

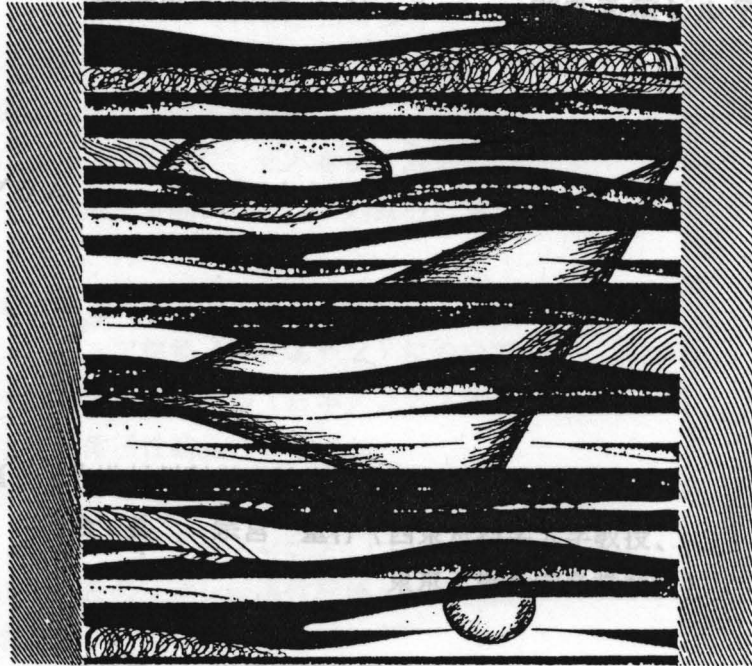
先進材料科学・技術研究会 (Advanced Materials Science and Engineering Society)

新素材研究委員会

テーマ ジルコニア セラミックス
(第11回ジルコニアセラミックス)

日時 1990年10月12日(金) 9:25 ~ 19:00

場所 講演要旨集 講堂 (TEL. 03-299-3831)



1990.10.12 東京新宿

株式会社ケイエスビー内(担当 藤、堀川)

TEL (044)819-2001 FAX (044)819-2009

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プログラム

- 9:25 開会
- 9:30 1 ジルコニアの相安定性(そのII) - 準安定正方晶ジルコニアの相安定性に及ぼす熱的・機械的および化学的応力蓄積
吉村昌弘(東北大学)
- 10:00 2 **先進材料科学・技術研究会**
新素材研究委員会(第11回ジルコニアセラミックス)
宮沢憲一、佐久間隆人(東京大学)
- 10:30 3 ジルコニアの高圧相転移
嵐 治夫(東北大学)
- 11:00 4 高圧X線回折法によるY-TZP焼結体の構造解析
テーマ 幸重 ジルコニアセラミックス
登 倉
- 12:30 5 Y-PSZにおける変位型変態の現象論的解析
日時 川元 達 1990年10月12日(金) 9:25 ~ 19:00
- 13:00 6 3000MPaの抗折強度を持つ $ZrO_2 - Al_2O_3$ 系セラミックスの特性評価
場所 方良一 理学電機(株)会議室 (TEL. 03-299-3831)
新宿区西新宿 7-15-3 三省堂新宿ビル7F
- 13:30 7 $ZrO_2 - Al_2O_3$ セラミックスの特性評価
福原幹夫(東芝タンガロイ)
- 14:00 8 Y-TZP焼結体の強度解析
野口謙一、大石 学、正木孝樹(東レ)
- 14:30 9 **プログラム 別紙のとおり**
イットリア添加正方晶ジルコニアの疲労に対するイットリア含量および粒径の影響
戸塚正博(九州工業大学)、窪田吉孝(東ソー)
- 15:00 10 導電性ジルコニア材料(NPZ-2)について
佐々木豊重、城山正治(日本タングステン)
- 15:30 11 TZP強化生体活性結晶ガラス
主 催 先進材料科学・技術研究会
会 長 宗宮 重行(西東京科学大学教授、
東京工業大学名誉教授)
中島紀
- 16:30 12 ジルコニア薄板のイオン伝導性評価
山名一男(石川県工業試験場)
- 17:00 13 大工試における材料の性能評価
事務局 川崎市高津区坂戸100-1 西304 〒213
株式会社ケイエスピー内(担当 縣、堀川)
TEL (044)819-2001 FAX (044)819-2009
- 17:30 14 部分安定化ジルコニアの焼結特性
早川暢博、川合 尊、山田達哉、高見昭雄(日本特殊陶業)
- 18:00 15 機械加工可能なバインダー・フリーのY-TZP粉末
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- 18:30 16 ジルコニアの疲労(仮題)
岩本信也(大阪大学)
- 19:00 閉会

プログラム

- 9:25 開会
- 9:30 1 ジルコニアの相安定性(そのⅡ) - 準安定正方晶ジルコニアの相安定性に及ぼす熱的・機械的および化学的応力蓄積
吉村昌弘(東京工業大学)
- 10:00 2 正方晶ジルコニアのドメイン構造(仮題)
宮沢憲一、佐久間健人(東京大学)
- 10:30 3 ジルコニアの高圧相転移
嵐 治夫(東北大学)
- 11:00 4 高圧X線回析法によるY-TZP焼結体の構造解析
北野幸重、正木孝樹(東レ)
- 昼 食 -
- 12:30 5 Y-PSZにおける変位型変態の現象論的解析
早川元造、岡 宗雄(鳥取大学)
- 13:00 6 3000MPaの抗折強度を持つ $ZrO_2 - Al_2O_3$ 系セラミックスの特性評価
四方良一、浦田佳孝(燻セメント)、塩野剛司、西川友三(精工製鋼)
- 13:30 7 $ZrO_2 - Al_2O_3 - TiC(SiC)$ 三元素複合セラミックスの諸特性
福原幹夫(東芝タンガロイ)
- 14:00 8 Y-TZP焼結体の強度解析
野口健一、大石 学、正木孝樹(東レ)
- 14:30 9 イットリア添加正方晶ジルコニアの疲労に対するイットリア含量および粒径の影響
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- 15:30 11 TZP強化生体活性結晶ガラス
中島紀一(新東工業)、春田敏弘(HOYA)
- コーヒーブレイク -
- 16:30 12 ジルコニア薄板のイオン伝導性評価と成形技術
山名一男(石川県工業試験場)
- 17:00 13 大工試における「燃料電池」研究-ジルコニア系材料の応用可能性
棚瀬繁雄、奥山博信、児玉皓雄(大阪工業技術試験所)
- 17:30 14 部分安定化ジルコニアの応用-広領域空燃比センサー
早川暢博、川合 尊、山田達哉、高見昭雄(日本特殊陶業)
- 18:00 15 機械加工可能なバインダー・フリーのY-TZP粉末
奥田吉弘、P.Stark(ICI Japan)
- 18:30 16 ジルコニアの接合(仮題)
岩本信也(大阪大学)
- 19:00 閉会

Phase Stability of Zirconia (Part II) - Thermal, Mechanical and Chemical Stress Accumulation Influencing Phase Stability of Metastable Tetragonal Zirconia -

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Abstract

In the Part I [1], I have introduced a concept of metastability by the kinetical stabilization in addition to the thermodynamic stabilization, which correlates with the equilibria and phase diagrams. In the t-m phase transformation, where both t and m phases are metastable, stress accumulation is required in the tetragonal grain(s) to overcome nucleation barrier as the activation energy from t to m.

The present study deals with the origin and mechanism of the stress accumulation in the metastable t grains. Even if the composition (stabilizer concentration) were homogeneous, every part of the grains is in different stress state, because it depends upon the location and thermal, mechanical and chemical histories which might cause different nanostructures [2]: defects, dislocations, anti-phase bounceries, twins, sub-grain boundaries, etc. A simple model based upon the assumption that every part of t-grains has a normal distribution of effective free energy including non-chemical energies such as local strain and surface energies could explain the t-m transformation behavior during mechanical grinding [3] for rapidly quenched $ZrO_2-RO_{1.5}$ solid solutions with different dopant concentrations.

This suggests that a certain part where the accumulated strain energies exceed a critical value can provide the nucleation site of the transformation, and that the nucleation occurs inhomogeneously in the domain of probably a few tens nanometer size. The transformation behavior, therefore, can be controlled by the accumulated strain energies caused by the interaction between thermal, mechanical and chemical nanostructure of grains.

[1] M. Yoshimura, Ceramic Bulletin, 67[12], 1950-55 (1988)
[2] T. Noma, M. Yoshimura, S. Sōmiya, M. Kato, M. Shibata-
Yanagisawa, and H. Seto, Advances in Ceramics, Vol. 24,
Science and Technology of Zirconia III, ed. S. Sōmiya, N.
Yamamoto and M. Yanagida, pp. 377-84, 1988
[3] M. Yashima, T. Noma, N. Ishizawa, and M. Yoshimura, J. Am.
Ceram. Soc. to be published

/1/ J. Faber, Jr. and M.H. Mueller : Physical Review b, 17(1978), 4884
/2/ T. Sakuma : Transactions of the Japan Institute of Metals, 29(1989), 275

Domain Structure of Tetragonal Zirconia

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In the tetragonal partially stabilized zirconia(t-PSZ) containing Y₂O₃, it has been reported that oxygen atoms are alternately shifted along c-axis from their fluorite sites/1/. On the other hand, forbidden diffractions with indexes of odd odd even, which are considered to be excited due to the above displacement, are observed by TEM. A domain structure characteristic to the t-phase can be seen in each variant with the forbidden diffractions. It has been reported that this domain structure appears with the diffusionless c-t phase transformation and that the domain boundary is considered to be the antiphase boundary which has a close relation with the displacement of oxygen atoms/2/. The purpose of this study is to make a further discussion on the relation between the domain structure and the displacement of oxygen atoms.

Various compositions of button-shaped Y-PSZs were melted in an arc furnace and cooled rapidly on a copper plate. Those specimens obtained were sliced by a diamond blade, lapped by the diamond powder and processed into a thin foil using a ion milling apparatus. TEM observation was carried out with 2000FX(JEOL) and 11800(Hitachi) at 200 kV. Diffraction patterns were calculated with the dynamical theory, considering the displacement of oxygen atoms, film thickness, excitation error, and orientation of beam incidence. The absorption of the electron beam was neglected in this calculation.

TEM observation showed that the domain boundaries have a structure of closed curve when they are observed in a thin area of specimen by using 112 forbidden diffraction. This result supports the idea that the domain boundary is an antiphase boundary which must be closed, if the oxygen atoms shift strictly parallel to only c-axis. It can be seen that the {112} planes are shifted each other to form a π-boundary if the domain boundary is an antiphase boundary in the arrangement of oxygen atoms. However, the contrast varied according to the domains. This means that the direction and magnitude of the displacement of oxygen atoms are not homogenous in the same variant. The observation of diffraction patterns showed that forbidden diffractions, for example 110, by the double reflection appear even if the incident electron beam was parallel to the zone axis, while the double diffractions were too weak to be detected in the calculated diffraction patterns, which is considered to be caused by the dynamic extinction effect. In the calculation, the double reflections appeared only if the incident beam was tilted slightly from the zone axis direction. This fact suggests that the direction of the displacement of oxygen atoms is not perfectly parallel to the c-axis.

Although the appearance of the odd odd even diffractions is characteristic to the t-PSZ, they were also observed around the composition of ZrO₂-8 mol% Y₂O₃ with very weak intensity. The dark-field observation showed that extremely fine particles existed scattering in the whole field. The fine particles are supposed to be nuclei of t-PSZ. Further discussions are expected on this point.

/1/ J.Faber, Jr. and M.H.Mueller : Physical Review b, 17(1978), 4884
/2/ T.Sakuma : Transactions of the Japan Institute of Metals, 29(1988),879

Photon Factory at the Synchrotron Radiation Facility
between the orthorhombic high pressure phase and the tetragonal high temperature phase.

Phase Transformations of ZrO_2 at High Pressures

Haruo ARASHI

Research Institute for Scientific Measurements,
Tohoku University

Recently, zirconia ceramics have been investigated with much emphasis on their toughness. The toughening mechanism of zirconia is explained by a transformation induced by a stress field. Thus the investigation of the phase transformation at high pressure in ZrO_2 , from a microscopic view point, is considered to be important. Raman scattering provides a useful means in investigating phase transformations because it reflects the dynamical properties associated with the change in crystal structure. Pressure dependence of Raman spectra in ZrO_2 was measured by using Diamond Anvil Cell (DAC). From the Raman spectroscopic measurements of ZrO_2 at room temperature and up to 60 GPa, three successive phase transformations were observed. Atmospheric monoclinic phase transformed to orthorhombic phase at 3.5 GPa. In this transformation ZrO_2 single crystal of monoclinic phase non-distractively changed to a single crystal of high pressure phase. From this experimental fact, we have successfully determined a crystal structure of orthorhombic high phase by in situ single crystal X-ray diffraction method using DAC. The space group of the orthorhombic high pressure phase is Pbcm. Pressure dependence of Raman spectra indicated that this orthorhombic phase made a phase change at about 12 GPa. The crystal structure of high pressure phase above 12 GPa is not determined. Recently, we have found the new high pressure phase above 35 GPa. This high pressure phase was quenchable to ambient conditions. From X-ray diffraction using crystal quenched from 60 GPa, it was found that the new high pressure phase belonged to tetragonal system and several candidative space groups which were consistent with the experimental results obtained from X-ray and Raman measurements were proposed. P-T phase diagram of ZrO_2 was determined by in situ X-ray diffraction performed using "MAX-80" cubic anvil system installed in the Photon Factory at the Synchrotron Radiation Facility of the National Laboratory for High Energy Physics (Tokuba). The phase boundary between the orthorhombic high pressure phase and the tetragonal high temperature phase.

Phenomenological Analysis of the Displacive Transformation in Y-PSZ

Structural Analysis of Y-TZP Sintered Bodies

M. Hayakawa and M. Oka

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Abstract

ABSTRACT

Crystallography of phase transformation was studied of the cubic to the tetragonal and the tetragonal to the monoclinic phase in arc-melted ZrO_2 -2-3mol% Y_2O_3 alloys.

The specimens exhibited a well defined herringbone structure. The tetragonal-to-monoclinic phase transformation on ground and polished surfaces of tetragonal zirconia polycrystals containing 2.5 mol% yttria was studied using an in situ X-ray diffraction technique. The amount of monoclinic phase caused by thermal-stress-induced transformation reached a maximum value at 250°C, and the thermally stressed specimens exhibited much greater (111) peak intensity than that of (111), as similarly observed in specimens associated with mechanical stresses.

All available crystallographic parameters, such as lattice parameters, lattice orientation relations, habit planes, possible lattice invariant shear systems, etc., were collected by using transmission electron microscopy and X-ray diffraction techniques. In the case of the tetragonal herringbone structure, since no cubic matrix was retained, effective cancellation of shear strain in a volume was adopted for the minimum strain energy condition. For a monoclinic plate, the usual plane invariant shear strain was assumed to be fulfilled, whereas for the monoclinic herringbone structure self-accommodation was assumed to be operative among the plate variants. Measured parameters were used to predict the resulting structures under the respective energy minimization conditions.

The results were found to be consistent with observation and thus all of these structures were concluded to be controlled by the strain energy minimization principle.

Characterization of ZrO₂-Al₂O₃ composites

Phenomenological Analysis of the Displacive Transformation in Y-PSZ

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Abstract

Crystallography of phase transformation was studied of the cubic to the tetragonal and the tetragonal to the monoclinic phase in arc-melted ZrO₂-2-3mol%Y₂O₃ alloys.

The specimens exhibited a well defined herringbone structure of the tetragonal phase in the as cooled state from the melt, whereas an aging of a specimen at 300 deg C caused initiation of thin plates of the monoclinic phase and subsequent growth of these into another type of herringbone structure. All of these structures were interpreted as they were essentially controlled by strain energy minimization principle, and thus motivated an application of the phenomenological theory of martensitic transformations.

All available crystallographic parameters, such as lattice parameters, lattice orientation relations, habit planes, possible lattice invariant shear systems, etc., were collected by using transmission electron microscopy and X-ray diffraction techniques. In the case of the tetragonal herringbone structure, since no cubic matrix was retained, effective cancellation of shear strain in a volume was adopted for the minimum strain energy condition. For a monoclinic plate, the usual plane invariant shear strain was assumed to be fulfilled, whereas for the monoclinic herringbone structure self-accommodation was assumed to be operative among the plate variants. Measured parameters were used to predict the resulting structures under the respective energy minimization conditions.

The results were found to be consistent with observation and thus all of these structures were concluded to be controlled by the strain energy minimization principle.

al feature. crystal form. residual stress effects and fracture toughness of the composites are discussed.

Properties of (Y)ZrO₂-Al₂O₃ and (Y)ZrO₂-Al₂O₃-(TiC or SiC)
Ternary Composite Ceramics

Characterization of ZrO₂ - Al₂O₃ composites

with the bending strength of 3000MPa

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** Kyoto Institute of Technology

The effect of Al₂O₃ and (TiC or SiC) additions on various properties of a (Y)TZP (yttria-stabilized tetragonal zirconia polycrystal)-Al₂O₃-(TiC or SiC) ternary composite ceramic stronger than SiC at high temperatures. Adding Al₂O₃ to (Y)TZP improved transverse rupture strength and hardness but decreased fracture toughness. Y₂O₃-stabilized tetragonal zirconia polycrystals (Y-TZP) have been studied because of high fracture strength and toughness. TiC therefore

Recently, we have developed ZrO₂ - Al₂O₃ composites which had average bending strength of 3000MPa at room temperature. Starting materials of the composites were ZrO₂ powder (3mol% Y₂O₃) with crystallite size of 20nm and Al₂O₃ powder with 0.54 μm. In the sintering process, ZrO₂ could be sintered easily, but Al₂O₃ could be sintered well. As the result, the composites with the microstructure in which a large Al₂O₃ grain existed in the matrix of ZrO₂ with small grains, was obtained. The mechanisms of the enhancement of fracture strength, microstructural feature, crystal form, residual stress effects and fracture toughness of the composites are discussed.

must have inhibited the $\beta \rightarrow \alpha$ ZrO₂ martensitic transformation. It was concluded that a continuous skeleton of TiC prevented grain-boundary sliding between ZrO₂ grains. For the (Y)TZP-Al₂O₃-TiC ternary composite material, we proposed a high-temperature crystallization process that could produce a large amount of TiC.

1. M Fukuhara, J Amer Ceram Soc, 72(2), 236-42 (1989).

Properties of (Y)ZrO₂-Al₂O₃ and (Y)ZrO₂-Al₂O₃-(TiC or SiC) Ternary Composite Ceramics ¹

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The effect of Al₂O₃ and (TiC or SiC) additions on various properties of a (Y)TZP (yttria-stabilized tetragonal zirconia polycrystal)-Al₂O₃-(TiC or SiC) ternary composite ceramic were investigated of developing a zirconia-based ceramic stronger than SiC at high temperatures. Adding Al₂O₃ to (Y)TZP improved transverse rupture strength and hardness but decreased fracture toughness. This binary composite ceramic revealed a rapid loss of strength with increasing temperature. Adding TiC to the binary ceramic suppressed the decrease in strength at temperatures above 1573 K. The residual tensile stress induced by the differential thermal expansion between ZrO₂ and TiC therefore must have inhibited the t → m ZrO₂ martensitic transformation. It was concluded that a continuous skeleton of TiC prevented grain-boundary sliding between ZrO₂ and Al₂O₃. In contrast, for the ternary material containing β-SiC in place of TiC, the strength decreased substantially with increasing temperature due to incomplete formation of the SiC skeleton.

For the (Y)TZP -Al₂O₃- TiC ternary composite material, we proposed a high-temperature strength mechanism that may be called a *tensile-stress-constrained martensitic transformation*.

Reference

1. M.Fukuhara, J.Amer.Ceram.Soc., **72**(2), 236-42(1989).

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EFFECT OF YTTRIA CONTENTS AND GRAIN SIZES ON FATIGUE BEHAVIOR
OF YTTRIA CONTAINING TETRAGONAL ZIRCONIA POLYCRYSTALS

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Strength Analysis of Y-TZP Sintered Bodies

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Fatigue behavior of 2, 3 and 4 mol% Y_2O_3 containing tetragonal zirconia polycrystals were studied by measuring their strength as a function of stressing rate (dynamic fatigue). At room temperature, relationships between stress and displacement showed the linear ones indicating elastic behavior for all specimens. At 250°C, their relationships showed elastic behavior at whole stressing rate for 3mol% Y_2O_3 -TZP (Z3Y) and 4mol% Y_2O_3 -TZP (Z4Y), and at stressing rate above 3.02 MPa/s (crosshead speed : 0.05 mm/min) for 2mol% Y_2O_3 -TZP (Z2Y). On the other hand, the stress-displacement relationship of Z2Y deviated from a linear relationship at the stressing rate of 1.02 MPa/s.

ABSTRACT

Tensile strength of Y_2O_3 -stabilized ZrO polycrystals (Y-TZP) was measured by a newly developed tensile testing method with a rectangular bar. The tensile strength of Y-TZP was lower than that of three-point bend strength, and the shape of the tensile strength distribution was quite different from that of three-point bend strength distribution.

It was quite difficult to predict the distribution curve of the tensile strength using the data of the three-point bend strength by one-modal Weibull distribution. The distribution of the tensile strength was analyzed by two-or-three-modal Weibull distribution coupled with an analysis of fracture origins.

The distribution curve of the three-point bend strength which was estimated by multimodal Weibull distribution agreed favorably with that of the measured three-point bend strength values.

A two-modal Weibull distribution function was formulated approximately from the distribution of the tensile and three-point bend strengths, and the estimated two-modal Weibull distribution function for the four-point bend strength agreed well with the measured four-point bend strength.

The fracture surface of TZP after dynamic fatigue test at room temperature showed a smooth region near the fracture origin followed by a rougher area being spread in a radial manner. The fatigue fracture surfaces were observed on the fracture surface of 2mol% Y_2O_3 -TZP and 3mol% Y_2O_3 -TZP with the grain size of about $1\mu m$ after dynamic fatigue test at 250°C, but was not observed for 4mol% Y_2O_3 -TZP with the grain size of $1\mu m$. The fatigue fracture surface of Z2Y was larger than that of Z3Y.

Failure times under constant stress were measured for Z2Y of grain size $0.5\mu m$, and Z3Y and Z4Y of $1\mu m$ (static fatigue) and were compared with those predicted from dynamic fatigue data. n values obtained from static fatigue technique were similar to those from dynamic fatigue technique for Z3Y and Z4Y. The failure times obtained by static fatigue technique were smaller than that predicted from dynamic fatigue data for Z2Y, larger for Z3Y and near to the predicted value for Z4Y.

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EFFECT OF YTTRIA CONTENTS AND GRAIN SIZES ON FATIGUE BEHAVIOR
OF YTTRIA CONTAINING TETRAGONAL ZIRCONIA POLYCRYSTALS

Masahiro ASHIZUKA

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Fatigue behavior of 2, 3 and 4 mol% Y_2O_3 containing tetragonal zirconia polycrystals were studied by measuring their strength as a function of stressing rate (dynamic fatigue). At room temperature, relationships between stress and displacement showed the linear ones indicating elastic behavior for all specimens. At 250°C, their relationships showed elastic behavior at whole stressing rate for 3mol% Y_2O_3 -TZP(Z3Y) and 4mol% Y_2O_3 -TZP(Z4Y), and at stressing rate above 3.02 MPa/s (crosshead speed : 0.05 mm/min) for 2mol% Y_2O_3 -TZP(Z2Y). On the other hand, the stress-displacement relationship of Z2Y deviated from a linear relationship at the stressing rate of 0.301 MPa/s (crosshead speed : 0.005 mm/min) at 250°C and showed inelastic behavior. Relationships between $\log \sigma_f$ and $\log \dot{\sigma}$ for Z2Y, Z3Y and Z4Y were linear over the whole range of stressing rate at room temperature. On the other hand, relationships between $\ln \sigma_f$ and $\ln \dot{\sigma}$ at 250°C increased with increasing stressing rate $\dot{\sigma}$ for low stressing rate, but showed a tendency to become a constant value over 30.2MPa/s for Z3Y with grain size of 1 μ m and 3.02MPa/s for Z4Y with grain size of 1 and 2 μ m. The crack growth parameter N from these slopes were obtained.

The crack growth parameters N at room temperature decreased with increasing Y_2O_3 contents but all the values became more than 32, and were not affected by the grain size. The N values of TZP containing 2, 3 and 4 mol% Y_2O_3 belonged to the grain size groups of 1 μ m at 250°C showed the constant value of average 9.2 indicating remarkable fatigue. While, in the case of the grain size group of 0.5 μ m at 250°C, the N value for 3mol % Y_2O_3 -TZP was about 50 indicating little fatigue, but, the N values for 2 and 4 mol% Y_2O_3 -TZP decreased until about 22 and 32, respectively.

The monoclinic zirconia contents in the fracture surface after dynamic fatigue test were a constant value regardless of stressing rate. At a constant Y_2O_3 content, the monoclinic zirconia ratio increased with increasing grain size. On the other hand, at a constant grain size, that ratio decreased with increasing Y_2O_3 contents. For the grain size group of 0.5 μ m, the monoclinic zirconia content became about zero at 4mol% Y_2O_3 .

The fracture surface of TZP after dynamic fatigue test at room temperature showed a smooth region near the fracture origin followed by a rougher area being spread in a radial manner. The fatigue fracture surfaces were observed on the fracture surface of 2mol% Y_2O_3 -TZP and 3mol% Y_2O_3 -TZP with the grain size of about 1 μ m after dynamic fatigue test at 250°C, but was not observed for 4mol% Y_2O_3 -TZP with the grain size of 1 μ m. The fatigue fracture surface of Z2Y was larger than that of Z3Y.

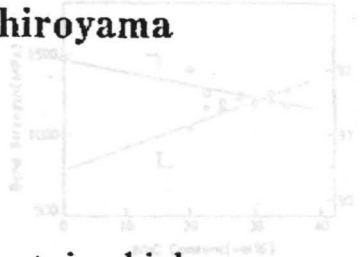
Failure times under constant stress were measured for Z2Y of grain size 0.5 μ m, and Z3Y and Z4Y of 1 μ m (static fatigue) and were compared with those predicted from dynamic fatigue data. N values obtained from static fatigue technique were similar to those from dynamic fatigue technique for Z3Y and Z4Y. The failure times obtained by static fatigue technique were smaller than that predicted from dynamic fatigue data for Z2Y, larger for Z3Y and near to the predicted value for Z4Y.

Properties of conductive PSZ

はじめに
セラミックス材料は、耐摩性、耐食性、耐熱性などの特徴を生かした用途で使用されるようになってきた。これらの信頼性や高硬度脆性材料のための前加工性と書った問題点もあり、十分に活用されていない状態である。そのために信頼性の高い材料の開発や各種成形法の検討が行われている。さらにセラミックスの機械加工の面で放電加工、レーザー加工などの研究¹⁾²⁾がおこなわれ、新しい加工方法の進歩により、切断や孔明け等を簡単に行なうことも出来るようになった。しかし、構造用セラミックスは一般に電気絶縁性であり放電加工は困難である。そこで最近、構造用セラミックス材料に電気伝導性を付与した材料開発が盛んに行なわれるようになった。³⁾⁴⁾ 導電性ジルコニア材料(弊社商品名NPZ-2)は室温付近では絶縁材料である部分安定化ジルコニア(PSZ)に放電加工やワイヤカット加工が可能な導電性を付与し、PSZの特徴である高強度高靱性を合せ持つセラミックス材料である。ここでは導電性ジルコニア材料の特徴を中心に述べ、電気伝導のメカニズムおよび本材料の応用面によ

り、放電加工の進歩により、切断や孔明け等を簡単に行なうことも出来るようになった。しかし、構造用セラミックスは一般に電気絶縁性であり放電加工は困難である。そこで最近、構造用セラミックス材料に電気伝導性を付与した材料開発が盛んに行なわれるようになった。³⁾⁴⁾ 導電性ジルコニア材料(弊社商品名NPZ-2)は室温付近では絶縁材料である部分安定化ジルコニア(PSZ)に放電加工やワイヤカット加工が可能な導電性を付与し、PSZの特徴である高強度高靱性を合せ持つセラミックス材料である。ここでは導電性ジルコニア材料の特徴を中心に述べ、電気伝導のメカニズムおよび本材料の応用面によ

Toyoshige Sasaki Masaharu Shiroyama



2 NPZ-2の材料特性

2-1 電気伝導率

NPZ-2は放電加工材料の電気伝導率と、放電加工の可否を決定する。炭化物の添加量の増加とともに、電気伝導率は低下を示した。PSZに対して、一方炭化物は7.4×10¹⁰ohm⁻¹cm⁻¹の導電性でありこの電子と導電性の粒子とが混合し、放電加工は導電性粒子がところを選択的に放電加工分散状態が影響して

Recently special attention has been paid to Y₂O₃ partially stabilized zirconia which retains high strength as well as a high degree of toughness. However there are a number of problems which must be addressed and solved quickly in many ceramic materials including Y-PSZ. The fundamental characteristics of ceramic materials ie. hardness and brittleness make machining of such ceramic materials difficult.

Therefore machining method of ceramic materials is different. Electric discharge machining is the method used to machine the workpiece accurately and efficiently. Recently Electric discharge machining of various ceramic materials are examined thoroughly. However there are few reports of Y-PSZ.

We develop Y-PSZ materials having the possibility of electric discharge machining,(NPZ-2;trade name of Nippon Tungsten) and report on the materials mechanical, thermal and electric properties.

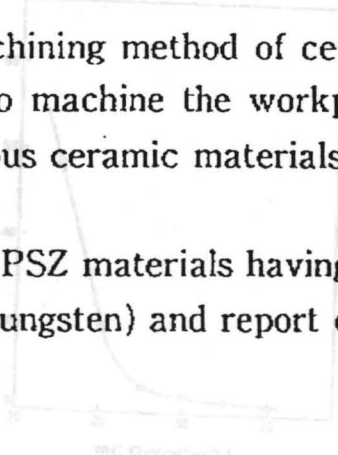


図1 電気伝導率(20°C)と炭化物の添加量との関係

2-2 熱安定性

PSZには、200~300°Cに長時間保持していると、その結晶構造が正方晶から単斜晶に相変換し、その相変換に伴う体積変化で破壊するという問題があり、熱安定性についての研究⁵⁾⁶⁾が行われて

いては、100~200時間までは急激に増加する。これが原因で、100~200時間までは急激に増加する。これが原因で、100~200時間までは急激に増加する。

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ト2 曲げ強さおよび靱さ

ジルコニア (PSZ) 系材料の特徴は、室温に近いアルミナ、ジルコニア系材料

1 はじめに

セラミックス材料は、耐摩性、耐食性、耐熱性などに優れた性質を有しておりこれらの特徴を生かした用途で使用されるようになった。しかし、欠点として強度面での信頼性や高硬度脆性材料のための難加工性と書いた問題点もあり、十分に活用されていない状態である。そのために信頼性の高い材料の開発や各種成形法の検討が行われている。さらにセラミックスの機械加工の面で放電加工、レーザー加工などの研究^{1,2)}がおこなわれ、著しい加工方法の進歩により、切断や孔明け等を簡単に行なうことも出来るようになった。しかし、構造用セラミックスは一般に電気絶縁性であり放電加工は困難である。そこで最近、構造用セラミックス材料に電気伝導性を付与した材料開発が盛んに行なわれるようになった。^{3,4)} 導電性ジルコニア材料(弊社商品名NPZ-2)は室温付近では絶縁材料である部分安定化ジルコニア(PSZ)に放電加工やワイヤカット加工が可能な導電性を付与し、PSZの特徴である高強度高靱性を合せ持つセラミックス材料である。ここでは導電性ジルコニア材料の特性を中心に述べ、電気伝導のメカニズムおよび本材料の応用面にふれる。

2 NPZ-2の材料特性

2-1 電気抵抗率

NPZ-2は放電加工ができる程度の導電性を付与した材料であるが、放電加工は材料の電気抵抗率と強い相関があり電気抵抗率をコントロールすることによって放電加工の可否を決定できる。図1に焼結体の電気抵抗率と炭化物の添加量との関係を示す。炭化物の添加量の増加とともに電気抵抗率は低下し、25vol%付近で著しい低下を示した。PSZは電気抵抗率が常温で $2 \times 10^{12} \Omega \cdot \text{cm}$ の絶縁性セラミックスで、一方炭化物は $7.4 \times 10^{-5} \Omega \cdot \text{cm}$ の導電性でありこのような絶縁性の粒子と導電性の粒子とが混合している場合には電流は導電性粒子が繋がったところを選択的に流れ、導電性粒子の分散状態が影響してくる材料の導電率(1/電気抵抗率)は導電性に寄与している導電性粒子の全導電性粒子に対する割合によって決まると考えられ導電性粒子がある体積率以上にならなければ全体を貫く導電路はできないと考えられており、この系では25vol%付近に臨界値があると考えられる。実際に放電加工を行なってみると、電気抵抗率が $5.7 \times 10^{-2} \Omega \cdot \text{cm}$ の焼結体でも加工できるが、安定な放電加工をおこなうためには電気抵抗率は $10^{-3} \Omega \cdot \text{cm}$ 以下が望ましい。

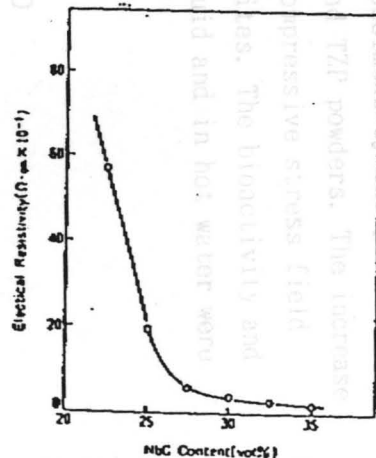


図1 電気抵抗率と炭化物添加量との関係

2-2 曲げ強さおよび硬さ

ジルコニア(PSZ)系材料の特徴は、室温においてセラミックスの中でも

げ強さを有することである。図2に曲げ強さおよび硬さ(ロックウェル硬さ)と炭化物の添加量との関係を示す。図2からわかるように曲げ強さは添加量の増加とともに徐々に低下する。しかし先に述べた安定な放電加工ができる組成において1200MPa程度あり、NPZ-2はPSZに比べれば曲げ強さは若干低下しているが一般のセラミックスに比べれば相当に高強度な材料であり、導電性と高強度高靱性の特性を合せ持つセラミックス材料であることがわかる。また硬さについては高硬度の炭化物の増加とともに上昇しており、他のセラミックスに比べ硬さが低いPSZより高くなっており、耐摩耗性はPSZに比べ向上している。

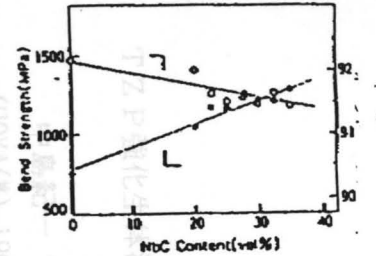


図2 曲げ強さ、硬さと炭化物添加量との関係

2-3 熱安定性

PSZには、200~300℃に長時間保持していると、その結晶構造が正方晶から単斜晶に相変態し、その相変態に伴う体積変化で崩壊するという問題があり、熱安定性についての研究^{5,6)}が行われている。NPZ-2はPSZ主体の材料であり、この熱安定性について検討することは重要である。そこでNPZ-2についても200℃大気中で2000時間のエージングテストを行なった。その結果を図3に示す。図3からわかるように、曲げ強さにおいて2000時間経過してもほとんど低下は認められない。また試料表面のX線回折による単斜晶率については、100~200時間までは急激に増加するがそれ以後はほとんど変わらないことがわかる。このようにNPZ-2は200℃に長時間保持しても相変態に伴う強度低下を起こすことなく熱的に安定していることがわかる。

以上のような特徴を導電性ジルコニアNPZ-2は有し、金型やダイス、摺動部品、電子部品、薄刃等に使用されている。

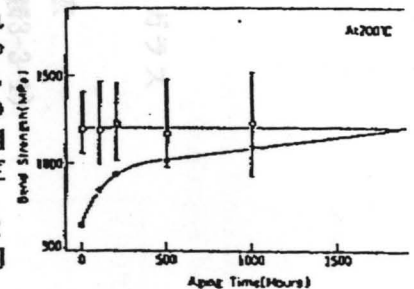


図3 NPZ-2のエージングテスト結果(大気中)

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- 6) 鳥井、沖中、宮沢、清田：粉体および粉末冶金, 32 [4] 141-144 (1985)

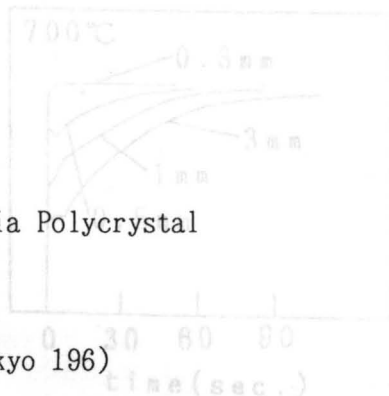
Ionic Conductivity and Deformation of Zirconia Sheet

K. Yasuda, S. Nakamura, S. Kanno (Ind. Res. Inst. of Ishikawa)
T. Yoshimura, K. Ina (Kanebo LTD), K. Kitagawa (Kanazawa Univ.)

T Z P 強化生体活性結晶化ガラス

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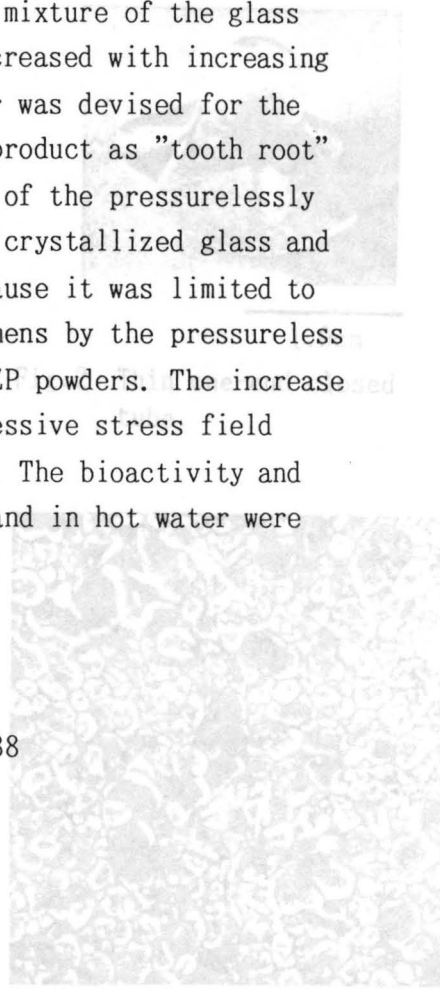


Bioactive Glass-Ceramics Toughened by Tetragonal Zirconia Polycrystal

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Two types of high strength bioactive glass-ceramic composites, a composite of crystallized glass matrix /dispersed tetragonal zirconia polycrystal(TZP) grains and a composite of TZP matrix /dispersed crystallized glass grains, were developed. The former was fabricated by hot-pressing the mixture of the glass and TZP powders. The bending strength of the composite increased with increasing TZP content showing 600 to 900 MPa at 40 vol%. The latter was devised for the purposes of manufacturing such a complicatedly designed product as "tooth root" and of mass-producing by means of hot-isostatic-pressing of the pressurelessly sintered specimens the shape of which the mixture of the crystallized glass and TZP powders was molded into by an injection machine, because it was limited to the case of a lower TZP content to fabricate dense specimens by the pressureless sintering of the molds of the mixture of the glass and TZP powders. The increase in strength would be considered to result from the compressive stress field generated during the sintering process in both composites. The bioactivity and the phase transformation of TZP in simulated body fluid and in hot water were estimated.



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Fig.3 Microstructure observed by SEM.

Ionic Conductivity and Deformation of Zirconia Sheet

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T.Yoshimura, K.Ina (Kanebo LTD), K.Kitagawa (Kanazawa Univ.)

S. Tanase, H. Okuyama and T. Todama

Having an ionic conductivity, a zirconia material is used as oxygen sensors in various fields such as the application for an electric fuel injection and a steelmaking process etc.. In this study, we have dealt with an automobile oxygen sensor. It is known that an automobile oxygen sensor needs to have the lower operation temperature and the more rapid response time. Therefore, the following subjects were studied.

(1) The sheets of various thicknesses were produced and these ionic conductivities were evaluated. The relation between the response time and the electromotive force was measured.

(2) The one-end closed tube for the automobile oxygen sensor, was made by the superplastic deformation (deep drawing) which phenomenon was found out by Wakai et al. (1986). A thickness of the sensor was produced thinner in order to obtain the more rapid response time.

(3) A tetragonal zirconia decreases in strength after aging at low temperature (200~300°C) but a cubic zirconia doesn't because it is a stable phase. However, the cubic zirconia has larger grain growth in comparison with tetragonal zirconia. Therefore it is difficult to be deformed. It is necessary to develop the cubic zirconia with the small grains. Several kinds of additives were added into the Y_2O_3 -stabilized cubic zirconia and the microstructures were observed by SEM.

The results were obtained as follows .

(1) The response times were examined for the various thicknesses at 700°C (Fig.1). As the thickness was thinner, the response time became more rapidly. In the case that the measurement temperature was given below 700°C, thin sheets showed similarly the rapid response time.

(2) The thinner zirconia sheets (0.2~0.3mm) which were produced by the doctor-blade method, were deformed using the superplastic processing. The one-end closed tube was obtained as shown in Fig.2. The production condition was given as follows : the maximum temperature was 1450°C and the press speed was 0.145mm/min..

(3) The Al_2O_3 -additive was added in the zirconia by a co-precipitation method, and 5.5mol% Y_2O_3 -added zirconia with 5wt% Al_2O_3 which became a cubic phase. was produced. The microstructure showed the small grains and the homogeneous texture (Fig.3). Consequently, the deformation was larger and the hat-like form was made at the condition where the maximum temperature was 1450°C and the press speed was 0.5mm/min.. In addition, electric resistivities were measured for these samples. The complex impedance plots showed a little increase for the bulk resistivity but the large decrease for the grain boundary resistivity, as compare with no Al_2O_3 -added sample.

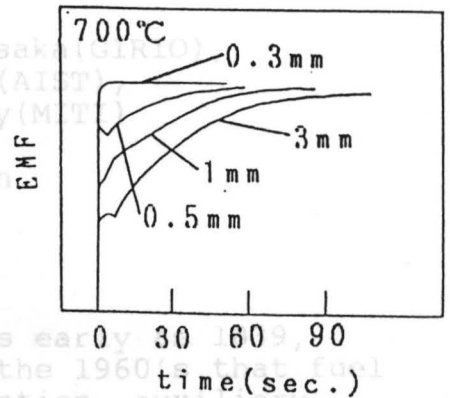


Fig.1 Relation between thickness and response time.

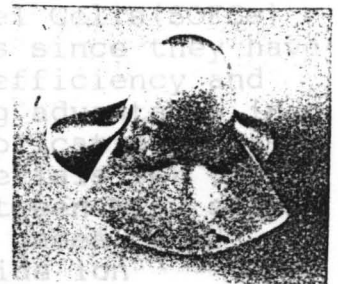


Fig.2 Thin one-end closed tube.

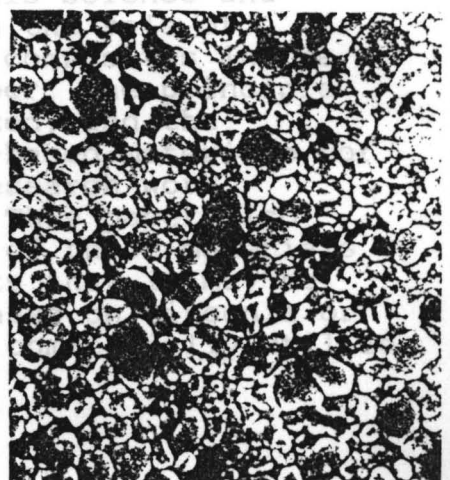


Fig.3 Microstructure observed by SEM.

ZIRCONIA AND ITS APPLICATION TO FUEL CELLS

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ABSTRACT

Fuel cells, invented by Sir W. Grove as early as 1839, have received considerable attention since the 1960's that fuel cell systems found their first major application, auxiliary power sources for the Gemini space flights. During the intervening 120 years, a number of concepts of fuel cells relating to converting chemical energy to electrical energy, types of fuels, and temperature ranges for operation were alluded in the research work. Of the fuel cells, Molten Carbonate Fuel Cells(MCFCs) and Solid Oxide Fuel Cells(SOFCs) have attracted special interest in recent years since they have merits such as high electric power generation efficiency and availability of various fuels as well as siting advantages in electric and gas utility and for industrial applications.

Zirconia is one of the most important materials for these fuel cells; zirconia felt serves as a gasket between MCFC stack and the manifold distributing fuel and oxidant gases, and zirconia doped with yttria, exhibiting high oxide ion conductivity, acts as an electrolyte for SOFCs and is essential at the present stage, and a zirconia-nickel cermet, which is a composite, has been applied as the electrode. Besides these applications, zirconia-based materials can be used as a structural component, e.g., separator, substrate, and housing, to fabricate SOFCs and batteries.

From the viewpoint of advanced materials science and engineering, it seems to be worth reviewing the role of zirconia and its related compounds and the composites in the field of fuel cell technology. In this paper, the principle and the features of fuel cells are summarized, and the feasibility of the utilization of zirconia-based materials for fuel cells are discussed on the basis of research work, including literature searching, at GIRIO. This paper also describes the advantages and disadvantages of those materials which can be presently obtained and suggests that it may be urgent to develop the advanced materials based on zirconia or to research the new materials, in order to commercially utilize fuel cells in the near future.

Prepared on July 14, 1990

Application of Y-PSZ ; Wide Range Air-to-Fuel Ratio Sensor

大工試における「燃料電池」研究

—ジルコニア系材料の応用の可能性—

Hebunhiro Hayakawa, Takeshi Kawai, Tetsuo Tamada and Akio Takami

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ABSTRACT

1. 燃料電池とは？

—原理・特徴—

The sensor element was composed of Y-PSZ with cubic and tetragonal phase. The sensor element was used to measure the concentration of oxygen gas and/or combustion gas. The sensor output was proportional to the logarithm of the oxygen concentration and a little dependence on temperature.

リン酸型(PAFC、第1世代)、熔融炭酸塩型(MCFC、第2世代)、固体電解質型(SOFC、第3世代)、その他(アルカリ型、イオン交換膜型、…)

2. ジルコニア系材料の応用の可能性

The sensor based on electrochemical pumping cell and oxygen concentration cell was able to measure the concentration of oxygen gas and/or combustion gas with high sensitivity. The sensor output was proportional to the logarithm of the oxygen concentration and a little dependence on temperature.

2-1. MCFC→ジルコニア・フェルトのガスケット(マニホールド)への適用
 2-2. SOFC→ジルコニアの電解質(膜)への適用、
 ニッケル・ジルコニア(サーメット)の電極(アノード)への適用、
 (多孔質)ジルコニアの基体(管)への適用、
 ジルコニアのマニホールドへの適用

3. ジルコニア系材料の改良(特にSOFCについて)

3-1. 部分安定化ジルコニアの利用→強度の増加

3-2. 添加(安定化)剤の変更、材料の多元化($ZrO_2-CaO-CeO_2$ 、…)

→酸化物イオン導電性の向上

3-3. 製造加工方法の変更：テープ・キャストイング、イオン注入、…

4. 燃料電池用材料開発の要点

4-1. 導電性(電子、イオン)

4-2. 雰囲気安定性(酸化・還元)

4-3. 熱特性(相転移、熱膨張)

4-4. 反応性(材料間：電極・電解質)

4-5. 電気化学的活性(電極反応)

5. まとめ

ジルコニアは高温作動の燃料電池にとって極めて重要な材料である。特に、これ無しに現在のSOFCを語ることはできない。しかし、ジルコニアの改良と併せて、新規な電池材料の探索(開発)研究も必要かもしれない。

New Y-TZP cost savings from Z-TECH

Application of Y-PSZ ; Wide Range Air-to-Fuel Ratio Sensor

Yoshihiro Okuda, P. Stark (ICI Japan)

Nobuhiro Hayakawa, Takeshi kawai, Tesho Yamada and Akio Takami

ABSTRACT

A sensor element was composed of Y-PSZ with cubic and tetragonal phase. The electrical conductivity of tetragonal zirconia corresponded to about 82 % of the cubic zirconia.

The sensor based on electrochemical pumping cell and oxygen concentration cell was able to measure concentration of oxygen gas and/or combustible gas (ex. H₂, CO and HC) with high sensitivity. The sensor output was proportional to Air-to-Fuel ratio of combustion gas and had a little dependence on temperature.

- reduced firing time (about 15 hrs less, greater with large parts)
- significant increase in furnace productivity and less complex firing schedules
- less problems with cracking and distortion of large parts during binder burnout
- no furnace emissions due to binder burnout (less pollution)
- easier recycling of scrap from green machining
- fewer pores with no binders, so higher sintered density.

This product thus enables fabricators to achieve results which can otherwise only be achieved by the addition of binders, but without facing the problems which binders introduce. A typical comparison is given in the table :

New Y-TZP cost savings from Z-TECH

Yoshihiro Okuda, P. Stark (ICI Japan)

	Green Body		Sintered Ceramic	
	Density	Flexural strength	Density	Flexural strength in 4 pt bending
Conventional	3.10	2.3	6.08	1060
Z-TECH	3.10	2.3	6.08	1060

The international zirconia powder supplier Z-TECH, part of the ICI Group, has introduced a new machinable, binder free yttria stabilised zirconia which offers extensive cost saving advantages to manufacturers of zirconia ceramics.

In modern engineering ceramics, yttria stabilised zirconia, or Y-TZP, has achieved a major position, being used for cutting implements, wear components, ferrules, and a whole range of specialised machine parts where its high strength, wear and corrosion resistance are vital. This ceramic is produced from stabilised zirconia powders made to very exacting requirements.

Z-TECH's "SY-ULTRA 5.2" is stabilised with 3 mole % Y_2O_3 , to give a high performance Y-TZP ceramic with outstanding properties. It has the new advantage that it can be isostatically pressed without binders, then machined to a high surface finish in the green state before firing. The ability to green machine without the need to incorporate binders gives the fabricator a number of important new benefits:

- reduced firing time (about 15 hrs less, greater with large parts)
- significant increase in furnace productivity and less complex firing schedules
- less problems with cracking and distortion of large parts during binder burnout
- no furnace emissions due to binder burnout (less pollution)
- easier recycling of scrap from green machining
- fewer pores with no binders, so higher sintered density.

This product thus enables fabricators to achieve results which can otherwise only be achieved by the addition of binders, but without facing the problems which binders introduce. A typical comparison is given in the table :

Joining of ZrO_2

	Green Body		Sintered Ceramic	
	Density (g/ml)	Flexural strength (MPa)	Density (g/ml)	Flexural strength in 4 pt bending (MPa)
a) <u>NO BINDER</u>				
• SY-ULTRA 5.2 (Z-TECH)	3.10	8.3	6.08	1060
• Conventional Y-TZP powder without binder	2.98	3.8	6.08	1050
b) <u>BINDER ADDED</u>				
• Y-TZP powder with 3% PVA binder	3.15	8.6	6.02	711

Green machining of complex shapes with standard lathe techniques has been extensively tested. Recommendations on pressing, machining and firing are offered to customers to achieve maximum performance of 'SY-ULTRA'.

'SY-ULTRA' powder then can give the green body performance of a powder with binder, but the firing performance of a binder free powder.

Photo : Examples of green bodies which have been machined from pressed cylinders of SY-ULTRA 5.2.

Joining of ZrO₂

Nobuya Iwamoto

Welding Research Institute
Osaka University
11-1, Mihogaoka, Ibaraki, Osaka 567

Abstract

ZrO₂ is an important ceramic for the use of oxygen sensor and widely used for the control of fuel combustion to generate electric power and metallurgical process. Further ZrO₂ as refractory material having ultra high tensile strength value and good fracture toughness is going to produce in Japan. In this presentation, the author would like to summarize chemical properties such as chemical reaction and wettability against many kind of metal and alloy. Furthermore joining behavior with steel and the influence of ion implantation to promote wetting property are also discussed.

1990年 2月

先進材料科学・技術研究会
会長 野宮 賢行

〔 西東京大学大学院 理工学部長
東京工業大学名誉教授 〕

先進材料科学・技術研究会
学術シンポジウムの開催について (御案内)

拝啓、時下ますます御清業のこととお喜び申し上げます。
さて、当研究会では、昨年度にひきつづき、きたる12月13日(金)、14日(土)の
両日かながわサイエンスパーク(川崎市)におきまして、下記要綱により、
第2回年次総会および学術シンポジウムを開催することといたしました。詳細
プログラムにつきましては、あらかじめ御送付申上げますが、会員各位なら
びに多方面からの多数の方々の積極的な御参加をたまたまりますよう御案内申し
あげます。

とくに、「(4)「ポスター」による研究成果発表」および「(5)先進材料
(製品)の解説・紹介」につきましては、別紙のとおり、発表者を公募いたし
ておりますので、御関係の方々に御紹介、応募御勧誘たまわりますようお願い
いたします。

敬 具

通 伸

先進材料科学・技術研究会(Advanced Materials Science and Engineering
Society,「AMSES」)は、学術研究・素材開発・加工技術・応用技術の各
分野にかたる「材料」に関する専門家による「横断的」研究会として、1985年
3月設立され、以来関係各位の御協力・御参加をよび、学術シンポジウム・
研究会の開催、機関誌「AMSESニュース」の発行等の活動を行ってまいり
ました。

当研究会は、また、海外の材料関連研究機関との連絡・協力につとめてきて
おり、米国MRS、ヨーロッパMRS、中国MRS、台湾MRS、オーストラ
リアMRS、メキシコMRS、インドMRSとともに、1989年11月設立された
International Materials Research Committee (IMRC)のFounding
Memberであります。

本研究会の運営を御理解いただき、積極的に御参加・御協力をたたまわります
よう懇ねてお願い申し上げます。

各位

先進材料科学・技術研究会

会長 宗宮重行

西東京科学大学教授・理工学部長

東京工業大学名誉教授

先進材料科学・技術研究会

学術シンポジウムの開催について（御案内）

拝啓 時下ますます御清栄のこととお喜び申し上げます。

さて、当研究会では、昨年度にひきつづき、きたる12月13日(木)、14日(金)の両日かながわサイエンスパーク(川崎市)におきまして、下記要領により、第2回年次総会および学術シンポジウムを開催することといたしました。詳細プログラムにつきましては、あらためて御連絡申し上げますが、会員各位ならびに多方面からの多数の方々の積極的な御参加をたまわりますよう御案内申し上げます。

とくに、「(4)「ポスター」による研究成果発表」および「(5)先進材料(製品)の解説・紹介」につきましては、別紙のとおり、発表者を公募いたしておりますので、御関係の方々に御紹介、応募御勧誘たまわりますようお願いいたします。

敬 具

追 伸

先進材料科学・技術研究会(Advanced Materials Science and Engineering Society,「AMSES」)は、学術研究・素材開発・加工技術・応用技術の各分野にわたる「材料」に関する専門家による「横断的」研究会として、1989年3月設立され、以来関係各位の御協力・御参加をえて、学術シンポジウム・研究会の開催、機関誌「AMSESニュース」の発刊等の活動を行ってまいりました。

当研究会は、また、海外の材料関連研究機関との連絡・協力につとめてきており、米国MRS、ヨーロッパMRS、中国MRS、台湾MRS、オーストラリアMRS、メキシコMRS、インドMRSとともに、1989年11月創立されたInternational Materials Research Committee(IMRC)のFounding Memberであります。

本研究会の趣旨を御理解いただき、積極的な御参加・御協力をたまわりますよう重ねてお願い申し上げます。

記

1. 日 時 1990年12月13日(木)、14日(金) 10:00 ~ 19:00
2. 場 所 かながわサイエンスパーク KSPホール
(川崎市高津区坂戸100-1 KSP西棟3F)
3. 内容・日程
- | | 12月13日(木) | 12月14日(金) |
|---------------------|--|---------------|
| (1) 年次総会 | 13:00 - 13:30 | - |
| (2) 記念講演 | 13:30 - 15:00 | - |
| (3) シンポジウム | 10:00 - 12:00
15:00 - 17:30 | 10:00 - 17:30 |
| 第1シンポジウム | 先進材料 | |
| 第2シンポジウム | センサー材料 | |
| 第3シンポジウム | シリカ系非晶質材料の不完全構造
(財)ニューガラスフォーラム NGF と共催) | |
| (4) 「ポスター」による研究成果発表 | | |
| 展 示 | 10:00 - 19:00 | 10:00 - 17:00 |
| プレゼンテーション | 10:30 - 13:00 | - |
| 表彰式 | 17:30 - | - |
| (5) 先進材料(製品)の解説紹介 | 10:00 - 19:00 | 10:00 - 17:00 |
| (6) 懇親会 | 17:30 - 19:00 | |
4. 参加費(資料代とも) 会 員: 法人・個人 10,000円 学生 3,000円
非会員: " 20,000円 " 5,000円
懇親会参加費 " 5,000円 " 2,000円
5. 主 催 先進材料科学・技術研究会

事務局 株式会社ケイエスピー内 (担当 蘇・堀川)

(連絡先) 〒213 川崎市高津区坂戸100-1 KSP西304

Tel. 044-819-2001 Fax. 044-819-2009

以上

I-記念講演、シンポジウム

1. 記念講演

- (1) イオン交換法によるウラン濃縮技術(仮題)
講師:旭化成工業㈱ 武田邦彦 氏
- (2) センサー材料としての有機物結晶の現状と将来(仮題)
講師:工業技術院繊維高分子材料研究所 中西八郎 氏

2. シンポジウム

- 第1シンポジウム 先進材料/Advanced Materials
責任者:堂山 昌男(西東京科学大学),
宗宮 重行(西東京科学大学),
長谷川正木(東京大学)
- 第2シンポジウム センサー材料/Sensor Materials
責任者:長谷川正木(東京大学),
工藤 徹一(東京大学)
- 第3シンポジウム シリカ系非晶質材料の不完全構造/
Structural Imperfections in SiO₂-Based
Amorphous Materials
(財)ニューガラスフォーラム NGF と共催)
責任者:川副 博司(東京工業大学),
今川 宏(東洋大学),
荒井 和男(工業技術院電子技術総合研究所)
細野 秀雄(名古屋大学)

注1. 各種先進材料に関する講演会です。

注2. シンポジウム講師につきましては、各シンポジウム責任者から個別に御依頼いたしますので、御協力たまわりますようお願いいたします。

II-「ポスター」による研究成果発表

学生および若手の研究者のための研究成果発表の場であり、優れた発表に対しては奨励賞を授与いたします。積極的な御参加をお願いいたします。

【募集要領】

1. 応募資格 先進材料の研究・技術開発に従事している科学者・技術者および学生
2. テーマ 先進材料(Advanced Materials)に関する研究
A. 先進材料(B、Cを除く)
B. センサー材料
C. 非晶質シリカ
注. 奨励賞の審査等は合同で行います。
3. 発表方法および形式
①ポスター:ヨコ 728×タテ1030mmのスペース(パネルは用意してあります)に研究内容をまとめ、ポスターに構成してシンポジウム開催期間中(12月13-14日)会場に展示する。
②アブストラクト: A4版1枚、英文のアブストラクトを講演要旨集に掲載する。
③プレゼンテーション:12月13日(木)10:30-13:00 口頭によるプレゼンテーション(1人3分程度 OHPが使用できます)を行う。
4. 奨励賞 次の4部門に分けて審査し、優秀な発表者を表彰します。
学生 学士課程 5人程度(各賞状・副賞 5,000円)
修士課程 5人程度(")
博士課程 5人程度(")
一般(参加制限はありませんが、賞の対象は35才以下の方とします。) 5人程度(")
5. 参加申込締切期日 1990年11月24日(土)
アブストラクト提出期日 1990年11月24日(土)
注. ポスターは12月13日(木) 8:30 ~ 9:30 の時間内に会場で発表者自身作成願います。

先進材料科学・技術研究会入会申込

(Advanced Materials Science and Engineering Society)

1. 会員の特典 会員の特典は次のとおりです。
- ・学術大会、研究会、講演会への割引価格での参加
 - ・研究、調査への参加
 - ・会誌への投稿、会誌の配布
 - ・学術大会等のプロシーディングの割引価格での配布

年会費	個人会費	年額	10,000円
	学生会費	"	2,000円
	法人会員(事業所単位)1口	"	100,000円
	海外会員(OECD加盟国の者)	"	10,000円
	(上記以外の者)	"	2,000円

振込先 安田信託銀行溝の口支店
普通預金 No.609680
先進材料科学・技術研究会

2. 会員の種別 法人会員/個人会員/学生会員により、別紙の入会申込書に所定の内容を御記入の上、下記事務局まで御送付ください。

4. 事務局(問合せ先)

〒213
川崎市高津区坂戸100-1 KSP西304
株式会社 ケイエスピー気付
先進材料科学・技術研究会
(担当者 縣, 堀川)
Tel. 044(819)2001 Fax. 044(819)2009

3. 初年度年会費 会費は次の通りです。下記銀行口座へお振込みください。なお、請求書が必要なときは事務局までお申し出下さい。

入会申込書(個人/学生会員用)

入会申込書(法人会員用)

年 月 日

年 月 日

先進材料科学・技術研究会の主旨に賛同し、個人会員・学生会員として入会を申込みます。

先進材料科学・技術研究会の主旨に賛同し、法人会員として入会を申込みます。

所属機関	所在地 (Address)	〒 Tel. Fax.
	(ふりがな) 名称 (Affiliation)	
	職名等 (Title)	
(ふりがな) 氏名 (Name)		
住所 (Address)	〒 Tel. Fax.	
専門分野 (Specialty)		
学生会員の場合は 指導教授等の確認印 (修了見込)	印 (年 月 課程修了見込)	
特に関心のある分野・シンポジウム/講演会テーマがあればご記入ください。		

(ふりがな) 法人名・事業所名		
研究会への代表者	英 文 所属・職名 (ふりがな) 氏 名	
研究会への事務連絡者	所在地 Tel. Fax.	〒
	法 人 名 所属・職名 (ふりがな) 氏 名	
専門分野		
入会申込 口数	口 (請求書 要/不要)	
特に関心のある分野・シンポジウム/講演会テーマがあればご記入ください。		