The Structure of Materials

Samuel L. Allen and Edwin L. Thomas
(John Wiley, New York, 1999)
xvi + 447 pp., $102.95
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Physics of Materials

Yves Quéré
(Gordon and Breach, Amsterdam, 1998)
xi + 483 pp.
$60.00 Cloth, ISBN 90-5699-118-3
$25.00 Paper, ISBN 90-5699-119-1

The two undergraduate textbooks, *The Structure of Materials* and *Physics of Materials*, under combined review represent important innovations. Although the second book is used by undergraduate students in France, I suspect that in United States it would be regarded as more appropriate for graduate students.

Sam Allen and Ned Thomas' book is part of a new MIT Series for the undergraduate level in materials science and engineering (MSE). The authors explain their unusual objective, "Our text looks at one aspect of our field, the structure of materials, and attempts to define it and present it in a generic, 'materials catholic' way. We focus on three different states of solid condensed matter—glasses, crystals, and liquid crystals—and develop one set of tools, or structural descriptors, for describing all of them." In this aim, they have triumphantly succeeded. Apart from a chapter wholly devoted to liquid crystals, the text treats materials in a way that is nowhere specific to one category alone. For example, random-walk mathematics are applied in the same chapter both to diffusion in crystals and to the conformation of long-chain polymer molecules. Likewise, in a chapter devoted to crystal imperfections, point defects and dislocations (in both inorganic crystals and organic liquid crystals) are combined with disclinations, and the same chapter carries an illuminating comparison of ferromagnetic domain walls and microdomain walls in liquid crystals; the behavior of point defects in ionic crystals—relevant, of course, to "physical ceramics"—is carefully analyzed.

The authors attempt wherever possible to apply mathematical rigor to their presentations, but not to the extent that the underlying physics is obscured. The most substantial single block of quantitative argument is the chapter on formal crystallography, ranging from point groups to space groups: Here again, the argument is carefully quantitative, but by means of step-by-step operational argument rather than the use of group theory, which would have left many readers hopelessly confused. Nevertheless, this chapter provides enough analysis for students to grasp the systematic argument in the process of detailed classification.

Both of the distinguished authors make use of their own research in picking examples—for instance, Allen in writing about antiphase domains in an iron aluminide and Thomas in explaining the use of triblock copolymer liquid crystals in industrial display units. This is entirely as it should be. A number of "example problems" with associated solutions are interspersed with the text, along with a number of concise exercises at the ends of chapters: These vary between graphic and mathematically biased approaches.

It will be extremely interesting, in due course, to have a considered analysis of the effectiveness of this mode of teaching at a fairly early stage of materials science courses; an early version of the text has, it is remarked, already been tried in a course at the University of California—Berkeley.

Yves Quéré's book is at a substantially different level. It is a translation from a French text published a decade earlier; the excellent translation (by a professional linguist—a welcome touch!) was financially supported by the École Polytechnique and the French government, a fact which is reflected in the remarkably low price of the book. I have just one quibble about the translation: The French word "*élaboré*" is incorrectly translated as "elaborated"; the English equivalent is "processed."

The author is a highly distinguished French physicist who has specialized in point-defect research and on irradiation effects in solids. The specific course for which this book was prepared at the École Polytechnique is an option at the end of the science program, following (to mention just the physics component) compulsory courses in quantum mechanics and statistical physics. Accordingly, the level of mathematical sophistication at which, for instance, the electron theory of metals is treated (both in its archaic Drude form and in its modern [Bloch] variant) would be inaccessible to undergraduate materials science students in most schools in the United States and Britain. The emphasis is more on the physics than on the materials.

In the preface, Quéré wrote, " The content of a course is one thing, how it is approached is another. The route taken here is heavily intuitive. Since the beginning of time, materials science has built on the astute empiricism and industrious intuition of smiths and potters. It has now, God be thanked, adopted the scientific method for its own, but it is necessary for it not to challenge or forget its past: it never progresses as well as when it is able to marry rigor and astuteness, logic and intuition." To this reviewer, there seems to be more rigor and logic than intuition; there is plenty of astuteness.

The treatment parallels that of the first book in its focus on defects of various kinds, on crystal packing, and on diffusion mechanisms, and is more detailed on plastic deformation of metals. There are only a few sentences on liquid crystals, and polymers generally find little space. An exception is in the truly formidable array of 19 problems at the end of the book (they occupy nearly 200 pages!) These include such practical issues as rubber elasticity, swelling of nuclear fuels (due to the release of fission gases), ferroelectricity in barium titanate, and even "instability of carotene...or why carrots are red." Detailed, invariably highly mathematical solutions are appended to each problem. The problems are taken from final examinations for the École Polytechnique's hard-pressed students. As a teaching device, these problems are impressive indeed, but as exercises for typical students, without provided solutions, they would merely be depressing.

In sum, Quéré's book seems to be more appropriate for advanced, physically biased courses at graduate level; it would be challenging indeed, but highly motivated students would learn a great deal from it.

Reviewer: *Robert W. Cahn is a physical metallurgist turned materials scientist, currently attached in nominal retirement to Cambridge University. He is in the middle of writing a historical book,* The Coming of Materials Science. *He is a member of the Editorial Board of* MRS Bulletin *and of its Book Review Board.*

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