sition to realize this goal.

Fleischer's story begins with a medical need for ~5 μm filters to isolate cancer cells in human blood. This was realized by the irradiation of thin polycarbonate plastic with alpha particles from californium-252 and then etching the plastic until the pits became holes. This was General Electric's first nuclear-track-related product and it is now sold through a freestanding spin-off company Nuclepore, that is the leader in an industry, with current earnings well in excess of $50 million per year. Today, these filters are used not only to isolate cancer cells but also to capture microscopic marine organisms from seawater and particulate matter from the air and to separate yeast from beer. (With these filters, sea-urchin sperm have been shown to move overwhelmingly though membranes head first, not surprising, since sea urchins continue to exist.)

Radon monitors using track-etch techniques have been another commercial success, again stimulating the formation of a spin-off company, Terradex. These detectors work by capturing the radon's polonium daughters on a plastic surface that is in contact with a known volume of air for a known period of time. Etching the plastic reveals the pit density and thus the radon concentration, which, if significant, can place occupants of a building at risk of lung cancer.

Nuclear tracks can also elucidate the age of things. Micas created millions of years ago deep in Earth's crust and subsequently brought to the surface by some geological event will, by the density of uranium-235 fission tracks they contain, reveal their age. Likewise, decorative museum glass that incorporated potassium-40 at its creation have been dated to ages as recent as 20 to 100 years. Tracks in glass shards from the Olduvai Gorge in Tanzania have been essential in placing early humans at that site 1.75 million years ago.

The nuclear-track technique is not restricted to detecting highly electrically charged particles, or even real particles. In the MACRO (Monopole Astrophysics and Cosmic Ray Observatory) experiment located in a chamber under Italy's Grand Sasso Mountain, trays containing m^2 sheets of CR 39 plastic lie in wait for the passage of a magnetic monopole. A signal of a slowly moving particle registered in the surrounding scintillation detectors will be the occasion for these sheets to be removed and etched. The track of a (137/2)e Dirac magnetic charge would be unique, while the myriad usual singly electrically charged muons leave no tracks.

Fleischer's chronicle is useful in that it provides a window on the activity of an important industrial research laboratory, a side of physics with which few academics have even the briefest acquaintance. That said, I have some quibbles. The narrative is to me somewhat overwrought at times ("this book describes the marvelous simplicity . . ."); a more measured tone would have improved the presentation. The current fashion of introducing chapters with pithy aphorisms, courtesy of Bartlett, from never-read sources, is here both affected and annoying (". . . show the tracks of knowledge." Lucretius in *On the Nature of Things*). The space devoted to references—consuming about one-tenth of this slim volume—many of which appeared in the Fleischer–Price–Walker book, would better have been used for the retelling of anecdotes. Finally, if this book had been published by a university press in paperback, students could afford a copy. The cost, at approximately 25¢ a page, is an outrage.

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Foundations of Vacuum Science and Technology

Edited by James M. Lafferty
Wiley, New York, 1998. 728 pp. $135.00 hc ISBN 0-471-17593-5

In 1962, a second edition of the classic 1949 *Scientific Foundations of Vacuum Technique* (Wiley), by Saul Dushman, was published. The editor of that volume was James M. Lafferty; revisions were made by members of the research staff of General Electric Co. Subsequently, Lafferty was encouraged by the education committee of the American Vacuum Society and John Wiley & Sons to bring the story up to date in a new edition. Lafferty chose 15 vacuum specialists from the US, Canada, the UK, Italy and Germany to contribute to "a survey of fundamental ideas in physics and chemistry that would be useful to both scientists and engineers dealing with the use, production and measurement of high vacuum."

Foundations of Vacuum Science and Technology is the result. Because of the many advances in vacuum science and technology made during the past three decades, readers familiar with the earlier works will find much of the material to be new. It is to the editor's credit that he was largely successful in upholding the tradition of the original book and avoiding the main pitfalls of multiauthored volumes (variation in the styles of presentation and excessive overlap in the material covered).

The first two chapters begin at the beginning, with the kinetic theory of gases and the flow of gases through tubes and orifices. While the basic laws have not changed over the years, the subject matter has been expanded to include all flow regimes, from free molecular flow to atmospheric pressure. Three chapters are then devoted to vacuum pumps, including the old standbys—oil-sealed positive displacement pumps and diffusion pumps—as well as new types, such as liquid-ring pumps, dry pumps, turbo pumps, getter pumps and cryopumps. A chapter on leak detectors includes their enhanced capacity for quantitative measurements in everyday use.

We learn that the art of pressure measurement has benefited from many advances in the design and understanding of the limitations of ionization, thermal conductivity, viscosity and capacitance diaphragm gauges. The partial-pressure analyzer has provided knowledge of the gas composition in a vacuum system, useful for vacuum diagnostics or process monitoring; it was the invention of the quadruple mass spectrometer that made such measurements relatively simple.

Ultrahigh vacuum is now a mature procedure rather than the state-of-the-art technology it was 40 years ago. Pressures as low as 10^{-11} pascal have been measured in the laboratory, below the transition from ultrahigh vacuum to extreme high vacuum, 10^{-10} Pa. In the chapter on this truly rarefied regime, it is shown that progress has been made by extending vacuum techniques to their limit and developing an understanding of gas–surface interactions and diffusion in solids. (The editor reminds his readers that the pascal is the ISO (International Organization for Standards) unit of pressure. For those of us who may find old habits hard to break, I suggest remembering just one simple conversion factor: 10^5 Pa is about 1 bar (1 atmosphere). Since the bar is about 1000 torr, we can easily return to what still may be a comfort zone.)

The material on calibration and standards may be common knowledge to those involved in calibration and quality control. It should nonetheless be useful to the many who (in my experience) are not aware of the accuracy limitations of vacuum measuring instruments.

There are two possible audiences for this book: those who use vacuum primarily as a tool—a means to an end—in the conduct of an experiment or a process, and those who specialize in vacuum technology. I believe both groups will find their needs met by the extensive coverage provided in this latest and most up-to-date volume on the subject.

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Understanding Materials Science: History, Properties, Applications

Rolf E. Hummel
Springer-Verlag, New York, 1998. 407 pp. $59.95 hc
ISBN 0-387-98303-1

Although materials have always played an important role in society, few books have presented the story for a general audience. Rolf Hummel, in his *Understanding Materials Science: History, Properties, Applications*, attempts to provide an introduction to the history, uses and development of materials for students of engineering and physics as well as the general public. The book holds a special interest for me as a result of my own efforts to present, as part of a public television series, the results of research in our laboratories at the University of California, Santa Barbara, and my subsequent development of a general-education undergraduate course on materials and society.

Hummel, a professor of materials science at the University of Florida, has previously written books on the optical properties of metals and alloys and on electro- and thermotransport in metals and alloys. More recently, he wrote a successful senior-level textbook for engineering students on the electronic properties of materials. In his new book, he provides a more general presentation of a wider array of subjects and relates them to their history and applications.

There is a real need for books like this, since a visit to any large bookstore will reveal very few popular science books that deal with the practical impacts of the enormous materials revolution that has defined and enabled our present technological era. Hummel tries—and succeeds—to relate the historical developments in the various materials eras (stone, bronze, iron and electronic) to the principal defining features of the various classes of materials. He interleaves short chapters on the historical development of mechanical and electrical materials with longer, but relatively simple and easy to understand, descriptions of the basic physics and chemistry of the various classes of materials.

The treatments roughly parallel the approaches normally taught in a one-semester course on materials. They include quantitative discussions and presentation of the key equations. Each chapter on mechanical and electronic materials concludes with problems, most of which require basic calculations. The chapters on ceramics and polymers are less quantitative than the others and are interwoven more closely with the historical descriptions; these chapters are centered around applications in pottery, glass, fibers and plastic, which will interest the more general reader.

Among the other books that attempt elementary descriptions of the fundamentals and applications of materials and materials science, Peter Thrower's admirable textbook *Materials in Today's World* (McGraw Hill, 1996) is aimed at a more general and less technical audience. Thrower's book is based on an innovative and popular general-education course on materials that he developed at Pennsylvania State University and that currently attracts 2000 students each year. The Hummel book is thinner, less detailed and less quantitative than the more standard undergraduate texts for materials science and engineering students, such as William Callister's *Materials Science and Engineering* (Wiley, 1994) or Donald Askeland's *Science and Engineering of Materials* (PWS Publishing, 1994). But Hummel's book covers the same main ideas as the more complete texts.

A wonderful supplement to these texts is John Russ's *Materials Science, A Multimedia Approach* CD-ROM, (PWS Publishing, 1996), which Russ and his students developed at North Carolina State University. This is a series of over 600 illustrations, animations, explanations and tests designed to accompany the traditional texts. It offers a marvelous and creative way to visualize and learn the key concepts and background of materials and calls for lots of student input.

An additional aspect of materials that is nicely covered in Hummel's book is the environmental and economic implications of society's use of materials. The discussions of world resources, the remaining supply of various materials and the fundamentals underlying waste disposal and recycling will be fascinating to both the science student and the general reader. These important areas of science are strong motivators for the wider study of science and technology by the larger public.

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Advanced Stellar Astrophysics

William K. Rose
Cambridge U. P., New York, 1998. 480 pp. $80.00 hc ($34.95 pb)
ISBN 0-521-58188-5 hc
(0-521-58833-2 pb)

Because of the limited market for graduate texts in astrophysics, few are produced, and any new addition is always greeted with enthusiasm. But when I read the promotional material for William K. Rose's *Advanced Stellar Astrophysics*, indicating that this was "the first advanced textbook on stellar astrophysics in nearly three decades," it dampened my enthusiasm. Perhaps it was a marketing ploy to overlook such venerable texts as *Stellar Atmospheres* by Dimitri Mihalas (W. H. Freeman, 1978), *Stellar Structure and Evolution* by Rudolf Kippenhahn and Alfred Weigert (Springer-Verlag, 1990), the three-volume *Introduction to Stellar Astrophysics* by Erika Böhm-Vitense (Cambridge U. P., 1989/1992), or my own *Fundamentals of Stellar Astrophysics* (W. H. Freeman, 1989). Unfortunately, the lack of references to them and other, even if older, standards in the field, such as *Principles of Stellar Structure* by John Cox and R. Thomas Giuli (Gordon & Breach, 1968), left me to assume that the author was simply unfamiliar with the literature. While overlooking important references is a serious flaw in any textbook, a very lucid presentation of the material can be a compensation.

Unfortunately, Rose provides no unifying theme to which students can fit the details of the subject matter and from which they can obtain an ordered, comprehensive picture of the subject. Rather, the book is a heterogeneous collection of topics presented in no apparent order. Compared to treatments found in the above texts, most of the topics are dealt with too cursorily and simplistically.

Far too often phrases such as "it can be shown . . ." appear in this book. A compressed and often naive treatment of a collection of topics is the book's hallmark. For example, in his three-page discussion of stellar rotation, the author spends a page and a half on the proof of what is generally known as the Taylor–Proudman theorem and then moves on to rotational solutions outside the star. There is no mention of von Zeipel's theorem, which demonstrates the difficulties of the subject, and no reference to Jean-Louis Tassoul's *Theory of Rotating Stars* (Princeton U. P., 1978) where the student can find a more complete and correct treatment of this subject. The segment's