

**A88-49492 Thermal expansion of ceramics of the type  $ZrO_2$ - $In_2O_3$  (Termicheskoe rasshirenie keramiki sistemy  $ZrO_2$ - $In_2O_3$ ).** A. A. AKOPIAN, B. M. BARYKIN, and G. P. CHERNYSHOV, *Teplofizika Vysokikh Temperatur* (ISSN 0040-3644), Vol. 26, May-June 1988, pp. 504-508. 6 Refs.

Experimental results are presented on thermal expansion of zirconium-indium oxide ceramics of general composition  $(x)ZrO_2/(100-x)In_2O_3$ , with  $x$  between the values of 50 to 90, which were prepared as described by Akopian et al. (1987). Experiments were conducted in a high-temperature high-vacuum dilatometric facility, in the temperature range of 300-1600 K, using a noncontact measurement method. It was found that a complete stabilization of zirconia, with formation of cubic solid solution, was accomplished at 20 mol pct  $In_2O_3$  (i.e., when the value of  $x$  was 80). It was also found that the dominant effect in the thermal expansion of the  $ZrO_2$ - $In_2O_3$  ceramics is rendered by a continuous solid solution of zirconium-oxide rather than by the indium oxide phase, which might be present, depending on its content, in the form of inclusions or as a second continuous phase.

**A89-13236 Effect of doping and radiation treatment on the physical properties of transparent PLZT ferroelectric ceramics (Lead Lanthanum Zirconium Titanate) (Vliianie legirovaniia i radiatsionnoi obrabotki na fizicheskie svoystva prozrachnoi segnetokeramiki TsTSL).** G. ZH. GRINVALDS, V. I. DIMZA, S. S. DINDUN, A. E. KAPENIEKS, A. N. RUBULIS et al., *Avtometriia* (ISSN 0320-7102), July-Aug. 1988, pp. 50-58. 25 Refs.

Specimens of a transparent lead lanthanum zirconium titanate (PLZT) ferroelectric ceramic were doped by transition metal (Mn, Fe, and Co) and lanthanoid (Eu) ions in concentrations up to 1 at. pct and irradiated by electrons and gamma rays. It is found that doping and irradiation produce changes in the structural, optical, and dielectric characteristics of the material which vary with the nature of the dopant and the type of ionizing radiation. The results are interpreted in terms of various ion implantation and vacancy redistribution mechanisms.

**A89-21669 High-temperature superconductivity in multiphase ceramic specimens of the Bi-Ca-Sr-Cu-O system (Vysokotemperaturnaia sverkhprovodimost' v mnogofaznykh keramicheskikh obraztsakh sistemy Bi-Ca-Sr-Cu-O).** A. G. MERZHANOV, S. V. LYSIKOV, M. D. NERSESIAN, I. P. BOROVINSKAIA, I. G. MOROZOV et al., *Pis'ma v Zhurnal Tekhnicheskoi Fiziki* (ISSN 0320-0116), Vol. 14, Oct. 12, 1988, pp. 1770-1772.

The superconducting transition in multiphase Bi-Ca-Sr-Cu-O specimens was investigated on the basis of dc (10 mA) resistance measurements. Also investigated was the temperature dependence of the susceptibility, measured on the basis of the change in the  $Q$  of a coil with the specimen at a frequency of 30 MHz. It is concluded that most of the tested specimens possessed superconductivity at a transition temperature above the liquid-nitrogen boiling point.

**A88-29854 Observation of possible localization effects in metal oxides by the electron tunneling method (Nabludenie vozmozhnykh effektov lokalizatsii v metallooksidakh metodom elektronnoho tunnelirovaniia).** A. I. KHACHATUROV, M. A. BELOGOLOVSKII, V. M. SVISTUNOV, and V. I. TARENKOV, *Fizika Nizkikh Temperatur* (ISSN 0132-6414), Vol. 14, Jan. 1988, pp. 101-103. 7 Refs.

A giant zero-bias anomaly is identified in the differential conductivity of tunnel junctions based on lanthanum and yttrium ceramics that do not exhibit superconducting properties. The anomaly is attributed to disordering effects responsible for the transition of metal oxides to the normal state. The disordering itself is attributed to the formation of oxygen vacancies during the fabrication of ceramic materials. The presence of the corresponding random potential leads to carrier localization and, consequently, to the Anderson transition to the insulator state.

**A89-23680 Thermal shock resistance of a silicon-nitride ceramic (Soprotivlenie nitridkremnievoi keramiki termoudaru).** K. A. KAZAKI-AVICHUS, D. B. NARBUTENE, E. N. CHASOVSKOI, A. F. BATURA, and V. G. VEREVKA, *Problemy Prochnosti* (ISSN 0556-171X), Nov. 1988, pp. 57-60. 7 Refs.

Results of an experimental study of the thermal softening of a reaction-bonded silicon nitride ceramic are reported. It is found that when specimens of the silicon nitride ceramic heated to 400-480 C are submerged into water their strength decreases by a factor of 6-7. The first cracks in the specimens may occur within 0.1 s from the moment they are submerged. No softening is observed in specimens heated to lower temperatures.

**A89-18373 SAW screening effect in a layered structure consisting of a ZnO piezoelectric film on silicon (Effekt ekranirovaniia poverkhnostnoi akusticheskoi volny v sloistoi strukture p'ezoelektricheskoi plenki ZnO na kremnii).** I. V. BEL'SKII and V. A. OSIPENKO, *Radiotekhnika i Elektronika* (ISSN 0033-8494), Vol. 33, Oct. 1988, pp. 2197-2200.

Results are reported on the influence of the screening of the SAW electric component in silicon on the electromechanical coupling coefficient (EMCC) of a ZnO/Si structure. Experimental results are presented on the dependence of the EMCC on the ratio of film thickness to SAW length. The design of a SAW filter using the results presented is discussed.

**A89-10793 Investigation of high-temperature superconductivity in Ti-Ba-Ca-Cu-O ceramic (Issledovanie vysokotemperaturnoi sverkhprovodimosti Ti-Ba-Ca-Cu-O-keramik e).** B. B. BOIKO, A. I. AKIMOV, V. I. GATAL'SKAIA, S. E. DEM'IANOV, A. L. KARPEI et al., *Pis'ma v Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki* (ISSN 0370-274X), Vol. 48, July 25, 1988, pp. 103-105. 6 Refs.

Stable and reproducible results on the high-temperature superconducting ceramic  $Tl(1.4)BaCaCu(1.5)O(y)$  synthesized under various conditions were obtained. The highest transition temperature obtained in this system was 125.3 K. It is concluded that the one-step fabrication technique provides for significantly higher values of transition temperature than the twostep technique.

**A88-49480 Structure of an AlN-SiC ceramic (Struktura keramiki sistemy AlN-SiC).** V. A. MEL'NIKOVA, V. K. KAZAKOV, and A. N. PILIANKEVICH, *Poroshkovaia Metallurgiiia* (ISSN 0032-4795), June 1988, pp. 100-105. 8 Refs.

The structure and mechanical properties of a hot-pressed composite ceramic based on AlN and SiC are investigated experimentally, with the mass content of the two components varying from 10 to 90 percent. It is found that many of the strength characteristics of the ceramic are higher than those of the individual components. The effect of hardening in the system AlN-SiC is explained by the formation of a disperse structure, alternation of phases of varying microplasticity, and substructural characteristics of the ceramic.

**A88-36074 Anomalies of the electrical resistance of a Y-Ba-Cu-O ceramic (Anomalii elektrosoprotivleniia keramiki sistemy Y-Ba-Cu-O).** B. B. BOIKO, A. I. AKIMOV, V. I. GATAL'SKAIA, S. E. DEM'IANOV, L. A. KUROCHKIN et al., *Fizika Metallov i Metallovedenie* (ISSN 0015-3230), Vol. 65, Feb. 1988, pp. 402-404. 9 Refs.

Ceramic specimens of the system Y-Ba-Cu-O have been synthesized which, in addition to the typical superconducting transitions at 90-100 K, exhibit an anomalous behavior at higher temperatures. The anomalies of the temperature dependence of the electrical resistance of  $Y_1Ba_2Cu_3O$  (gamma) ceramic specimens observed at about 200 K need to be further investigated to identify the phases involved. The temperature dependences of the electrical resistance of the ceramic are shown graphically.

## Japanese Aerospace Literature This month: *Ceramics*

**A90-35942 High density silicon carbide-carbon ceramics.** K. KIJIMA, T. UETSUKI, and K. TANAKA, *Proceedings of the 1st MRS International Meeting on Advanced Materials*, Tokyo, Japan, May 31-June 3, 1988, Vol. 5 (A90-35926 15-27). Pittsburgh, PA, Materials Research Society, 1989, pp. 101-106. 9 Refs.

Consideration is given to the plasma sintering conditions needed to make highly densified silicon carbide containing a great deal of free carbon. It is expected that high density SiC-C ceramics should have high performance properties such as low friction and low electrical resistance. An experiment to produce high density SiC-C ceramic is reported. The plasma sintering apparatus and plasma sintering process used in the experiment are described. The characteristics of the plasma sintered SiC and commercially available SiC heater are compared, showing that the increase in carbon produces an increased Vicker hardness and fracture toughness values.

**A90-35933 Cyclic fatigue behavior of ceramics under rotary bending.** H. N. KO, *Proceedings of the 1st MRS International Meeting on Advanced Materials*, Tokyo, Japan, May 31-June 3, 1988, Vol. 5 (A90-35926 15-27). Pittsburgh, PA, Materials Research Society, 1989, pp. 43-48. 20 Refs.

Results are presented from rotary bending tests on sintered  $Al_2O_3$  and  $Si_3N_4$  at room temperature. Results from a rotary bending fatigue machine are compared with the static bending strengths obtained from a nonrotating fatigue machine. The fracture surfaces after the tests, the fatigue limit, the character of rotary bending strength, and the fracture features of fatigue are examined. It is found that the life of each material increases as the stress amplitude decreases. Also, the fracture surfaces of  $Si_3N_4$  after fatigue and static tests are shown to have mirrors, while those of  $Al_2O_3$  have no mirrors.

**A90-35969 Static and cyclic fatigue in ceramics.** TAKASHI KAWAKUBO *Proceedings of the MRS 1st International Meeting on Advanced Materials*, Tokyo, Japan, May 31–June 3, 1988, Vol. 5 (A90-35926 15-27). Pittsburgh, PA, Materials Research Society, 1989, pp. 525-530.

The static and cyclic fatigue behavior of different ceramics was investigated in room temperature air. Flexural specimens with an indentation induced flaw at the center were tested under a static or cyclic load applied by four-point bending. All ceramics were shown to be susceptible to fatigue failure. By comparing the static and cyclic fatigue life, a large fatigue acceleration by cyclic loading was demonstrated in silicon nitride, alumina II, TZP, and zirconia-alumina. These cyclic loading effects on the fatigue were discussed under several hypotheses. It is suggested that the acceleration is related to the nonlinear microfractures in the process zone, such as crack branching, deflection and multiple cracking of intergranular cracking in elongated columnar polycrystals for silicon nitride, and a stress induced transformation in the process zone for zirconia.

**A90-35961 Strength degradation of ceramics by contact stress damage.** H. MAKINO, N. KAMIYA, S. WADA, and O. KAMIGAITO, *Proceedings of the 1st MRS International Meeting on Advanced Materials*, Tokyo, Japan, May 31–June 3, 1988, Vol. 5 (A90-35926 15-27). Pittsburgh, PA, Materials Research Society, 1989, pp. 373-378. 5 Refs.

Contact damage induced in ceramics such as Si<sub>3</sub>N<sub>4</sub>, SiC, and TZP by blunt indenters and the effects of such damage on the strength are studied. The strength degradation of Si<sub>3</sub>N<sub>4</sub> is due to structural damage in the plastic deformation zone. Many intergranular and intragranular cracks as well as dislocations are seen in the damaged region. The residual stress formed around the impression causes the strength degradation in TZP. The damage structures observed in Si<sub>3</sub>N<sub>4</sub> are not formed in TZP at experimental loads. Hertzian cracking is the cause of strength degradation in SiC.

**A90-35960 Load dependent hardness and time dependent strength of ceramics.** TATSUYA YAMADA, HIDEO AWAJI, and JUN-ICHI KON, *Proceedings of the 1st MRS International Meeting on Advanced Materials*, Tokyo, Japan, May 31–June 3, 1988, Vol. 5 (A90-35926 15-27). Pittsburgh, PA, Materials Research Society, 1989, pp. 355-360.

The load dependence of the Vickers hardness and the time dependence of the flexural strength were studied in alumina and silicon nitride, and the results are reported. The load dependence of the hardness was apparent at indentation loads lower than 9.8 N, but the dependence decreased at loads greater than 9.8 N, when cracks were created around the indentation. The stress rate dependence of the flexural strength was apparent for alumina, but less for silicon nitride.

**A90-35959 Evaluation of dynamic fracture toughness in ceramics.** T. KISHI, K. SUZUKI, and B. N. KIM, *Proceedings of the 1st MRS International Meeting on Advanced Materials*, Tokyo, Japan, May 31–June 3, 1988, Vol. 5 (A90-35926 15-27). Pittsburgh, PA, Materials Research Society, 1989, pp. 349-354. 8 Refs.

The dynamic fracture toughness of ceramics was evaluated using the strain gage method at room temperature over the loading rate range up to 10 to the 6th MPa sq rt m/s. The method was verified using the two-dimensional dynamic finite element method. The fracture toughness of alumina and tetragonal zirconia polycrystal (TZP) increased with loading rate, while that of sialon and SiC remained almost constant. For TZP, the effect of the amount of both slow crack growth and transformation to monoclinic phase on toughness is discussed.

**A90-35958 Fracture toughness of engineering ceramics measured by indentation fracture method at elevated temperatures.** SHUJI SAKAGUCHI, NORIMITSU MURAYAMA, and FUMIHIRO WAKAI, *Proceedings of the 1st MRS International Meeting on Advanced Materials*, Tokyo, Japan, May 31–June 3, 1988, Vol. 5 (A90-35926 15-27). Pittsburgh, PA, Materials Research Society, 1989, pp. 337-342. 9 Refs.

Fracture toughness measurements were carried out on engineering ceramics using the indentation fracture method at temperatures up to 1200 C. A general equation for the method is proposed:  $K(IC) = a \times (E/H) \exp t \times (P/c \exp 3/2)$ . For silicon nitride and silicon carbide, the constant  $a$  is determined to be 0.0074 and the exponent  $t$  is determined to be 0.8. The difference between the fracture toughnesses obtained by the indentation fracture method and by the chevron notched beam method is about 10 percent. In applying the new equation to tetragonal zirconia polycrystals, the fracture toughnesses obtained from the two methods differ due to a palmqvist crack forming at low temperatures instead of a median crack.

**A89-51580 Fracture strength properties and unified estimation method for structural ceramics.** HAGATOSHI OKABE, HIDEYUKI HIRATA, MASAMITSU MURAMATSU, and SEIICHI HAMADA, *Japan Society of Materials Science Journal* (ISSN 0514-5163), Vol. 38, July 1989, pp. 783-788. 12 Refs.

An analysis method for estimating the intrinsic strength of a structural ceramic using tensile, bending, creep, and fatigue data is proposed. A strength equation in which the strength data is examined in terms of Weibull statistics is derived. The relations between the strength decrement index, the inverse of the crack growth rate index, the strength normalized for cumulative effective hold time, and the effective volume are studied. The proposed estimating method is applicable to creating reliability designs or for quality control of ceramic components.

**A90-35500 Foreign object damage resistance of structural ceramics.** M. MASUDA, H. TSURUTA, T. SOMA, and M. MATSUI, *Ceramic materials and components for engines; Proceedings of the Third International Symposium*, Las Vegas, NV, Nov. 27-30, 1988 (A90-35451 15-27). Westerville, OH, American Ceramic Society, Inc., 1989, pp. 1031-1038. 6 Refs.

The equipment for the impact damage testing was successfully developed by using gun accelerators. The chipping fracture mode was investigated by using several kinds of Si<sub>3</sub>N<sub>4</sub>, SiC, Al<sub>2</sub>O<sub>3</sub> and TZP. The critical velocity (which is the threshold impact velocity for fracture) was determined. The critical velocity of the chipping fracture mode was dependent on the K(IC) and the strength of the target material. Chipping fracture mode also depends on the hardness and the shape of the projectile. SiC shows small resistance against foreign object damage (FOD). The relationship between the FOD resistance and the mechanical properties of the ceramics and the mechanism of impact damage are discussed.

**A90-35492 Strengthening of oxide ceramics by SiC and Si<sub>3</sub>N<sub>4</sub> dispersions.** K. NIIHARA and A. NAKAHARA, *Ceramic materials and components for engines; Proceedings of the Third International Symposium*, Las Vegas, NV, Nov. 27-30, 1988 (A90-35451 15-27). Westerville, OH, American Ceramic Society, Inc., 1989, pp. 919-926. 19 Refs.

The Al<sub>2</sub>O<sub>3</sub>SiC, Al<sub>2</sub>O<sub>3</sub>Si<sub>3</sub>N<sub>4</sub> and MgO-SiC composites series have been investigated to improve mechanical and thermomechanical properties of Al<sub>2</sub>O<sub>3</sub> and MgO ceramics. These composites were prepared by hot-pressing mixtures of fine powders at 1500 to 1900 C with 28 MPa applied pressure. The striking finding in these composites is that the fracture strength of Al<sub>2</sub>O<sub>3</sub> and MgO ceramics was increased approximately 1.5 to 3 times by incorporating very fine SiC and Si<sub>3</sub>N<sub>4</sub> particles, and this strength improvement was also observed even in the temperature range from 1200 to 1400 C.

**A90-35486 Strength degradation of silicon nitride based ceramics by hot corrosion in alkali sulfate and carbonate melts.** M. SHIMADA, T. SATO, Y. KOIKE, and T. ENDO, *Ceramic materials and components for engines; Proceedings of the Third International Symposium*, Las Vegas, NV, Nov. 27-30, 1988 (A90-35451 15-27). Westerville, OH, American Ceramic Society, Inc., 1989, pp. 831-840. 11 Refs.

The effect of additives on the corrosion rate and strength degradation of Si<sub>3</sub>N<sub>4</sub>-based ceramics in K<sub>2</sub>SO<sub>4</sub> and K<sub>2</sub>CO<sub>3</sub> melts was experimentally studied, along with the time to rupture for the corroded Si<sub>3</sub>N<sub>4</sub> ceramics. It was found that the surface chemical reaction-controlled shrinking core model can be applied to describe the relationship between the degree of the corrosion and the reaction time for the corrosion of Si<sub>3</sub>N<sub>4</sub>-based ceramics in K<sub>2</sub>SO<sub>4</sub> and K<sub>2</sub>CO<sub>3</sub> melts. The corrosion rate in K<sub>2</sub>CO<sub>3</sub> melts decreased with increasing content of aluminum and yttrium ions in the specimen. Corrosion resulted in roughness of specimen surfaces and degraded fracture strengths to 2/3-2/5 of their original values up to 2 percent of weight loss. Fracture strength was almost constant up to 30 percent of weight loss.

**A90-33988 Corrosion and degradation in strength of silicon nitride based ceramics by alkali sulfate and carbonate melts.** M. SHIMADA, T. SATO, Y. KOIKE, and T. ENDO, *Proceedings of the 1st MRS International Meeting on Advanced Materials*, Tokyo, Japan, June 2, 3, 1988, Vol. 4 (A90-33959 14-23). Pittsburgh, PA, Materials Research Society, 1989, pp. 319-324. 10 Refs.

An investigation of the effect of additives on the corrosion rate and strength degradation in Si<sub>3</sub>N<sub>4</sub> based ceramics is presented. Hot isostatically pressed Si<sub>3</sub>N<sub>4</sub> without additives, hot pressed Si<sub>3</sub>N<sub>4</sub>, and hot pressed sialons containing 0, 30, 60, and 100 percent of alpha phase were corroded by K<sub>2</sub>SO<sub>4</sub> and K<sub>2</sub>CO<sub>3</sub> melts at 1150-1300 C and 925-1150 C respectively, and it is demonstrated that apparent activation energies in both melts are 380-608 and 157-344 kJ/mol respectively. The corroded specimens show an extensive roughening of the surface with a considerable degradation of their fracture strength. The fracture strength degrades to 2/3-2/5 of the original values until it causes 2 percent of weight loss, and then is almost constant up to 30 percent of weight loss. It is shown that the resistance to corrosion in K<sub>2</sub>CO<sub>3</sub> melt decreases considerably with an increase of Al and Y ion content.

**A89-49672 Effect of grinding residual stress on bending strength of ceramics.** KENJI SUZUKI, KEISUKE TANAKA, HEIZABURO NAKAGAWA, and YUJI YAMAMOTO, *Japan Society of Materials Science Journal* (ISSN 0514-5163), Vol. 38, June 1989, pp. 582-588. 16 Refs.

The X-ray diffraction method was used to measure the residual stress on and beneath the surfaces of sintered alumina and silicon nitride ground with diamond wheels of number 200 and number 80 grains. The residual stress measured on the ground surface was the largest compression on the surface of silicon nitride ground with a number 80 diamond wheel. The depth of the compression zone from the surface was between 20 and 30 microns. The compressive residual stress due to grinding with a number 200 diamond wheel improved the bending strength of ceramics. On the other hand, grinding with a number 80 wheel often introduced flaws into ceramics, reducing the beneficial effect of the compressive residual stress. The effect of grinding residual stress on the relation between the bending strength and the defect size is discussed. A model is proposed for assessing the effects of the residual stress and the material defect on the ceramic bending strength.

**A90-33050 Development of plane bending fatigue testing machine for fine ceramics and experimental results on sintered silicon nitride.** TSUNESHICHI TANAKA, SHIGERU YAMAMOTO, NAGATOSHI OKABE, and HIDEAKI NAKAYAMA, *Japan Society of Materials Science Journal* (ISSN 0514-5163), Vol. 39, March 1990, pp. 318-324. 17 Refs.

This paper describes a new pneumatic resonance-type plane bending fatigue testing machine developed for systematic evaluations of the cyclic fatigue strength characteristics of fine ceramics. Using this machine, statistical fatigue tests were carried out on sintered silicon nitride thin plate specimens. Excellent performance of the testing machine was illustrated. The results indicate that the distribution of the fatigue lives obeys the three-parameter Weibull distribution function.

**A90-27676 Fracture strength data base and reliability-based design system for ceramics.** HIDEYUKI HIRATA, NAGATOSHI OKABE, and MASAMITSU MURAMATSU, *Japan Society of Materials Science Journal* (ISSN 0514-5163), Vol. 39, Jan. 1990, pp. 26-31. 11 Refs.

A data base system for fracture strength of ceramics was developed by compiling various fracture strength test data of ceramics together with data on their manufacturing process and the test environment. It is shown that the fracture strength values obtained by different tests for the same materials and test environments varied. For estimating the strength as a material constant independent of each testing method, this system performs a unified analysis for all the fracture strength test data retrieved. In addition, a reliability design system was developed for analyzing the strength reliability of the structural components of ceramics against the actual service loads. The system makes it possible to determine the allowable design stress by applying the normalized strength properties to the probabilistic analysis.

**A90-26115 Formation of the high-T<sub>c</sub> phase in rapidly quenched Bi-Pb-Sr-Ca-Cu-O ceramics.** TSUNEYUKI KANAI, TOMOICHI KAMO, and SHINPEI MATSUDA, *Japanese Journal of Applied Physics, Part 2* (ISSN 0021-4922), Vol. 28, Dec. 1989, pp. L2188-L2191. 9 Refs.

Amorphous ceramics with the composition of Bi<sub>2</sub>Pb (0.4) Sr<sub>2</sub>Ca<sub>2</sub>Cu<sub>3</sub>O (y) were prepared by rapid quenching. The change in crystalline structure during annealing and the effect of seeding with the high-T<sub>c</sub> phase were investigated. The volume fraction of the high-T<sub>c</sub> phase increases with annealing time; however, the low-T<sub>c</sub> phase reaches a maximum value of 38 percent for 1h annealing and decreases on prolonged annealing. The formation rate of the high-T<sub>c</sub> phase changes when the volume of the high-T<sub>c</sub> phase reaches about 30 percent. TEM observation shows that the high-T<sub>c</sub> phase is often located between the low-T<sub>c</sub> phase and the nonsuperconducting phase. The addition of the seed crystals with the high-T<sub>c</sub> phase is effective in forming the high-T<sub>c</sub> phase in shorter annealing times, but a smaller volume fraction of the high-T<sub>c</sub> phase was obtained after annealing for 50 h.

**A89-53400 Detection of hypervelocity impact of microprojectile by piezoelectric ceramics.** HIDEKI TAMURA, MOTOHIDE TOHYAMA, and AKIRA B. SAWAOKA, *Japanese Journal of Applied Physics, Part 2* (ISSN 0021-4922), Vol. 28, July 1989, pp. L1314L1317. 5 Refs.

The electric response of the piezoelectric ceramic plate, Pb(Zr<sub>0.52</sub>Ti<sub>0.48</sub>)O<sub>3</sub> (PZT 52/48), is used to detect the hypervelocity impact of a microprojectile. The projectiles are accelerated by a gas gun and a plasma accelerator. The output voltage signal of PZT 52/48 is evaluated with respect to the diameter and momentum of the projectile. A good linear relation is found in the momentum range up to 0.0001 kg x m/sec. The experiment confirms the suitability of PZT 52/48 plate as a material for the detection of the hypervelocity impact of a microprojectile up to 4.2 km/sec.

**A89-52258 Mullite ceramics prepared by spray-drying of solution.** ZENBE-E NAKAGAWA, YUTAKA OHYA, MINORI HASEGAWA, HIROSHI KAWABE, and KENYA HAMANO, *Research Laboratory of Engineering Materials Report* (ISSN 0385-3799), No. 14, 1989, pp. 39-47. 5 Refs.

The preparation of mullite ceramics by spray-drying (at 350 C and maximum pressure 300 mm Hg) from solutions of tetraoxysilane and either aluminum nitrate or aluminum sulfate is investigated experimentally. The materials produced are characterized by means of SEM, DTA, and TG, and the nitrate solution is found to produce mullite directly from the amorphous state at 980 C. Firing experiments performed on the nitrate-produced materials at 1760 C are also described. High postfiring densities with low glass-phase fractions are obtained by high-temperature calcination, crushing the calcined powder, and lowering the nitrate concentration in the original spray-drying solution.

**A89-41729 On the evaluation method of compressive strength for ceramics.** TSUNESHICHI TANAKA, SHIGERU YAMAMOTO, NAGATOSHI OKABE, HIDEAKI NAKAYAMA, and YUSUKE HUKUCHI, *Japan Society of Materials Science Journal* (ISSN 0514-5163), Vol. 38, April 1989, pp. 437-443. 6 Refs.

A method was developed for the precise determination of the compressive fracture strength of engineering ceramics using a simple loading device. The results obtained on two engineering ceramics, Si<sub>3</sub>N<sub>4</sub> and SiC, indicate that, when radial and tangential tensile stresses are generated in the end face layer of specimen, vertical cracking-type fracture occurs. When the above stress condition can be avoided, the specimens showed crushing type fracture following cleavage cracking of small flakes at the side face near the corner edge of specimen, where tensile radial stress of high intensity is generated.

**A89-51589 Comparison of mechanical and dielectric strength distributions for variously surface-finished titanium dioxide ceramics.** AKIRA KISHIMOTO, KUNIHITO KOUMOTO, and HIROAKI YANAGIDA, *American Ceramic Society Journal* (ISSN 0002-7820), Vol. 72, Aug. 1989, pp. 1373-1376. 12 Refs.

Mechanical and dielectric strength distributions were studied for variously surface-finished TiO<sub>2</sub> ceramics. Roughly finished specimens showed small Weibull modulus for both kinds of failures, and clear analogies between mechanical and dielectric strength distributions were found in both rough- and fine-surface specimens. The validity of the dielectric strength measuring method as an alternative method to evaluate the structural reliability of brittle ceramics is discussed.

**A89-51579 Bending strength analysis of ceramics based on the statistical theory of stress and fracture location.** YOSHIFUMI TANIGUCHI, JUNICHI KITAZUMI, and TOSHIRO YAMADA, *Japan Society of Materials Science Journal* (ISSN 0514-5163), Vol. 38, July 1989, pp. 777-782. 12 Refs.

Three-point bending data for Si<sub>3</sub>N<sub>4</sub> and PSZ rectangular bar specimens and ZrO<sub>2</sub> round specimens are analyzed. Multimodal Weibull distributions and two-parameter Weibull distributions representing the strength distributions of specimens are presented and studied. True stress distributions for the specimens are calculated in terms of the statistical theory of stress and fracture location. Comparison of the computed and experimental data reveal a good correlation between the distributions. Additional bending tests in which the specimen size and loading method vary are performed on the ZrO<sub>2</sub> specimen. It is observed that the Weibull moduli increase as the effective size decreases; the cause of this relationship is examined.

**A89-50776 The effects of water on friction and wear of ceramics.** SHINYA SASAKI, *Japan Society of Lubrication Engineers, Journal International Edition* (ISSN 0389-5483), No. 10, 1989, pp. 21-26. Translation. 11 Refs.

The effects of water on the friction and wear of ceramics, Al<sub>2</sub>O<sub>3</sub>, ZrO<sub>2</sub>(PSZ), SiC, Si<sub>3</sub>N<sub>4</sub>, were investigated at room temperature using two types of pin-on-disk machine, one of which was for the experiments in humidity-controlled air, and the other in water. From the experiments, the wear mechanisms were considered to be divided into two main classes, the fracture wear and the tribochemical wear. On the fracture wear, water has two antithetic effects: to reduce the wear and to increase the wear. Tribochemical wear was observed in Al<sub>2</sub>O<sub>3</sub>, SiC, and Si<sub>3</sub>N<sub>4</sub> in water. The friction coefficients in water decreased with the increase of sliding velocity. Especially in SiC and Si<sub>3</sub>N<sub>4</sub>, the friction coefficients became under 0.01. This phenomenon was considered to be caused by tribochemical reaction and hydrodynamic lubrication.

**A89-49676 Thermal shock fatigue of Al<sub>2</sub>O<sub>3</sub> ceramics.** ICHIRO MAEKAWA, HIROSHI SHIBATA, AKIRA KOBAYASHI, TSUTOMU WADA, *Japan Society of Materials Science Journal* (ISSN 0514-5163), Vol. 38, June 1989, pp. 658-662. 7 Refs.

The effects of a single thermal shock and its repetition on the initiation and growth of cracks were studied experimentally using notched Al<sub>2</sub>O<sub>3</sub> ceramic specimens. The boiling point of water, instead of water temperature, seems to be appropriate as the low-side temperature for determining the critical temperature difference for the initiation of a crack by a single thermal shock as well as for the increase of crack density under the repetition of thermal shocks with small temperature differences. For determining the increase in the number of surface cracks, including branched ones, the temperature of cooling water seems to be appropriate as the low-side temperature under repeated thermal shock conditions. The threshold temperature difference for increasing the crack density under repetitive thermal shocks agrees with the critical temperature difference for crack initiation by a single thermal shock.

**A89-38860 Thermal diffusivity of SiO<sub>2</sub> and Y<sub>2</sub>O<sub>3</sub> added AlN ceramics.** TAKESHI YAGI, KAZUO SHINOZAKI, NOBUYASU MIZUTANI, MASANORI KATO, and AKIHIKO TSUGE, *Journal of Materials Science* (ISSN 0022-2461), Vol. 24, April 1989, pp. 1332-1336. 13 Refs.

An evaluation is made of microstructure and physical property consequences obtainable through the addition of SiO<sub>2</sub> and Y<sub>2</sub>O<sub>3</sub> to AlN. The compositional changes effected are found to result in a decrease of 27R polytype in specimens sintered above 1600 C, in conjunction with an enhancement of thermal diffusivity. The modified AlN ceramics were found to be fully densifiable by liquid-phase sintering; the formation temperature of the liquid phase was more substantially lowered by the addition of both SiO<sub>2</sub> and Y<sub>2</sub>O<sub>3</sub> than by the addition of Y<sub>2</sub>O<sub>3</sub> only.

**A89-38021 Effect of crack size on the tensile strength of ceramics in a high-temperature corrosive environment.** YOSHIYUKI MUNAKATA and TETSUYA SENDA, *JSME International Journal, Series I* (ISSN 0914-8809), Vol. 32, April 1989, pp. 287-291.

Ceramics with considerable defects in corrosive ash were tested at temperatures of 650 C for PSZ and 900 C for SiC. Corrosive ash containing vanadium pentoxide and sodium sulphate was applied to an artificial flaw produced by a Vickers indentation on the specimen. The surface damage of PSZ in a high-temperature corrosive environment does not significantly influence the tensile strength. The corrosive ash on SiC ceramics with surface flaws contributes little to the strength as compared to that on PSZ ceramics.