

# Fracture Nanomechanics

2nd edition

Takayuki Kitamura • Takashi Sumigawa  
Hiroyuki Hirakata • Takahiro Shimada



# Fracture Nanomechanics Second Takayuki Kitamura

**Jin-Ying Zhang**



## **Fracture Nanomechanics Second Takayuki Kitamura:**

Fracture Nanomechanics Takayuki Kitamura, Hiroyuki Hirakata, Takashi Sumigawa, Takahiro Shimada, 2011-09-06 Small structures of the micro nanometer scale such as electronic optic devices and MEMS NEMS have been developed and the size of their elements now approaches the nano atomic scale This book discusses the fracture behavior of nano atomic elements nanofilms nanowires and so on and focuses on the initiation and propagation of interface crack and mechanical instability criterion of atomic structures This covers the fundamentals and the applicability of the top down conventional fracture mechanics to nanoscale and bottom up atomic mechanics including ab initio simulation concepts New areas such as multiphysics characteristics of nanoelements are introduced as well Fracture Nanomechanics, Second Edition Takayuki Kitamura, Hiroyuki Hirakata, Takashi Sumigawa, Takahiro Shimada, 2015-12-31 Materials of micro nanometer dimensions have aroused remarkable interest motivated by the diverse utility of unconventional mechanical and electronic properties distinguished from the bulk counterpart and various industrial applications such as electronic optic devices and MEMS NEMS The size of their elements is now ultimately approaching nanometer and atomic scales Since the conventional theory of fracture mechanics is based on the continuum body approximation its applicability to the nanoscale components is questionable owing to the discreteness of atoms Moreover for describing the fracture behavior of atomic components it is necessary to understand not only the mechanical parameters e g stress and strain but also the fracture criterion in the atomic scale This book systematically provides recent understanding of unusual fracture behaviors in nano atomic elements nanofilms nanowires etc and focuses on the critical initiation and propagation of interface crack and the mechanical instability criteria of atomic structures through the introduction of state of the art experimental and theoretical techniques It covers the fundamentals and the applicability of top down conventional fracture mechanics to nanoscale and bottom up atomistic mechanics including quantum mechanical effects concepts This second edition of Fracture Nanomechanics newly includes dramatic advances in unconventional fracture mechanics in nanofilms extraordinary fatigue mechanics and mechanisms in nanometals and a new area of multiphysics properties in nanoelements **Fracture Nanomechanics** Takayuki Kitamura, Hiroyuki Hirakata, Takashi Sumigawa, Takahiro Shimada, 2016-01-06 Materials of micro nanometer dimensions have aroused remarkable interest motivated by the diverse utility of unconventional mechanical and electronic properties distinguished from the bulk counterpart and various industrial applications such as electronic optic devices and MEMS NEMS The size of their elements is now ultimately approaching nano *Advances in Heterogeneous Material Mechanics 2008* Jinghong Fan, Haibo Chen, 2008 The International Conference on Heterogeneous Material Mechanics ICHMM in Huangshan China June 3 8 2008 follows the successful inaugural ICHMM held in ChongQing China in June 2004 The ICHMM series is the first international forum that focuses exclusively on various issues related to the behavior of heterogeneous materials in a broad sense The object of the ICHMM is to present and publicize integrated scientific and

engineering approaches to the measurement and modeling of phenomena at the interface of materials science physics chemistry biology and solid mechanics Preface p xxxix      **Fracture Nanomechanics** Takayuki Kitamura,2011      **Special Issue on Nanomechanics and Nanofracture** W. W. Gerberich,International Conference on Fracture,1998      **Fracture mechanics : twenty-second symposium. 2** S. N. Atluri,1992      Progress in Fracture Mechanics George C. Sih,D. François,1983      **Fracture of Nano and Engineering Materials and Structures** E.E. Gdoutos,2008-01-08 The 16th European Conference of Fracture ECF16 was held in Greece July 2006 It focused on all aspects of structural integrity with the objective of improving the safety and performance of engineering structures components systems and their associated materials Emphasis was given to the failure of nanostructured materials and nanostructures including micro and nano electromechanical systems MEMS and NEMS      *Fracture, Plasticity, Micro- and Nanomechanics* ,2009      **Proceedings of the National Symposium on Fracture Mechanics** National Symposium on Fracture Mechanics,American Society for Testing and Materials. Committee on Fracture Testing of Metals,1976      *Non-Linear Fracture* W.G. Knauss,Ares J. Rosakis,2013-03-09 From time to time the International Journal of Fracture has presented special matters thought to be of interest to its readers In previous issues for example Dr H W Liu as Guest Editor assembled a series of review papers dealing with fatigue processes and characteristics in metals and non metals December 1980 and April 1981 Five years ago Guest Editor W G Knauss collected works dealing with dynamic fracture March and April 1985 Continuing this policy Dr W G Knauss and Dr A J Rosakis of the California Institute of Technology as Guest Editors have now organized an extensive set of papers concerning the influence of non linear effects upon the mechanics of the fracture process This collection is based upon contributions to a relatively small international Symposium on Non Linear Fracture Mechanics held under the auspices of the International Union of Theoretical and Applied Mechanics IUTAM and convened at the California Institute of Technology in March 1988 It should be noted that although the description of non linear fracture inherently encompasses a strong material science component this aspect is not heavily emphasized in the ensuing papers due to the intentional focus upon mechanics Volume 42 of the International Journal of Fracture will therefore in successive issues deal respectively with topics in 1 Damage 2 Interfaces and Creep 3 Time Dependence and 4 Continuum Plasticity On behalf of the editors and publishers I wish to express our appreciation to Dr Knauss Dr Rosakis and their colleagues for their collective efforts

**Special Issue on Nanomechanics and Nanofracture** ,1998      ECF 13 M. Fuentes,2000      Nonlinear Fracture Mechanics M. P. Wnuk,2014-09-01      Fracture micromechanics of polymer materials V.S. Kuksenko,Vitauts P. Tamusz,2014-03-14 Within the last two decades fracture theory has been one of the most rapidly advancing fields of continuous media mechanics Noteworthy success has been achieved in linear fracture mechanics where the propagation of the macrocrack in elastic materials is under study However fracture of materials is by no means a simple process since it involves fracture of structural elements ranging from atomic sizes to macrocracks To obtain all information about how and

why materials fail all stages of the process must be studied For a long time both mechanical engineers and physicists have been concerned with the problem of the fracture of solids Unfortunately most of their work has been independent of the others To solve the problem not only requires the minds and work of mechanical engineers and physicists but chemists and other specialists must be consulted as well In this book we will consider some conclusions of the physical and mechanical schools acquired by the A F Joffe Physics Technical Institute of the USSR Academy of Sciences in Leningrad and the Institute of Polymer Mechanics of Latvian SSR Academy of Sciences in Riga The methods for studying the phenomena of fracture applied at both Institutes are different yet complimentary to one another the materials tested are also sometimes different

**Micromechanics of Fracture in Generalized Spaces** Ihar Alaksandravich Miklashevich, 2008-01-08 By the detailed analysis of the modern development of the mechanics of deformable media can be found the deep internal contradiction From the one hand it is declared that the deformation and fracture are the hierarchical processes which are linked and unite several structural and scale levels From the other hand the sequential investigation of the hierarchy of the deformation and destruction is not carried out The book's aim is filling this mentioned gap and investigates the hot topic of the fracture of non ideal media From the microscopic point of view in the book we study the hierarchy of the processes in fractured solid in the whole diapason of practically used scales According the multilevel hierarchical system ideology under microscopic we understand taking into account the processes on the level lower than relative present strata From hierarchical point of view the conception of microscopic fracture can be soundly applied to the traditionally macroscopic area namely geomechanics or main crack propagation At the same time microscopic fracture of the nanomaterials can be well grounded too This ground demands the investigation on the level of inter atomic interaction and quantum mechanical description The important feature of the book is the application of fibred manifolds and non Euclidean spaces to the description of the processes of deformation and fracture in inhomogeneous and defected continua The non Euclidean spaces for the dislocations description were introduced by J F Nye B A Bilby E Kröner K Kondo in fiftieth In last decades this necessity was shown in geomechanics and theory of seismic signal propagation The applications of non Euclidean spaces to the plasticity allow us to construct the mathematically satisfying description of the processes Taking into account this space expansion the media with microstructure are understood as Finsler space media The bundle space technique is used for the description of the influence of microstructure on the continuum metrics The crack propagation is studied as a process of movement in Finsler space Reduction of the general description to the variational principle in engineering case is investigated and a new result for the crack trajectory in inhomogeneous media is obtained Stability and stochastization of crack trajectory in layered composites is investigated The gauge field is introduced on the basis of the structure representation of Lie group generated by defects without any additional assumption Effective elastic and non elastic media for nanomaterials and their geometrical description are discussed The monograph provides the basis for more detailed and exact description of real processes in the material The

monograph will be interesting for the researchers in the field of fracture mechanics solid state physics and geomechanics It can be used as well by the last year students wishing to become more familiar with some modern approaches to the physics of fracture and continual theory of dislocations In Supplement written by V V Barkaline quantum mechanical concept of physical body wholeness according to H Primas is discussed with relation to fracture Role of electronic subsystem in fracture dynamics in adiabatic and non adiabatic approximations is clarified Potential energy surface of ion subsystem accounting electron contribution is interpreted as master parameter of fracture dynamics Its features and relation to non euclidean metrics of defected solid body is discussed Quantum mechanical criteria of fracture arising are proposed Fracture Process Zone Zenzile Z. Brooks,Massachusetts Institute of Technology. Department of Civil and Environmental Engineering,2013 Cracks begin and end at a crack tip the Fracture Process Zone FPZ is a region of damage around the crack tip The context of this research is the FPZ in quasi brittle materials which is characterized by cracking at various scales This study focuses on crack propagation and FPZ development at a fundamental material scale the scale of the grain With regard to the FPZ the study seeks to understand how the FPZ develops and manifests in quasi brittle material what the physical and mechanical structure of the FPZ is and how pre existing material microstructure influences the developed FPZ The attainment of several research objectives marks the course of the investigation the development of a multi disciplinary technique to assess both intact and FPZ regions of quasi brittle material the assessment of the fundamental properties microstructure small scale mechanical properties of intact and FPZ quasi brittle material and a conceptual model of FPZ development in quasi brittle material In pursuit of these objectives the study uses nanoindentation to probe the nanomechanical properties of the FPZ for two marbles of varying grain size and microscopy to probe the structure of the FPZ at the grain scale The marbles are from Carrara Italy typical grain size 300 m and Danby Vermont typical grain size 520 m Grids of nanoindentations and microscopy were placed within the FPZ regions of Danby and Carrara marble specimens Both marbles exhibited lower nanomechanical properties near the crack tip and or near the area of future wing crack formation i e the FPZ However the Danby marble exhibited this trend over a larger distance and thus nanomechanically supports the increase of the FPZ with grain size The microscopy investigations suggested increased microcracking near FPZ regions and increased microcrack density with decreased grain size Ultimately the study provides four contributions to the study of fracture of quasi brittle materials an algorithm for the automatic assessment of microcracking from ESEM micrographs new nanomechanical information on the two marble types validation of the use of nanomechanics as a tool for identifying damage in quasi brittle materials and a quantitative assessment of the role of grain size in the damage of quasi brittle materials

**Fracture Mechanics** ,1961      **Nonlinear Fracture Mechanics** M.P. Wnuk,1990-12-11

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