

*High-Pressure Shock Compression of  
Condensed Matter*

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# Solids Under High-Pressure Shock Compression

Mechanics, Physics, and Chemistry

With 98 Illustrations



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R.A. Graham  
Sandia National Laboratories  
Advanced Materials Physics Department  
Albuquerque, NM 87185-5800  
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# Dedication

Two hundred years ago, John Adams expressed my sentiments on priorities better than I can.

“Let me have my Farm, Family and Goose Quil, and all the Honours and Offices this world can bestow may go to those who deserve them better and desire them more. I covet them not.”

This book is dedicated to Barbara, the love of my life, my constant companion and supporter, the mother of our children, “Abi” to our grandchildren. Through strength, devotion, and love of humanity, she made the lives of so many that she touched happy. Because she lived, the world is a better place.

# Preface

The period from 1955 to 1985 will certainly be viewed as the golden age of shock-compression science. During that period the field grew from first recognition as a distinct scientific field with contributions from only a few highly innovative scientists to a many-faceted, broadly based discipline with major contributions to scientific knowledge and industrial technology. Scientists worldwide responded with vigor to the opportunity to study the properties of matter at unprecedented pressures and at unprecedented speeds. The scientific base grew to a world-wide science. As a result, our knowledge of geophysics, planetary physics, and astrophysics has been substantially improved with high pressure equation of state and polymorphic phase transformation data. Shock processes have become standard industrial methods in materials synthesis and processing. Shock-compression data have become the standard for the static high pressure scale. Elastic, viscoelastic, and viscoplastic deformation of solids at the highest of strain rates has been substantially defined. Large deformation elastic, piezoelectric, and dielectric properties have been studied. Chemical synthesis has been routinely carried out at unusually high pressures. Physical properties of solids have been studied at unusually high defect concentrations. Time resolution of measurement has been improved by perhaps 3 orders of magnitude. The technology has moved from remote sites to university laboratories. Characterizations of shock-compressed matter have been broadened and enriched with involvements of the fields of physics, electrical engineering, solid mechanics, metallurgy, geophysics, and materials science.

In spite of these accomplishments, shock-compression science is not documented in book form. The volumes in this series of books attempt to remedy that deficiency. The description of shock-compressed matter derived from physical and chemical observations, as presented in this book, is significantly different from that derived strictly from mechanical characteristics, which are the classical descriptions. It is hoped that the book will provide an adequate introduction for interested scientists and engineers.

This book is an edited and significantly expanded version of a dissertation presented to the Tokyo Institute of Technology in partial fulfillment of the

requirements for a Doctor of Science Degree in Materials Science and Engineering. The degree was under the direction of Professor Akira B. Sawaoka. Given the press of time in an active research career, it is unlikely that the book would have been written without the requirement to write the dissertation. Much of the content of this book is developed from information in the substantial review by Lee Davison and me. That review contained over 800 references. This book adds over 100 references dated since that review.

The author has been given that superlative scientific opportunity of participating in the early development of a rapidly growing field in an unusually capable and rapidly growing research group. The solid state physics research group that nurtured the work has left its indelible mark. Certainly, this book reflects the influence of many colleagues and coauthors to whom the author is deeply indebted. They are so numerous that perhaps it is best not to attempt to list them individually. The author is deeply appreciative of the consistent and persistent support for his work from his Sandia managers and supervisors, who have performed that task with the greatest of skill and wisdom.

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