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Procedia Chemistry 19 (2016) 619 – 625

Procedia Chemistry

5th International Conference on Recent Advances in Materials, Minerals and Environment (RAMM) & 2nd International Postgraduate Conference on Materials, Mineral and Polymer (MAMIP), 4-6 August 2015

Structural and Electrical Characterizations of CuNi Thin Film Resistors

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Abstract

This work studied the development of Cu-Ni for thin film resistor; specifically reported in this paper is the surface morphology and resistance. Films were deposited on the substrate of commercialized flame retardant (generally known as FR4) printed circuit board by using thermal evaporator. The thickness of the film was set to 100 nm and the dc current was maintained at 26 A. The sheet resistance and bulk resistivity of the thin films were measured via four-point probe test. The stability of thin film resistor was measured through temperature coefficient of resistance (TCR). According to the experimental results, it can be seen that the sheet resistance of the thin film resistor decreased with increasing copper composition.

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Peer-review under responsibility of School of Materials and Mineral Resources Engineering, Universiti Sains Malaysia

Keywords:CuNi thin film, four-point probes test, thin film resistor

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1. Introduction

Thin films technology in the electronic industries especially as resistor are developing very fast since they have potential applications in computers, smartphones, tablets and other electronic devices[1–7]. Copper nickel (Cu-Ni), an alloy made up between copper and nickel either physically mixing or chemically mixing to form homogeneous solid solution[7,8], is one of the material that is commercially used in fabrication of resistor since it is cheaper compared toother materials such as nickel chromium. Different sizes, shapes and composition of Cu-Ni alloys contribute to

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Peer-review under responsibility of School of Materials and Mineral Resources Engineering, Universiti Sains Malaysia
doi:10.1016/j.proche.2016.03.061

different properties however Cu-Ni alloys generally have low resistivity and low temperature coefficient of resistance (TCR) which are guaranteed to provide low and constant resistance over a temperature range [7,9]. These properties are required in microelectronic industries to improve batteries consumption. The most common copper alloy used in resistor is known as 'constantan' which is Cu alloyed with 45% Ni with low resistivity less than 50 μΩ.cm and extremely low temperature coefficient resistance (TCR) value less than 50 x 10^{-6} /K. There are a lot of techniques have been used in order to form Cu-Ni alloys such as mechanical alloying[7,9], sol gel method[10] and electrochemical process[11]. In this current work, we prepared Cu-Ni thin film resistor by using evaporation process and examined the surface morphology, and the dependence of electrical properties such as resistivity and TCR.

2. Methodology

A mixture of copper and nickel with appropriate composition were mixed according to the intended weight percentage. The alloy was milled for 3 hours using zirconia ball with ratio 1:10 of powder to ball before it was then palletized using pressing method. The pallet was used as the target source in evaporation technique using EMITECH K950X Turbo Evaporator. A 3.5 mm x 3.5 mm printed circuit board was used as the substrate in the deposition process. In order to see the effect of composition on the thin film resistor, the composition of copper was set to 50 wt. %, 60 wt. %, 70 wt. % and 80 wt. % of Cu. The electrical properties of the film such as sheet resistance and bulk resistivity were analyzed using JANDELL Cylindrical four-point probes with the samples were divided into 9 sites. In order to examine the stability of film against temperature, a set of TCR experiment was set up using the Wheatstone bridge theory as shown in Figure 1. The value of TCR can be obtained from the slope of temperature against resistance. Scanning electron microscope (SEM) model S-36; Leica Cambridge Ltd. with a Leo Supra 35VP system and X-ray fluorescence (XRF) were used for material characterization and verification including verification of samples composition, surface morphology and thickness cross section. Phase analysis was carried out using XRD (Philip PW 1820) to confirm the presence of Cu-Ni coated film after sputtering method with the addition of Xpert Highscore Software.

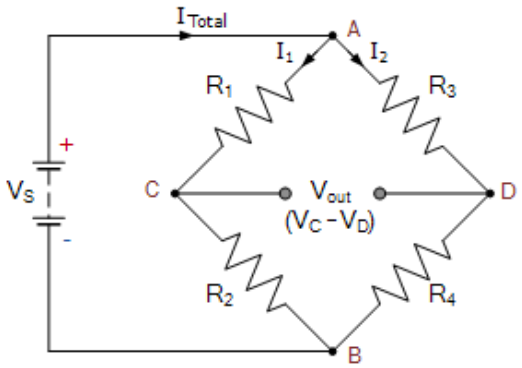

Fig. 1. Circuit used as TCR test

3. Results and Discussion

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