Thermal Ground Plane Optimization for Phone Performance

Kelvin Thermal
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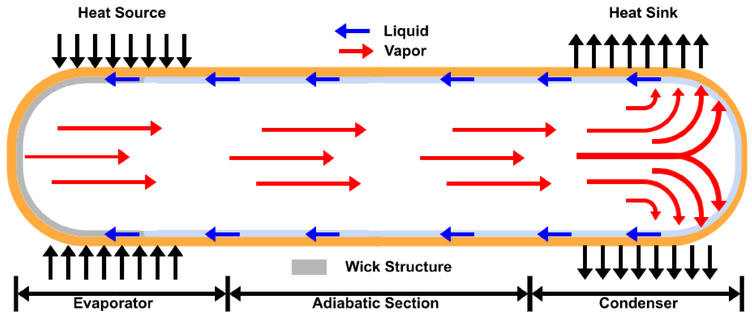
Background

Thermal Ground Planes (TGP's) are micron-thick planes composed of vapor and liquid cores which combine to make excellent heat spreaders. TGP's when functioning remain very isothermal.

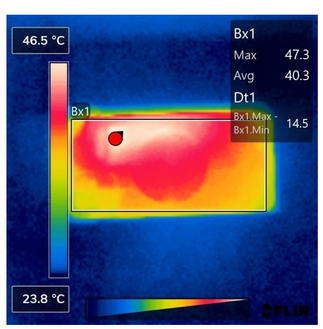


Project Requirements

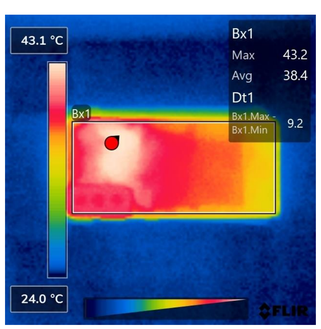
- Testing showing improved performance and a lower ΔT during high-power workloads
- Design an optimized TGP for both iPhone 12 and Samsung Galaxy S21
- Phone case design for both iPhone 12 and Samsung Galaxy S21
- Stretch Goal: Develop a manufacturing plan for production of cases

Phase 1: Testing

- Designed a test fixture to produce repeatable results
- 3D Mark Wildlife used to determine the phones performance
- Thermal imaging used to determine maximum temperature and ΔT across the phone



Bare iPhone

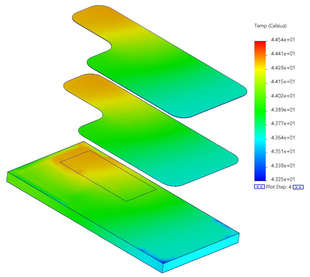


Bare Samsung

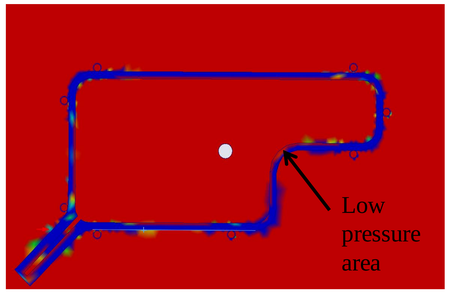
Phase 2: Tooling Design

iPhone and Samsung with custom TGP

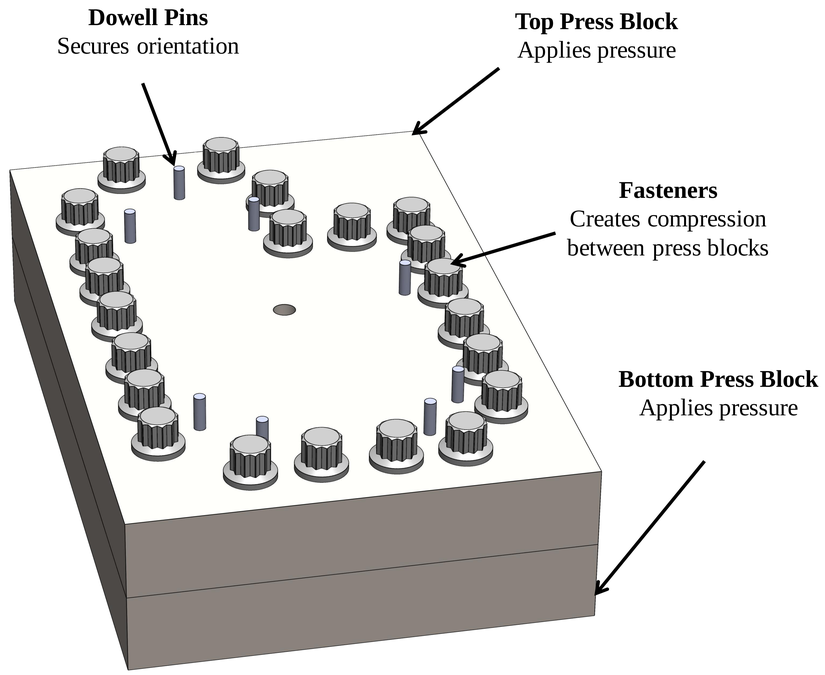
- FEA was used to ensure a consistent high bond line pressure
- Thermal simulation was used to dictate thickness of vapor layer within TGP
- TGP shape optimized to maximize heat flow across entire back of the phone



Thermal analysis of TGP heat spreading



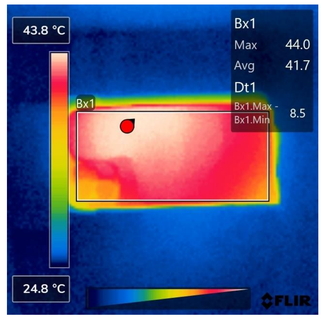
FEA analysis of TGP bond line pressure



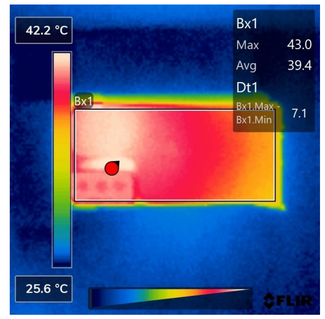
- Tooling must be made of 17-4 Stainless or P20 steel to withstand temperature and stress conditions of manufacturing

Results

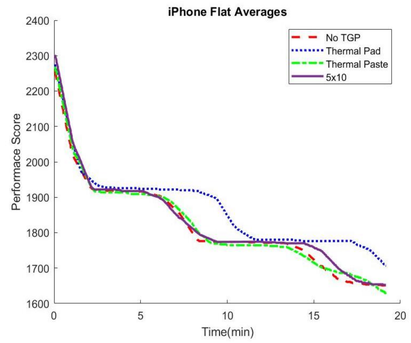
- Decreased Maximum Temperature by up to 4.4° C (7.92F)
- Decreased the ΔT by up to 7.3°C (13.14F)
- Improved stability of phone performance curve



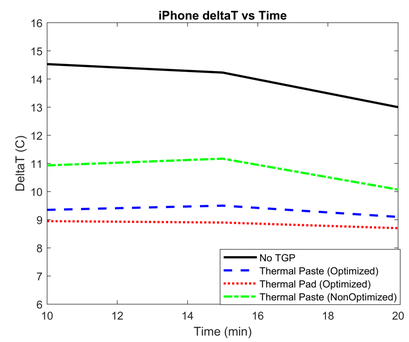
iPhone with TGP



Samsung with TGP



iPhone Performance Data

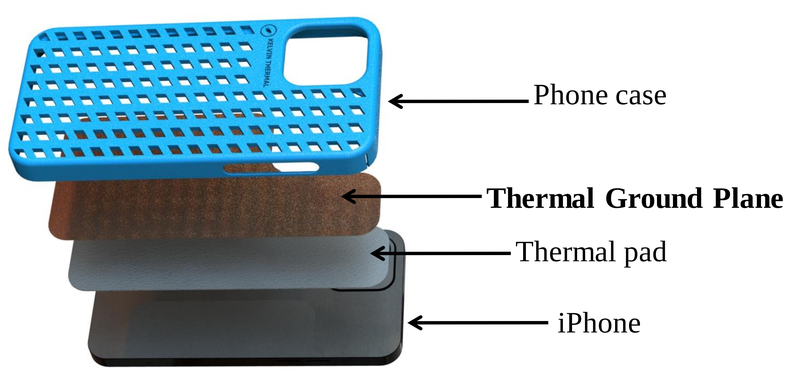


iPhone ΔT Data

Phase 3: Case Design

Thermal Pad Testing

- Tested graphite, silicon, and non-silicon pads.
- Selected .5mm silicon 5 W/m-k
  - Yielded similar results to the thermal paste



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