

Montecatini Terme, Tuscany • Italy • June 6-11, 2010



12th International Ceramics Congress



CIMTEC 2010

INTERNATIONAL CONFERENCES ON MODERN MATERIALS & TECHNOLOGIES

CE-P05 Effects of the Pin-on-disc Test Parameters on the Wear of Alumina

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Searching for wear resistant materials, attention has been paid to Si₃N₄, SiC, Al₂O₃ and ZrO₂ ceramics. As compared to metals and polymers, these ceramics are inert and present better mechanical and corrosion properties, hardness and high-temperature resistance. Although brittleness and low toughness have posed some obstacles to industrial use of the above mentioned ceramics, recent improvements in alumina processing have lessened these restrictions and suggest improvements in wear resistance which in turn have driven some research on this. Since a direct comparison between the many published works regarding this wear improvement is impossible due to the fact wear resistance is a response of the microstructure, material and testing condition, the work herein presented aims to first do a literature review on the main parameters to be controlled in a pin-on-disc apparatus on the wear of alumina and then made some test and analyze the influence of critical parameters as load, sliding speed, sliding distance and environment in a pin-on-disc wear test in a sub micrometer alumina. At the end of this work the procedure followed was indicated.

CE-P06 Structure Evolution in Al₂O₃ - ZrO₂ (Y₂O₃) Ceramic Composites during Sintering

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The paper demonstrates the possibility to control the degree of tetragonal zirconia stabilization, microstructure and physical and mechanical behavior of Al₂O₃ - ZrO₂(Y₂O₃) ceramic composite. Control is exerted via the process variables during deposition synthesis of nanosized composite powders from hydroxide salts, and their subsequent heat treatment and consolidation. Morphology features of nanosized powder systems and microstructures of the consolidated nanostructured materials were characterized by BET surface area measurements, scanning electron microscopy (both standard and HR), and large-angle X-ray diffraction. Correlations are established between microstructure parameters, physical and mechanical behavior of composite ceramics and a degree of stabilization of tetragonal ZrO₂.

CE-P09 Fabrication of Reaction-Bonded SiC Composites by Liquid Silicon Infiltration

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Silicon carbide (SiC) is known to be attractive candidate material for high temperature application, e.g., components of combustion chamber, gas turbines and heat exchangers, because of its good tribological properties, high strength at high temperatures, low thermal expansion coefficient and excellent thermal shock resistance. This work describes the microstructure, strength and fabrication of Si-SiC composites by reaction-bonded sintering due to liquid silicon infiltration using C-SiC green bodies and embedded Si. α -SiC powders used in this work are large or mixed composition of 44 - 1 μ m of wide particle size. Carbon black as source of carbon was used. SiC powders, carbon black and organic binder were mixed at different volume ratios and ball-milled in ethanol for 24 h to obtain homogeneous slurries. The typical composition of the green compacts consisted of 60-80 wt% SiC, 20-40 wt% carbon black. Sintered bodies were obtained by reaction-bonded sintering of embedded Si on green compacts at 1500-1600 °C in a graphite furnace of vacuum. Microstructure and morphology of SiC composites were observed by SEM. The reaction-bonded sintered bodies have a high density with <1% of porosity. The effect of microstructure on mechanical properties of composites will be described.

CE-P10 Structural Ceramics Based on Nanosized Si₃N₄ Powders

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Ceramics based on nanosized plasma chemistry Si₃N₄ powder compositions s (30-100 nm) is processed by activated pressureless sintering, hot pressing and hot isostatic pressing. Microstructure characterization of the obtained materials by means of light and scanning microscopy revealed no correlation between microstructure and the bulk consolidation method. Average grain size in all cases was 200-300 nm. Comparative characterization of the physical and mechanical behavior of the analyzed samples showed the following results: relative density - over 99%, flexural strength - over 700 MPa, Vickers hardness - 15-17GPa, fracture toughness - 6.5-7.4 MPa·m^{1/2}. The activated

pressureless sintered samples demonstrated physical and mechanical behavior comparable to the samples consolidated by other methods. Activated pressureless sintering of nanosized plasma chemistry Si₃N₄ powders led to considerable economic advantages in processing Si₃N₄ spherical rotation bodies for hybrid roller bearings and cutting tools.

CE-P11 Stereological Description of Microstructure of Silicon Carbide-based Structural Ceramics as a Composite Material

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Within unified stereological approach the silicon carbide-based ceramics SiSiC, SSiC, and LPSiC are treated as binary compositions, that despite certain structure ordering differences might be similarly described as comprising topologically continuous component (that provides the high level of physical and mechanical properties), and a discrete component. The paper demonstrates the necessity of using dimensionless criterial parameters for adequate description of the integral microstructure ordering level, said parameters including the characteristics of both continuous and discrete components of the composite ceramic material. Generalized equations are derived for compound stereological parameters of the discussed materials, along with statistically reliable approximations of the strength characteristics as functions of these parameters.

CE-P12 Consolidation of SiC Deposits by Polymer Infiltration and Pyrolysis Method

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The polymer infiltration and pyrolysis (PIP) method is used to consolidate SiC deposits prepared by electrophoretic deposition. Due to the high initial density of the deposits (62%) only few cycles were needed in order to achieve a high density material. Microstructures and thermal properties of the material are assessed and compared to the deposits consolidated by standard sintering techniques. Thermal conductivity of the deposits consolidated with PIP was significantly improved in comparison to the deposits consolidated with standard sintering at high temperatures (2373 K) or deposits sintered at low temperatures (1673 K) with the use of transient eutectoid. The influence of microstructure and porosity on thermal conductivity of the material was also evaluated. Although porosity influences the thermal properties of the material to some extent, it is not the governing parameter. Crystallite size and the amount of impurities have shown to have much greater influence on thermal properties of the material.

CE-P13 Processing and Thermal Properties of Cu-AlN Composites

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Heat transfer by conduction is involved in the use of heat sinks to dissipate heat from the electronic devices. Effective transfer of heat requires using materials of high thermal conductivity. In addition, it requires appropriate values of thermal expansion, matched to the semiconductor materials, high purity of used materials and good contact between bonded elements across which heat transfer occurs. The conventional materials are not able to fulfill the still raising and complex requirements. The solutions of this problem could be composites materials, where the combinations of different properties is possible. This study presents the technological tests and the analysis of correlation between processing parameters and the properties of copper-aluminium nitride composites. The composite materials were obtained by mixing in planetary ball mill and then sintered by hot pressing. The microstructure of obtained composite materials were analyzed by scanning electron microscopy. Coefficient of thermal expansion (CTE) and thermal conductivity (TC) were investigated related to the process conditions.

CE-P14 Diffusion Studies Involving Nanometric and Submicrometric Alumina Based Composites with Gray Cast Iron

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Machining processes require tool materials with properties such as high hardness at high temperature, high fracture toughness and chemical stability with the workpiece. Advances in science and industry, as well as the development of harder materials have permitted cutting tool technology to evolve. In cutting processes, the contribution of different wear mechanisms to total wear is related to the mechanical and chemical properties of the two materials in contact. The high temperatures at tool-workpiece contact zones often result in diffusion of material from the workpiece to the cutting tool. Diffusion experiments were carried

out to understand wear mechanisms involved at cutting edges of ceramic tools and the influence of microstructure on diffusion without the interference of mechanical wear processes. The chemical stability was determined from static interaction couple experiments at 1100°C with ceramic composite materials and gray cast iron. To investigate the influence of grain size on diffusion, sub-micrometric and nanometric alumina based composites with NbC as the second phase were used. These experiments helped demonstrate the influence of grain size on diffusion and the relative inertness of the composites in the presence of gray cast iron.

CE:P15 Phase, Structural and Microstructural Changes in TiC1-x - Cr3C2 Materials

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Earlier studies showed that addition of different chromium carbides to nonstoichiometric fine titanium carbide improves sintering in the similar way. The phase, structural and microstructural changes for addition of various chromium carbides were also similar. In the present work composite materials were made of various carbon quantity saturated titanium carbide (as matrix) and commercial chromium carbide Cr3C2 (as additive). The titanium carbide powders with variable content of carbon in the structure were synthesized by SHS. 7.5 vol% chromium carbide was added to the initial mixture. The influence of various stoichiometry of titanium carbide on onset temperature of sintering was examined by high temperature dilatometry. The phase and structural changes of materials during sintering were investigated by XRD and the

Rietveld method. The evolution of microstructure, vs different stoichiometry titanium carbides was observed by scanning electron microscopy.

CE:P16 Influence of Residual Thermal Stresses on the Properties of the NiAl Matrix Composites Reinforced with Ceramic Particles

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One of the most important problems in both the fabrication and exploitation of ceramic-metal composites are residual thermal stresses. The paper presents the results of a numerical analysis (by the Finite Elements Method) of the stress state induced in the NiAl matrix composites reinforced with spherical particles of a ceramic phase (Al2O3, ZrO2, TiC), including examinations of the dependence of the stress state on the volumetric fraction of the ceramics (20 to 50 vol %). The stress state prevailing in this composite appeared to be complex. In all the samples, the stresses active in the ceramic regions were compressive whereas those active in the metal matrix were tensile in the circumferential direction and compressive in the radial direction. An increase of the ceramic volumetric fraction resulted in an increase of the tensile stresses in the NiAl matrix and a decrease of the compressive stresses in the ceramic particles. These theoretical results were verified experimentally by examining the properties of the NiAl-Al2O3, NiAl-ZrO2 and NiAl-TiC (20 and 30 vol.% fraction of the ceramics) composites produced by hot-pressing. The microstructure, porosity, elastic modulus and bending strength of these composites were examined, and the results are discussed in the paper.

Symposium CF

CERAMICS FOR CHEMICAL, ELECTROCHEMICAL AND ENVIRONMENTAL APPLICATIONS

Oral Presentations

Session CF-1

Ceramics in Chemical and Biochemical Sensors

CF-1:IL01 Effective Designs for High Temperature Ceramic Gas Sensors

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Solid-state electrochemical devices composed of stabilized zirconia electrolytes (YSZ), e.g., oxygen sensor is used extensively for sensing in combustion environments. However, sensors for detecting other gases have not been as forthcoming. We will present our work in the area of total NOx sensors based on YSZ and catalysis research. In the presence of oxygen, the heterogeneous catalytic reactions occurring on the surface of metal-oxide electrodes and electrolytes compete with electrochemical reactions. We find that the heterogeneous catalytic activity of WO3, yttria-stabilized zirconia (YSZ), and Pt containing zeolite Y (PtY) have a significant influence on the performance of solid-state potentiometric gas sensors. Pt electrodes covered with PtY and WO3 are used as the reference and working electrodes because of the significant reactivity difference, with WO3 being largely inactive toward catalytic NOx equilibration. Using highly catalytic active PtY to filter incoming gas mixtures can effectively remove interferences from 2000ppm CO, 800ppm propane, 10ppm NH3, as well as minimize effects of 1~13% O2, CO2, and H2O. New ways of deposition of electrodes as well as increasing sensitivity to ppb levels will be presented. In addition, we will also review our latest results on high temperature ceramic CO and CO2 sensors.

CF-1:IL02 VOCs Detection with Potentiometric Oxygen Sensor with Modified Pt Electrode

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We proposed the use of the modified electrode of Pt with some second materials for potentiometric oxygen sensor to detect sub-ppm level VOCs in the temperature range of 400 and 550 °C. For all examined sensors, the contamination with ethanol and toluene induced the shift of the EMF. For ethanol, a larger shift of the EMF was observed by the over-coating of Pt with Au (Sensor-2) and the coating with SmFeO3 (Sensor-5) induced a decrease in the EMF response. The coating with SiC (Sensor-3) or Sm2O3 (Sensor-4) induced a larger shift of the EMF in initial period and then slightly recovered. For toluene, the EMF response was clearly influenced by the over-coating and the EMF in toluene was in the order of Sensor-2 ~ Sensor-3 > Sensor-4 > Sensor-1 (Pt|YSZ|Pt) > Sensor-5. The observed EMF shifts with the contamination of ethanol suggested a more decrease in the oxygen activity of Au, SiC and Sm2O3-coated electrode than that of Pt electrode and the coating of Pt electrode with SmFeO3 depressed a decrease in the oxygen activity by the ethanol contaminations. For toluene, the coating on the Pt electrode induced a more decrease in the oxygen activity on the Pt site in the order of Au > SiC > Sm2O3 > SmFeO3.

CF-1:IL03 Plasmonic Based Harsh Environment Compatible Chemical Sensor

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The development of novel harsh environment compatible chemical sensing technologies is a critical need for a variety of combustion applications. The plasmonic properties of embedded gold nanoparticles (AuNP) in yttria stabilized zirconia (Au-YSZ) nanocomposite films as a