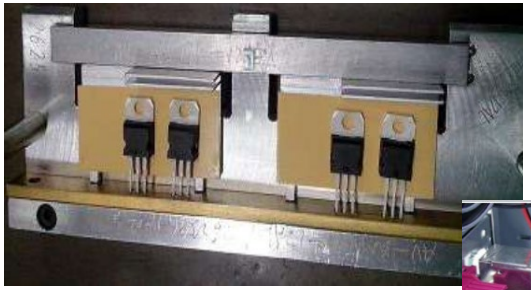
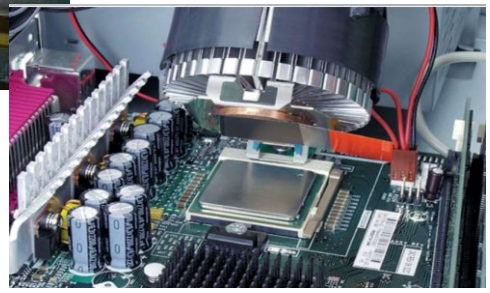
FREEDM INOVATIONS



HENKEL SOLUTIONS



FREEDM SYSTEM SYMPOSIUM

RITA MOHANTY, FEBRUARY 21, 2023

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RITA MOHANTY

Education: PhD, Chemical Engineering, University of Rhode Island

Lean Six Sigma Master Blackbelt, Dartmouth College, NH

Expertise: Electronics material, assembly equipment and process

Career Highlights:

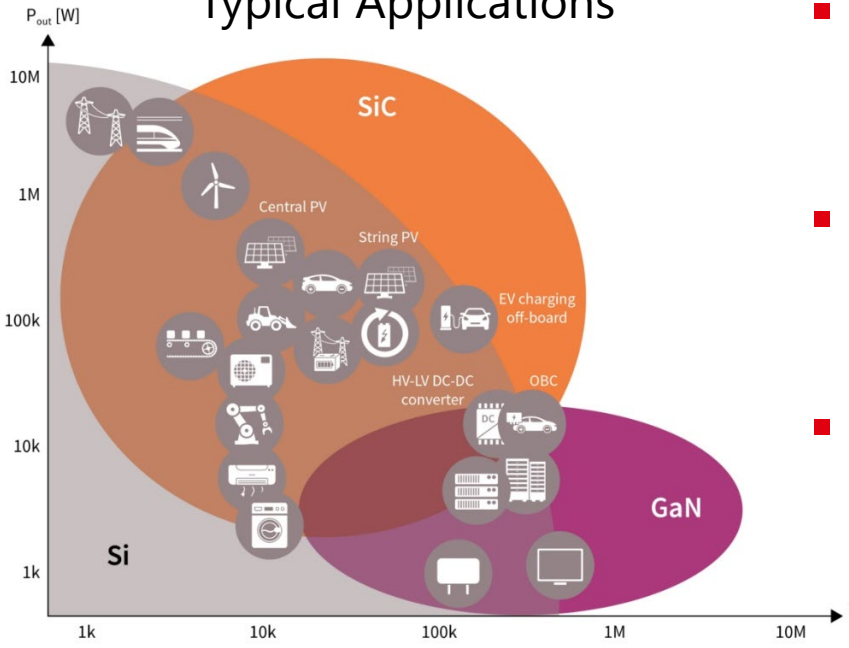
- Director Application Engineering, **Henkel**
- Senior Technical Consultant, **DfR Solutions**
- Director Global R&D, **Enthone (McDermidAlpha)**
- Director Advanced Development at **ITW Speedline Technologies**
- Adjunct Professor, **Dartmouth College, NH**
- Global SMT Manager at **Arkless Electronics (ITW)**

Fun fact:

- Marathon runner, love cooking and gardening (Master Gardner…)

WIDE BANDGAP SEMICONDUCTOR (WBG)

Typical Applications *



- Allows increased power efficiency, smaller size, lighter weight, and lower overall cost
- Proper thermal management is critical to the performance enhancement
- The NREL research suggested that TIM with lower thermal resistance and is “reliable at functional temperatures,” is critical

* https://www.infineon.com/cms/en/product/technology/wide-bandgap-semiconductors-sic-gan/

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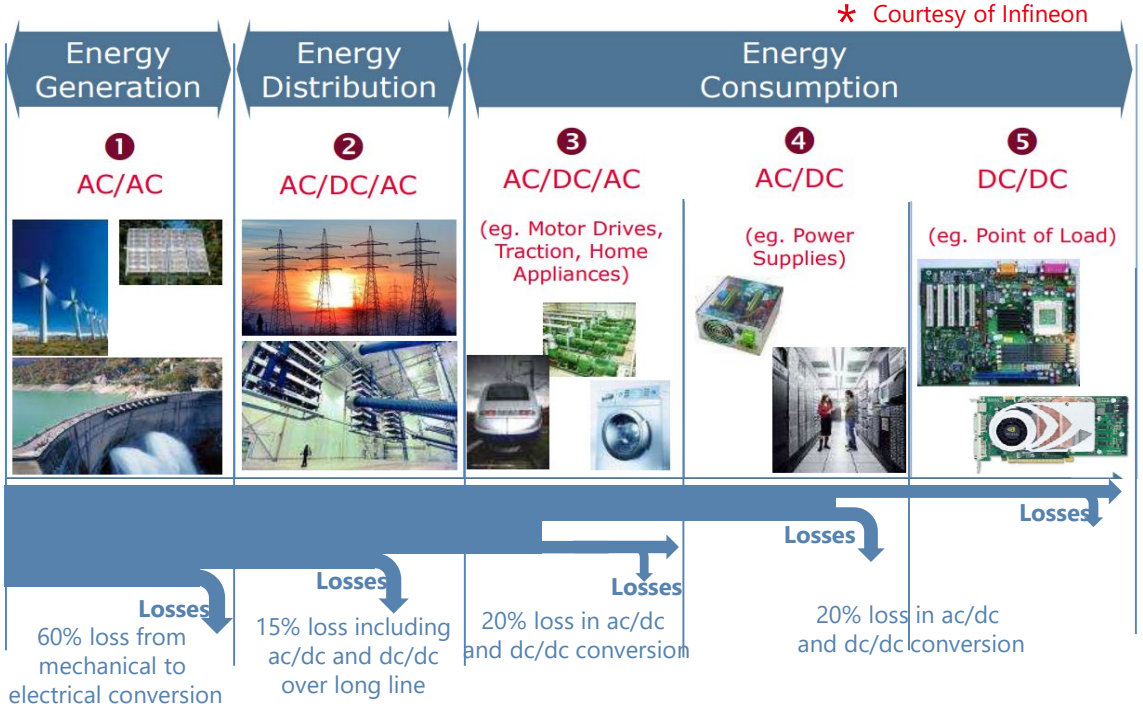
POWER LOST AS HEAT*



- Bottom line:
- Electronics generate a lot of heat
- It must be managed to meet safety and reliability of products around us

One of the most cost-effective cooling options is passive cooling using Thermal Interface Materials

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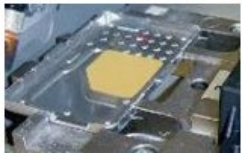
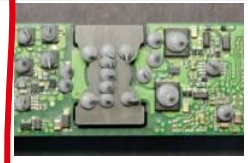
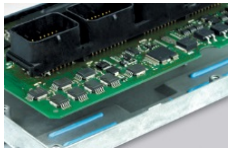
THERMAL MANAGEMENT PRODUCTS

- WBG components will require lower thermal resistance TIM

Increased Thermal Resistivity

Grease	Phase Change Material	Gels	2K Gap Filler	Thermal Adhesive	Sil Pad	Gap Pad
Liquid	Solid/liquid	Liquid	Liquid	Liquid/film	Film	Pad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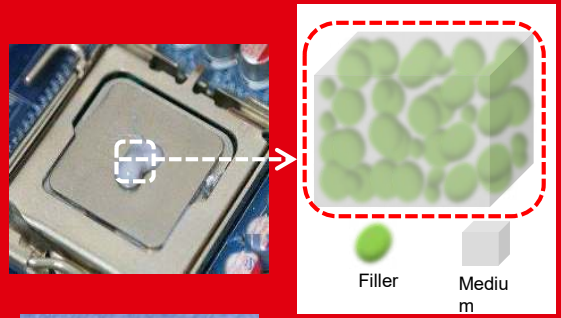
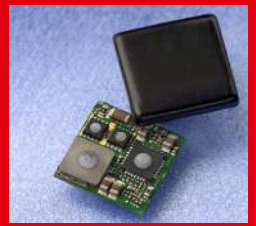
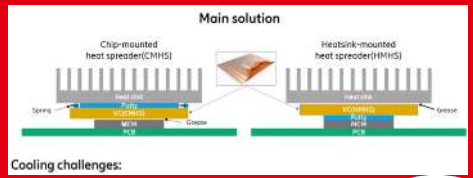
THERMAL GREASE

- A composite of thermally conductive fillers dispersed in silicone or hydrocarbon oil
- Grease are the oldest form and most efficient TIM
- Used in very thin bondline (~>150µ)
- Non-Electrically Insulating → not suitable for high power components
- Very low interfacial resistance due to excellent wet-out
- Thermal transfer remains intact only if the material stays in place
- Prone to pump-out and dry-out
- Typically used in TIM 1.5 and TIM 2 applications





"Bake out" or "caking" Oil/filler separation "Pump out"



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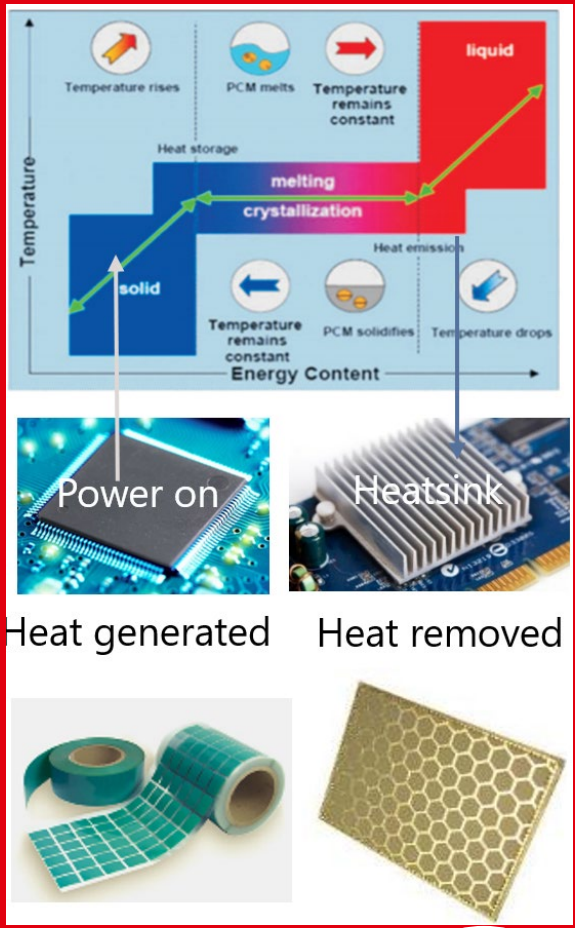
PHASE CHANGE MATERIALS (PCM)

- PCMs are wax-like compounds that goes from solid to liquid at a specific temperature (45C-60C)
- It comes in film or printable paste which can be electrically or non-electrical isolating
- Very low thermal impedance and extremely good wetting
- Highly effective for low bond line thickness (~<200µ)
- Printable paste for high throughput and film form for ease of application
- Along with effective thermal management, film can provide electrical isolation when necessary



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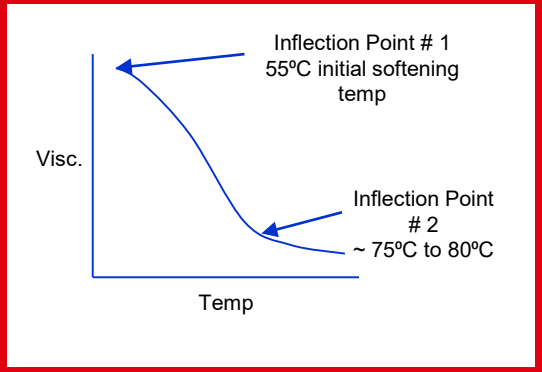
PHASE CHANGE MATERIAL SELECTION

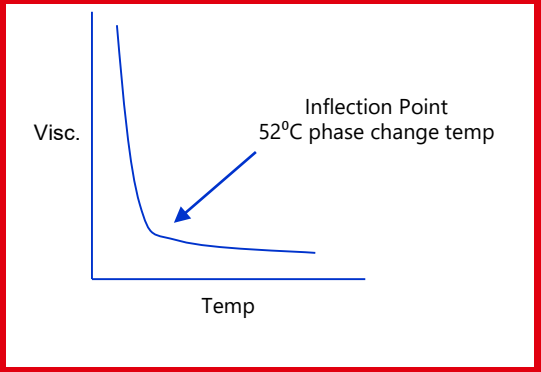
- Inflection Point 1- represents the initial softening point where viscosity will continue to drop linearly
- Inflection Point 2 - viscosity will start to flatten out
- Thermal performance is optimized after point #2

- Inflection Point - at which point viscosity drop is immediate
- Thermal performance is optimized immediately upon reaching In theory, bond-line thickness is minimized immediately upon reaching inflection point

Phase Change Softening Temp



Phase Change Liquified Temp



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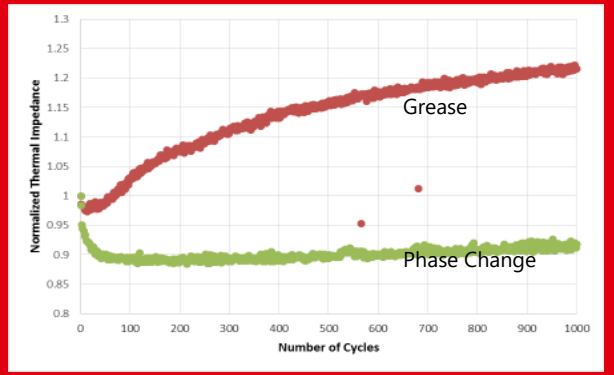
PHASE CHANGE MATERIAL VS. GREASE

Power Cycling Comparison

- High consistency phase change material initially improves with better wet-out as initial wet-out may be poor.
- Pump out degradation is too much with higher cycles for Grease
- Pump out degradation for PCM is minimum with higher cycles, as the phase change is liquid only partly during thermal cycle



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SUMMARY

- WBG semiconductors are fueling the growth in smart grid and green technologies while reducing total cost
- As WBG chips operate at higher temperature with a smaller footprint, it generate higher amount of heat
- New thermal management solutions are being developed at a warp speed to address thermal needs of WBG devices
- Advanced PCM will be one of the enabling solution to manage heat for WBG semiconductors devices

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THANK YOU