Study of Thermal Contact Resistance on Interface Materials

Sandesh G Shetty[1], Gourav Shanbhag[2], Saiprasad Shetty[3], Abhishek Shetty[4], Kumar Swamy MC[5]

[1,2,3,4] *Student, Dept. of Mechanical Engineering, Alvas Institute of Engineering and Technology, Karnataka, India*
[5] *Asst. Professor, Dept. of Mechanical Engineering, Alvas Institute of Engineering and Technology, Karnataka, India*

***

Abstract - *Thermal Interface Materials (TIMs) play a key role in the thermal management of microelectronics devices by providing a path of low thermal impedance between heat generating devices. TIMs provide mechanical coupling between the silicon device and the heat spreader sink. During device operation, the adhesive joint between the heat generating device and heat spreader sink is subjected to thermos mechanical stresses due to differences in thermal expansion coefficients of the silicone device and the heat spreader material. The adhesive joint can consequently de laminate the mating surfaces causing a significant increase in thermal impedance across the thermal interface material. TIMs offers improved thermal performance as well as enhanced reliability. In this present work experimentation carried out for different thickness of Bronze plates with constant loading conditions to determine the thermal resistance. Thermal resistances obtained from the experimentations concluding that the resistance for lower thickness and loading conditions are less.*

Keywords—TIM, Thermal resistances, heat transfer, Thermocouples, surface topography

1. INTRODUCTION

The efficiency of heat transfer from heat source to the heat spreader becomes a true challenge which novel electronics technology needs to manage. Generally commercial electronic devices can generate a large amount of heat. Thus, it means that the heat dissipation technology becomes more and more significant to ensure proper operating of electronic devices. The operation of integrated circuits (IC) at elevated temperature is a major cause of failures in electronic devices and a critical problem in developing more advanced electronic packages [1]. According to Moore's law, the number of transistors that can be placed inexpensively on integrated circuits doubles approximately every two years. The thermal management in such systems is therefore an important area of research [2]. The thermal interface materials are commonly one of the best choices to meet the thermal issue requirements. The thermal interface materials basic function is to fill micro-sized surface roughness (i.e. gaps, holes, etc) between two solid materials to improve the conduction of the heat from one material to another by reducing the thermal contact resistance between them. Thermal interface materials include thermal fluids, thermal greases (pastes), resilient thermal conductors, solders (applied in the molten state), and phase change materials (PCMs, which change to the liquid state from the solid state while they are in service) [3].The major challenge in TIM testing is caused by the fact that there is a significant difference between standardized lab test data and application-specific (or 'in-situ') test results in a given set of application conditions [4-5]. Standardized test methodologies are mandatory because the user has the right to a fair comparison between various TIMs from various vendors

2. WORKING METHODOLOGY

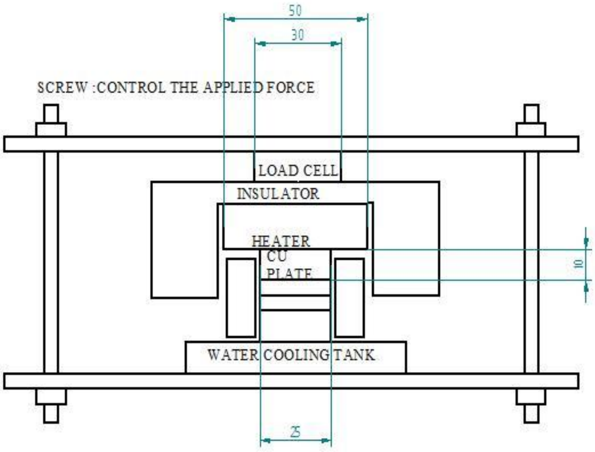

Fig 1. Experimental Setup

The apparatus comprise of three slabs of different materials of same thickness clamped on both sides using bolts and nuts. On one side of the composite wall a heater is fitted as shown in Figure 1.

Thermocouples are fitted at the interface of the plates at different points as to obtain average temperature for each surface. Heat conducted through the composite wall is taken away by circulating water on the outside of the wall whose rate of flow and an increase in temperature can be recorded.

First start the main switch, then by adjusting the dimmer knob give heat input to heater. Take the readings of all thermocouples after attaining the steady state. Make the dimmer knob to 'zero' position and then the main switch off. Repeat the procedure for different heat input.

3. RESULTS AND DISSCUSSIONS

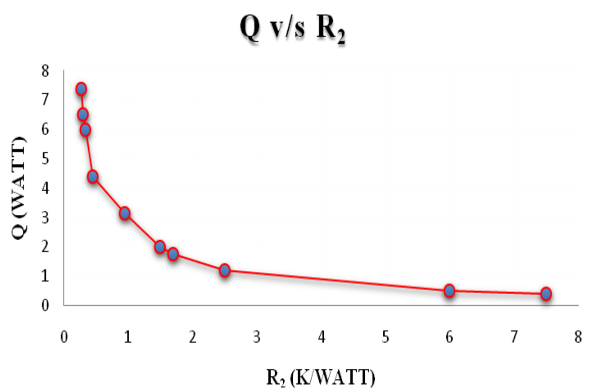

Chart-1: Heat transfer (Q) v/s Resistance (R_2)

Chart 2 shows that heat transfer versus resistance graph of Bronze material without load with thickness of 0.3mm, in that thermal resistance is increases due to the presence of air gap between interface material and the sink.

Table-1: Temperature distribution for bronze material with different surface finish

SI. NO	Q=VI (watts)	100 mesh polished			120 mesh polished		
		T1 °C	T2 °C	T3 °C	T1 °C	T2 °C	T3 °C
1	0.4	34	33	32	34	31	30
2	0.75	36	35	34	36	33	32
3	1.2	38	37	36	38	34	33
4	1.75	41	40	39	40	36	35
5	2.4	43	42	41	43	39	38
6	3.15	46	45	44	45	40	39
7	4	49	48	47	48	44	43
8	4.4	53	52	51	51	47	46
9	5.4	57	56	55	54	50	49
10	6.5	60	59	58	57	52	51

Table 1 provides the temperature distribution between the interface materials. T_1 shows the heater temperature, T_2 shows the temperature between heater and interface material and T_3 Shows the temperature between interface and sink. It has been observed that for 120mesh polished surface temperature distribution is more uniform compared to 100 mesh polished surface. This is because of the fine surface finish has more contact surface between the two material and also less air gap between the surfaces.

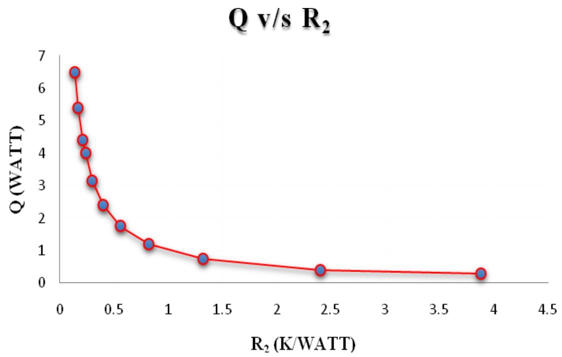

Chart-2: Heat transfer (Q) v/s Resistance (R_2)

Chart 3 shows that, as the material is polished with 100 mesh emery papers with 15kg load condition and thickness there is a rapid decrease in thermal resistance between the interface material and the sink. This is because the air gap between the interfacial material and the sink is decreased as the contact area increases. It can be observed that the resistance decrease when the surface is polished compared to loaded condition

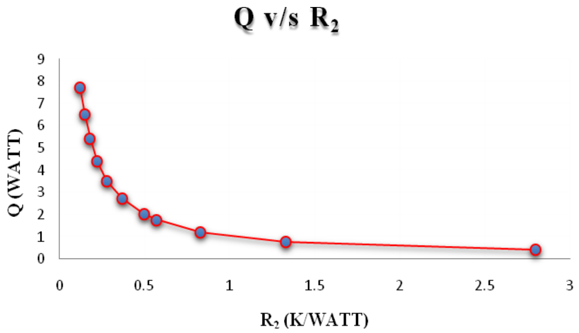

Chart-3: Heat transfer (Q) v/s Resistance (R_2)

Chart 4 shows that, as the material is polished with 120 mesh emery paper, in this case also heat transfer rate is increased between the interface material and the sink. This is because the smooth surface, air gap between the interfacial material and the sink is decreased as the contact area increases even more than 100 mesh size. Hence results in even more decrease in thermal resistance.

4. CONCLUSION

The work is carried out to determine the thermal resistance variation and temperature of interface material. Bronze is selected as an interface material. Tested are conducted for different surface topography and constant load. Surface topography has achieved by emery papers of different mesh size. Experimentation concludes that the thermal resistance decreases as the surface is mirror finished and also the temperature variation within the material is less. When the results are compared between load free and with load condition then the resistance and temperature variation is less in with load condition.

REFERENCES

[1]. Jack Hu X, Padilla Antonio A, Xu Jun, Fisher Timothy S, Goodson Kenneth E. "3-Omega measurements of vertically oriented carbon nanotubes on silicon" J Heat Transfer 2006; 128, pp.1109–13.

[2]. Narayana Swamy R, Narayan Prabhu K "Effect of Load and Interface Materials on Thermal Contact Resistance Between Similar and Dissimilar Materials" Applied Mechanics and Materials (Vols 592-594),pp 1493-1497

[3]. D.D.L. Chung "Thermal Interface Materials" Journal of Materials Engineering and Performance Vol 10(1) pp 56-59

[4]. Andra´ s Vass-Va´ rnaia,b,n, Zolta´nSa´rka´nya,b, Ma´ rtaRencza,b Characterization method for thermal interface materials imitating an in-situ environment", Microelectronics Journal Vol. 43 (2012), pp. 661– 668.

[5]. R. E. Clarke,B. Shabani, G. Rosengarten, Interface resistance in thermal insulation materials with rough surfaces Energy and Buildings, 44 (2017) pp. 346-357