THE DEVELOPMENT OF FLEXIBLE GRAPHITE HEAT SPREADERS FOR ELECTRONICS COOLING APPLICATIONS

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Abstract

GrafTech International has pioneered the use of anisotropic, flexible graphite heat spreaders in a variety of electronic thermal management applications, encompassing most display types (plasma, LCD, and OLED), notebook computers and hand held devices. These materials are characterized by their high in-plane thermal conductivity (up to 1500 W/mK), low thru-thickness thermal conductivity, light weight and good conformability. The materials have proven ideal in applications where hot spot mitigation and improved temperature uniformity are needed, particularly in ultra-thin form factor, fanless devices.

Discussion

Anisotropic flexible graphite materials are broadly used in electronic cooling applications, as thermal interfaces[1], heat sink fins[2-3] and heat spreaders[4-6]. In heat spreading applications, graphite is attractive because of its light weight (~ 1.3-2.2g/cm^3), high in-plane thermal conductivity (~ 300-1500 W/mK) and excellent conformability. Because of its relatively low thru-thickness thermal conductivity (~ 3-10 W/mK), graphite is thermally anisotropic (or orthogonally isotropic) and is significantly different from other heat spreader materials such as aluminum, copper and diamond.

Graphite heat spreaders are manufactured as large rolls in a continuous high volume manufacturing process. Material thickness is in the range of 10µm to 1.5mm. Coils of material, Figure 1, are sent to converters who apply adhesives, plastics or metals and then die cut or form the material to finish shape. Typical peel-and-stick die cut parts for a handset application are also shown in Figure 1.

Fig. 1 Rolls of graphite material with representative die cut parts for a handset application

Graphite heat spreaders are used in applications where improved temperature uniformity, hot spot reduction or cooling is required. Hot spot reduction is illustrated in Figure 2 which shows infrared images from an ABS plastic case with and without an attached graphite heat spreader. The top image shows a 0.8W heat source, simulating a power amplifier, contacting the plastic case and generating a hot spot temperature of 90ºC. In the bottom image, a 110µm thick 400 W/mK graphite heat spreader is attached to the plastic case; the hot spot temperature is dramatically reduced while, at the same time, the heat source power has increased to 3.3W.

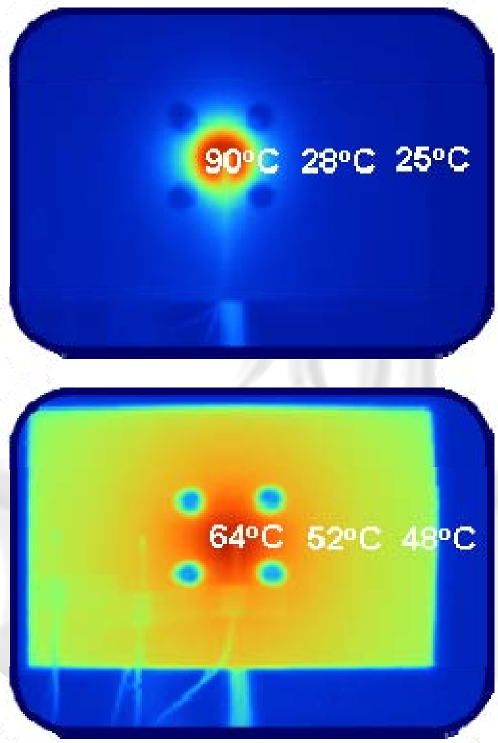

Fig. 2 IR images of a bare ABS plastic case with a 0.8W heat source attached (Top) and the same case with a 110µm thick 400 W/mK graphite heat spreader and 3.3W heat source attached (Bottom)

This performance has resulted in wide spread adoption of flexible graphite in handset, laptop and display applications where the heat generated from power amplifiers, processors, chipsets, wireless devices, etc., has to be shielded from the case (to reduce touch temperature) or from other temperature sensitive devices, such as the battery or certain display types (e.g. OLED). This has become particularly important with the trend towards fanless thermal management solutions that extend battery life, reduce power consumption and noise, and enable thinner form factors in handset, ultra-light notebook and netbook applications.

A real world application in the Sony VAIO P netbook application is shown in Figure 3. In the bottom left corner of this figure, the graphite heat spreader is shown attached to the case. Infrared images of the outside surface of the netbook, with and without a graphite heat spreader, are shown in Figure 4. The peak hot spot touch temperature was reduced by 8°C by using a 0.38mm thick 400W/mK graphite heat spreader.

Fig. 3 The application of a graphite heat spreader to reduce touch temperature in the Sony VAIO P netbook.

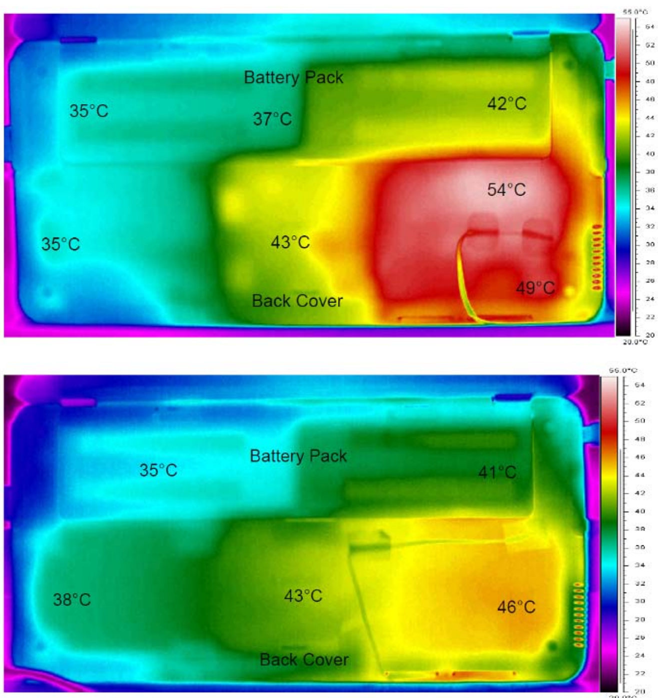

Fig. 4 IR images of the bottom surface of the Sony VAIO P netbook without (Top) and with (Bottom) a graphite heat spreader.

Other uses of graphite heat spreaders are in cooling applications, where the spreaders are attached to the heat generating device with thermal interface materials. An example of this is shown in Figure 5 where a 0.25mm thick 450 W/mK graphite heat spreader cools an N270 1.6GHz Intel® Atom™ processor (~2.5W max TDP) and an Intel 945GSE Express Chipset (~ 9.3W TDP) in the Gigabyte M912V netbook.

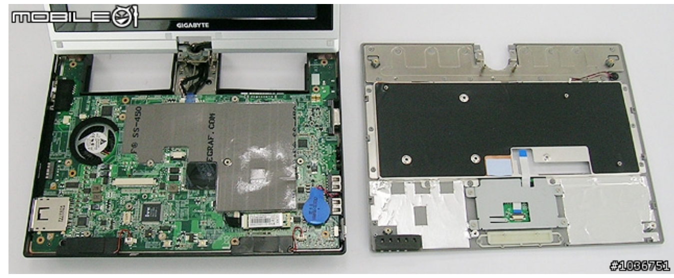

Fig. 5 The application of a graphite heat spreader to cool an Intel Atom Processor and Chipset in the Gigabyte M912V netbook.

Recent slim form factor handset and OLED display designs, where space for a thermal management solutions are extremely limited, demand a new generation of even thinner, higher thermal conductivity materials. Figure 6 shows a 20µm thick 1500 W/mK graphite heat spreader in the Sharp SH001 cell phone. The heat spreader is underneath the main PCB, facing the top of the RF and Baseband engines, and is attached to the metal back plate of the key pad. It shields the heat from the main PCB to the key pad and reduces touch temperatures.

Fig. 6 A 20µm thick 1500 W/mK graphite heat spreader inside the Sharp SH001 cell phone.

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