PCM: Optimizing Material Properties: Enthalpy and Conductivity

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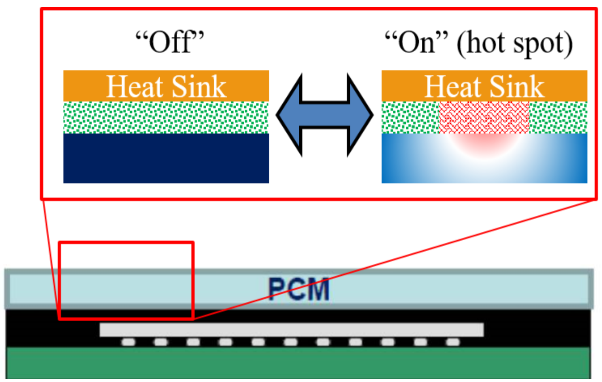
Objectives

The goal of this project is to experimentally and theoretically evaluate fundamental limits of enthalpy and thermal conductivity enhancement with fillers and foams integrated in a simple phase change material matrix (polymer or wax).



Schematic illustrating possible integration location of the PCM at the chip level to alleviate hot spots. During intense heating, the PCM changes phase absorbing energy at a nearly constant temperature.

Approach

1. Synthesize novel PCMs, experimentally characterize the material properties, and correlate to system level performance of PCMs.
2. Develop an analytical model to evaluate the fundamental limits of enthalpy and thermal conductivity enhancement.

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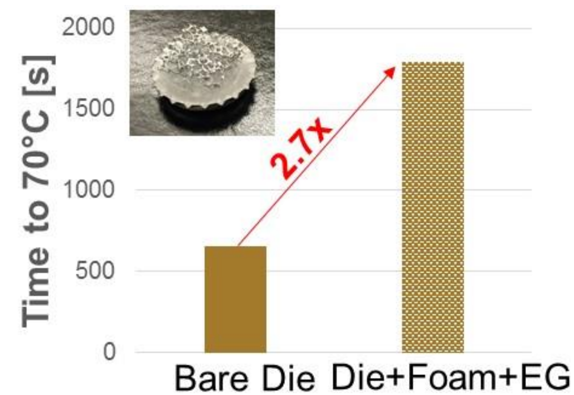
Key Questions

- What is the effect of high heating rate versus low heat rate on PCM performance? Specifically, is there crystallization limit with cooling rate and cycling?
- How does repeated cycling or aging of the polymer impact crystal formation?
- At what point does the heating rate become limited by the thermal conductivity? And is there a cross-over point where conductivity vs latent heat dominates?
- To what extent do particle shape and size affect conductivity and phase change?
- How does particle dispersion within the material impact performance (enthalpy and conductivity)? Does it impact melting and freezing transitions?

Selected Publications

Yash.G , Amy,M. "Passive Thermal Management Using Phase Change Materials: Experimental Evaluation of Thermal Resistances." *ASME Interpack 2015*

Bruce, A. N., Ganatra, Y., Marconnet, A., Howarter, J. A. "Block Copolymers as Phase Change Materials for Mitigating Heat Spikes in Handheld Consumer Electronics." *TMS 2016*



As an example, combining high conductivity foams and expanded graphite microflakes with a traditional paraffin wax phase change material significantly improves thermal performance during *in situ* tests.

Impact

- Optimizing the properties of the PCM thermal management solution will grant longer duration for operation of the package and/or device before the thermal limit of the package/system is reached
- This technology would enable locally high removal rates at hot spot locations (phase change + improved thermal conduction), allowing convenient integration and application to existing device configurations.
- The developed metrics will enable *ex situ* comparison of PCM performance