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Reinforced Thermal-Shock Resistant Ceramics

The problem:

A need exists for material systems highly resistant to oxidizing environments at temperatures above 2000°F. Many materials, such as the refractory metals, have adequately high melting temperatures and mechanical strength, but deteriorate rapidly due to oxidation at high temperatures. Much effort has been spent in developing oxidation resistant coatings for refractory materials. The very stable oxides, such as zirconia and thoria, which have melting temperatures of 4700°F or greater, are ideal materials for resisting oxidation at very high temperatures. However, the oxides are characteristically brittle and prone to cracking when exposed to thermal shock. Attempts have been made to develop composite materials using oxides reinforced with wires or screens of refractory metals such as tungsten or molybdenum. However, use of such composites has been limited by: (1) high temperature recrystallization of the tungsten and molybdenum reinforcing materials during processing, with consequent major loss of strength and ductility; (2) oxidation of the refractory metal reinforcement causing its deterioration; and (3) separation of the matrix and reinforcement materials due to difference in thermal coefficients of expansion.

The solution:

A composite material is made by dispersing short tungsten-rhenium fibers randomly throughout zirconium oxide. The high melting ceramic resists oxidation and the composite material is also thermal stress resistant.

How it's done:

A tungsten-rhenium alloy, generally tungsten-3% rhenium in wire or screen form is used as the material for reinforcement of the oxide matrix materials. The advantages of the tungsten-rhenium materials are: (1) tungsten-rhenium when recrystallized during processing as part of a metal-reinforced oxide composite

retains a high measure of its strength and maintains ductility to temperatures near room temperature; (2) since the tungsten-rhenium can be recrystallized without serious loss of strength or ductility, the composite materials can be formed by conventional hot pressing and high temperature sintering. Such techniques have proven advantageous for developing optimum densification, bonding, and strength in the oxide matrix. The tungsten-rhenium alloy has a greater thermal coefficient of expansion than that of unalloyed tungsten. This is desirable for a more favorable match with the matrix oxide materials, such as thoria and zirconia. The tungsten-rhenium alloy has greater oxidation resistance than either unalloyed tungsten or molybdenum. Laboratory data for the tungsten-3% rhenium alloy show an improvement of 65% in its oxidation resistance above 2000°F as opposed to that of unalloyed tungsten. This is advantageous in the event of exposure of the reinforcement to an oxidizing environment.

Note:

The major use of this development is in the fabrication of thermal shock resistant oxides by the use of wire reinforcements that do not deteriorate either by the processing method or by subsequent environment.

Patent status:

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act [42 U.S.C. 2457 (f)], to TRW Inc., 23555 Euclid Avenue, Cleveland, Ohio 44117.

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of TRW Incorporated
under contract to
Lewis Research Center
(LEW-10376)

Category 03