Infrared Detectors By Antonio Rogalski

The first edition of the Encyclopedia of Optical and Photonic Engineering provided a valuable reference concerning devices or systems that generate, transmit, measure, or detect light, and to a lesser degree, the basic interaction of light and matter. This Second Edition not only reflects the changes in optical and photonic engineering that have occurred since the first edition was published, but also: Boasts a wealth of new material, expanding the encyclopedia's length by 25 percent Contains extensive updates, with significant revisions made throughout the text Features contributions from engineers and scientists leading the fields of optics and photonics today With the addition of a second editor, the Encyclopedia of Optical and Photonic Engineering, Second Edition offers a balanced and up-to-date look at the fundamentals of a diverse portfolio of technologies and discoveries in areas ranging from x-ray optics to photon entanglement and beyond. This edition's release corresponds nicely with the United Nations General Assembly's declaration of 2015 as the International Year of Light, working in tandem to raise awareness about light's important role in the modern world. ALSO AVAILABLE ONLINE This Taylor & Francis encyclopedia is also available through online subscription, offering a variety of extra benefits for

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An up-to-date view of the various detector/emitter materials systems currently in use or being actively researched. The book is aimed at newcomers and those already working in the IR industry. It provides both an introductory text and a valuable overview of the entire field.

When you look closely, nature is nanotechnology at its finest. From a single cell, a factory all by itself, to complex systems, such as the nervous system or the human eye, each is composed of specialized nanostructures that exist to perform a specific function. This same beauty can be mirrored when we interact with the tiny physical world that is the realm of quantum mechanics. This book focuses on the application of nanotechnology to modern semiconductor optoelectronic devices. Electrons, photons, and even thermal properties can all be engineered

at the nanolevel. The 2D quantum well, possibly the simplest aspect of nanotechnology, has dramatically enhanced the efficiency and versatility of electronic and optoelectronic devices. While this area alone is fascinating, nanotechnology has now progressed to 1D (quantum wire) and 0D (quantum dot) systems that exhibit remarkable and sometimes unexpected behaviors. With these components serving as the modern engineer's building blocks, it is a brave new world we live in, with endless possibilities for new technology and scientific discovery.

Infrared thermography enables the non-contact measurement of an object’s surface temperature and presents the results in form of thermal images. The analysis of these images provides valuable information about an object’s thermal state. However, the fidelity of the thermal images strongly depends on the pose of the thermographic camera with respect to the surface. 3D thermography offers the possibility to overcome this and other limitations that affect conventional 2D thermography but most 3D thermographic systems developed so far generate 3D thermograms from a single perspective or from few noncontiguous points of view and do not operate in real time. As a result, the 3D thermograms they generate do not offer much advantage over conventional thermal images. However, recent technological advances have unlocked the possibility of implementing affordable

handheld 3D thermal imaging systems that can be easily maneuvered around an object and that can generate high-fidelity 3D thermograms in real time. This thesis explores various aspects involved in the real-time generation of high-fidelity 3D thermograms at close range using a handheld 3D thermal imaging system, presents the results of scanning an operating industrial furnace and discusses the problems associated with the generation of 3D thermograms of large objects with complex geometries.

In the past, infrared imaging has been used exclusively for military applications. In fact, it can also be useful in a wide range of scientific and commercial applications. However, its wide spread use was impeded by the scarcity of the imaging systems and its high cost. Recently, there is an emerging infrared technology based on quantum well intersubband transition in III-V compound semiconductors. With the new technology, these impedances can be eliminated and a new era of infrared imaging is in sight. This book is designed to give a systematic description on the underlying physics of the new detectors and other issues related to infrared imaging. Contents:FundamentalsEnergy Levels in One-Dimensional Quantum WellsQuantum Wells in Crystal LatticesQuantum Wells in the Presence of InteractionIntersubband Transition in Quantum WellsOptical Coupling for Quantum Well Infrared PhotodetectorsHot-Electron

TransistorsExcitation Hot-Electron Spectroscopy of Quantum WellsTransport Properties of Multiple Quantum Well StructuresQuantum Well Infrared PhotodetectorInfrared Hot-Electron TransistorNoise Properties of Infrared Hot-Electron TransistorMulti-Color QWIP and IHETPerformance of Quantum Well Infrared Photodetectors Readership: Solid state physicists, device physicists, materials scientists and infrared engineers. keywords:Infrared Detector;Quantum Well;Optoelectronics;Intersubband Transition;Hot-Electron;Transistor;Noise;Optical Coupling;Focal Plane Array;Excitation Spectroscopy

Completely revised and reorganized while retaining the approachable style of the first edition, Infrared Detectors, Second Edition addresses the latest developments in the science and technology of infrared (IR) detection. Antoni Rogalski, an internationally recognized pioneer in the field, covers the comprehensive range of subjects necessary to un

Radiometry -- Infrared systems fundamentals -- Infrared detector characterization -- Fundamental performance limitations of infrared detectors -- Coupling of infrared radiation with detector -- Heterodyne detection -- Thermopiles -- Bolometers -- Pyroelectric detectors -- Pneumatic detectors -- Novel thermal detectors -- Theory of photon detectors -- Intrinsic silicon and germanium detectors -- Extrinsic silicon and germanium detectors -- Photoemissive

detectors -- III-V detectors -- HgCdTe detectors -- IV-VI detectors -- Quantum well infrared photodetectors -- Superlattice photovoltaic detectors -- Quantum dot infrared photodetectors -- Infrared barrier photodetectors -- Cascade infrared photodetectors -- Overview of focal plane array architectures -- Thermal detector focal plane arrays -- Photon detector focal plane arrays -- Third generation infrared detectors -- Terahertz detectors and focal plane arrays

Numerical Simulation of Optical Wave Propagation is solely dedicated to wave-optics simulations. The book discusses digital Fourier transforms (FT), FT-based operations, multiple methods of wave-optics simulations, sampling requirements, and simulations in atmospheric turbulence.

Introduction -- Comparison of Photon and Thermal Detectors Performance -- GaAs/AlGaAs Based Quantum Well Intra-red Photodetector Focal Plane Arrays -- GaInAs(P) Based Qwips on GaAs, InP and Si Substrates for Focal Plane Arrays -- InAs/(Galn)Sb Superlattices: A Promising Material System for Infra-red Detection -- GaSb/InAs Superlattices for Infra-red FPAs -- MCT Properties, Growth Methods and Characterization -- HgCdTe 2D Arrays -- Technology and Performance Limits -- Status of HgCdTe MBE Technology -- Silicon Infra-red Focal Plane Arrays -- PolySiGe Uncooled Microbolometers for Thermal Infra-red Detection -- Infra-red Silicon/Germanium Detectors -- Fundamentals of Spin Filtering in Ferromagnetic Metals with Application to Spin Sensors.

Handbook of Optoelectronics offers a self-contained reference from the basic science and light sources to devices and modern applications across the entire spectrum of disciplines utilizing optoelectronic technologies. This second edition gives a complete update of the original work with a focus on systems and applications. Volume I covers the details of optoelectronic devices

and techniques including semiconductor lasers, optical detectors and receivers, optical fiber devices, modulators, amplifiers, integrated optics, LEDs, and engineered optical materials with brand new chapters on silicon photonics, nanophotonics, and graphene optoelectronics. Volume II addresses the underlying system technologies enabling state-of-the-art communications, imaging, displays, sensing, data processing, energy conversion, and actuation. Volume III is brand new to this edition, focusing on applications in infrastructure, transport, security, surveillance, environmental monitoring, military, industrial, oil and gas, energy generation and distribution, medicine, and free space. No other resource in the field comes close to its breadth and depth, with contributions from leading industrial and academic institutions around the world. Whether used as a reference, research tool, or broad-based introduction to the field, the Handbook offers everything you need to get started. John P. Dakin, PhD, is professor (emeritus) at the Optoelectronics Research Centre, University of Southampton, UK. Robert G. W. Brown, PhD, is chief executive officer of the American Institute of Physics and an adjunct full professor in the Beckman Laser Institute and Medical Clinic at the University of California, Irvine.

2D Materials for Infrared and Terahertz Detectors provides an overview of the performance of emerging detector materials, while also offering, for the first time, a comparison with traditional materials used in the fabrication of infrared and terahertz detectors. Since the discovery of graphene, its applications to electronic and optoelectronic devices have been intensively researched. The extraordinary electronic and optical properties allow graphene and other 2D materials to be promising candidates for infrared (IR) and terahertz (THz) photodetectors, and yet it appears that the development of new detectors using these materials is still secondary to

those using traditional materials. This book explores this phenomenon, as well as the advantages and disadvantages of using 2D materials. Special attention is directed toward the identification of the most-effective hybrid 2D materials in infrared and terahertz detectors, as well as future trends. Written by one of the world's leading researchers in the field of IR optoelectronics, this book will be a must-read for researchers and graduate students in photodetectors and related fields. Features • Offers a comprehensive overview of the different types of 2D materials used in fabrication of IR and THz detectors, and includes their advantages/disadvantages • The first book to compare new detectors to a wide family of common, commercially available detectors that use traditional materials.

This collection of 104 papers is divided into two parts. Part One, Image Intensification, focuses on developments with image intensified tubes. Part Two, Thermal Imaging, concentrates on the practical applications of night vision technology for its main users: the armed forces.

This book presents a comprehensive overview of state-of-the-art quantum dot photodetectors, including device fabrication technologies, optical engineering/manipulation strategies, and emerging photodetectors with building blocks of novel quantum dots (e.g. perovskite) as well as their hybrid structured (e.g. 0D/2D) materials. Semiconductor quantum dots have attracted much attention due to their unique quantum confinement effect, which allows for the facile tuning of optical properties that are promising for next-generation optoelectronic applications. Among these remarkable properties are large absorption coefficient, high photosensitivity, and tunable optical spectrum from ultraviolet/visible to infrared region, all of which are very attractive and favorable for photodetection applications. The book covers both fundamental and frontier research in order to stimulate readers' interests in developing novel ideas for

semiconductor photodetectors at the center of future developments in materials science, nanofabrication technology and device commercialization. The book provides a knowledge sharing platform and can be used as a reference for researchers working in the fields of photonics, materials science, and nanodevices.

Microbolometers: Fundamentals, Materials, and Recent Developments describes the fundamentals of microbolometers, their historic evolution, operational principles and material choices. It also explains the impact of materials on the processing and development of device characteristics. Sections address various aspects of optical properties and recommend models of properties of materials of interest for the fabrication of the uncooled microbolometers. In addition, the book presents two case studies, Honeywell and Texas Instruments, that focus on the design and manufacture of microbolometers. Finally, recent developments, applications, patents and future trends are presented. The chapter on patents will summarize the strengths and weaknesses of each of the technologies. Describes the fundamentals of uncooled infrared detectors, operational principles and material approaches Includes case studies based on Honeywell and Texas Instruments' work on microbolometers Provides analyses of current patents with a look towards their strengths and weaknesses

The choice of available infrared (IR) detectors for insertion into modern IR systems is both large and confusing. The purpose of this volume is to provide a technical database from which rational IR detector selection criteria evolve, and thus clarify the options open to the modern IR system designer. Emphasis concentrates mainly on high-performance IR systems operating in a tactical environment, although there also is discussion of both strategic environments and low- to medium-performance system requirements.

The Department of Defense recently highlighted intelligence, surveillance, and reconnaissance (ISR) capabilities as a top priority for U.S. warfighters. Contributions provided by ISR assets in the operational theaters in Iraq and Afghanistan have been widely documented in press reporting. While the United States continues to increase investments in ISR capabilities, other nations not friendly to the United States will continue to seek countermeasures to U.S. capabilities. The Technology Warning Division of the Defense Intelligence Agency's (DIA) Defense Warning Office (DWO) has the critical responsibility, in collaborations with other components of the intelligence community (IC), for providing U.S. policymakers insight into technological developments that may impact future U.S. warfighting capabilities. To this end, the IC requested that the National Research Council (NRC) investigate and report on key visible and infrared detector technologies, with potential military utility, that are likely to be developed in the next 10-15 years. This study is the eighth in a series sponsored by the DWO and executed under the auspices of the NRC TIGER (Technology Insight-Gauge, Evaluate, and Review) Standing Committee.

Photoluminescence spectroscopy is an important approach for examining the optical interactions in semiconductors and optical devices with the goal of gaining insight into material properties. With contributions from researchers at the forefront of this field, Handbook of Luminescent Semiconductor Materials explores the use of this technique to study semiconductor materials in a variety of applications, including solid-state lighting, solar energy conversion, optical devices, and biological imaging. After introducing basic semiconductor theory and photoluminescence principles, the book focuses on the optical properties of wide-bandgap semiconductors, such as AlN, GaN, and ZnO. It then presents research on narrow-

bandgap semiconductors and solid-state lighting. The book also covers the optical properties of semiconductors in the nanoscale regime, including quantum dots and nanocrystals. This handbook explains how photoluminescence spectroscopy is a powerful and practical analytical tool for revealing the fundamentals of light interaction and, thus, the optical properties of semiconductors. The book shows how luminescent semiconductors are used in lasers, photodiodes, infrared detectors, light-emitting diodes, solid-state lamps, solar energy, and biological imaging.

This introduction to uncooled infrared focal plane arrays and their applications is aimed at professionals, students, and end users. Topics include principal uncooled thermal detection mechanisms; fundamental performance limits and theoretical performance; the state of the art; and applications, technical trends, and systems employing uncooled arrays.

These 86 papers cover developments in the field of thermal and photon IR detectors, with an emphasis on thermal detectors, directed toward improving the performance of single-element devices and large electronically scanned arrays, enabling IR detectors to operate at higher temperatures, and making IR detectors cheaper and more convenient to use.

Optoelectronics ranks one of the highest increasing rates among the different industrial branches. This activity is closely related to devices which are themselves extremely dependent on materials. Indeed, the history of optoelectronic devices has been following closely that of the materials. KLUWER Academic Publishers has thus rightly identified "Materials for Optoelectronics" as a good opportunity for a book in the series

entitled "Electronic Materials; Science and Technology". Although a sound background in solid state physics is recommended, the authors have confined their contribution to a graduate student level, and tried to define any concept they use, to render the book as a whole as self-consistent as possible. In the first section the basic aspects are developed. Here, three chapters consider semiconductor materials for optoelectronics under various aspects. Prof. G. E. Stillman begins with an introduction to the field from the point of view of the optoelectronic market. Then he describes how III-V materials, especially the Multi Quantum Structures meet the requirements of optoelectronic functions, including the support of microelectronics for optoelectronic integrated circuits. In chapter 2, Prof.

Semiconductor Opto-Electronics focuses on opto-electronics, covering the basic physical phenomena and device behavior that arise from the interaction between electromagnetic radiation and electrons in a solid. The first nine chapters of this book are devoted to theoretical topics, discussing the interaction of electromagnetic waves with solids, dispersion theory and absorption processes, magneto-optical effects, and non-linear phenomena. Theories of photo-effects and photo-detectors are treated in detail, including the theories of radiation generation and the behavior of semiconductor lasers and lamps. The rest of this text deals with the group IV elements, III-V compounds, and selection of the most important chalcogenides. This publication is intended primarily for physicists engaged in academic research or commercial device

development and for honors students specializing in solid-state physics.
Completely revised and reorganized while retaining the approachable style of the first edition, Infrared Detectors, Second Edition addresses the latest developments in the science and technology of infrared (IR) detection. Antoni Rogalski, an internationally recognized pioneer in the field, covers the comprehensive range of subjects necessary to understand modern IR detector theory and technology. He presents each topic with a brief summary of historical background followed by summary of principles underlying performance, an overview of properties, and analysis of the state of the art. Divided into four sections, the book covers fundaments of IR detection, IR thermal detectors, IR photon detectors, and focal plane arrays. It begins with a tutorial introduction to essential of different types of IR detectors and systems. The author explores the theory and technology of different thermal detectors and then moves on to the theory and technology of photon detectors. He concludes his treatment with a discussion of IR focal plane arrays where relations between performance of detector array and infrared system quality are considered. New to the Second Edition: Fundamentals of IR detection, radiometry, and flux-transfer issues needed for IR detector and system analysis Major achievements and trends in the development of IR detectors Novel uncooled detectors such as cantilever, antenna, and optically coupled detectors Type II superlattice detectors Quantum dot IR detectors Terahertz (THz) arrays and new generation of IR detectors, so-called third generation detectors The author

accomplishes the difficult task of making the information accessible to a wide readership. A comprehensive analysis of the latest developments in IR detector technology and basic insight into the fundamental processes important to evolving detection techniques, the book provides the most complete and up-to-date resource of its kind, including a summary of useful data, guide to the literature, and overview of applications.

"Among the many materials investigated in the infrared (IR) field, narrow-gap semiconductors are the most important in IR photon detector family. Although the first widely used narrow-gap materials were lead salts (during the 1950s, IR detectors were built using single-element-cooled PbS and PbSe photoconductive detectors, primary for anti-missile seekers), this semiconductor family was not well distinguished. This situation seems to have resulted from two reasons: the preparation process of lead salt photoconductive polycrystalline detectors was not well understood and could only be reproduced with well-tried recipes; and the theory of narrow-gap semiconductor bandgap structure was not well known for correct interpretation of the measured transport and photoelectrical properties of these materials"--

This series of books, which is published at the rate of about one per year, addresses fundamental problems in materials science. The contents cover a broad range of topics from small clusters of atoms to engineering materials and involve chemistry, physics, materials science, and engineering, with length scales ranging from Ångstroms up to

millimeters. The emphasis is on basic science rather than on applications. Each book focuses on a single area of current interest and brings together leading experts to give an up-to-date discussion of their work and the work of others. Each article contains enough references that the interested reader can access the relevant literature. Thanks are given to the Center for Fundamental Materials Research at Michigan State University for supporting this series. M. F. Thorpe, Series Editor E-mail: thorpe@pa. msu. edu East Lansing, Michigan V PREFACE It is hard to believe that not quite ten years ago, namely in 1991, nanotubes of carbon were discovered by Sumio Iijima in deposits on the electrodes of the same carbon arc apparatus that was used to produce fullerenes such as the “buckyball”. Nanotubes of carbon or other materials, consisting ofhollow cylinders that are only a few nanometers in diameter, yet up to millimeters long, are amazing structures that self-assemble under extreme conditions. Their quasi-one-dimensional character and virtual absence of atomic defects give rise to a plethora of unusual phenomena.

This volume descibes, in up-to-date terminology and authoritative interpretation, the field of neurolinguistics, the science concerned with the neural mechanisms underlying the comprehension, production and abstract knowledge of spoken, signed or written language. An edited anthology of 165 articles from the award-winning Encyclopedia of Language and Linguistics 2nd edition, Encyclopedia of Neuroscience 4th Edition and Encyclopedia of the Neorological Sciences and Neurological Disorders, it provides the most comprehensive one-volume reference solution for scientists working with language and the brain ever published.

Authoritative review of this dynamic field placed in an interdisciplinary context Approximately 165 articles by leaders in the field Compact and affordable single-volume format

This book presents approaches, materials, and devices that eliminate the cooling requirements of IR photodetectors operating in the middle- and long-wavelength ranges of the IR spectrum. It is based mainly on the authors' experiences in developing and fabricating near room temperature HgCdTe detectors at Vigo Systems Ltd. and at the Institute of Applied Physics Military University of Technology (both in Warsaw, Poland).The text also discusses solutions to other specific problems of high-temperature detection, such as poor collection efficiency due to a short diffusion length, the Johnson-Nyquist noise of parasitic impedances, and interfacing of very low resistance devices to electronics.

This thesis makes a significant contribution to the development of cheaper Si-based Infrared detectors, operating at room temperature. In particular, the work is focused in the integration of the Ti supersaturated Si material into a CMOS Image Sensor route, the technology of choice for imaging nowadays due to its low-cost and high resolution. First, the material is fabricated using ion implantation of Ti atoms at high concentrations. Afterwards, the crystallinity is recovered by means of a pulsed laser process. The material is used to fabricate planar photodiodes, which are later characterized using current-voltage and quantum efficiency measurements. The prototypes showed improved sub-bandgap responsivity up to 0.45 eV at room temperature. The work is further supported by a collaboration with STMicroelectronics, where the supersaturated material was integrated into CMOS-based sensors at industry level. The results show that Ti supersaturated Si is compatible in terms of contamination, process integration and uniformity. The devices showed similar performance to non-implanted devices

in the visible region. This fact leaves the door open for further integration of supersaturated materials into CMOS Image Sensors.

This new edition of Infrared and Terahertz Detectors provides a comprehensive overview of infrared and terahertz detector technology, from fundamental science to materials and fabrication techniques. It contains a complete overhaul of the contents including several new chapters and a new section on terahertz detectors and systems. It includes a new tutorial introduction to technical aspects that are fundamental for basic understanding. The other dedicated sections focus on thermal detectors, photon detectors, and focal plane arrays.

In this monograph, investigations of the performance of narrow-gap semiconductor photodiodes are presented, and recent progress in different IR photodiode technologies is discussed: HgCdTe photodiodes, InSb photodiodes, alternatives to HgCdTe III-V and II-VI ternary alloy photodiodes, lead chalcogenide photodiodes, and a new class of photodiodes based on two-dimensional solids. Investigations of the performance of photodiodes operated in different spectral regions are presented.

Addressing the growing demand for larger capacity in information technology, VLSI Micro- and Nanophotonics: Science, Technology, and Applications explores issues of science and technology of micro/nano-scale photonics and integration for broad-scale and chip-scale Very Large Scale Integration photonics. This book is a game-changer in the sense that it is quite possibly the first to focus on "VLSI Photonics". Very little effort has been made to develop integration technologies for micro/nanoscale photonic devices and applications, so this reference is an important and necessary early-stage perspective on this field. New demand for VLSI photonics brings into play various technological and scientific issues, as well as

evolutionary and revolutionary challenges—all of which are discussed in this book. These include topics such as miniaturization, interconnection, and integration of photonic devices at micron, submicron, and nanometer scales. With its "disruptive creativity" and unparalleled coverage of the photonics revolution in information technology, this book should greatly impact the future of micro/nano-photonics and IT as a whole. It offers a comprehensive overview of the science and engineering of micro/nanophotonics and photonic integration. Many books on micro/nanophotonics focus on understanding the properties of individual devices and their related characteristics. However, this book offers a full perspective from the point of view of integration, covering all aspects of benefits and advantages of VLSI-scale photonic integration—the key technical concept in developing a platform to make individual devices and components useful and practical for various applications.