## The Diamond Makers

*Robert M. Hazen*
*(Cambridge Univ. Press, Cambridge, 1999)*
*x + 258 pages, $15.95*
*ISBN 0-521-65474-2*

Buckyballs, nanotubes, graphite, diamond! A few of carbon's manifold forms! Undoubtedly, diamond has gripped the human imagination more profoundly than carbon's other, equally fascinating allotropes. Is it the glitter, allure, and glamour of the gemstone? We marvel at diamond's brilliance, certainly. Perhaps that very brilliance tends to blind us to many other unique properties—high thermal conductivity, low coefficient of friction, and extreme chemical inertness, to name a few—that make diamond a desirable, valuable, and potentially very widely useful material.

Robert M. Hazen tells us in detail a part of the story of the synthesis and commercialization of synthetic diamond. Hazen's book concentrates almost entirely on the high-pressure, high-temperature synthesis of diamond and devotes only one chapter of 13 pages to the low-pressure or chemical-vapor-deposition (CVD) methods that have become a worldwide research and development effort in the last 20 years. However, the story that he tells is a darn good yarn, and he tells it superbly well as he ferrets out the details of a fascinating story by talking whenever possible to the participants themselves. The central portion of the book, as it should be, is devoted to the efforts of the group of scientists and engineers at the General Electric Company (GE) who succeeded in the early 1950s to transform graphite to diamond under equilibrium conditions at high pressures and high temperatures. Hazen is eminently qualified to tell this particular tale because he is a high-pressure man himself, having worked for many years at the Carnegie Institution of Washington's Geophysical Laboratory. His book is a combination of historical romance and detective story. We learn, among other things, about diamond's attraction for kings and their queens and mistresses, as well as about the gradual realization that natural diamonds are associated with kimberlite and that they probably have their origin under high-pressure, high-temperature conditions deep underground. Sir William Crookes was perhaps the first scientist fully to grasp the key role of pressure in diamond synthesis, but we are also reminded that people like Hannay, Moissan, and Parsons all tried their hand at it and helped, in one way or another, to set the stage for ultimate success.

Nobel Laureate Percy Bridgman is generally considered to be the father of high-pressure science, and he too tried to use the steadily advancing technology for producing high pressures to synthesize diamonds. Ultimately, he did reach that goal, but only as a guest at the GE Laboratory, being instructed by Strong, Hall, and others in the use of the "belt" machine. The key to success, of course, was the simultaneous application of pressure and heat, as dictated by the phase diagram of carbon elucidated by Francis Bundy.

Hazen describes in detail the startling successes achieved by the GE group. The description rivals that revealed in *The Double Helix* by Watson and Crick concerning the controversy surrounding credit for the ideas behind an important scientific breakthrough. The diamond work probably deserved a Nobel Prize, and Hazen lays part of the blame on GE for not enabling this to happen. It is important for the sponsors of a research program to recognize that the motivations that drive scientists are not primarily financial, but must be paid careful attention nonetheless, in order to encourage the best efforts of creative minds.

It is well known that most industrial diamonds, hundreds of tons a year, are today synthetic diamonds. Hazen shows that the commercial success of synthetics is largely traceable to the control over the size and shape of the diamond crystallites that can be achieved by adjusting processing parameters such as pressure, temperature, temperature gradients, time, and catalysts. In this way, synthetic diamonds could be optimized for various applications: rock sawing and polishing, machining of hard steels and carbides, glass cutting and polishing, and the cutting and polishing of diamond itself. This list makes it clear that the GE process results in forms of diamond that make use primarily of its hardness. About 20 years ago, the low-pressure CVD process was developed by Eversole and Angus in the United States; Deryaguin, Spitsyn, and Fedoseev in the former Soviet Union; and Matsumoto and Sekata in Japan. More recent developments have given us the ability to accurately control crystal size from several micrometers to several nanometers. This fascinating chapter in the diamond story deserves more space and detail than is to be found in this book. Hazen does quote (p. 199) a 1990 remark by John Angus, one of the pioneers of CVD diamond, to the effect that diamond is going to be everywhere: pots, pans, drill bits, razor blades, copying machines, and hard disks. Hazen himself (p. 208) believes that the age of revolutionary diamond semiconductors manufactured by CVD technology could be close at hand. The recently acquired ability to *n*-dope nanocrystalline diamond might be combined with known *p*-type doping to make *n–p* as well as *p–n–p* and *n–p–n* junctions. In this event, diamond would become an electronic material useful in some applications.

The exquisite control over diamond microstructure achievable through CVD methods opens applications that can make use of many of the important properties of diamond such as a wide potential window for electrochemical electrodes, photolithography and etching for high-feature-resolution microelectromechanical systems devices, and highly demanding tribological uses.

As these uses for diamond coatings and precision structures expand, perhaps Hazen will work on a new edition of his excellent book to give a more complete version of low-pressure CVD diamond synthesis. In the meantime, I highly recommend this most enjoyable read to anyone with an interest in learning how good science is done in the real world.

***Reviewer:*** *Dieter Gruen is a senior scientist and an associate director of the Materials Science Division at Argonne National Laboratory. He received the Materials Research Society Medal in 2000 for "the low-pressure synthesis of nanocrystalline diamond films from fullerene precursors."*

## Glasses for Photonics

*Masayuki Yamane and Yoshiyuki Asahara*
*(Cambridge Univ. Press, Cambridge, 2000)*
*281 pages, $90.00*
*ISBN 0-521-58053-6*

The book *Glasses for Photonics*, by M. Yamane and Y. Asahara, presents a concise treatment of many of the fundamental subjects relevant to optical and photonic glasses. The authors present a general overview of glass structure, glass properties, and glass formation and then proceed to a discussion of optical theory and the role of glass in a variety of photonic applications. *Glasses for Photonics* is not a book aimed at the typical undergraduate student or novice. Although many fundamental topics are addressed, their treatment is cursory and would appropriately serve a more mature and advanced readership. Some familiarity with the subjects covered is necessary, and thus the book is well suited to the graduate-level reader or to professionals in glass science or photonics.

This book should not be regarded as an exhaustive treatise on photonic glasses, but rather should be viewed as a useful bridge between photonic materials and their applications that introduces and enumerates upon a number of topics of interest. This approach, combined with the brevity of the book, precludes it from covering any particular subject matter in great depth. Rather, most of the discussions are written in the style of general topical overviews. As such, many notable and technologically relevant applications of photonic glasses are not included in the text, such as photosensitivity and photochromism, second-harmonic generation (SHG) in optical glass fibers, and electric-field-induced SHG effects in glass. Those subjects that are covered are well presented, and more detail is provided in certain particular areas, as in some of the GRIN optics sections. In addition, for the professional, *Glasses for Photonics* contains a large number of exceptionally useful tables and figures covering everything from tabulations of common and relevant glass compositions and glass properties to examples of radiative lifetime and lasing-transition states for laser glass dopants. In this regard, *Glasses for Photonics* is a book that a researcher may reference often.

***Reviewer:*** *Kelly Simmons-Potter is a Principal Member of the Technical Staff at Sandia National Laboratories in the Lasers, Optics, and Remote Sensing Department.*

## Soft and Fragile Matter: Nonequilibrium Dynamics, Metastability and Flow

*M.E. Cates and M.R. Evans, Editors*
*(Scottish Universities Summer School in Physics and Institute of Physics Publishing, Bristol and Philadelphia, 2000)*
*xi + 393 pages, $57.00*
*ISBN 0-7503-0724-2*

*Soft and Fragile Matter* is a volume of the proceedings of the 53rd Scottish Universities Summer School in Physics. But do not let the word "proceedings" discourage you from opening this book. It is more than the compilation of articles found in most proceedings and can even serve as a graduate textbook on soft matter. Most chapters of the book start from an introduction into the subject accessible to a non-expert in the field and end with a selection of topics at the cutting edge of current research. Of course, the size of individual chapters (approximately 30 pages each) prevents them from being extensive reviews of each topic. These chapters can be viewed as samples that give the reader a taste of a particular subfield of soft matter.

The book emphasizes the conceptual principles underlying dynamic properties of soft matter. The book can be roughly divided into three main sections: phenomena of soft condensed matter, concepts of nonequilibrium statistical physics, and dynamics of colloidal and granular systems. The properties of the main classes of soft and fragile materials, including polymers, colloids, surfactants, emulsions, and granular matter, are addressed in the 15 chapters of the book. An effort is made to describe each class of soft materials from the point of view of unifying concepts such as "aging" in glassy dynamics of soft gels and dense emulsions, or "jamming" in driven diffusive systems such as colloids under flow. Experimental, theoretical, and simulation studies of these materials are covered in a balanced way. There is a reasonable amount of cross-referencing between the chapters, a decent index consisting of several hundred key words, and a comprehensive list of references at the end of each chapter.

The book clearly achieves its goal of leading the reader from basic principles to the most recent developments in the fascinating field of soft and fragile matter. It is written by some of the best experts in the field, and I believe that it is one of the best introductions into the rapidly growing area of soft materials. I recommend it to anybody who is interested in learning fundamental concepts of the diverse field of soft condensed matter.

***Reviewer:*** *Michael Rubinstein is a professor in the Chemistry Department of the University of North Carolina at Chapel Hill. He is an expert in polymer physics, with interests ranging from dynamics of polymeric solutions, melts, networks, associating, and charged polymers to their adsorption at surfaces and interfaces.*

## Handbook of Superconductivity

*Charles P. Poole Jr.*
*(Academic Press, San Diego, 2000)*
*xiii + 693 pages, $95.00*
*ISBN 0-12-561460-8*

This year marks the 15th anniversary of the discovery of high-temperature superconductivity, and there are few—if any—other subjects that have resulted in a comparable number of scientific publications in such a short time. The task of compiling all this published information into a manageable handbook is a formidable one, and Charles P. Poole Jr., coauthor of the early review *Copper Oxide Superconductors* (John Wiley & Sons, 1988) and the encyclopedic treatment *Superconductivity* (Academic Press, 1996) has produced a remarkable volume. Contrary to the *Handbook of Applied Superconductivity*, edited by B. Seeber (Institute of Physics Publishing, 1998), this new book focuses on the materials themselves rather than their applications, and this clearly defined scope renders the handbook under review easy to use.

The information contained within its pages is particularly valuable for researchers involved in various experimental aspects of superconductivity, with a special focus on the cuprate high-$T_c$ materials. Including contributions from 14 authors, the handbook presents a concise and authoritative collection of data that are not always easy to find. From our own experience, for example, finding the Poisson ratio of $YBa_2Cu_3O_{7-x}$ was a considerable task in the past; now the answer is at our fingertips.

The book starts with a clear summary of the most relevant formulas and definitions, beginning with Maxwell's equations, Brillouin zones, and Fermi surfaces, followed by an overview of models and theories, with the different superconductor types summarized in a narrative form. Do not expect a treatment of controversial ideas and interpretations (the term "stripes" does not appear in the index); those issues are appropriately left out of this handbook of established concepts and data. Clearly organized and listed in tables are properties such as coherence lengths, critical fields and currents, mechanical properties, and phase diagrams. Less easy to use as a reference are the chapters on thermal and magnetic properties; however, these parts are written in a clear narrative style that makes them excellent introductions to the field.

The strongest section, encompassing almost half the book, treats the crystal structure of superconductors, ranging from single elements to complex layered cuprates. There is an unmistakable bias toward the complex high-$T_c$ materials, with elaborate and clear drawings of their atomic structures and a wealth of other information.

One weakness of the book is the absence of an extensive index of the materials discussed, which may make it harder to quickly find the desired information. This is particularly true for the chapter on the structure of cuprates because the materials are listed in numerical order according to four-digit codes. So, for example, $La_2CuO_4$ (which is not in the index) is listed in the family of compounds with a 0201 structure, and $YBa_2Cu_3O_7$ in the 1212 family. Within each structure family, however, there are data clearly presented for compounds with different chemical compositions, as well as a narrative containing some historical notes and other useful information.

Therefore, the *Handbook of Superconductivity* is likely one of those items that will never end up too far from the owner's desk—except when a co-worker borrows it.

***Reviewers:*** *Hong-Ying Zhai and Hans M. Christen work on issues related to applied superconductivity, particularly film growth on textured metal tapes, and fundamental studies in metal-oxide thin films in the Solid State Division of the Oak Ridge National Laboratory.*

## Intermetallic Compounds

**Reprint Volume 1: Crystal Structures of Intermetallic Compounds**

**Reprint Volume 2: Basic Mechanical Properties and Lattice Defects of Intermetallic Compounds**

**Reprint Volume 3: Structural Applications of Intermetallic Compounds**

**Reprint Volume 4: Magnetic, Electrical and Optical Properties of Intermetallic Compounds**

*J.H. Westbrook and R.L. Fleischer, Editors*
*(John Wiley & Sons, New York, 2000)*
*Vol. 1: xxiv + 276 pages*
*Vol. 2: xxiv + 255 pages*
*Vol. 3: xxiv + 317 pages*
*Vol. 4: xxiv + 248 pages*
*$460/4-vol. set*
*ISBN 0-471-60814-9 (set)*

J.H. Westbrook and R.L. Fleischer edited a major survey of the broad theme of intermetallic compounds, and Wiley brought this out in 1995 in two volumes (one devoted to "Principles," the other to "Practice"). I reviewed this in great detail in *Intermetallics* **4** (1996) p. 169. The publishers in due course decided to bring out a reduced version of this *magnum opus* in softcover; the set of four volumes under review is the result. Essentially, the chapters now published are reprints of some of the 1995 chapters with just a correction of misprints and factual errors; a very few of the chapters have short addenda to update them.

The original work had 75 chapters in 1878 pages; the new version in total has 42 chapters in 1096 pages. The price of the original version was $1200 hardcover, the new version costs $460. So, size and price have been reduced approximately in proportion.

Volume 1 reprints the entire set of 11 chapters devoted to crystal structures in the original version. Volume 3 incorporates all of the 13 chapters on mainline structural intermetallics. The other two volumes pick out substantial subsets of their respective themes; thus, phase-transformation topics are reprinted only in part. What is missing now is the pure physics of "bonding and stability" (10 chapters), and the discussions under "formation and constitution"; thus, a chapter on metastable phases has disappeared. A range of "miscellaneous applications" have been excluded, including shape-memory alloys, dental amalgams, and high-temperature coatings for gas turbines.

Some readers will find here almost everything they require; this especially applies to those whose research concerns focus on possible aerospace applications of intermetallics. Nevertheless, many chapters are missing that I have used repeatedly over the past five years, and I cannot help but conclude that the original hardback version, which I praised to the skies in 1996, is a somewhat better value despite its considerably higher price.

***Reviewer:*** *Robert W. Cahn is a metallurgist and materials scientist, attached to Cambridge University. He serves* MRS Bulletin *as a 2002 Volume Organizer, as well as a member of the Editorial and Book Review Boards.*

**Correction**

In P. Johnson's news item on page 428 of Research/Researchers in the June 2001 issue of *MRS Bulletin*, research by R. Rinaldi and colleagues was published in the May 28 issue of *Physical Review Letters*.

In S.K. Kaldor's news item on page 432 of the same issue, a misprint was made; the corrected sentence is, "The fluorescence emitted by the Co atoms was incident on this Fe foil, causing the elastically scattered primary x-ray beam along with Co k$\alpha$ radiation to be absorbed, so that only Co k$\alpha$ photons along with some inelastically scattered photons reached the detector."