

## **ZIRCONIA V**

### **STUDY OF THE SURFACE PROPERTIES OF MODIFIED AND UNMODIFIED ZIRCONIA**

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#### **ABSTRACT**

The electrokinetic, surface charge behaviour and surface chemical compositions of zirconia (ZrO<sub>2</sub>) unmodified and modified with Tris [1-(2-methyl) aziridiny] -phosphine oxide (MAPO), Tri-n-butyl phosphine oxide (TBPO) and Hydroxy Terminated Poly Butadiene (HTPB) have been investigated using microelectrophoresis, infrared spectroscopy and X-ray photoelectron techniques. The isoelectric point (IEP), the point of zero charge (PZC), zeta potential, surface charge and surface chemical composition of modified zirconia varied, depending on the physical and chemical properties and structures of the modifiers and surface reactivities between the modifier and the surface of zirconia.

## **ZIRCONIA V**

### **ZIRCON PROSPECTS: WHAT PRICE SECURITY?**

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#### **ABSTRACT**

When examining the supply situation for zircon and baddeleyite it is important to note that both are produced as by-products and are not exploited in their own right. Consequently, their availability is always dependent on the fortunes of the minerals with which are associated as well as on demand factors. Zircon is most commonly found as a constituent of heavy mineral sand assemblages, which also incorporate ilmenite, rutile, leucoxene, monazite and xenotime, in varying proportions. These deposits are usually worked for their titanium mineral content. Thus, if markets for titanium minerals are soft, production is likely to be curtailed, thereby reducing the availability of zircon. This is the case right now and, because zircon markets are also slack, prevailing market conditions should prove beneficial in balancing the supply/demand equation.

Baddeleyite is commercially produced in only two countries, South Africa and Russia. In the former, it is found in the Palabora Complex, which plays host to phosphate, copper, vermiculite, iron, uranium and gold, as well as zirconium mineralisation. Here baddeleyite production is largely dependent on the requirements for phosphates, copper and uranium. In Russia it is obtained as a by-product of iron mining.

## **ZIRCONIA V**

# **EVALUATION OF HOT HARDNESS, CREEP, FATIGUE AND FRACTURE PROPERTIES OF ZIRCONIA CERAMICS BY AN INDENTATION TECHNIQUE**

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### **ABSTRACT**

Zirconia ceramics have wide range engineering applications at room and elevated temperatures. For understanding the mechanical behaviour, the indentation technique was adapted for quick evaluation of hot hardness, creep, fatigue and fracture properties. A Vicker's diamond indenter with 10N load was employed for hot hardness and creep measurement up to 1300°C. The fatigue data were evaluated at room temperature by repeated indentation with a constant load (10-2500N) at the same location for a dwell time of 5s until it resulted in the formation of a lateral chip on the sample surface. Thus, the number of cycles for chip formation at a specific indentation load was obtained. The fracture toughness was evaluated at room temperature with a load of 300N using a Vicker's diamond indenter. The results of hot hardness, creep, fatigue, and fracture data of 3Y-TZP and Mg-PSZ are discussed along with their microstructural features.

## **ZIRCONIA V**

# **SOLID OXIDE FUEL CELL RELATED R&D ACTIVITIES IN JAPAN**

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### **ABSTRACT**

Japan's R&D activities on SOFC range from basic research to the development of 10 kW stacks. Research on physico-chemical properties of component materials, processing of components and electrode reaction mechanisms has been mainly carried out at several universities. Two national laboratories, ETL and NCLI, have also performed R&D for stack fabrication. Public and private companies have carried out development on SOFC-related materials and stacks for themselves. The first phase of the Moonlight project has been conducted by AIST and NEDO for 3 fiscal years, 1989-1991. The second phase of the 6 year program started in 1992. Since 1990, the Petroleum Energy Center has contracted some oil-refining companies to develop SOFC using hydrocarbons.

\*\*Chairman, Solid Oxide Fuel Cell Society of Japan

## **ZIRCONIA V**

# **TETRAGONAL-CUBIC INVERSION IN UNSTABILIZED ZIRCONIA DISPERSED IN AN ALUMINA MATRIX**

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### **ABSTRACT**

The effect of sintering atmosphere on the content of zirconia phases present in  $\text{Al}_2\text{O}_3\text{-ZrO}_2$  ceramics was studied. It was demonstrated that, in the case of high vacuum-sintered ceramics, 100% of the zirconia is found in the cubic form, in contrast with 83.5% of tetragonal form observed in the air-sintered ceramics. The appearance of transformable cubic zirconia is a result of sintering in high vacuum and accompanies oxygen non-stoichiometry.

By changing the vacuum level, a critical value of oxygen content in a sintering atmosphere responsible for "low temperature" tetragonal-cubic inversion of unstabilized zirconia inclusions dispersed in alumina matrix was estimated.

## **ZIRCONIA V**

# **THE EFFECT OF ALLOY ADDITIVES ON THE PHASE STABILITY OF ZIRCONIA-CALCIA-TITANIA CERAMICS**

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### **ABSTRACT**

In this study, the effect of alloy additives (NiCr alloys) on the phase stability of ZrO<sub>2</sub>-CaO- TiO<sub>2</sub> ceramics has been investigated by means of X-ray diffraction. The results show that the additions of NiCr alloy will restrain the detrimental effect of TiO<sub>2</sub>, on the phase stability in CaO-stabilised ZrO<sub>2</sub> ceramics. Furthermore, SEM and EDX studies show that TiO<sub>2</sub> accumulates in the NiCr phase and the content of TiO<sub>2</sub> in the surrounding ZrO<sub>2</sub> phase is reduced. The removal of TiO<sub>2</sub> from ZrO<sub>2</sub> to the NiCr phase may explain why the detrimental effect of TiO<sub>2</sub> on cubic ZrO<sub>2</sub> phase stability is reduced by the addition of NiCr.

## **ZIRCONIA V**

# **INDENTATION FRACTURE TOUGHNESS OF ZIRCONIA CRYSTALS**

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### **ABSTRACT**

Indentation tests were used to measure fracture toughness of partially stabilized (Y-PSZC) and fully stabilized (Y-FSZC) zirconia crystals. It was established that radial cracks were first formed from the corners of a Vickers impression on a Y-PSZC specimen at a load of about 20 N, which is much higher than the critical load for Y-FSZC. Y-PSZC samples do not exhibit any anisotropy of fracture toughness on the (001) plane, which is typical of Y-FSZC. Y-PSZC samples were noticed to have Palmqvist-type radial cracks while in Y-FSZC they were of half-penny type. A semiempirical equation to determine fracture toughness from radial crack length measurements was derived; it gives results in agreement with those obtained from edge-notched bending tests.

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# COMPARISON OF SHORT AND LONGER TERM LOADING ON THE CREEP BEHAVIOUR OF ALUMINA-SILICON CARBIDE WHISKER COMPOSITES

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### ABSTRACT

The incorporation of SiC whiskers into alumina ceramics has resulted in several improved room temperature properties of the composite such as fracture toughness, strength, erosion resistance and fatigue. The creep resistance has also been generally observed to increase with the addition of whiskers. However, significant scatter in measured secondary creep rates still exist, depending on the material and the test conditions that were utilized.

The objective of this investigation was to compare two separate creep tests performed in compression using a SiC<sub>w</sub>/Al<sub>2</sub>O<sub>3</sub> material obtained from the same process batch. The differences in creep behaviour between the tests could thus be ascribed to the difference in creep conditions solely. In one case the creep behaviour was studied under short term loading (<3 h) conditions in air, while longer term loading (<100 h) conditions in argon were applied in the other case. The creep results and the microstructure of the samples were compared and related to each other, and to previous results in the literature.

## **AUSTCERAM 92**

# **A DEPENDENCY OF GLAZING COLOUR ON THE CONTENT OF $(Zr_{1-x}Pr_x)O_2SiO_2$ PIGMENT**

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### **ABSTRACT**

A colour of glazing is one of the factors that determine the quality of product. In practice, it depends on pigment content, pigment thermic stability interaction between glazing and pigment, thickness of layer, conditions of thermic treatment etc.

In definition of glazing colour, colorimetric methods can be used for: investigation of stability of glazing and pigments, determination of the optimum pigment content and control of product quality on the basis of colour of pigment or colour of mixture of pigments with this the colour of glazing can be predicted or improved.

The results of investigation presented in this work are a contribution to a better understanding of glaze colouring.

## **AUSTCERAM 92**

# **A THEORETICAL APPROACH TO THE DESIGN AND FABRICATION OF MATERIALS FOR THERMAL INSULATION**

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### **ABSTRACT**

Thermal insulation materials are fundamental to modern technology, being found in the home (loft insulation, refrigerator insulation, double glazed windows), in automobiles (insulators around catalytic convertors), and in a very wide range of industrial applications (furnaces, heatshields, protective clothing, fireproofing etc). Our understanding of the principles of heat flow is well developed, so that insulation can be provided which will behave very much as predicted. Materials are available to cover the range of temperatures from little above absolute zero up to temperatures of 3000K or even higher. There are several basic techniques for protection from high temperatures:

- Reflection of radiated heat
- Conduction of heat away from source by a highly conducting heatsink
- Forced cooling by air or other fluid
- Use of low-conductivity materials such as refractories

Despite the many studies of heatflow processes, the great majority of insulation materials are manufactured from naturally occurring minerals. Some of these eg diatomite and vermiculite, possess interesting properties and are highly effective, although very little control can be exercised over their physical properties.

Probably the most significant synthetic insulation material is ceramic fibre, which is now used in the production of blanket, paper, board and loose-fill insulation. Although ceramic fibre materials are very efficient insulators, they may cause health dangers if not treated with the greatest care.

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### **SOL-GEL-DERIVED LEAD TITANATE POWDERS**

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#### **ABSTRACT**

A review of the literature will be presented detailing the complexation chemistry of lead-titanium sol-gel solutions. On the basis of this chemistry, the rationale will be described for the preparation of homogeneous, doped and undoped lead titanate powders. Powders prepared by Silicon Technologies Australia Limited (STA) using this complexation rationale will be described.

## **AUSTCERAM 94**

### **PLATELET ORIENTATION IN THE CERAMIC PLATELET REINFORCED CERAMIC MATRIX COMPOSITES**

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#### **ABSTRACT**

3 mol% yttria stabilized zirconia matrix has been incorporated with 10 wt % single crystal  $\alpha$ -alumina platelets to enhance the mechanical reliability. The composites have been produced by different forming techniques, namely, slip casting, tape casting, and injection moulding followed by pressureless sintering. Relative density ~ 99 % has been obtained. Texture of the platelets in the material was analyzed by processing the images taken from scanning electron microscopy. Strong platelet orientation along the walls of the slip cast mould has been observed. Mechanical properties of the composites were evaluated, and co-related to the alignment of the platelets.

## **AUSTCERAM 94**

### **FRACTURE MECHANICS OF FUNCTIONALLY GRADIENT MATERIALS**

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#### **ABSTRACT**

In this article after a brief discussion of the elementary concepts of fracture mechanics in homogeneous and nonhomogeneous materials, a number of typical problem areas relating to the fracture of functionally gradient materials are identified. The main topics considered are the investigation of the nature of stress singularity near the tip of a crack fully embedded in a nonhomogeneous medium. In addition, the general problem of debonding of an FGM coating from a homogeneous substrate, the basic surface crack problem in FGMs cracking perpendicular to the interfaces, periodic surface cracking, the associated problem of stress, energy relaxation, the problem of stress concentration and the initiation and growth of delamination cracks from the stress-free ends of FGM-coated homogeneous substrates under residual or thermal stresses are also explained. Each topic is very briefly reviewed, some sample results are presented and comparisons with the corresponding results obtained from homogeneous materials are made.

## **AUSTCERAM 94**

# **MEASUREMENT OF THE FIBER DIAMETER DISTRIBUTION OF MAN MADE VITREOUS FIBER INSULATION MATERIALS**

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### **ABSTRACT**

A fast method using optical microscopy for the determination of the fiber diameter distribution of high temperature ceramic insulation has been developed. The method has been used to measure the diameter distribution of commercially available fiber insulation. The calculated specific surface area obtained from these measurements is in excellent agreement with BET surface area measurements obtained by nitrogen adsorption. Optical and SEM micrographs of these specimens are compared to each other. The average size of refractory fiber specimens obtained by this technique is larger than that obtained by other methods. The average sizes obtained are greater than 3 microns, the size normally considered to be the limit of those that are respirable.

## **AUSTCERAM 94**

# **INDUSTRIES OF THE FUTURE, MATERIALS NEEDS ASSESSMENTS, AND TECHNOLOGY TRANSFER**

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### **ABSTRACT**

The mission of the Office of Industrial Technologies (OIT), Energy Efficiency and Renewable Energy, of the U.S. Department of Energy is to work directly with industry to develop and commercialize technologies to improve energy efficiency and productivity, while preventing or minimizing pollution. The expertise and facilities of the DOE National Laboratories are available to OIT and industry to assist with this mission. The major, energy consuming process industries, including iron and steel, aluminum, pulp and paper, glass, refineries, and chemicals are currently developing "Visions of the Future", facilitated by OIT. Industry organizations and individual representatives are asked to define the industries as they are today, identify the drivers for change, and describe the industry as it will be ten, twenty, or thirty years in the future. From these visions, technology needs are being identified and OIT is using these for program planning and priority setting. The Advanced Industrial Materials (AIM) Program is supporting the initiatives by preparing assessments of materials needs and opportunities. DOE National Laboratory materials researchers and industry representatives have been meeting to identify needs and potential materials or processing technologies to satisfy those needs. To date, a materials assessment has been completed for the pulp and paper industry and another is proceeding for the glass industry. Many research, development, and commercialization opportunities have already been identified in the pulp and paper industry and AIM is supporting work in Fiscal Year 1994 and will increase that support in following years.

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### **RTC - REFRACTORIES TESTING CENTRE**

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#### **ABSTRACT**

Refractories, like all engineered materials, must be tested to establish their properties and likely performance in service. Refractory lining designers must have accurate data with which to select optimum materials. Refractory manufacturers must know that their products will satisfy the process requirements of the customers. Refractory users must know the advantages of improved materials and the limitations of those currently in service.

## **AUSTCERAM 94**

### **CHEMICAL RESISTANCE OF CERAMIC PIPES**

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#### **ABSTRACT**

Ceramic pipes have been used for waste water drainage systems in many processing industries. They have been extensively used for this purpose in dairy factories. Their rapid deterioration in this application prompted a research programme to determine suitable testing procedures to ascertain the effect on the pipes of the most common chemical effluent discharged through them. Whilst the British Standard BS65:1988 was accepted as the normal standard for assessing the chemical resistance of ceramic pipe, it did not adequately address alkali resistance. Using the principles of BS65:1988, procedures were developed to determine alkali resistance. The results relating to the deterioration of a number of manufacturers' pipes, together with details of the test procedures used, were reported in 1992 (Milestone & Sowry). Further testing, including tests on additional manufacturers' pipes and bends were undertaken in 1993. This testing showed a large difference in the resistances of the bends when compared with the pipes from the same manufacturer and also differences from the previous results. To verify the results and further the research project, a comprehensive testing programme was undertaken on two brands of ceramic pipe systems, consisting of both pipes and bends.

The tests undertaken determine the chemical resistance to boiling hydrochloric acid and 10% sodium hydroxide solution over a temperature range from 30 to 80°C for 24 hours. Water absorption was also determined along with X-ray diffraction analysis of the pipes and bends. To ensure that the pH remained constant over the 24 hour testing period, the consumption of hydroxyl ion from the test solution was also measured.

This paper presents the results determined in the latest testing.

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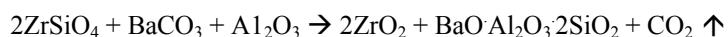
# REACTION SINTERING OF A ZIRCONIA-CONTAINING BARIUM FELDSPAR CERAMIC

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### ABSTRACT

Zircon ( $\text{ZrSiO}_4$ ) is a natural mineral resource known to react with certain oxides to produce a dispersion of zirconia particles within ceramic or glass-ceramic matrices. Barium aluminosilicates, particularly the celsian polymorphs of  $\text{BaO}\cdot\text{Al}_2\text{O}_3\cdot 2\text{SiO}_2$  display oxidation resistance and refractory characteristics commensurate with the properties required of high temperature materials. Such properties, coupled with the high melting point of  $\text{ZrO}_2$  ( $2680^\circ\text{C}$ ), suggest that barium aluminosilicates and zirconia are an ideal combination from which to fabricate high temperature materials. A recent study has indicated that a barium aluminosilicate containing up to 40mol%  $\text{ZrO}_2$  can be prepared via a sol-gel process. However, the desire to utilise a natural resource in the form of zircon in the present work has led to the choice of reaction sintering as an alternative processing route. The current work was undertaken to investigate the possibility of forming a zirconia-containing barium feldspar composite material using the reaction sintering of zircon and assuming the following stoichiometric reaction:



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# **HYDROXYLAPATITE VS. POROUS INGROWTH IN CANINE UNCEMENTED HIP REPLACEMENT MODEL AT 6 WEEKS AND 13 MONTHS: OSTEOLYSIS AND FIXATION**

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### **ABSTRACT**

Hydroxylapatite (HA) ceramic is being applied as a plasma spray coating to total joint replacement prosthetic implants in order to promote biological fixation of the implant via osseointegration. HA promotes direct bone healing to its surface, which can provide secure mechanical fixation of the implant. This study was undertaken to compare HA coating to conventional porous coatings (PC) of implants with regard to rate and degree of mechanical fixation, and to study the long term fate of the potentially soluble HA coating, as well as its ability to seal the bone implant interface against the intrusions into the critical bone-implant interface of potentially dangerous particulate wear debris from the joint's articular surface. HA coatings provided more secure fixation at both time intervals from implantation studied (6 and 56 weeks) than PC controls. The vigorous bone healing response to the HA coating prevented intrusion of particulate debris with its accompanying osteolysis into the bone-implant interface which was observed with the PC controls, and the HA did not appear to undergo any loss of thickness over the 56 week course of the study.

## **AUSTCERAM 94**

# **THE MEASUREMENT OF THE ADHESIVE STRENGTH OF TiN COATINGS ON MILD STEEL USING THE PERIODIC CRACKING METHOD**

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### **ABSTRACT**

Protective coatings must adhere to the surfaces they are designed to protect. However adhesive failure, between the coating and substrate, often occurs under shear loading. The adhesive shear strength can be measured by the periodic cracking method. This method consists of applying a tensile strain to a flat-coated specimen, and monitoring the spacing between the cracks that appear in the coating. With increasing applied strain the crack spacing reaches a lower limit from which the adhesive shear strength can be calculated. In this paper the periodic cracking method and its application to TiN coated mild steel is described. We discuss how the residual stress in the coating can affect the value of the adhesive shear strength.

## **AUSTCERAM 94**

# **TECHNOLOGY AND REGULATORY CONSEQUENCES OF FLUORINE EMISSIONS IN CERAMIC MANUFACTURING**

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### **ABSTRACT**

Fluorine is a constituent of natural raw materials including clays; it is usually present in the range of 0.01-0.2 weight percent. It is evolved on dehydroxylation of clay in the general range of 500-900°C. The amount of fluorine released from the ware is typically 40-65% of the fluorine contained in the unfired material, but release of up to about 99% of the fluorine is possible. The amount of fluorine released has been shown to be related to the chemistry of raw materials and to variables in the firing process. To control fluorine emissions, fluorine scrubbers employing limestone absorbents have been employed throughout the world.

The ceramic industry in the United States faces fluorine regulation under the Clean Air Act and its Amendments of 1990. This act includes hydrogen fluoride or HF among a list of 189 Hazardous Air Pollutants. Implementation of regulations in the source category "Clay Products Manufacturing" will be completed in the year 2000. However, many important regulatory decisions are yet to be finalized. The industry as a whole can still influence aspects of the regulatory process. However, immediate action is required if any benefit to industry is to be realized.

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# **BASIC CONCEPTS IN THE DESIGNING OF BRICK AND ROOFING TILE PLANT ARTIFICIAL DRYERS**

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### **ABSTRACT**

The process of clay drying and the relationship between the internal mechanisms and the drying cycle program will be discussed. In order to do this, factors such as water carrying capacity of air at various temperatures and relative humidities will be explained, while the significance of these factors will be applied to the various components necessary in the construction of dryers. This relates to the selection of hot air supply fans and heat sources for the dryer. Other important factors such as the design of the drying chamber and internal recirculation and its capacity will also be covered. This information will be applied to a practical example of dryer chamber design.