



Thermal Management Expo

“Thermal Interface Materials (TIMs) with functional fillers such as alumina, graphene & CNTs for next-generation”

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+26 000
Employees



9
Countries



6,6
Billion in
revenues



75
Production &
R&D Centers

Exterior Plastics



Interior Plastics



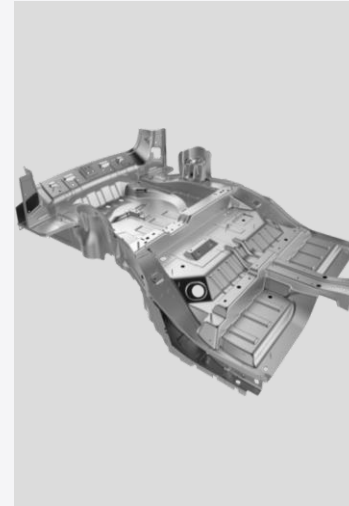
Mechanical Assemblies



Exterior Metals



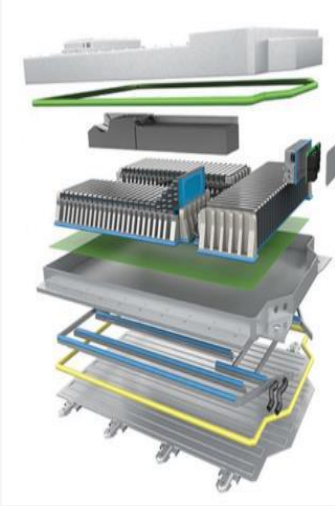
Metal Body Structure



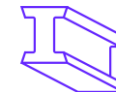
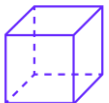
Lighting Systems



Battery Innovation Center

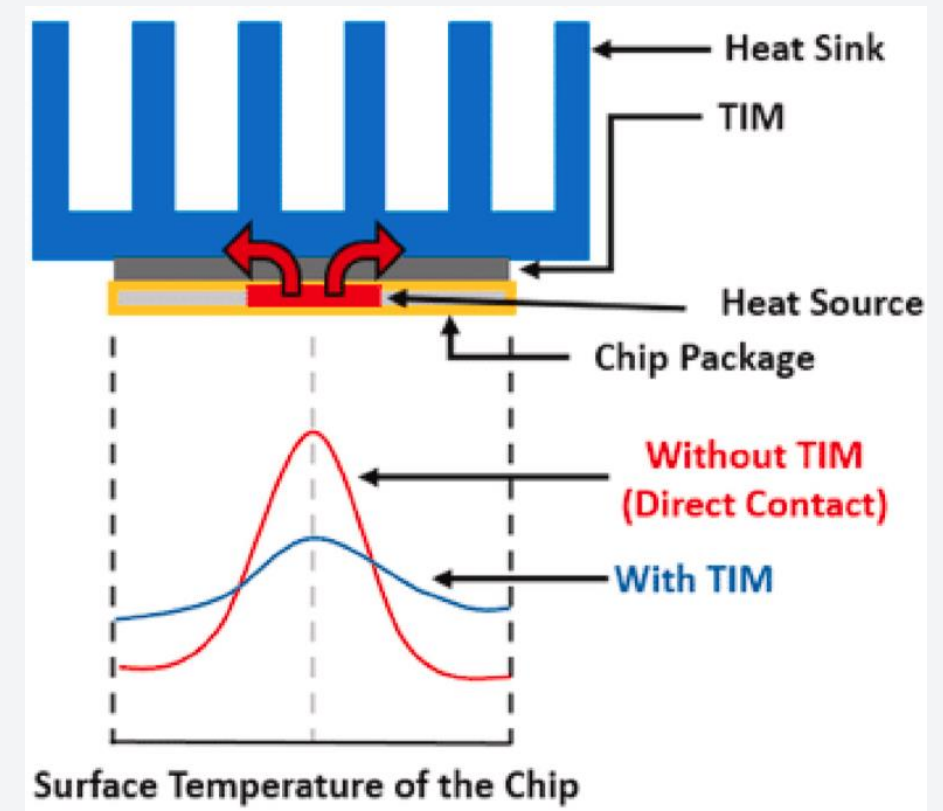
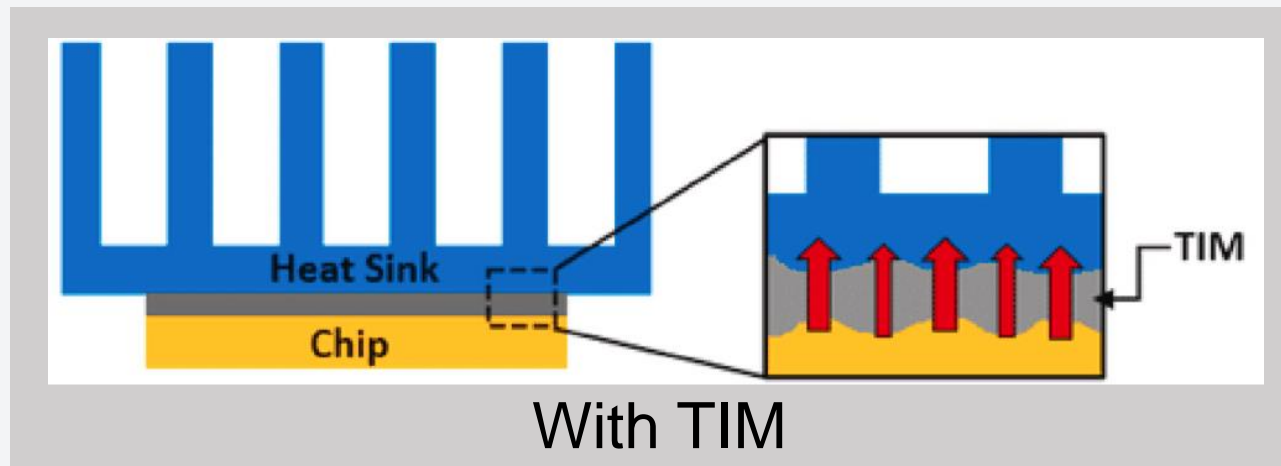
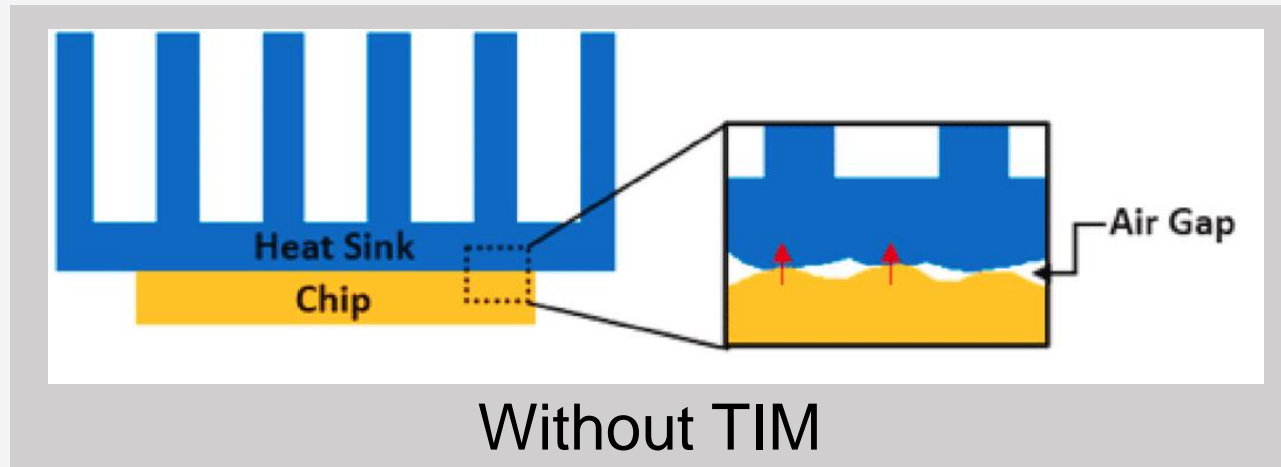


FLEX-ION





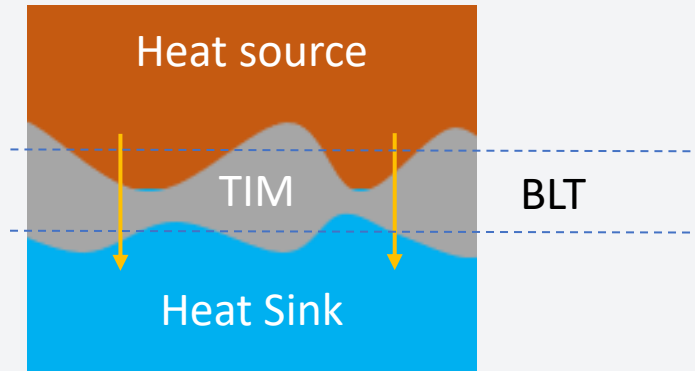
Need for Thermal Interface Materials (TIM):





The two critical criteria for a TIM:

- High Thermal conductivity (K) (lower resistance)
- Proper elastic modulus (fill the gap between both surfaces) with lower contact resistance (R).



$$R = BLT/K$$

Organic TIMs

Grease/Thermal pads/Phase change materials

Low Resistance

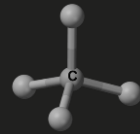
Low Thermal Conductivity

Inorganic TIMs

Copper/Indium

High Resistance

High Thermal Conductivity

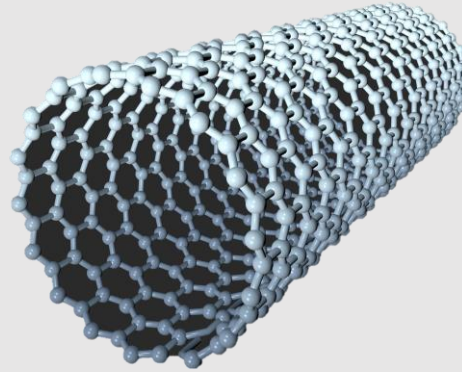


Carbon Based TIMs:

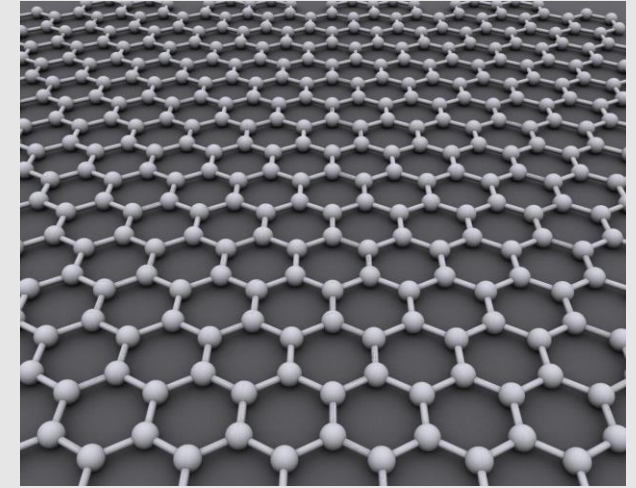
- Carbon Nanotubes (CNT)
- Graphene/ 3D Graphene

Factors affecting TIM performance:

- Path length
- Carrier mobility (charge carriers)
- Thermal conductivity
 - Thickness
 - Interfaces (contact)
 - Domain size



CNT



Graphene

**Merits:**

- Excellent in-plane thermal conductivity (in plane ~ 5300 W/mK)
- Lightweight
- Flexible

Demerits:

- Thru-plane conductivity is low usually (single layer)

Graphene as filler for polymer based TIMs:

- Improved TC of polymer by 20-30 times.
- Thermal performance better than CNTs for same filler fraction.
- Better than Epoxy, grease and phase change materials.



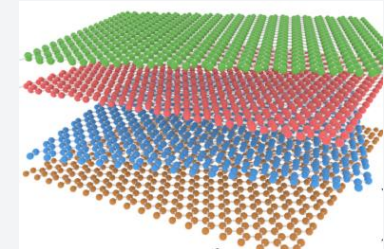
Processing of Graphene:

Alignment of Gr:

- Multilayer graphene has to be aligned in an effective way to reduce resistance.
- Various processes includes infiltrating epoxy and creating magnetic field to align graphene.

Dispersion:

- Uniform dispersion is required to boost the performance.
- Higher filler loading would yield in higher conductivity but also looses mechanical properties.
- Optimal filling offers more flexibility



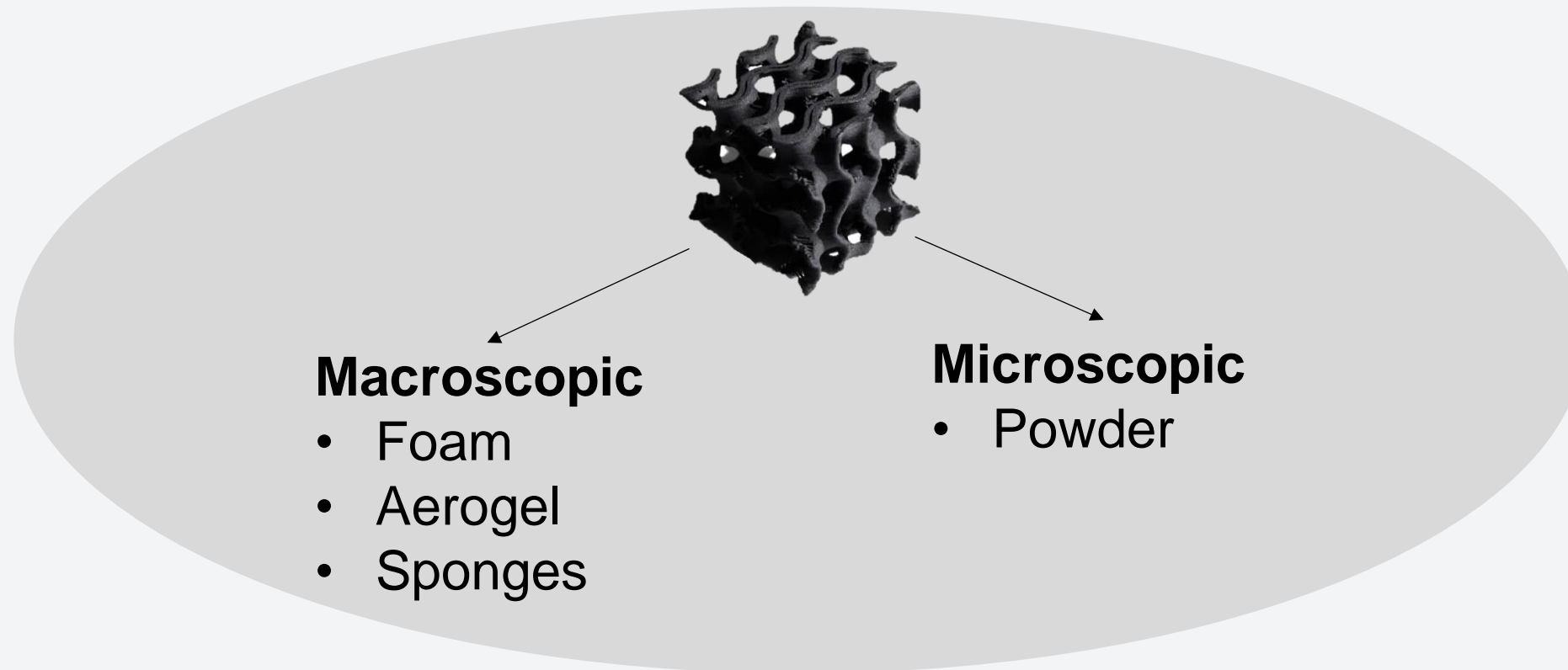
Sizing and layers:

- TC of epoxy increases with increasing layers of graphene.
- Lot of processing is required to use graphene as filler due to its electrical conduction.



3D - Graphene:

- Graphene materials that form 3D networks or structures, rather than just individual sheets.
- Offer advantages like high surface area, porosity, and tunable properties.





Challenges:

- Improve thru-plane by maintaining flexibility.
- Long-term reliability for harsh conditions – ageing and thermal shock tests.
- Controlling electrical conductivity.
- Low-cost and large-scale manufacturing for various applications.
- 3D Graphene – has potential but need more studies.



THANK YOU

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