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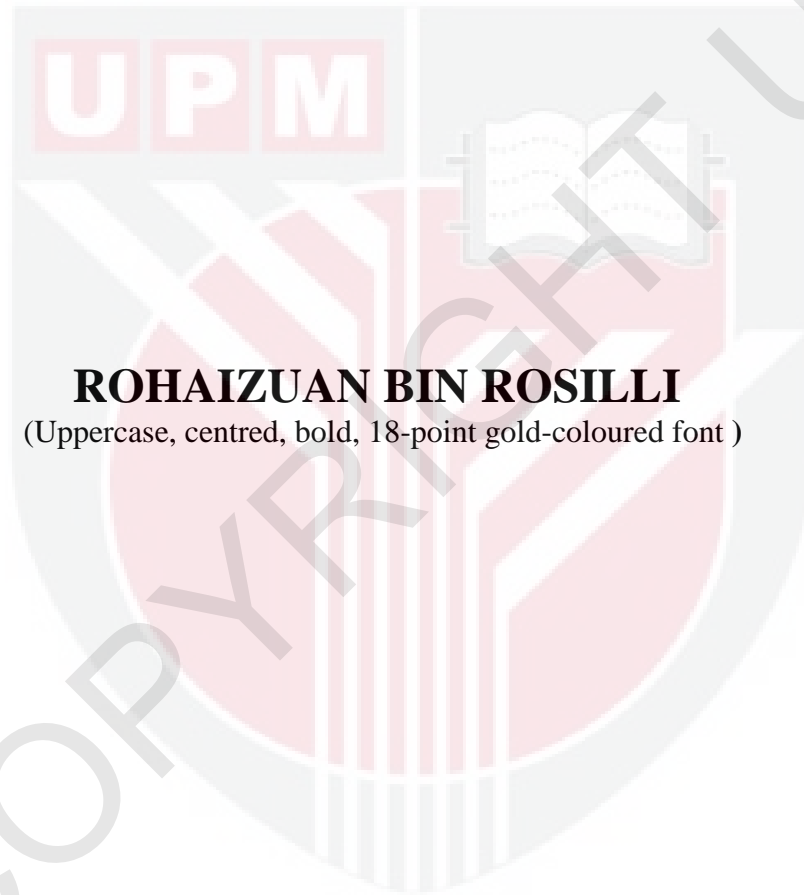
***BISMUTH-ARGENTUM ALLOYS AS ALTERNATIVE HIGH
TEMPERATURE LEAD-FREE SOLDER***

ROHAIZUAN BIN ROSILLI

FK 2012 28

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**MASTER OF SCIENCE
UNIVERSITI PUTRA MALAYSIA**

2012

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**BISMUTH-ARGENTUM ALLOYS AS ALTERNATIVE HIGH
TEMPERATURE LEAD-FREE SOLDER**



By

ROHAIZUAN BIN ROSILLI

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in
Fulfilment of the Requirements for the Degree of Master of Science**

September 2012

DEDICATION

Firstly, I would like to thank Allah the Almighty for having blessing of me with this opportunity and protecting me from obstacles in fulfilling this thesis. I might not know where the life's road will take me, but walking with You, Allah, through this journey has given me the strength.

Secondly, this thesis is dedicated to my parents who have been my side these latest years in spite of the little time I have been able to devote to them. They have never failed to give financial and moral support during my works in finishing my thesis.

Lastly, I'd like to express gratitude to all my friends for without them I would not be here and much less finishing the thesis.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master Science.

BISMUTH-ARGENTUM ALLOYS AS ALTERNATIVE HIGH TEMPERATURE LEAD-FREE SOLDER

By

ROHAIZUAN BIN ROSILLI

September 2012

Chairman : Azmah Hanim Binti Mohamed Ariff, PhD

Faculty : Engineering

Solder reaction is one of the oldest metallurgical processes for joining metal parts. Today, the use of solder in modern microelectronic technology is ubiquitous. Lead solder has been widely used in the semiconductor industry for a long time. However, despite the long term acceptance of lead by human society, lead poisoning is known well health treat. The common types of lead poisoning may be classified as alimentary, neuromotor and encephalic. Although Tin-Lead (Sn-Pb) can be replaced by lead free solder for low temperature applications, but there is no lead free solder available in the market that can replace the high temperature leaded solders. Most of the internal joining such as in first level interconnection flip chip is using 90-95 weight percent of lead. Stated in the RoHS (The Restriction on the Use of Hazardous Substances) regulation, the law gave exemptions to the industry by allowing the use of solder with above 85 weight percent of lead. Despite numerous studies on lead free solders in recent years,

there are only limited number of reports and journal on the research and development for high temperature lead free alternative solders. High temperature lead free soldering is a key technology for electronic components and assemblies, and requires a high level of process control. This technology can provide value-added characteristics to the products, including excellent heat conductivity and high reliability. High lead-bearing solders are still in use and hinder the recycling of consumer electronic products even though the circuit boards are assembled with intermediate temperature range lead free solder such as Tin-Silver-Copper (Sn-Ag-Cu). Tin-Antimony (Sn-Sb) and Sn-Sb based alloys are promising lead free solders for high temperature application. This is especially true of Tin-5Antimony (Sn-5Sb) because the melting point range is 234 °C to 240 °C. However the melting point is not above 260 °C to enable it in replacing Lead-10Tin (Pb-10Sn). Thus, the establishment of high temperature lead free solders or other interconnection technologies is an urgent priority in the electronics industry. In this research, three samples of Bismuth-Silver (Bi-Ag) alloys with different compositions were investigated using Differential Scanning Calorimetry (DSC) to check their melting point. For Sample 1 Bismuth-1.5Silver (Bi-1.5Ag), Sample 2 Bismuth-2.5Silver (Bi-2.5Ag) and Sample 3 Bismuth-3.5Silver (Bi-3.5Ag) are produced by using casting process. This research carried out some testing to compare their characteristics and properties such as comparison of Copper (Cu) grooving, Copper (Cu) grooving thickness, Copper-rich (Cu-rich) particles size in solder bulk and wetting angle using Optical Microscope in terms of cross sectional area. The area elemental analyses were carried out using Scanning Electron Microscope-Energy Dispersive X-ray (SEM-EDX). Mechanical grooving appeared in all samples and no intermetallic compound (IMC)

formed at the interface for first reflow, second reflow and third reflow process. Sample 3 that contain higher wt% of Ag is better compared to Sample 2 and Sample 1 because it increases the melting point, have greater Copper (Cu) grooving, give higher average of Copper-rich (Cu-rich) particles size and lower wetting angle. Third reflow process gives higher Copper (Cu) grooving and give a higher Copper-rich (Cu-rich) particles size average. But, it lowers the wetting angle value.



Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

**BISMUTH-ARGENTUM ALOI SEBAGAI ALTERNATIF PATERI TANPA
PLUMBUM BERSUHU TINGGI**

Oleh

ROHAIZUAN BIN ROSILLI

September 2012

Pengerusi : Azmah Hanim Binti Mohamed Ariff, PhD

Fakulti : Kejuruteraan

Reaksi pateri adalah salah satu proses metalurgi tradisional yang digunakan untuk menyambungkan bahagian logam. Penggunaan pateri dalam mikroelektronik teknologi moden hari ini adalah meluas. Pateri berplumbum telah digunakan secara meluas dalam industri semikonduktor untuk masa yang lama. Walaupun plumbum telah digunakan dalam jangka masa yang lama oleh masyarakat, keracunan plumbum kini dikenalpasti menjejaskan kesihatan. Jenis-jenis biasa keracunan plumbum boleh diklasifikasikan sebagai pencernaan, serat saraf dan kecacatan otak. Walaupun Timah-Plumbum (Sn-Pb) boleh digantikan dengan pateri tanpa plumbum untuk aplikasi suhu yang rendah, tetapi tidak ada pateri tanpa plumbum yang terdapat di pasaran yang boleh menggantikan pateri berplumbum yang bersuhu tinggi. Kebanyakan penyambungan dalaman seperti di peringkat pertama sambungtara cip terbalik menggunakan 90-95 peratusan plumbum. Dinyatakan dalam peraturan RoHS (Sekatan ke atas Penggunaan Bahan Berbahaya), undang-undang memberikan pengecualian kepada industri dengan membenarkan

penggunaan pateri melebihi 85 peratusan plumbum. Walaupun banyak kajian dijalankan pada pateri tanpa plumbum kebelakangan ini, terdapat hanya sebilangan kecil laporan dan jurnal penyelidikan dan pembangunan alternatif untuk pateri tanpa plumbum bersuhu tinggi. Pateri tanpa plumbum bersuhu tinggi merupakan teknologi utama bagi komponen elektronik dan pemasangan, dan memerlukan tahap kawalan proses yang tinggi. Teknologi ini dapat memberikan ciri-ciri tambahan bernilai kepada produk termasuk kekonduksian haba yang baik dan ketahanan yang tinggi. Pateri berkadungan plumbum yang tinggi sekiranya masih digunakan akan menghalang kitar semula produk elektronik pengguna walaupun papan litar telah dipasang dengan pelbagai pateri tanpa plumbum bersuhu sederhana seperti Timah-Perak-Kuprum (Sn-Ag-Cu). Timah-Antimoni (Sn-Sb) dan aloi berasaskan Sn-Sb telah menjanjikan pateri tanpa plumbum untuk aplikasi bersuhu tinggi. Hal ini berlaku kerana julat takat lebur Timah-5Antimoni (Sn-5Sb) adalah 234°C hingga 240°C . Walau bagaimanapun, takat leburnya tidak melebihi 260°C untuk membolehkannya menggantikan Plumbum-10Timah (Pb-10Sn). Oleh itu, pembuatan pateri tanpa plumbum bersuhu tinggi atau teknologi penyambungan lain adalah satu keutamaan segera dalam industri elektronik. Dalam kajian ini, tiga sampel aloi Bismuth-Perak (Bi-Ag) dengan komposisi berbeza telah dikaji dengan menggunakan Kalorimetri Imbasan Pembezaan (DSC) untuk memeriksa takat lebur. Bagi Sampel 1 Bismuth-1.5Perak (Bi-1.5Ag), Sampel 2 Bismuth-2.5Perak (Bi-2.5Ag) dan Sampel 3 Bismuth-3.5Perak (Bi-3.5Ag) dihasilkan dengan menggunakan proses tuangan. Kajian ini telah dijalankan dengan beberapa ujian untuk membandingkan ciri-ciri mereka dan sifat-sifat seperti perbandingan alur Kuprum (Cu), ketebalan alur Kuprum (Cu), saiz partikel dalam pateri aloi dan sudut pelarutan dengan

menggunakan Mikroskop Optik dari segi keratan rentas. Analisis kawasan unsur telah dijalankan menggunakan Mikroskop Imbasan Elektron-Sebaran Tenaga Sinar-X (SEM-EDX). Alur mekanikal muncul dalam semua sampel dan tiada sebatian di antara logam (IMC) terbentuk antara muka untuk kitar pertama, kitar kedua dan proses kitar ketiga pematerian. Sampel 3 yang mengandungi peratusan Perak (Ag) lebih tinggi adalah lebih baik berbanding Sampel 2 dan Sampel 1 kerana ia meningkatkan takat lebur, mempunyai alur Kuprum (Cu) yang lebih tinggi, memberikan purata saiz partikel Kuprum (Cu) yang lebih tinggi dan sudut pembasahan yang rendah. Proses kitar ketiga pematerian turut memberikan alur Kuprum (Cu) yang tinggi dan purata saiz partikel Kuprum (Cu) yang lebih tinggi. Namun, ia mengurangkan nilai sudut pembasahan.

ACKNOWLEDGEMENTS

Thanks Allah for helping me out while I am about to give up and unbelievably close support most of the time. I gratefully would like to express my expression to those who has helped me for completing this project.

First, I would like to express my highest appreciation to my former supervisor, Dr. Azmah Hanim Mohamed Ariff and co-supervisor, Dr. Tang Sai Hong. Without their guidance and dedication throughout all the stages of this project, it is hardly for me to complete the work. Their overwhelming friendliness did make it a pleasure to work with them. I also appreciate the support and love of my parents and my family.

I also would like to thanks Mr. Ismail Bin Abdul Ghani from Chemical Process Engineering Lab 1 (SEM & EDX) in Department of Chemical & Environmental Engineering UPM, Mr. Ahmad Shaifudin Ismail, Mr. Tajul Ariffin Md. Tajuddin, Mr. Ishak Mohd Yusof from Casting Laboratory in Department of Mechanical and Manufacturing Engineering, UPM who helped me in conducting the research and gave full cooperation to me until I finished my work.

I also would like to extend my thanks to Mrs Noriza Maslan from Faculty Science and also for Mr Mohd Kadri Masaud from Institute of Advanced Technology (ITMA), UPM that helped me in characterization techniques.

My deepest appreciation goes to my beloved parents and family who always showers me in each and every moment with love, motivation and prayers.

Last but not least, to my friend, Shahrul Fadzli Muhamad Zam and also those who had giving a hand, directly or indirectly in helping me to finish my project and thesis successfully.



I certify that a Thesis Examination Committee has met on 10 September 2012 to conduct the final examination of Rohaizuan Bin Rosilli on his thesis entitled "Bismuth-Argetum Alloys As Alternative High Temperature Lead-Free Solder" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

Members of the Thesis Examination Committee were as follows:

Mohd Khairol Anuar b. Mohd Ariffin, PhD

Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Faizal b. Mustapha, PhD

Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Nuraini bt. Abdul Aziz, PhD

Senior Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Mohd Zaidi b. Omar, PhD

Associate Professor
Faculty of Engineering and Built Environment
Universiti Kebangsaan Malaysia
(External Examiner)

SEOW HENG FONG, PhD

Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 22 November 2012

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of **Master of Science**. The members of the Supervisory Committee were as follows:

Azmah Hanim bt. Mohamed Ariff, PhD

Senior Lecturer

Faculty of Engineering

Universiti Putra Malaysia

(Chairman)

Tang Sai Hong, PhD

Associate Professor

Faculty of Engineering

Universiti Putra Malaysia

(Member)

BUJANG BIN KIM HUAT, PhD

Professor and Dean

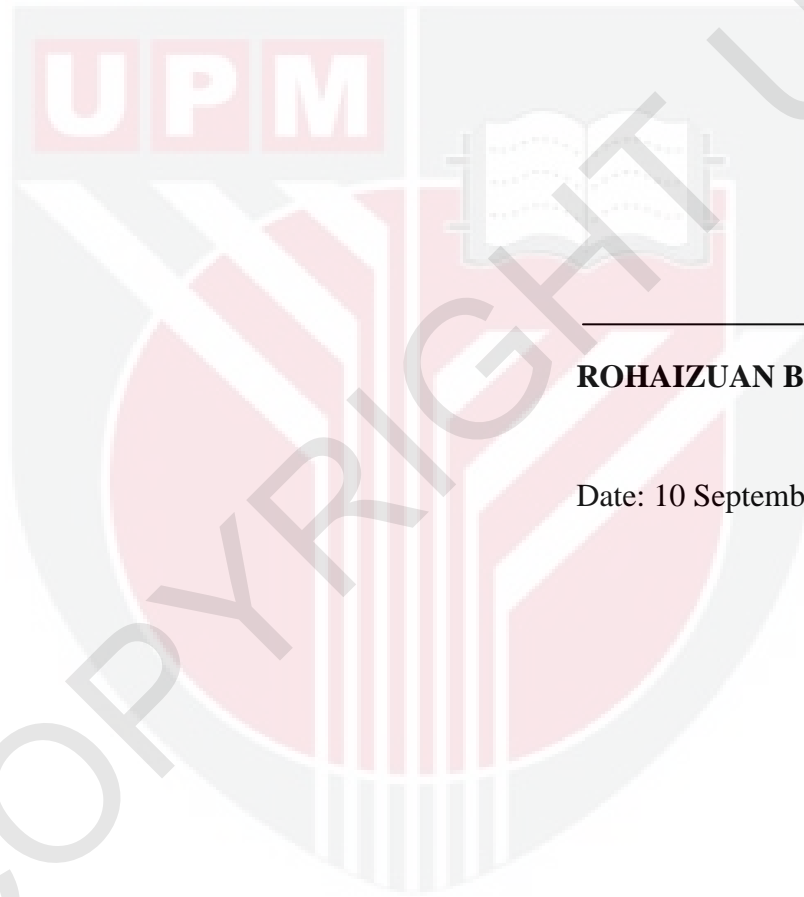
School of Graduate Studies

Universiti Putra Malaysia

Date:

DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.



ROHAIZUAN BIN ROSILLI

Date: 10 September 2012

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