SURFACE MORPHOLOGY AND ELECTRICAL PROPERTIES OF COPPER-NICKEL ALLOY THIN FILM DEPOSITED ON PRINTED CIRCUIT BOARD USING THERMAL EVAPORATION METHOD

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by

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LIST OF ABBREVIATIONS

.gbr	Gerber file
BCC	body-centred cubic
Cu-Ni	Copper-Nickel
CVD	chemical vapor deposition
DC	direct current
DSC	Differential scanning calorimetry
FCC	face-centred cubic
I/O	Input Output
Ni-Cr	nickel-chromium
PCB	printed circuit board
PTH	Plated through Hole
PVD	physical vapor deposition
SI	Signal Integrity

SiC	silicon carbide
SMT	Surface Mounted Technique
TCR	temperature coefficient of resistance
T_g	Transition temperature
TGA	thermogravimetry analysis

LIST OF SYMBOLS

ε_r	Permittivity
λ	Mean free path
e	Electron charge
R	resistance
ρ	resistivity
R_s	Sheet resistance
α	Temperature coefficient of resistance

ABSTRACT

The increased in input/output (I/O) density due to the demand of high performances in devices caused the routing density on printed circuit board increased. This caused the board size increases due to the increased of trace width and trace spacing. Apart from that, the consumers preferred a small devices. This definitely against the customer's need because increasing in width trace caused the size of package also increases. One way to overcome this is by replacing the passive resistor with the thin film resistor. Therefore in this study CuNi thin film was selected as a thin film resistor material. The experiments consists of 3 parts (1) to measure the thickness of the thin film with desired resistance (2) to determine the Cu content with the desired electrical properties (3) to build the prototypes of the thin film resistor into suitable size as used by the industry and simulate the design to obtain a high value of insertion loss and low value of return loss. All samples were deposited using thermal evaporator at constant pressure. The adhesion between the film and the substrate were observed by using peel off test. The morphology were observed using SEM while the composition of the phase of the samples were confirmed using XRF, EDX and XRD. It was found out that 70 nm is the minimum thickness that suitable for thin film resistor. The quality of thin film resistors depends on Cu contents. 80/20 wt.% CuNi was found to be the desired composition with the best electrical properties compared to others. The same compositions was used for simulation purpose. From the simulation it can be said that all the thin film resistor are able to perform in frequency up to 5GHz. 80/20 wt.% CuNi able to achieved -2 dB for insertion loss and -30 dB for return loss

ABSTRAK

Peningkatan ketumpatan kemasukan/pengeluaran disebabkan oleh permintaan yang tinggi terhadap prestasi peranti menyebabkan kepadatan penghalaan pada papan litar tercetak meningkat. Ini menyebabkan saiz papan meningkat disebabkan peningkatan terhadap kelebaran dan jarak surih. Selain itu, pengguna juga lebih gemarkan peranti yang kecil. Ini pastinya menyanggahi keperluan pengguna kerana peningkatan dalam jejak lebar menyebabkan saiz pakej juga meningkat. Satu cara untuk mengatasinya ialah dengan menggantikan perintang pasif dengan perintang filem tipis. Oleh itu dalam kajian ini CuNi filem tipis dipilih sebagai bahan perintang filem tipis. Eksperimen ini terdiri daripada 3 bahagian (1) untuk mengukur ketebalan filem nipis dengan rintangan yang dikehendaki (2) untuk menentukan kandungan Cu dengan sifat-sifat elektrik yang dikehendaki (3) untuk membina prototaip perintang filem nipis ke saiz yang sesuai seperti yang digunakan oleh industri dan mensimulasikan reka bentuk untuk mendapatkan nilai kerugian kemasukan yang tinggi dan nilai kehilangan pulangan yang rendah. Semua sampel disimpan menggunakan penyejat haba pada tekanan malar. Lekatan antara filem dan substrat diperhatikan dengan menggunakan ujian pengupasan. Morfologi diperhatikan menggunakan SEM manakala komposisi fasa sampel disahkan menggunakan XRF, EDX dan XRD. Telah didapati bahawa 70 nm adalah ketebalan minimum yang sesuai untuk perintang filem tipis. Kualiti perintang filem nipis bergantung kepada kandungan Cu. CuNi berkomposisi 80/20 wt.% didapati komposisi yang dikehendaki dengan sifat elektrik yang terbaik berbanding dengan yang lain. Komposisi yang sama digunakan untuk tujuan simulasi. Dari simulasi, boleh dikatakan bahawa semua perintang filem tipis mampu beroperasi pada frekuensi sehingga 5GHz. CuNi berkomposisi 80/20

wt.% mampu mencapai -2 dB untuk kehilangan sisipan dan -30 dB untuk kehilangan kembali.

CHAPTER ONE

INTRODUCTION

1.1 Background

In general, electronic components can be classified into two; active or passive according to their effect on the power of signals applied to them. An active component can increase the power of signal, using energy that is supplied usually by a direct current (DC) supply. Passive component on the other hands, cannot increase the power of any signals applied to them and will inevitably cause power to be lost. They can be used to reduce power of a signal deliberately, to select part of a signal by its voltage, its frequency or its time relationship to another signal, to change shape of a waveform or to pass a signal from one section of a circuit to another, but in every case the power of a signal is decreased or unchanged (Kuphaldt, 2009).

Resistors, capacitors and inductors are the fundamental passive components. Resistors are one of the passive components that are commonly seen on the printed circuit board (PCB) of the electronic packaging. A resistor is used to reduce the flow of electricity in an electric circuit. Depending on the applications, resistors can come in a fixed resistor or a variable type. A fixed resistor cannot be changed as it set at a specific value, whereas variable resistor can manage flow at and below specific level (Sinclair, 2001). Resistors can be manufactured from a variety of materials and some of these materials have been used for a very long time example of the material used as resistor was copper alloy (Kang *et al.*, 2005a; Jeon, *et al.*, 2008). However, in this research study, the film resistors will be focused on.