UNIVERSITI TEKNOLOGI MARA

ACTIVATION ENERGY STUDY OF INTERMETALLIC WITH THE ADDITION OF GRAPHENE NANOSHEETS INTO Sn-3.5Ag LEAD-FREE SOLDER

AMIRAH BINTI SALLEH

MSc

September 2021

AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

Name of Student	:	Amirah binti Salleh
Student I.D. No.	:	2015530563
Programme	:	Master of Science (Physics) – AS759
Faculty	:	Applied Sciences
Thesis Title	:	Activation Energy Study of Intermetallic with the Addition of Graphene Nanosheets into Sn-3.5Ag Lead-free Solder
Signature of Student	:	Amirah ……..
Date	:	September 2021

ABSTRACT

Sn-Pb solder has been used in electronic industry as interconnection for electronic packaging but Pb has been restricted as it high in toxicity which can harmful to human health and environment. Due to harmful effect, many research have been done in order to find a suitable replacement for the lead solder. Although many lead-free solders are available, the Sn-3.5Ag solder seem to be a suitable candidate due to its low cost. However, a minor addition of graphene nanosheets were added into the solder to improve the brittle formation of the intermetallic formation. In this study, 0.07 wt.% graphene nanosheets was added into the Sn-3.5Ag solder and this composite solder was prepared under powder metallurgy method. Experimental results showed that addition of graphene nanosheets to the Sn-3.5Ag solder alloy slightly increased the melting temperature and resistivity value of the solder. Meanwhile, the coefficient of thermal expansion of the solder was decreased. For the intermetallic study, the solder was reacted with copper substrate at 250 °C for one minute and aging for 100 hours up till 500 hours at 100, 125, 150 and 180 °C. For joint strength analysis, two copper strips were soldered together and was aged at temperature 100 °C for 500 hours. Scanning Electron Microscope (SEM) was used to observe the interfacial reaction and Instron machine was used to determine the joint strength. Cu_6Sn_5 intermetallic layer was formed at the interface between the Cu substrate and the solder. Composite solder showed the retardation of the intermetallic growth compared to the plain solder. The thickness values of the intermetallic was used to calculate the growth rate the intermetallic compound layer. The graphene nanosheets added solder has lower growth rate. From the kinetic analysis, the calculated activation energies for the intermetallic layers growth form for the Sn-3.5Ag and Sn-3.5Ag-0.07GNSs solder joints were 65.9 kJ/mol and 77.0 kJ/mol, respectively. Higher activation energy means more energy is required for the Sn-3.5Ag-0.07GNSs solder to undergo intermetallic formation.The surface diffusion of intermetallic was suppressed by graphene nanosheets because of their high barrier against diffusion of metal atoms. In addition, solder joints containing graphene nano-particles displayed higher joint shear strength compared to plain solder joint. The shear strength values of Sn-3.5Ag and Sn-3.5Ag-0.07GNSs solder joints after 1 minute reaction at 250 °C were about 94.0 MPa and 110.0 MPa, respectively meanwhile, their shear strength values after aging 500 hours were about 60.0 MPa and 77.5 MPa, respectively.

TABLE OF CONTENTS