

THE EFFECTS OF PROCESSING PARAMETERS ON MELT INTERCALATION OF POLYMER-SILICATE NANOCOMPOSITES

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ABSTRACT

Polymer-silicate nanocomposites were prepared by polymer melt intercalation, an efficient and simple method. The starting materials included layered mica-type silicates (sodium-montmorillonite and organically modified bentonite), and poly(ethylene oxide). The polymer/silicate mixtures were heated at 85°C and 95°C, and characterization of the nanocomposites was performed using XRD, DSC and SEM. The effects of various processing parameters on the materials synthesis are studied. Discussion focuses on the effects of heating temperature, time, and green body density on the intercalation process. A mechanism of melt intercalation is proposed.

KEYWORDS

Melt intercalation, nanocomposites, polymer-silicate, hybrid, processing parameter.

REACTION SINTERING OF A CLAY-CONTAINING SILICON NITRIDE BONDED SILICON CARBIDE REFRACTORY

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ABSTRACT

Aspects of the reaction sequence for the reaction bonding of a cast refractory, which in the green state was composed of 79 wt-% SiC grit, 16 wt-% Si powder and 5 wt-% clay were established. As it was fired up to 1600°C in flowing N₂(g), weight gains were noted and phase evolution was monitored by X-ray diffraction. However, details of the reaction sequence were not determined directly from this material because several reaction-bonding processes occurred simultaneously. Reaction features were ascertained by contrasting the weight changes and phase evolution in the refractory with those observed during reaction-bonding of (a) Si and clay without the SiC and (b) SiC and clay without the Si. In addition to silicon nitridation and the development of sialon phases by silicothermal and carbothermal reduction-nitridation processes, indirect evidence suggested that α -Si₂N₄ formed by the carbothermal reduction-nitridation (CRN) of SiO(g).

KEYWORDS

Carbothermal reduction, refractories, sialon, silicon carbide, silicothermal reduction.

AUSTRALIAN REFRACTORY STANDARDS - WORTH PERSEVERING WITH?

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ABSTRACT

This paper will be based on Australian refractory standards AS 1774, "Refractories and refractory materials - Physical test methods", which has been trenchantly criticized by sections of industry for a host of reasons. The complaints are examined to determine their validity because if most are true then the continued production of AS 1774 would appear to be questionable.

There is one other reason for examining the production of the standard. It relates to the continual downscaling of refractories laboratories. This means the testing processes in the future must use less direct labour, a factor which should be recognised in the methodology espoused.

KEYWORDS

Australian, refractory, standards, problems, solutions.

HEAT FLOW CALCULATIONS - WORTHWHILE OR WORTHLESS?

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ABSTRACT

Many assumptions are made in the calculation of steady-state heat flow through a mass of refractory, however many of them are unfounded. The various assumptions, implicit and explicit, are examined, from the heat conductivity value through to the change in heat flow of the refractory lining with time. There are a number of computer programmes for quantifying the heat flow and interfacial temperatures, but they all do not give the same answer. The possible reasons for any discrepancies are explored. In addition the reasons for the failures of calculated heat flow to agree with reality are suggested. Although some of the theoretical conflicts have been identified, no attempt is made here to correct the problems.

KEYWORDS

Heat-flow, calculations, assumptions, problems, usefulness.

DEVELOPMENT AND USES OF SELF FLOW CASTABLES IN SOUTH AFRICA

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ABSTRACT

When self-flow castables arrived in South Africa during the 1980's, they offered good installation properties but were limited by the need for expensive modifications to existing machinery. A local company set out to develop a range of products that were easy to install using existing equipment but would have the same improved installation characteristics. The need to use existing raw materials available in the country was important from a strategic and commercial point of view. The development of the range has lead to some very interesting discoveries and some new development in steel fibre reinforced refractories.

KEYWORDS

Self flow, dilatent, thixotropic, fibre reinforcement.

CORROSION OF MgO BY ALUMINA-CONTAINING SLAGS

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ABSTRACT

The drop quench technique has been used to investigate the corrosion of MgO crucibles at 1500°C in air using the CaO-SiO₂-MgO-Al₂O₃ slag system. Following the slag attack for 2 h or more, clusters of newly-formed crystals containing Mg, Fe and Al, presumably spinel, were observed to be separated from the MgO surface by a slag region of relatively constant thickness of about 150 - 200 µm. The separation of the spinel crystals and the magnesia is in broad agreement with previous work by Rait under similar experimental conditions. Results for samples attacked for shorter times suggest that the crystals initially formed on MgO surface, and that clusters of these crystals subsequently broke away along the MgO-crystals interface. Samples attacked by Al₂O₃-free slag under similar conditions did not show any sign of newly-formed phase in the interfacial region, nor any indication of the MgO surface being altered. The presence of alumina in slag is suggested to have a critical role in the corrosion of MgO including the formation and detachment of spinel crystals.

KEYWORDS

MgO, refractory, slags, spinel, optical microscope, electron microscope.

ASSESSMENT OF SPINEL-CONTAINING REFRACTORIES FOR COPPER SMELTING AND REFINING

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ABSTRACT

Concern over the potential treatment of spent mag-chrome refractories as hazardous waste has provided incentive for the consideration of chrome-free materials as a replacement in copper smelters, converters, and refining furnaces. A four-year joint U.S.-Australian research program is considering several potential replacements, using both qualitative and quantitative testing methods. The results of dip testing of different refractory materials in copper-containing calcium ferrite slags are presented. The slags react with magnesia-alumina spinel grain to form a (Fe,Mg)Al₂O₄ solid solution, increasing the slag MgO content and reducing its ability to penetrate. Calcium aluminate cement tends to dissolve in the slags, and presents no barrier to penetration.

KEYWORDS

Refractories, copper smelting, spinel, microstructure.

HIGH DENSITY, LOW OPEN POROSITY MAGNESIA CERAMICS

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ABSTRACT

Many modern high-tech applications require magnesia ceramic components with high bulk densities and very low apparent porosities. Quite commonly, bulk densities above 3500 kg.m^{-3} and open porosities close to zero are specified for such applications of magnesia ceramics.

Following an R & D project in which Rojan's R & D team was involved together with academic staff and last year university students from the School of Applied Chemistry -Curtin University of Technology, Rojan Advanced Ceramics Pty Ltd. in Perth, Western Australia, were able to develop their capability of producing high quality magnesia ceramic materials and components.

The paper presents the recent achievements of Rojan in the field of high density, very low open porosity magnesia ceramic materials and special products, including labware and planar components.

KEYWORDS

Magnesia, high density, low porosity.

DEVELOPMENT OF FORSTERITE CERAMIC MATERIALS AT ROJAN ADVANCED CERAMICS

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ABSTRACT

Forsterite is a crystalline magnesium silicate with the chemical formula Mg_2SiO_4 or $2MgO \cdot SiO_2$. It is best known for having, like the other magnesium silicate, clino-enstatite, with the formula $MgSiO_3$ or $MgO \cdot SiO_2$, an extremely low electrical conductivity. This makes forsterite ceramics the ideal substrate materials for electronics.

In addition, forsterite ceramics are considered as some of the most adequate materials for applications as manifolds for SOFC - Solid Oxide Fuel Cells - due to them having a linear thermal expansion coefficient perfectly matching with the other cell components and a very high stability in fuel cell environments.

The paper presents some of the results of the technology R & D performed at Rojan Advanced Ceramics Pty Ltd. in Perth, Western Australia, together with some material characteristics and several forsterite ceramic products, from crucibles and boats to planar components.

KEYWORDS

Forsterite, slip casting, water/ethanol slurry.

PHASE AND MICROSTRUCTURAL EVOLUTION OF Ca α -SiAlON CONTAINING ELONGATED GRAINS

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ABSTRACT

Rare earth stabilised α -SiAlONs are commonly observed with an equiaxed grain morphology. Elongated α -SiAlON has been observed in some of these systems; however it usually results from special techniques such as pressure sintering. The formation of elongated α -SiAlON grains during pressureless sintering has been shown to commonly occur in the Ca α -SiAlON system. Examination of phase and microstructural development in three Ca α -SiAlON compositions in the temperature range 1400° to 1800°C showed that phase development and grain growth occurred at different temperatures. It was found that chemical reactions were completed by 1550°C; however significant grain growth did not occur at this temperature. Grain growth progressed from 1600°C and continued up to 1800°C, the maximum temperature investigated. At 1800°C, α -SiAlON was found to be compatible with AlN and related phases.

KEYWORDS

Sialon, calcium, microstructure, morphology, grain growth.

THE EFFECT OF LIQUID AND MULLITE FORMATION ON THE HOT STRENGTH OF LOW AND ULTRA LOW CEMENT CASTABLES

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ABSTRACT

The effects of both anorthite or mullite formation on the hot strength of low and ultra low cement castables have been investigated. Anorthite was found to reduce the strength of the low cement castable above 1300°C due to liquid formation. If the cement content was sufficiently low, the reduction in strength is countered by the production of mullite above 1300°C. This improvement in hot strength up to 1400°C is due to the refractoriness of mullite and its interlocking acicular crystals. However, above 1400°C the viscosity of the matrix liquid is substantially reduced, which results in the hot strength being reduced although the mullite concentration increases up to 1500°C. This indicates that the viscosity of the liquid surrounding the mullite needles primarily controls the hot strength of castable forming mullite within their matrixes.

KEYWORDS

Refractory, low cement castable, mullite, hot strength, viscosity.

SYNTHESIS OF ALUMINIUM NITRIDE WHISKERS AND THEIR PROPERTIES

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ABSTRACT

Synthesis of aluminum nitride (AlN) whiskers by floating-type fluidized-bed nitridation of aluminum (Al) powder and their chemical properties were investigated. Al powder as a raw material was continuously fed into nitrogen stream with flow rate of 0.8×10^{-2} m/s to 5.2×10^{-2} m/s from the end of the reactor, and was nitrided at 1350°C to 1550°C. Pure white and/or transparent AlN whiskers were deposited on the reactor wall of alumina tube, and also hollow spherical AlN particles were produced. Length and diameter of AlN whiskers were directly proportional to nitriding time after an initial induction period required for a nucleation process. Since the system in this study includes no iron at the tip of the whiskers, the growth mechanism is thought to be vapor-solid (VS). Transparent and high strength AlN ceramics was obtained from the white whiskers by hot-pressing at 1900°C for 120min under 30Mpa; however, it could not be obtained from the transparent whiskers.

KEYWORDS

Aluminum nitride whisker, aluminum, direct nitridation, growth mechanism, property.

THE STABILISATION OF α -SIALONS USING MULTIPLE ADDITIVES

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ABSTRACT

Multi-cation α -Sialon ceramics were prepared using mixtures of samarium with calcium, magnesium, yttrium and ytterbium, and compared with a pure Sm-Sialon of equivalent total stabilising cation composition. A ratio of 80eq% samarium to 20eq% of the second stabilising additive was used. Samples were fired at 1820°C and subsequently heat treated at 1450°C. XRD phase analysis showed that all additives resulted in greater α -Sialon stability, and that calcium was the most effective additive for the stabilisation of the α -Sialon phase.

KEYWORDS

Sialon, stabilisation, heat treatment, x-ray diffraction, melilite, EDXS.

A REVIEW AND CRITICAL ISSUES OF DENTAL CERAMICS

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ABSTRACT

Dental ceramics in restorations are essentially oxide based glass-ceramic systems. They have three essential features/requirements: i) ease of fabrication of complex shapes, ii) sufficient mechanical and corrosion resistance, and iii) appropriate aesthetic appeal. In the last few decades there has been tremendous advances in the mechanical properties and methods of fabrication of these materials. Whilst porcelain based materials are still a major component of the market there have been moves to replace metal cored systems with all ceramic systems. In this brief review the following topics will be addressed: natural teeth and their properties, alternate restorative materials and the various ceramic compositions and their usage by the dental practitioner. Examples of the microstructure property relationships for these ceramic materials will be addressed.

THE EFFECT OF OXIDE ADDITIVES ON THE SYNTHESIS AND SINTERING OF X-SIALON

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ABSTRACT

The effect is reported of seven inorganic oxide additives on both the formation mechanism and the densification of X-sialon prepared by a silicothermal process. The oxides were added to the starting mixture of halloysite clay, alumina and elemental silicon at a level of 1 wt% of the calculated final product, and fired in nitrogen at 1200-1500°C. The formation of X-sialon was monitored by thermal analysis, powder XRD and ^{27}Al and ^{29}Si solid state MAS NMR. The effects of the additives are temperature dependent and influence the various stages of the reaction by differing degrees. The oxides which best promote the formation of crystalline X-sialon (Y_2O_3 , CaO and MgO) are also those which facilitate the conversion of initially-formed Si_3N_4 to SiO_2N_2 and SiO_3N units. Densification is most enhanced by Y_2O_3 , CaO and CeO_2 ; MgO exerts its maximum effect on sintering at lower temperatures.

KEYWORDS

X-sialon, fabrication, oxides, additives, densification.

NEW SYNTHESIS ROUTES FOR SIALON AND SIALON-BONDED CERAMICS

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ABSTRACT

The use of sialon ceramics has been restricted by the high temperature required for synthesis and the expense of the pure oxide and nitride raw materials required. For refractory applications the purity required is less demanding and it has been possible to exploit the outstanding durability of the sialons at moderate cost.

New low cost manufacturing routes are being developed by nitriding silicon metal powder at relatively low temperature with clay and various additives depending on the sialon required. For example, the introduction of carbon or fine silicon carbide allows the preparation of beta sialons and alpha sialons, which can be stabilised by including the appropriate cations. A wide range of composite sialon bodies with diverse properties can be prepared by a one step process.

Current projects developing the synthesis routes are aimed, in the first instance, at refractory manufacture but are showing promise for more sophisticated applications.

ANALYSIS ON THE PARTICLE GROWTH IN SILANE PCVD REACTOR FOR SEMICONDUCTOR PROCESSING

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ABSTRACT

The particle growth by coagulation was investigated theoretically in bulk plasma region of plasma CVD reactor. The predator particles in bulk plasma region grow by the coagulation with small protoparticles and the model equations for the particle size and particle charge distribution were solved for various plasma conditions. Most of the protoparticles in plasma reactor were charged negatively, but a few percent of the particles were neutral or positively charged and those particles were found to be very active for particle growth by coagulation. As the time increases, the predator particle sizes and the average charges on predator particles increase and the coagulation coefficients between predator particles and protoparticles increase.

KEYWORDS

Protoparticles, predator particles, Gaussian distribution, particle charge distribution, particle growth model, plasma conditions.

PHYSICAL AND MICROSTRUCTURAL CHARACTERISTICS OF HIPed ALUMINA/CALCIUM-HEXALUMINATE COMPOSITES

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ABSTRACT

The use of hot-isostatic-pressing (HIPing) on the densification, microstructure, and properties of alumina/calcium-hexaluminat (0-30 wt% CA₆) composites was investigated. The phase development of CA₆ was studied by x-ray diffraction and differential thermal analysis. The resultant grain morphology and microstructures were characterised using scanning electron microscopy. Vickers indentation was used to evaluate the microhardness. The results show that with an increase in the CA₆ content, the shrinkage, density, and hardness decreased, but the porosity increased. The plate-like CA₆ grains were confirmed by Ca x-ray mapping. When compare to pressure-sintering, the use of HIPing imparted significant improvements in densification and hardness.

KEYWORDS

Alumina, calcium-hexaluminat, platelets, composites, hot-isostatic-pressing.

THE REACTIVE MELT INFILTRATION PROCESS ACCELERATED BY SILICA GLASS FOR THE FABRICATION OF Al₂O₃/Al COMPOSITES

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ABSTRACT

Al₂O₃/Al composites were fabricated at 900~1200°C by a reactive infiltration in an oxygen atmosphere with the addition of boro-silicate glass powder spread onto the interface between Al compact and Al₂O₃ pre-form. The infiltration distance increased linearly with time. The relative density increased with Al₂O₃ particle size and decreased with the infiltration temperature. Fracture toughness increased with Al₂O₃ particle size but decreased with the fabrication temperature.

KEYWORDS

Reactive melt infiltration, alumina/aluminium composite, fracture toughness.

A MODIFIED BONDED-INTERFACE TECHNIQUE WITH IMPROVED FEATURES FOR STUDYING INDENTATION DAMAGE OF MATERIALS

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ABSTRACT

A modified "bonded-interface" technique with improved features for studying contact damage of ceramic (Al_2O_3 , graded $\text{Al}_2\text{TiO}_5/\text{Al}_2\text{O}_3$, Ti_3SiC_2) and non-ceramic (epoxy, tooth) materials is developed and compared with the conventional method. This technique enables the surface damage around and below an indenter to be studied. When used in conjunction with Nomarski illumination and atomic force microscopy, this technique can reveal substantial information on the topography of indentation surface damage. In particular, it is ideal for monitoring the evolution of deformation-microfracture damage of quasi-plastic materials. The technique is much less sophisticated, less time consuming, and user-friendly. It does not require a highly experience user to be proficient in the procedure. When compared with the conventional tool-clamp method, this modified technique gives similar, if not, identical results.

KEYWORDS

Contact damage, bonded-interface, surface topography, indentation, Vickers.

OPTIMIZATION OF YTTRIA ADDITIONS IN ZIRCONIA TOUGHENED ALUMINA

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ABSTRACT

The stress-induced transformation of included zirconia from tetragonal phase to monoclinic phase offers an important contribution to toughening of ceramic composites. Stabilization of the tetragonal phase is affected by the zirconia content and its grain size, and by stabilizing agents such as yttria. The zirconia phases in zirconia toughened alumina (ZTA) with several levels of zirconia (5 to 40 vol%) and yttria additions (0 to 3.0 mol% of zirconia) were analyzed by quantitative X-ray diffraction. The combined effect of zirconia and yttria on hardness, toughness, and retention of the tetragonal phase was investigated. The amount of yttria required to stabilize the optimum mixture of tetragonal and monoclinic zirconia was determined for 5 vol% zirconia.

KEYWORDS

Alumina, zirconia, yttria, X-ray diffraction, toughness.

MACHINING OF INSULATING ZrO₂ CERAMICS BY EDM USING GRAPHITE ELECTRODE

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ABSTRACT

As we proposed and reported before, insulating ceramics may be made into machinable materials with electrical discharge machining method by using an assisting electrode method. The machining properties depend on the formation mechanism of carbonization layer, which has electrical conductivity on the ceramics surface during discharge. A big difference in machinability occurs between oxide and non-oxide ceramics. When ZrO₂ ceramics are machined with a copper tool electrode, which was used for a machining of the non-oxide ceramics Si₃N₄, the electrical conductive layer is not formed on the machined surface uniformly. In this paper, in order to activate a carbonization reaction on the ceramics surface during discharge, the use of a porous graphite tool electrode is described. As a result of that, carbonized reaction occurs actively on the discharge gap and the uniform carbonized layer adheres to the machined surface. The surface roughness is much improved compared with previous machining conditions.

KEYWORDS

Assisting electrode method, electrical discharge phenomena, insulating zirconia, surface modification.

PREDICTION OF THERMAL SHOCK FRACTURE OF Mg-PSZ CERAMIC ANNULUS

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ABSTRACT

This paper proposes to use an appropriate finite element package (LUSAS) to analyse and predict the fracture occurrence of Mg-PSZ (Magnesia-partially stabilised zirconia) ceramic annuli subjected to heating on the inner surface at several constant heating rates. This model has been applied to thermal shock experiments reported in the literature which were conducted on three commercial grades of Mg-PSZ (TS, TSE, TSN). The resulting temperature and thermal stress distributions were obtained by this numerical analysis. Applying boundary conditions in accordance with the experimental set-up and using relevant temperature-dependent thermal and mechanical properties gave calculated values, which agree well with experimental observation. An analytical study was also carried out and this shows excellent agreement with the LUSAS results.

KEYWORDS

Mg-PSZ, annulus, Finite Element Analysis, heating rate, thermal stress.

THE EFFECTS OF IMPACT ANGLE ON SLURRY EROSION RATES OF ALUMINA CERAMICS

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ABSTRACT

Two kinds of commercial alumina ceramics with different microstructures and mechanical properties were subjected to the slurry jet apparatus. The effects of angle of impact on the erosion rate of these materials were studied. A large difference in erosion resistance corresponding to shallow angle and normal impact was observed. Such a difference could be accounted for in terms of the erosion mechanism in the light of SEM micrographs of eroded surfaces. The erosive wear behaviours of these two alumina ceramics were also different. It is concluded that the primary factor controlling the erosion behaviour of alumina ceramics was the microstructure.

KEYWORDS

Slurry erosion, angular dependence, alumina, microstructure, SEM.

CHARACTERISTICS OF LAYERED AND GRADED ALUMINA/CALCIUM HEXALUMINATE COMPOSITES

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ABSTRACT

In this paper, results on the synthesis, physical characteristics and microstructure of layered and graded $\text{Al}_2\text{O}_3/\text{CaAl}_2\text{O}_9$ (LGM) systems produced from an innovative infiltration process are described. This process is relatively simple and offers excellent control over the depth of infiltration, which dictates the depth of graded layer. The CaAl_2O_9 (CA_6) grains display a platelet morphology and their presence imparts grain-refinement to the alumina matrix. The presence of the *in-situ* platelet CA_6 phase in the alumina matrix also has a profound influence on the graded and physical properties of the composites. The characteristics, microstructure and properties of LGM have been studied using X-ray diffraction, scanning electron microscopy, energy-dispersive x-ray spectrometry, differential thermal and gravimetric analysis, and Vickers indentation.

KEYWORDS

Layered, graded, alumina, calcium hexaluminate, infiltration.

PHYSICAL AND MICROSTRUCTURAL CHARACTERISTICS OF β -SPODUMENE MODIFIED ALUMINA/CALCIUM- HEXALUMINATE COMPOSITES

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ABSTRACT

The use of β -spodumene has been investigated as a liquid-phase sintering aid for the densification of alumina/calcium hexaluminate (CA₆) ceramics. XRD, DTA, and SEM were used to characterise the effect of spodumene on the phase relations, densification behaviour, and microstructure of alumina/CA₆. The results show that the presence of spodumene had a profound influence on the phase relations, densification, and microstructure of alumina/CA₆. SiO₂, anorthite, and glassy phases formed in samples containing spodumene additions greater than 2.5 wt%. The CA₆ phase reacted completely with spodumene additions <10 wt% to form anorthite.

KEYWORDS

β -spodumene, alumina, calcium-hexaluminate, liquid-phase-sintering, reaction-sintered.

CHARACTERISTICS OF MULLITE CERAMICS PREPARED FROM KAOLIN AND ALUMINOUS MATERIALS

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ABSTRACT

Properties of mullite ceramics prepared from a mixture of (a) ESP dust and kaolin, and (b) alumina and kaolin, are described. In these ceramics, the amount of unreacted corundum present increased with the ESP or alumina content. Mullite ceramics prepared from ESP/kaolin are softer, more porous, and of lower strength when compared to those produced from alumina/ kaolin. Thermal shock damage as a result of microcracking was evident in all thermally shocked samples with critical temperature difference for quenching into boiling water for the stoichiometric mullite samples being between 150 and 200°C.

KEYWORDS

Mullite, kaolin, alumina, ESP dust, thermal shock.

PHASE TRANSFORMATIONS ACCOMPANYING ROLLING AND SLIDING WEAR OF Mg-PSZ

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ABSTRACT

Two commercially available grades of Magnesia-Partially-Stabilized Zirconia (Mg-PSZ) were subjected to rolling and sliding contact wear against steel countersurfaces. Phase transformations occurring during wear were monitored using Raman spectroscopy and the worn surfaces were examined microscopically. Rolling contact resulted in a rough surface with spalls of material being removed after a period of testing. Rolling contact also induced tetragonal-to-monoclinic and tetragonal-to-orthorhombic phase transformations. Sliding contact generated a very smooth worn surface with just a few fine scratches and little phase transformation.

KEYWORDS

Zirconia, wear, Raman spectroscopy.

CHARACTERISATION OF ZIRCONIA PHASES IN A SILICON OXYNITRIDE - ZIRCONIA COMPOSITE

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ABSTRACT

The influence of 2 and 8 wt-% calcia additions on the microstructure and stability of zirconia in a Si₂N₂O-ZrO₂ composite material was studied using X-ray diffraction and transmission electron microscopy. For refractory applications, a stable zirconia phase is desirable to avoid cracking upon heating and cooling. However, only a partially stabilised tetragonal phase was attained and chemical analysis showed that CaO mostly segregated to the grain-boundary glass.

KEYWORDS

Reaction-bonding, refractories, silicon-oxynitride, transmission electron microscopy, zirconia.

RAW MATERIAL ASSESSMENT AND CONTROL AS A FACTOR IN MANUFACTURING QUALITY

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ABSTRACT

Global market forces are demanding greater product diversity, higher yields and greater flexibility in the production process. Close control of raw material properties is a key factor in achieving these objectives. The paper focuses on the testing of incoming raw materials that will provide world quality products. Topics such as the need for testing, the choice of raw materials, sampling, the key material parameters and test procedures are discussed.

KEYWORDS

Raw materials, assessment, testing, quality.

EFFECT OF IRON ADDITION ON REACTION OF YALLOURN CHAR WITH CO₂ AND DEVELOPMENT OF MICROSTRUCTURE IN PRODUCTS

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ABSTRACT

Yallourn chars were prepared within the temperature range of 800 to 2000°C. The effects of iron on the gasification of Yallourn chars heat-treated at various temperatures, and on the development of microstructure like an activated carbon were investigated. The reaction of char with CO₂ at 800°C was performed by using thermogravimetric analysis (TG) with different amounts of iron added to the chars. It was found that the reaction rates of the char with iron at the initial stage of reaction were higher than those without iron. The reactivity of the char prepared at 2000°C was much higher than that of the others. The chars prepared at temperatures between 800 and 1500°C did not depend on the heat-treatment temperature. The reactivity was recognized to change depending upon the stage of burn-off of the char. The relationship between reactivity and the form of iron oxides was discussed. In high activation regions, however, iron addition did not effect the development of microporosity.

KEYWORDS

Char, gasification, heat treatment, iron, BET surface area.

THE ADHESION OF DENTAL PORCELAIN TO VARIOUS METALS

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ABSTRACT

Adhesion of porcelain to metal in dentistry has been studied using different techniques. The highest stress at bond failure was reported in most studies, which may not represent the real bonding characteristics correctly. This study aimed to evaluate bonding characteristics in porcelain fused to metal system by determining the strain energy release rate at the interface of porcelain and metals used in dentistry. Porcelain-veneered metal plates cast from gold, palladium, and nickel-chromium alloys were made to dimensions of 25mm x 8mm x 3mm with equal and uniform thickness of each layer. The pre-cracked samples were subjected to the load-unload cycles under four-point bending test. The resultant strain energy release rates were 91.97 ± 12.82 , 57.25 ± 22.26 and 42.08 ± 4.19 J/m² in gold, palladium and nickel-chromium groups respectively. The values of energy per unit area used for breaking the bond between two materials can clearly describe the bonding characteristics of these materials.

KEYWORDS

Adhesion, bonding, dental porcelain, metals, dental alloys.

HYDRATION OF SLAG ACTIVATED BY ALKALIS

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ABSTRACT

Alkali activated slag (AAS) is a new type of binder used in concrete manufacture. It requires much less energy for its production than ordinary portland cement (OPC), utilises industrial by-products, and is therefore, a more environment friendly product. It also has some superior properties to OPC such as low heat of hydration, high early strength, and excellent durability.

This investigation is focused on chemistry of alkali activation of slag. Isothermal calorimetry was used in study of early hydration. X-ray diffraction (XRD) was utilised in investigation of the reaction products during 12 months. Hydration products of slag activated by alkalies are similar to portland cement, but the process of hydration lacks the extended dormant period. This indicates that significant differences exist in the mechanisms of hydration between these two materials. Results on the preparation of the materials based on alkali activated slag binder and their properties are presented.

KEYWORDS

Slag, alkali activation, hydration, calorimetry.

PHOSPHATE BONDING CEMENTS AND THEIR APPLICATIONS

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ABSTRACT

Phosphate bonding is the basis of many refractories and cements and has been the subject of two previous reviews. Kingery summarised the literature up to 1950 and Cassidy reviewed the progress up to 1977. This paper deals with the major developments in the applications of phosphate bonding in the last two decades, with special emphasis on cold setting cements. A brief summary of the content of the previous reviews is also presented by way of introduction.

Two main areas of development are considered in this review. The first of these is the development of magnesia phosphate cements for applications in the rapid repair of concrete. These cements are well suited for this purpose because they set and gain strength quickly and bond well with Portland cement composites. The second area is the use of phosphate bonding cements in biomedical applications. Zinc phosphates have long been common as dental cements, but recently, calcium phosphates have been the focus of research, not just as dental cements but also as bone cements in procedures such as hip replacements. They have also been touted as possible slow release delivery systems for antibiotics.

KEYWORDS

Phosphate, cement, review, ceramic, biocement.

EFFECT OF PROCESS VARIATIONS ON THE PROPERTIES OF PLASTER MOULDS

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ABSTRACT

A number of process variables, such as blend proportioning, slurry mixing and mould drying influence the strength, porosity and permeability of plaster moulds. Poor attention to mould manufacture will lead to faults in manufacture and reduced mould life. This paper will outline best practice methods for mould production with a view to improving the manufacturing process.

KEYWORDS

Plaster, best practice, process variables.

PROPERTIES OF POLYSTYRENE AGGREGATE CONCRETE HAVING THE DENSITIES OF 1300 AND 1900 kg/m³

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ABSTRACT

Lightweight expanded polystyrene can be used with the conventional concrete making materials to produce polystyrene aggregate concrete (PAC), having a wide range of densities. This paper reports the results of an investigation into the engineering properties of PAC, having the nominal densities of 1300 and 1900 kg/m³. Compressive, tensile and flexural strengths together with modulus of elasticity were reduced significantly with the reduction of concrete density. The compressive strength is least affected in relation to other properties and strength development was stabilised at the age of 14 days. The flexural creep of PAC is increased substantially with the decrease in the density of the concrete. It is increased when the concrete is allowed to dry under the sustained load.

KEYWORDS

Expanded polystyrene, lightweight concrete, elastic modulus, creep, strength.

SELF-COMPACTING CONCRETE - A REVIEW

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ABSTRACT

Self-compacting concrete that can fill all corners of formwork without vibration was initially developed in Japan, and its research, development and application have been of increasing interest in recent years in other countries. This paper reviews the applications, research and development of self-compacting concrete in the world, especially in Japan, Europe and at the University of Wollongong, Australia. The actual applications indicate that this new generation type of concrete can be considered as an innovative material for the 21st century.

KEYWORDS

Self-compacting concrete, building materials, construction, concrete, cement.

MODELLING THE ELASTIC PROPERTIES OF CONCRETE: A REVIEW

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ABSTRACT

An overview is presented of the various two-, three-, and four-phase models that have been developed to model the elastic behavior of concrete. However, due to the limitation in the assumptions of all these models, no one model has, as yet, proven satisfactory and further development is required. A new idea that considers both the effects of inhomogeneous transition zone and the shape and volume of arbitrary distributed elliptical aggregate on the overall elastic moduli of cement-based composites is proposed. This review places the new method in the content of previous work.

KEYWORDS

Elastic modulus, transition zone, concrete materials, aggregate, interface bonding.

TEMPERATURE DEVELOPMENT IN CONCRETE WITH EXPANDED POLYSTYRENE BEADS

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ABSTRACT

This paper reports the results of an experimental study into the effects of incorporating expanded polystyrene beads in concrete on the temperature development in an insulated thick concrete section. A varying amounts of non-heat conducting expanded polystyrene beads by partially replacing the normal weight aggregates to obtain the unit weights of 2215, 2100, and 1835 kg/m³. Cement content and water to cement ratio for the mixtures were kept constant at 500 kg/m³ and 0.30, respectively. The concrete mixture with the largest amount of polystyrene beads produced a peak temperature of 85.6°C compared to 70.6°C for the control concrete mixture due to the reduction in the amount of heat-absorbing aggregate particles in the concrete system. Therefore, consideration to curing should be given to prevent temperature-induced cracking in thick concrete sections when non-heat conducting aggregates are used in concrete.

KEYWORDS

Expanded polystyrene, heat of hydration, mass concrete, temperature rise, lightweight concrete, compressive strength, modulus of elasticity, tensile strength.

COLOUR-GIVING BY-PRODUCTS AS CERAMIC RAW MATERIALS

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ABSTRACT

It is commonly known that metal ions dye the ceramic body. Normally, the production of coloured ceramic pieces is relatively expensive. At the same time the metal and mining industry produce huge amounts of slag as their by-products. This study investigates the suitability of by-products containing metal ions for raw materials in ceramics production process. The variables in the tests were the firing, the quality and the amount of by-products. In addition to colour this study also examines other effects that by-products caused to the various properties of ceramics, such as shrinkage, sintering, porosity, and utility value in ceramic process.

KEYWORDS

By-product, ceramic, design, colour, waste.

SYNTHESIS AND PROPERTIES OF *IN-SITU* LAYERED AND GRADED ALUMINIUM TITANATE /ALUMINA COMPOSITES

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ABSTRACT

A novel route to simple processing of layered and graded aluminium titanate (AT) /alumina composites is described. The processing involves partial infiltration of porous alumina preforms with titanium ethoxide to yield a surface layer of alumina and a graded layer of AT/alumina. The homogeneous fine-grained alumina provides strength, hardness, and wear resistance, while the heterogeneous graded AT/alumina imparts toughness and damage tolerance. Vickers indentation tests are used to demonstrate the capacity of the graded layer to absorb damage and its potential to shield the propagation of dangerous cracks from the outer alumina layer. The mechanism of damage control is by profuse debonding, sliding, and push-out of grains.

KEYWORDS

Layered and graded material, alumina, aluminium titanate, Vickers indentation, damage mechanisms.

SYNTHESIS AND PROPERTIES OF ALUMINIUM TITANATE AND ZIRCONIA-DISPERSED ALUMINIUM TITANATE CERAMICS MODIFIED WITH β -SPODUMENE

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ABSTRACT

The use of β -spodumene ($\text{Li}_2\text{O}\cdot\text{Al}_2\text{O}_3\cdot 4\text{SiO}_2$) has been investigated as a sintering aid for the densification of aluminium titanate (AT) and zirconia-dispersed AT ceramics. XRD and DTA were used to characterise the effect of both additives on the phase relations, sintering and densification behaviour of AT. The results show that the presence of both β -spodumene and zirconia significantly resulted in reduced porosity, lower thermal expansion, improved densification and hardness, and enhanced thermal stability. Excess β -spodumene recrystallised in all the AT samples.

KEYWORDS

β -spodumene, aluminium titanate, zirconia, liquid-phase-sintering, thermal stability.

CRITICAL AGEING AND CHEMISTRY OF NANOCRYSTALLINE HYDROXYAPATITE SOL-GEL SOLUTIONS

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ABSTRACT

In previous work we have demonstrated that using alkoxide precursors, it is possible to produce crystalline hydroxyapatite coatings with potential uses in orthopaedic and dental applications. However, to produce monophasic hydroxyapatite coatings, sols must be aged for a minimum of 24 hours prior to deposition. ³¹P NMR has been used to analyse chemical changes occurring in the sol during the ageing process and have revealed that P-O-C bonds present in the precursor material are gradually replaced by P-O-Ca bonds with an accompanying change in oxidation state from P(III) to P(V). Thermal analysis was used to examine hydrolysed gels and showed that sols aged less than 24 hours contain unreacted calcium diethoxide, which produces CaO upon heating. These findings have been confirmed by x-ray diffraction.

KEYWORDS

Hydroxyapatite, ageing, sol-gel, alkoxide, bioceramic.

QUANTITATIVE ALKALI AND ACID RESISTANCE OF SOME DIRECT-ON PORCELAIN ENAMEL COATINGS

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ABSTRACT

Enamel grade steel (<0.005 % carbon) was enamelled with three coating types; namely, gloss green, gloss brown and matt black "direct-on" enamels. Testing of these enamels was undertaken in order to ascertain the difference between their corrosion resistance properties when exposed to alkaline and acidic environments. The resistance assessment of the enamel coatings to an alkali environment was undertaken using the Australian Standard AS 2219.1.1, while for vapour and liquid acid resistance (boiling citric acid), Australian Standard AS 2210.1.4 was used.

The gloss coatings were observed to have better acid and alkali resistance than the matt coating and therefore would be expected to have better chemical resistance for appliances. The matt black coating was observed to have very little acid resistance, but it was considered that the alkali resistance would be sufficient for certain appliances.

KEYWORDS

Porcelain enamel, alkali resistance, acid resistance, Australian Standard tests, optical microscopy.

ANALYSIS OF EU²⁺ IN GLASS FORMING MELTS BY UV-VIS SPECTROSCOPY

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ABSTRACT

Eu²⁺ ion containing glasses are of interest for use in X-ray imaging devices. In this work a series of fluorozirconate glasses containing Eu²⁺ have been prepared by reduction in the melt prior to glass formation. A number of different reductant additives, a reducing atmosphere and electrochemical reduction are compared. Glasses are characterized via the position of the UV edge and the ⁷F₀ → ⁵D₃ transition in Eu³⁺. Reduction of Eu³⁺ → Eu²⁺ occurred in all cases, however, only the latter two methods produced glasses with high transparency; ultimately the flexibility of the electrochemical method will make it the procedure of choice.

KEYWORDS

Fluorozirconate glass, X-ray storage phosphor, UV-Vis spectroscopy.

**PREPARATION AND CHARACTERISATION OF YTTRIA
STABILISED ZIRCONIA THIN FILMS DEPOSITED ON Al₂O₃
(102) AND MgO (100) BY CVD**

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ABSTRACT

We have prepared yttria stabilised zirconia (YSZ) thin films with different yttria concentrations on single crystal Al₂O₃ (102) and MgO (100) substrates using chemical vapour deposition (CVD). The chemical composition of the thin films was investigated primarily by secondary ion mass spectrometry (SIMS) and x-ray photoelectron spectroscopy (XPS). Results will be discussed in terms of the effect of yttria concentration, substrate material and deposition temperature on the quality of the thin films.

KEYWORDS

YSZ, thin film, CVD, SIMS, XPS.

CHARACTERIZATION OF BORONIZING OF MANGANESE-BASED LOW ALLOY STEELS

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ABSTRACT

In this study, the effect of manganese on the mechanical and corrosion properties of borided low alloy steel was detailed. Thermochemical boronizing treatment was performed in slurry salt bath consisting of borax, boric acid, and ferro-silicon at 940°C for 5-7 h. The presence of non-oxide ceramic borides (FeB, Fe₂B, MnB, Mn₂B) was identified by classical metallographic technique, scanning electron microscopy (SEM) and x-ray diffraction (XRD) analysis. Wavelength dispersion x-ray (WDX) dot map showed that B had diffused into the substrate as much as 500 µm. The thickness and hardness of non-oxide ceramic borides formed on the surface of steel substrate were measured by means of Vickers microhardness tester under a load of 1-2 N. The hardness of non-oxide ceramic borides was over 1200 DPN. Depending on boronizing time, the thickness of borides ranged from 10 µm to 170 µm and the fracture toughness of non-oxide ceramic borides ranged between 4.41 and 5.88 MPa·m^{1/2}. Corrosion tests were performed in an acid solution essentially containing 10% H₂SO₄ at 56°C. Corrosion measurements were performed by weight loss method. It was observed that Mn has a positive role on the mechanical and corrosion resistance of borided Mn-based low-alloy steels.

KEYWORDS

Boronizing, borides, corrosion, hardness, fracture toughness.

THE SOLARISATION OF SODA SILICATE GLASSES CONTAINING CERIUM

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ABSTRACT

The solarisation of cerium doped soda silicate glasses was studied. It was shown that glasses containing cerium and vanadium solarised with transmission losses of up to 8 % at 500 nm. Pure soda silicate glasses also exhibited solarisation, losing up to 23 % transmission at 440 nm. The addition of cerium to this pure soda silicate glass was found to eliminate this transmission loss. The suppression of solarisation by cerium occurs when the glass is free from polyvalent elements such as vanadium. Ce³⁺ is believed to capture holes thus preventing the 440 nm and 620 nm absorption bands. The band that would arise from the generated electrons being trapped at defects is believed to be prevented by the Ce⁴⁺, which captures the electrons. Solarisation found to occur in commercial glasses could not be reproduced.

KEYWORDS

Solarisation, cerium, vanadium, glass.

MICROWAVE SINTERING OF ZIRCONIA TOUGHENED ALUMINA AT 28GHz

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ABSTRACT

Microwave radiation from a 10kW, CW gyrotron operating at 28 GHz was employed to sinter 10% zirconia toughened alumina (ZTA) ceramic samples. It has been established that the use of millimetre wave radiation circumvents the difficulties encountered during the sintering of ceramics, i.e. formation of hot spot, by radiation at industrially permissible frequency of 2.45GHz. Further, careful density measurement and microstructural characterisation of mm-wave and conventionally sintered samples by XRD, SEM and TEM has unequivocally demonstrated the effectiveness of mm-wave radiation for obtaining high density ceramics at lower sintering temperatures.

KEYWORDS

Conventional sintering, electron microscope, microwave sintering, x-ray diffraction, zirconia toughened alumina.

MICROSTRUCTURE AND MECHANICAL PROPERTIES OF TI IMPLANTED SILICON NITRIDE

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ABSTRACT

Microstructure of silicon nitride implanted with Ti ions at different doses and energies has been studied. A metal vapour vacuum arc (MEVVA) ion source was employed to implant Ti ions into silicon nitride. The implanted silicon nitride was characterised using Rutherford backscattering spectrometry (RBS) and cross sectional transmission electron microscopy (XTEM), in conjunction with nano-beam diffraction (NBED) analysis. The hardness of the implanted surface was examined using an Ultra Micro-Indentation System (UMIS). It was demonstrated that the implanted layer was in the range of 120 - 280 nm thick, depending on implantation fluence and energy. Titanium implantation, irrespective of dose or energy, always resulted in the formation of an amorphous layer. However, when Ti was implanted at a high dose, another layer comprising fine precipitates of titanium nitride was formed on top of the amorphous layer.

KEYWORDS

Amorphous layer, electron microscope, ion implantation, silicon nitride, titanium, TiN precipitates.

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HIGH-RESOLUTION ELECTRON MICROSCOPY OF NIOBIA-ZIRCONIA CERAMIC ALLOYS

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ABSTRACT

High-magnification images of niobia-zirconia ceramic alloys are displayed with point-to-point resolution nearing 2.5Å in some thin areas. Real-space structural aspects of the alloys are examined and evidence is presented that the periodically-modulated oxygen sub-lattice possesses considerable disorder.

KEYWORDS

Niobia-zirconia alloys, high-resolution electron microscopy.