MECHANICAL PROPERTIES OF VAPOR GROWN CARBON FIBER REINFORCED CARBON COMPOSITES

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INTRODUCTION

Recent advances in composites have established these materials as attractive candidates for thermal management applications.[1 2 3] Of these, carbon composite based on vapor grown carbon fiber (VGCF) exhibit the highest thermal conductivity, and are very attractive for spacecraft thermal management and also as candidate materials for use as plasma facing components in fusion reactors.[4 5 6] Although VGCF reinforced carbon (VGCF/C) composites have been shown to exhibit excellent thermal conductivities that cannot be achieved by using any other carbon fibers, the mechanical properties have received less attention. In this paper, we present mechanical properties of VGCF/C composites with different fiber loadings.

EXPERIMENTAL

A total of seven (7) VGCF preforms were prepared. These preforms have various fiber loadings and architecture. These preforms were densified using two pitch infiltration cycles and follow by a chemical vapor deposition (CVD). Two high temperature heat treatments were performed between the pitch infiltration cycles and after the CVD process, respectively. Selected specimens were analyzed using an optical microscope (OM) under polarized light. Each VGCF/C composite panel was then machined into at least three tensile bars for testing. The dimensions of a tensile bar were 1" by 0.5" by 0.04". The cross-head speed was 0.005 in/min. The tensile modulus, strength, strain, and Poisson's ratio of each composite were determined.

RESULTS AND DISCUSSION

In general, densification is considered to be homogeneous. However, large pockets are seen and associated with large-diameter VGCF. It is believed that the occurrence of these large pockets is a result of molding or compacting of fibers with various diameters. Although compact efficiency is independent of fiber diameter, the individual voids by larger diameter fiber are larger than those by smaller diameter fiber. Larger, un-filled space therefore exists around large diameter fibers after the densification.

Table I summaries data obtained from the testing. Each datum shown in Table I represents an average value of at least three data points. For the 1D composites, the modulus and Poisson's ratio increase with the fiber volume fraction. On the other hand, composite strength appears to be lower at high fiber volume fractions. Both the modulus and strength are lower than expected, indicating the fiber mechanical properties have not been translated well into the composites.

CONCLUSION

Tensile properties of VGCF/C composites are reported. These properties are lower than expected. However, the composite tensile modulus is comparable with that of aluminum. It is suggested that thermal properties of VGCF can better be translated into composite than are mechanical properties. The implications favors applications for thermal management where structural demands are less stringent.

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Table I. Tensile modulus, tensile strength, and strain of failure for VGCF/C composite specimens.

ρ (g/cc)	V_f	Modulus (GPa)	Strength (MPa)	Strain (%)	Poisson's Ratio	Architecture
1.58	15%	26.2	36.5	0.14	-	1D
1.72	41%	51.0	69.6	0.16	0.43	1D
1.79	52%	53.1	66.8	0.15	0.48	1D
1.78	61%	86.1	57.2	0.07	0.66	1D
1.71	42%	30.0	40.7	0.16	0.19	2D
1.83	52%	48.2	37.9	0.10	0.20	2D
1.72	62%	26.9	37.2	0.16	0.21	2D