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

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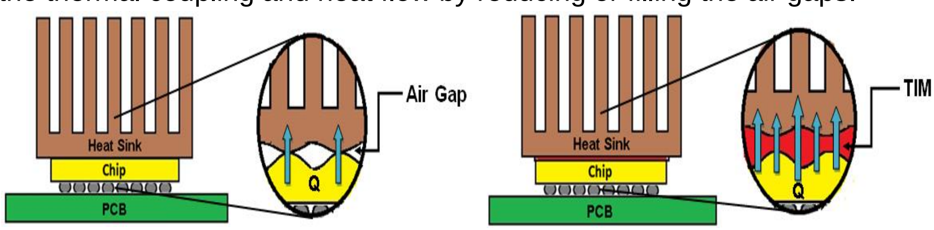
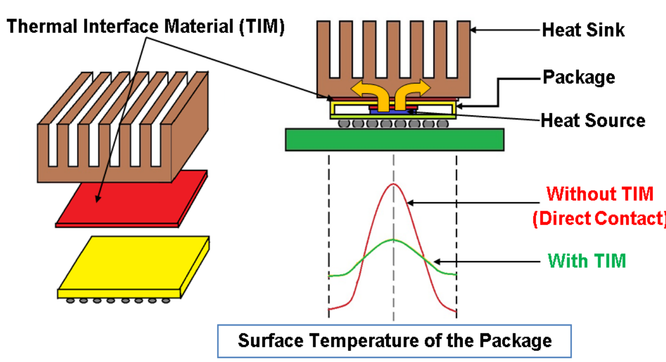
What is Thermal Interface Material (TIM)?

❑ 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.

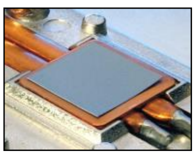
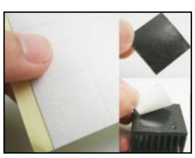
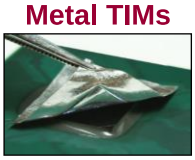


a) Direct Contact b) With TIM

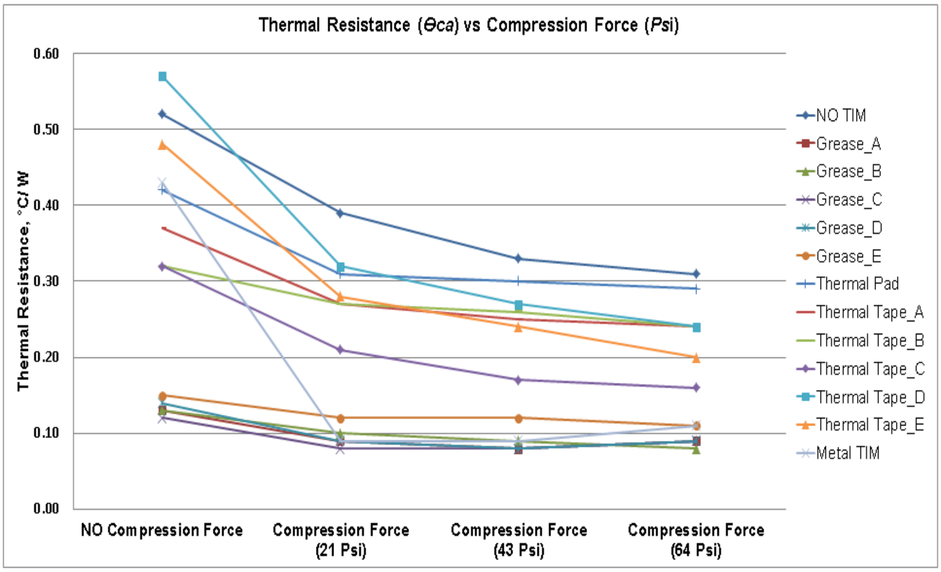
❑ When two surfaces are in contact, an air void will be formed due to roughness and unevenness of the contact surfaces. The air void is a very poor thermal conductor where it represents significant resistance to heat flow and it will decrease the efficacy of the heat transfer to the ambient environment.



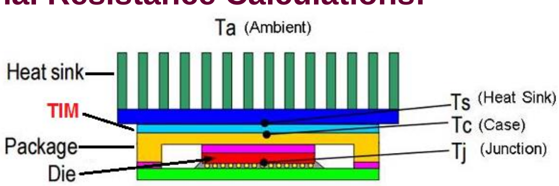
Basic Type of TIMs

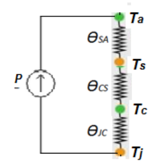
Description	Advantages	Disadvantages
Thermal Grease 	❑ High thermal performance ❑ Thinnest thermal join with minimal pressure ❑ No delamination issue	❑ Difficult to apply/ remove ❑ Excessive grease need to clean up after application ❑ Grease join dry out with time, resulting thermal resistance increased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

Experimental Results:



Thermal Resistance Calculations:





$$\Theta_{JA} = (T_j - T_a)/P$$
$$= \Theta_{JC} + \Theta_{CS} + \Theta_{SA}$$
$$= \Theta_{JC} + \Theta_{CA}$$

Where,

$$\Theta_{JC} = (T_j - T_c)/P$$
$$\Theta_{CS} = (T_c - T_s)/P$$
$$\Theta_{SA} = (T_s - T_a)/P$$
$$\Theta_{CA} = (T_c - T_a)/P$$

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 in used to obtain the best performance. It is important to understand function and target application for each type of TIM due to it's 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.