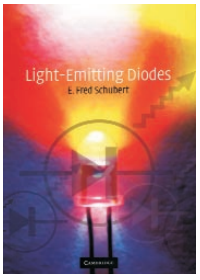
light-emitting efficiency has doubled about every 2 years, and their range of colors has greatly expanded. Today, LEDs serve as bright and colorful indicators, interior and exterior automobile lights, display elements, and backlights for nearly all electronic appliances. And IR LEDs are used for communications and remote control.



Most recently, the efficiency of LEDs has grown substantially. Their emission spectra have been expanded to include white light and the entire visible range; thus they can be used for traffic signals and outdoor, full-color displays. Researchers expect that LEDs will ultimately be applied to general illumination, which could lead to tremendous energy savings. In *Light-Emitting Diodes*, E. Fred Schubert provides an excellent review of the physics and technology of semiconductor LEDs.

The first LEDs were made of Carborundum (abrasive silicon carbide crystals). The material's properties were revealed when a curious someone touched an electrical probe to a nugget of SiC made for sandpaper grit, which caused it to emit visible light. Interesting anecdotes like this one, clearly written by someone with broad perspective and expertise, appear throughout the book, making it enjoyable to read. The first few chapters summarize the physics of carrier injection and recombination in LED operation. Although the descriptions are rather terse, they provide a good introduction to the basic mechanisms underlying the light-emission process.

Chapter 2 on radiative and nonradiative recombination processes is well referenced for those who want to dig deeper into the device physics. The sections on nonradiative recombination are especially notable, because the phenomenon represents a critical limitation to LED efficiency. Schubert provides an excellent description of the undesirable recombination pathway. LEDs have an operating current density that is one to two orders of magnitude lower than that of semiconductor laser diodes, and nonradiative processes caused by defects can be dominant at such low operating current densities.

The materials and processes required for fabrication of modern, high-brightness LEDs demand perfection. Despite their ubiquity, LEDs are difficult to make because the underlying technology is enormously sophisticated. Schubert's book explains how LEDs are made, starting from raw semiconductor materials that make up a layered heterostructure, which is processed into a die and then packaged into lamps. The text also discusses advanced designs for high-efficiency LEDs.

The recent introduction of high-brightness blue and green LEDs made from nitride semiconductors has led to a family of better full-color displays. However, understanding the benefits of visible LEDs requires some knowledge of how humans perceive colors, and Schubert has included a chapter on human vision to explain how LEDs produce a wider color gamut than that of displays based on phosphors or filtered white-light sources. Likewise, he offers a self-contained chapter on optical communication, which serves as background for the description of communications LEDs and their modulation characteristics.

The considerable attention paid to resonant-cavity LEDs in chapter 10 seems disproportionate because such LEDs are relatively rare. Still, Schubert has made pioneering contributions to those devices, and this variety of LED may become more widely used in the future. The chapter on visible LEDs summarizes the evolution of the semiconductor materials, from aluminum gallium arsenide and nitrogen-doped gallium arsenide phosphide to the nitride and phosphide alloys currently used to span the visible spectrum.

The book, however, provides relatively few details about the significant differences between nitride and phosphide semiconductors and how they impact visible-LED behavior. For example, only a brief mention is made of the apparent benefit of alloy segregation in the structurally imperfect nitride semiconductors and the role alloy segregation plays in the peculiar efficiency of nitride LEDs. Furthermore, the large polarization fields present in the nitride structures are not described. However, nitride LEDs are undergoing rapid development. Compared with more traditional materials, they are still not well explained, so such shortcomings in the book are understandable.

Overall, *Light-Emitting Diodes* is an excellent examination of the physics and technology of semiconductor LEDs. The narration is simple and direct, and the book is well referenced for those seeking a deeper understanding of the topic. Written for the graduate level, the text will appeal to a broad audience; and for specialists who make semiconductor LEDs and laser diodes, it will serve as a useful connection to the scientific literature. The book is also accessible to nonspecialists such as engineers and scientists who use LEDs or to those who simply wish to learn more about their operation and general characteristics.

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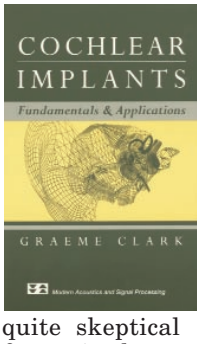
Cochlear Implants: Fundamentals and Applications

Graeme Clark
AIP Press/Springer-Verlag, New York, 2003. $129.00 (830 pp.). ISBN 0-387-95583-6



In the late 1950s, a small group of physicians and engineers proposed the idea that hearing might be restored in profoundly deaf individuals through direct electrical stimulation of the auditory nerve. At that time, however, the otology establishment was quite skeptical about the possibility of restoring hearing through electrical stimulation.

But Graeme Clark, author of *Cochlear Implants: Fundamentals and Applications*, was one of those early pioneers who was not discouraged by the establishment's criticisms or by initial failures. His lifetime of work has had enormous impact on the development and design of cochlear prostheses. Thus, Clark is well positioned to tell a wonderful success story that begins with some rudimentary hearing sensations evoked by electrical stimulation and ends with accounts of excellent speech perception by many cochlear-implant users.

In his 830-page book, Clark describes in great detail the development of cochlear prostheses and covers all aspects of cochlear implantation. The first chapter provides a good historical summary. It begins with a vivid description of Alessandro Volta's 1799 current-injection experiment and follows with the competitive efforts that have led to commercial implants that are able to restore usable hearing to individuals who are severely to profoundly hearing impaired. Readers will certainly notice that the research contributions by

Clark's group in Melbourne, Australia, are highlighted in the chapter titled "A History."

In the remaining chapters, Clark provides a basis for understanding the challenges researchers face regarding the coding and transmission of acoustic information to the auditory nerve using electrical stimulation. These chapters address subjects including neurobiology, electrophysiology, psychophysics, speech and sound processing, engineering, surgical anatomy, and surgical pathology. The author describes in detail cochlear-implant surgery and the impact of the devices on patients' lives after implantation. The book concludes with his vision about important remaining questions and ideas for future research.

In some ways, *Cochlear Implants* is easy to criticize. Although the book covers a number of subjects, the quality of information presented in each chapter varies. The clinically related topics and the description of the cochlear-implant electrodes are well organized. In contrast, the chapters on basic science would have benefited from having experts in those fields edit or offer their contributions to those chapters. It is unclear why some topics are not covered or are covered only superficially, or why Clark uses so many case reports instead of simply summarizing results. Moreover, the repetition of details and frequently used jargon challenge a broad audience. The book would have benefited from a good editor who could have condensed the writing and thereby shorten the text.

These criticisms, though, fail to capture the real essence of Clark's book. His true mission is not to turn readers into experts but, rather, make them fall in love with the subject. Through his personal recollections, the author seeks to excite readers by allowing them to participate in the experiences of the early pioneers.

Few books are available today that summarize the field and can be used to educate a broad audience or to teach audiology and otology students, and most are proceedings from scientific conferences. Only a few books like Clark's have made an attempt to cover the entire field. Examples of such excellent texts are *Cochlear Implants* (College-Hill Press, 1985), edited by Roger Gray, and *Cochlear Implants: Principles & Practices* (Lippincott Williams & Wilkins, 2000) edited by John Niparko and others. Compared with those earlier books, Clark adds little new knowledge except for the many case reports and detailed descriptions of the development of cochlear implants and cochlear implantation in Australia.

Cochlear Implants: Fundamentals and Applications, a vivid recollection by one of the pioneers in cochlear implantation, gives insight into the struggles of implementing new technologies to help hearing-impaired individuals. It also colorfully documents how the development of new technologies affects a field and its success.

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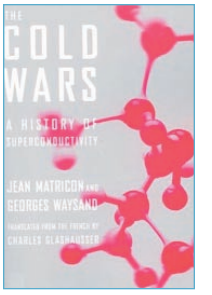
The Cold Wars: A History of Superconductivity

Jean Matricon and Georges Waysand (translated from French by Charles Glashausser)
Rutgers U. Press, New Brunswick, NJ, 2003. $65.00, $26.00 paper (271 pp.). ISBN 0-8135-3294-9, ISBN 0-8135-3295-7 paper

The Cold Wars: A History of Superconductivity provides an engaging historical narrative about the evolution of low-temperature physics with a focus on superconductivity. The book, written for a scientifically literate audience, is enriched by numerous anecdotes that illuminate the personalities of the diverse individuals who played a role in a tale that covers more than 180 years.



Jean Matricon participated in the theoretical group of Pierre-Gilles de Gennes in Orsay, France, during the "golden age" of low-temperature physics in the 1960s; Georges Waysand continues to conduct experimental research on superconductivity and has had an interest in relations between science and society. The authors' comments reveal their views about the sociology of science and their thoughts about increasingly frequent conflicts between the ideal of science for the sake of understanding and science as a utilitarian activity aimed at personal or national advancement.

The story begins with Michael Faraday's success in liquefying chlorine in 1823. Then, in 1877, Raoul Pictet and, independently, Louis Cailletet liquefied oxygen. In 1908 in Leiden, the Netherlands, Heike Kamerlingh Onnes liquefied helium, which provided the cooling needed for the discovery of superconductivity in mercury in 1911. After offering readers this historical background, the authors shift the discussion from obtaining "cold" to solving the mystery of superconductivity. For example, Matricon and Waysand give an insightful account of the old controversy surrounding Kamerlingh Onnes's role in the crucial experiments that led to the discovery of a transition to zero electrical resistance below a critical temperature T_c (approximately 4 K for mercury). They conclude that an unsung hero, a graduate student named Gilles Holst, was largely re-