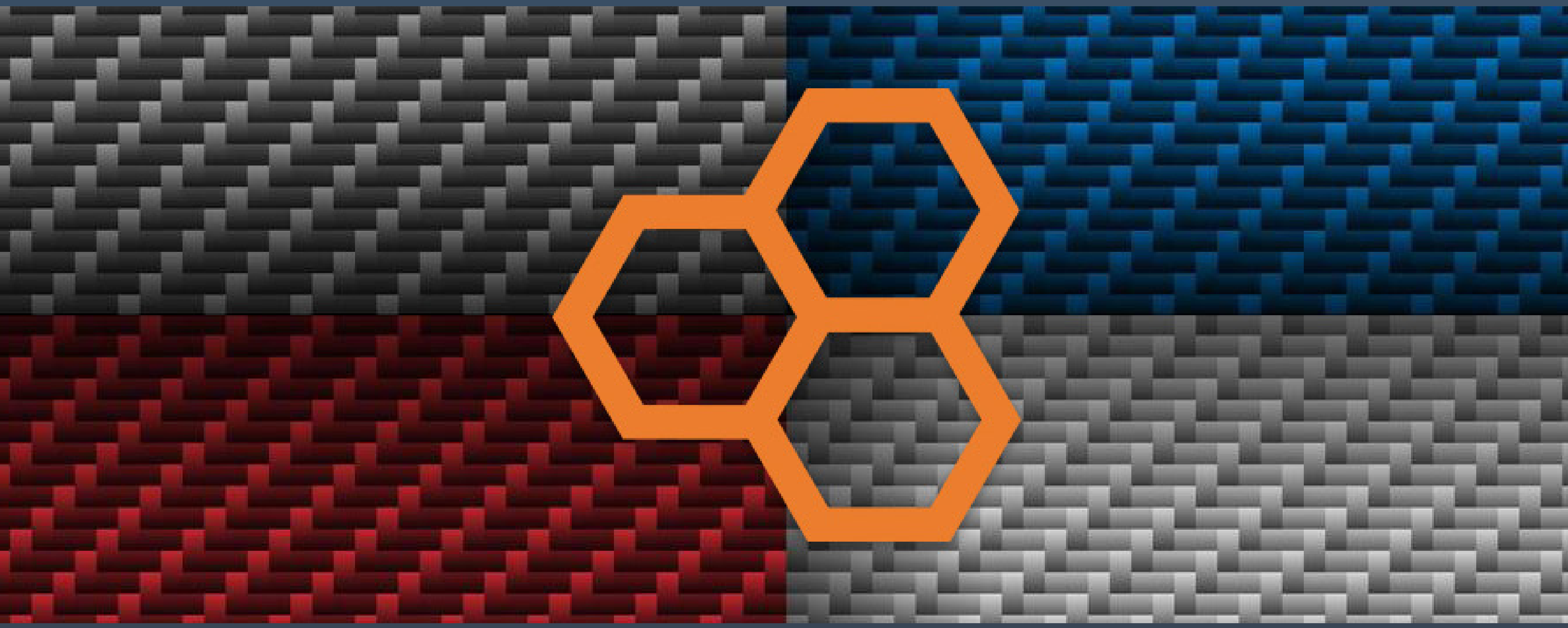
COMPOSITE ENVISIONS KNOWLEDGE HUB
PRACTICAL AND INSIGHTFUL COMPOSITES INFORMATION



HOW WELL CARBON FIBER AND OTHER FIBERS SHIELD RADIO WAVES

COMPOSITE ENVISIONS

INTRODUCTION

Carbon Fiber is known widely in aerospace, sports, racing, the marine industry for its strength, lightweight, and rigidity characteristics. The material's use will continue to grow just as technological advances in complex communication systems grow. In order to design around implications of material systems and communications being intertwined, Carbon Fiber's electrical properties must be studied. On the surface, little is to be said of CFs electrical properties. Unlike comparative material used today (Kevlar or Fiberglass) Carbon Fiber is a conductor of electricity; Meaning that it will carry an electrical current or flow in one or more directions. Looking into the future of the material system, this characteristic makes carbon fiber a special challenge, considering its matrix contains non-conductive traits. Electrical properties in composites are commonly defined by the material's resistivity to electrical current, its shielding effectiveness, attenuation features, and its dispersion of electrical current with a given ply structure.

CARBON FIBER AND CONDUCTIVITY

One of the most important properties in understanding the effects of Carbon Fiber and electromagnetic waves is conductivity. Generally, electromagnetic shielding can be directly related to a material's conductivity. Carbon fibers consisting of 90-100% carbon content have an electrical conductivity of approximately 106 S/m (Siemens per meter). In comparison to metals such as silver, copper, or aluminum which have a conductivity of (4-6) x 107 S/m. (Significantly less) Carbon Fiber composites are classified as anisotropic meaning carbon fiber laminates will carry loads differently as applied to different directions of the material. The same is true for electrical conductivity. Carbon fibers will conduct electricity better in the parallel to the fiber direction. However, most composite structures are made by stacking plys in differing orientations to achieve needed physical loading requirements. Thus, Carbon Fiber composites exhibit high conductivity in-plane while through-thickness conductivity is lower.

In structures made of Carbon Fiber, challenges such as lighting strike in aircraft are common hurdles in aerospace design. With older aluminum aircraft, lighting strike was not a common issue. Aluminum being a high conductor of electricity, kept high voltage hits on the surface of the aluminum rather than implicating passengers or electrical equipment. Carbon Fiber aircraft manufacturers must design around this feature in order to keep electrical components and passengers safe as electrical charges will find the least resistant path through a plane's electrical grid. Industrial remedies to this issue have been the addition of conductive surface layers placed in components to hold the electrical charge and ground to designated areas in the structure. Often referred to as lighting strike protection, a copper mesh ply is added to the layup of parts that may be susceptible to a lightning strike scenario. This layer of copper mesh is then attached to the structure's ground plane. This provides adequate protection at a cost of added weight, which is generally small and can be designed around.

Ongoing research of the black magic of carbon fiber's electrical properties are pushing through ideas of conductive resin matrix materials that provide comparable characteristics in strength, but most are not readily available on most commercial markets and not yet proven on a wide scale. The addition of nickel and copper coatings fibers are being studied heavily to understand the possible performance enhancements to electrical properties and thermal conductivities. In a study completed in 2019, comparisons to uncoated fibers, nickel coated carbon fibers have shown to double thermal conductivities in the fiber direction of laminates*. Likewise, Copper coated fibers have shown data to increase the amount six times in comparison to uncoated fibers. Electrical conductivity showed a gain of 3 orders in magnitude in nickel and copper coated fibers in the fiber direction. Science behind the coatings show that the plating materials around the fibers themselves result in easier contact through the fibers' conductive metal shells. Research also points to Fiber volume being a large contributing factor to both thermal and electrical properties. The higher the fiber percentage, the higher the conductivities presented. This however does come with a trade-off to lowering mechanical properties as the taking away matrix (resin) material has a tougher time surrounding the fibers in fractions above ~65%. There are however mixtures of the nickel coated fibers that show comparable values to that of the uncoated laminate's flexural properties.

While Carbon Fiber itself is a possibility for use of a Faraday cage, it is not going to protect as effectively as specifically designed "Faraday fabrics" that carry higher conductive properties and higher shielding effects. Carbon Fiber will absorb and attenuate Radio Frequency radiation between 3 kHz and 300 GHz. While CF may not be the best shield when used on its own, CF can be added to signal blocking layers, such as a when adding short carbon fibers to a conductive matrix such as concrete. This has been proven to elevate attenuation levels through the material. Carbon Fiber could be used for reinforcing Faraday structures if a highly conductive or shielding surface is added to the shell of the cage, providing a conductive and shielding outer layer.

Conductivity of carbon fiber poses issues to electrical components when antennas are connected to it causing radio frequency interference. When designing components around a carbon fiber structure, be sure that needed antenna(s) are out and visible to the radio waves. Design using fiberglass or Kevlar will not pose the same challenge as materials are not conductive and effectively become transparent to radio waves. However, neither fiberglass nor Kevlar have the same rigidity characteristics as carbon fiber.

CARBON TAPES & CELLPHONE SERVICE ELIMINATION

When used as a phone case, Carbon Fiber can decrease service capability. Carbon fiber, as a conductor has been shown to reduce Radio Frequency in cell service as much as 40-60% in specific applications. While many carbon fiber cases look downright amazing, it is not the best choice for a composite material in phone protection. However, the use of Kevlar (aramid) protection in cell phone cases poses a better option as Kevlar is not a conductor of electricity. Kevlar holds similar strength properties as carbon fiber and absorbs energy better as it is not as stiff as carbon fiber.

*Data sourced from: “Copper and Nickel Coating of Carbon Fiber for Thermally and Electrically Conductive Fiber Reinforced Composites” Simon Bard, Florian Schönl, Martin Demleitner, Volker Altstädt 7 May 2019

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