Microstructure and Mechanical Characterization of Carbon Fiber

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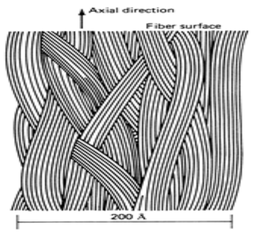
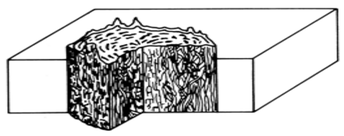
Introduction:

Carbon fibers after a 40 year period development and use in specialized applications, are now on the brink of broad commercialization. Their use is growing rapidly, fueled by significant price reductions during the 1990's and increasing availability. Changes in the performance/price ratio have resulted in the increased penetration of composites into applications formerly held by metals and has enabled their use in other applications previously not possible with existing materials. The earliest commercial use of carbon fibers is often attributed to Thomas Edison's carbonization of cotton and bamboo fibers for incandescent lamp filaments. However, practical commercial use of carbon fibers for reinforcement applications began in the late 1950s with the pursuit of improved ablative materials for rockets. Zylon fiber/epoxy composites are used at the NHMFL for structural reinforcement of high field pulse magnet coils. Zylon fibers have been chosen primarily because of high strength and elastic modules. However, carbon fiber is being considered for pulse magnet reinforcement material because of it's high stability. Currently, carbon fiber is used on aircraft for primary and secondary structure, golf club shafts, tennis rackets and fishing rods.





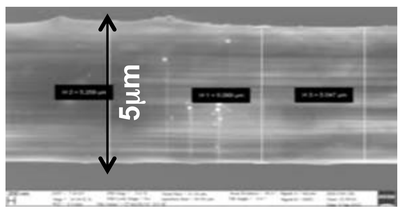
Carbon Fiber

Carbon Fiber Tennis Racket

Carbon Fiber Fishing Rod

Purpose:

Our task is to research the characteristics of carbon fiber IMS65 E23 24K 830tex as a possible reinforcement material for the casing of new pulsed magnets.



Scanning Electron Microscopy image of a single E23 Carbon Fiber

Procedures to make Carbon Fiber TEM Samples:

1. Carbon Fibers were cut to <3mm using a razor blade.
2. We mixed a drop of high strength Epoxy Glue.
3. A copper grid is placed under a microscope
4. Epoxy is placed on the edges of the copper grid
5. Carbon fiber is glued over the center of the copper aperture.
6. We placed sample on a dimple grinder to reduce thickness.
7. After initial grinding we placed copper grid samples on ion polisher to thin the material to about 100nm.
8. We checked our sample with the traditional TEM, before loading in the ARM for high resolution analysis.

Several different samples were made. The procedures for the Cross section, Tensile strength samples are similar to the copper grid samples.

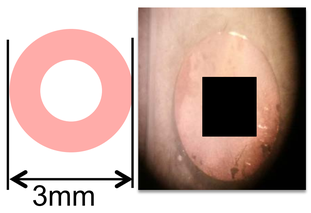
Cutting carbon fiber

Romy and Cedric making samples of epoxy

Paul making copper grid samples

Resulting Product:

A group of samples was created and its purpose was to allow the fibers to be analyzed and tested. The TEM samples must be thinner than 100 nm in order to become electron transparent and to create an image. Then they are attached to a 3mm grid for placement in the microscope.

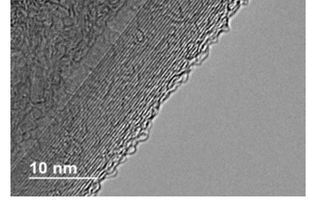


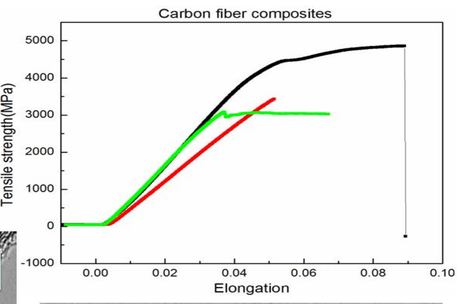
Copper grid with Carbon Fiber

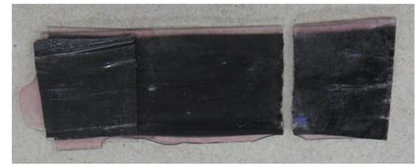
Samples of carbon fibers in epoxy

Experimental Data

Characteristics	Data
Filament Diameter	5µm
Tensile Strength [MPa]	3100-4800
Elongation at break	4-9%







Tensile test

Conclusion:

Much of the effort expended for carbon fibers study is directed at future pulsed magnet construction. The prospects of its properties have stimulated interest in many new applications. The Carbon/Epoxy composite tensile specimens have shown high tensile stress characteristics. Continued study of carbon fibers for use in pulsed magnet construction is warranted.

References:

R. Bacon and M.M. Tang, Carbonization of Cellulose Fibers I *Carbon*, Vol. 2, 1964, p. 211
T. Edison, U.S. Patent 223, 898, 1880
Y.K. Huang, P.H. Frings, and E. Hennes, "Mechanical properties of zylon/ epoxy composite," *Composites,* vol.33B, no. 2, pp. 109-115, 2002.

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To RET 2k14, I wish you guys and girls the best in the upcoming school year. Just imagine if all of us worked together, we would be an "A" school every year.

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