Efforts Toward a Board Level Holistic Thermal and EMI Solution for Mobile Electronic Devices

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Outline

- Market and drivers
- Current and proposed solutions
- Case studies – smartphone platform
  - Benchmarking
  - CPU performance
  - Thermal and EMI measurements
- Summary

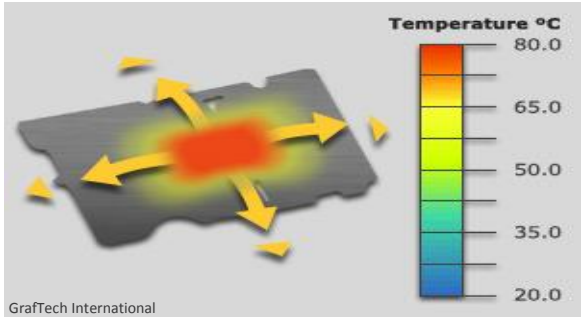
Market and Drivers

- Target market: Portable electronics/wearables, trend towards passive cooling
- Problem: Device performance, design, customer acceptance all limited by heat generation
- Goal: Increase CPU performance (reduce throttling) while meeting industry temperature constraints and providing design flexibility
  - Max surface temperature should be 45°C or less with a 5°C delta across the surface
  - Minimal use of TIMS in smartphones and wearables

Traditional methods to deal with waste heat in electronics

- Remove heat from the top
  - Heat sinks
- Spread heat and remove from device
  - Graphite
- Move heat to another location
  - Heat pipes


Fir0002/Flagstaffotos

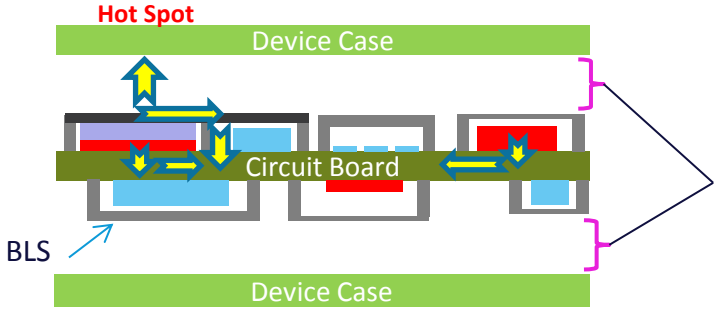


GrafTech International

Current Solution vs. Proposed Solution

Transient Cooling - Take advantage of heat capacity of cooler components & spread the heat at the board level

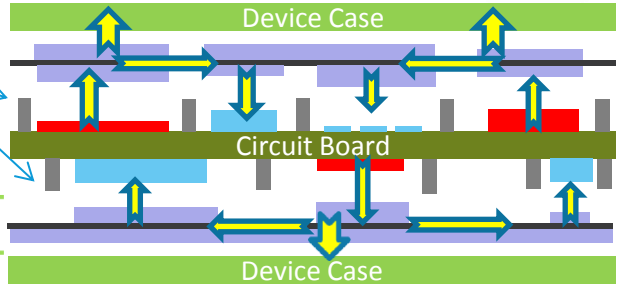
- **Current Solution**



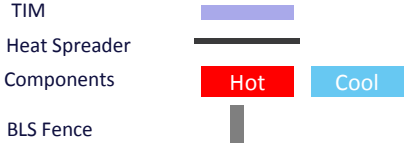
Air Gap

- **Holistic Solution**

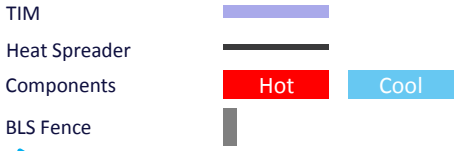
Standard Fences on PCB



Laird Solution



Heat Flow Hot to Cool Components



Moving to integrated part: increased performance, lower TCO

- Current solution utilizes air gaps
- TIMs limited
- BLS contain heat in air gaps
- Copper heat spreader / lid

- Holistic solution provides combines functions
- Fences remain on PCB
- EMI shielding intact
- TIMs selected to distribute heat

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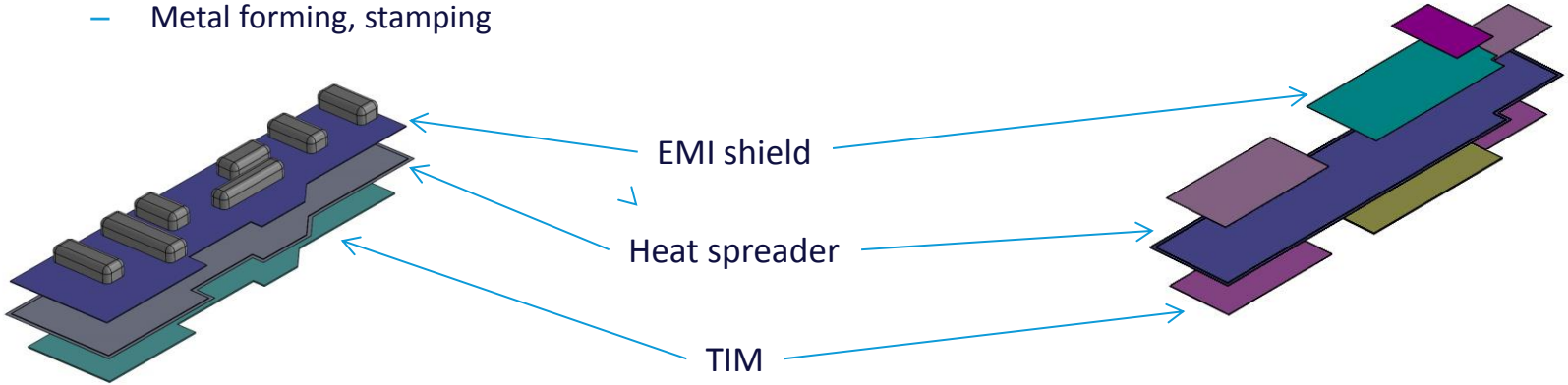
Integrated Capability

Utilize specific materials to enable:

- Heat Transfer
  - Thermally conductive gap fillers, phase change TIMs, and greases, thermal insulators, heat storage materials
- Heat Spreading
  - High thermal conductivity metal, graphite
- EMI containment
  - Shielding and absorbing materials
- Structural
  - Metal forming, stamping



Back side solution (PMIC)

Front side solution (CPU)

Case Studies – Smartphones

- Goals:
  - Increase CPU performance (reduce throttling) while meeting industry temperature constraints
  - Provide multiple functions in one part
  - Provide a flexible design enable optimization of key parameters

- Based on other trials with other devices (WPC, tablets, etc.)
  - Custom solution for each device
  - Reduce weight
  - Reduce power consumption

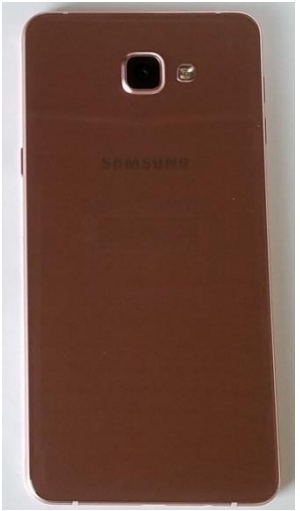
Case Studies

Flagship (2016)

BODY	Dimensions	149.4 x 73.9 x 7.7 mm (5.88 x 2.91 x 0.30 in)
	Weight	159 g (5.61 oz.)
	Build	Aluminum back panel – modular design
DISPLAY	Type	IPS LCD capacitive touchscreen
	Size	5.3 inches
PLATFORM	Chipset	Qualcomm MSM8996 Snapdragon 820
	CPU	Quad-core (2x2.15 GHz & 2x1.6 GHz)

High Mid Range (2016)

BODY	Dimensions	161.7 x 80.9 x 7.4 mm (6.37 x 3.19 x 0.29 in)
	Weight	200 g (7.05 oz.)
	Build	Corning Gorilla Glass 4 back panel
DISPLAY	Type	Super AMOLED capacitive touchscreen
	Size	6.0 inches
PLATFORM	Chipset	Qualcomm MSM8976 Snapdragon 652
	CPU	Octa-core (4x1.8 GHz & 4x1.2 GHz)



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Test Methods

CPU Stress Test

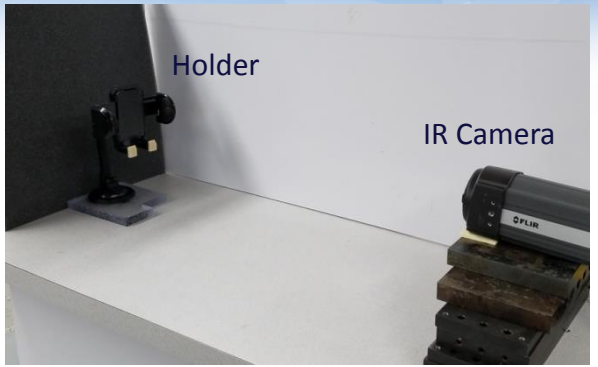
- Application – CPURun is a tool to consume CPU resources at a constant usage rate.
- Typical test length was 30 minutes, minimum

IR Test Configuration

- FLIR A300 IR Camera
- Smartphone holder positioned to hold the phone vertically

Thermocouple Temperature Measurement

- Type T thermocouples utilized
- Positioned above the hot spots determined from the IR images on the screen and back sides of stock phone



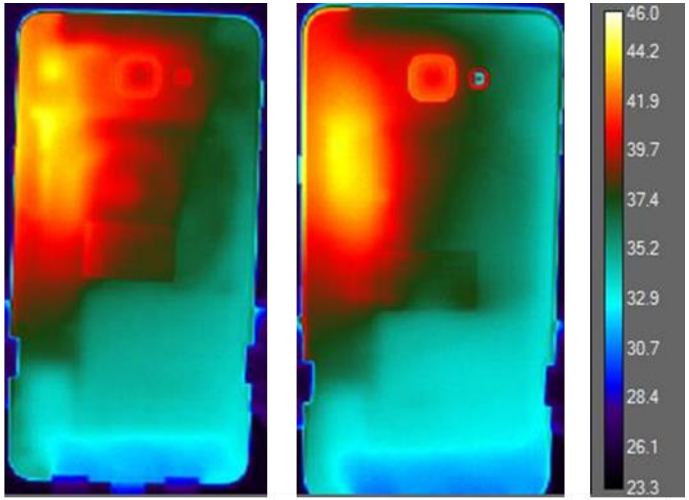
Holistic Solution Back Side – Mid-Range Smartphone

Stock Holistic Solution

- Analyses were conducted to determine the Holistic Solution configuration and thickness based on measured air gaps
- The back side solution is comprised of TIMs, heat spreading materials and conductive adhesive to form a complete thermal and EMI solution
- The base heat spreading material has an additional adhesive material that interfaces with the top of the fences to complete the EMI shield
- Image is showing the prototype installation
  - The thermal grease that interface the ICs with the heat spreader are shown on the underside of the HS
  - The TIMs that interface the heat spreader with the mid plate are shown in place on the heat spreader

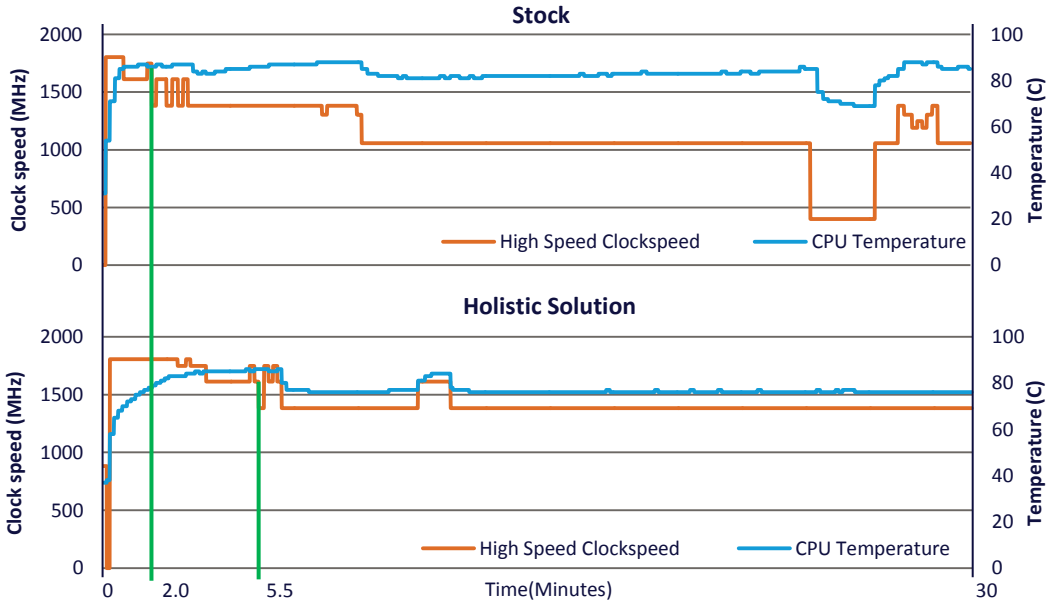
Case Study Mid-Range Smartphone – Performance Summary

Criteria	Stock (30 min)	Holistic Solution (30 min)
Average high speed CPU clock speed (MHz)	1125.77	1457.42 (30% increase)
Average CPU temperature (°C)	82.90	77.42 (5.5°C decrease)
Maximum surface temperature (°C)	44.7	45.6 (< 1°C increase)



Stock
Hot spot: 44.7°C
ΔT: 4.9°C

Holistic Solution
Hot spot: 45.6°C
ΔT: 4.3°C



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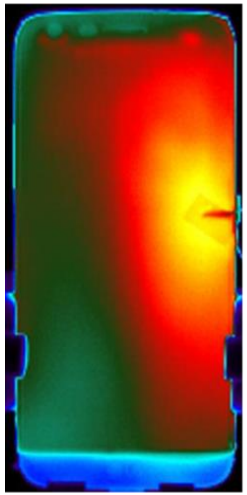
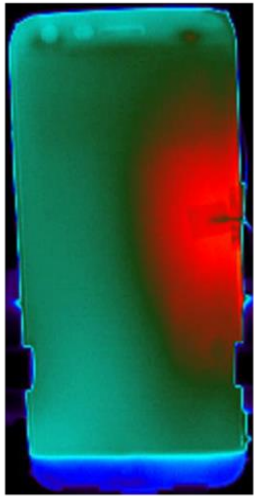
Case Study Flagship Smartphone – Performance Summary

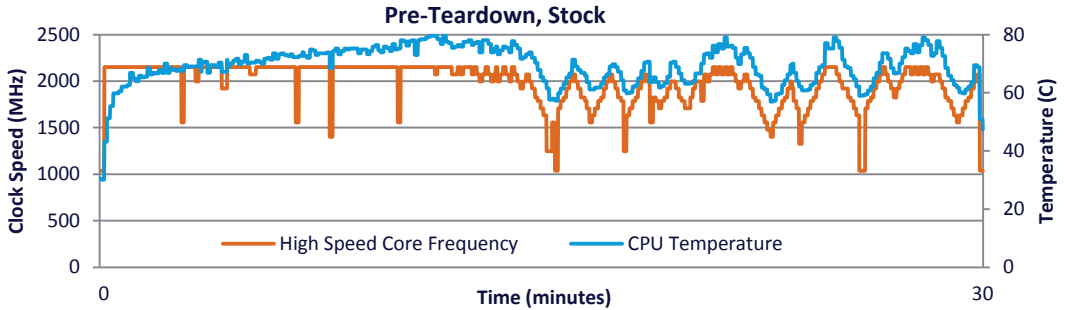
Criteria	Stock (30 min)	Holistic Solution (60 min)
Average high speed CPU clock speed (MHz)	1979.2	2134.4 (7.8% increase)
Average CPU temperature (°C)	69.9	56.2 (13.7°C decrease)
Maximum surface temperature (°C)	44.0	41.0 (3.0°C decrease)

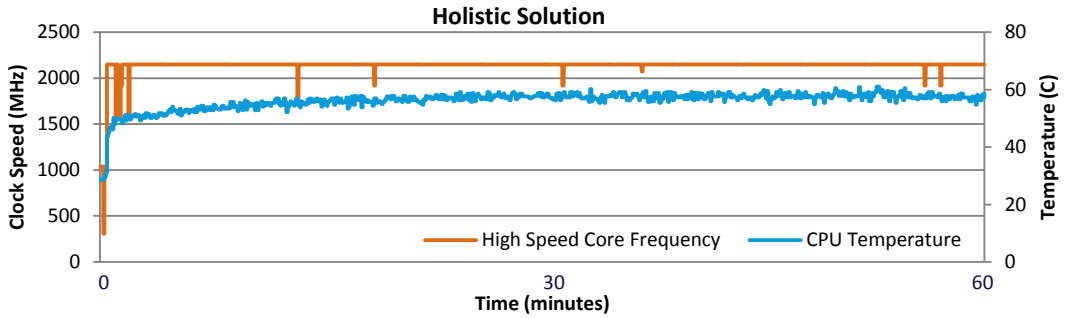


Stock
Hot spot: 44°C
30 minutes



Holistic Solution
Hot spot: 41°C
60 minutes



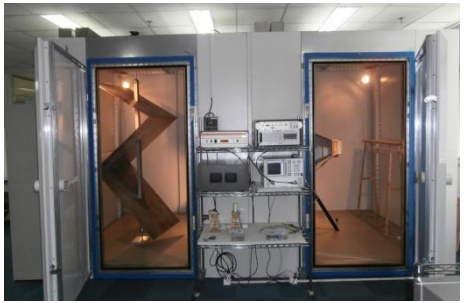


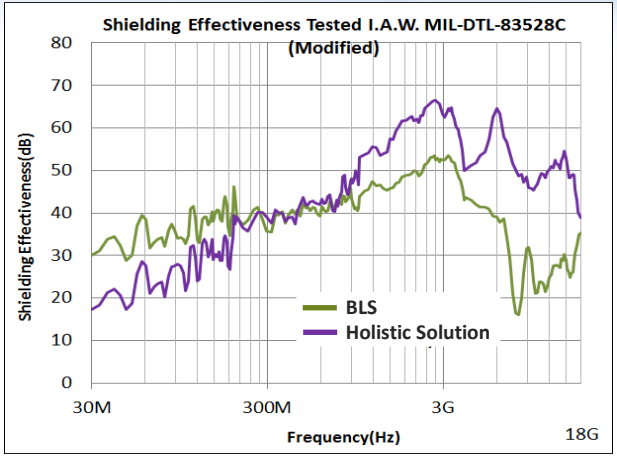
Case Study Smartphone – EMI Performance Summary

High end, mid-range model: Compare EMI performance of BLS lid vs Holistic solution

Far Field

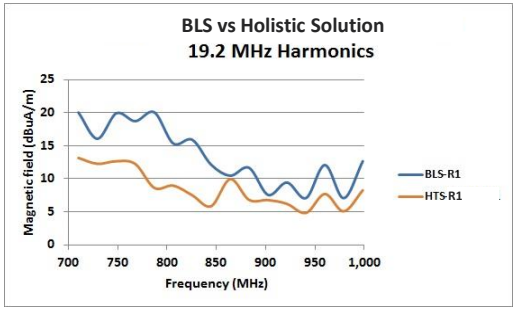
SE similar to conventional BLS
> 40 dB @ 1.5GHz





Near Field

SE similar to conventional BLS
> 20 dB



✔ ***Shielding Effectiveness Similar in Both Near and Far Field Tests***

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Summary

PERFORMANCE

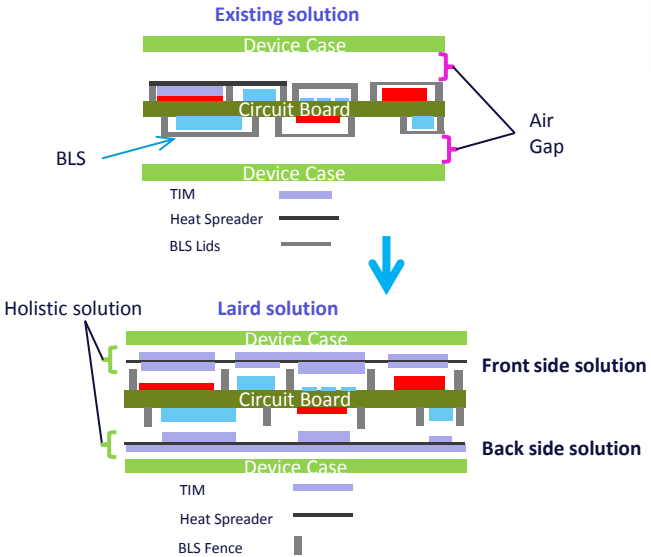
Improved Device Performance

- Mid-range Smartphone
  - High speed core freq. increased performance > 30%
  - CPU Temp unaffected
- Flagship Smartphone
  - CPU temperature reduced by > 16˚C
  - CPU performance increased 8%
  - Device skin temperature reduced > 4˚C
- EMI Shielding Equivalent

LOWER TCO

Reduce part #s & manufacturing cost

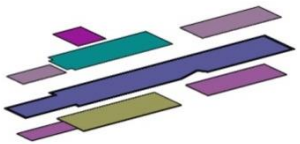
- Integrates multiple EMI & thermal products
- Pick and place complete solution



FLEXIBILITY

Extreme flexibility in solutions

- Vast portfolio of market leading TIMs, heat spreaders, EMI shielding and absorbing materials
- Leverage products in development pipeline
- Optimize performance



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