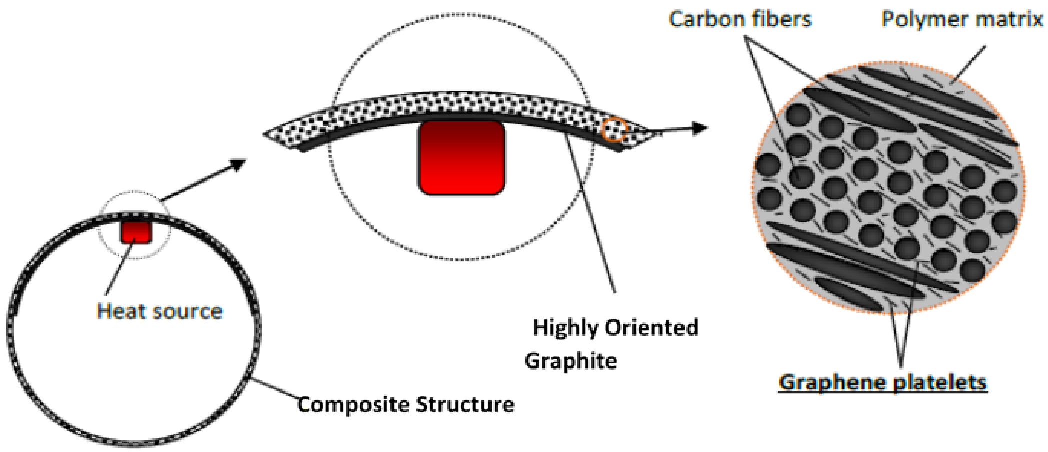
ADVANCED THERMAL MANAGEMENT FOR RADAR SYSTEMS

Executive Summary:

Stryke has conceived, developed, implemented, and utilized several advanced thermal management technologies for defense applications. These technologies range from more traditional systems such as cold plates, heat pipes, and thermal interface materials (TIMs) to advanced and novel systems such as nanomaterial enhanced electronic enclosure materials, phase change materials, advanced thermal barrier coatings, and thermally enhanced printed circuit boards. These technologies can be implemented synergistically to allow full utilization of the radar or other electronic system.

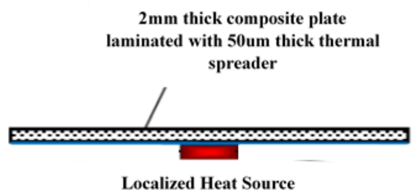
Thermally Conductive Carbon Fiber Composites:

Of specific applicability to radar systems, the Stryke team has proposed the development and deployment of a thermally conductive carbon fiber reinforced composite (CFRC) for structural and enclosure applications. This enhanced CFRC material would utilize thermally conductive graphene nanomaterials, as well as highly conductive graphite sheets to maximize the in-plane thermal conductivity of the polymer composite. It has been demonstrated that increasing the in-plane thermal conductivity of the structure will have a much larger impact on heat dissipation than similar improvements in through-plane conductivity. Stryke intends to utilize a multi-scale, synergistic solution where nanomaterials are incorporated with macro-scale fibers and bulk, highly oriented graphite. A schematic illustration of the concept is given below:

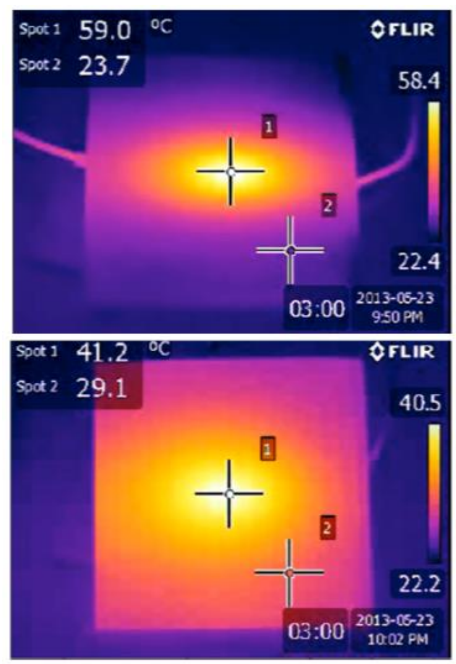


Schematic illustration of the proposed solution for in-plane thermal conductivity improvement. Highly thermally conductive graphene nanomaterials will be incorporated into the polymer matrix while a highly oriented graphite thermal spreader will be applied to the inner wall of the composite structure.

By tailoring the thickness of the thermal spreader, different levels of in-plane conductivity can be achieved. This allows application specific parameters to dictate the material parameters instead of bulk material properties dictating the performance specifications of the internal components. When compared to traditional thermal spreader materials such as copper and aluminum, the highly oriented graphite can achieve the same level of bulk composite conductivity at 18% spreader thickness for copper and 9% for aluminum. Similarly, the weight to achieve equivalent conductivity using the highly oriented graphite is 4.8% and 7.2% that of copper and aluminum, respectively.



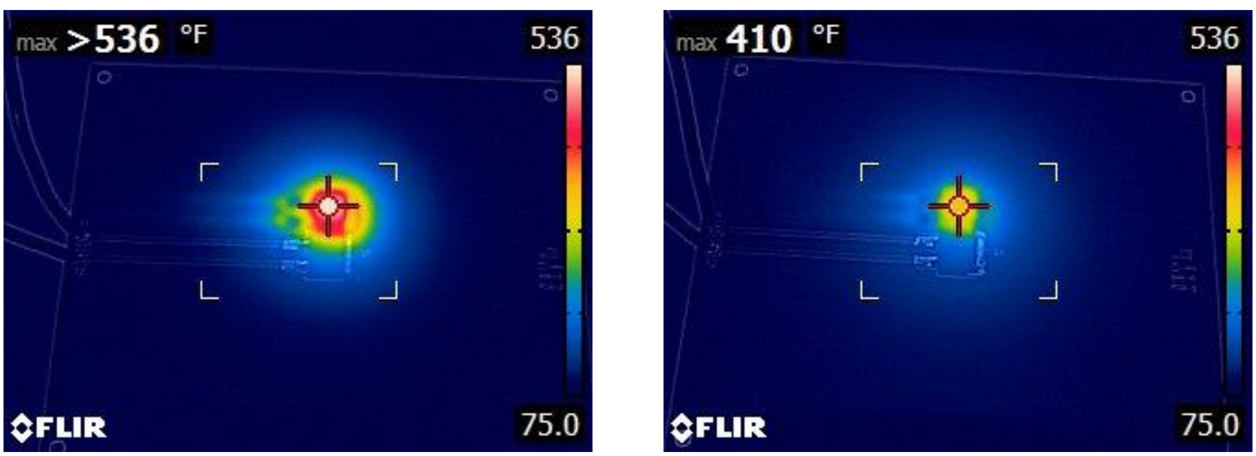
Above: Experimental design, Right: Thermal spreading comparison of 50 um thick copper (top right) and 50 um thick graphite (bottom right) yielding maximum spot temperatures of 59°C and 41.2°C, respectively.



Thermally Enhanced Printed Circuit Boards:

Stryke has conceived of a thermal management solution incorporated into a traditional printed circuit board (PCB). This concept builds upon the extraordinary thermal dissipation characteristics of highly oriented graphite to provide significant thermal management at the board level. Traditionally, PCBs are comprised of alternative layers of composite and copper. The composite insulates the surrounding integrated chips, vias, and connections while the copper power and ground layers provides the electrical pathways necessary for completing the electrical circuits. The Stryke concept, referred to as a thermal printed circuit board (tPCB), builds upon this architecture by incorporating additional layers dedicated to dissipating thermal energy generated during the circuitries operation. In many applications, a limited number of high power components generate the vast majority of the heat signature of a board. These components are often subject to throttling to maintain operating temperatures within acceptable limits, thereby reducing the overall performance of the electronics. By rapidly and efficiently dissipating the heat from these components and shunting it to other, less sensitive areas of the board, these thermal ground planes, notionally made of highly oriented graphite, may significantly enhance the operational capability of many high power electronic systems, potentially including radar systems.

In proof of concept testing, where boards were developed and built with either traditional copper or the aforementioned highly oriented graphite, the latter displayed significantly enhanced chip cooling capacity by dramatically expanding the thermal dissipation effects. In relevant applications, this result, while very early, would manifest as lower integrated chip temperature and therefore expanded operating and performance windows. As clearly demonstrated in the figure below, the incorporation of graphite lowers the chip temperature from > 536 ^{o}F to 410 ^{o}F. The thin nature of the graphite, in addition to the density of graphite, results in an additional weight and space saving solution.



Left: Thermal signature of powered IC with 1 oz copper layer (approximately 35 um). Right: Thermal signature of powered IC with 25 um highly oriented graphite layer.

Status and Way Ahead:

Stryke has conceived both aforementioned technologies and believes they potentially provide a strong value proposition to the electronics industry and end-users. Both technologies require additional maturation and relevant environment validation prior to implementation. The enhanced thermal conductivity composite has a TRL of 3-4 while the tPCB has a TRL of 2-3. Stryke is actively seeking government and industry partners to assist in the development, characterization, and maturation of the proposed technologies for radar and other thermal management applications. While the core concepts and materials knowledge is held within Stryke, an ideal partner would bring in-depth applications understanding and relevant environment requirements to ensure the most efficient and rapid technology maturation.

About Stryke:

Stryke Industries, headquartered in Ft. Wayne, Indiana, is a non-traditional defense contractor specializing in the deployment of novel materials and technology within the defense industry. With two divisions, Advanced Materials and Manufacturing and Cyber Security and Software Solutions, Stryke has, and continues to be, a key participant in many OTA and traditional R&D programs. Stryke combines its own core competencies, expertise, and technology, with those of its consortium to bring complete, innovative, and valuable solutions to its customers and clients.

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