Contents

Symposium on Dynamic Deformation: Constitutive Modeling, Grain Size, and Other Effects–In Honor of Prof. Ronald W. Armstrong

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Foreword

Ronald W. Armstrong

Introduction:

This group of papers represents the proceedings of the Third TMS/ASM sponsored Symposium on "Dynamic Behavior of Materials". The symposium was held in honor of Professor Ronald Armstrong and took place at the TMS Annual Meeting in San Diego, CA, March 2-7, 2003. The first symposium under this same title was held during the TMS/ASM Fall Meeting in Rosemont, IL, during October 3-5, 1994. A number of the papers presented at that symposium were published in *Metallurgical and Materials Transactions,* Volumes 26A, October 1995 and 27A, July 1996. A second symposium was also held in Rosemont, IL, during the TMS/ASM Fall Meeting, October 11-15, 1998. Some of those papers also were published in *Metallurgical and Materials Transactions,* Volume 31A, 2000, mid-March issue. The good reception of the two symposia, measured by the excellent participations in terms of the number and quality of the papers presented, and the audience attendance, stimulated the planning for this third 2003 symposium, which by the same measure was even more successful. The current volume contains twenty papers that resulted from over sixty presentations. The theme of this symposium was expanded to include grain-size effects, a research area to which Professor Armstrong has made notable contributions.

Prof. Armstrong was educated at Johns Hopkins University and Carnegie Institute of Technology (now part of Carnegie Mellon University). A post-doctoral year was spent at the Houldsworth School of Applied Science, Leeds University, England. After being at Westinghouse Research Laboratory, Ronald Armstrong held tenured appointments at Brown University and the University of Maryland, where he is currently professor emeritus. Additional overseas visiting appointments were spent at the CSIRO Division of Tribophysics, University of Melbourne, Australia; the University of Cambridge, England; and, the University of Strathclyde, Glasgow, Scotland. And, in the United States, research periods were spent at the U.S. Steel E.C. Bain Research Laboratory, PA; Lawrence Livermore National Laboratory, CA; Oak Ridge National Laboratory, TN; Institute for Defense Analyses, VA; United Technologies Research Center, CT; National Science Foundation, Science Education Directorate; National Institute of Standards and Technology; Naval Research Laboratory; Office of Naval Research, European Scientific Office, London; David Taylor Naval Ship Research and Development Center, Annapolis, MD; Naval Surface Warfare Center, Silver Spring, MD; Laboratory for Physical Science, College Park, MD; and, Johns Hopkins University, Baltimore, MD. He was the Founding Director of the Center for Energetic Concepts Development (CECD); a research cooperation between the University of Maryland and the Indian Head Division of the U.S. Naval Sea Systems Command. Most recently, a tour of duty was spent as Senior Scientist at the Air Force Research Laboratory, Munitions Directorate, Eglin AFB, FL. Professor Armstrong's research activities have led to more than 300 publications on topics including:

(1) dislocation mechanics descriptions of the polycrystal grain size dependence of mechanical properties, with N.J. Petch, and temperature and strain rate constitutive equation influences, with F.J. Zerilli;
(2) indentation hardness testing of energetic and inert crystals, with W.L. Elban;

(3) x-ray diffraction topography, in recent years with W.T. Beard, Jr.; and,
(4) micromechanical modeling of shock waves and detonation.

Ronald Armstrong received the Robert Lansing Hardy Gold Medal from TMS-AIME in 1962. He was a Senior Fulbright–Hays Research Fellow at the DSIR Physics and Engineering Laboratory, New Zealand, in 1974; and, in 1984 was Research Fellow, now Life Member, at Clare Hall, University of Cambridge, England. NATO Advanced Study Institute lectures were given on x-ray diffraction topography, in England in 1979, and on deformation of energetic crystals, in Crete in 1985. He was made Fellow of the American Society of Metals, 1985; the Materials Research Society of India, 1995; and, the Indian Institute of Metals, 1996. Recent book projects include: (1) the co-edited Materials Research Society Proceedings Volume 800; "Synthesis, Characterization, and Properties of Energetic/Reactive Nanomaterials", (MRS, Warrendale, PA, 2004); and, (2) the co-authored textbook "Deformable Bodies and Their Material Behavior", (John Wiley & Sons, Inc., NY, 2004).

It is interesting to note that Prof. Armstrong and Charles E. Feltner organized, in 1969, the Metallurgical Society of AIME: Institute of Metals Division Symposium "Deformation and Strength of Polycrystals". Leading researchers in crystal and polycrystal plasticity and grain size effects were brought together. The symposium included Fred Kocks (on single crystal/polycrystal relationships), Fred Rhines (on polycrystal stereology), James Li and Russell Chou (on dislocation pile-ups), and Charles Feltner and Thomas Johnston, (on the influence of slip character on the flow stress/grain size dependence). Armstrong contributed in the area of other grain size affected material strength properties. The proceedings were published in the first volume of *Metallurgical Transactions* as the new combined TMS-AIME and ASM journal: (*Metall. Trans*., Vol. 1, 1970). Hence this symposium, over thirty years later, is a fitting celebration to this occasion.

Symposium Theme:

The dynamic behavior of materials encompasses a broad range of phenomena with technological applications in military and civilian sectors. The field of dynamic behavior of materials comprises diverse phenomena such as deformation, fracture, fragmentation, shear localization, chemical reactions under extreme conditions, and processing (combustion synthesis; shock compaction; explosive welding and fabrication; shock and shear synthesis of novel materials). It has evolved considerably in the past twenty years and is now at a mature stage. This evolution has placed this field at a level of recognition comparable to fatigue, creep, and fracture. In extension of quasi-static deformation and fracture influences, the following effects play an increasingly important role in dynamic events:

1) *Mass inertia*; this leads to the propagation of elastic, plastic, and shock waves.
2) *Thermal inertia*: this leads to thermo-viscoplastic instabilities, most commonly known as adiabatic shear bands.
3) *Thermal activation and viscosity*: the behavior of dislocations, the primary carriers of plastic deformation, is strongly influenced by the imposed rate of material deformation. Dynamically imposed deformations drive dislocations into regimes unattainable under quasi-static deformation.

It is recognized today, as evidenced by the contributions herein, that materials aspects are of utmost importance in dynamic events. The macromechanical and physical processes that govern the phenomena manifest themselves, at the micro structural level, by a dazzling complexity of defect configurations and effects. Nevertheless, these processes/mechanisms can be quantitatively treated on the basis of accumulated knowledge. We are entering an exciting stage where our capabilities, from continuum and molecular dynamics computations, enable realistic predictions of material performances and are starting to guide not only the design process but also our further micromechanical understanding of deformation processes at every level, including the basic dislocation mechanisms.

The multiple technologies applications of this field include crashworthiness, machining, and the important military effects of armor and projectile designs, ballistic penetrations, and explosive dynamics, leading, in general, to the design of conventional and nuclear weapons. The dynamic behavior of materials during processing, including during compaction, synthesis, welding, forming, etc., is also of considerable importance. The symposium organizers hope that, through the publication of the present symposium articles, the materials community will become more exposed to this research field that has often been relegated to more specialized symposia, for example, the EXPLOMET series of conferences. The somewhat parallel TMS/ASM tradition now generated here, from the three dynamic deformation symposium proceedings, is hoped to be extended by holding such continuing symposia every four or five years. Indeed, the thought is in mind, perhaps, of transitioning the EXPLOMET conference series, started in 1980, to the broader TMS/ASM forum.

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