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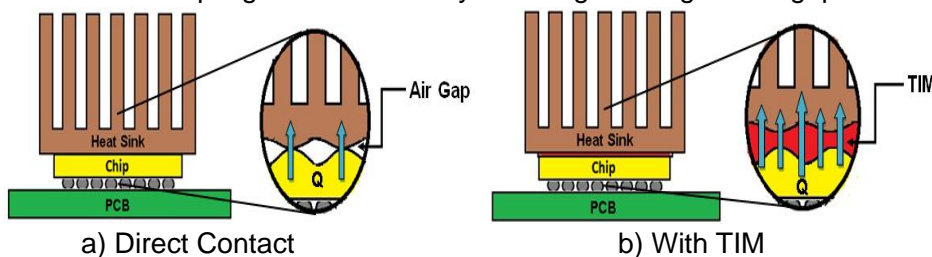
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Introduction of Thermal Interface Materials (TIMs) In Thermal Management Solution

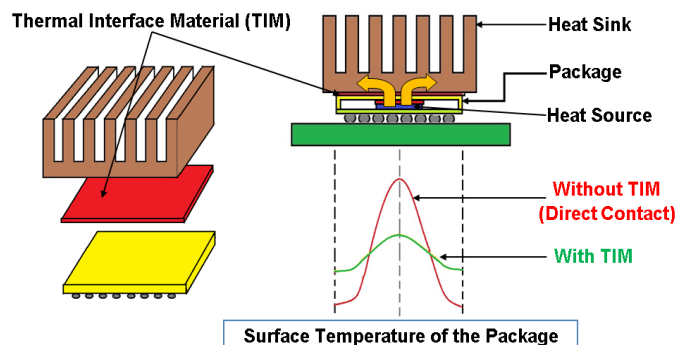
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What is Thermal Interface Material (TIM)?



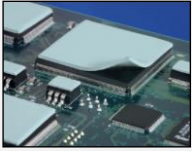
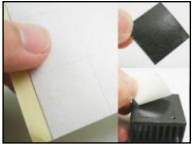
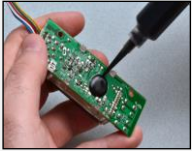
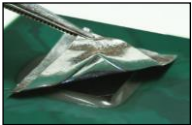
□ TIM is a heat conductive material that is inserted in between two components (such as semiconductor devices and heat sink) to enhance the thermal coupling and heat flow by reducing or filling the air gaps.



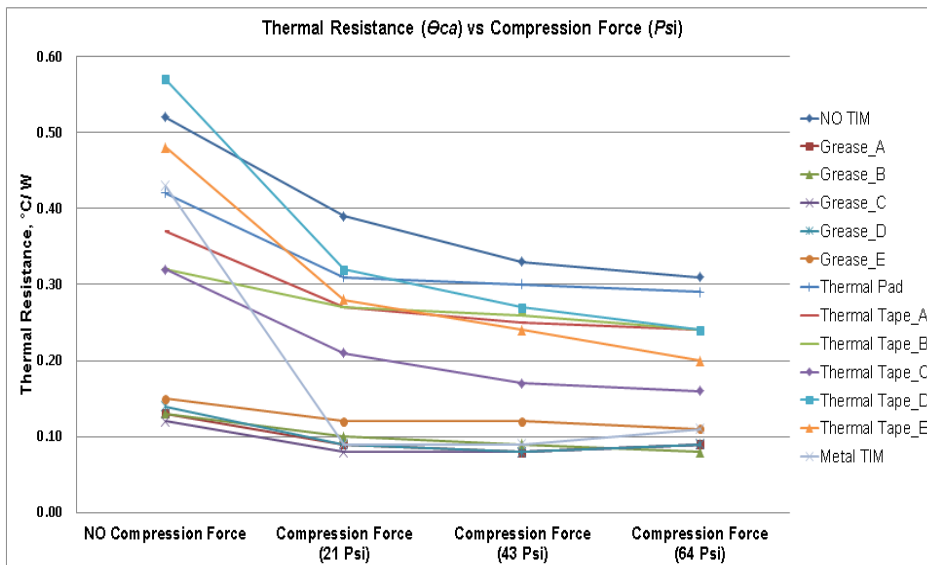
□ When two surfaces are in contact, an air void will be formed due to roughness and unevenness of the contact surfaces. The air void is a very poor thermal conductor where it represents significant resistance to heat flow and it will decrease the efficacy of the heat transfer to the ambient environment.



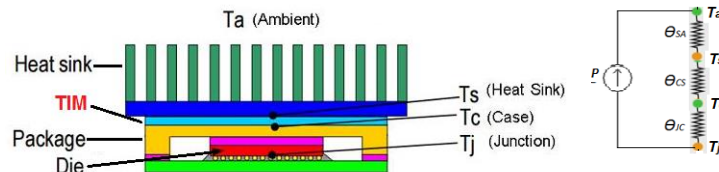
Basic Type of TIMs

Description	Advantages	Disadvantages
Thermal Grease 	<input type="checkbox"/> High thermal performance <input type="checkbox"/> Thinnest thermal joint with minimal pressure <input type="checkbox"/> No delamination issue	<input type="checkbox"/> Difficult to apply/ remove <input type="checkbox"/> Excessive grease need to clean up after application <input type="checkbox"/> Grease joint dry out with time, resulting thermal resistance increased
Phase Change Material (PCM) 	<input type="checkbox"/> Easy handling and installation <input type="checkbox"/> No delamination issue <input type="checkbox"/> No curing required <input type="checkbox"/> Prevent leaking while maintain high thermal resistance	<input type="checkbox"/> Attachment pressure required (moderate contact pressure for rework ability) <input type="checkbox"/> Pre- heating treatment necessary
Gap Filler Pad 	<input type="checkbox"/> Die-cut preforms in the precise shape needed for the application <input type="checkbox"/> Assembly is very simple	<input type="checkbox"/> High pressure are needed <input type="checkbox"/> Applications are limited to those with modest thermal requirements
Thermal Tape & Film 	<input type="checkbox"/> No pump put or migration concern <input type="checkbox"/> No curing required	<input type="checkbox"/> Attachment pressure required <input type="checkbox"/> Thermal conductivity is moderate (can only match or be slightly better than a direct contact of heat sinks and component)
Thermal Epoxy, Gel & Solder 	<input type="checkbox"/> Thermal performance close to thermal grease <input type="checkbox"/> Provide more secure (or permanent) joint between the heat sinks and component.	<input type="checkbox"/> Hard to use because of the curing or reflow processes <input type="checkbox"/> Difficult to rework
Metal TIMs 	<input type="checkbox"/> Easy to apply and remove <input type="checkbox"/> Mechanical compliance	<input type="checkbox"/> Attachment pressure required <input type="checkbox"/> Costly

Experimental Results:



Thermal Resistance Calculations:



$$\begin{aligned}\theta_{JA} &= (T_j - T_a) / P \\ &= \theta_{JC} + \theta_{CS} + \theta_{SA} \\ &= \theta_{JC} + \theta_{CA}\end{aligned}$$

Where,

$$\begin{aligned}\theta_{JC} &= (T_j - T_c) / P \\ \theta_{CS} &= (T_c - T_s) / P \\ \theta_{SA} &= (T_s - T_a) / P \\ \theta_{CA} &= (T_c - T_a) / P\end{aligned}$$

θ_{JA} = Thermal Resistance of Thermal Design Target
 θ_{JC} = Thermal Resistance of Package
 θ_{CS} = Thermal Resistance of TIM
 θ_{SA} = Thermal Resistance of Heat Sink
 θ_{CA} = Thermal Resistance of Cooling Solution Provided
 P = Heat Dissipation Power

Conclusion:

This study highlighted how critically the TIM can be used to improve heat transfer efficiency in a thermal solution. TIM thermal performance is pressure sensitive. Compression force must be applied when TIM is used to obtain the best performance. It is important to understand function and target application for each type of TIM due to its different material characteristics and thermal properties. Thermal resistance is an important factor to determine how well the thermal stack up design is. By utilizing the TIM as part of the thermal solution, it is proven that it can help to address critical thermal issues in order to optimize device performance while provide long-term reliability performance.