

6. Nonlinear Optical Properties of Glass

Marc Dussauze, Thierry Cardinal

Numerous innovations in photonics have been realized on the basis of nonlinear optical properties, notably in information technologies. To take advantage of the nonlinear optical properties of glass, multidisciplinary research efforts were necessary, combining optics, glass chemistry, material science, as well as development of optical or electrical polarizations processes. This chapter addresses both fundamental aspects of nonlinear optical responses and also the exploitation of nonlinear optical phenomena in glassy material. It starts by a general introduction to nonlinear optical phenomena and concepts. Then, the specific cases of second and third optical responses in glasses are treated separately and described in detail as a function of the corresponding optical phenomena, the various glass families, and their applications.

The investigations of nonlinear optical (NLO) properties of glass are intimately related to the discovery of lasers [5.1]. In the early age of lasers, most of the investigations were devoted to crystals and especially to noncentrosymmetric materials such as quartz, LiNbO_3 , KTiOPO_4 (KTP), and $\alpha\text{-BaB}_2\text{O}_4$ (BBO) [5.2]. Numerous innovations in photonics were realized, such as frequency conversion, which allows expansion of the range of accessible wavelengths by taking advantage of second and third harmonic generation or frequency sum or difference using only one or a few mono-chromatic laser lines due to the high-power laser material interaction. Glasses, due to their isotropic nature, do not exhibit second-order nonlinearity such as second harmonic generation (SHG) or electro-optic effects (Pockels effect). In contrast to the field of crystalline compounds for which the NLO properties have led to a rapid scientific and technological evolution, NLO phenomena in glass have been considered more like a constraint for practical use. Indeed, the interest in NLO properties of glass

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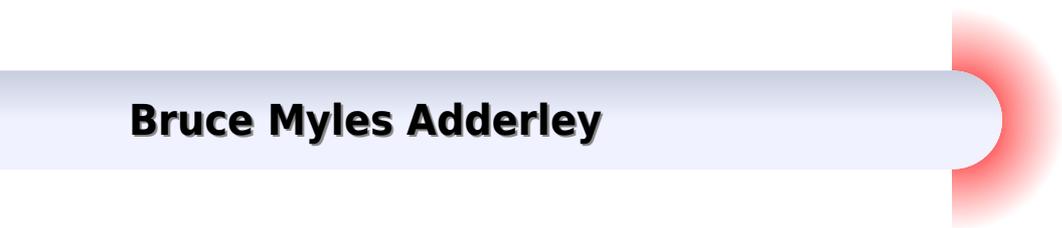
appeared with the development of high-power lasers and the growth of the optical information transmission in the telecom sector. The main objectives were to investigate the light propagation and the perturbation of the wave front while limiting the detrimental effects of NLO phenomena in waveguides where a high density of photons occurs. For instance, the Kerr effect (third-order nonlinearity), at the origin of a change in the refractive index with the laser intensity, is responsible for a spectacular self-focusing phenomenon due to the formation of a photo-induced lens directly linked to the intensity-spatial profile of the beam. This lensing could result, at worst, in an optical breakdown or in an alteration of the wave front propagation.

Such effects are still of importance for laser ignition facilities such as the megajoule laser (LMJ) in France or the National Ignition Facility in the USA. In the telecommunications sector, the issue was raised by the current use of small fiber core diameter of a few micrometers in which the power density of the optical

Part 6

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Bruce Myles Adderley



Non Linear Optical Properties Of Semiconductors Iopscience:

Optical and Wireless Technologies Vijay Janyani, Manish Tiwari, Ghanshyam Singh, Paolo Minzioni, 2018-02-12 This book presents selected papers from 1st International Conference on Optical and Wireless Technologies providing insights into the analytical experimental and developmental aspects of systems techniques and devices in these spheres It explores the combined use of various optical and wireless technologies in next generation networking applications and discusses the latest developments in applications such as photonics high speed communication systems and networks visible light communication nanophotonics and wireless and multiple input multiple output MIMO systems The book will serve as a valuable reference resource for academics and researchers across the globe

Behaviour of Electromagnetic Waves in Different Media and Structures Ali Akdagli, 2011-07-05 This comprehensive volume thoroughly covers wave propagation behaviors and computational techniques for electromagnetic waves in different complex media The chapter authors describe powerful and sophisticated analytic and numerical methods to solve their specific electromagnetic problems for complex media and geometries as well This book will be of interest to electromagnetics and microwave engineers physicists and scientists

6th International Conference on Nanotechnologies and Biomedical Engineering Victor Sontea, Ion Tiginyanu, Serghei Railean, 2023-09-11 This book reports on advances in fundamental and applied research at the interface between nanotechnology and biomedical engineering Gathering peer reviewed contributions to the 6th International Conference on Nanotechnologies and Biomedical Engineering ICNBME held on September 20 23 2023 in Chisinau Republic of Moldova this first volume of the proceedings focuses on nanotechnologies and nano biomaterials and their applications in medicine With a good balance of theory and practice the book offers a timely snapshot of multidisciplinary research at the interface between physics chemistry biomedicine materials science and engineering

Nanoelectronics Khurshed Ahmad Shah, 2025-10-21 The book covers the latest advancements in the field of nanoelectronics interaction of light with matter optical properties surface plasmons nanophotonic and plasmonic applications nanomaterials engineering in nanoelectronics fabrication techniques and applications It presents the structure properties and device applications of carbon nanotubes graphene and silicene The book further includes topics on perovskites and applications quantum dots for optoelectronic sensing devices computing applications and advanced applications in diagnostic and therapeutic tools This book Introduces topics on quantum phenomenon in nanoelectronics transistors in modern computing spintronic devices flexible and wearable electronics and case studies and includes topics on development of hybrid material of one dimensional 1D and 2D carbon in nanomedicine computed tomography ultrasound and stapled peptides drug Presents physical and electrical properties of nanoscale materials applications of carbon nanotubes such as batteries supercapacitors biosensors photodetectors and field emission sources and topics on the surface plasmon resonance nanolasers nanoantennas photonic crystals and luminescent materials Discusses quantum dots quantum electronic devices nanosensors quantum computing device applications of

perovskite materials spintronics drug delivery and gene therapy applications and the scaling laws in nanoelectronics materials for nano FET high speed computing and advanced nanoscale FET architectures Highlights recent developments in the field of nanoscale devices based on graphene and silicene such as biosensing and gas sensing thermoelectric devices and optoelectronic applications Explains the basic quantum theory pizelectricity in zinc oxide quantum dots and nanosensing includes the topics on data storage and quantum logic gates It is primarily written for senior undergraduates graduate students and academic researchers in the fields including physics computers nanoelectronics electrical engineering electronics and communications engineering nanoscience and nanotechnology

Transport Phenomena in Micro- and Nanoscale Functional Materials and Devices Joao B. Sousa, Joao O. Ventura, Andre Pereira, 2021-03-23 *Transport Phenomena in Micro and Nanoscale Functional Materials and Devices* offers a pragmatic view on transport phenomena for micro and nanoscale materials and devices both as a research tool and as a means to implant new functions in materials Chapters emphasize transport properties TP as a research tool at the micro nano level and give an experimental view on underlying techniques The relevance of TP is highlighted through the interplay between a micro nanocarrier s characteristics and media characteristics long short range order and disorder excitations couplings and in energy conversions Later sections contain case studies on the role of transport properties in functional nanomaterials This includes transport in thin films and nanostructures from nanogranular films to graphene and 2D semiconductors and spintronics and from read heads MRAMs and sensors to nano oscillators and energy conversion from figures of merit micro coolers and micro heaters to spincaloritronics Presents a pragmatic description of electrical transport phenomena in micro and nanoscale materials and devices from an experimental viewpoint Provides an in depth overview of the experimental techniques available to measure transport phenomena in micro and nanoscale materials Features case studies to illustrate how each technique works Highlights emerging areas of interest in micro and nanomaterial transport phenomena including spintronics

Nonlinear Optical Properties of Semiconductor N-i-p-i Structures Xiaohong Tang, 1997 *Nonlinear Optics in Semiconductors I*, 1998-10-22 Since its inception in 1966 the series of numbered volumes known as Semiconductors and Semimetals has distinguished itself through the careful selection of well known authors editors and contributors The Willardson and Beer Series as it is widely known has succeeded in publishing numerous landmark volumes and chapters Not only did many of these volumes make an impact at the time of their publication but they continue to be well cited years after their original release Recently Professor Eicke R Weber of the University of California at Berkeley joined as a co editor of the series Professor Weber a well known expert in the field of semiconductor materials will further contribute to continuing the series tradition of publishing timely highly relevant and long impacting volumes Some of the recent volumes such as Hydrogen in Semiconductors Imperfections in III V Materials Epitaxial Microstructures High Speed Heterostructure Devices Oxygen in Silicon and others promise that this tradition will be maintained and even expanded Reflecting the truly interdisciplinary

nature of the field that the series covers the volumes in Semiconductors and Semimetals have been and will continue to be of great interest to physicists chemists materials scientists and device engineers in modern industry Investigation of Nonlinear Optical Properties of Semiconductors D. G. Seiler, NORTH TEXAS STATE UNIV DENTON CENTER FOR APPLIED QUANTUM ELECTRONICS.,1984 Nonlinear optics is an increasingly interesting and exciting area of physics Many nonlinear optical effects have been discovered and various nonlinear optical devices constructed from a wide variety of materials In particular small band gap semiconductors like InSb can have unique optical properties because of their small effective masses and direct band gaps Unusual and often unexpected results are found in their nonlinear behavior optical bistability nonlinear refraction laser pulse limiting and shaping effects optical transistor action etc These effects can be described in terms of a third order susceptibility and are associated with the creation of free carriers by the light The creation of even a small number of free electrons or holes can strongly effect the dynamic nonlinear optical properties of the material In this project we used sensitive photoelectronic methods to investigate the nonlinear generation of electrons in InSb CdS and GaAs induced by two photon absorption of light A wide variety of photoelectronic effects are initiated by the creation of free carriers from the absorption of light in a semiconductor or insulator These include the photo Hall effect photoconductivity recombination trapping lifetimes all of which are important for understanding devices such as light detectors light emitters or energy converters *Optical Nonlinearities and Instabilities in Semiconductors* Hartmut Haug,2012-12-02 *Optical Nonlinearities and Instabilities in Semiconductors* deals with various aspects of nonlinear optical phenomena and related optical instabilities in semiconductors Measurements and explanations of the optical nonlinearities of various semiconductor materials and structures are presented along with optical bistability and diode laser thresholds self oscillations and chaos This text consists of 17 chapters and begins with an introductory chapter to the historical background of investigations of the resonance enhanced nonlinear optical properties of semiconductors and their manifestations in optical instabilities The discussion then turns to the experimentally observed optical nonlinearities in homogeneous semiconductors and the microscopic theory of the optical band edge nonlinearities This book considers the studies of the spectral region close to the band gap meant to exploit the resonance enhancement of the nonlinear optical behavior The remaining chapters focus on nonlinear optical properties of semiconductor quantum wells dense nonequilibrium excitations in gallium arsenide optical decay and spatial relaxation and optical bistability in semiconductor laser amplifiers A chapter that describes instabilities in semiconductor lasers concludes the book This book is intended for research students and active research workers who are interested in the basic physics or in the device applications of optical nonlinearities and instabilities in semiconductors

Nonlinear Optical Properties of Semiconductor Superlattices Bruce Myles Adderley,1992 **Nonlinear Optical Properties of Semiconductor Media** Vivien Wheeling Lee Talghader,1996 *Linear and Nonlinear Optical Properties of Semiconductors [microform]: Theory and Calculations* James L. P. Hughes,1998 **Nonlinear Optical Properties of**

Narrow Bands Gap Semiconductors Alexander MacKenzie Johnston,1980 **Characterization of Temperature Dependent Nonlinear Optical Properties of Semiconductor Materials** Vincent M. Cowan,2008 *Nonlinear optical properties of narrow band gap semiconductors* Arthur M. Johnston,1980 **Nonlinear Optical Studies of the Optical and Electronic Properties of Semiconductor Heterostructures** Duncan G. Steel,MICHIGAN UNIV ANN ARBOR HARRISON M RANDALL LAB OF PHYSICS.,1990 Experimental work emphasized demonstrating the use of high resolution frequency domain nonlinear laser spectroscopy for the study of materials particularly semiconductor heterostructures The work has demonstrated that cw four wave mixing spectroscopy provides new information regarding the origin of the nonlinear optical response in semiconductor materials as well as new information about structure and relaxation A summary of the current progress shows 1 First experimental observation of an interference effect in the nonlinear optical response in GaAs quantum well structures corresponding to a slow component in the nonlinear optical response The interference effect is evidence that the exciton resonance frequency is shifted in the presence of the electron hole plasma produced by the ionized exciton 2 Demonstration of frequency domain nonlinear optical spectroscopy methods for the direct measurement of the ambipolar diffusion coefficient and the electron hole recombination rate in GaAs quantum well structures 3 Measurement of the response time in strained quantum well structures where the heavy and light hole exciton overlap in energy and 4 Use of precision nonlinear optical spectroscopy methods for the study of phonon induced spectral diffusion of the heavy hole exciton at low temperature in GaAs quantum well structures Keywords Semiconductor junctions Nonlinear optical analysis cp

Linear and Nonlinear Optical Properties of Organic Semiconductors Ian Munro Craig,2010 **Nonlinear Optics in Semiconductors II** Elsa Garmire,Alan Kost,1999 Treatise editors Robert K Willardson and Eicke R Weber *Nonlinear Optics of Organics and Semiconductors* Takayoshi Kobayashi,1989-06-23 Just after the International Quantum Electronics Conference which took place in Tokyo July 18 21 1988 a symposium on Nonlinear Optics of Org ics and Semiconductors was held on the Hongo campus of the University of Tokyo on July 25 and 26 1988 Recently nonlinear optical materials have started to attract the attention of many scientists not only in the field of quantum electronics but also in organic chemistry and solid state physics especially semiconductor physics Therefore this area of investigation is really interdisciplinary and necessitates understanding from different viewpoints for continuous growth of the research activity in the field This book contains many papers written by scientists active in the field of nonlinear optics of organic materials and semiconductors The first two parts of the book discuss mainly the basic physics of nonlinear optics of semiconduc tors including bulk and quantum well structure semiconductors The papers in Parts ill VIII concern mainly organic materials They include the calculation of molecular polarizability synthesis the measurement of optical nonlinearity and characterization The final part is on potential device applications The symposium was organized in collaboration with Prof Shinsuke Umegaki of Tokyo Technical Institute and Dr Hachiro Nakanishi of the Research Institute of Polymers and Textiles Preparations for the

conference were made with the help of Dr Masayuki Yoshizawa Miss Nanae Indou Mrs Yoko Sasaki and graduate students Mrs T Hattori M Terauchi K Ichimura A Terasaki K Nonlinear Optical Properties of Nanostructured Supramolecular Organic Semiconductor ,2006 Resonant third order optical susceptibility and hyperpolarizability of donor polymer in chloroform were revealed to be $2.59 \times 10^{-20} \text{ m}^2 \text{ V}^{-2}$ and $8.610 \times 10^{-42} \text{ m}^5 \text{ V}^{-2}$ by degenerate four wave mixing in nanosecond scale at 532 nm which was attributed to the resonant enhancement

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