Preface

This book is the second volume of *Solids Volumes* in the *Shock Wave Science and Technology Reference Library.* These volumes are primarily concerned with high-pressure shock waves in solid media, including detonation and high-velocity impact and penetration events.

This volume contains four articles. The first two describe the reactive behavior of condensed-phase explosives, and the remaining two discuss the inert, mechanical response of solid materials. The articles are each self-contained, and can be read independently of each other. They offer a timely reference, for beginners as well as professional scientists and engineers, covering the foundations and the latest progress, and include burgeoning development as well as challenging unsolved problems.

The first chapter, by S. Sheffield and R. Engelke, discusses the shock initiation and detonation phenomena of solids explosives. The article is an outgrowth of two previous review articles: "Explosives" in vol. 6 of *Encyclopedia of Applied Physics* (VCH, 1993) and "Initiation and Propagation of Detonation in Condensed-Phase High Explosives" in *High-Pressure Shock Compression of Solids III* (Springer, 1998). This article is not only an updated review, but also offers a concise heuristic introduction to shock waves and condensed-phase detonation. The authors emphasize the point that detonation is not an uncontrollable, chaotic event, but that it is an orderly event that is governed by and is describable in terms of the conservation of mass, momentum, energy and certain material-specific properties of the explosive.

The article, written by two leading experimentalists in the field, is an excellent introductory or refresher reading for any class or workshop on condensed-phase detonation with focus on shock initiation and hydrodynamic phenomena. It also offers a quick reading of the most recent progress. The article compliments the chapter by M.R. Baer on "Mesoscale Modeling of Shocks in Heterogeneous Reactive Materials" in the first volume of the *Shock Wave Science and Technology Reference Library* (*High-Pressure Shock Compression of Solids II*).

The second chapter, by F. Zhang, S. Alavi, A. Hu and T.K. Wo, presents an overview of first-principles quantum-mechanical simulation of energetic materials, and select applications at high static and dynamic pressures. The latter are taken from their own studies on the dissociation of nitromethane and high-pressure, nonmolecular solid phases of polynitrogen. They are a testament not only to the progress made in inexpensive computing technology, but also to the power of the first-principles approach in gaining a basic understanding of materials at atomic scales. As is the case for the first article, it is thematically related to "What Is a Shock Wave to an Explosive Molecule" by C.M. Tarver in *High-Pressure Shock Compression of Solids VI* (Springer, 2003). In this field a few years is a long time, but the 2003 ITRI study "*Molecular Dynamics Simulations of Detonation Phenomena*", chaired by B.L. Holian, is still a valuable source of information.

The third chapter, "Combined Compression and Shear Waves," is a comprehensive topical review by two leading researchers in the field. It begins with a historical introduction, and is followed by an in-depth discussion of (1) the general theory for the combined waves in linear and nonlinear elastic solids and elastic-plastic solids and (2) a description of experimental and diagnostic methods for the combined *plane* waves. These techniques offer the fundamental value of enabling more complete characterizations of the shock-compressed state, as well as the state that is distinctly different from the principal Hugoniot. Only recently, the isentropic compression experiment (ICE) provided an alternative well-controlled method of determining off-Hugoniot states with good diagnostics. For the ICE, the reader is referred to the article by M.D. Knudson in *High-Pressure Shock Compression of Solids 1* of the *Shock Wave Science and Technology Reference Library.*

The section on applications includes investigations of rate-dependent plasticity in Al and Ti alloys, solid-state phase transformations in calcium carbonate and cadmium sulfate, high strain rate deformation of Al_2O_3, SiC and poly(methyl methacrylate), and sliding friction between WC and 4340 steel. The last example illustrates the potentials of the combined pressure and shear methods for investigating the response of dynamic materials that may not be accessible by other methods.

The fourth chapter is concerned with dynamic fragmentation of solids. The author is one of the leading authorities, if not the leading authority on the subject. He has written, among others, a review article entitled "Spall and Fragmentation in High-Temperature Metals" that appeared in *High-Pressure Shock Compression of Solids II* (Springer, 1995) and a definitive book "*Fragmentation of Rings and Shells*" (Springer, 2006). The current article, however, is a self-contained, book-length discourse on dynamic fragmentation, including many recent results from his own work, as well as insightful critiques of current thinking.

The article begins with select probabilistic issues associated with the phenomena of fragmentation, including both historic and recent theories. The introduction is followed by a survey and critical review of predictive methods for fragment size distributions by empirical and physics-based approaches. Special attention is focused on the unique features of dynamic fragmentation in brittle materials. A critical and insightful review is provided of several key ideas, such as the fractal nature of brittle fragmentation and the similarity between hydrodynamic turbulence and brittle fragmentation. Aspects of impact spall processes are explored as a special example of dynamic fragmentation.

This article is not only an authoritative reference, but is also an excellent graduate-level text for a one-semester course on the dynamic fragmentation of solids.

Eglin
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Yasuyuki (Yuki) Horie
AFRL/RWME

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