Rare-earth Information Center Insight

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Y-TZP/Ce-TZP Functionally Graded Composite

Functionally graded materials (FGMs) are characterized by gradients of composition, phase distribution, porosity, or texture, which translate into gradients of the associated properties such as hardness, density, resistance, thermal conductivity, modulus, etc. They are formed by such processes as chemical vapor deposition (CVD), plasma spraying, and green synthesis, followed by sintering. FGMs differ from layered composites in that the changes in properties are continuous rather than stepwise. This eliminates delamination problems common in layered composites. Originally, FGMs were developed for rocket engines, but the concept has been extended to many other areas. C. Zhao *et al.* {*J. Mater. Sci. Lett.*, **17**, 1453-5 (1998)} have reported Y_2O_3-stabilized Tetragonal Zirconia Polycrystals (Y-TZP) / CeO_2-stabilized Tetragonal Zirconia Polycrystals (Y-TZP) functionally graded composites formed by electrophoretic deposition (EPD). Y-TZP and Ce-TZP were selected because Ce-TZP exhibits higher fracture toughness than Y-TZP at the expense of a lower strength and hardness. In EPD, suspensions of ceramic particles are placed in a cell between two electrodes. The particles are generally sub-micron in size; in this case, nominally 0.20 μm for the Y-TZP and 0.35 μm for the Ce-TZP. The chemistry of the suspension is such that the particles develop a surface charge that prevents flocculation. When a voltage is applied across the electrodes, particles are deposited on one electrode. Very uniform green ceramic bodies can be formed by this method. If the composition of the suspension is changed as a function of time, a graded material is obtained. After drying, the green body is sintered to produce the final product. Zhao *et al.* demonstrated the ability to produce continuously graded material from pure Y-TZP to pure Ce-TZP with a corresponding grading of properties, demonstrating the ability to develop ceramics with engineered properties.

Optical Thermometers

Fiber optic thermometers have been the subject of considerable development in the last few years. The thermometers currently being developed differ from those that have been available for many years in that the older thermometers were essentially fiber optics fitted to conventional pyrometers. Sometimes a film that emitted well-defined black body radiation was deposited on the end of the fiber allowing very high accuracy. In any event, the fiber served as an optical path and not the sensing element. In the new designs, an optical fiber sensing element is spliced to the fiber optics. T. Sun *et al.* {*Rev. Sci. Instrum.*, **69**, [12], 4179-85 (1998) describe measurements of Yb based fiber optic temperature sensors, as well as providing references to other work in the area. Sun *et al.* studied the fluorescence-lifetime of Yb-doped fibers that are produced for applications as fiber lasers and amplifiers. The fluorescence-lifetime approached allows the use of commercially available fibers

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rather than requiring custom fibers for thermometry applications. While some dependence of the lifetime on Yb concentration was observed, the researchers found that with proper annealing promising results could be obtained. For the highly doped fiber, concentration not given, the temperature accuracy was limited by the stability of the test furnace, which was ±5°C over the range 60-600°C.

Switchable Mirrors

In the May 1996 and August 1997 *Insights,* work on optically switchable thin films of La, Y, or RE Mg alloys with protecting films of Pd was reported. When the films are exposed to H, they form hydrides with variable H content. In pure H, they are transparent while subsequent exposure to air reduces the H content, and they become metallic and reflecting. The RE-Mg alloy films have superior properties to the pure RE films. Recently, K. von Rottkay *et al.* {*J. Appl. Phys.*, **85**, [1], 408-13 (1999)} have reported detailed measurements of the refractive index changes of magnesium lanthanide switchable mirrors. The measurements were carried out in a simple cell made by pressing the film and substrate against an o-ring set in an Al holder forming a cavity that could be flushed with H. It was found that the required Pd film reduced the visible transparency, but in a sealed device where the Pd could be eliminated, transparency of 90% should be achievable with a 240 nm thick lanthanide magnesium film.

Company Notes

Vacuumschmelze GmbH has announced the development of a process for manufacturing thin, flexible magnetic films using rare earth permanent magnets. Trade named Vacophan, the films are ~200μm thick and are easily punched or cut. Energy products of 13 kJ/m^3 (1.7 MGOe) have been obtained for the isotropic films. The films can be fabricated using different rare-earth permanent magnet materials. Contact: Dr.Roland Zoller, telephone - 49 6181 38-2687, email - Roland.Zoller@HAU3.siemens.de.

Rhodia Rare Earths has announced a number of changes in its operations to increase its competitive position. The construction of a separation facility at its subsidiary Baotou Rhodia Rare Earths was started in January. Separation activities in Freeport, Texas will end at the end of the first quarter of 1999, and the plant will concentrate on finishing high performance products for the U.S. market. Also metal and alloy operations will be regrouped in Phoenix, Arizona. Contact: H. Alline, telephone - 33 (1) 47 68 01 43 or in the U. S., contact: K. Rotondo, telephone - (732) 821-3616.

On November 29, 1998, The Arnold Engineering Company, a subsidiary of SPS Technologies, announced the formation of a joint venture company, Jade Magnetics Ltd. with operations in Shenzhen. Owned 60% by Arnold Investments, Ltd. and 40% by Green Cartridge Company Ltd., Jade's manufacturing operations will include the production of specialized magnetic assemblies and bonded magnets primarily for reprographic and automotive applications. Further information can be found on the Arnold Web Site at www.grouparnold.com. Separately a new name, Group Arnold, has been created to reflect the role of Arnold in managing SPS Technologies magnet businesses.

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