

Cambridge University Press

978-1-107-41115-9 - Advanced Structural Ceramics: Materials Research Society

Symposia Proceedings: Volume 78

Editors: P. F. Becher, M. V. Swain and S. Sōmiya

Frontmatter

[More information](#)

Advanced Structural Ceramics

Cambridge University Press

978-1-107-41115-9 - Advanced Structural Ceramics: Materials Research Society

Symposia Proceedings: Volume 78

Editors: P. F. Becher, M. V. Swain and S. Sōmiya

Frontmatter

[More information](#)

MATERIALS RESEARCH SOCIETY SYMPOSIA PROCEEDINGS

ISSN 0272 - 9172

Volume 1—Laser and Electron-Beam Solid Interactions and Materials Processing,
J. F. Gibbons, L. D. Hess, T. W. Sigmon, 1981

Volume 2—Defects in Semiconductors, J. Narayan, T. Y. Tan, 1981

Volume 3—Nuclear and Electron Resonance Spectroscopies Applied to Materials
Science, E. N. Kaufmann, G. K. Shenoy, 1981

Volume 4—Laser and Electron-Beam Interactions with Solids, B. R. Appleton,
G. K. Celler, 1982

Volume 5—Grain Boundaries in Semiconductors, H. J. Leamy, G. E. Pike,
C. H. Seager, 1982

Volume 6—Scientific Basis for Nuclear Waste Management IV, S. V. Topp, 1982

Volume 7—Metastable Materials Formation by Ion Implantation, S. T. Picraux,
W. J. Choyke, 1982

Volume 8—Rapidly Solidified Amorphous and Crystalline Alloys, B. H. Kear,
B. C. Giessen, M. Cohen, 1982

Volume 9—Materials Processing in the Reduced Gravity Environment of Space,
G. E. Rindone, 1982

Volume 10—Thin Films and Interfaces, P. S. Ho, K.-N. Tu, 1982

Volume 11—Scientific Basis for Nuclear Waste Management V, W. Lutze, 1982

Volume 12—In Situ Composites IV, F. D. Lemkey, H. E. Cline, M. McLean, 1982

Volume 13—Laser-Solid Interactions and Transient Thermal Processing of Materials,
J. Narayan, W. L. Brown, R. A. Lemons, 1983

Volume 14—Defects in Semiconductors II, S. Mahajan, J. W. Corbett, 1983

Volume 15—Scientific Basis for Nuclear Waste Management VI, D. G. Brookins, 1983

Volume 16—Nuclear Radiation Detector Materials, E. E. Haller, H. W. Kraner, W. A.
Higinbotham, 1983

Volume 17—Laser Diagnostics and Photochemical Processing for Semiconductor
Devices, R. M. Osgood, S. R. J. Brueck, H. R. Schlossberg, 1983

Volume 18—Interfaces and Contacts, R. Ludeke, K. Rose, 1983

Volume 19—Alloy Phase Diagrams, L. H. Bennett, T. B. Massalski, B. C. Giessen,
1983

Volume 20—Intercalated Graphite, M. S. Dresselhaus, G. Dresselhaus, J. E. Fischer,
M. J. Moran, 1983

Volume 21—Phase Transformations in Solids, T. Tsakalakos, 1984

Volume 22—High Pressure in Science and Technology, C. Homan, R. K. MacCrone,
E. Whalley, 1984

Volume 23—Energy Beam-Solid Interactions and Transient Thermal Processing,
J. C. C. Fan, N. M. Johnson, 1984

Volume 24—Defect Properties and Processing of High-Technology Nonmetallic
Materials, J. H. Crawford, Jr., Y. Chen, W. A. Sibley, 1984

Cambridge University Press

978-1-107-41115-9 - Advanced Structural Ceramics: Materials Research Society

Symposia Proceedings: Volume 78

Editors: P. F. Becher, M. V. Swain and S. Sōmiya

Frontmatter

[More information](#)

MATERIALS RESEARCH SOCIETY SYMPOSIA PROCEEDINGS

Volume 25—Thin Films and Interfaces II, J. E. E. Baglin, D. R. Campbell, W. K. Chu, 1984

Volume 26—Scientific Basis for Nuclear Waste Management VII, G. L. McVay, 1984

Volume 27—Ion Implantation and Ion Beam Processing of Materials, G. K. Hubler, O. W. Holland, C. R. Clayton, C. W. White, 1984

Volume 28—Rapidly Solidified Metastable Materials, B. H. Kear, B. C. Giessen, 1984

Volume 29—Laser-Controlled Chemical Processing of Surfaces, A. W. Johnson, D. J. Ehrlich, H. R. Schlossberg, 1984.

Volume 30—Plasma Processing and Synthesis of Materials, J. Szekely, D. Apelian, 1984

Volume 31—Electron Microscopy of Materials, W. Krakow, D. A. Smith, L. W. Hobbs, 1984

Volume 32—Better Ceramics Through Chemistry, C. J. Brinker, D. E. Clark, D. R. Ulrich, 1984

Volume 33—Comparison of Thin Film Transistor and SOI Technologies, H. W. Lam, M. J. Thompson, 1984

Volume 34—Physical Metallurgy of Cast Iron, H. Fredriksson, M. Hillerts, 1985

Volume 35—Energy Beam-Solid Interactions and Transient Thermal Processing/1984, D. K. Biegelsen, G. A. Rozgonyi, C. V. Shank, 1985

Volume 36—Impurity Diffusion and Gettering in Silicon, R. B. Fair, C. W. Pearce, J. Washburn, 1985

Volume 37—Layered Structures, Epitaxy, and Interfaces, J. M. Gibson, L. R. Dawson, 1985

Volume 38—Plasma Synthesis and Etching of Electronic Materials, R. P. H. Chang, B. Abeles, 1985

Volume 39—High-Temperature Ordered Intermetallic Alloys, C. C. Koch, C. T. Liu, N. S. Stoloff, 1985

Volume 40—Electronic Packaging Materials Science, E. A. Giess, K.-N. Tu, D. R. Uhlmann, 1985

Volume 41—Advanced Photon and Particle Techniques for the Characterization of Defects in Solids, J. B. Roberto, R. W. Carpenter, M. C. Wittels, 1985

Volume 42—Very High Strength Cement-Based Materials, J. F. Young, 1985.

Volume 43—Fly Ash and Coal Conversion By-Products: Characterization, Utilization, and Disposal I, G. J. McCarthy, R. J. Lauf, 1985

Volume 44—Scientific Basis for Nuclear Waste Management VIII, C. M. Jantzen, J. A. Stone, R. C. Ewing, 1985

Volume 45—Ion Beam Processes in Advanced Electronic Materials and Device Technology, B. R. Appleton, F. H. Eisen, T. W. Sigmon, 1985

Volume 46—Microscopic Identification of Electronic Defects in Semiconductors, N. M. Johnson, S. G. Bishop, G. D. Watkins, 1985

Cambridge University Press

978-1-107-41115-9 - Advanced Structural Ceramics: Materials Research Society

Symposia Proceedings: Volume 78

Editors: P. F. Becher, M. V. Swain and S. Sōmiya

Frontmatter

[More information](#)

MATERIALS RESEARCH SOCIETY SYMPOSIA PROCEEDINGS

Volume 47—Thin Films: The Relationship of Structure to Properties, C. R. Aita,
K. S. SreeHarsha, 1985

Volume 48—Applied Materials Characterization, W. Katz, P. Williams, 1985

Volume 49—Materials Issues in Applications of Amorphous Silicon Technology,
D. Adler, A. Madan, M. J. Thompson, 1985

Volume 50—Scientific Basis for Nuclear Waste Management IX, L. O. Werme, 1986

Volume 51—Beam-Solid Interactions and Phase Transformations, H. Kurz, G. L. Olson,
J. M. Poate, 1986

Volume 52—Rapid Thermal Processing, T. O. Sedgwick, T. E. Seidel, B.-Y. Tsaur, 1986

Volume 53—Semiconductor-on-Insulator and Thin Film Transistor Technology,
A. Chiang, M. W. Geis, L. Pfeiffer, 1986

Volume 54—Thin Films—Interfaces and Phenomena, R. J. Nemanich, P. S. Ho, S. S. Lau,
1986

Volume 55—Biomedical Materials, J. M. Williams, M. F. Nichols, W. Zingg, 1986

Volume 56—Layered Structures and Epitaxy, J. M. Gibson, G. C. Osbourn, R. M. Tromp,
1986

Volume 57—Phase Transitions in Condensed Systems—Experiments and Theory,
G. S. Cargill III, F. Spaepen, K.-N. Tu, 1987

Volume 58—Rapidly Solidified Alloys and Their Mechanical and Magnetic Properties,
B. C. Giessen, D. E. Polk, A. I. Taub, 1986

Volume 59—Oxygen, Carbon, Hydrogen, and Nitrogen in Crystalline Silicon,
J. C. Mikkelsen, Jr., S. J. Pearton, J. W. Corbett, S. J. Pennycook, 1986

Volume 60—Defect Properties and Processing of High-Technology Nonmetallic
Materials, Y. Chen, W. D. Kingery, R. J. Stokes, 1986

Volume 61—Defects in Glasses, F. L. Galeener, D. L. Griscom, M. J. Weber, 1986

Volume 62—Materials Problem Solving with the Transmission Electron Microscope,
L. W. Hobbs, K. H. Westmacott, D. B. Williams, 1986

Volume 63—Computer-Based Microscopic Description of the Structure and Properties
of Materials, J. Broughton, W. Krakow, S. T. Pantelides, 1986

Volume 64—Cement-Based Composites: Strain Rate Effects on Fracture, S. Mindess,
S. P. Shah, 1986

Volume 65—Fly Ash and Coal Conversion By-Products: Characterization, Utilization
and Disposal II, G. J. McCarthy, F. P. Glasser, D. M. Roy, 1986

Volume 66—Frontiers in Materials Education, L. W. Hobbs, G. L. Liedl, 1986

Volume 67—Heteroepitaxy on Silicon, J. C. C. Fan, J. M. Poate, 1986

Volume 68—Plasma Processing, J. W. Coburn, R. A. Gottscho, D. W. Hess, 1986

Volume 69—Materials Characterization, N. W. Cheung, M.-A. Nicolet, 1986

Volume 70—Materials Issues in Amorphous-Semiconductor Technology, D. Adler,
Y. Hamakawa, A. Madan, 1986

Cambridge University Press

978-1-107-41115-9 - Advanced Structural Ceramics: Materials Research Society

Symposia Proceedings: Volume 78

Editors: P. F. Becher, M. V. Swain and S. Sōmiya

Frontmatter

[More information](#)

MATERIALS RESEARCH SOCIETY SYMPOSIA PROCEEDINGS

Volume 71—Materials Issues in Silicon Integrated Circuit Processing, M. Wittmer,
J. Stimmell, M. Strathman, 1986

Volume 72—Electronic Packaging Materials Science II, K. A. Jackson, R. C. Pohanka,
D. R. Uhlmann, D. R. Ulrich, 1986

Volume 73—Better Ceramics Through Chemistry II, C. J. Brinker, D. E. Clark, D. R.
Ulrich, 1986

Volume 74—Beam-Solid Interactions and Transient Processes, S. T. Picraux, M. O.
Thompson, J. S. Williams, 1987

Volume 75—Photon, Beam and Plasma Stimulated Chemical Processes at Surfaces, V. M.
Donnelly, I. P. Herman, M. Hirose, 1987

Volume 76—Science and Technology of Microfabrication, R. E. Howard, E. L. Hu,
S. Pang, S. Namba, 1987

Volume 77—Interfaces, Superlattices, and Thin Flims, J. D. Dow, I. K. Schuller, 1987

Volume 78—Advances in Structural Ceramics, P. F. Becher, M. V. Swain, S. Sōmiya, 1987

Volume 79—Scattering, Deformation and Fracture in Polymers, B. Crist, T. P. Russell,
E. L. Thomas, G. D. Wignall, 1987

Volume 80—Science and Technology of Rapidly Quenched Alloys, M. Tenhover, L. E.
Tanner, W. L. Johnson, 1987

Volume 81—High-Temperature Ordered Intermetallic Alloys, II, C. C. Koch, C. T. Liu,
N. S. Stoloff, O. Izumi, 1987

Volume 82—Characterization of Defects in Materials, R. W. Siegel, R. Sinclair, J. R.
Weertman, 1987

Volume 83—Physical and Chemical Properties of Thin Metal Overlays and Alloy
Surfaces, D. M. Zehner, D. W. Goodman, 1987

Volume 84—Scientific Basis for Nuclear Waste Management X, J. K. Bates, W. B.
Seefeldt, 1987

Volume 85—Microstructural Development During the Hydration of Cement, L. Struble,
P. Brown, 1987

Volume 86—Fly Ash and Coal Conversion By-Products Characterization, Utilization and
Disposal III, G. J. McCarthy, F. P. Glasser, D. M. Roy, S. Diamond, 1987

Volume 87—Materials Processing in the Reduced Gravity Environment of Space, R. H.
Doremus, P. C. Nordine, 1987

Volume 88—Optical Fiber Materials and Properties, S. R. Nagel, G. Sigel, J. W. Fleming,
D. A. Thompson, 1987

Volume 89—Diluted Magnetic (Semimagnetic) Semiconductors, J. K. Furdyna, R. L.
Aggarwal, S. von Molnar, 1987

Volume 90—Materials for Infrared Detectors and Sources, R. F. C. Farrow, J. F.
Schetzina, J. T. Cheung, 1987

Cambridge University Press

978-1-107-41115-9 - Advanced Structural Ceramics: Materials Research Society

Symposia Proceedings: Volume 78

Editors: P. F. Becher, M. V. Swain and S. Sōmiya

Frontmatter

[More information](#)

MATERIALS RESEARCH SOCIETY CONFERENCE PROCEEDINGS

VLSI-I—Tungsten and Other Refractory Metals for VLSI Applications, R. S. Blewer,
1986; ISSN: 0886-7860; ISBN: 0-931837-32-4

VLSI-II—Tungsten and Other Refractory Metals for VLSI Applications II, E.K.
Broadbent, 1987; ISSN: 0886-7860; ISBN: 0-931837-66-9

TMC—Ternary and Multinary Compounds, S. Deb, A. Zunger, 1987;
ISBN:0-931837-57-x

Cambridge University Press

978-1-107-41115-9 - Advanced Structural Ceramics: Materials Research Society

Symposia Proceedings: Volume 78

Editors: P. F. Becher, M. V. Swain and S. Sōmiya

Frontmatter

[More information](#)

MATERIALS RESEARCH SOCIETY SYMPOSIA PROCEEDINGS VOLUME 78

Advanced Structural Ceramics

Symposium held December 1-3, 1986, Boston, Massachusetts, U.S.A.

EDITORS:

P. F. Becher

Oak Ridge National Laboratory, Oak Ridge, Tennessee, U.S.A.

M. V. Swain

CSIRO, Victoria, Australia

S. Sōmiya

Tokyo Institute of Technology, Yokohama, Japan



MATERIALS RESEARCH SOCIETY

Pittsburgh, Pennsylvania

Cambridge University Press

978-1-107-41115-9 - Advanced Structural Ceramics: Materials Research Society

Symposia Proceedings: Volume 78

Editors: P. F. Becher, M. V. Swain and S. Sōmiya

Frontmatter

[More information](#)

CAMBRIDGE UNIVERSITY PRESS

Cambridge, New York, Melbourne, Madrid, Cape Town,

Singapore, São Paulo, Delhi, Mexico City

Cambridge University Press

32 Avenue of the Americas, New York NY 10013-2473, USA

Published in the United States of America by Cambridge University Press, New York

www.cambridge.org

Information on this title: www.cambridge.org/9781107411159

Materials Research Society

506 Keystone Drive, Warrendale, PA 15086

<http://www.mrs.org>

© Materials Research Society 1987

This publication is in copyright. Subject to statutory exception
and to the provisions of relevant collective licensing agreements,
no reproduction of any part may take place without the written
permission of Cambridge University Press.

This publication has been registered with Copyright Clearance Center, Inc.
For further information please contact the Copyright Clearance Center,

Salem, Massachusetts.

First published 1987

First paperback edition 2012

Single article reprints from this publication are available through
University Microfilms Inc., 300 North Zeeb Road, Ann Arbor, MI 48106

CODEN: MRSPDH

ISBN 978-1-107-41115-9 Paperback

Cambridge University Press has no responsibility for the persistence or
accuracy of URLs for external or third-party internet websites referred to in
this publication, and does not guarantee that any content on such websites is,
or will remain, accurate or appropriate.

Cambridge University Press

978-1-107-41115-9 - Advanced Structural Ceramics: Materials Research Society

Symposia Proceedings: Volume 78

Editors: P. F. Becher, M. V. Swain and S. Sōmiya

Frontmatter

[More information](#)

Contents

Preface.....	xiii
PART I - TRANSFORMATION ANALYSIS	
Displacive Phase Transformation in Zirconia-Based Ceramics.....	3
B.C. Muddle	
A Study of Rhombohedral Phase in Y_2O_3 -Partially Stabilized Zirconia.....	17
Y. Kitano, Y. Mori, A. Ishitani and T. Masaki	
Texture on Ground, Fractured, and Aged Y-TZP Surfaces.....	25
F. Reidinger and P.J. Whalen	
Constitutive Laws for Ceramics Exhibiting Stress-Induced Martensitic Transformation.....	35
J.C. Lambropoulos	
The Stress Induced Transformation by Fracture in Y_2O_3 Containing Tetragonal Zirconia Polycrystals.....	43
G. Katagiri, H. Ishida, A. Ishitani and T. Masaki	
Reversible Transformation Plasticity in Uniaxial Tension-Compression Cycling of Mg-PSZ.....	51
K.J. Bowman, P.E. Reyes-Morel and I-W. Chen	
PART II - TRANSFORMATION PLASTICITY AND TOUGHNESS	
Deformation of Transformation Toughened Zirconia.....	61
J. Lankford	
Transformation Plasticity and Transformation Toughening in Mg-PSZ and Ce-TZP.....	75
I-W. Chen and P.E. Reyes-Morel	
The Temperature Dependence of Yield Stress and Fracture Toughness in Unstabilized Zirconia Crystals.....	89
T.W. Coyle, R.P. Ingel and P.A. Willging	
Strength and Toughness of Mg-PSZ and Y-TZP Materials at Cryogenic Temperatures.....	97
S. Veitch, M. Marmach and M.V. Swain	
Crack Propagation in Mg-PSZ.....	107
M.J. Readey, A.H. Heuer and R.W. Steinbrech	

Cambridge University Press

978-1-107-41115-9 - Advanced Structural Ceramics: Materials Research Society

Symposia Proceedings: Volume 78

Editors: P. F. Becher, M. V. Swain and S. Sōmiya

Frontmatter

[More information](#)

**PART III - MECHANICAL PROPERTIES AND MICROSTRUCTURES
OF ZIRCONIA TOUGHENED CERAMICS**

Mechanical Property and Microstructure of TZP and TZP/Al ₂ O ₃ Composites.....	123
K. Tsukuma and T. Takahata	
Evaluation of Commercially Available Transformation Toughened Zirconia.....	137
J.J. Swab	
Mechanical Properties and Thermal Stability of Yttria-Doped Tetragonal Zirconia Polycrystals with Diffused Ceria in the Surface.....	147
T. Sato, S. Ohtaki, T. Fukushima, T. Endo and M. Shimada	
Strength Improvement in Transformation Toughened Ceramics Using Compressive Residual Surface Stresses.....	155
R.A. Cutler, J.J. Hansen, A.V. Virkar, D.K. Shetty and R.C. Winterton	
Zirconia Dispersed Mullite Ceramics Through Hot-Pressing of Amorphous ZrO ₂ -SiO ₂ -Al ₂ O ₃ Obtained by Rapid Quenching.....	165
M. Yoshimura, T. Noma, Y. Hanaue and S. Sōmiya	

PART IV - MECHANICAL BEHAVIOR OF REINFORCED CERAMIC COMPOSITES

Strength and Interfacial Properties of Ceramic Composites.....	175
D.B. Marshall	
The Strength of Fibres in All-Ceramic Composites.....	181
K. Kendall, N.McN. Alford and J.D. Birchall	
Weibull Modulus of Toughened Ceramics.....	189
K. Kendall, N.McN. Alford and J.D. Birchall	
Effect of Changes in Grain Boundary Toughness on the Strength of Alumina.....	199
R.F. Cook	
Erosion of a Silicon Carbide Whisker Reinforced Silicon Nitride.....	207
C.T. Morrison, J.L. Routbort and R.O. Scattergood	
Comparison of Matrix Variation in Nicalon (SiC) Fiber Reinforced Composites.....	215
W.L. Johnson, III and R.G. Brasfield	
Interfacial Characterizations of Fiber-Reinforced SiC Composites Exhibiting Brittle and Toughened Fracture Behavior.....	223
M.H. Rawlins, T.A. Nolan, D.P. Stinton and R.A. Lowden	
Analysis by SIMS and by EELS-EDX in a Stem of SiC Fibers Reinforced Composites.....	231
M. Lancin, F. Anxionnaz, M. Schumacher, O. Dugne and P. Trebbia	

Cambridge University Press

978-1-107-41115-9 - Advanced Structural Ceramics: Materials Research Society

Symposia Proceedings: Volume 78

Editors: P. F. Becher, M. V. Swain and S. Sōmiya

Frontmatter

[More information](#)

PART V – FRACTURE AND DEFORMATION BEHAVIOR IN CERAMIC COMPOSITES

Strain and Fracture in Whisker Reinforced Ceramics.....	241
P. Angelini, W. Mader and P.F. Becher	
On Prevalent Whisker Toughening Mechanisms in Ceramics.....	259
A.G. Evans, M. Rühle, B.J. Dagleish and M.D. Thouless	
Microstructure Development in Si_3N_4 -Based Composites.....	273
S.T. Buljan and G. Zilberstein	
Deflection-Toughened Corundum-Rutile Composites.....	283
S. Hori, H. Kaji, M. Yoshimura and S. Sōmiya	
Processing and Creep Performance of Silicon Carbide Whisker Reinforced Silicon Nitride.....	289
J.R. Porter, F.F. Lange and A.H. Chokshi	
Deformation Behavior of SiC Whisker Reinforced Si_3N_4	295
R.D. Nixon, S. Chevacharoenkul, M.L. Buckabee, S.T. Buljan and B.F. Davis	
Author Index.....	303
Subject Index.....	305

Cambridge University Press

978-1-107-41115-9 - Advanced Structural Ceramics: Materials Research Society

Symposia Proceedings: Volume 78

Editors: P. F. Becher, M. V. Swain and S. Sōmiya

Frontmatter

[More information](#)

Cambridge University Press

978-1-107-41115-9 - Advanced Structural Ceramics: Materials Research Society

Symposia Proceedings: Volume 78

Editors: P. F. Becher, M. V. Swain and S. Sōmiya

Frontmatter

[More information](#)

Preface

The papers contained in this proceedings were presented at the symposium on "Advanced Structural Ceramics" held in Boston, Massachusetts, December 1-3, and 1986 sponsored by the Materials Research Society. The symposium addressed recent research in the field of toughened ceramics and included that on transformation toughening and fiber and whisker reinforced ceramics. The symposium was international in character which is indicative of the wide interest in exploring mechanisms to enhance the fracture resistance of ceramics. The research presented at the symposium provides considerable insight into our progress in these areas.

The success of any symposium also reflects the support of others. This symposium was made possible by the financial support of the U.S. Department of Energy through the Division of Materials Sciences, Office of Basic Energy Sciences and the Energy Conversion and Utilization Technologies Materials Program, Office of Renewable Energy. We would like to especially acknowledge A.H. Heuer, D.R. Clarke, F.F. Lange, R.J. Gottschall, and R.M. Cannon for subchairing this session and coordinating manuscript reviews. Their efforts contributed greatly to the success of this symposium. Finally, sincere thanks are extended to Fauna Stooksbury who provided not only secretarial services but also handled and coordinated many of the details required to conduct the symposium and publish the proceedings.

P.F. Becher
M.V. Swain
S. Sōmiya