

Bulk Metallic Glasses

Bulk Metallic Glasses

Edited by
Peter K. Liaw
Raymond A. Buchanan

Symposium Sponsored by
the Mechanical Behavior of Materials Committee of
the Structural Materials Division (SMD) of
TMS (The Minerals, Metals & Materials Society)

Held during the
TMS 2006 Annual Meeting in
San Antonio, Texas, USA
March 12-16, 2006

A Publication of
TMS

A Publication of TMS (The Minerals, Metals & Materials Society)
184 Thorn Hill Road
Warrendale, Pennsylvania 15086-7528
(724) 776-9000

Visit the TMS web site at
<http://www.tms.org>

Statements of fact and opinion are the responsibility of the authors alone and do not imply an opinion on the part of the officers, staff, or members of TMS, The Minerals, Metals, and Materials Society. TMS assumes no responsibility for the statements and opinions advanced by the contributors to its publications or by the speakers at its programs. Registered names and trademarks, etc., used in this publication, even without specific indication thereof, are not be considered unprotected by the law.

No part of this book may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, microfilming, recording, or otherwise, without written permission from the publisher.

Printed in the United States of America
Library of Congress 2006920377
ISBN: 978-0-87339-612-7

Authorization to photocopy for internal or personal use beyond the limits of Sections 107 and 108 of the U.S. Copyright Law is granted by TMS, provided that the base fee of \$7.00 per copy is paid directly to the Copyright Clearance Center, Inc., 222 Rosewood Drive, Danvers, MA 01923 USA, www.copyright.com. Prior to photocopying items for educational classroom use, please contact the Copyright Clearance Center, Inc.

For those organizations that have been granted a photocopy license by the Copyright Clearance Center, a separate system of payment has been arranged.

This consent does not extend to copying items for general distribution or for advertising or promotional purposes or to republishing items whole or in part in any work in any format.

Please direct republication or special copying permission requests to the Copyright Clearance Center, Inc., 222 Rosewood Drive, Danvers, MA 01923 USA; (978) 750-8400; www.copyright.com.

If you are interested in purchasing a copy of this book, or if you would like to receive the latest TMS publications catalog, please telephone (800) 759-4867 (U.S. only) or (724) 776-9000, EXT. 270.

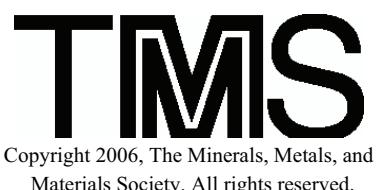


Table of Contents

Elastic, Plastic Behavior, and Computation

Rate-Dependnet Shear Banding in a Zr-Based Bulkmetallic Glass.....	3
<i>W.H. Jiang, G.J. Fan, F.X. Liu, G.Y. Wang, H. Choo, and P.K. Liaw</i>	

Mechanical Behaviors

Mechanical Properties and Devitrification Behavior of Cu-Zr-Ti-NM (NM-Noble Metals) Bulk Glass-Forming Alloys	13
<i>D.V. Louzguine-Luzgin, and A. Inoue</i>	

Evolution of Mechanical Properties of Tilt Cast Zr-Cu-Al Glassy Alloys by Annealing Treatment	21
<i>Y. Yokoyama, P.K. Liaw, R.A. Buchanan, and A. Inoue</i>	

Fatigue Behavior of Bulk Metallic Glasses: Role of Free Volume	45
<i>J.J. Kruzic, M.E. Launey, and R. Busch</i>	

Elevated Temperature Mechanical Behaviour of Mg-Based Amorphous Alloys Produced by Low-Pressure Die-Casting.....	51
<i>B. Gun, K.J. Laws, and M. Ferry</i>	

Atomic Study and Processing

Local Structural Fluctuations in a Supercooled Liquid	59
<i>R.S. Aga, J.R. Morris, V. Levashov, and T. Egami</i>	

Optimizing Chemistry of Bulk Metallic Glasses for Improved Thermal Stability.....	65
<i>G.S. Dulikravich, and I.N. Egorov</i>	

Processing and Characterization

Atom Probe Tomography Characterization of a Gas Atomized Metallic Glass.....	77
<i>M. Miller, S. Venkataraman, J. Eckert, L. Schultz, and D. Sordelet</i>	

Physical Properties

Fabrication of Amorphous Alloy Surface Composites by High-Energy Electron-Beam Irradiation	89
<i>K. Lee, S. Lee, and N.J. Kim</i>	
Metallic Glass Layers Produced by High Power Lasers.....	99
<i>D.T.A. Matthews, V. Ocelík, and J.Th.M. de Hosson</i>	
Numerical Prediction and Experiments on Casting Fe-Based Bulk Amorphous Strips on a Twin Roll Caster and on a Horizontal Single Belt Strip Caster	109
<i>D. Li, M. Isac, R.I.L. Guthrie, J. Wright, C. Qiu, F. Hamel, and S. Turcotte</i>	
Production of High Quality Bulk Metallic Glass Samples by Low-Pressure Die-Casting	119
<i>K.J. Laws, B. Gun, and M. Ferry</i>	

Processing and Mechanical Behaviors

Mechanical Property of a Zr-Based Metallic Glass at 300 K and 77 K	129
<i>H. Li, K. Tao, C. Fan, H. Choo, and P.K. Liaw</i>	
Production of High Iron Content Amorphous Steels Without the Use of Rare Earth Elements	135
<i>J. Cheney, and K. Vecchio</i>	
Cu-Based Bulk Metallic Glass Composites Containing In-Situ TiC and TiB Particles	145
<i>H. Wang, H.M. Fu, H.F. Zhang, and Z.Q. Hu</i>	

Characterization and Mechanical Behaviors

Densification Mechanism in Warm Extrusion of Al-Ni-Ce-Fe-Cu Alloy Powder Containing Amorphous Phase.....	155
<i>Y. Liu, Z. Liu, S. He, S. Guo, and B. Huang</i>	
The Effect of Pre-Annealing on Crystallization and Deformation Behavior of a Zr-Based Bulk Metallic Glass.....	163
<i>M.S. Kim, H.-J. Jun, K.S. Lee, and Y.W. Chang</i>	
Author Index	171
Subject Index	173

Author Index

A

Aga, R.S., 59

B

Buchanan, R.A., 21

Busch, R., 45

C

Chang, Y.W., 163

Cheney, J., 135

Choo, H., 3, 129

D

de Hosson, J.Th.M., 99

Dulikravich, G.S., 65

E

Eckert, J., 77

Egami, T., 59

Egorov, I.N., 65

F

Fan, C., 129

Fan, G.J., 3

Ferry, M., 51, 119

Fu, H.M., 145

G

Gun, B., 51, 119

Guo, S., 155

Guthrie, R.I.L., 109

H

Hamel, F., 109

He, S., 155

Hu, Z.Q., 145

Huang, B., 155

I

Inoue, A., 13, 21

Isac, M., 109

J

Jiang, W.H., 3

Jun, H.-J., 163

K

Kim, M.S., 163

Kim, N.J., 89

Kruzic, J.J., 45

L

Launey, M.E., 45

Laws, K.J., 51, 119

Lee, K., 89, 163

Lee, S., 89

Levashov, V., 59

Li, D., 109

Li, H., 129

Liaw, P.K., 3, 21, 129

Liu, F.X., 3

Liu, Y., 155

Liu, Z., 155

Louzguine-Luzgin, D.V., 13

M

Matthews, D.T.A., 99

Miller, M., 77

Morris, J.R., 59

O

Ocelík, V., 99

Q

Qiu, C., 109

S

Schultz, L., 77

Sordelet, D., 77

T

Tao, K., 129

Turcotte, S., 109

V

Vecchio, K., 135

Venkataraman, S., 77

W

Wang, G.Y., 3

Wang, H., 145

Wright, J., 109

Y

Yokoyama, Y., 21

Z

Zhang, H.F., 145

Subject Index

α Parameter, 135

A

Al-Based Alloy, 155

Alloy Chemistry, 65

Alloys Design, 65

Amorphous Alloy, 89

Amorphous Steel, 135

Atom Probe Tomography, 77

B

Bulk Metallic Glass(es) (BMG), 3, 13, 51, 119, 145, 155, 163

Bulk Metallic Glass(es) (BMG) Composites, 145

C

Casting Defects, 119

Charpy Impact Test, 21

Compression Test, 163

Cryogenic Temperature, 129

Crystalline Phase Particle, 89

Crystallization, 51

Cu-Based Bulk Metallic Glass(es) (BMG), 145

D

Deformation, 51

Deformation Behavior, 163

Densification Mechanism, 155

Die Casting, 119

Ductility, 145

E

Eutectic, 135

F

Fatigue, 45

Fatigue Limit, 21

Fe-Based Amorphous Alloys, 109

Fracture, 45

Free Volume, 21, 45

G

Glass Transition, 59

H

Hardness, 99

High-Energy Electron Beam Irradiation, 89

Horizontal Single Belt Strip Casting, 109

L

Laser, 99

M

Mechanical Behavior, 45, 129

Metallic Glass(es), 65, 77, 99, 129

Molecular Dynamics, 59

Multi-Objective Optimization, 65

N

Nanoscale Icosahedral Phase, 13

P

Plastic Deformation, 3

Powder Metallurgy, 155

Pre-Annealing, 163

R

Rapid Cooling, 109

Rapid Solidification, 77

S

Shear Band, 3

Sliding Wear, 99

Solidification, 119

Structural Relaxation, 21, 45

Supercooled Liquid(s), 51, 99

Surface Composites, 89

Surface Treatment, 99

T

Twin Roll Casting, 109

V

Vickers Hardness, 21

Z

Zr-Cu-Al Bulk Glassy Alloy, 21