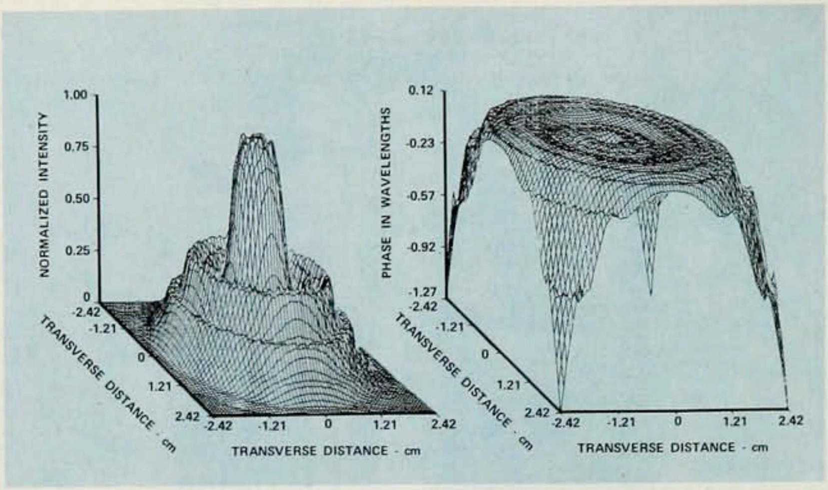


**Near-field intensity** and phase profiles from a large-scale computer simulation of a gas-dynamic $CO_2$ laser. The illustrations show a bare resonator for the lowest-order eigenmode. (Reproduced from *Lasers* by permission of the publisher.)

advanced as well as elementary texts: The continuously evolving field demands new books that explain the principles and applications of lasers in the wake of exciting new developments.

Siegman's *Lasers* is an excellent exposition of laser theory and some applications, by a stalwart in the field. Intended as a text for graduate students and well-prepared seniors in science or engineering, the book will find a place on the shelves of all students and researchers in quantum electronics and modern optics. "The unique feature of this book," as Siegman points out, "is that it removes much of the quantum mystique from the 'quantum electronics,'" thus making lasers understandable to those who have very little background in quantum mechanics. The book comprises three parts. The first part of the book, entitled "Basic Laser Physics," should be valuable to beginning students. In this part the basic operating mechanisms of the laser are described in detail. The topics discussed include rate equations, laser amplification, optical pulse propagation and some recent developments such as the soliton laser and optical bistability. The second part, "Optical Beams and Resonators," provides a systematic and lucid treatment of resonator optics and mathematics. This deserves to become the classic pedagogical treatment of the subject. I found chapter 22 on unstable resonators and chapter 23 on advanced analysis of unstable resonators especially interesting. The book finishes with more advanced topics in laser physics, such as mode locking (that is, passive locking), injection locking and applications to such systems as the ring laser gyro.

The book deals with a vast number of topics, many of them in great detail. There are, however, some gaps. To me, the most obvious is the omission of a coherent discussion of certain topics in nonlinear optics such as second-harmonic generation and optical phase conjugation.

Siegman has done a masterful job of organizing information and communicating it in a most effective way. Almost every section starts with a brief introduction outlining the objectives and ends with a set of references and problems that bring new insight to the text. And complex concepts are elucidated by means of a large number of illustrative figures.

It is safe to say that Siegman's latest book will stand the test of time.

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## Transition Metal Impurities in Semiconductors

**E. M. Omel'yanovskii and V. I. Fistul'**
*Adam Hilger, Bristol, UK (US dist. Taylor and Francis, Philadelphia), 1986 [1983]. 243 pp. $77.00 hc ISBN 0-85274-493-5*

Transition metal impurities, particularly those from the 3d series, are perhaps the best studied defects with deep energy levels in semiconductor physics. Aside from their technological importance as centers that control carrier lifetimes, as luminescence centers and as agents of semi-insulating behavior, these impurities exhibit a rich repertoire of fascinating physical phenomena associated with the coexistence of both localized, magnetically active d orbitals and delocalized ("resonating") s–p states. By providing a natural extension of the classic theoretical tools of crystal-field and ligand-field models (originally developed for ionic transition metal coordination compounds) into the realm of covalent structures, this research field has naturally bridged the otherwise disparate disciplines of coordination chemistry, semiconductor technology and impurity physics. The concomitant application of a large number of optical, electrical and magnetic probes to study experimentally 3d impurities ranging from Ti to Cu in virtually all III–V and II–VI semiconductors, coupled with the recent development of theoretical techniques for studying deep, d orbital centers, has created an urgent need for a comprehensive text summarizing the status of the field, offering perspective and identifying new challenges.

*Transition Metal Impurities in Semiconductors* is a response to this challenge. On the side of theoretical approaches, E. M. Omel'yanovskii and V. I. Fistul' review the phenomenological, classical crystal-field and ligand-field models but do not tell the reader how these models should be modified in a covalent semiconductor. They then describe the effective-mass method (with and without pseudopotential central-cell corrections) but acknowledge its irrelevance to impurities that introduce a fundamentally new type of orbital into the system (such as d orbital impurities in an s–p bonded host crystal). Next they discuss early applications of crystal models. The authors conclude pessimistically that impurity theory was capable merely of confirming the existence of deep levels without being able to reliably predict their positions or other measurable properties of such systems. My review (*Solid State Phys.* **39**, 275, 1986) of more recent theoretical work suggests that their pessimism is unwarranted.

On the experimental side, this book contains a detailed review of the data on 3d impurities in Si, Ge and III–V semiconductors. A reader entering the field will find it very useful. Regrettably, the abundant data on 3d impurities in II–VI compounds are omitted. While the experimental section of the book, suitable both as an introductory and advanced level text, describes clearly the substantial progress made in the 1970s, it sorely lacks more recent material: Although the book was updated in 1986, only 5% of the references quoted were published after 1979; virtually none after 1983. Later work has resolved many of the issues the book describes as unresolved puzzles. These include the conflicting data on the electrical levels of Si:3d (critically reviewed and sorted out by Eike Weber, *Appl. Phys. A* **30**, 7, 1983), the puzzling zero-phonon lines of GaAs:Cr observed in 1980 (reviewed by B. Clerjaud, *J. Phys. C* **18**, 3615, 1985) and the failure to characterize correctly the charge states of GaAs doped with Cr, $Co^{2+}$ or $Ni^{1+}$ (all observed before 1981). The book may thus misguide someone wishing to contribute to the solution of outstanding experimental and theoretical problems in this field.

The book contains an excellent comparison of data obtained by different experimental probes, provides an in-depth review of magnetic susceptibilities (lacking in most other reviews) and identifies the need for obtaining data by different techniques. As such, it may become an excellent reference to the general field of deep impurities. The delightful English of the translator, Albin Tybulewicz, promises to make much of the hitherto untranslated Russian literature in this field accessible to many.

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## Underwater Acoustics: A Linear Systems Theory Approach

**Lawrence J. Ziomek**
*Academic, San Diego, Calif., 1985. 290 pp. $53.50 hc*
*ISBN 0-12-781720-4*

*Underwater Acoustics* presents the ocean medium as a linear random filter. Along the way, it provides appropriate background material from electrical engineering and physics. This background material includes a chapter on linear, time-varying, space-varying filters, both deterministic and random; and an additional two chapters on complex spatially continuous apertures and spatially sampled arrays, which couple electrical signals to the ocean medium. Near-field and far-field (along with one-, two- and three-dimensional) apertures and arrays are introduced in these two chapters, and well-known related concepts are defined, including beam steering and focusing, directivity index and array gain, and grating lobes. A chapter on signal processing covers such topics as fast-Fourier-transform beam forming, quadrature demodulation, bandpass sampling, ambiguity functions, common waveforms, time delays, the Doppler shift, and time-compression stretch. The final background chapter covers acoustic wave propagation in inhomogeneous media, including the WKB approximation, ray acoustics and the parabolic equation approximation.

The last chapter, on "the random ocean medium transfer function," is the book's highlight. Basic equations that couple the transmitted and received electrical signals to the transfer function of the ocean medium via the transmitted and received far-field directivity functions provide the foundation. The generalized coherence function of the ocean is a fundamental measure of a random transfer function. From this, the effects of a time-varying, space-varying, random ocean medium on small-amplitude wave propagation can be described in terms of coherence in time, in space, in bandwidth and in angle. Lawrence Ziomek derives two expressions for the generalized coherence function. One, for an ocean medium that varies only in the vertical dimension, is based on the WKB approximation. The other is based on the parabolic equation approximation for the more general ocean medium, which can vary in all three spatial dimensions.

The book's presentation is mathematical, with emphasis on general derivations that lead to common specific forms presented as special cases. Little effort is spent in discussing derived results. Such discussion would have helped the reader develop more insight into the concepts presented.

While a consistent notation is used throughout the book, its complexity at times tends to obscure the concepts. Also, because the early chapters lay the groundwork for what follows, it would have been helpful had they contained summary highlights of results. Ziomek sometimes refers to earlier results that lie right in the middle of a derivation, and rereading the derivation was sometimes necessary to recall the meaning of terms. Such highlighting would have extended interest beyond the author's primary audience of students in a classroom setting—for example, to the practicing engineer.

My overall impression is that the book would be useful as a text for those who wish to lecture on the ocean as a linear random filter and to cover the necessary background material. However, additional courses on signal processing and underwater acoustics, using more comprehensive texts de-