

Lee Davison  
Y. Horie  
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Editors

# High-Pressure Shock Compression of Solids IV

Response of Highly Porous  
Solids to Shock Loading



Springer

# High Pressure Shock Compression Of Solids

**L.C. Chhabildas, Lee Davison, Y. Horie**



## **High Pressure Shock Compression Of Solids:**

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example the temperature may be as high as a few electron volts 1 eV 11 500 K for very strong shocks and the densification may be as high as four times the normal density **High-Pressure Shock Compression of Solids II** Lee Davison, Dennis E. Grady, Mohsen Shahinpoor, 2012-12-06 This volume concerns the fracture and fragmentation of solid materials that occurs when they are subjected to extremes of stress applied at the highest possible rates The plan for the volume is to address experimental theoretical and computational aspects of high rate dynamic fracture and fragmentation with emphasis on recent work We begin with several chapters in which the emphasis falls on experimental methods and observations These chapters address both macroscopic responses and the microscopic cause of these responses This is followed by several chapters emphasizing modeling the physical explanation and mathematical representation of the observations Some of the models are deterministic while others focus on the stochastic aspects of the observations Often the overall objective of investigation of dynamic fracture and fragmentation phenomena is provision of a means for predicting the entire course of an event that begins with a stimulus such as an impact and proceeds through a complicated deformation and fracture process that results in disintegration of the body and formation of a rapidly expanding cloud of debris fragments Analysis of this event usually involves development of a continuum theory and computer code that captures the experimental observations by incorporating models of the important phenomena into a comprehensive description of the deformation and fracture process It is to this task that the work of the last few chapters is devoted **High-pressure Shock Compression of Solids**, 1993

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examination of the shock compressed solid material Shock waves are also prevalent in the larger universe and have played a prominent role in shaping the solar system as we know it The material in interstellar gas and dust clouds comets etc is processed by shock waves producing important chemical effects including formation of complex organic molecules The process of accretion of planets involves impacts of dust particles at relative velocities ranging from a fraction of a millimeter per second to impacts of larger bodies at velocities as great as several tens of kilometers per second The resulting shock waves cause both chemical and physical changes that are manifest in the bodies involved

**High-Pressure Shock Compression of Solids IV** Lee Davison,Y. Horie,Mohsen Shahinpoor,2012-12-06 Much of the current interest in shock compression of porous solids stems from the desire to bond hard refractory powders into strong and dense solids However while much is known about the effects of shock compression on monolithic materials the unusual physical and chemical processes that take place when a porous medium is shocked have been little studied thus far This volume with contributions by leading researchers in condensed matter physics physical chemistry metallurgy mechanics and materials science begins to address that gap The focus is on heterogeneous deformation mechanisms nonequilibrium thermodynamics and chemical processes The contributions discuss such topics as modeling the complex interplay of thermal mechanical and chemical processes experimental data on pore collapse and their interpretation and synthesis of new materials through shock induced chemical reactions By presenting not only the most recent results but also the open questions that remain these essays convey the excitement of developing a scientific basis for understanding shock compression of highly porous solids Topics covered include Shock Compression Science in Highly Porous Solids Shock Loading of Porous High Explosives Continuum Mixture Modeling of Reactive Porous Media Two Phase Media Model of Shock Compression with Chemical reaction Constitutive Modeling of Shock Induced Reactions in Powder Mixtures Discrete element Modeling of Shock Processes in Powders

**High-Pressure Shock Compression of Solids VIII** L.C. Chhabildas, Lee Davison,Y. Horie,2004-12-13 Research in the field of shock physics and ballistic impact has always been intimately tied to progress in development of facilities for accelerating projectiles to high velocity and instrumentation for recording impact phenomena The chapters of this book written by leading US and European experts cover a broad range of topics and address researchers concerned with questions of material behaviour under impulsive loading and the equations of state of matter as well as the design of suitable instrumentation such as gas guns and high speed diagnostics Applications include high speed impact dynamics the inner composition of planets syntheses of new materials and materials processing Among the more technologically oriented applications treated is the testing of the flight characteristics of aeroballistic models and the assessment of impacts in the aerospace industry

**High-Pressure Shock Compression of Solids VII** Vladimir E. Fortov,L.V. Altshuler,R.F. Trunin,A.I. Funtikov,2013-03-09 Presenting some of the most recent results of Russian research into shock compression as well as historical overviews of the Russian research programs into shock compression this volume will provide Western researchers

with many novel ideas and points of view The chapters in this volume are written by leading Russian specialists various fields of high pressure physics and form accounts of the main researches on the behavior of matter under shock wave interaction The experimental portions contain results of studies of shock compression of metals to high and ultra high pressure shock initiation of polymorphic transformations strength fracture and fragmentation under shock compression and detonation of condensed explosives There are also chapters on theoretical investigations of shock wave compression and plasma states in regimes of high pressure and high temperature The topics of the book are of interest to scientists and engineers concerned with questions of material behavior under impulsive loading and to the equation of state of matter Application is to questions of high speed impact inner composition of planets verification of model representations of material behavior under extreme loading conditions syntheses of new materials development of new technologies for material processing etc Russian research differs from much of the Western work in that it has traditionally been wider ranging and more directed to extremes of response than to precise characterization of specific materials and effects Western scientists could expect to benefit from the perspective gained from close knowledge of the Russian work

#### **High-Pressure Shock Compression of Solids VI**

Yasuyuki Horie, Lee W. Davison, Naresh N. Thadani, 2003 Both experimental and theoretical investigations make it clear that mesoscale materials that is materials at scales intermediate between atomic and bulk matter do not always behave in ways predicted by conventional theories of shock compression At these scales shock waves interact with local material properties and microstructure to produce a hierarchy of dissipative structures such as inelastic deformation fields randomly distributed lattice defects and residual stresses A macroscopically steady planar shock wave is neither plane nor steady at the mesoscale The chapters in this book examine the assumptions underlying our understanding of shock phenomena and present new measurements calculations and theories that challenge these assumptions They address such questions as What are the experimental data on mesoscale effects of shocks and what are the implications Can one formulate new mesoscale theories of shock dynamics How would new mesoscale theories affect our understanding of shock induced phase transitions or fracture And what new computational models will be needed for investigating mesoscale shocks

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*Solids Under High-Pressure Shock Compression* R.A.

Graham, 2012-12-06 Since the 1950s shock compression research contributed greatly to scientific knowledge and industrial technology As a result for example our understanding of meteorite impacts has substantially improved and shock processes have become standard industrial methods in materials synthesis and processing Investigations of shock compressed matter involve physics electrical engineering solid mechanics metallurgy geophysics and materials science The description of shock compressed matter presented here which is derived from physical and chemical observations differs significantly from the classical descriptions derived from strictly mechanical characteristics This volume with over 900 references provides an introduction for scientists and engineers interested in the present state of shock compression science

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**Shock Compression of Solids VI** Yasuyuki Horie, Lee Davison, Naresh Thadani, 2012-12-06 Both experimental and theoretical investigations make it clear that mesoscale materials that is materials at scales intermediate between atomic and bulk matter do not always behave in ways predicted by conventional theories of shock compression At these scales shock waves interact with local material properties and microstructure to produce a hierarchy of dissipative structures such as inelastic deformation fields randomly distributed lattice defects and residual stresses A macroscopically steady planar shock wave is neither plane nor steady at the mesoscale The chapters in this book examine the assumptions underlying our understanding of shock phenomena and present new measurements calculations and theories that challenge these assumptions They address such questions as What are the experimental data on mesoscale effects of shocks and what are the implications Can one formulate new mesoscale theories of shock dynamics How would new mesoscale theories affect our understanding of shock induced phase transitions or fracture What new computational models will be needed for investigating mesoscale shocks

**High-Pressure Shock Compression of Solids VIII** L.C. Chhabildas, Lee Davison, Y. Horie, 2010-10-21 Research in the field of shock physics and ballistic impact has always been intimately tied to progress in development of facilities for accelerating projectiles to high velocity and instrumentation for recording impact phenomena The chapters of this book written by leading US and European experts cover a broad range of topics and address researchers concerned with questions of material behaviour under impulsive loading and the equations of state of matter as well as the design of suitable instrumentation such as gas guns and high speed diagnostics Applications include high speed impact dynamics the inner composition of planets syntheses of new materials and materials processing Among the more technologically oriented applications treated is the testing of the flight characteristics of aeroballistic models and the assessment of impacts in the aerospace industry

Shock Wave Science and Technology Reference Library, Vol. 3 Yasuyuki Horie, 2008-09-18 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 Sheild 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 d

onation 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

**Shock Wave Reflection Phenomena** Gabi Ben-Dor, 2007-08-28 This book is a comprehensive state of the knowledge summation of shock wave reflection phenomena from a phenomenological point of view It includes a thorough introduction to oblique shock wave reflections dealing with both regular and Mach types It also covers in detail the corresponding two and three shock theories The book moves on to describe reflection phenomena in a variety of flow types as well as providing the resolution of the Neumann paradox

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**Static Compression of Energetic Materials** Suhithi M. Peiris, Gasper J. Piermarini, 2009-01-03 Developing and testing novel energetic materials is an expanding branch of the materials sciences Reaction detonation or explosion of such materials invariably produce extremely high pressures and temperatures To study the equations of state EOS of energetic materials in extreme regimes both shock and static high pressure studies are required The present volume is an introduction and review of theoretical experimental and numerical aspects of static compression of such materials Chapter 1 introduces the basic experimental tool the diamond anvil pressure cell and the observational techniques used with it such as optical microscopy infrared spectrometry and x ray diffraction Chapter 2 outlines the principles of high nitrogen energetic materials synthesis Chapters 3 and 4 examine and compare various EOS formalisms and data fitting for crystalline and non crystalline materials respectively Chapter 5 details the reaction kinetics of detonating energetic materials Chapter 6 investigates the interplay between static and dynamic shock studies Finally Chapters 7 and 8 introduce numerical simulations molecular dynamics of energetic materials under either hydrostatic or uni



axial stress and ab initio treatments of defects in crystalline materials This timely volume meets the growing demand for a state of the art introduction and review of the most relevant aspects of static compression of energetic materials and will be a valuable reference to researchers and scientists working in academic industrial and governmental research laboratories

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