Mathematical Problems In Semiconductor Physics Lectures Given At The Cime Summer School Held In Cetraro Italy June 15 22 1998 Lecture Notes In Mathematics

On the the mathematical aspects of the theory of carrier transport in semiconductor devices. The subjects covered include hydrodynamical models for semiconductors based on the maximum entropy principle of extended thermodynamics, mathematical theory of drift-diffusion equations with applications, and the methods of asymptotic analysis.

The book provides a collection of recent theoretical and methodological advances which can provide support and stimulus to scientists and scholars involved in research activity in the fields of interest.

Part of my lecturing work in the School of Mathematics at the University of Leeds involved teaching quantum mechanics and statistical mechanics to mathematics undergraduates, and also mathematical methods to undergraduate students in the School of Electronic and Electrical Engineering at the University. The subject of this book has arisen as a result of research collaboration on device modelling with members of the School of Electronic and Electrical Engineering. I wanted to write a book which

would be of practical help to those wishing to learn more about the mathematical and numerical methods involved in heteroju- tion device modelling. I have introduced only a comparatively small number of t- ics, and the reader may think that other important topics should have been included. But of the topics which I have introduced, I hope that I have given the reader some practical advice concerning the implementation of the methods which are discussed. This practical advice includes demonstrating how the implementation of the me- ods may be tailored to the speci?c device being modelled, and also includes some sections of computer code to illustrate this implementation. I have also included some background theory regarding the origins of the routines.
This book provides a new mathematical theory for the treatment of an ample series of spatial problems of electrodynamics, particle physics, quantum mechanics and elasticity theory. This technique proves to be as powerful for solving the spatial problems of mathematical physics as complex analysis is for solving planar problems. The main analytic tool of the book, a non-harmonic version of hypercomplex analysis recently developed by the authors, is presented in detail. There are given applications of this theory to the boundary value problems of electrodynamics and elasticity theory as well as to the problem of quark confinement. A new approach to the linearization of special classes of the self-duality equation is also considered. Detailed proofs are given throughout. The book contains an extensive bibliography on closely related topics. This book will be of particular interest to academic and professional specialists and students

in mathematics and physics who are interested in integral representations for partial differential equations. The book is self-contained and could be used as a main reference for special course seminars on the subject.

This collection of papers arises from a workshop held at the Istituto per le Applicazioni del Calcolo of the Italian CNR. The first part of the book includes the material covered by three mini-series of lectures at graduate level on some advanced mathematical topics in semiconductor physics. The second part of the book includes more specialized topics, covered by invited speakers in their individual lectures.

Simulation based on mathematical models plays a major role in computer aided design of integrated circuits (ICs). Decreasing structure sizes, increasing packing densities and driving frequencies require the use of refined mathematical models, and to take into account secondary, parasitic effects. This leads to very high dimensional problems which nowadays require simulation times too large for the short time-to-market demands in industry. Modern Model Order Reduction (MOR) techniques present a way out of this dilemma in providing surrogate models which keep the main characteristics of the device while requiring a significantly lower simulation time than the full model. With Model Reduction for Circuit Simulation we survey the state of the art in the challenging research field of MOR for ICs, and also address its future research directions. Special emphasis is taken on aspects stemming from miniturisations to the nano scale. Contributions cover complexity reduction using e.g., balanced truncation, Krylov-techniques or POD approaches. For semiconductor applications a focus is on generalising current techniques to differential-algebraic equations, on including design parameters, on preserving stability, and on including nonlinearity by means of piecewise linearisations along solution trajectories (TPWL) and interpolation techniques for nonlinear parts. Furthermore the influence of interconnects and power grids on the physical properties of the device is considered, and also top-down system design approaches in which detailed block descriptions are combined with behavioral models. Further topics consider MOR and the combination of approaches from optimisation and statistics, and the inclusion of PDE models with emphasis on MOR for the resulting partial differential algebraic systems. The methods which currently are being developed have also relevance in other application areas such as mechanical multibody systems, and systems arising in chemistry and to biology. The current number of books in the area of MOR for ICs is very limited, so that this volume helps to fill a gap in providing the state of the art material, and to stimulate further research in this area of MOR. Model Reduction for Circuit Simulation also reflects and documents the vivid interaction between three active research projects in this area, namely the EU-Marie Curie Action ToK project O-MOORE-NICE (members in Belgium, The Netherlands and Germany), the EU-Marie Curie Action RTN-project COMSON (members in The Netherlands, Italy, Germany, and Romania), and the German federal project System reduction in nano-electronics (SyreNe).

A classical problem in the calculus of variations is the investigation of critical points of functionals {\cal L} on normed spaces V. The present work addresses the question: Under what conditions on the functional {\cal L} and the underlying space V does {\cal L} have at most one critical point? A sufficient condition for uniqueness is given: the presence of a "variational sub-symmetry", i.e., a one-parameter group G of transformations of V, which strictly reduces the values of {\cal L}. The "method of transformation groups" is applied to second-order elliptic boundary value problems on Riemannian manifolds. Further applications include problems of geometric analysis and elasticity.

This volume aims to disseminate a number of new ideas that have emerged in the last few years in the field of numerical simulation, all bearing the common denominator of the "multiscale" or "multilevel" paradigm. This covers the presence of multiple relevant "scales" in a physical phenomenon; the detection and representation of "structures", localized in space or in frequency, in the solution of a mathematical model; the decomposition of a function into "details" that can be organized and accessed in decreasing order of importance; and the iterative solution of systems of linear algebraic equations using "multilevel" decompositions of finite dimensional spaces.

This volume contains the texts of the four series of lectures presented by B.Cockburn, C.Johnson, C.W. Shu and E.Tadmor at a C.I.M.E. Summer School. It is aimed at providing a comprehensive and up-to-date presentation of numerical methods which are nowadays used to solve nonlinear partial differential equations of hyperbolic type, developing shock discontinuities. The most effective methodologies in the framework of finite elements, finite differences, finite volumes spectral methods and kinetic methods, are addressed, in particular high-order shock capturing techniques, discontinuous Galerkin methods, adaptive techniques based upon a-posteriori error analysis.

This book contains about 20 invited papers and 40 contributed papers in the research areas of theoretical continuum mechanics, kinetic theory and numerical applications of continuum mechanics. Collectively these papers give a good overview of the activities and developments in these fields in the last few years.

This volume collects six articles on selected topics at the frontier between partial differential equations and spectral theory, written by leading specialists in their respective field. The articles focus on topics that are in the center of attention of current research, with original contributions from the authors. They are written in a clear expository style that makes them accessible to a broader audience. The articles contain a detailed introduction and discuss recent progress, provide additional motivation, and develop the necessary tools. Moreover, the authors share their views on future developments, hypotheses, and unsolved problems.

Physics of Semiconductor Devices covers both basic classic topics such as energy band theory and the gradual-channel model of the MOSFET as well as advanced concepts and devices such as MOSFET short-channel effects, low-dimensional devices and single-electron transistors. Concepts are introduced to the reader in a simple way, often using comparisons to everyday-life experiences such as simple fluid mechanics. They are then explained in depth and mathematical developments are fully described. Physics of Semiconductor Devices contains a list of problems that can be used as homework assignments or can be solved in class to exemplify the theory. Many of these problems make use of Matlab and are aimed at illustrating theoretical concepts in a graphical manner.

International ISAAC (International Society for Analysis, its Applications and Computation) Congresses have been held every second year since 1997. The proceedings report on a regular basis on the progresses of the field in recent years, where the most active areas in analysis, its applications and computation are covered. Plenary lectures also highlight recent results. This volume concentrates mainly on partial differential equations, but also includes function spaces, operator theory, integral transforms and equations, potential theory, complex analysis and generalizations, stochastic analysis, inverse problems, homogenization, continuum mechanics, mathematical biology and medicine. With over 350 participants attending the congress, the book comprises 140 papers from 211 authors. The volume also serves for transferring personal information about the ISAAC and its members. This volume includes citations for O. Besov, V. Burenkov and R.P. Gilbert on the occasion of their anniversaries.

The book is divided into three parts, which contain respectively recent results in the kinetic theory of granular gases, kinetic theory of chemically reacting gases, and numerical methods for kinetic systems. Part I is devoted to theoretical aspects of granular gases. Part II presents recent results on modelling of kinetic systems in which molecules can undergo binary collisions in presence of chemical reactions and/or in presence of quantum effects. Part III contains several contributions related to the construction of suitable numerical methods and simulations for granular gases.

The Handbook of Mathematical Fluid Dynamics is a compendium of essays that provides a survey of the major topics in the subject. Each article traces developments, surveys the results of the past decade, discusses the current state of knowledge and presents major future directions and open problems. Extensive bibliographic material is provided. The book is intended to be useful both to experts in the field and to mathematicians and other scientists who wish to learn about or begin research in mathematical fluid dynamics. The Handbook illuminates an exciting subject that involves rigorous mathematical theory applied to an important physical problem, namely the motion of fluids.

The summer school on Mathematics inspired by Biology was held at Martina Franca, Apulia, Italy in 1997. This volume presents five series of six lectures each. The common theme is the role of structure in shaping transient and ultimate dynamics. But the type of structure ranges from spatial (hadeler and maini in the deterministic setting, Durrett in the stochastic setting) to physiological (Diekmann) and order (Smith). Each contribution sketches the present state of affairs while, by including some wishful thinking, pointing at open problems that deserve attention.

Designing complex integrated circuits relies heavily on mathematical methods and calls for suitable simulation and optimization tools. The current design approach involves simulations and optimizations in different physical domains (device, circuit, thermal, electromagnetic) and in a range of electrical engineering disciplines (logic, timing, power, crosstalk, signal integrity, system functionality). COMSON was a Marie Curie Research Training Network created to meet these new scientific and training challenges by (a) developing new descriptive models that take these mutual dependencies into account, (b) combining these models with existing circuit descriptions in new simulation strategies and (c) developing new optimization techniques that will accommodate new designs. The book presents the main project results in the fields of PDAE modeling and simulation, model order reduction techniques and optimization, based on merging the know-how of three major European semiconductor companies with the combined expertise of university groups specialized in developing suitable mathematical models, numerical schemes and e-learning facilities. In addition, a common Demonstrator Platform for testing mathematical methods and approaches was created to assess whether they are capable of addressing the industry's problems, and to educate young researchers by providing hands-on experience with state-of-the-art problems.

This book presents a hierarchy of macroscopic models for semiconductor devices, studying three classes of models in detail: isentropic drift-diffusion equations, energy-transport models, and quantum hydrodynamic equations. The derivation of each, including physical discussions, is shown. Numerical simulations for modern semiconductor devices are performed, showing the particular features of each. The author develops modern analytical techniques, such as positive solution methods, local energy methods for free-boundary problems and entropy methods.

This volume is a survey/monograph on the recently developed theory of forward-backward stochastic differential equations (FBSDEs). Basic techniques such as the method of optimal control, the 'Four Step Scheme', and the method of continuation are presented in full. Related topics such as backward stochastic PDEs and many applications of FBSDEs are also discussed in detail. The volume is suitable for readers with basic knowledge of stochastic differential equations, and some exposure to the stochastic control theory and PDEs. It can be used for researchers and/or senior graduate students in the areas of probability, control theory, mathematical finance, and other related fields.

The territory of preserver problems has grown continuously within linear analysis. This book presents a cross-section of the modern theory of preservers on infinite dimensional spaces (operator spaces and function spaces) through the author's corresponding results. Special emphasis is placed on preserver problems concerning some structures of Hilbert space operators which appear in quantum mechanics. In addition, local automorphisms and local isometries of operator algebras and function algebras are discussed in detail.

Mathematical Problems in Semiconductor PhysicsLectures given at the C.I.M.E. Summer School held in Cetraro, Italy, June 15-22, 1998Springer Science & Business Media

This volume contains papers that were presented at HYP2006, the eleventh international Conference on Hyperbolic Problems: Theory, Numerics and Applications. This biennial series of conferences has become one of the most important international events in Applied Mathematics. As computers became more and more powerful, the interplay between theory, modeling, and numerical algorithms gained considerable impact, and the scope of HYP conferences expanded accordingly.

Proceedings from the 14th European Conference for Mathematics in Industry held in Madrid present innovative numerical and mathematical techniques. Topics include the latest applications in aerospace, information and communications, materials, energy and environment, imaging, biology and biotechnology, life sciences, and finance. In addition, the conference also delved into education in industrial mathematics and web learning.

The aim of this volume that presents lectures given at a joint CIME and Banach Center

Summer School, is to offer a broad presentation of a class of updated methods providing a mathematical framework for the development of a hierarchy of models of complex systems in the natural sciences, with a special attention to biology and medicine. Mastering complexity implies sharing different tools requiring much higher level of communication between different mathematical and scientific schools, for solving classes of problems of the same nature. Today more than ever, one of the most important challenges derives from the need to bridge parts of a system evolving at different time and space scales, especially with respect to computational affordability. As a result the content has a rather general character; the main role is played by stochastic processes, positive semigroups, asymptotic analysis, kinetic theory, continuum theory, and game theory.

This volume gives an introduction to a fascinating research area to applied mathematicians. It is devoted to providing the exposition of promising analytical and numerical techniques for solving challenging biomedical imaging problems, which trigger the investigation of interesting issues in various branches of mathematics.

This book presents a collection of papers emphasizing applications of mathematical models and methods to real-world problems of relevance for industry, life science, environment, finance and so on. The biannual Conference of ECMI (the European Consortium of Mathematics in Industry) held in 2014 focused on various aspects of industrial and applied mathematics. The five main

topics addressed at the conference were mathematical models in life science, material science and semiconductors, mathematical methods in the environment, design automation and industrial applications, and computational finance. Several other topics have been treated, such as, among others, optimization and inverse problems, education, numerical methods for stiff pdes, model reduction, imaging processing, multi physics simulation, mathematical models in textile industry. The conference, which brought together applied mathematicians and experts from industry, provided a unique opportunity to exchange ideas, problems and methodologies, bridging the gap between mathematics and industry and contributing to the advancement of science and technology. The conference has included a presentation of EU-Maths-In (European Network of Mathematics for Industry and Innovation), a recent joint initiative of ECMI and EMS. The proceedings from this conference represent a snapshot of the current activity in industrial mathematics in Europe, and are highly relevant to anybody interested in the latest applications of mathematics to industrial problems.
This book primarily concerns quasilinear and semilinear elliptic and parabolic partial differential equations, inequalities, and systems. The exposition quickly leads general theory to analysis of concrete equations, which have specific applications in such areas as electrically (semi-) conductive media, modeling of

biological systems, and mechanical engineering. Methods of Galerkin or of Rothe are exposed in a large generality.

The Paris-Princeton Lectures in Financial Mathematics, of which this is the fourth volume, publish cutting-edge research in self-contained, expository articles from outstanding specialists - established or on the rise! The aim is to produce a series of articles that can serve as an introductory reference source for research in the field. The articles are the result of frequent exchanges between the finance and financial mathematics groups in Paris and Princeton. The present volume sets standards with five articles by: 1. Areski Cousin, Monique Jeanblanc and Jean-Paul Laurent, 2. Stéphane Crépey, 3. Olivier Guéant, Jean-Michel Lasry and Pierre-Louis Lions, 4. David Hobson and 5. Peter Tankov.

Semiconductor devices are ubiquitous in the modern computer and telecommunications industry. A precise knowledge of the transport equations for electron flow in semiconductors when a voltage is applied is therefore of paramount importance for further technological breakthroughs. In the present work, the author tackles their derivation in a systematic and rigorous way, depending on certain key parameters such as the number of free electrons in the device, the mean free path of the carriers, the device dimensions and the ambient temperature. Accordingly a hierarchy of models is examined which is

reflected in the structure of the book: first the microscopic and macroscopic semi-classical approaches followed by their quantum-mechanical counterparts.
These lecture notes by very authoritative scientists survey recent advances of mathematics driven by industrial application showing not only how mathematics is applied to industry but also how mathematics has drawn benefit from interaction with real-word problems. The famous David Report underlines that innovative high technology depends crucially for its development on innovation in mathematics. The speakers include three recent presidents of ECMI, one of ECCOMAS (in Europe) and the president of SIAM.
This book contains about 20 invited papers and 40 contributed papers in the research areas of theoretical continuum mechanics, kinetic theory and numerical applications of continuum mechanics. Collectively these papers give a good overview of the activities and developments in these fields in the last few years. The proceedings have been selected for coverage in: • Index to Scientific & Technical Proceedings® (ISTP® / ISI Proceedings) • Index to Scientific & Technical Proceedings (ISTP CDROM version / ISI Proceedings) • CC Proceedings — Engineering & Physical Sciences Contents:Chaos in Some Linear Kinetic Models (J Banasiak)Inverse Problems in Photon Transport. Part I: Determination of Physical and Geometrical Features of an Interstellar Cloud (A

Belleni-Morante et al.)Inverse Problems in Photon Transport. Part II: Features of a Source Inside an Interstellar Cloud (A Belleni-Morante & R Riganti)The Riemann Problem for a Binary Non-Reacting Mixture of Euler Fluids (F Brini & T Ruggeri)Rate of Convergence toward the Equilibrium in Degenerate Settings (L Desvillettes & C Villani)Asymptotic and Other Properties of Positive Definite Integral Measures for Nonlinear Diffusion (J N Flavin)Thermocapillary Fluid and Adiabatic Waves Near its Critical Point (H Gouin)Constitutive Models for Atactic Elastomers (C O Horgan & G Saccomandi)Considerations about the Gibbs Paradox (I Müller)Transport Coefficients in Stochastic Models of the Revised Enskog and Square-Well Kinetic Theories (J Polewczak & G Stell)Some Recent Mathematical Results in Mixtures Theory of Euler Fluids (T Ruggeri)From Kinetic Systems to Diffusion Equations (F Salvarani & J L Vázquez)Non-Boussinesq Convection in Porous Media (B Straughan)and other papers Readership: Researchers, academics and graduate students working in the fields of continuum mechanics, wave propagation, stability in fluids, kinetic theory and computational fluid dynamics. Keywords:Discontinuity and Shock Waves;Stability in Fluid Mechanics;Small Parameter Problem;Kinetic Theories Towards Continuum Models;Non-Equilibrium Thermodynamics;Numerical Applications This IMA Volume in Mathematics and its Applications SEMICONDUCTORS, PART II is based on the proceedings of the IMA summer program "Semiconductors." Our goal was to foster interaction in this interdisciplinary field which involves electrical engineers, computer scientists, semiconductor physicists and mathematicians, from both university and industry. In particular, the program was meant to encourage the participation of numerical and mathematical analysts with backgrounds in ordinary and partial differential equations, to help get them involved in the mathematical as pects of semiconductor models and circuits. We are grateful to W.M. Coughran, Jr., Julian Cole, Peter Lloyd, and Jacob White for helping Farouk Odeh organize this activity and trust that the proceedings will provide a fitting memorial to Farouk. We also take this opportunity to thank those agencies whose financial support made the program possible: the Air Force Office of Scientific Research, the Army Research Office, the National Science Foundation, and the Office of Naval Research. A vner Friedman Willard Miller, J r. Preface to Part II Semiconductor and integrated-circuit modeling are an important part of the high technology "chip" industry, whose high-performance, low-cost microprocessors and high-density memory designs form the basis for supercomputers, engineering work stations, laptop computers, and other modern information appliances. There are a variety of differential equation problems that must be solved to facilitate such mod eling.

A Sobolev gradient of a real-valued functional on a Hilbert space is a gradient of that functional taken relative to an underlying Sobolev norm. This book shows how descent methods using such gradients allow a unified treatment of a wide variety of problems in differential equations. For discrete versions of partial differential equations, corresponding Sobolev gradients are seen to be vastly more efficient than ordinary gradients. In fact, descent methods with these gradients generally scale linearly with the number of grid points, in sharp contrast with the use of ordinary gradients. Aside from the first edition of this work, this is the only known account of Sobolev gradients in book form. Most of the applications in this book have emerged since the first edition was published some twelve years ago. What remains of the first edition has been extensively revised. There are a number of plots of results from calculations and a sample MatLab code is included for a simple problem. Those working through a fair portion of the material have in the past been able to use the theory on their own applications and also gain an appreciation of the possibility of a rather comprehensive point of view on the subject of partial differential equations.
This volume presents a collection of courses introducing the reader to the recent progress with attention being paid to laying solid grounds and developing various basic tools. It presents new results on phase transitions for gradient lattice models.
This book introduces the treatment of linear and nonlinear (quasi-linear) abstract evolution equations by methods from the theory of strongly continuous semigroups. The

theoretical part is accessible to graduate students with basic knowledge in functional analysis, with only some examples requiring more specialized knowledge from the spectral theory of linear, self-adjoint operators in Hilbert spaces. Emphasis is placed on equations of the hyperbolic type which are less often treated in the literature.
Nowadays we are facing numerous and important imaging problems: nondestructive testing of materials, monitoring of industrial processes, enhancement of oil production by efficient reservoir characterization, emerging developments in noninvasive imaging techniques for medical purposes - computerized tomography (CT), magnetic resonance imaging (MRI), positron emission tomography (PET), X-ray and ultrasound tomography, etc. In the CIME Summer School on Imaging (Martina Franca, Italy 2002), leading experts in mathematical techniques and applications presented broad and useful introductions for non-experts and practitioners alike to many aspects of this exciting field. The volume contains part of the above lectures completed and updated by additional contributions on other related topics.