Enhancing Carbon Fiber Properties

Much as fiberglass did with many recreational products years ago, the use of carbon fiber has fundamentally changed the performance of a wide range of sporting goods, aerospace, and industrial products. Golfers can now drive a golf ball over 300 yards because their golf shafts are made of carbon fiber. Bicyclists can ride longer and climb higher with less effort. Both Boeing with its 787 and Airbus with its A350 are relying on more carbon fiber to lower both fuel and maintenance costs. Once made of wood or metals, these products are now lighter and stronger because of carbon fiber.

While applications for carbon fiber will continue to increase in the future, there are certain applications where carbon fiber needs help. There are numerous carbon fibers on the market with a wide range of tensile strength and elastic modulus, allowing any designer to use the proper version to meet the needs of the application. However, there is one property of carbon fiber that is inadequate, and that is compressive strength. Compressive strength can be defined as the stress state caused by an applied load that acts to reduce the length of the material in the axis of the applied load, in other words the stress state caused by squeezing the material. While the compressive strength of carbon fiber is notably low, the compressive strength of boron fiber is particularly high. That is why adding a small amount of boron fiber to carbon fiber composites can have a spectacular effect on the overall compression strength of the composite.

To visualize why carbon fiber and boron fiber are so different in compressive strength, imagine these fibers on a larger scale. Carbon fiber is typically a bundle of small diameter (7 to 12 micrometers) yarns. It is much like everyday rope in that sense. When you pull on rope (tensile force), it is quite strong and resistant to failure, yet pushing the rope at both ends (compressive force) collapses it with minimal force. Conversely, boron fiber on a macro scale is more like a telephone pole. It is an individual filament with a diameter of 100 micrometers, or roughly an order of magnitude larger than carbon filaments. Pull on the pole and it will be strong. Push on both ends of the pole, and it will still be strong.

The following chart displays a range of carbon fiber composites and their measured tensile and compressive strengths. Much of these data were obtained from MIL-HDBK-17-2E. Included are data for carbon composites when varying amounts of boron fiber are added to one of these composites. Specialty Materials, Inc. has named this hybrid composite **Hy-Bor®**, since it is a hybrid composite of carbon and boron fibers. As you can also see from the photomicrograph displayed after the chart, the smaller diameter carbon filaments fit very nicely around the larger diameter boron filaments, thus optimizing fiber volume packing.

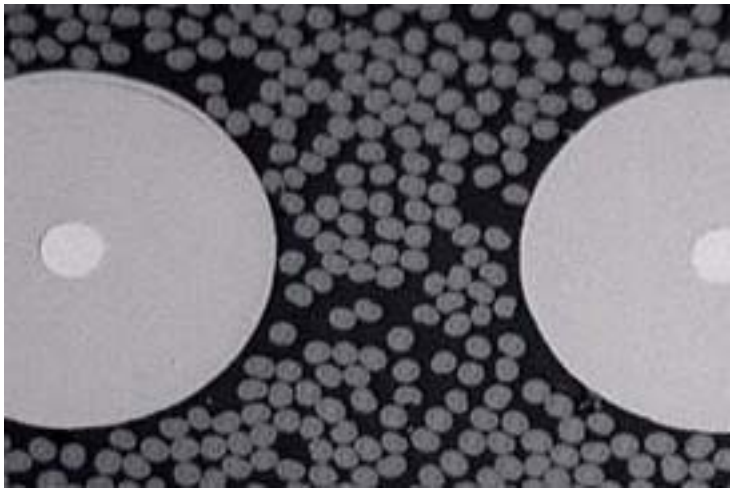
SPECIALTY MATERIALS, INC.

Manufacturers of Boron and SCS Silicon Carbide Fibers and Boron Nanopowder

Properties of various carbon fiber composites with and without boron fiber added

Composites	Tensile Strength (ksi)	Compressive strength (ksi)
AS4/EK78	303	245
Celion 12K/EK78	293	206
M55J/954-3	324	136
IM-7/3501-6	370	210
MR-40/301	295	180
4mil B (100 fibers/inch) + MR-40/301	235	340
4 mil B (208 fibers/inch) + MR-40/301	275	400

Photomicrograph of Hy-Bor®



By combining carbon fiber with boron fiber, Hy-Bor® achieves the maximum compression strength of any continuous filament-based composite material. It can be tailored to meet specific materials properties and design objectives by customizing the graphite fiber and resin type and the boron fiber ratio.

To learn more about this material go to http://www.specmaterials.com/hyborprepregtape.htm

SPECIALTY MATERIALS, Inc. - 1449 Middlesex Street Lowell, Massachusetts 01851
Phone: 978-322-1900 • Fax: 978-322-1970 info@specmaterials.com