

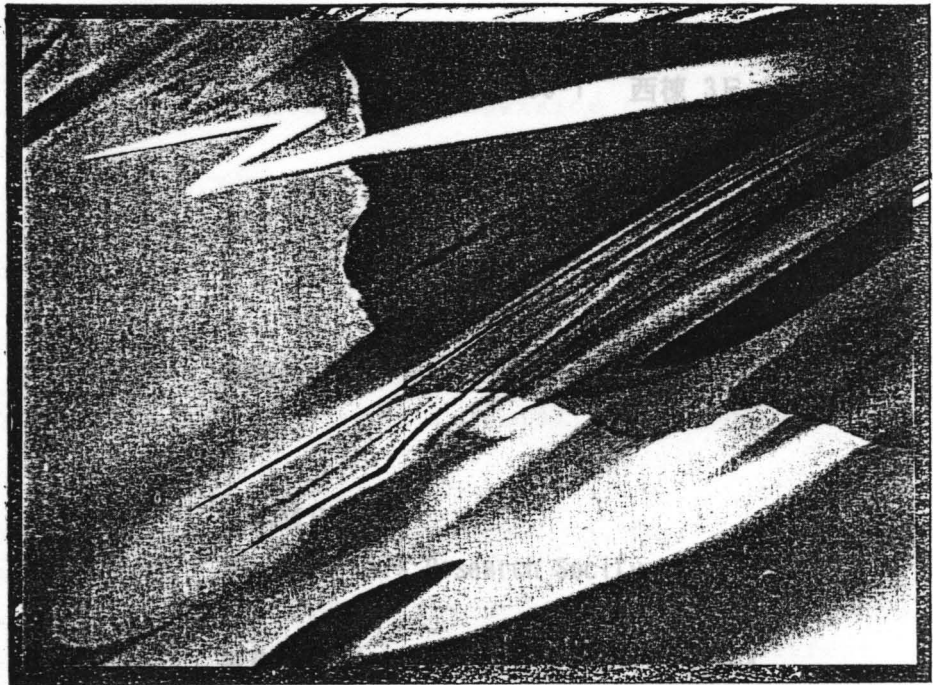
MRS-J

The Materials Research Society of Japan

日本MRS学術シンポジウム アドバンスト セラミックス

日時 1991年10月24日(木) 9:45~20:30

講演要旨集



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The Materials Research Society of Japan

MRS-Japan Sympojium
Advanced Ceramics

1991.10.24 (thurs)

at KSP (Kanagawa Science Park)

"Grain Growth of ZnO and of ZnO in ZnO-Bi₂O₃ and ZnO-Sb₂O₃ Ceramics
by T. Senda and R.C. Bradt

9:45 Opening

10:00 (1) R.C. Bradt, T. Senda (Nevada University)

Grain Growth of ZnO and of ZnO in ZnO-Bi₂O₃ and ZnO-Sb₂O₃ Ceramics. The phenomenon of the grain growth of ZnO is reviewed for sintered ZnO and ZnO in ZnO-Bi₂O₃ and ZnO-Sb₂O₃ with systematic additions of Bi₂O₃ and Sb₂O₃. The grain growth is described according to the phenomenological grain growth equation.

10:50 (2) E. Matijevic, (Clarkson University)

Well Defined Ceramic Powders: Achievements and Problems

Lunch

13:00 (3) M.V. Swain, E.H. Lutz (University of Sydney), C.J. Bettles (CSIRO)

Mechanical Properties of Dispersion Containing Ceramics

13:50 (4) P.F. Becher, K.B. Alexander, A. Bleier

(Oak Ridge National Laboratory)

The Effect of Microstructure on Transformation Toughening in Zirconia Ceramics and Composites. In the pure ZnO, the grain growth exponent is observed to be three and the activation energy is observed to be 224 kJ/mol, indicative of Zn²⁺ ion diffusion controlled grain growth. Additions of Bi₂O₃ increase the grain growth exponent to 2.5, and the activation energy to 150 kJ/mol, suggesting a boundary reaction process. At higher levels of Bi₂O₃, above ten weight percent, the activation energy for Zn grain growth increases to 310 kJ/mol, suggesting that the rate controlling mechanism becomes one of ZnO diffusion through the liquid phase at high Bi₂O₃ content.

14:40 (5) G. Petzow, M.J. Holtzman (Max-Planck-Institute for Metals Research)

Opportunities for Microstructural Development in Si₃N₄ Ceramics

Coffee Break

16:00 (6) K.H. Kim, (Korea Advanced Institute for Science and Technology)

Prospect of Ceramic Sciences for Resolving Current Enviromental Problems. The grain growth inhibition is that the grain growth exponent is 2.5 and the activation energy is 150 kJ/mol, suggesting a boundary reaction process. Initially, a mechanism for twin formation is addressed explaining why there is only a single twin in each ZnO grain. The addition of Sb₂O₃ activates the twin boundary.

16:50 (7) W.D. Kingery, (University of Arizona)

Materials Innovations in Context.

17:40 (8) R.C. Pohanka, (Office of Naval Research)

Recent Advances in Materials.

18:30 Party and Ceremony for Prof. W.D. Kingery, Prof. E. Matijevic and Prof. G. Petzow.

20:30 Closing

Well Defined Ceramics
"Grain Growth of ZnO and of ZnO in ZnO-Bi₂O₃ and ZnO-Sb₂O₃ Ceramics"
by T. Senda and R.C. Bradt

Egon Matijević

Center for Advanced Materials Processing
The phenomenon of the grain growth of ZnO is reviewed for sintered "pure" ZnO ceramics and also for the same ZnO powder with systematic additions of Bi₂O₃ and Sb₂O₃. The grain growth process is described and analyzed according to the phenomenological grain growth equation.

New results regarding the preparation of inorganic colloids of interest in ceramics will be discussed. It will be shown that a large number of finely dispersed materials of different chemical composition, size, and shape are now available. Special emphasis will be on composite particles, consisting of more than one cation, on cores coated with a shell of a
$$G^n - G_0^n = K_0 t \exp(-Q/RT)$$

The grain growth of ZnO in the three systems is then compared on the basis of the grain growth exponents and the activation energies. These results are compared and contrasted with other literature results for the same materials. Interesting microstructural observations are also reported.

In the pure ZnO, the grain growth exponent is observed to be three and the activation energy is observed to be 224 kJ/mol, indicative of zinc ion diffusion controlled grain growth. Additions of Bi₂O₃ increase the grain growth exponent to five, but decrease the activation energy to 150 kJ/mol. There is a change of the rate controlling mechanism to that of a phase boundary reaction process. At higher levels of Bi₂O₃, above ten weight percent, the activation energy for ZnO grain growth increases to 270 kJ/mol, suggesting that the rate controlling grain growth mechanism becomes one of ZnO diffusion through the liquid phase at high Bi₂O₃ contents.

Additions of Sb₂O₃ react with the ZnO to form the zinc-antimony spinel. This phase pins the grain boundaries and strongly inhibits grain growth. It also causes the formation of twins in the ZnO. The result of the grain growth inhibition is that the grain growth exponent increases to six and the activation energy to nearly 600 kJ/mol, the latter is characteristic of a particle drag mechanism of grain growth inhibition. Finally, a mechanism for twin formation is addressed explaining why there is only a single twin in each ZnO grain and how the addition of Sb₂O₃ nucleates the twin boundary.

MECHANICAL PROPERTIES OF DISPERSION CONTAINING CERAMICS

Well Defined Ceramic Powders: Achievements and ProblemsC.J. Bettles¹, E.H. Lutz^{1†} and M.V. Swain^{1†}

Egon Matijević

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University of Sydney NSW 2006
Australia

New results regarding the preparation of "monodispersed" inorganic colloids of interest in ceramics will be discussed. It will be shown that a large number of finely dispersed materials of different chemical composition, size, and shape are now available. Special emphasis will be on composite particles, consisting of more than one cation, on cores coated with a shell of a different composition, and on hollow spheres. Optical, magnetic, electric, adsorptive, and other properties of such powders as a function of their morphological characteristics will be illustrated. Furthermore, a method for continuous generation of uniform powders by precipitation will be described.

A number of problems which still require intensive studies will be pointed out. For example, questions of predictability of particle shapes or of the internal composition of solids consisting of more than one metal compound (e.g., mixed metal oxides), obtained by precipitation from homogeneous solutions, remain unresolved.

MECHANICAL PROPERTIES OF DISPERSION CONTAINING CERAMICS

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Abstract

Abstract:

The variously developed approaches to determine the strength and toughness of dispersion containing ceramics are reviewed. They are then compared with observations of model duplex ceramic materials and ceramic-diamond composites. A simple fracture mechanics basis is developed to rationalise the strength data. The toughness data is not so well generalised. The toughness of one ceramic-diamond composite system is considered in detail and compared with available models.

THE EFFECT OF MICROSTRUCTURE ON TRANSFORMATION TOUGHENING IN ZIRCONIA CERAMICS AND COMPOSITES*

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Abstract

The contribution of the stress-induced martensite transformation to the fracture resistance of ceramics containing tetragonal zirconia is dependent upon its stability. It is shown that the stress required to initiate the transformation σ_c^T decreases as the martensite start temperature M_s of the tetragonal phase increases and approaches the test temperature T . Both the type and amount of stabilizer solute incorporated in the zirconia and the zirconia grain size can be used to alter M_s and σ_c^T . The magnitude of these changes is also a function of the tetragonal zirconia content of the system. The grain size dependence is related to residual stress effects associated with thermal expansion mismatch at grain junctions which result in increasing M_s and decreasing σ_c^T as the grain size increases. As a result when $T > M_s$, the transformation toughening contribution increases with increase in the zirconia grain size. The analysis of the grain size effects and experimental results for zirconia (12 mol % ceria) ceramics and alumina-zirconia (12 mol % ceria) composites are discussed.

*Research sponsored by the Division of Materials Sciences, U.S. Department of Energy, under contract DE-AC05-84OR21400 with Martin Marietta Energy Systems, Inc.

Prospects of Ceramic Sciences
for Resolving Current Environmental Problems

OPPORTUNITIES FOR MICROSTRUCTURAL DEVELOPMENT IN

Si_3N_4 -CERAMICS

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The microstructural optimization of high strength, high temperature Si_3N_4 ceramics are discussed. It is demonstrated that microstructural development is predominantly controlled by the properties of the Si_3N_4 starting powder and the sintering temperature, whereas the sintering additive composition has only a minor influence.

Optimum conditions for the growth of Si_3N_4 grains with a needle-like morphology is analysed in pressureless sintered and gas pressure sintered specimens as well as in oxynitride glasses. The growth kinetics during α/β transformation and Ostwald ripening have been determined on isolated Si_3N_4 crystals embedded in supersaturated Y-Si-Al-O-N glasses. Finally a crystallization model is introduced to describe the growth mechanisms in relation to the Si_3N_4 crystal structure. It is demonstrated that a fine-grained Si_3N_4 has the highest potential for high strength properties.

Degradation of the Si_3N_4 properties at temperatures $> 1200^\circ\text{C}$ is influenced mainly by the chemistry of the grain boundary phase. Therefore the importance of a more complete understanding of phase relationships in the Si_3N_4 -sintering additive ceramic systems is necessary. TEM observations reveal an amorphous grain boundary film in two-grain junctions even in "fully" crystalline Si_3N_4 ceramics. The equilibrium thickness of these amorphous layers depends on the chemistry of the sintering additives and is expected to control the high temperature properties.

Prospects of Ceramic Sciences
for Resolving Current Environmental Problems

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As the 20 century turbulently draws to a close, World is facing with the threshold of megashift of value and norms, various systems and institutions of politics, economics, society, and especially of science and technology and of current environmental countermeasurements. In resolving the environmental problems of the global warming, pollutions, acid rains, energy depletion etc., ceramic science and technology should also play a vital role in conjunction with other disciplines. Therefore hard disciplines of ceramics should be explored evermore, and new disciplines combined with "Hard and Soft" be introduced. The lowering firing temperature without sacrificing quality can contribute to energy frugality and entropy decrease. Alternative bonding technology such as hydrothermal, direct bonding and boundary formation agents is in progress. We hope to develop a new production process in which CO₂ emission is eliminated or drastically reduced before the Brazilian Treaty of the global warming be effective, or the released CO₂ be isolated or converted to other product without causing the global warming. We may take advantages of zeolite function for removing water pollution: zirconia sensors can contribute to smooth combustion of automobile engine, so that air pollution has been drastically reduced. Those ceramics contributing so much to environmental problems can be classified in term of "Environmental ceramics." Their role must be expanded in collaboration with intelligent ceramics and bioceramics. In the present paper, a new look for ceramic sciences under megashift of modern science and technology is shown especially focussing the global environmental problems.

Materials Innovations Contexts

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during the past year significant progress has been made in structural materials interface
Abstract functional materials in the Materials Research Program of the office of
Naval A consideration of the role of materials in innovative technology shows that
materials, microstructures and properties are rarely of much interest standing alone.
design They gain significance as component in devices that are parts of systems having
value for society. Some of the many-layered contexts affecting materials innovation in
emerging and infant industries are discussed. matrix composites; e. the enhancement of aluminum
passivity through the use of surface alloying with tungsten; f. The use of laser ablation to
pattern high temperature superconducting thin films for microwave resonators; g. The
development of ceramic (piezoelectric)-metal composites with pressure stable hydrophone
properties that are two orders of magnitude greater than lead zirconate titanate.

The Materials Research Society of Japan

Recent Advances In Materials

本研究会は、先進材料に関する科学技術の専門家の横断的な研究交流を通じて、
 学術・応用研究および産業化の一層の促進をはかることを目的としている。
 また、International Union of Material Research Societies (IUMRS) の
 founding member です。

R. C. Pohank

Office of Naval Research

Arlington, VA 22217

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日本MRS事務局

During the past year significant progress has been made in structural materials, interface science and functional materials in the Materials Research Program of the office of Naval Research.

This paper will summarize the following accomplishments: a. The initial work on the atomistic design of steels; b. The direct observation of in-situ fatigue cracks in metals;

c. The development of electrochemical routes for processing metal matrix composites; d. The exploration of new oxidatively stable ceramic matrix composites; e. The enhancement of aluminum passivity through the use of surface alloying with tungsten; f. The use of laser ablation to pattern high temperature superconducting thin films for microwave resonators; g. The development of ceramic (piezoelectric)-metal composites with pressure stable hydrophone properties that are two orders of magnitude greater than lead zirconate titanate.

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The Materials Research Society of Japan

本研究会は、先進材料に関する科学技術の専門家の横断的な研究交流を通じて、
 学術・応用研究および実用化の一端の発展をはかることを目的としている。
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日本MRS入会申込
 The Materials Research Society of Japan

日本MRS入会申込
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