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Ceramic Material Systems with Composite Structures: Towards Optimum Interface Control and Design

N. Takeda, L.M. Sheppard, and J. Kon, eds.
(The American Ceramic Society, Westerville OH, 1998)
566 pages, $100
ISBN 1-57498-065-3

Structural ceramics have shared with gallium arsenide the epithet "a material of the future, always has been, always will be." Gallium arsenide has since become the basis of semiconductor optics, but structural ceramics are still a promise unfulfilled. The problem has been an inability to obtain reliable high strengths by means of an economical processing method. Possible solutions have included silicon nitride, with its elongated grains and high toughness; partially stabilized zirconia; flaw-free fine-grained ceramics; ceramics reinforced with fibers or whiskers analogous to polymer composites; ceramics with toughening metal particles; and a range of progressively more complex variants on these.

During this process, there has been one notable success, carbon–carbon composites, if one is willing to make carbon an honorary ceramic for the occasion. The applications, however, do not depend on strength, but on good thermal conductivity, low thermal expansion, and very high temperature resistance. These are valuable in special applications, but not in the ceramic engine for which we have been waiting.

The present volume is a collection of 51 papers from a symposium held in Nagoya in March 1998. Most of the directions just mentioned are represented, with special emphasis on the composite approaches. The outstanding problems include the difficulty of getting sintering to high density around fibers, the vulnerability to oxidation at the surface of carbon and silicon carbide reinforcements, and the fact that the toughness increases are really not that large. Most of the work concerns refinements aimed at resolving one of these problems. As a snapshot of where we have got to in ceramic composites, this book would be very valuable to anyone contemplating joining the field.

Models of biological evolution include the idea of punctuated equilibrium. During a period of stasis, things change only slowly until a small modification in structure, or a change in the environment, allows a new type of behavior that then drives rapid change. Structural ceramics have been in stasis for about 40 years. Surely the takeoff point must be soon.

Reviewer: *Paul Calvert is in the Department of Materials Science and Engineering at the University of Arizona and works on free-forming ceramics and composites.*

Electronic Properties of Engineering Materials

James D. Livingston
(John Wiley & Sons, New York, 2000)
xiv + 320 pages, ~$100
ISBN 0-471-31627-X

As James Livingston stresses at the very outset, electrons dominate the behavior of materials. They were the first of the fundamental particles to be found, and their peculiar properties spurred the discovery and elaboration of quantum mechanics. Their role in metals, semiconductors, magnets, and much else has occupied the attention of solid-state physicists and electronic engineers for more than 50 years. Consequently, students newly embarking upon the study of materials are faced with a boundless vista, or perhaps a maze, of facts and fancies, watertight theory and hopeful speculation; where are they to start? Here is one possible approach, based on several years' experience of presentations to sophomores at the Massachusetts Institute of Technology and on a background of many more years in research and teaching. This is a mature work by one who knows what he is aiming for, and it can be recommended to all who have set out on the journey.

Since the reader is assumed to have little knowledge of quantum mechanics, the first seven chapters (out of 16) introduce many basic concepts without its use, and it is encouraging to find how far one can get without leaving the everyday classical world. After all, most materials scientists, who spend their days among real, old-fashioned things one can touch and see, develop ways of housetraining recalcitrant ideas to be useful rather than repulsive—one can go far on treating the electron, most of the time, as a little negatively charged spinning ball (unless it happens to be missing, when it is a little positively charged ball). This sort of classical introduction inevitably has dangers, as there are in any introduction to a complex subject. Oversimplification may make students too confident of their grasp—it is much worse to leave them with a plausible explanation that will have to be unlearned later, but there is commendably little of this danger here. Occasionally, the details of an argument are so pared that the reader is puzzled, but problems are presented at the end of each chapter that, taken seriously, will encourage readers to fill in the gaps for themselves.

The classical part of the book introduces conductors and insulators (including their optical properties) to magnets and to superconductors. In the quantum part, metals and semiconductors are treated more thoroughly, but still in appropriately general terms. It is good to see the origin of energy bands developed, both from overlapping orbitals and from the lattice interactions of free electrons. These two approaches are too-often met in different books or lecture courses with no explanation of their connection. The last two chapters properly concern themselves with applications of semiconductors as well as with the basic theory. Overall, the field is covered well, enough to show what lies ahead for the students who (as one must hope) plan to take things further.

Mistakes are few and of little importance (if Leon Brillouin were still alive, he might take exception at twice being called Louis). The only really misleading physics concerns the optical properties of metals; various statements leave one confused as to whether their opacity is due to reflection or absorption, and whether a free electron can directly absorb a low-energy photon. In an early (p. 31) sample problem, the solution promotes an incorrect notion of how far an electromagnetic wave can penetrate into a metal; to be sure, the matter is corrected a page or two later, but it would have been better to do so on the spot.

Sometimes the explanation of new concepts takes too much precedence over the presentation of experimental facts. Very little extra would be needed to correct the balance; thus when the reader is asked (p. 252) to apply the Hume–Rothery rule to find the composition at which there is a change in the crystal structure of various copper alloys, it would be easy to supply observations to compare with the calculated answers. Similarly, the reader, invited to predict the sign of the Hall coefficient in aluminum, might be interested or even surprised to learn that it reverses as the magnetic field is increased.

One last point: Where, as here, there are a fair number of references, a marginal note of the relevant page is helpful. I have never had objections from publishers about the very little extra work involved and believe that textbook readers would welcome more general use of this device. None of these criticisms should be taken to detract from the overall merit of the book; it deserves wide success.

Reviewer: *Brian Pippard is emeritus professor of physics at the University of Cambridge. An interview with him was published in the August 1999 issue of* MRS Bulletin, *for Profiles & Perspectives.*