HIGH-STRENGTH THERMALLY STABLE MAGNESIUM ALUMINOSILICATE GLASS-CERAMIC MATRIX SIC FIBER COMPOSITE

This is a continuation of application Ser. No. 644,003, filed Aug. 24, 1984, now abandoned, which is a division of application Ser. No. 476,301, filed 3/17/83.

TECHNICAL FIELD

The field of art to which this invention pertains is fiber reinforced composites.

BACKGROUND ART

Because of the scarcity and increasing expense of many conventional high temperature stable structural metals, increased attention has focused on non-metal containing composites as replacements for conventional high temperature use metal-containing materials. Use of metal replacement, high strength fiber reinforced resin and even high strength fiber reinforced metal matrix composites has progressed to the point of commercial acceptance in products ranging from sporting goods to advanced jet aircraft components. One of the big problems with these composites, however, has been their maximum use temperature.

Ceramic, glass, and glass-ceramic bodies are known to the art which can be employed in high temperature applications. Unfortunately, however, these bodies frequently lack the mechanical strength desired and are invariably deficient in toughness and impact resistance. This situation has given rise to the preparation of composite bodies consisting of a matrix of ceramic, glass, or glass ceramic material with inorganic fibers dispersed in continuous or discontinuous fashion therewithin.

Nevertheless, while such composites, for example, graphite fiber reinforced glass and alumina fiber reinforced glass, can be utilized at higher use temperatures than conventional high temperature structural metals, there is still much room for improvement. To illustrate, while the graphite fiber reinforced glass composite demonstrates high levels of strength, fatigue resistance, and fracture toughness, it is also susceptible to detrimental fiber oxidation at elevated temperatures. And while composites such as alumina fiber reinforced glass are oxidatively stable at high temperatures, the overall strength and toughness levels obtainable with these composites are less than those possible with a graphite reinforced glass system, for example. Similarly, high strength and toughness properties have been obtainable with silicon carbide fiber reinforced glass composites (note U.S. Pat. No. 4,314,852) and silicon carbide fiber reinforced ceramic composites (note U.S. Pat. No. 4,324,843).

Although glass-ceramic bodies customarily exhibit greater refractoriness and strength than their precursor glasses, there has been the desire to impart even higher mechanical strengths thereto. However, silicon carbide fibers have demonstrated a tendency to react with glass-ceramic matrices at high temperatures, which phenomenon has been a limiting factor in their utility as reinforcing elements. Accordingly, what is needed in the art is a composite with high strength, high fracture toughness, and oxidation stability at high temperatures.

DISCLOSURE OF INVENTION

The present invention is directed to a solution to the high temperature strength, fracture toughness, and oxidation stability problems which exist with composites of the prior art and comprises silicon carbide fiber reinforced glass-ceramic composites, wherein said glass-ceramic matrices have compositions within the base magnesium aluminosilicate system and contain magnesium oxide (MgO) and barium oxide (BaO).

The high strength composites according to the present invention comprise silicon carbide fibers in a glass-ceramic matrix of magnesium aluminosilicate containing by wt. about 5% to about 15% magnesium oxide and about 5% to about 25% barium oxide. The composite has high strength and thermal stability at temperatures in excess of 1200° C. and is substantially non-reactive with nickel superalloys at temperatures in excess of about 800° C.

Another aspect of the invention comprises a process of forming such composites by hot pressing a mixture of silicon carbide fibers and the above-described glass-ceramic matrix at temperatures of about 1200° C. to about 1500° C. Following the hot pressing, the composite is heat treated at temperatures of about 1100° C. to about 1200° C. in air to convert the glassy matrix material to the crystalline ceramic phase.

The foregoing, and other features and advantages of the present invention, will become more apparent from the following description and accompanying drawing.

BRIEF DESCRIPTION OF DRAWING

The FIGURE shows a fiber reinforced composite according to the present invention with the matrix in the crystalline state.

BEST MODE FOR CARRYING OUT THE INVENTION

A glass, which can be converted to a glass-ceramic, is the ideal matrix material to form the composites of the present invention. During composite densification the matrix is retained in the glassy state, thus avoiding fiber damage and promoting densification under low applied pressure. After densification to the desired fiber plus matrix configuration, the glassy matrix can be converted to the crystalline state, the degree and extent of crystallization being controlled by the matrix composition and heat treatment schedule employed. Specifically, it has been found that there exists a range of compositions in the Ba stuffed cordierite and barium osumilite systems that contain MgO (7.1–12.9 wt%) and BaO (5.7–14.1 wt%) and, at least in the bulk form, can be crystallized at 1100°–1200° C. to refractory crystal phases. These compositions are shown in Table I. Compositions 1, 2, and 3 are Ba stuffed cordierite while 4, 5, and 6 and 7, 8, and 9 are "fully stuffed" and "half stuffed" barium osumilites, respectively. The Nb_2O_5 in compositions 2, 5, and 8 and the Ta_2O_5 in compositions 3, 6, and 9 are present such that the formation of NbC and TaC reaction barrier layers around the SiC fibers that occurs during composite fabrication, as detailed in copending application Ser. No. 380,458, filed May 20, 1982, now U.S. Pat. No. 4,485,179 could be compared to similar components in the copending application, the disclosure of which is incorporated by reference.

The results of flexural strength tests done on hot-pressed samples are shown in Table II. From these results it can be seen that at least two compositions (#4