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Thermally Activated Mechanisms in Crystal Plasticity

D. Caillard and J.L. Martin
(Pergamon, Oxford, 2003)
xviii + 424 pages, $195.00
ISBN 0-08-042703-0

The aim of the authors is to confront quantitatively the theories of thermally activated mechanisms in crystal plasticity with carefully designed experiments. This necessarily involves detailed discussion of many special cases. The result is a book that will be indispensable to anyone who is or hopes to be a leader in the field, heavy work for the reader with a general interest in plasticity, and far too detailed for an undergraduate student. A particular benefit for the English-speaking reader is the authors' close contact with the methods of thought of the French school. The book is modern in two senses. Published in 2003, it refers to work which appeared in the same year. But its field of interest is also modern.

When I began to study these matters, we tried to understand the plasticity of face-centered cubic aluminum and copper. Maverick body-centered iron was best left alone. The important thermally activated mechanism was the passage of primary dislocations through a forest of secondary dislocations. Once it had cut through a tree in the forest, the speed of a dislocation segment was limited by phonon drag, or, at low temperatures, by electron drag. Here, forest dislocations receive about two pages of discussion, phonon drag ten lines, and electron drag no mention. The interest in aluminum is largely concentrated on non-octahedral glide at high temperatures; there is little discussion of copper. However, the subtle experimental techniques that occupy much of Chapter 2 reveal some totally new information about the kinetics of glide in copper. For example, when, in a stress relaxation test, the strain rate has fallen to one-tenth of its initial value, only a quarter of the mobile dislocations have become trapped in dislocation cell boundaries. Information such as this is derived from a complicated analysis of repeated stress-relaxation tests at constant strain or repeated transient creep observations after small increments of stress, a technique developed by Martin's group in the Ecole Polytechnique Federale de Lausanne. (I do have one problem with this analysis. No distinction is made between "isotropic" frictional stresses and "kinematic" directed stresses. This may not be relevant to the analysis, but it deserves some discussion.)

A central topic in the book is the movement by double-kink nucleation and migration of a dislocation locked in the lattice. The analysis of Hirth and Lothe is used (in a simplified form) and extended. (There seems to be an undue emphasis on an equation numbered 3.28, where, for a rather special case, the drag force of solute atoms on a moving dislocation is independent of the concentration of these atoms, and also of the strength of the interaction between the solute atoms and the dislocation. More seriously, Figure 3.7 shows the drag force increasing at high speeds of the dislocation. No clear reason is given why the interaction with solute atoms should show such an effect, which I suspect is due to the neglected phonon drag.)

Another field in which the research groups of both authors have made major contributions is the plasticity of $L1_2$ alloys such as Ni_3Al, structures which control the strength of "superalloys." Here, a major, if slightly tentative, conclusion has been reached, that the strength of these alloys is predominantly controlled by the surface energies of their complex stacking faults.

Finally, a historical correction. There is frequent reference to "the Burger's vector" that the late W.G. Burgers used to explain that "***b*** *is die vector of mijn broeder*." The aerodynamicist J.M. Burgers was the first to show that the mathematics of hydrodynamical vortex lines carrying a scalar charge could be extended to treat dislocation lines carrying pseudo-vector charge.

Reviewer: *F.R.N. Nabarro, Honorary Professorial Research Fellow at the University of the Witwatersrand in Johannesburg, South Africa, has held various offices at the university, including head of the Department of Physics. His principal research interest is in the atomic processes underlying the strength of metals and alloys. He is the author or co-author of several books, including* Theory of Crystal Dislocations, *originally published in 1967, and more recently,* The Physics of Creep *(1995).*

Novel Nanocrystalline Alloys and Magnetic Nanomaterials

Brian Cantor, Editor
(Institute of Physics Publishing, Bristol and Philadelphia, 2005)
xiii + 325 pages; $135.00
ISBN 0-7503-1002-2

This book, subtitled "An Oxford–Kobe Materials Text," records the proceedings of the 4th Oxford–Kobe Materials Seminar, held in 2001, the latest in a series organized by the Kobe Institute. This organization is primarily financed by Japanese industry and operated in collaboration with St. Catherine's College, Oxford, which also sponsored this meeting jointly with the Materials Department in Oxford. The strong Japanese flavor of the proceedings can be gauged from the fact that 13 of the 20 chapters are wholly or partly written by Japanese authors (mostly academics). The editor is an eminent British metallurgist who is now president of the University of York.

The foregoing is only an outline account of the complex collaboration represented by this Oxford–Kobe text. The scientific outcome is simpler; there is some truly excellent new science here, well deserving of the attention of those researchers who have a special interest in metallic materials, and of those who smile on nanomaterials (and who does not?). The "nano" aspect of all the alloys presented here refers to the size of the crystal grains or phase dispersions in continuous materials; the subject matter includes little about tiny separate particles. The focus of several of the chapters is on bulk metallic glasses that have been wholly or partly crystallized at the nanoscale; a subsidiary focus is on metal–ceramic nanocomposites.

Throughout the first part of the book, the emphasis is on the remarkable mechanical properties that can be attained in such materials. Later, optical and (especially) magnetic properties take pride of place; both ultrasoft and ultrahard (permanent) magnetic materials feature in different chapters. The last chapter in the book is particularly intriguing, devoted as it is to permanent magnets made by combining a large magnetization in a soft metallic phase and a large magnetocrystalline anisotropy in a second, hard magnetic phase. This chapter shows how very sophisticated the development of Nd-Fe-B magnets has now become.

A noteworthy feature of the book is the excellent command of English almost throughout, a tribute to skillful copy editing at the publishers. This is nowadays so unusual as to be worthy of special emphasis.

Reviewer: *Robert W. Cahn, a physical metallurgist, is a "distinguished research fellow" at the University of Cambridge and has, in recent years, focused on extensive editing of textbooks and encyclopedias. In 2001, through Elsevier, he published a historical study entitled* The Coming of Materials Science.

Handbook of Thick- and Thin-Film Hybrid Microelectronics

Tapan K. Gupta
(John Wiley & Sons Inc., Hoboken, NJ, 2003)
424 pages; $99.95
ISBN 0-471-27229-9

This is truly a handbook, as opposed to a textbook, geared toward an entry-level scientist/engineer working in the microelectronics field. The focus is on providing information about thick- and thin-film hybrid devices and not on teaching this material. The book covers a broad range of topics with a relatively small level of detail given to each topic as is appropriate for a handbook. A very large number of references are cited in each chapter and additional references are recommended at the end of some chapters. Many tables are given that contain typical dimensions, materials constants, and materials characteristics. A nice glossary is provided at the end of the book immediately before the index.

The introductory chapter provides a motivation for hybrid microelectronic devices and provides many examples of the devices as well as the industries that benefit from this development. This chapter could be reorganized to provide a more effective and efficient treatment of the diverse applications; much of the information is repeated in the applications section of the chapter, after earlier treatment of the need for hybrid devices. Generally, the handbook covers historical as well as current trends, although in the introduction, it is stated that the hybrid segment of the microelectronic industry is in transition as new technology (e.g., MCM) has emerged in the market. Multichip modules are not considered to be a new technology by electronics packaging practitioners. Some statements, such as this one, show an indication of dated material.

The figures in the handbook generally come from various other sources and are typically photographs that attempt to illustrate the size or complexity of a circuit board, while flow charts for circuit design illustrate the decision-making required for designers.

The book is generally clear, although it sometimes lacks focus. Some chapters have a shallow level of writing for a topic, followed by a more involved level that does not fit the writing style of a handbook. An example is the treatment in the etching chapter, in which an introductory discussion of etching moves quickly toward more complicated issues such as plasma sheath potentials. Also, some of the transitions to different concepts are not always smooth. One example of this is in Chapter 2, "Mathematical Foundations, Circuit Design, and Layout Rules," which moves from a standard treatment of resistance and noise issues to modeling thick- and thin-film deposition. The groundwork for deposition processes is not given until much later in the handbook. Occasional confusion occurs regarding physical vapor deposition (PVD). In Chapter 7, thermal evaporation is considered to be a PVD process that does not include sputtering. All other textbooks show sputtering and evaporation to be part of the broad category of PVD processes.

Overall, this handbook provides standard reference material for the hybrid microelectronics area, with a level of detail consistent with a handbook. It provides a reference list for more information on each topic.

Reviewer: *Susan Burkett is associate head of the Electrical Engineering Department at the University of Arkansas in Fayetteville. Her research interests include integrated-circuit fabrication techniques, advanced circuit-interconnect schemes, and microelectronic materials.*

Optical Applications of Liquid Crystals

L. Vicari, Editor
(Institute of Physics Publishing, Bristol, 2003)
284 pages, $70.00
ISBN: 0-7503-0857-5

This text is a compilation of work from a number of different authors, emphasizing existing as well as possible future applications of liquid crystals. The first chapter provides a wonderful introduction to liquid crystals in general, although its emphasis is specifically on ferroelectric and antiferroelectric systems and their applications. Many terms and phenomena common to the liquid-crystal literature are explained in this chapter, while only a few very important equations are used. Many of the topics discussed also include clear, well-designed illustrations.

This first chapter goes a long way toward making this text accessible to relative newcomers with only a moderate level of knowledge in optical physics and liquid crystals. From there, the discussion proceeds through a number of more specific systems, with a greater emphasis on emerging technologies for use in holography, adaptive optics, new displays, light shutters, sensors, and smart windows. These later chapters generally require

more knowledge of optical physics and the associated mathematics (some require significant prior knowledge). This is perhaps most true for the chapter on polymer dispersed liquid crystals, for which the multiple equations describing liquid-crystal organization and droplet light scattering are likely only of relevance to those working on these specific materials. The text concludes by emphasizing issues more directly related to the engineering of new devices. From a chemical perspective, new optical means for controlling liquid-crystal alignment and for patterning of liquid-crystal devices are described in the second-to-last chapter. The final chapter, although very brief, will be of most importance to those interested in the internal workings of liquid-crystal devices. Emphasis is given to the supporting optics, electronics, and electrode structures required to make them function. While such topics are addressed throughout the book, and in some cases in more depth, this chapter presents the most cohesive discussion of these issues.

Overall, this text is very well done and very accessible to advanced students and researchers with an interest in liquid-crystal device technology. Sufficient references to important works in the field are given at the end of most chapters, allowing for interested readers to easily explore particular topics in greater depth. The material covered is very timely, reasonably comprehensive, and is appropriately balanced between existing liquid-crystal device technologies and emerging systems.

Reviewer: *Daniel A. Higgins is an associate professor of chemistry at Kansas State University, with research interests in optical microscopic investigations of polymer/liquid-crystal composite thin films.*

The following new journals and recently published books, relevant to materials research, have come to *MRS Bulletin's* attention. Some of the books listed here may be reviewed in future issues of *MRS Bulletin*. To review a book from the list or to offer recommendations of additional books, contact K. Wilson, Editorial Assistant, *MRS Bulletin*, 506 Keystone Drive, Warrendale, PA 15086-7573, USA; e-mail bulletin@mrs.org.

Journals

Nanotechnology Law & Business. Four issues; first issue: 2004. Subscription rate: $85 (Individual), $235 (Institutional), and $495 (Corporate). Berkeley Electronic Press, 805 Camelia Street, Second Floor, Berkeley, CA 94710, USA; tel. 510-559-1500, fax 510-559-1550; pubs.nanolabweb.com.

Particle and Fibre Toxicology. Launch: 2004. Subscription rate: Free (open access). BioMed Central Ltd., Middlesex House, 34-42 Cleveland Street, London W1T 4LB, United Kingdom; tel. 44-0-20-7323-0323, fax 44-0-20-7631-9923, or e-mail info@biomedcentral.com; inquiries about content or submissions should be addressed to Ken Donaldson, editor-in-chief, at e-mail ken.donaldson@ed.ac.uk; www.particleandfibretoxicology.com.

Soft Matter. Launch: Summer 2005. Subscription rate: $580; free to subscribers of the *Journal of Materials Chemistry, Organic & Biomolecular Chemistry*, and *Physical Chemistry Chemical Physics*. Carol Stanier, Commissioning Editor, Royal Society of Chemistry, Thomas Graham House, Science Park, Milton Road, Cambridge CB4 0WF, United Kingdom; tel. 44-0-1223-420066, fax 44-0-1223-420247, or e-mail softmatter@rsc.org; www.rsc.org.

Books

Experimental Techniques

Practical Guide to Designed Experiments: A Unified Modular Approach, Paul D. Funkenbusch, Marcel Dekker, 2005, 177 pp., $99.95, ISBN 0-8247-5388-7.

History, Biography, and Unclassified

Chicago Guide to Communicating Science, Scott L. Montgomery, University of Chicago Press, 2003, 239 pp., $15.00, ISBN 0-226-53485-5.

Handbook of Nanotechnology: Business, Policy, and Intellectual Property Law John C. Miller, Ruben Serrato, Jose Miguel Represas-Cardenas, and Griffith Kundahl, John Wiley & Sons, 2004, 368 pp., $125.00, ISBN 0-471-66695-5.

Nobel Laureates and Twentieth-Century Physics, Mauro Dardo, Cambridge University Press, 2005, 546 pp., $50.00, ISBN 0-521-54008-9.

Inorganic Chemistry, Electrochemistry, Other Chemistry, and Ceramics

Inorganic Materials Chemistry Desk Reference, *2nd Ed.*, D. Sangeeta and John R. LaGraff, CRC Press, 2005, 384 pp., $149.95, ISBN 0-8493-0910-7.

Materials Processing

Luminous Chemical Vapor Deposition and Interface Engineering, Hirotsugu Yasuda, Marcel Dekker, 2004, 819 pp., $189.95, ISBN 0-8247-5788-2.

Sintering: Densification, Grain Growth, and Microstructure, Suk-Joong L. Kang, Elsevier, 2005, 280 pp., $79.95, ISBN 0-7506-6385-5.

Metallurgy

Crack Dynamics, A. Ivankovic and M.H. Aliabadi, Wiley InterScience, 2004, 224 pp., $133.00, ISBN 1-85312-948-8.

Kinetic Processes: Crystal Growth, Diffusion, and Phase Transitions in Materials, Kenneth A. Jackson, Wiley-VCH, 2004, 424 pp., $130.00, ISBN 3-527-30694-3.

Materials for Automobile Bodies, Geoffrey Davies, Elsevier, 2004, 304 pp., $75.00, ISBN 0-7506-5692-1.

Materials Selection in Mechanical Design, Michael Ashby, Elsevier, 2005, 624 pp., $64.95, ISBN 0-7506-6168-2.

Understanding Solids: The Science of Materials, Richard Tilley, John Wiley & Sons, 2004, 593 pp., $65.00, ISBN 0-470-85276-3.

Physics and Electronics

CMOS: Circuit Design, Layout, and Simulation, *2nd Ed.*, R. Jacob Baker, John Wiley & Sons, 2004, 1080 pp., $99.95, ISBN 0-471-70055-X.

Enabling Technologies for MEMS and Nanodevices, Henry Baltes, Oliver Brand, Gary K. Fedder, Christofer Hierold, Jan G. Korvink, and Osamu Tabata, John Wiley & Sons, 2004, 439 pp., $245.00, ISBN 3-527-30746-X.

Future Trends in Microelectronics: The Nano, the Giga, and the Ultra, Serge Luryi, Jimmy Xu, and Alex Zaslavsky, John Wiley & Sons, 2004, 424 pp., $64.95, ISBN 0-471-48405-9.

Nano-CMOS Circuit and Physical Design, Ban Wong, Anurag Mittal, Yu Cao, and Greg Starr, John Wiley & Sons, 2004, 393 pp., $94.95, ISBN 0-471-46610-7.

Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience, Edward L. Wolf, John Wiley & Sons, 2004, 187 pp., $84.95, ISBN 3-527-40407-4.

Polymer Chemistry and Biomaterials

Handbook of Polymer Synthesis, Hans R. Kricheldorf, Oskar Nuyken, and Graham Swift, Marcel Dekker, 2005, 965 pp., $269.95, ISBN 0-8247-5473-5.

Matèriaux Composites à Matrice Organique *(TM Volume 15)*, Jan Anders Manson, Pierre-Etienne Bourban, Leif Carlsson, and Jean-Pierre Mercier, Presses Polytechniques et Universitaires Romandes, 2004, 284 pp., $96.00, ISBN 2-88074-528-4.

Molecular Simulation Methods for Predicting Polymer Properties, Vassilios Galiatsatos, John Wiley & Sons, 2005, 295 pp., $99.95, ISBN 0-471-46481-3.

Polymer Processing Instabilities: Control and Understanding, Savvas G. Hatzikiriakos and Kalman B. Migler, Marcel Dekker, 2004, 470 pp., $169.95, ISBN 0-8247-5386-0.

Structure of Materials

Molecularly Imprinted Materials, Mingdi Yan and Olof Ramstrom, Marcel Dekker, 2004, 734 pp., $179.95, ISBN 0-8247-5353-4.

What is What in the Nanoworld: A Handbook on Nanoscience and Nanotechnology, Victor E. Borisenko and Stefano Ossicini, John Wiley & Sons, 2004, 347 pp., $185.00, ISBN 3-527-40493-7. □