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Book Reviews

Excitons

Editor: K. Cho
With contributions by
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Topics in Current Physics, Vol. 14

Springer-Verlag, Berlin, Heidelberg, New York 1979
[p. i–xi+274, with 118 figures]

Excitons are a relatively new field of interest in non-metalic solids. The theoretical and experimental data have been collected for almost 50 years, i.e. since the first works by J. Frenkel (Phys. Rev. **37** (1931), 1276), and G. H. Wannier (Phys. Rev. **52** (1937), 191), but intense activities have started quite recently, being concentrated on excitons in semiconducting materials, in particular. Progress in physics of excitons is now in a specific point: there exist already many comprehensive monographs on this subject, while the studies on excitons, being extensively continuated in many directions, multiply the material to be presented. This renders the obvious difficulties in material selection, if attempting to write a single-volume monograph, which would be representative for the actual state of affairs in this field and indicate the probable trends in its further development.

The arrangement of this book seems to be the consequence of this situation. Thus, Chapter 1 provides non-specialists with an introduction to the theory of excitons. Chapter 2 deals with internal structure of excitons with the emphasis on the external perturbation effect. Chapter 3 is mainly devoted to bound excitons in semiconductors, but since this topic has not been reviewed so extensively so far, this long Chapter differs somehow from the others by its more reviewing character. The surface exciton-polaritons studied in Chapter 4 represent an interesting type of excitations, which propagate along the crystal-dielectric boundary. Finally, the recent advances in the experimental research on excitons and exciton-phonon interactions obtained by using the resonant Raman and Brillouin scattering techniques are discussed in Chapter 5.

This monograph is written in the form of a collection of separate papers (chapters), each having its own abstract, introduction, references, etc. In the referee's opinion, such an arrangement of the book, though not the best for a monograph, was probably the only solution, considering the international set of contributors. Chapters 3, 4, and 5 seem to be of the greatest cognitive value so far as the collection of numeral data and their extensive interpretation is concerned.

In particular, Chapter 3 shows the present state of bound excitons in semiconductors which were not predicted until 1958 (M. Lampert, Phys. Rev. Lett. **4** (1958), 361). The authors draw our attention to some theoretical problems, like the classification of zero-field states, the exciton binding, the site symmetry effect, the magnetic and uniaxial stress perturbation, etc. The approach used seems to be a phenomenological rather that pure mathematical one, which makes the text easier for non-specialists. On the other hand, carefully selected references give the readers an opportunity to get aquainted with the fundamental papers, in which the consideration are carried out more basically. A rich experimental illustration, concerning the compounds of III–V, and II–VI type, is also worth mentioning. In the second part of Chapter 3 the problem, which deserves our attention, concerns the different selective transitions, which may be experimentally observed. The part devoted to the

Auger processes and quantum-mechanical interference phenomena, which may be encountered in exciton spectra, are also very interesting.

As it is well known, two forms of exciton can exist, one involving a very localized excitation process (the so-called Frenkel-type excitons), and the other, a much more extended state (the Wannier–Mott excitons). Surface exciton-polaritons exactly correspond to bulk delocalized excitations of the Wannier–Mott type. The fundamental theoretical description of these states is made in Chapter 4. This extensive review of experimental results published up to 1979 deserves our attention.

In the past years, the inelastic scattering of light solids, generally known as Brillouin scattering (by acoustic waves) or Raman scattering (by other kind of elementary excitations in solids) become a powerful technique for studying phonons, magnons and plasmons. The ability of these types of scattering to probe electronic transitions is due to the dependence of the scattering cross-section on the exciting photon energy. This fact justifies the term: resonant Raman and Brillouin spectroscopies used in the text. Some recent advances in the study of excitons in semiconductors and their interactions with phonons using these measurement techniques are reviewed in Chapter 5. The most important here, is the fact that the experimental techniques require a strong, monochromatic light source, which should be tunable. The schematic diagram of the experimental setup is equipped with a dye laser, which is the best source of radiation for resonant light scattering studies. Experimental data for zincblende-type and wurzite-type semiconductors are also extensively discussed in this Chapter.

The number of problems discussed by the authors is limited by the reasonable volume of the monograph. The content of the book reflects the authors view concering the importance of the problems to be selected for this presentation. Hence, the book may be criticized for its fragmentarity, but its publication is fully justified and the information provided can give an orientation in the present state of the exciton physics.

This biook may be recommended to all scientific workers acting in the field of solid state physics, especally to those specializing in semiconductors. The book may be also of considerable interest to all non-specialists wanting to widen their knowledge in the field discussed (as some chapters have evidently an introductory character). For the scientist working directly in the physics of excitons this book is a nice review of the last achievements.

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Excimer Lasers

Editor: Ch. K. RHODES

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[pp. i–ix+194, with 59 figures]

The concept of the excimer laser operation has been formulated by F. G. Houtermans as early as in the year 1960, but the first experimental works appeared first in 1972. They initiated a rapid development of investigation in this new field of physics and laser techniques.

The excimer lasers may generate continuous spectra in the UV-range while their efficiency ranges between 10 and 20%. This allows to hope that the excimer lasers will become, in the future, equally important effective high-power radiation sources in the UV-region as are now molecular lasers in the i.r.-region. The excimer lasers are expected to be more useful in such applications in which, in addition to the high power of the beam, high energies of the photons are requested, to name photochemistry as an example.

The excimer lasers operation is based on the fact that in many gaseous media containing excited or ionized two-atom molecules or atom-molecule complexes the electron energy levels suffer from deformation which results in their mutual overlapping and creation of new structures of energy levels similar to those in the band-model of the solids. Thus the continuous transitions from the upper to the lower energy levels become possible. However, if an energy gap — the forbidden band — appeares in the energy level structure then the radiant transitions become possible. If the condition of population inversion is additionally fulfilled, the stimulated emission and the radiation amplification are also realizable in the medium. The width of the forbidden band varies depending on the external physical conditions. This fact offers some tuning possibility for excimer laser.

The book *Excimer Lasers* is a collection of six articles by seven authors, distinguished experts in the field of excimer laser physics (Ch. A. BRAU, A. GALLAGHER, P. W. HOFF, M. KRAUSS, M. V. MCCUSKER, F. H. MIES, and Ch. K. RHODES).

Its first chapter gives a cursory introduction to the problem of excimer lasers. The energy level structure of the excimer laser has been outlined for the molecule He_2, as an example, without much discussion in which way and under what conditions the excited dimer systems are produced.

The second chapter presents an outline of theoretical interpretation of electron structure and radiative transitions for the valence system, ion-pairs and Rydberg systems. Theoretical interpretation of continuous spectra is very difficult, mainly due to lack of such efficient method, as those offered, for instance, by the theory of oscillation-rotation levels when applied to the interpretation of line spectra of molecules. Under this conditions it is possible to classify the experimental observations rather than to formulate a uniform theory of the phenomenon.

In chapters 3, 4 and 5 additional informations are given concerning the best known excimer laser system in rare gas dimers, rare gas oxides, two-atom halogen molecules, compounds of rare gases with halogens and vapours of some metals. Very essential problems of laser excitation and, in particular, the excitation by electron and nuclear beams are additionally discussed in the chapter 4. It has been indicated that the main difficulty in the experimental works concerning the excimer lasers is connected with the necessity of achieving a suitably high degree of medium excitation in order to obtain the sufficient amplification overcoming the generation threshold.

The short chapter 6 gives a review of possible applications in the field of photochemistry including the multiphoton processes, isotop separation etc. It is also expected that the excimer laser technique may enable the generation of soft X-ray radiation, which at the time being, depends on the quick development of the intense pumping techniques. Short-wave lasers enable a further progress in such fields as high density plasma diagnostics, biochemical and genetic investigations and the X-ray holography.

The book reviewed, being in reality a collection of several papers, is nonuniform in its content and presentation. It seems that the main goal of the authors was to explain the mechanisms of physical functioning of different excimer systems. Consequently, the predominant part of the book is devoted to descriptions of all possible active media and the observed spectra including their interpretation. Some problems are repeatively discussed in different parts of the book which is, however, inevitably in the publication of this kind. Too little space (except fot the chapter 4) has been devoted to the descripton of experimental techniques associated with different active media. Therefore, the readers interested in this topic have to look for other literature sources. It is a pity that the problem of reactions leading to the appearence of the excited dimer as well as the problem of intense pumping (which appear first in chapter 4) were not discussed in the first introductory chapter. This would facilitate the beginner-readers a better understanding of the whole problem and would be also helpful in explaining the experimental difficulties connected with this field. On the other hand, the presentation of the actual state-of-affairs of the investigations carried out in the excimer laser field in the form of one book is certainly a well come event.

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The boundary-layer method in diffraction problems

V. M. Babič, N. Y. Kirpičnikova
(translated by F. F. Kuester)

Springer Series in Electrophysics, Vol. 3

Springer-Verlag, Berlin, Heidelberg, New York 1979
[p. i-vi+140, with 7 figures]

The book reviewed, being a translation from the Russian original edited by the Izdatelstvo Leningradskogo Universiteta in 1974, is probably well known to all interested readers who can read Russian. The edition of the English version will be certainly wellcome by those scientific workers specializing in the diffraction theory of acoustic, electromagnetic and optical waves to whom the English language is more familiar.

The English edition provided an opportunity to improve the text in many respects. Firstly, the translater (in his introduction) provided the book with his valuable introductory part, in which the position of the boundary layer method, as related to the other approaches to diffraction problems (like geometrical theory of diffraction or uniform asymptotic theory), is considered and the essence of the boundary-layer method is clarified by discussing a well thought set of simple examples. Secondly, the authors and the translator corrected the errors noticed in the original text. Thirdly, the translator added a considerable number of references that appeared in the mean-time. Fourthly, the equation numbering system has been also replaced by a more convenient one.

It is obvious that all this editorial manipulations have considerably improved the English version without affecting its basic content.

The main purpose of this book is to explain the fundamentals of the boundary-layer method by considering a number of the carefully selected examples of application rather than giving a rigorously formalized boundary-layer theory. Another value of this approach is that some of the problems considered may be also solved by other means, and the respective comparisons may be very instructive as far as both the strong and weak points of the methods are concerned.

The author starts (Chapter 2) with the ray method of solving the scalar wave equation with variable velocity via eikonal equation, ray coordinate technique and the respective recurrence formulae. The chapter ends with discussion of reflection for the wave represented by a ray expansion.

Next, the basic ideas of the method are explained for the case of planar field in the neighbourhood of a nonsingular part of a caustic (Chapter 3), the problem being well-studied also by other methods. Chapter 4 is devoted to construction of asymptotic formulae for whispering gallery and creeping waves based on boundary-layer method. The discussion includes the related cavity quasi-mode description and the corresponding matching problems. Chapter 5 presents the boundary-layer approach to the oscilations concentrated in the neighbourhood of a ray as well as to quasi-modes of the "bouncing ball" type for first and higher order approximations. Additionally, the stability conditions are discussed.

The problem of shortwave diffraction from a smooth convex body considered in Chapter 6 consists in finding the reflected wave satisfying the Helmholtz equation with a variable velocity, if the incident wave is given by its ray expansion, while the combination of incident and reflected waves is required to satisfy the Dirichlet boundary condition. The parabolic equation method presented here in details is followed by an analysis of the boundary layer in a deep shadow zone and by discus-

sion of continuation of the solution from the vicinity of the point C to the transition region. The neighbourhood of the limiting ray is considered in terms of the analytic representation of the incident wave, the system of recurrence equations and the extension of the transition region to the limiting ray neighbourhood. In the final part of this Chapter the formulae for the field in both the shadow and preambre are derived.

The Chapter 7, being the last but one, discusses the oscillations of a point source immersed in an inhomogeneous medium. The analysis carried out in the three-dimensional version includes the presentation of the ray method for the central field of rays and discussion of the ray expansion to both the transition region and the neighbourhood of the origin.

The last Chapter contains a survey of literature as related to particular Chapters, and is also brought up to date.

As it is clear from the above this relatively thin book contains a rather extensive material. Only the authors which have really much to say are able to write in this way. It is no wonder that the argumentation is very clear and the language precise and communicative (may be in the original version even more than in the English translation). I absolutely agree with the Editor of the original version when he says that the book is directed to "the theoretisians working in the field of diffraction theory of acoustic, electromagnetic and other waves and to the mathematisians interested in asymptotic methods of mathematical physics".

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Raman Spectroscopy of Gases and Liquids

Editor: A. WEBER

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[pp. i-xi+318, with 103 figs, 25 tables]

Since application of lasers to molecular spectroscopy, new areas of its development have been revealed. It is also true in case of Raman spectroscopy. The impact made by lasers is so great that the denomination "Laser Raman Spectroscopy" is now often used in order to emphasize modern and creative aspect of its development.

This book deals, according to the editor's intentions, with basic investigations of the Raman scattering of light by gases, with some attention being also devoted to liquid substances, however, the spotlight has been given on a single molecule.

This is a multi-author work with expert contributions to separate chapters. After an introductory chapter written by A. Weber and serving as a review of the historical development of Raman spectroscopy of gases, high-resolution rotation-vibrational and pure rotational Raman spectroscopy, the six succeeding chapters deal with the following problems: high-resolution rotaion-vibrational Raman spectroscopy written by S. Brodersen; high-resolution rotational Raman spectra of gases reviewed by A. Weber. H. W. Schrörret and H. W. Klöckner have nicely described the problem of "Raman Scattering Cross-Sections in Gases and Liquids". An important contribution to this book is a chapter entitled "Intermolecular Forces Revealed by Raman Scattering" written by R. P. Srivastava and H. R. Zaidi. D. L. Rouseau, J. M. Friedman and P. F. Williams gave a brief account of "The Resonance Raman Effect". The last chapter deals with "Coherent Anti-Stokes Raman Spectroscopy" written by J. W. Nibler and G. V. Knighten.

Most of the chapters contain concise discussions of relevant theories and of some well-chosen experimental results. Pieces of information about the experimental techniques are also given, where necessary. The chapters on rotation–vibration and rotation spectra give a comprehensive coverage of recent works on Raman spectra of small gaseous molecules. Other chapters confine themselves only to certain selected problems of special interest.

This book is mainly addressed to the professional spectroscopist. There are many cases when multi-author books contain a great deal of overlaps between the contents of the chapters. Yet the Editor of this work deserves our special appreciation and thanks for reducing all the overlaps to the minimum amount necessary for the continuity of the text.

References are given at the end of each chapter. A subject index is given at the end of the book, but, unfortunately, there is no author index.

Certainly, this book may be recommended to everyone who is working in the field of molecular sciences and particularly in the field of vibrational spectroscopy.

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Holographic Interferometry

From the Scope of Deformation Analysis of Opaque Bodies

W. SCHUMANN, M. DUBAS

Springer Series in Optical Sciences, Vol. 16

Edited by David L. MACADAM

[pp. i-x+194, with 73 figures]
Springer-Verlag, Berlin, Heidelberg, New York 1979

After almost fiften years of development the holographic interferometry became a fully formed technique of measurements widely brought into practice. It is now a habitual tool in many fields of engineering, a common method for non-destructive testing of mechanical constructions and a usual laboratory technique in a rigid body investigations.

Papers suggesting a one more new method of holographic fringes interpretation, a new experimental configuration or a new particular application of holographic interferometry, or books being a compilation of such works have become less common lately. There is a time for a comprehensive study including an uniform and compact theory of holographic interferometry. This was probably an intention of Prof. Walter Schumann and Dr. Michel Dubas — the authors of a book "Holographic Interferometry". Its sub-heading: "From the Scope of Deformation Analysis of Opaque Bodies" specifies and restricts the domain of problems touched in the book.

Two parts of different character compose the book. First three chapters constitute the introductory part. Very short first one brings a historical note about holography. The second one: "Some Basic Concepts of Differential Geometry and Continuum Mechanics" contains a short introduction into the tensor calculus and differential geometry as well as into the elements of continuum mechanics (deformation, strain and its relation to the displacement). The next chapter ("Principles of Image Formation in Holography") brings a description of the principles of holography, an idea of holographic interferometry and the influence of changes in holographic geometry on the image.

The principal part of the book is contained in two last chapters. In "Fringe Interpretation in Holographic Interferometry" the authors present an uniform theory of holographic interferometry in a general form. Problems of fringes visibility and localization are discussed there. The influence of different changes at the reconstructing step (holograms movement, shifting of the reconstructing source, etc.) on the shape of interference fringes are analysed. Methods of the displacement vector determination from the double-exposure holograms are discussed in details. It is worth nothing that different interferometric methods used in practice (e.g. Aleksandrov and Bonch-Bruevich, Ennos or sandwich holograms methods) are considered there as specific cases resulting in a natural way from the general theory. The detailed analysis of interferometric, measurements of the second-order derivatives of the displacement, which correspond to the changes of the curvature of the investigated body surface is presented in the last chapter "Second Derivatives of the Displacement and of the Optical-Path Difference". This problem is the most difficult one in holographic interferometry and probably most interesting in many applications to the investigations of a rigid body.

The book seems to be adressed to two kinds of readers. One group is represented by the optics

people working in holographic interferometry who want to be better acquainted with the specifity of the objects measured. The other one consists of the mechanic engineers to whom holography is a tool and who want to know better how they measure. This is a justification for the first part of the book. This introductory part can built a bridge between opticians and mechanicians. First of them can get acquainted with continuum mechanics problem and, what is also very important, to get used to tensor form of notation which is widely applied in complicated mechanical calculations. Mechanic engineers have an opportunity to be better introduced into holography form physical point of view, and to recognize some subtleties of this method.

This task, however, can be fulfilled only for the persons who have already certain knowledge in the problems mentioned above. The book is written very briefly and it is difficult to treat the introductory part of it as a main and the only source of knowledge about holography and continuum mechanics. It can rather play a role of a short resumé of problems treated in the rest of the book and in particular cases it can be necessary to consult more elementary books on tensor calculus, continuum mechanics or principles of holography.

. The most interesting and most important is the second part of the book. The holographic interferometry is presented there as a uniform and consistent theory. This is no doubt a great advantage of the book. Such uniformity and consistency of presentation the authors got thanks to the tensor notation consequently adopted in the whole book. In such way readers can find there very smart presentation of known problems but in uncommon form. For instance, in classic papers on holography, a tensor form of aberrations or a tensor description of image forming process can be hardly found. The tensor notation makes holographic interferometry seemingly "more physical" (thoung probably more difficult and less handy). This is surely a very interesting aspect of the book.

The book presents the holographic interferometry from the theoretical point of view. It is not an elementary handbook and it cannot be recommended to the persons who barely begin to be interested in the holographic interferometry. There are neither descriptions of pracitcal methods of hologram making nor formulae for computing the displacement from interferogram in a ready-to-use form. There are no schems of typical set-ups for holography and no remarks about experimental work. The book is not a vade-mecum for an experimenters looking for practical advices and ready solutions. However, such information can be found in other manuals or papers very widely cited in the reviewed book.

On the other hand — the book can be very useful for those who have already a certain practice in holographic interferometry but do not want to reduce their knowledge to a set of simple rules of calculations.

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Nonlinear optics of free atoms and molecules

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Springer Series in Optical Sciences, Vol. 17

Springer-Verlag, Berlin, Heidelberg, New York, 1979
[p. i-ix + 351, with 82 figures and 10 tables]

The reviewed book is an extensive monography dealing with the problems of nonlinear optical processes in free atoms and molecules. The authors use time-dependent perturbation method of the appropriate range to describe various nonlinear optical phenomena in an electric-dipole approximation. The book is characterized by a relatively high contents of information which require concentration from a reader acquainted with some elements of quantum transition theory and statistical physics as well as the principles of quantum electronics and nonlinear optics.

Initially intensive research in the field of optics was concentrated mainly upon crystalline media showing the strong nonlinear properties. Recently, gaseous media (as nonlinear media) seem to be also of great interest. It was mainly caused by the rapid progress of tunable visible and UV lasers of the frequency which can be tuned in to the frequency of the atomic transitions and, consequently, a strong resonance enhancement of the nonlinear properties of medium can be reached. Moreover, the generation of various nonlinear optical effects in atomic vapours, molecular gases and cryogenic liquids is possible with considerably high efficiency of nonlinear process without irreversible damage at high intensities. This book gives a theoretical description of these effects and presents a variety of experimental achievements. The authors would like to focus the reader's attention to nonlinear effects which can be applied as sources of tunable coherent radiation. These effects in the field of spectroscopy are not taken into account (e.g. Doppler-free two-photon absorption).

The book can be divided into two parts: general theory (Chaps. 2 and 3), and experimental aspects (Chaps. 4-8). The opening Chapter (Introduction) presents generally the subject and aim of the nonlinear optics studies and shows the reasons for which the interest from crystals towards vapours and gaseous media was shifted. Individual optical nonlinear phenomena, which are the subject of particular Chapters are also described with a stress on the gaseous conditions. The second Chapter deals with the theory of nonlinear optical susceptibilities. The general formulae of the n-th order susceptibilities are the starting point of the theoretical consideration. From these formulae the susceptibilities for the particular processes (e.g. third-harmonic generation, sum-and difference frequency generation, sitmulated Raman and hyper-Raman scattering, two-photon absorbing, etc.) are calculated and their symmetry aspects discussed. The susceptibility formalism of nonlinear optics and number of distinct approaches (for example, the ideas of adiabatic states and multiphoton Bloch equations as well as the vector models) concerning the resonant interactions with a two-level or three-level atom are also described in this Chapter. Since the perturbative as well as nonperturbative treatments in resonant nonlinear interactions are now used the discussion on the relations between these approaches is fully valid.

The third Chapter deals with the effects concerning propagation of strong optical fields in nonlinear medium with restriction to the case of planar waves. Several aspects of mode complicated beams, e.g. Gaussian beam, are shown in Chaps. 4 and 5. On the grounds of the relation between nonlinear

polarization and Maxwell's equations the general waves equation describing time-spatial dependence of the optical field propagation in a medium is obtained. Making some additional assumptions this equation goes over into the inhomogeneous Helmholtz equation which is the basis for further consideration. Then the formulae concerning the radiation power generated in parametric and nonparametric processes are derived and the course of these processes is presented in detail. The formulae derived are given in the form well fitted to numerical calculations, that is of value to experiments. This Chapter contains also the discussion of more complicated processes, which are both parametric and nonparametric (i.e. the phenomena asociated with two-photon resonant nonlinear process). The authors confine themself to closer analysis of biharmonic pumping and give the coupled wave in case of small- and large-signals. The formulae, determining the intensity of light beam generated in nonparametric nonlinear processes initiated by noises which are then amplified in nonlinear medium, are derived in the last part of the Chapter.

In conclusion to the theoretical part of the book I would like to add that it is written concisely and the SI system is used in a consistent way. If a reader (conversant with the tensor calculus) wades through intricacies of the higher-order notation he avile the systematic and general scope of nonlinear optical phenomena considering not only gaseous media.

The further Chapters of the book concern the experimental part of the investigation from a single coherent unit. It is among other due to the way in which the formulae, being simplification of the general expression given in the theoretical part, have been derived. This way seems to be valid to describe the experiments in question.

Chapters 4-6 deal with experimental aspects of atomic vapours as nonlinear media. Chapter 4 presents the problems of sum frequency and harmonic generation. It begins with the discussion on the principles of optimum focussing and phase matching. Then the way of nonlinear susceptibility calculations of atomic vapours is shown mainly for the alkali-metal vapours, since they have been investigated in details and the necessary data are available. However, a lot of questions presented can be also applied to other vapours. The results are illustrated by numerous diagrams and listed in the tables. Some manners of the phase matching realization (including the question of group-velocity matching) are described and a fairly complete summary of results achieved up to the beginning of 1979 is given in tables. In the final part of the Chapter some of the limiting processes, such as multiphoton ionization, multiphoton absorption, breaking of the phase-matching condition, etc. are briefly presented.

Chapter 5 shows the results obtained from stimulated Raman scattering (SRS) in atomic vapours, a process described by the authors as stimulated electronic Raman scattering (SERS), because the energy levels involved being those of isolated atoms are thus purely electronic. First of all, the authors give some order-of-magnitude estimation of Raman gain showing the effect of resonance enhancement and demonstrate the fact that SERS gain coefficients in alkali metals vapours are comparable to the highest SRS gains in liquids. The application of SERS to tunable-infrared generation, giving dependences of tuning ranges and infrared bandwidth on the various experimental parameters (vapour pressures, inducing laser beam frequencies, power and focussing conditions) is detailed paying particular attention to the application of high-power UV lasers. The advantage of the SERS method which is economical and simple in construction and operation, compared with other available tunable infrared sources is emphasized. Examples of calculations of SERS gain in different practical situations are given. The role of various mechanisms which can limit the efficiency of infrared waves generation by the SERS is detailed in further part of the Chapter. The competing processes, line broadaning processes, saturation and limitations due to diffraction are classified among these mechanisms. The last part of the Chapter includes the description of stimulated processes related to the SERS, i.e. hyper-Raman scattering, two-photon emission and anti-Stokes stimulated Raman scattering.

In Chapter 6 four-wave mixing processes enhanced by Raman-type of resonance are considered. The Raman resonance also enhances the nonlinear susceptibility for sum- and difference-frequency generation. Since the sum-frequency process (known as the coherent anti-Stokes Raman scattering) received a considerable attention over the past few years, the authors describes mainly the Raman resonant difference mixing (RRDM) in alkali vapours taken rarely into account. This process allows

to generate widely tunable (up to date, complete coverage of the range 2-30 μm have been achieved) coherent IR radiation. Several corrections are discussed which result from theory (Chap. 3) concerning the Raman gain coefficient and intensity generated in the RRDM as well as the different process. The corrections presented are illustrated by well matched experiments. Some technical difficulties and the role of saturation is considered, too.

Various nonlinear optical processes in free molecules are the main subject of Chapter 7. The interesting feature of molecules as nonlinear media is that, owing to their vibrational and rotational motion, they have resonance in the infrared region. As in the case of atoms, these resonances can be used in the form of Raman-type resonance, or in the form of two-photon absorption (TPA). Gaseous molecular hydrogen (H_2) and liquid N_2 are the popular media to study in detail the behaviour of the SRS, since they are free from a number of competing processes (stimulated Brillouin scattering and self focussing) which are prevalent in many organic liquids. Similarly, a liquid CO is a very promising nonlinear medium for a TPA resonance, admitting for third-harmonic conversion of a CO_2 laser beam with efficiency of the order of 2-4%, and two-photon resonant 4-wave mixing. The authors give a general discussion of different two-photon resonant schemes, then consider the CO medium in some detail and also examine the case of HCl gas as the nonlinear medium. In the end of this Chapter experimental results of coherent Raman mixing in H_2 gas and far-infrared generation by the resonance Raman effect in polar molecules are presented. The authors point out also the role of the research of nonlinear effects in free molecules for the increasing availability of high-power tunable infrared sources and extending their infrared tuning ranges.

In the last Chapter some miscellaneous less familiar topics, which are the areas of recent interest of nonlinear optics of free atoms and molecules, are briefly described. The topicsse — multipole light-matter interactions, laser-induced inelastic collision and phase conjugation — give a good illustration of the variety of possible nonlinear effects which may be observed under resonance conditions. It seems to be reasonable to discuss them separately, because they do not fit readily to the earlier experimental sections but they share the same theoretical background.

Three annexes — Unit for nonlinear optical susceptibilities, Universal constant (used in the text), and List of major symbols and acronyms — complete the book. The reference list enclosed is adjusted according to the content of chapters and contains 469 units, so it seems to be sufficiently comprehensive. On the other hand, the literature inspires restrictions on its contents; it misses many valuable works by authors from Eastern as well as Western countries, which should be known to the authors of the book reviewed. Also, there are no works polemizing with the results obtained by the authors (e.g. W. Hartig, Appl. Phys. **15**, 427 (1978)). Different systems of units for the description of figures do not have a bad effect on their legibility. The notation presented is concise, correct and well performed. Some inessential deficiencies do not screen the contents of the book.

In conclusion, the book seems to be a conscise and well-studied review of the latest both theoretical and experimental scientific achievements in nonlinear optics of atoms and molecules. It contains a rich experimental part; the authors consider, however, almost only the systems of tunable conversion of coherent radiation. There is no doubt that the book provides a lot of valuable information on the problems of nonlinear optics and can be recommended to a wide circle of readers.

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Optoelektronik I

Lumineszenz- und Laserdioden

by G. WINSTEL, C. WEYRICH

Halbleiter-Elektronik, Vol. 10

Springer-Verlag, Berlin, Heidelberg, New York 1980

[p. 315, with 152 figures (in German)]

This book provides an extended introduction to the physics and technology of semiconductor light emitting diodes (LED) and injection lasers. It covers the physical fundamentals of the charge carriers radiative recombination processes in semiconductors with direct and indirect energy gaps and presents concrete examples of practical application of these physical phenomena.

The authors, who are leading scientists in semiconductor optoelectronics at the research laboratories of Siemens AG Co. in Munich, West Germany, have written a book to introduce the newcomers in the field, into the subject of semiconductor light source.

The evolution of early GaAs and GaP LEDs into a variety of coherent and incoherent light and infrared radiation sources as well as the present commercial implementation of these devices have required the collaboration of scientists and engineers from several areas of the physical and chemical sciences. Many diverse skills had to be brought together to achieve an understanding of the fundamental principles the preparation and the operating characteristics of semiconductor light sources. Future work, which will extend the research to other materials and structures, will continue to require an interdisciplinary understanding of this field. Indeed, the understanding of light emitting diodes or junction lasers requires the knowledge of wave propagation, solid-state physics, and material science — thus, few individuals have mastered all the aspects of their fabrication, characteristics and functions. In writing this text, the authors considered these points and arranged their book accordingly.

The book *Optoelektronik I* is a tutorial research monograph with the emphasis on the interdisciplinary nature of the subject. Only those topics that are sufficiently well understood to be suitable in a tutorial work, have been included. Each major topic is introduced along with the basic laws that govern the observed phenomena. The expressions relevant to different light or infrared radiation sources are derived from the basic laws and realistic numerical examples are given.

The derivations include definitions and many details permitting the reader to study an unfamiliar subject. For example, a crystal grower may not have studied the generation or propagation of electromagnetic radiation in a semiconductor, while a physicist interested in those subjects may not have dealt previously with phase equilibria and diagrams or crystal growth technologies. Both these aspects, the more physical and the more chemical ones are clearly presented in the subsequent chapters of the book.

In view of a large number of current publications on semiconductor light emitters and heterojunction lasers the authors have provided each chapter with the most representative references only, so that the interested reader might start a library search on a particular topic. It is, however, noteworthy that the references up to the 1978 literature have been included in almost all chapters of the book.

The book is organized as follows. After a general introduction in which a scope of the materials that can be used for LEDs and junction lasers is presented and where the development history of these devices is described, the physics of radiative and nonradiative recombination processes in semiconductors is treated in details. Then the mechanisms of electrical current conduction in LEDs, as well as external and internal quantum efficiencies of these devices are comprehensively discussed in relation to GaAs, GaP and $GaAs_{1-x}P_x$ diodes. This is followed by an introduction to the crystal growth technology of GaP and GaAs bulk crystal and to the different kinds of epitaxies of layered GaP, GaAs, $GaAs_{1-x}P_x$ and Al_xGa_{1-x} diode structures. The principles of chemical vapour deposition processes and liquid phase as well as molecular beam epitaxies are described.

Subsequently, the photometric and radiometric parameters used to characterize a LED are defined. Then the constructions of GaP, GaAs, InP, $GaAs_{1-x}P_x$, $Al_xGa_{1-x}As$, $Ga_xIn_{1-x}P$, $Al_xIn_{1-x}P$, $Al_xGa_{1-x}P$, GaN, SiC, ZnS-ZnSe LEDs are described and discussed in details.

The next chapter is devoted to injection lasers. It is divided in eight sections describing the phenomenological parameters of the laser, the fundamentals of injection laser physics (laser conditions, recombination kinetics, emission intensity), construction principles of a laser diode, mode structure of laser radiation, time dependent phenomena of the laser action, special kinds of semiconductor lasers (Fabry-Pérot cavity lasers, distributed feedback lasers, optically integrated lasers, cathodoluminescence lasers), and basic laser technology.

The two concluding chapters of the book present two short reviews. One concerns the application possibilities of LEDs and injection lasers, the second deals with the degradation phenomena occurring in these devices.

Aside from the pedagogical and philosophical considerations which are involved in writing a book such as *Optoelektronik I*, physical limitations necessitate that some material be excluded.

Most important topics related to LEDs and lasers have been treated quite adequately, but the authors have decided to neglect the physics of semiconductor heterojunction structures and related questions. Thus, for instance, no discussions of electrical transport, optical waveguiding phenomena and lattice matching problems in double heterojunction structures, or the nature of the dark line defects playing important role in degradation phenomena are included.

The text resolves the problem of description of a continuously changing field, by emphasizing the fundamental principles and basic understanding. Within the next few years the chapters concerning LEDs should be almost unaffected by new developments, but the chapters describing lasers, applications and degradation phenomena may well require revisions.

These remarks are not meant in indicate shortcomings of the book — they are intended to define its scope.

Optoelektronik I by Winstel and Weyrich should be useful for engineers and physicists practicing in solid state electronics as well as for graduate students in physics or electronics as an introductory course in this part of semiconductor optoelectronics which deals with light and infrared radiation sources. For the person working in the semiconductor optoelectronics field alone the book is useful too. The researcher primarily concerned with semiconductor light sources will also find much that is valuable in this text.

As described above the choice of topics, organization of the book, and clarity of presentation are fine.

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Holography and Coherent Optics

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Ctranslated from Russian by A. TYBULEWICZ)

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The book reviewed is an English translation of the original Russian text edited almost ten years earlier by the Izdatelstvo Nauka. When comparing the two different-language versions of the Soroko's monograph no essential changes may be noticed except for small corrections made by the author. This fact surprising at the first sight becomes understandable when looking once more the whole text through. Of course, the English edition of the essentially unchanged Soroko's text doee not bear the feature of novelty, which was so striking in 1971, when this book became first available to the Russian-speaking readers. However, it can still be an interesting intelectual advanture due to the richness and importance of concepts it contains, not necessarily only for the beginners in the field of holography and coherent optics.

.Three fields of modern optical science are well represented in the text: i) fundamentals of the modern physical optics, including the theory of coherence, and principles of holography, ii) an extensive treatment of opitcal fields (optical signal) as a carrier or/and processor of information, iii) both the above fields are supplemented with a review of fundamental mathematical tools employed most frequently in modern optics. These three current topics constituting the major part of the book are interlaced and interrelated. Such an approach may be very helpful for readers who want to be introduced into the whole complexity of the interrelation between the physical and informational structures of the optical field. On the other hand, the same may be somewhat inconvenient for those readers who would prefer to be systematically acquainted with only one of these fields or to find a solution of only one problem of interest, as certain topics are touched in many places of the book.

To be more precise let us briefly review the content of the book. The author decided to start with an elementary discussion of interference and holography, based on the respective geometrical properties of both fields. This was certainly a good idea for the first Russian edition, as holography was then a relatively now branch. Though it is no more the case this may still serve as an instructive introduction for the beginners. The physical considerations begun in this way are then continued in Chapters 4 and 6 devoted to coherence of light and holography. The first of those two Chapters discusses typical topics in the respective field, like mutual coherence function (including its generalized version) and its theoretical and experimental estimation, temporal and spatial coherence, partial coherence in diffraction problems and the like. The Chapter 6 offers an extensive treatment on holography, including its principles and basic systems, hologram classifications and properties, computer-generated holograms, role of particular coherence in holographic imaging and the like. Additionally, a variety of more special problems is considered, like the properties and information capacity of emulsions, correlative compensation of extended source effects, achromatic holography, to name some of them.

The information-carrying and processing aspects of the light field are studied mainly in Chapters 2, 5 and 7. The discussion starts with mathematical formalisms usually employed for description of optical signals in their complex form, followed by a survey of basic transformations (Fourier

transforms in single- and multi-dimensional spaces, cross-correlation, convolution, Hilbert- and Hankels-transforms, filtering, Fresnel-transform and the more important relations between them). In Chapter 5 the information structure of optical signals is studied starting with indeterminance principle. The problem of classical representability of optical fields is followed by a series of problems concerning determinability of optical signals for important special cases of functions with bounded spectrum or finite duration. The sampling theory which is here extensively employed enables, among others, to define the illumination matrix and intensity matrix and to discuss the role of detector matrix in the image plane. The last Chapter of the series (Chapter 7) gives a survey of optical information processing methods and principles. The following topics may be mentioned: optical filtering (including matched filtering), optical correlator, systems for image recognition, multistage and multichannel optical systems, incoherent processing of optical information, two-dimensional translator, side looking radar and the like.

The Chapter 3, devoted to an analysis of random signals, gives a review of basic statistical concepts like: stationary randomness, statistical correlation and cross-correlation and their transformations, average power and random noise. These concepts are then used to describe the statistical aspects of interference. They are also employed in other parts of the book like those dealing with partial coherence and informational structure of optical fields.

As may be easily noticed from the above, the book contains no new ideas or solutions. It is kind of pity that the author did not take the opportunity offered by the English edition of his book to mention, at least, some of the recent achievements is the respective fields. However, this does not mean that the book is out-of-date as the whole. The majority of topics discussed are still actual and formulated in a modern way. The lack of the most modern results has been milded to some extent by the Translation Editor's idea of providing the text with an Appendix containing three well known articles published earlier by him and his co-workers in *Science* and *IEEE* and dealing with optical computing, retrieval of good images from accidently blurred photographs and, finally, the image improvement and three-dimensional reconstruction using holographic image processing. This kind of modernising intervention, having already some tradition, is of course better than nothing, being, however, by nature of relatively selective character is far from what could be optimally expected.

In summing, the book may be recommended to those reareds who are interested either in being introduced into field modern optics in a relatively broad way, or in deepening their general knowledge in this field.

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