

IUTAM Symposium on Size Effects on Material and Structural Behavior at
Micron- and Nano-Scales

SOLID MECHANICS AND ITS APPLICATIONS
Volume 142

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Aims and Scope of the Series

The fundamental questions arising in mechanics are: *Why?*, *How?*, and *How much?*
The aim of this series is to provide lucid accounts written by authoritative researchers giving vision and insight in answering these questions on the subject of mechanics as it relates to solids.

The scope of the series covers the entire spectrum of solid mechanics. Thus it includes the foundation of mechanics; variational formulations; computational mechanics; statics, kinematics and dynamics of rigid and elastic bodies; vibrations of solids and structures; dynamical systems and chaos; the theories of elasticity, plasticity and viscoelasticity; composite materials; rods, beams, shells and membranes; structural control and stability; soils, rocks and geomechanics; fracture; tribology; experimental mechanics; biomechanics and machine design.

The median level of presentation is the first year graduate student. Some texts are monographs defining the current state of the field; others are accessible to final year undergraduates; but essentially the emphasis is on readability and clarity.

For a list of related mechanics titles, see final pages.

IUTAM Symposium on Size Effects on Material and Structural Behavior at Micron- and Nano-Scales

Proceedings of the IUTAM Symposium held in
Hong Kong, China, 31 May–4 June, 2004

Edited by

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(Participants and organizers of the IUTAM Symposium on *Size Effects on Material and Structural Behavior at Micron- and Nano-Scales* at the Conference Hall of the University Center in the campus of Hong Kong University of Science and Technology on 1 June 2004).

Preface

The Symposium on “Size effects on material and structural behavior at micron- and nano-scales” was held from 31 May – 4 June, 2004 at the Hong Kong University of Science and Technology, Hong Kong. The aim of this symposium was to bring engineers, researchers and scientists from material science, biology, physics and mechanics together to discuss different aspects of and the latest advances in this active multi-discipline field. Sponsored by the International Union of Theoretical and Applied Mechanics (IUTAM), this 4-day symposium followed the tradition of IUTAM held in the single session format of IUTAM symposia. The scientific presentations and discussions focused on the following topics:

1. Behaviors of materials and structures at micron- and nanometer-scales;
2. Physical bases of size effects;
3. Adaptive and multi-functional behaviors of materials at small scales;
4. Size effects in fracture and phase transformation of solids;
5. Multi-scale modeling and simulation;
6. Microstructure and deformation with moving interfaces;
7. Size effects in material instability and its propagation.

Thirty five oral presentations were made by distinguished scholars. Theoretical, experimental and computational aspects of the subject were discussed and addressed in the symposium. Two round table discussions were held on the future research directions. The open and friendly environment provided excellent opportunities for stimulating discussion and intensive exchange of ideas among all participants. Also, local research graduate students participated in the meeting and involved in the organization of the Symposium.

A total of sixty registered participants (some of them are PhD students and post-doctorates) attended the technical sessions of the Symposium. Thirty five invited speakers came from eight countries: Australia (1), China mainland (10), France (3), USA (7), China Hong Kong (10), UK (1), Sweden (1), Germany (1), Poland (1), and Taiwan (1).

This volume collects twenty five written contributions to the Symposium from the invited speakers. Time and effort spent by these authors in participating in the meeting and preparing their manuscripts for this book is greatly appreciated. As in every successful scientific conference, financial support is an essential part of the symposium. Thanks are due to the IUTAM Bureau, the Research Grants Council of Hong Kong SAR, the National Natural Science Foundation of China, the US Army Research Office-Far East, the Hong Kong University of Science and Technology, and the Hong Kong Society of Theoretical and Applied Mechanics for sponsoring the meeting and providing partial funding to bring the international participants to Hong Kong.

Finally, the editors would like to thank all the speakers and contributors to this symposium for their invaluable contributions. The editors also wish to thank the

Organizing Committee for their dedicated work. Special thanks also are due to Kluwer Academic Publishers, for their effort and cooperation to produce this attractive Symposium Proceedings.

Qingping SUN, Hong Kong, China
and
Pin TONG, USA

October 2005

International Scientific Committee of the Symposium

P. Tong (Chairmen, Hong Kong, China),
N. Fleck (UK),
H. Gao (Germany),
J. Hutchinson (USA),
K.C. Hwang (Beijing, China),
W. Nix (USA),
A. Zaoui (France),
W. Zhong (Dalian, China),
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Sponsors

- IUTAM (The International Union of Theoretical and Applied Mechanics)
- RGC (Research Grant Council of Hong Kong SAR)
- US National Science Foundation (NSF)
- Kluwer Academic Publishers
- Hong Kong University of Science and Technology
- HKSTAM (The Hong Kong Society of Theoretical and Applied Mechanics)

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Program of the Symposium:

MONDAY MAY 31, 2004

- 09:00-09:30 **OPENING CEREMONY:** *P. Tong and Q.P. Sun*
Welcome address from the University Administration
- 09:30-10:00 Deformation and Diffusion in Nano-grained Metals
*Wei Yang, XinLing Ma, HongTao Wang, Wei Hong, Tsinghua
University, China*
- 10:00-10:30 **BREAK**
- Chair:** *K.C. Hwang*
- 10:30-11:00 Multiscale Analysis of Strength Enhancement of Cellular Materials
under Impact Loading
*H. Zhao, S. Abdenadher, I. Nasri, Laboratoire de Mécanique et
Technologie, ENS-Cachan/CNRS/University, France*
- 11:00-11:30 Micromechanics of Micropolar Composites
Gengkai Hu, Beijing Institute of Technology, China
- 11:30-12:00 An MD Investigation of the Size Effect on Multiscale Simulation of
Thin Film Delamination
Zhen Chen, Luming Shen, University of Missouri-Columbia, USA
- 12:00-14:00 **LUNCH**

Chair: J.H. Fan

14:00-14:30 Fracture Analysis in the Conventional Theory of Mechanism-based Strain Gradient (CMSG) Plasticity
K.C. Hwang, Tsinghua University, China
S. Qu, Y. Huang, H. Jiang, University of Illinois, Urbana
C. Liu, Materials Science and Technology Division, Los Alamos National Laboratory, Los Alamos
P.D. Wu, Alcan International Limited, Kingston Research and Development Center, Canada

14:30-15:00 Fractal and Scaling Phenomena on Fracture at Micro-scales
Chunsheng LU, Yiu-Wing MAI, The University of Sydney, Australia

15:00-15:30 **BREAK**

Chair: Y.W. Mai

15:30-16:00 A Multi-Scale Modeling Scheme for Sub-Micron Size Effects on Cyclic Plasticity
Jinghong Fan, Zhihui Gao, Xiangguo Zeng, Chongqing University, China
Jinghong Fan, Alfred University, USA

16:00-16:30 Level Set Simulations of the Formation of Dislocation Networks and Junctions
Yang Xiang, Hong Kong University of Science and Technology, HK
David J. Srolovitz, Weinan E, Princeton University, USA
Li-Tien Cheng, University of California, San Diego, USA

16:30-17:00 Issues and Challenges in Multiscale Modeling of Bio/Nano Systems
A.M. Rajendran, U.S. Army Research Office, RTP, NC 27709-2211, USA

18:00-19:00 **DINNER**

TUESDAY JUNE 1, 2004

Chair: H. Petryk

09:00-09:30 Nucleation of Phases and Local Minimizers of Energy
John Ball, University of Oxford, UK

09:30-10:00 Solid-solid Phase Transformations: Non-existence of One-dimensional Stress Problems, Model Equation and Uniqueness Conditions

Hui-Hui Dai, City University of Hong Kong, Hong Kong

10:00-10:30 **BREAK**

Chair: *H.H. Dai*

10:30-11:00 Morphological Instability and Kinetics of an Elastic Film on a Viscoelastic Substrate

R. Huang, The University of Texas, USA

11:00-11:30 Magnetization Reversal and Hysteresis in Nanocrystalline Ferromagnets

Jiangyu Li, Heliang Qu, University of Nebraska-Lincoln, USA

11:30-12:00 Effects of the Structural Topology and Connection Size on the Strength of Circular Honeycombs under In-plane Compression

T.X. Yu, D. Karagiozova, The Hong Kong University of Science & Technology, HK

D. Karagiozova, Bulgarian Academy of Sciences, Bulgaria

12:00-14:00 **LUNCH**

Chair: *J.Y. Li*

14:00-14:30 Size Effects of Nanoindentation Creep

H. Li, A.H.W. Ngan, The University of Hong Kong, HK

14:30-15:00 Multi-scale Characterizations for Ductile Thin Film Delamination

Yueguang Wei, Chinese Academy of Sciences, China

Guanshui Xu, University of California at Riverside, USA

15:00-15:30 **BREAK**

Chair: *A.H.W. Ngan*

15:30-16:00 An Experimental Investigation of the Relationship between Molecular Structure and Length Scales in Inelastic Deformation of an Amorphous Thermoplastic

Jessica Agde Tjernlund, E. Kristofer Gamstedt, Zhi-Hui Xu, Royal Institute of Technology (KTH), Sweden

16:00-16:30 Impact of Phase Transition on the Nano-indentation Hardness and Microwear Behavior of NiTi Shape Memory Alloy

Linmao Qian, Xudong Xiao, Qingping Sun, Tongxi Yu, The Hong Kong University of Science and Technology, HK

- 16:30-17:30 **Round Table Discussion On Future Research Directions**
(Chair: *K.C. Hwang and P. Tong*)
- 18:00-20:00 **Banquet**

WEDNESDAY JUNE 2, 2004**Chair:** *W.L. Guo*

- 09:00-09:30 Particle Size Effects in NANocomposites
A. Zaoui, V. Marcadon, E. Hervé, Ecole Polytechnique, France
- 09:30-10:00 Mechanism-based Strain Gradient Crystal Plasticity
Chung-Souk Han, Huajian Gao, Max Planck Institute for Metals Research, Germany
Chung-Souk Han, William D. Nix, Stanford University, USA
Yonggang Huang, University of Illinois, USA

10:00-10:30 **BREAK****Chair:** *X.Q. Feng*

- 10:30-11:00 Size Effect in Magnetic Materials
X.X. Zhang, Hong Kong University of Science and Technology, HK
- 11:00-11:30 On Modeling Deformation Instability and Pattern Formation during Phase Transition in NiTi Microtubing
Y. J. He, Hong Kong University of Science and Technology, HK
- 11:30-12:00 Plastic Deformation of Rough Surfaces in the Nanoindentation Test
Tong-Yi Zhang, Hong Kong University of Science and Technology, HK

12:00-14:00 **LUNCH****Chair:** *T.Y. Zhang*

- 14:00-14:30 Multiscale Mechanics of Carbon Nanotubes and Their Composites
Xi-Qiao Feng, Tsinghua University, China
- 14:30-15:00 A Phase-Field Method for Optimization of Solid Structures: Cahn-Hilliard Model
Michael Yu Wang Shiwei Zhou, The Chinese University of Hong Kong, HK

15:00-15:30 **BREAK**

Chair: *B. Wang*

15:30-16:00 Modeling of Austenite/martensite Laminates with Interfacial Energy Effect

H. Petryk, S. Stupkiewicz, G. Maciejewski, Polish Academy of Sciences, Poland

16:00-16:30 Size Effect in Nano/molecular Electromechanical Systems: Function over Strength

Wanlin Guo, Nanjing University of Aeronautics and Astronautics, China

16:30-17:30 **Round Table Discussion On Future Research Directions**
(Chair: *Z. Zaoui and H. Petryk*)

18:00-19:00 **DINNER**

THURSDAY JUNE 3, 2004

Chair: *M. Cherkaoui*

09:00-09:30 Size Effects of Phase Transition in Thin Films

C.H. Woo, B. Wang, Z. Man, Hong Kong Polytechnic University, HK

Hanchen Huang, Rensselaer Polytechnic Institute, USA

09:30-10:00 Tunable Ferroelectric Phase Transition

Biao Wang, C.H. Woo, The Hong Kong Polytechnic University, HK

10:00-10:30 **BREAK**

Chair: *S.Q. Shi*

10:30-11:00 Mechanical Strengths of Low-K Dielectric Thin Films

Sanboh Lee, T.C. Liu, National Tsing Hua University, Taiwan

B.-T. Chen, S. M. Jang, Taiwan Semiconductor Manufacturing Company, Advanced Module Technology division, Taiwan

11:00-11:30 Energy Penalties in Materials with Microstructures of Phase Transitions

Yongzhong Huo, Fudan University, China

- 11:30-12:00 Homogenization Method for Strength and Inelastic Behavior of Nanocrystalline Materials
Laurent. Capolungo, Jianmin Qu, University of Metz, Ile du Saulcy, France
Mohammed. Cherkaoui, George W. Woodruff, School of Mechanical Engineering, USA
- 12:00-14:00 **LUNCH**
- Chair:** *YZ. Huo*
- 14:00-14:30 Effects of Surface Energy on the Elastic Behavior of Nano-particles
Remi Dingreville, Jianmin Qu, Georgia Institute of Technology, USA
Mohammed Cherkaoui, University of Metz, France
- 14:30-15:00 Size Effect in Formation of Junctions and Defects in Carbon Nanotubes
San-Qiang Shi, F.Y. Meng, L.G. Zhou, The Hong Kong Polytechnic University, HK
F.Y. Meng, R. Yang, Institute for Metal Research, Chinese Academy of Sciences, Shenyang, China
- 15:00-15:30 **BREAK**
- Chair:** *Q.P. Sun*
- 15:30-16:00 Size effect of Hair Sized Structures — Numerical Results
P. Tong, University of California at San Diego, USA
- CLOSING**