USE OF SUBMICRON DIAMETER CARBON FILAMENTS AS A SECOND FILLER BETWEEN CONTINUOUS CARBON FIBER LAYERS IN A POLYMER-MATRIX COMPOSITE FOR ENCHANCING THE VIBRATIONAL DAMPING ABILITY AND TRANSVERSE MODULUS

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INTRODUCTION

The vibrational damping ability of carbon fiber polymer-matrix composites are important for sporting goods, anti-sonar submarines, loudspeaker diaphragms and aerospace structures. Carbon filaments (as opposed to carbon fibers) are made catalytically from carbonaceous gases. Their small diameter results in a large filler-matrix interface area when the filaments are used as a filler in a composite. The large interface area in turn results in good damping ability, as shown in this work, in which the filaments were used as a second filler between continuous carbon fiber (first filler) layers.

EXPERIMENTAL METHODS

Composite samples were made from unidirectional carbon fiber prepreg tapes (ICI Fiberite Hy-E 1076E), which consisted of a 976 epoxy matrix and 10E graphite fibers. The carbon filaments (Applied Sciences, Inc., ADNH) had diameter 0.1 - 0.2 μm and length > 100 μm. Eight 4 x 7 in. fiber layers cut from the prepreg tape were stacked in a mold. For laminates with a second filler, the second filler material was spread out on each ply as they were laid up, producing laminates with eight layers of carbon fibers and seven interlaminar regions which contained the second filler. A uniform layer of second filler material (0.03 g) was assured by the fact that only a monolayer of filaments would adhere to the tacky prepreg plies. The densities of the laminates were 1.530 and 1.555 g/cm^3 without and with the second filler respectively. The thickness of a second filler layer was 8 μm, as found by difference between thicknesses of laminates with and without second filler; that of a first filler layer was 110 μm. The volume fraction of second filler layers in the composite with second filler was 6%. The volume fraction of second filler in a second filler layer was 10%. The volume fraction of first filler in a composite without second filler was 52%; the volume fractions of first and second fillers in a composite with second filler were 56.5% and 0.6% respectively. The laminates were cured according to the ICI Fiberite C-5 cure cycle. Afterward, they were cut to pieces of size 25 x 2.5 mm to produce both longitudinal and transverse specimens.

Dynamic testing of the composite beams

was performed on a Perkin-Elmer Dynamic Mechanical Analyzer (DMA7e). The specimens were tested in three-point bending.

RESULTS AND DISCUSSION

Table 1 gives tan δ and storage modulus at 30°C. The addition of the second filler increased tan δ in both longitudinal and transverse directions, though the increase was more significant in the transverse direction. The modulus decreased by a small fraction in the longitudinal direction, but increased by a larger fraction in the transverse direction. The effect on tan δ is attributed to the damping due to the filler-matrix interface slippage and the large interface area when the second filler was present. The effect on the transverse modulus is attributed to the domination of the transverse modulus by the matrix and the existence of filaments in the transverse direction within the second filler layer. The effect on the longitudinal modulus is attributed to the low modulus of the second filler compared to that of the first filler.

CONCLUSION

The incorporation of 0.1 - 0.2 μm diameter carbon filaments as a second filler between continuous carbon fiber layers in an epoxy-matrix composite during composite fabrication was found to greatly increase transverse and longitudinal tan δ values, increase the storage bending modulus in the transverse direction, and slightly decrease the modulus in the longitudinal direction.

Table 1 Tan δ and storage modulus at 30°C

	Without second filler		With second filler	
	0.2 Hz	1.0 Hz	0.2 Hz	1.0 Hz
Tan δ				
Longitudinal	0.008	<0.0001	0.017	<0.0001
Transverse	0.010	0.090	0.220	0.180
Storage modulus (GPa)				
Longitudinal	101	97	92	92
Transverse	7.9	8.3	9.1	9.5