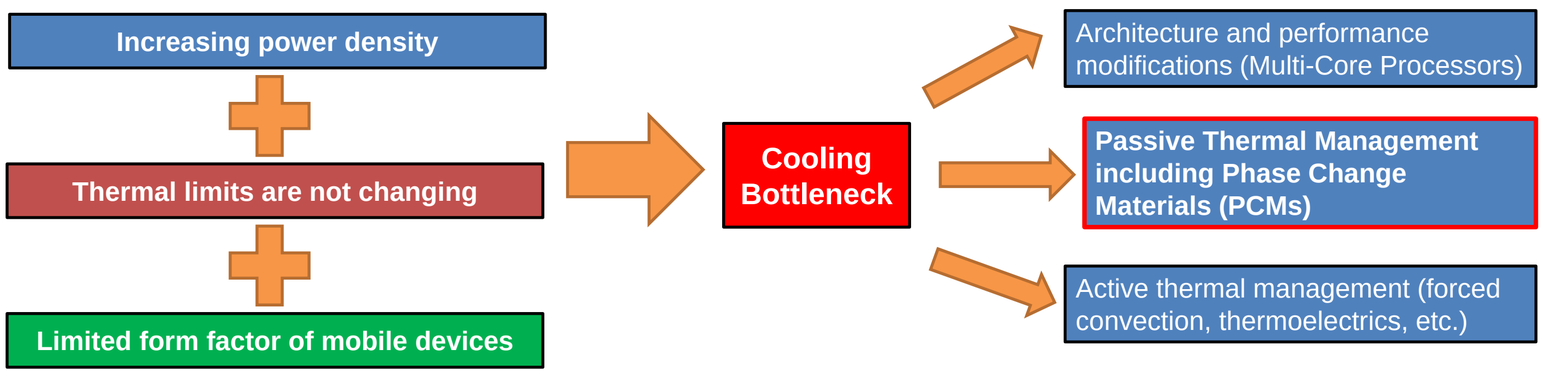
Passive Thermal Management using Phase Change Materials

Javieradrian Ruiz

Mentors: Yash Ganatra, Alex Bruce, and Zhenhuan Xu **PI's**: Amy Marconnet and John Howarter

Motivation

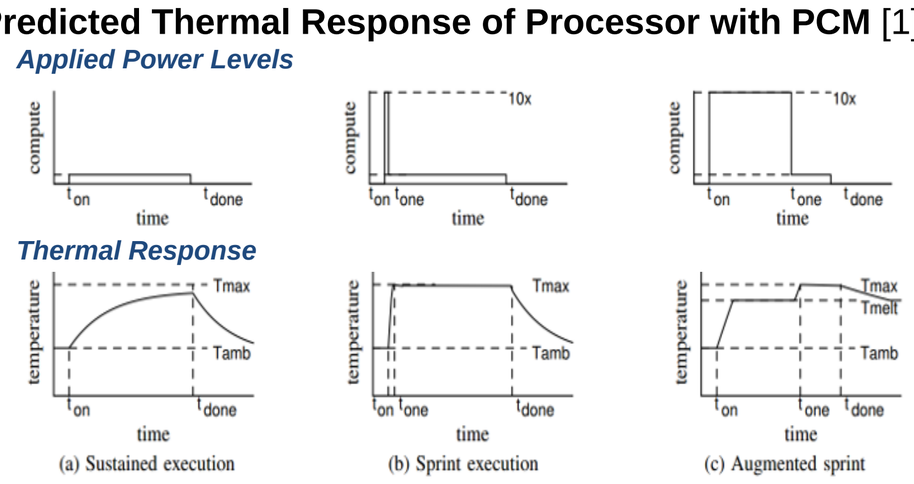
- Implementing new and more powerful processors in cellphones is limited by the significant heat generated by their use.
- Typically, the computational power of the processor is limited (by the software) once the temperature exceeds a certain threshold to prevent damage to the device.
- To improve the performance of modern mobile devices, new thermal management strategies are needed.
- Phase change materials (PCMs) absorb thermal energy during melting, while limiting spikes in temperature, and are promising for passive thermal management schemes.

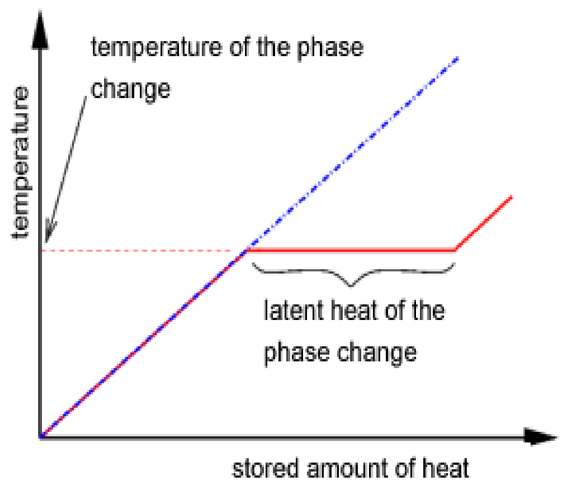


Background & Literature Review

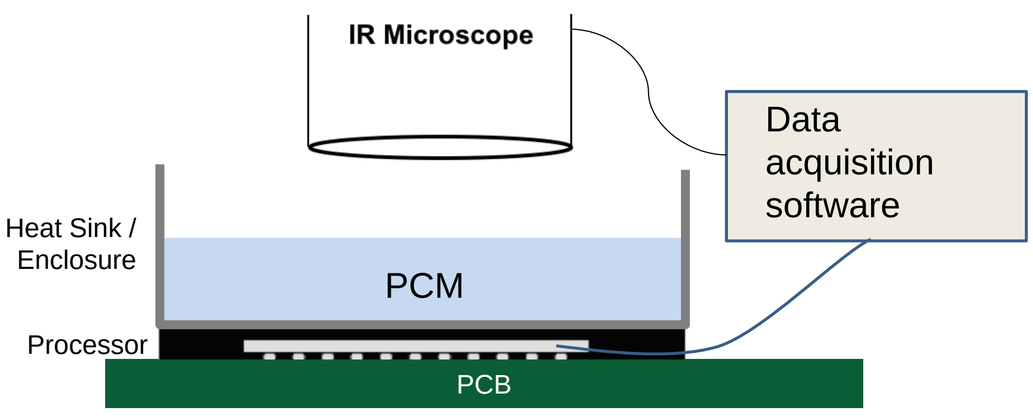
- When a PCM begins to melt, the absorbed energy goes into breaking the intermolecular bonds of the material increasing the internal energy of the material but not raising the temperature.
- This energy storage allows the processor to run at a higher performance level for an extended period of time.

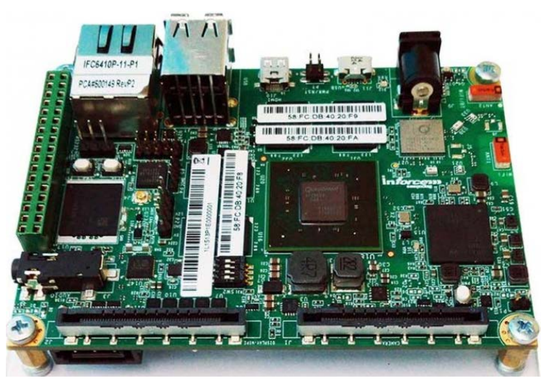
Predicted Thermal Response of Processor with PCM [1]





Experimental Design

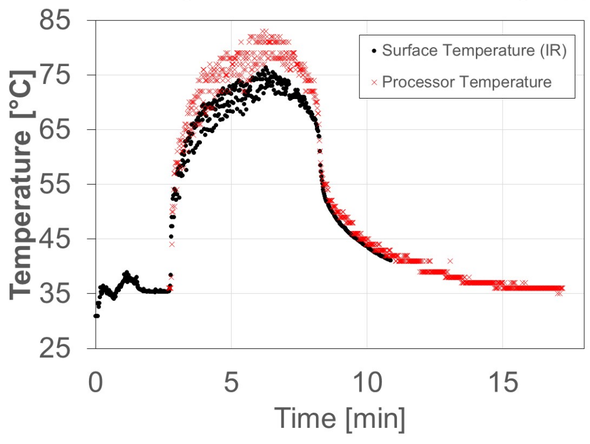


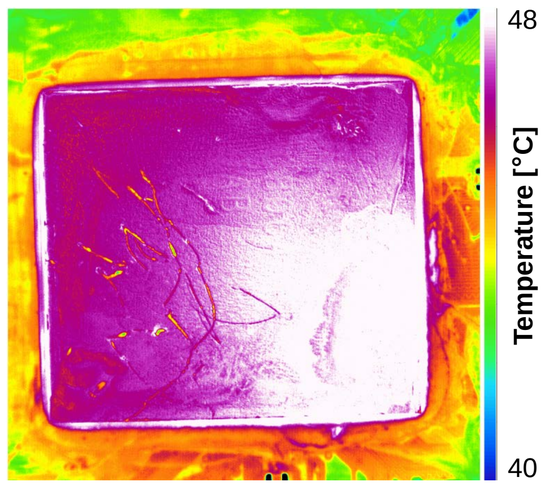


INFORCE 6410PLUS™ with Qualcomm Snapdragon processor

- We designed and built a testing fixture to measure the effect of the PCM on the internal and surface temperature of the processor.
- An enclosure filled with PCM is placed directly on the processor of a single board computer (SBC).
- An IR camera and external thermocouples measure the surface temperature of the PCM and built in sensors on the chip monitor the temperature processor.
- To stress the system, a benchmarking app (Linpack) is executed on the processor while temperature data is measured.
- Initial data in the absence of the PCM has been collected to provide a baseline performance metric. Test with PCM are in progress.

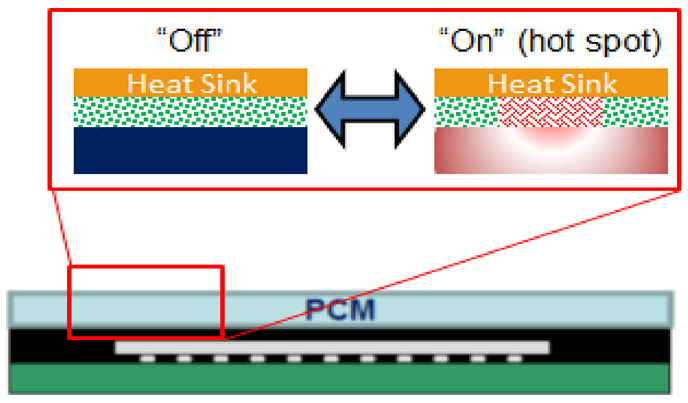
Baseline Thermal Data (no PCM) while Executing Linpack Benchmarking App





Project Goals

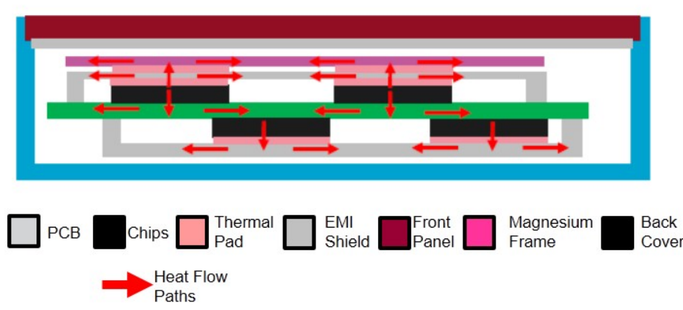
- Develop a thermal management solution based on phase change materials (PCMs) in order to store energy generated by transient and localized hotspots in processors.
- Test which integration method and which PCMs will prove most useful for the use in passive thermal management in cellphones.
- Enable devices to operate at a higher performance level for longer periods of time.



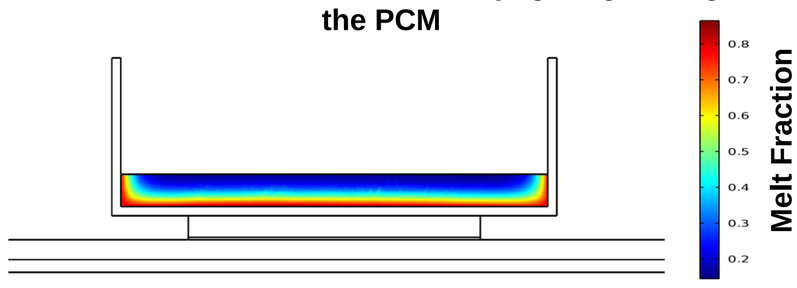
Computational Model

A computational model is being developed to visualize what might be expected in our experiments, interrogate the uncertainty of the results, and translate the experimental data to cell phone applications.

Heat flow paths in a modern cell phone [3]



COMSOL Model of Melt Front Propagating through the PCM



Summary & Conclusions

- Preliminary test for the processor without PCM have been conducted, and measurements with the PCM are in progress.
- The impact of the thickness and volume of PCM, as well as different types of PCMs will be interrogated to determine the optimum configuration for thermal management.
- In combination with numerical modeling, these results will determine whether PCMs are effective for thermal management of mobile devices.

References

1. Shao, Lei, et al. "On-chip Phase Change Heat Sinks Designed for Computational Sprinting." (2014).
2. Shao, Lei, et al. "On-chip Phase Change Heat Sinks Designed for Computational Sprinting." (2014).
3. Z. Zhao, *SEMITHERM*, 2013