah dilakukan pada substrat tembaga C11000 menggunakan proses aliran piawai, bermula dari pembersihan dan pembuangan minyak, pembilasan, pengaktifan, pembilasan sebelum penyaduran, penyaduran timah, pembilasan selepas saduran dan pempasifan timah. Menggunakan formula *Faraday's Law*, masa penyaduran timah dapat diketahui dengan 1016, 711 dan 545 saat, untuk ketumpatan arus pada 7, 10 dan 13 mA/cm^2. Pemendapan dilakukan pada kadar ketumpatan arus yang berbeza. Mikrostruktur pada salutan timah dapat dilihat menggunakan SEM dan XRD untuk analisa kristalografinya. Menggunakan ujian kekerasan Micro Vickers, kekerasan pada permukaan dapat diketahui dengan 37.33, 68.63 dan 86.07 HV untuk ketumpatan arus pada 7, 10 dan 13 mA/cm^2. Salutan yang sekata diantara ketiga-tiga ketumpatan arus yang telah diuji adalah pada ketumpatan arus 13 mA/cm^2. Kenaikan ketumpatan arus menigkatkan kadar penyaduran. Penambahan aditif dan proses-proses yang lain meningkatkan kualiti permukaan penyaduran.

ABSTRACT

Copper is commonly used as an electrical conductor because of its high conductivity and less expensive compared to silver and gold. Nonetheless, due to low resistance to corrosion and oxidation to water, copper is required to be coated. Tin coating is therefore used as a corrosion-resistant coating that prevents the copper's oxidation, thereby maintaining its conductivity. Due to high efficiency and easy mass production, tin electroplating on copper is commonly used method for coating tin on copper. The quality of the tin coating, however, is highly dependent on the parameter of tin electroplating such as current density. The method is already fixed by the supplier for the tin plating procedure. The tin electroplating current density has a significant effect on the microstructure of the tin coating, hardness and deposition rate. It is therefore necessary to investigate it. Tin electroplating was conducted on a C11000 copper substrate using a standard process flow from cleaning and degreasing, rinsing, activation, rinsing before plating, tin electroplating, rinsing after plating and passivation of tin. Using the Faraday's Law Equation, the tin plating time is calculated with 1016, 711 and 545 seconds for the current density of 7, 10 and 13 mA/cm^2. The deposition is done at varying current density. The tin coating microstructure is observed using SEM while XRD analyzes its crystallinity. Using Micro Vickers hardness tester, the surface hardness is measured with 37.33, 68.63 and 86.07 HV for the current density of 7, 10 and 13 mA/cm^2. It shows that a uniform coating is produced by the current density at 13 mA/cm^2 between the three of the current density tested. The rise in current density increases the rate of tin electroplating. Addition of additive and other processes increases electroplating surface quality.

DEDICATION

Only

my beloved father, Sulaiman bin Jusoh

my beloved mother, Rahimah binti Che Omar

my adored brothers, Khairul, Shahrul and Ezwan

my supervisor, Dr. Muhammad Zaimi bin Zainal Abidin

for giving me moral support, money, cooperation, encouragement, guidance and also understandings

Thank you so much and love you all forever

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LIST OF ABBREVIATIONS

Cu	-	Copper
MSDS	-	Material Safety Data Sheet
H_2SO_4	-	Sulfuric Acid
Sn	-	Tin
$SnSO_4$	-	Tin Sulfate
XRD	-	X-ray Diffraction
SEM	-	Scanning Electron Microscope
Al_2O_3	-	Aluminium Oxide
Ni	-	Nickel
OH	-	Hydroxide

LIST OF SYMBOLS

cm	-	Centimeter
m	-	Meter
%	-	Percent
g/cm^3	-	Grams per centimeter cube
mm	-	Millimeter
°C	-	Degree Celsius
kg	-	Kilogram
g	-	Gram
m	-	Mass
V	-	Volt
A	-	Ampere
m^2	-	Square Meter
s	-	Seconds
N	-	Newton
wt%	-	Weight Percent

CHAPTER 1

INTRODUCTION

1.1 Research Background

This study is going to discuss about tin electrodeposition on copper substrate for flexible connector industries. Electroplating is an electrolysis plating process from one metal to another that removes dissolved metal cations through the use of electrical current to create a thin, coherent metal coating on an electrode. Tin plating is famous because it can be used in the industries of medicine, marine, food and hardware. Certain electroplating uses include improving contact resistance, enhancing material longevity, and making it difficult to oxidize in moisture. The electrolytic cell (electroplating unit) is the core part of the electroplating system. A current which contains electrolyte is passed through a bath, anode, and cathode in the electrolyte cell, while steps are also taken in industrial production, pre-treatment, and post-treatment.

Electroplating tin from acidic plating solutions has been reported for over a hundred years. Besides stannous ions, the plating solutions contain different additives which make them complicated and difficult to monitor (Anqiang, 2007). The work piece to be placed is placed in a cathode (negative terminal) and the part of the anode will have a sacrificial anode (dissolvable anode) or permanent anode (inert anode). And typically, the sacrificial anodes for the deposited anode, and the permanent anode for the completion of the circuit as the deposition of the platinum and copper solution as inert anodes cannot be extracted. Electrolyte is the electrical conductor carrying the current in ions rather than free electron so that the positive ions are directed towards the cathode to complete the electrical circuit while negative ions pass on to the anode. It gives electrons to decrease certain strongly charged particles to metallic form as they reach the adversely charged work piece, and after that the metal ions are deposited on the surface of the counter-charged work piece.

Tin plating is achieved using three (3) elements that are tin anode as the origin of tin, the substrate as the working electrode, and the electrolyte tin salt solution. In industries, the electrolyte is usually made up of tin sulfate, sulfuric acid and additives known as accelerators, suppressors, and levelers that modulate electrodeposition levels on different substrate surfaces. Additives also play a role in the electroplating cycle as a stabilizer and brighter. Effect of additives on the tribological properties such as hardness, roughness and wear rates are very important in term of the quality.

Most of the surface property issues, however, are related to these three (3) stages. First, surface cleaning where pre-treatment takes place. Secondly, in the solution of tin plating and thirdly, after treatment with plating. Because the plating methods, surface cleaning and post-plating treatment have already been set, the tin electroplating parameters such as current density are the remaining variable parameters that have a direct effect on the quality of the tin plating and need to be examined.

Commercial tin plating usually uses commercial plating solutions including additives, special surface preparation, and also surface passivation to achieve standard coating and desired quality (brightness, roughness, uniform thickness, low internal stress etc.). The tin plating procedures in laboratories, however, are very different and require proper study to determine the effect of time, plating bath pH, and current density plating parameters.

In this study, the impact of tin plating on the formation of tin deposition is investigated based on effect of current density, additive concentration and pH of the bath. Tin plating rate, microstructure, microhardness, are evaluated between tin and copper substrate.

1.2 Problem Statement

The method of tin plating and the chemical content in the industries are usually fixed to ensure good tin coating standards such as thickness, hardness, roughness and cleanliness of the substrate. Deficiencies such as blisters, no plating and micro pit are usually associated with cleaning, degreasing and activation pre-treatment procedures. After the plating process, tarnish tin coating includes. Many defects, including low hardness, low thickness, no-plating surface, hydrogen embrittlement and surface-attached contaminant, can be determined during tin plating. The uneven thickness can be solved by changing the substrate holder, while by filtering the plating solution and regulating the concentration of the solution compounds, no-plating surface and contaminant can be reduced. The plating time, the plating bath pH and the density of the plating current are the three main variables which have a significant effect on tin plating rate, hardness and thickness.

However, the new plating line is yet to be tested in term of electrodeposition quality that produced by SUBITEC Sdn Bhd. Although from the MSDS as well as the manual have already stated the plating parameter, the chemical concentrations and current density effect on its properties are less known. In this study, the plating line and laboratory scale experiment is done by using electrodeposition method to study the copper substrate for flexible connector industries. The effect of current density, additive concentration and bath pH on the tin plating quality is studied using XRD, SEM and Micro Vickers hardness tester to evaluate surface morphological properties. Thus, it is important to study the effect of the quality of tin plating using the basic element of tin plating.

1.3 Research Objectives

The objectives of this study are as follows:

i. To electroplate tin coating on a copper substrate surface using standard process flow as per company requirements at various current density and deposition time.
ii. To study the tin plating surface morphology properties of the tin electroplating coating using scanning electron microscope, surface roughness measurements, micro Vickers hardness tester.

1.4 Scopes of the Research

The scope is focused on the project's limitation. In essence, this research focuses on the tin plating behavior on the copper plate. The research will be carried out by electroplating the deposition of tin on the copper substrate and the line plating lab scale has been established according to the industrial flow. The tin plating deposition will be conducted at specific current density. Using SEM, surface morphology is studied, then the hardness and roughness of the coating is determined by using micro Vickers hardness tester and portable surface roughness. For the elemental composition, XRD will be used for this study.

1.5 Important of Study

The important study as follows:

i. Can save time, costs and increase the deposition rate by using the appropriate plating method
ii. Improve the efficiency of the plating process
iii. Enhancing the process of electroplating
iv. Could differentiate between each process and its purpose
v. Produce the database on the impact of the electroplating process

1.6 Thesis Outline

The thesis starts with Chapter 1, outlining the research background problem statement, objectives, research scope and research justification on the impact of different process parameters on tin electroplating. Chapter 2 is a literature review that has compromised the parameter relevant to this paper of many previous study, test method and theory of tin electroplating process. Chapter 3 is a research methodology that explains the approach to research and the data analysis to be used in this study. Chapter 4 is a result and discussion that obtained during this study and the engineering knowledge will be applied to interpret and analyze the data. Chapter 5 will be focused on conclusion and recommendations; it will give the overall conclusion from this study. It also acknowledges the limitations and suggests further research which may be useful to carried out this study.

CHAPTER 2

LITERATURE REVIEW

This chapter is intended to explain the theory and work that was described and carried out before this by different researchers. Based on their work on the impact of different bath parameters on tin electroplating, related information from previous studies is extracted as references and discussion.

2.1 Tin Plating

According to (Kanani, 2004), every method has its own system and the process impact that helps us to pick the ideal plating. There are different processes that are mostly used in the electroplating industry, including mass plating, rack plating, continuous plating and line plating. Every process has its own particularity, such as the process to be used for the type of material to be coated.

2.1.1 Mass Plating

Mass plating is a process of electroplating which is used very quickly to plating a large number of components. Mass plating is performed by the barrel is loaded with parts and then placed in a container filled with the coating material. The barrel is then rotated to ensure that all barrel components are properly coated to protect against corrosion. Since mass plating is an electroplating process, the barrel cannot be made from an electrically conductive material because it could have a negative impact on the inside part coating quality. Mass plating barrels are commonly made of some kind of polymer. There are rods and other electricity carrying devices inside the barrel used to transfer an electrical charge to the internal components (Pandey, 2017).

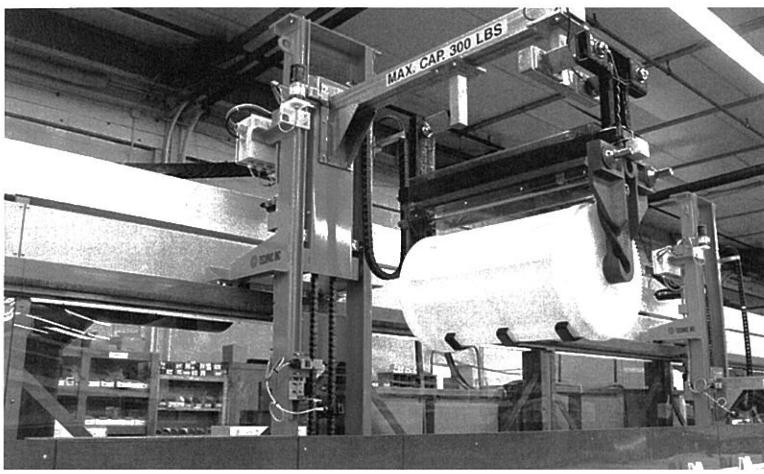

Figure 2.1: Mass plating (Image courtesy Technic Inc.)

2.1.2 Rack Plating

Rack plating is a process that provides certain methods to electroplate frail, large and complex components that are difficult to plate. The components are mounted on a fixture or jig, known as a 'rack' and subsequently immersed in a bath solution. Metal hooks are used when holding the parts in place on the rack to provide the necessary electrical contact. Uniform distribution of thickness is achieved as the rack can hold different parts that are plated simultaneously. The electroplating is carried out on parts of complex geometry with special finishing. Rack plating can be used to do so while minimizing time and expense, as it can hold several parts, as compared to submerging individual parts in a bath.

The fixture or jig is of metallic nature, providing a complete galvanic cell electroplating circuit. Screws, wires and pins provide the least electrical contact to ensure high-quality finishing for complex contours and fragile parts. Scratches and damage were prevented during the plating process of the rack by positioning the pieces well on the jig.

This is a labour-intensive and expensive method, however, as hanging the parts takes time. The shape, quantity and size of the parts should be considered before deciding on this method (Board, 2005).

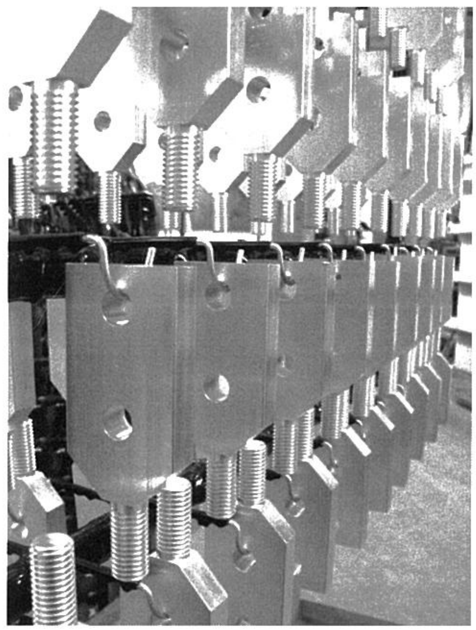

Figure 2.2: Rack plating (Image courtesy of Advanced Plating Technologies)

2.1.3 Continuous Plating

Continuous plating features a belt-type conveyor system where the coating substratum is guided through the system and directly coated. The belt goes through a variety of concurrent tanks with different processing solutions. As the substratum speed in all tanks is therefore constant, the substratum material is exposed to each bath for the same period of time. Since the complete system layout is matched to a particular substratum and product, the change to a new product usually involves the complete reconstruction of the system, but very large surfaces can be covered by the wide belts with constant quality. Flat plane belts require very low anode / cathode length, resulting in relatively constant coating results across the belt size, well reproducible and constant coating results. Continuous plating provides extremely high throughput, which significantly reduces the costs of coating relative to single plating components. Due to the equal distribution of the coating density, the results are