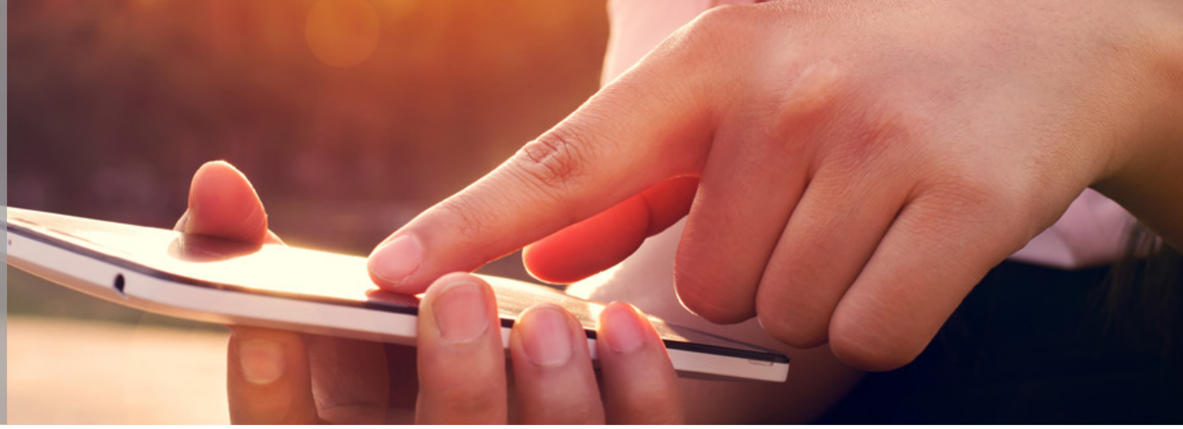


MATERION

PRODUCT BRIEF

A NEW APPROACH TO THERMAL MANAGEMENT

As demands for mobile devices with new and enhanced capabilities continue to grow, and with emerging technologies such as 5G and augmented or virtual reality requiring more computational power than ever before, thermal management becomes an increasingly important consideration for teams working on next-generation device designs. While large electronic devices typically have manual cooling systems such as fans to ensure they do not overheat, handheld devices are limited in the ways they can maintain the proper temperatures, relying almost exclusively on passive cooling systems. To put more processing power into devices such as smartphones, engineers need better materials options to manage the thermal load.

Many mobile device designs include components made of stainless steel because its stiffness and strength help maintain the integrity of the device shape and protect sensitive parts from bending. However, the poor conductivity of steel often requires additional materials such as graphite or copper to transfer heat away from local hot spots such as the SoC or Li-Ion battery and evenly distribute it across the surface of the device. Graphite is an effective heat spreader, but as additional graphite is needed to improve thermal performance in devices with greater processing power, the size or mechanical strength of the device may be sacrificed.

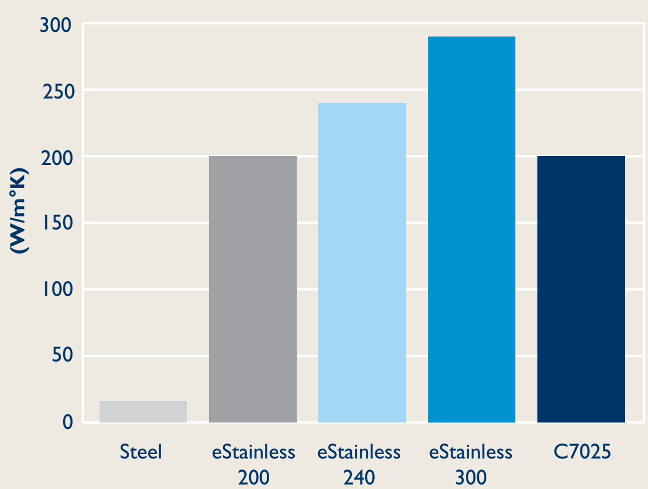
A BETTER MATERIALS SOLUTION FOR ELECTRONICS

To address the market-wide challenge of thermal management, engineers at Materion created a unique solution—eStainless® steels. This stainless steel alternative combines the structural performance of steel with the conductivity of copper or aluminum. The result is effective heat spreading without adding volume to the device.

Similar to I-beams used in construction, eStainless steels are structured composites that optimize materials utilization and achieve performance that is unattainable with a homogeneous metal. In order to achieve this state for eStainless steel, the center core of a traditional stainless steel metal strip is replaced with a highly conductive copper or aluminum alloy. The result is a three-layer metal composite that maintains the strength and stiffness of steel but with the beneficial thermal conductivity of copper alloys.

The following charts show the properties for three grades of eStainless steels compared with Stainless 316 and C7025 copper alloy, demonstrating the potential stiffness and thermal performance improvement.

THERMAL CONDUCTIVITY



BENDING MODULUS

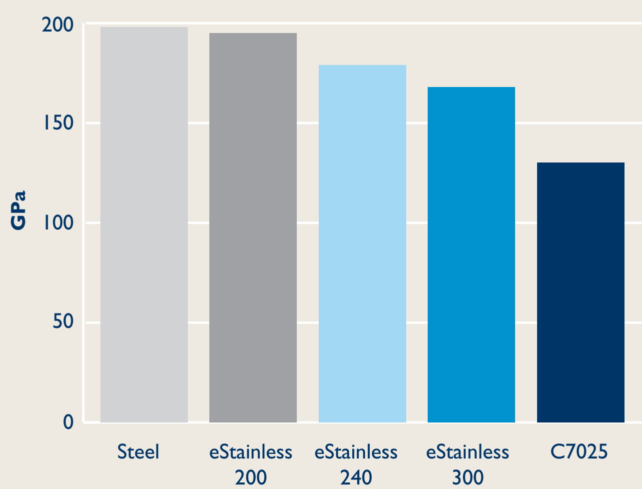


Figure 1: (Left) Thermal conductivity in x-y orientation for of common metals used in electronics design, demonstrating superior performance possible with copper cored eStainless Steel. (Right) Bending stiffness for the same common materials, showing close performance to stainless steel, but with a dramatic improvement to thermal conductivity.

FEA COMPARISON OF ESTAINLESS® STEEL WITH COMMON HEAT SPREADING SOLUTIONS

To compare the heat spreading capabilities of eStainless steel with other materials, we used thermal FEA models to develop a smartphone design with a mid-frame of 0.36mm thick stainless steel.

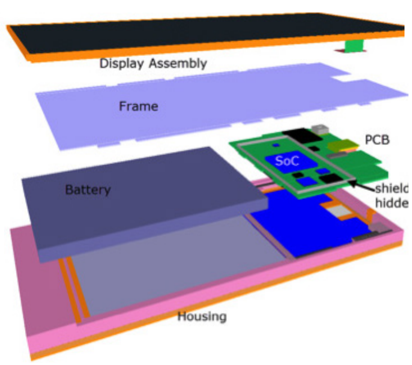


Figure 2: Schematic of the model smartphone used for thermal analysis. The frame component of steel and graphite was substituted directly with eStainless steel.

One model utilized the conventional design of 0.36mm thick stainless steel mid-frame laminated with a 25 µm 1600 W/m-K commercially available heat spreader (total thickness of steel and graphite including adhesives was 0.41mm). We compared this with a direct drop in of 0.36mm eStainless steel with no secondary heat spreader.

The thermal model was used to apply increasing power to the SoC, and the maximum steady-state surface temperature was determined as a function of input power. This allowed the relative thermal management performance of the two designs to be evaluated.

eStainless steel is a thermally conductive stainless steel for heat spreading in consumer electronics. It is a drop-in replacement for most existing steel components and creates thinner, lighter and cooler devices.

	THICKNESS (mm)	X-Y CONDUCTIVITY
Steel and Graphite		
Steel	0.36	16
Graphite	0.025	1600
Adhesives & Encapsulants	0.025	~0
	______	
Overall Thickness	0.41mm	
eStainless Steel - Al	0.36	167

Figure 3: Thickness and thermal conductivity of the various components included in the mode.

TEMPERATURE RISE WITH INCREASING POWER CONSUMPTION

In testing, the design that incorporated eStainless steel showed a significant reduction in the surface temperature when exposed to the same processing power as the stainless steel and graphite design. The surface temperature of the eStainless steel model increased at a rate of 6.3°C/W compared with 7.7°C/W for the graphite solution.

The slower pace of the temperature increase that occurs with eStainless steel allows more power to be consumed before hitting the material's temperature limit.

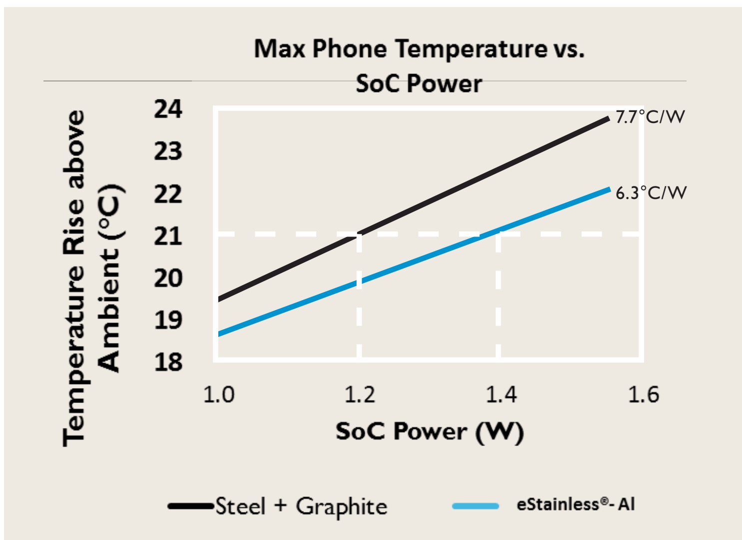


Figure 4: Maximum surface temperature of the smartphone with steel and graphite compared with eStainless steel for increasing SoC power. For a given maximum temperature rise above ambient, the eStainless steel design is capable of supporting significantly higher power inputs.

REDUCED POWER THROTTLING

Power throttling is when a handheld device restricts computing speed during power hungry tasks such as gaming or video calls. This throttling back of computational power prevents the device from overheating and potentially causing damage to the silicon or causing discomfort to the user; however, when computing speed is reduced it commonly results in performance lags and a degraded user experience.

The temperature and SoC power data presented in Figure 4 demonstrates that for a 21°C temperature rise above ambient, the eStainless steel smartphone design could handle 15% more power than the steel and graphite design (1.38W compared with only 1.19W). Many power throttling schemes often reduce power consumption by 10-20% to prevent overheating. Therefore, the improvement in allowable power consumption demonstrated here with eStainless will enable devices to sustain higher continued power consumption without performance degradation.

CONSERVING INTERNAL DEVICE SPACE

With 80-95% of the stiffness of stainless steel, eStainless steels are an effective replacement for the stainless steel frame and chassis structures typically found in mobile devices. eStainless steels can also contribute to a reduction in the overall thickness of a mobile device (a 50 μm possible reduction in thickness was demonstrated in the current model).

The standard design practice in electronics design is to use steel structural components laminated with thin graphite sheets to spread heat. This graphite is expensive and has limited performance due to micron scale thickness. A head-to-head comparison demonstrates superior performance that is achievable with eStainless steel materials.

WHY CHOOSE ESTAINLESS STEEL

Materion's new eStainless steel materials harness the strength and stiffness of stainless steel in a material with 12-18 times the thermal conductivity of traditional stainless steel, which improves functionality without sacrificing device space. As a structural component, eStainless steels improve heat spreading and dissipation without taking up valuable internal volume. In addition, eStainless steels are produced in high volumes at low costs and can be formed for any device.

Visit www.materion.com/estainless to learn more or call 401-288-0614 or to speak with a Materion design engineer to learn how eStainless steel can enhance the performance and end-user experience of your device design.