A STUDY ON THERMAL MANAGEMENT™ IN ELECTRONIC PACKAGING COMPONENTS

AWANG ALIAS BIN AWANG MASRI

Tesis Dikemukakan Kepada
Fakulti Kejuruteraan, Universiti Malaysia Sarawak
Sebagai Memenuhi Sebahagian daripada Syarat
Penganugerahan Sarjana Muda Kejuruteraan
Dengan Kepujiaan (Kejuruteraan Elektronik dan Telekomunikasi)
2002

ACKNOWLEDGEMENT

Directly and indirectly, many people have involved in the preparation of this thesis. Firstly, I would like to thank to my supervisor, En Al-Khalid Othman for his guidance, advices, comments and encouragement in finishing this project. Also thanks to the all lecturer faculty of engineering of UNIMAS, for their support.

I also would like to take this opportunity to thank my family especially to my father, En Awang Masri Bin Awang Telaha and my mother, Puan Yot Bin Bujang for their helps and motivation along the way to completing this project.

I would also like to thank the laboratory assistants and technicians, En Wan Abu Bakar and En Zakaria for their unflagging supports during completing my project.

Finally, I would like to thanks all my friend especially Dullah, Zaki, Dyg Azra, Fadly, Eugene and Mohd Ariffin, who gave given their constant support and encouragement to me. To all those named above and any others, who may have been omitted, I'm extremely grateful.

ABSTRACT

Thermal Management is the most important protection of the Integrated Circuit (IC) and electronic component. This is because TM is important to ensure or to provide the desired mechanical and environmental protection to ensure reliability and performance of the product. Thermal Management is one of the keys that had been purposes to the electronic packaging to cool and maintain the integrated circuit and electronic component. It is commonly believed that a significant fraction of electronic "failures" are directly related to thermally induced problems. As devices get smaller and power goes higher, electronics designers need to continually challenge traditional methods of design to develop more reliable product designs and Thermal Management be apply to extend the useful lifetime of the electronic product. Therefore if we want our phones, computers, radio, hand pone and any component to work well for a long time we must seriously consider thermal management when designing any component electronic.

ABSTRAK

Pegurusan terma merupakan salah satu perlindungan utama dalam melindungi litar bersepadu dan komponen elektronik. Ini adalah kerana Pengurusan terma adalah penting dalam menyediakan keadaan mekanikal dan persekitaran yang terlindung dan sesuai untuk mempastikan kebolehharapan dan penampilan sesuatu produk. Pengurusan terma juga merupakan salah satu kunci yang telah diaplikasikan di dalam bungkusan elektronik untuk proses menyejuk serta menstabilkan litar bersepadu dan komponen-komponen elektronik. Adalah dipercayai bahawa sedikit kegagalan dalam alat elektronik adalah berkait rapat dengan masalah pengurangan terma. Oleh kerana peralatan elektronik semakin hari semakin kecil dan kuasa yang digunakan semakin meningkat, jurutera elektronik haruslah meneruskan tradisi cabaran untuk mereka cipta peralatan yang lebih boleh diharap dan pengurusan terma diaplikasikan untuk mempastikan produk elektronik dapat digunakan untuk masa yang lebih panjang. Oleh itu sekiranya kita ingin mempastikan telefon, komputer, radio, telefon bimbit dan komponen dapat digunakan dalam keadaan yang lebih baik pada masa yang lebih lama kita haruslah mengambil berat akan masalah terma sebelum mereka sebarang peralatan electronik.

LIST OF CONTENT

LIST OF FIGURE

Pages

LIST OF TABLE

LIST OF GRAPH

CHAPTER 1

INTRODUCTION

1.1 ABOUT THE PROJECT

The project is about a study on thermal management(TM) in electronic packaging component. The basic idea of this project are through quantitative methodologies which can be devide into experimental methodologies and computational methodologies. The experimental methodologies is a done by collecting data on actual response of the passive component that are test at difference type of failure mechanism. Example of passive component are resistor and capacitor. After the data are collected the computational method are analyse by using a Matrix Laboratory (MATLAB) software which can analyze the data and tranform or simulate its into a graph.

1.2 OBJECTIVES

The project required a study and investigation of the thermal management on electronic packaging component especially on the passive component. The project also involves experimental work and simulation by using MATLAB. The specific objective of this study is to bring both theoretical and practical aspects of electronics engineering and basic experimental work by:

a) Investigate the TM of the second level electronic packaging component on carbon resistor and capacitor using a hybrid, computational and experimental approach.

b) Study the different types of electronic component or TM-Characteristics by using a data collection.

c) Understand the basic idea of Analysis and experimental work in the laboratory.

d) Understanding the simulation step by using MATLAB and do some analysis.

1.3 METHODOLOGY

The first method is by making a literature review of the project. This literature review involves information regarding the thermal management in electronic packaging component. Then the project continues with experimental test with the selected component, preparation of the component and a location needed for experimental. Finally an analysis by using MATLAB by developing a simple program and analyzed the output.

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL INFORMATION

Nowadays Thermal Management TM is one of the most important way to protect the Integrated Circuit (IC) and the electronic component. TM is one of the important approaches to ensure or to provide the desired mechanical and environmental protection for reliability and performance. Thermal Management is one of the keys that had been purposes to the electronic packaging to cool and maintain the integrated circuit. There are two objectives of Thermal Management, and there are:

a) To prevent catastrophic thermal failure.

b) To extend the useful lifetime of the electronic system

Catastrophic thermal failure is usually the result of thermal fracture of a mechanical element or separation of leads. It cans also a result in semiconductor material failure due to overheating.

As devices get smaller and power goes higher, electronics designers need to continually challenge traditional methods of design to develop more reliable product designs and Thermal Management be apply to extend the useful lifetime of the electronic product.

2.2 THERMAL DESIGN CONSIDERATIONS

There is a need to consider Thermal Design and Thermal Management due to the increasing power dissipation of modern electronic systems and their components. The demand for higher integration, which is placing more functionality and performance into smaller volumes that compounds the problems need to be associate with providing adequate cooling. Without adequate cooling there is risk of increased production line fallout and field failures in electronic component. Many strategies for improved cooling, such as heat sinks, higher airflow, fans and ventilation are counter-acting to the requirements of other product design considerations. [Steyer, 1994]

As System operating frequencies increase, electronic components must dissipate more power to accommodate the needed reduction in access time. Thermal considerations become increasingly important in designs as power consumption approaches the limits of the package power dissipation.

2.3 THERMAL INTERFACE MATERIALS

Today's semiconductors, whether discrete power or logic ICs, are smaller and run faster, therefore they generate more heat. Some microprocessors dissipate power levels that were once the exclusive domain of discrete power devices, namely 10 to 25 watts. These power levels require thermal management techniques involving large capacity heat sinks, good airflow and careful management of thermal interface resistances. A well-designed thermal management program will keep operating temperatures within acceptable limits in order to optimize device performance and reliability.[Steyer, 1994]

Every component in microelectronic are kept within their operating temperature limits by transferring junction generated waste heat to the ambient environment, usually the surrounding room air or in the casing itself. This is best accomplished by attaching a heat sink to the component package surface thus increasing the heat transfer between the hot case and the cooling air. Heat sinks may be selected to provide optimum thermal performance. Once the correct heat sink has been selected, it must be carefully joined to the component package to ensure efficient heat transfer through this newly formed thermal interface. The rate of conductive heat transfer, Q, across the interface is given by:

$$Q = \frac{kA(Tc - Ts)}{L}$$

Where k is the thermal conductivity of the interface, A is the heat transfer area, L is the interface thickness and Tc and Ts are the device case and heat sink temperatures respectively. The thermal resistance of a joint, Rc-s, is given by

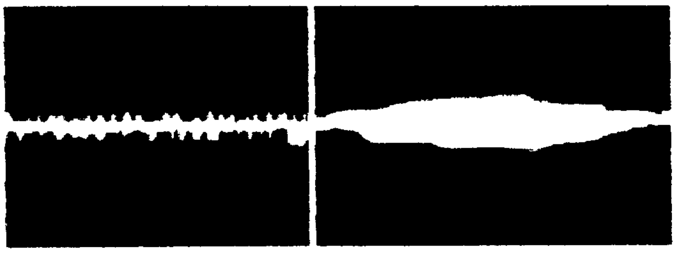
$$Rc - s = \frac{(Tc - Ts)}{Q}$$

And on rearrangement,

$$Rc - s = \frac{L}{kA}$$

Thus, the thermal resistance of the joint is directly proportional to the joint thickness and inversely proportional to the thermal conductivity of the medium making up the joint and to the size of the heat transfer area. Thermal resistance is minimized by making the joint as thin as possible, increasing joint thermal conductivity by eliminating interstitial air and making certain that both surfaces are in intimate contact.

Attaching a heat sink to a component package requires that two solid surfaces be brought together into intimate contact. Unfortunately, no matter how well prepared, solid surfaces are never really flat or smooth enough to permit intimate contact. All surfaces have a certain roughness due to microscopic hills and valleys as shown in Figure 2.1 A. Superimposed on this surface roughness is a macroscopic non-planarity in the form of a concave, convex or twisted shape as shown in Figure 2.1 B. As two such surfaces are brought together, only the hills of the surfaces come into physical contact. The valleys are separated and form air-filled gaps.



A. Surface roughnes: B. Poor surface flatness

FIGURE 2.1: Representation of surface irregularity[Miksa, 1995)

When two typical electronic component surfaces are brought together, less than one percent of the surfaces make physical contact. There are as much as 99% of the surfaces is separated by a layer of interstitial air. Some heat is conducted through the physical contact points, but much more has to transfer through the air gaps. Since air is a poor conductor of heat, it should be replaced by more conductive material to increase the joint conductivity and thus improve heat flow across the thermal interface.

Several types of thermally conductive materials can be used to eliminate air gaps from a thermal interface, including greases, reactive compounds, elastomers and pressure sensitive adhesive films. All are designed to conform to surface irregularities. Thus eliminating air voids and improving heat flow through the thermal interface.