LOW-COST C-C COMPOSITES

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Carbon-carbon (C-C) composites offer unique thermal, mechanical and corrosion properties. However, their commercial application is limited due to very high cost. A new process to manufacture high quality C-C composites in one step (no densification) was developed. The manufacturing process is very flexible: both fiber tow and fabrics can be utilized, as well as pitch-based and PAN-based carbon fibers. In addition, net shape manufacturing has been accomplished. Processing-structure-property relationship for these novel composites will be presented.

INTRODUCTION

Carbon-carbon composites offer in-plane properties that are equivalent or better than organic composites, while at the same time exhibiting much higher through-thickness thermal conductivities, typically 40 W/mK. They appear to be more attractive than metals or organic composites for heat dissipation components. Carbon-carbon composites, developed at MER, are much less expensive and have significantly shorter fabrication times than state-of-the-art composites. The MER carbon-carbon composites offer low-cost because they employ a filled matrix precursor that achieves the desired composite density and properties in the first fabrication cycle. This paper examines the properties of these composites for space applications.

EXPERIMENTAL

High thermal conductivity C-C composites were produced using a one step process describe elsewhere [1]. P-30X 4k fiber were used combined with thermoset-based carbon material. Fiber-tow process was used to make pre-preggs which were subsequently molded onto 0/90 configuration..

Thermal diffusivity was measured using a laser flash method while the heat capacity was measured with DSC. Thermal conductivity was calculated as a product of density, heat capacity and thermal diffusivity. Flexure strength was measured using a four-point bending 40:1 span-to-depth ratio. Tensile and compressive strength was measured using a dog bone specimen. Density was calculated on the geometric basis. SEM was used to assess composite integrity.

RESULTS AND DISCUSSION

Figure 1 show a SEM photo of a high thermal conductivity fabric-based 1:1 C-C composite. Virtually no transverse cracking is observed combined with good fiber bundle penetration. Figure 2 shows a SEM of fabric based 4:1 C-C composite. Microstructural characteristics are similar to the 1:1 C-C composite. Table I shows the properties of high thermal conductivity fabric-based C-C composites as compared to Al. C-C composites offer clear thermal benefits over Al (specific thermal conductivity). Figure 3 shows a SEM of a C-C composite face sheet. No excessive porosity or cracking is observed. Table II shows the corresponding properties. C-C composite face sheet offers significant thermal benefits over Al and equivalent performance to Gr/cy composites. Table III shows the properties of pitch-based C-C composites. Thermal performance is similar to the phenolic-based composites but compressive strength is greatly compromised. Figure 4 shows the corresponding SEM micrographs. Significant matrix cracking is observed, Figure 4. Thus, the use of pitch for one-step processing employed in this work appears to be very limited.

CONCLUSIONS

1. One-step, C-C thermal doublers (0.3 cm thick) can be produced in one-step exhibiting good thermal and mechanical properties.
2. One-step, C-C face sheets (0.1 cm thick) can be produced in one step exhibiting good thermal and mechanical properties.
3. One-step processing of C-C composites with high thermal conductivity was demonstrated in sizes up to 30 cm x 30 cm.
4. Low-cost pitch-based process employed in this work resulted in poor compressive strength.

REFERENCES

1. W. Kowbel, MRS 454 (1987) p.57

TABLE I OXIDATION RESULTS

Oxidation Rate (g/m^2*min)	% B	HT (°C)	Air Flow
0.2	0	2800	Static
0.32	0	2500	Static
0.4	0	2300	Static
0.05	10	2800	Static
0.006	20	2800	Static
0.005	20	2300	Static
0.0024	20	2500	Static
0.002	20	2300	Static
0.001	20	2500	Static
0.0038	20	2800	Static
0.0015	20	2500	dynamic (1 l/min)

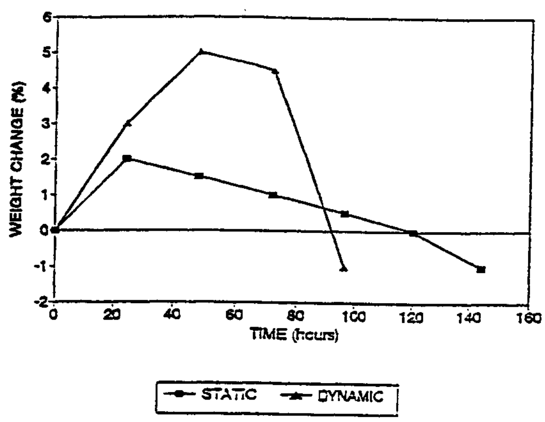

Figure 1. Oxidation of boron inhibited C-C composite.

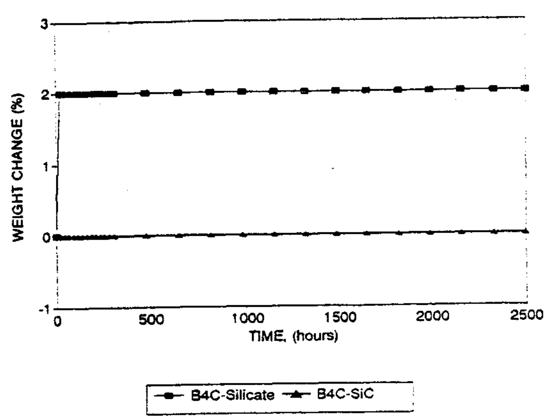

Figure 2 Dynamic Oxidation of C-C Composites.

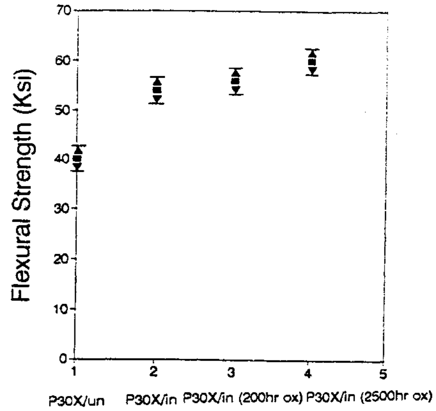

Figure 3 Flexural Strength of C-C Composites.

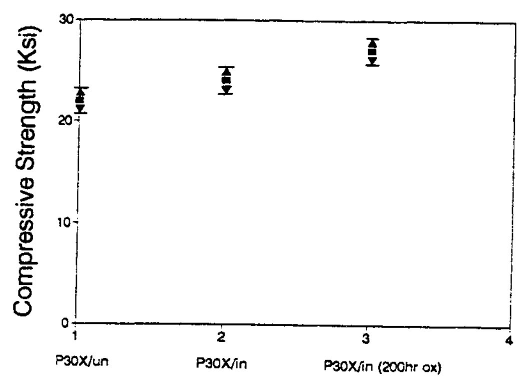

Figure 4 Compressive strength of C-C composites.