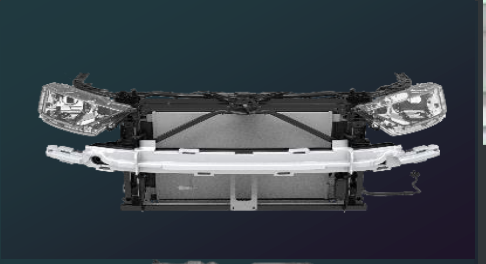








FLEX N GATE

Thermal Management Expo

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

Abishek Kanagali

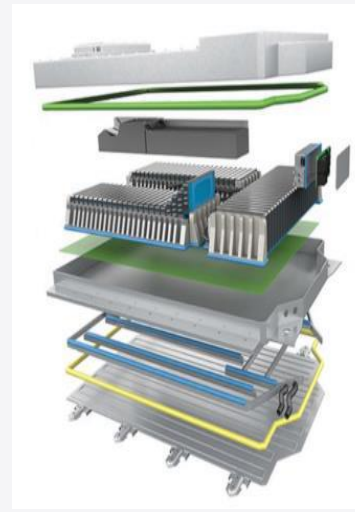
Thermal Engineering Manager CAE

+26 000 Employees

9 Countries

6,6 Billion in revenues

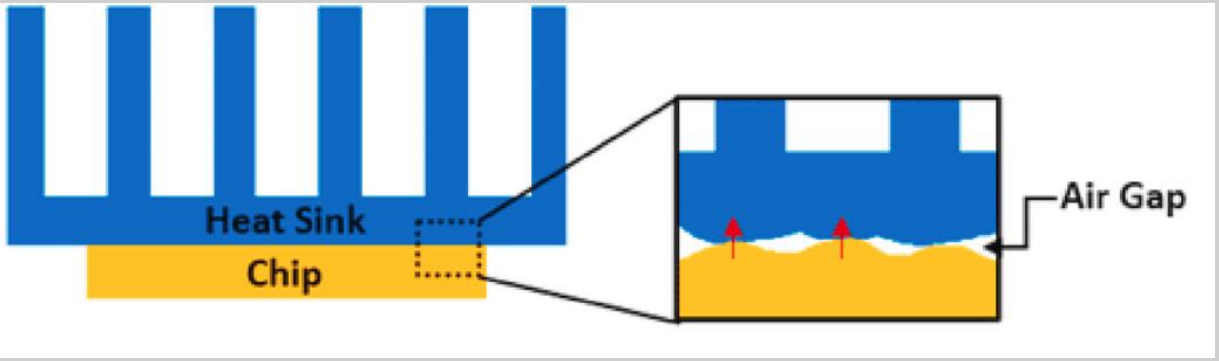
75 Production & R&D Centers

Exterior Plastics	Interior Plastics	Mechanical Assemblies	Exterior Metals	Metal Body Structure	Lighting Systems	Battery Innovation Center
						

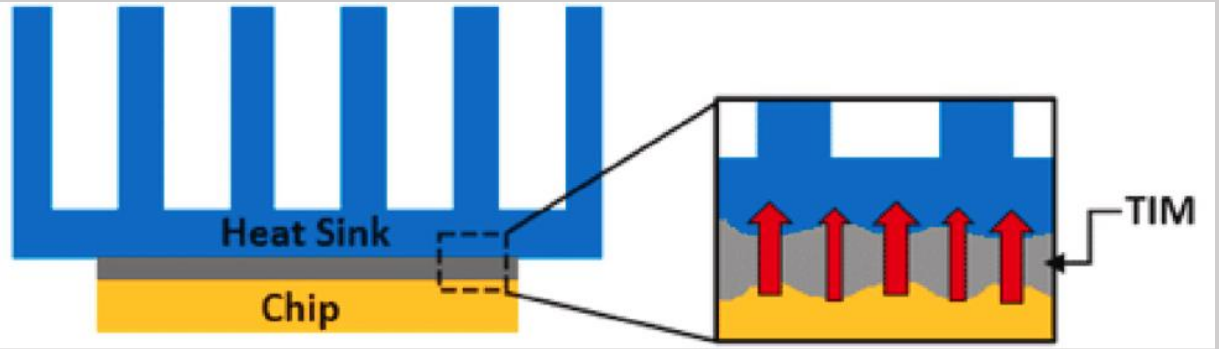
FLEX-ION

Abishek Kanagali

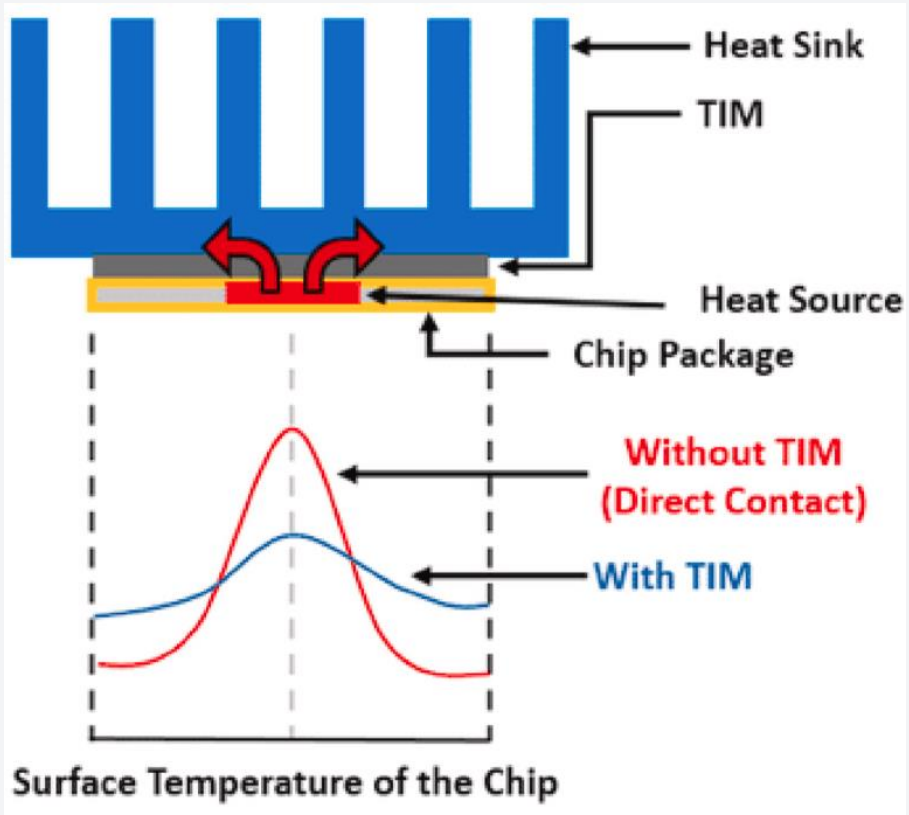
Need for Thermal Interface Materials (TIM):



Without TIM

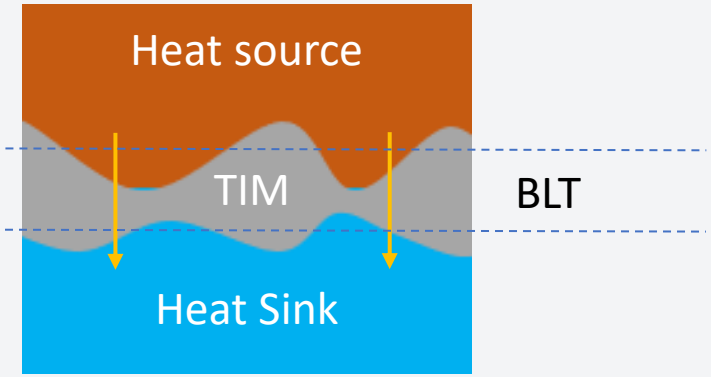


With TIM



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

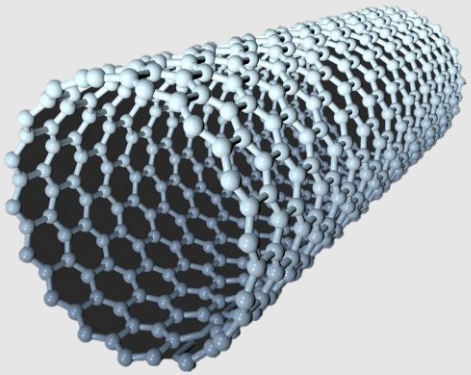
Copper/Indium

High Resistance ↓

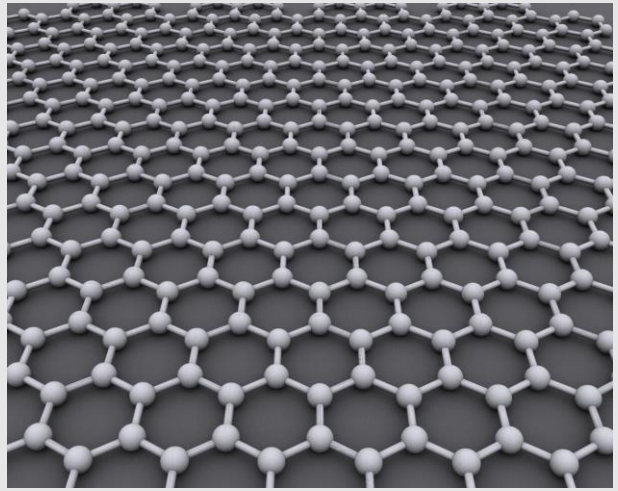
High Thermal Conductivity ↑

Carbon Based TIMs:

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



CNT



Graphene

Factors affecting TIM performance:

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

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.

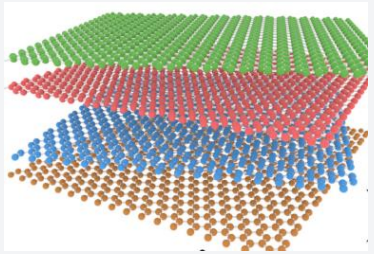
Processing of Graphene:

Alignment of Gr:

- Multilayer graphene has to be aligned in an effective way to reduce resistance.
- Various processes includes infiltering 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.

Macroscopic

- Foam
- Aerogel
- Sponges

Microscopic

- Powder

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