Book Reviews

Materials Engineering for Nobody

The Technology and Applications of Engineering Materials. By *M. S. Ray*. Prentice Hall, Englewood Cliffs, N. J., USA 1987. xxv, 736 pp., paperback, $ 27.95.—ISBN 0-13-902081-0

Many years ago, a review of another book on materials opened with the words: "Of books on Shakespeare's plays, the Malaise of Modern Man, and materials science, there is no end. No blinding new insights are to be expected on any of these topics: selection, clarity and economy must be our touchstones." Since I wrote those despairing words in 1974, my shelf of such books has grown to bend increasingly under the burden of several dozens of such volumes (see the book under review, pp. 458–60, 'Bending of Beams'). Any new general text on the science and technology of materials has to be of exceptional quality to succeed in a crowded market place. *Martyn Ray*'s book, I regret to say, fails the tests of selection, clarity and economy: I cannot give it even a qualified welcome.

Texts for students of Materials Science and Engineering (MSE) set out with different objectives. At one extreme is the physics-centered, fundamental interpretative approach, setting out to explain properties in terms of atomic and crystal structure, quantum mechanics and statistical mechanics. The first such book was Cottrell's *Theoretical Structural Metallurgy* of 1948, followed some years later by Wert and Thomson's *Physics of Solids* (1964). Another, even earlier, and extremely influential physics-based book was Barrett's *Structure of Metals* (1943), which has lasted well in the form of successive editions. The same fundamental approach is possible in regard to the chemical approach to materials. The classic here is Darken and Gurry's *Physical Chemistry of Metals* of 1953. Midway between the physical and chemical approaches one finds Swalin's *Thermodynamics of Solids* (1962).

The fundamental approach to polymers was a little slower in coming and probably began with Treloar's 1958 book, *The Physics of Rubber Elasticity*. Since then, the polymer scientists have also been well served with fundamentally biased texts, with a strong undertow of statistical mechanics. From the 1970s on, basic texts began to use the term *materials science*. Notable examples include Ruoff's *An Introduction to Materials Science* of 1972 and Hornbogen's *Werkstoffe* of 1973.

At the other extreme there are texts aimed at the engineer who selects materials for incorporation in his designs, and also at the materials processing specialist who converts materials into semi-finished or finished products. These have been, if anything, even more numerous than the science-centered texts. Early ones had titles such as *Metallurgy for Engineers* (Rollason, 1939) and *Physical Metallurgy for Engineers* (Clarke and Varney, 1952). Later titles covered a broader range of materials; among the better are *Engineering Materials* by Jastrzebski (1959), *The Principles of Engineering Materials* by Barrett, Nix and Tetelman (1973), *Structure and Properties of Engineering Materials* by Harris and Bunsell (1977), as well as the comprehensive *Metals, Ceramics and Polymers* by Wyatt and Dew-Hughes (1974), which was the volume that drew forth the reviewer's words cited at the outset.

A good example of a book aimed specifically at processes is Alexander and Brewer's *Manufacturing Properties of Materials* (1963). More recently still have come some splendid texts aimed directly at developing for fledgling engineers a systematic approach for selecting materials during the design process: *Engineering Materials—An Introduction to their Properties and Applications*, by Ashby and Jones (1980) is a good example.

The titles cited here are only a small selection and include some of the best and most durable. Some of them, especially in the "engineering" group, are really broad treatments that succeed in marrying the S and E of MSE: the books by *Wyatt* and *Dew-Hughes* and by *Harris* and *Bunsell* are examples. The engineers who are to learn from these books are paid the compliment of being supposed intelligent and curious, of wanting to understand complex facts rather than to learn them by rote (and then promptly forget them). By contrast, *Ray*'s book (the volume under review) assumes that his readers do not want to understand—or, perhaps, are incapable of understanding? I am sorry to have to add that this attitude may well stem from a frequent and unmistakable lack of understanding by the author himself. A diet of bare uninterpreted fact, often so vague as to be unintelligible even as fact, has to substitute for insight.

A few quotations will give the flavor: "The molecular weight used to characterize a polymer may be based upon several criteria. The most popular are the viscosity average, number average and weight average molecular weights. For a molecular weight distribution these averages have different values, although they would be identical if the polymer possessed a unique molecular weight." That is all on this subject. Another quotation: "The creep process occurs because of two mechanisms; these are grain boundary sliding and dislocation movement by climbing past obstacles." That is all there is in the book on the role of dislocations in plastic deformation ... yet the cover is decorated by a large diagram of an edge dislocation! Another: "The TTT diagrams described so far are obtained by cooling a

steel isothermally at a series of temperatures." One of the illustrations in the chapter on joining consists of a variety of screw heads!

Several features of the book, especially the very extensive lists of standard specifications and numerous tables of numerical values of properties, betray a measure of confusion between the roles of a textbook and a handbook (such as the *Metals Reference Book*). 100 pages are devoted to elementary school mechanics, which have no place in a book of this kind, supposedly directed at professional engineers-to-be. According to the preface, the book is in fact directed not only at these but also at technicians taking pre-degree courses. But these, also, need and deserve understanding, not just a diet of undigested and sometimes erroneous fact.

Ray also has the peculiar habit of providing a list of keywords for each chapter, apparently in the hope that the reader can check for himself whether he has learned key concepts. In a chapter on engineering design, the list of keywords includes, inter alia, "perseverance, willpower, scientific knowledge, conceptual ability". The author has demonstrated the first two but not, alas, the last two.

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Liquid Crystals

Thermotropic Liquid Crystals. Edited by *G. W. Gray*. Wiley, New York 1987. 178 pp., £ 38.00.—ISBN 0-471-91504-1

As long ago as 1962, *G. W. Gray* published the book "Molecular Structure and the Properties of Liquid Crystals", which was a classic for a long time. Display technology has stimulated the synthesis of thousands of new liquid crystal compounds; many of the technologically relevant ones come from *Gray*'s laboratory. Usually, a purely physical approach is chosen for the presentation of the field of thermotropic and lyotropic liquid crystals. This is convenient because it is necessary to describe precisely the properties of anisotropic fluid systems. Furthermore, a great variety of physical measurement techniques directly related to technological applications has to be mastered. Chemists, however, will be more familiar with the approach chosen in this book that has been edited by *G. W. Gray*; it contains six articles written by different authors.

The wealth of mesomorphic phases in organic compounds, and in particular the recently discovered phases, require a refinement of the classification scheme. This is outlined by *A. J. Leadbetter* (27 pages) with special regard to structural analysis by X-ray and neutron diffraction. The phases are characterized essentially by positional order, orientational order, and molecular orientation. This makes it possible to distinguish between different smectic phases and, more generally, between a liquid crystal and a true (though disordered) crystal; such a clear cut distinction has not always been made in the literature. Discotic phases are briefly mentioned. They are not formed exclusively by aromatic compounds, as is erroneously stated.

K. Toyne (36 pages) presents a detailed discussion of the influence of individual structural elements of the rigid backbone and the terminal or lateral substituents on transition temperatures, especially for the nematic to isotropic phase transition. The correlation of this temperature with the length/breadth ratio and the packing density is outlined. The influence of the chemical structure of a compound on properties relevant for technological applications is only briefly mentioned. However, *I. Sage* (35 pages) describes the known correlations with optical and dielectric anisotropy, elastic constants and viscosity. The structures and modes of operation of the most important types of displays employing nematic phases are also discussed.

The requirements for compounds and mixtures with smectic A and C phases are considered by *D. Coates* (21 pages). In this chapter the reader is familiarized with displays that make use of these smectic phases. *D. G. McDonnell* (25 pages) gives a survey on the current state of development of thermochromic cholesteric liquid crystals. He outlines clearly the influence of different parameters on the selective reflection of light. The description of the influence of chemical structure on the optical rotatory power and the sign of rotation of the helix characteristic for the cholesteric phase is particularly interesting to read. *H. Finkelmann* (26 pages) gives a good overview of the synthesis, the phase behavior (as influenced by the molecular structure), and the properties and applications of liquid crystalline linear and branched polymers. This contribution contains many details that are important for a deeper understanding.

All the articles are written with great care, and focus on the essentials of this rapidly progressing field. An extensive up to date reference list is also provided. Thermotropic liquid crystals are discussed with particular regard to their application potential in display technology. For this reason the book treats almost exclusively calamitic, as opposed to discotic or other recently discovered molecular assemblies of fluid systems. The figures, chemical formulas, tables and physical equations are well selected and useful. The book can be recommended as a reference work to chemists active in the field, as well as to physicists having a basic knowledge of chemistry. It will also be valuable for newcomers.

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