

## **NOVEL GELFORMING PROCESS FOR NEAR NET SHAPE CERAMIC COMPONENT PRODUCTION**

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### **ABSTRACT**

A novel gelforming process for producing near-net shape ceramic components has been developed. A low viscosity, high volume fraction, ceramic suspension containing a small amount of bio-polymer is poured or injected into a mould. The suspension is gelled within the mould by a temperature activated cross-linking mechanism. The rheological behaviour of the body within the mould is changed from liquid-like to solid-like in a short period of time. The wet mechanical strength of the gelled bodies is sufficient to allow the body to be demoulded and handled without damaging the component. Near net shapes of complex geometry are formed in this way. The wet green body is then dried and densified using traditional methods. Potentially this process can be used to produce inexpensive reliable high strength ceramic components quickly and safely.

### **KEYWORDS**

Gelforming, gelcasting, near-net shape, forming processes, gelation, alumina, rheology.

## **CERAMIC MEMBRANE TECHNOLOGIES FOR GAS SEPARATION**

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### **ABSTRACT**

Solid state electrochemical cells based on oxygen-ion or proton conduction (pure ionic or mixed ionic/electronic conductors) allow selective transport of oxygen (oxygen-ion conducting materials) or hydrogen (for proton conducting materials) in the form of ionic flux at high temperatures. Thus these systems can act as filters for molecular oxygen or hydrogen and can be used for both generation or removal of these gases selectively. The usage of such devices are numerous including control of atmosphere in industrial environments to production of power and chemicals, in petroleum and medical industries, and in combustion processes. In this paper, a brief overview of the technology has been given and various materials for construction of such devices have been briefly reviewed.

### **KEYWORDS**

Ceramic membrane technology, oxygen separation, hydrogen separation, oxygen pump, hydrogen pump.

## **PERFORMANCE CHARACTERISTICS OF POROUS ALUMINA CERAMIC STRUCTURES**

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### **ABSTRACT**

Porous ceramics have found a wide range of applications as filters for liquids and gases. The suitability of materials for use in these types of applications depends on the microstructure (grain size, pore size and pore volume fraction) and hence the mechanical and thermal properties. In this study alumina ceramics with different levels of porosity and controlled pore sizes were fabricated and the surface damage and fracture properties were examined.

### **KEYWORDS**

Porous structure, filters, alumina, pore size, microstructure, mechanical properties, contact damage.

## **THE ENVIRONMENTAL IMPACT OF THE CERAMIC TILE INDUSTRY. NEW APPROACHES TO THE MANAGEMENT IN EUROPE**

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### **ABSTRACT**

This paper aims to review the evolution of the environmental impact control and management activities in the last years, for the ceramic floor and wall tile sector. The objective of "sustainable development" requires new environmental analysis tools, on which the scientific and industrial research has been focused recently. A Life Cycle Assessment procedure specific for the ceramic tile industry has been developed, and used to compare the environmental performances of different products and technologies. Attention has been focused, in particular, on techniques having cross media effects (for example, the purification of gaseous emissions and cogeneration): the LCA procedure applied enables to identify and quantify possible environmental benefits or risks associated to these techniques. These results can be used in the development - for the ceramic tile industry - of design criteria for measures intended to achieve an integrated pollution prevention and reduction, and thus a global protection of the whole environment.

### **KEYWORDS**

Ceramic floor & wall tile, environmental impact, Best Available Techniques, Life Cycle Assessment.

## **ISO/IEC 17025 - A NEW STANDARD FOR LABORATORIES**

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### **ABSTRACT**

The publication of ISO/IEC 17025 heralds a new era in the operation and evaluation of laboratories. ISO/IEC 17025 establishes an internationally recognised standard for laboratory practice and offers criteria for the evaluation of competence in testing and calibration laboratories. These criteria cover both management systems requirements and technical requirements relevant to the production of meaningful testing results. They are relevant to all testing and calibration laboratories, and can be applied in diverse fields, from mechanical and chemical testing laboratories to those engaged in electrical, optical and biological testing.

The paper will consider:

- the historical development of the standard;
- the needs of users, underlying the development of a laboratory-specific standard;
- the management systems and technical requirements in detail, and outline new requirements for laboratories;
- the means of achieving national and international recognition.

### **KEYWORDS**

Laboratory accreditation, testing, quality, standards, conformity assessment.

## **PHYSICO-CHEMICAL EFFECTS OF CHINA CLAY SUSPENSION OVER-DEFLOCCULATION**

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### **ABSTRACT**

The effects of increasing the concentration of deflocculating agents to clay suspensions, past the minimum of viscosity, is an area of research that seems to have been largely disregarded by ceramic and colloidal scientists. In the present study the physico-chemical consequences of over-deflocculating a high solids china clay suspension using a polyelectrolyte-dispersing agent have been investigated. A simple mathematical model has been developed that has been used to explain the effects of particle-particle interaction on the suspension rheology. It is anticipated that this work will lead to greater understanding of the deflocculation mechanisms displayed by such dispersing agents and of the interactions of clay particles in suspension.

### **KEYWORDS**

Characteristic curve, china clay, deflocculation, electroviscous effects, kaolinite, polyacrylate, thixotropy, zeta potential.

## **PRELIMINARY INVESTIGATIONS INTO CRYSTAL GROWTH IN CERAMIC GLAZES**

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### **ABSTRACT**

The aim of this study was to develop a range of high temperature crystalline glazes suitable for use on ceramic wares, and to determine the factors that contribute to crystal development. Using several glaze formulae which had been developed through previous experimentation, a range of colorants and combinations thereof were mixed with the glazes and fired using several firing cycles in an attempt to maximise crystalline growth within the glazes. The results indicate that there are many variables that influence the size and quality of crystal growth. These variables fall into three main categories: the clay body, glaze (formulae, application, characteristics), and the firing cycle including atmosphere conditions within the kiln.

### **KEYWORDS**

Crystalline glazes, zinc silicate crystals, firing cycle, crystalline glaze formulae.

## **STATISTICAL EXPERIMENTAL DESIGN FOR REFRACTORY COATINGS**

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### **ABSTRACT**

The application of paint to a substrate, processing of some food items, manufacture of many cosmetic products, and application of refractory coatings on metal casting moulds all depend on the development of suitable rheological characteristics, such as viscosity and thixotropy, in the product. In practice, the optimisation of composition, in terms of both rheological behaviour and final properties, often is found by trial-and-error which can be quite expensive and time consuming. A more efficient approach is to use a statistical model to evaluate the effects of composition on rheology and other properties. In this paper, the basic concepts of mixture design and analysis are applied to the formulation of a refractory coating, with illustration by a worked example. Experimental data of coating viscosity versus composition are fitted to the model to obtain a reliable method of predicting the optimal formulation of the coating.

### **KEYWORDS**

Experimental design, refractory coating, viscosity.

## **OPTIMISATION OF CERAMIC DENTAL BRIDGES**

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### **ABSTRACT**

An anterior dental bridge made of the new ceramic material In-Ceram is the focus of this study. The mechanical behaviour of a pre-existing model has been compared with an optimised profile obtained from a newly developed evolutionary algorithm known as Evolutionary Structural Optimisation (ESO). Such a comparison was made using Finite element analysis (FEA).

The results highlighted that the mechanical behaviour of the original bridge was mainly restricted by the properties of the porcelain veneer, i.e. there existed an ideal specific thickness that minimised the maximum tensile principal stress. It also suggested that the shape of the bridge, particularly in the notched regions affected the physical performance of the bridge.

The ESO method demonstrated its capability to produce an optimised bridge, resulting in a more uniform stress along the boundary whilst producing a design that very much imitates those produced by technicians today.

### **KEYWORDS**

Anterior dental bridge, pontic, In-Ceram, Evolutionary Structural Optimisation.

## **INVESTIGATION OF SUB-SURFACE DAMAGE DURING DRY WEAR OF ALUMINA USING FOCUSED ION-BEAM MILLING**

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### **ABSTRACT**

This paper investigates clearly observed changes in wear rate and mechanism of alumina by observing subsurface damage through the use of focused ion beam (FIB) milling. Initially wear rate experiments were undertaken. These were followed by extensive subsurface microscopic investigations.

Changes of wear rate at different contact pressures, measured by a pin-on-disc tribometer, were calculated from changing of wear scar area on the hemispherical pin tip. It was revealed that different wear mechanisms occurred as contact pressure decreased. Friction profiles from series of wear tests were also analysed. The coefficient of friction dramatically increased at high contact pressure and then it gradually decreased as contact pressure reduced.

By using a focused-ion-beam milling technique, cracking and surface layer formation were observed through the cross-section made by this device. This sample preparation technique combined with wear data and electron and ion imaging provided a much clearer understanding of the mechanical and tribological wear mechanisms that occurred under sliding contacts than has been previously shown.

A surface layer was observed to form. X-ray photoelectron spectroscopy (XPS) identified this as an oxide/hydroxide layer formed due to the moisture in the room. This process affects wear rates and its identification and features are presented.

### **KEYWORDS**

Wear, alumina, sub-surface damage, focused ion beam.

## **MECHANICAL AND WEAR CHARACTERISTICS OF ZIRCONIA-ALUMINA-SiC PLATELET COMPOSITES**

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### **ABSTRACT**

Both zirconia-based and alumina-based composites reinforced with SiC platelets were prepared by filter pressing and hot pressing. The SiC platelets in the zirconia-based composites resulted in a slight increase in hardness, toughness, and wear resistance but also decreased fracture strength. Furthermore, the zirconia-based composite with composition of Y-TZP + 15 vol. % Al<sub>2</sub>O<sub>3</sub> + 30 vol. % SiC exhibited high strength and high toughness (706 MPa and 10.4 Mpa.m<sup>0.5</sup>, respectively), whereas the alumina-based composite with composition of Al<sub>2</sub>O<sub>3</sub> + 15 vol. % Y-TZP + 30 vol. % SiC demonstrated outstanding hardness (18.11 GPa) and excellent wear resistance. Nevertheless, there was no single relationship between the wear resistance and the mechanical properties such as hardness, strength, and toughness.

### **KEYWORDS**

Zirconia, silicon carbide, platelets, alumina, wear.

## **ADVANCED CERAMICS VIA POWDER METALLURGY ROUTE: NOVEL SYNTHESIS OF 'HIGH PHASE-PURITY' Mg<sub>2</sub>SnO<sub>4</sub> FROM METALLIC PRECURSORS**

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### **ABSTRACT**

A novel yet simple technique of synthesizing oxide ceramics from metallic precursors has been described. Magnesium orthostannate, Mg<sub>2</sub>SnO<sub>4</sub>, a potential candidate for applications in high temperature-high frequency domain as a ceramic capacitor element, was synthesized from metallic tin and magnesium powders. An alloy of composition Mg<sub>2</sub>Sn was prepared by the conventional powder metallurgy route. This upon heating in air under carefully designed ordinary and mild experimental conditions, yielded single-phase inverse spinel type Mg<sub>2</sub>SnO<sub>4</sub>. The present method totally obviates the use of resilient oxides and of carbonate and nitrates precursors, which are invariably the source of environmental pollutants such as CO<sub>2</sub> and NO<sub>x</sub>. The difficulties normally encountered in ceramic syntheses from the significant difference in particle size of the starting powders are also eliminated. The technique offers an environmental-friendly viable solution to making dense ceramics provided a suitable metallic alloy precursor can be found in the relevant binary/ternary phase diagram.

### **KEYWORDS**

Metallic precursors, powder metallurgy, magnesium orthostannate, electroceramics.

## **FRACTURE TOUGHNESS IMPROVEMENT OF ALUMINA WITH ELONGATED GRAINS**

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### **ABSTRACT**

Mechanical properties and microstructure characteristics of hot-pressed and pressureless sintered Al<sub>2</sub>O<sub>3</sub> ceramics were investigated. The materials were produced using  $\alpha$ -alumina powder from calcined commercial aluminium hydroxide and seeded by wet-grinding abrasion  $\alpha$ -Al<sub>2</sub>O<sub>3</sub> milling medium. A microstructure of elongated  $\alpha$ -Al<sub>2</sub>O<sub>3</sub> grains was obtained by hot-pressing the alumina powder compacts. Elongated  $\alpha$ -Al<sub>2</sub>O<sub>3</sub> grain, however, could not be observed in the pressureless-sintered samples. In the pressureless sintered samples, only platelet grains and abnormal equiaxed grains were formed. It is thought that the elongated grains were developed from the fine  $\alpha$ -Al<sub>2</sub>O<sub>3</sub> abrasion seeds under suitable sintering conditions. Increased fracture toughness of 6 MPa·m<sup>1/2</sup> and flexural strength of 547 MPa were achieved for the samples with the elongated grain structure hot-pressed at 1600°C.

### **KEYWORDS**

$\alpha$ -Al<sub>2</sub>O<sub>3</sub> elongated grains, fracture toughness, alumina ceramics, aluminium hydroxide powder.

## **MICROSCOPIC FEATURES OF HYDROXYAPATITE COATINGS DEPOSITED BY A MODIFIED SOL-GEL TECHNIQUE**

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### **ABSTRACT**

The formation of hydroxyapatite (HAp) coatings deposited from a sol-gel precursor were studied using X-ray diffraction and scanning electron microscopy. HAp coatings were deposited on titanium substrates from precursor sols prepared from calcium nitrate, diammonium hydrogen phosphate and glycine. Precursor sols were dip-coated onto titanium substrates and pre-fired at 400°C for 30 minutes. Formation of HAp was identified using X-ray diffraction and Fourier Transform Infrared spectroscopy. The energy and weight changes of the coatings during heat-treatment were recorded by differential thermal analysis and thermogravimetric analysis. Microscopic features of the coatings were characterized using scanning electron microscope. This work illustrates the utilization of a novel sol-gel technique to deposit HAp coatings onto titanium substrates.

### **KEYWORDS**

Hydroxyapatite, sol-gel, dip-coating, microscopic features, sintering, grain growth, X-ray diffraction, infrared spectroscopy.

## **ENCAPSULATION OF BIOLOGICAL SPECIES IN SOL-GEL MATRICES**

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### **ABSTRACT**

Two examples are given of the gelation of silica sols containing biocatalysts, resulting in their encapsulation in porous matrices. Urease was encapsulated in gels made from a mixture of TMOS and alkyltrimethoxysilane. Enzyme activities, monitored by measuring the rate of production of ammoniacal nitrogen as urea was decomposed, ranged up to 60% of that of the unencapsulated species. Anaerobic sulphate-reducing bacteria were encapsulated in a gel produced from colloidal silica, thus avoiding contact with alcohol. The detection of H<sub>2</sub>S produced in the doped gel indicated that the bacteria were able to continue normal metabolic function within the gel matrix. A gel initially doped with  $\sim 5 \times 10^5$  cells cm<sup>-3</sup>, exhibited an optimum sulphate reduction rate of 11 ug h<sup>-1</sup> cm<sup>-3</sup>; this reduction rate was quickly re-established after storage of the gel for 14 weeks.

### **KEYWORDS**

Sol-gel, biocatalyst, immobilisation, encapsulation, urease, sulphate-reducing bacteria.

## **SYNTHESIS OF NANO-SIZE Ca- $\alpha$ SiAlON POWDERS BY CARBOTHERMAL REDUCTION-NITRIDATION**

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### **ABSTRACT**

Carbothermal reduction-nitridation (CRN) of SiO<sub>2</sub> is an attractive method for manufacturing Si<sub>3</sub>N<sub>4</sub> powders with controlled grain morphology. Moreover,  $\beta$ -sialon powders could also be synthesized from either pure powder mixtures or some inexpensive raw minerals by CRN. The resultant powders have shown some advantages, especially in manufacturing sialon products at low cost. However, there have been only a few works on preparing  $\alpha$ -sialon powders. In this work, Ca- $\alpha$  sialon powder was synthesized by CRN of a SiO<sub>2</sub>-Al<sub>2</sub>O<sub>3</sub> and CaCO<sub>3</sub> powder mixture. An unusual morphology of hollow balls of 200 to 500nm with many nano size  $\alpha$ -sialon particles of 10 to 30nm was identified from the resultant Ca- $\alpha$  sialon powders. This has never been previously reported for sialon ceramics. It was consequently confirmed that the morphologies of the products were clearly related to the intermediate products appearing during CRN reaction.

### **KEYWORDS**

Ca- $\alpha$  sialon, synthesis, Carbothermal Reduction-Nitridation (CRN), nano-size powder, morphology, hollow ball.

## **SYNTHESIS OF FINE ZIRCONIUM NITRIDE POWDERS BY FLOATING-TYPE REDUCTION-NITRIDATION OF ZIRCONIA POWDER**

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### **ABSTRACT**

Floating-type reduction-nitridation of spherical zirconium oxide (ZrO<sub>2</sub>) powder, which had about 50nm size, was continuously carried out at 1250 to 1550°C in N<sub>2</sub>-NH<sub>3</sub>-C<sub>6</sub>H<sub>6</sub> gas, and ultra-fine zirconium nitride (ZrN) powders having 50nm size were obtained above 1350°C. The residence time of ZrO<sub>2</sub> particles at reduction-nitriding temperature range was estimated to be a few seconds. These ZrN powders had high electrical conductivity and good sinterability. It was found that the formation mechanism of ZrN consisted of several elementary reaction process; deposition of carbon film at ZrO<sub>2</sub> particle, reduction-nitridation of the particle by the carbon film and NH<sub>3</sub>. From the above formation conditions and the properties of resultant ZrN powder, the synthesis method designed in this work is considered to be advantageous compared to conventional methods.

### **KEYWORDS**

Zirconium nitride, ZrO<sub>2</sub>, NH<sub>3</sub>, C<sub>6</sub>H<sub>6</sub>, ZrO, Lattice parameter, floating-type reduction-nitridation, fine powder.

## **MULLITE FROM SILLIMANITE: INFLUENCE OF DIFFERENT ADDITIVES**

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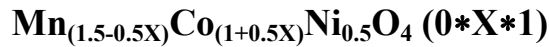
### **ABSTRACT**

In the present work the influence of different additives on the properties of the mullite material obtained from thermal reaction of sillimanite was studied. The original sillimanite mineral contains iron oxides and mica as main impurities. The powders obtained from this material were treated to eliminate the impurities, then mixed with alumina or silicon carbide and finally uniaxially pressed. Samples without additives were also prepared in order to compare their properties with those of the others ones. All the samples were heat treated in the range of 1200°C-1700°C, and then characterised by the traditional methods. The microstructure of the mullite phase obtained in the samples with Al<sub>2</sub>O<sub>3</sub> addition was different from that observed in the samples with SiC. In both cases the additives improved the final properties.

### **KEYWORDS**

Mullite, sillimanite, alumina, silicon carbide, aluminosilicate.

## **PREPARATION AND ELECTRICAL PROPERTIES OF SINTERED BODIES WITH MONOPHASE SPINEL-TYPE OXIDES**



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### **ABSTRACT**

Monophase cubic spinel-type oxides of  $\text{Mn}_{(1.5-0.5X)}\text{Co}_{(1+0.5X)}\text{Ni}_{0.5}\text{O}_4$  were prepared by oxidizing specimens sintered at 1400°C in Ar. The oxidation was conducted at 800°C where spinel oxides are stable. The electrical conductivity ( $\sigma$ ) of the sintered bodies was confirmed to increase exponentially with increasing temperature.  $\sigma$  decreased with increasing X in  $\text{Mn}_{(1.5-0.5X)}\text{Co}_{(1+0.5X)}\text{Ni}_{0.5}\text{O}_4$ . In all ranges of X, Seebeck coefficients (Qs) increased with decreasing X. In the region of  $0 \leq X \leq 0.44$ , Qs were positive, indicating that the carrier of the oxides is holes. In the region of  $0.47 \leq X \leq 1$ , Qs were negative, indicating that the carrier of the oxides is electrons. It seemed likely that the composition dependence of the electrical properties was based on the existence ratio of  $\text{Mn}^{3+}$  to  $\text{Mn}^{4+}$  in octahedral sites of spinel structure. The electrical conduction of the specimens was considered to be controlled by small polaron hopping.

### **KEYWORDS**

Mn-Co-Ni oxide, cubic spinel, monophase, electrical conductivity, Seebeck coefficient, cation distribution, Thermistor, oxidation.

## **THE DEVELOPMENT OF ZIRCONIA MEMBRANE OXYGEN SEPARATION TECHNOLOGY**

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### **ABSTRACT**

The oxygen separation technology based on ceramic membranes constructed from stabilised zirconia is currently under development for applications ranging from oxygen generation or air enrichment for medical use to control of oxygen concentration or oxygen removal from gas streams and enclosures for semiconductor, food packaging and process control instrumentation industries. The technology is based on a rugged tubular design with extensive thermal cycling capability. Several single and three tube devices have been operated for periods up to 5000h. An eight tube module, as a building block for larger scale oxygen production or removal devices, has been constructed and is being evaluated. In this paper, the construction of the device, oxygen generating capacity, life time tests and performance of the ceramic membrane device under development at CSIRO will be discussed.

### **KEYWORDS**

Oxygen separation technology, zirconia membranes, oxygen-ion conductivity, gas purification, oxygen generation, oxygen pump.

## **GELCASTING OF SiC/Si FOR PREPARATION OF SILICON NITRIDE BONDED SILICON CARBIDE**

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### **ABSTRACT**

In the present paper, gelcasting of aqueous slurry with coarse silicon carbide(1mm) and fine silicon particles was investigated to fabricate silicon nitride bonded silicon carbide materials. Through the examination of influence of different polyelectrolytes on the Zeta potential and viscosity of silicon and silicon carbide suspensions, a stable SiC/Si suspension with 60 vol% solid loading could be prepared by using polyelectrolyte of D3005 and sodium alginate. Gelation of this suspension can complete in 10-30 min at 60-80°C after cast into mold. After demolded, the wet green body can be dried directly in furnace and the green strength will develop during drying. Complex shape parts with near net size were prepared by the process. Effects of the debinding process on nitridation and density of silicon nitride bonded silicon carbide were also examined.

### **KEYWORDS**

Gelcasting, silicon carbide, silicon, silicon nitride bonded silicon carbide(SNBSC).

## **POLING OF PIEZOELECTRIC CERAMICS**

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### **ABSTRACT**

The effectiveness of poling of piezoelectric ceramics primarily depends on the field and the temperature-time profile used. These parameters may need to be adjusted for production runs of parts with different shapes and different profiles. One poling technique involves heating the parts to above the Curie point temperature and poling at a field less than the coercive field. This technique may be useful for large and thick parts. This paper compares the piezoelectric and dielectric properties of TLZ-5 ceramic made by Thomson Marconi Sonar when poled using various temperature and voltage profiles and shows some of the consequent difficulties with the very high temperature poling technique. In addition, it is shown that different poling programs can be required for modifications to the basic TLZ-5 composition with different Ti/Zr ratios.

### **KEYWORDS**

Poling, lead zirconate titanate, Curie point, piezoelectric properties.

**A PERSONAL VIEW:  
APPLICABILITY OF SOLID OXIDE FUEL CELL SYSTEMS  
AND THE LONG TERM IMPACT ON CERAMICS R&D**

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**ABSTRACT**

A historic overview is given which shows the development path leading to the present set of combustion based generators, which are being applied in optimised energy structures. The demand for energy services changes with time. New future infrastructure requirements will be for additional relatively small-scale, decentralised power and heat generators. Reasons are discussed. SOFC-based systems have the potential to provide these energy services better than conventional combustion based generators. This is discussed on the basis of different SOFC system concepts. Recent field-tests look very promising, indicating that SOFC technology approaches implementation. Finally, the impact of different applications on ceramics R&D is discussed.

**KEYWORDS**

Power generation, history, CHP, energy market, fuel cells, solid oxide fuel cells, ceramics, materials research.