

# The Gunn-Hilsum Effect

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# The Gunn Hilsum Effect

**Neil Sellers**



## **The Gunn Hilsum Effect:**

**The Gunn-Hilsum Effect** Melvin Shaw, 2012-12-02 The Gunn Hilsum Effect covers the physical principles controlling the operation of transferred electron devices. These devices have been proven quite useful in the generation, amplification, and processing of microwave signals well into tens of gigahertz range. Organized into seven chapters, the book focuses on the analytical and numerical approaches of the two vital aspects of device behavior for a given bulk semiconductor boundary conditions or contacts and the local circuit environment. The opening chapter of this book discusses the negative differential mobility (NDM) characteristics for a range of electric fields in the velocity-field relation of specific semiconductors and the response of such a sample to a charge fluctuation leading to the growth of stationary and/or traveling high electric field domains. The next two chapters describe how the boundary conditions and the circuit control the manifestation of current instabilities in such systems and how this control can be understood in a simple manner. Chapters 4 and 5 discuss the numerical and experimental investigations of comparatively long bulk samples with an emphasis on the essential NDM semiconductor  $n$ -GaAs. These chapters also examine the production of different current-voltage relationships and instabilities by cathode contacts and the control of the oscillatory characteristics of an electrically unstable sample by different circuit conditions. Chapter 6 presents both time-independent and time-dependent computations with the latter focusing on the small-signal impedance and stability aspects. The last chapter of this book addresses the construction and evaluation of typical short devices, describes how their oscillatory characteristics compare with the long samples studied in the first six chapters, and discusses the use of short devices as amplifiers. This book is an ideal source for device engineers and designers wishing to apply transferred electron devices in creative ways.

**The Gunn-Hilsum Effect** Shaw M.P., *GaAs Devices and Circuits* Michael S. Shur, 2013-11-21 GaAs devices and integrated circuits have emerged as leading contenders for ultra-high-speed applications. This book is intended to be a reference for a rapidly growing GaAs community of researchers and graduate students. It was written over several years and parts of it were used for courses on GaAs devices and integrated circuits and on heterojunction GaAs devices developed and taught at the University of Minnesota. Many people helped me in writing this book. I would like to express my deep gratitude to Professor Lester Eastman of Cornell University whose ideas and thoughts inspired me and helped to determine the direction of my research work for many years. I also benefited from numerous discussions with his students and associates and from the very atmosphere of the pursuit of excellence which exists in his group. I would like to thank my former and present co-workers and colleagues Drs. Levinstein and Gelmont of the A. F. Ioffe Institute of Physics and Technology, Professor Melvin Shaw of Wayne State University, Dr. Kastalsky of Bell Communications, Professor Gary Robinson of Colorado State University, Professor Tony Valois, and Dr. Tim Drummond of Sandia Labs for their contributions to our joint research and for valuable discussions. My special thanks to Professor Morko for his help, his ideas, and the example set by his pioneering work. Since 1978 I have been working with engineers from Honeywell Inc. Drs.

**Electro-Optical Effects to Visualize Field and Current Distributions in Semiconductors** Karl W. Böer, 2010-02-02

This book describes the basic principles that relate to field and current inhomogeneities in semiconductors and their kinetics that occur in the regime of negative differential conductances of semiconductors      The Physics of Instabilities in Solid State Electron Devices Harold L. Grubin, V.V. Mitin, E. Schöll, M.P. Shaw, 2013-11-11 The past three decades have been a period where useful current and voltage instabilities in solids have progressed from exciting research problems to a wide variety of commercially available devices Materials and electronics research has led to devices such as the tunnel Esaki diode transferred electron Gunn diode avalanche diodes real space transfer devices and the like These structures have proven to be very important in the generation amplification switching and processing of microwave signals up to frequencies exceeding 100 GHz In this treatise we focus on a detailed theoretical understanding of devices of the kind that can be made unstable against circuit oscillations large amplitude switching events and in some cases internal rearrangement of the electric field or current density distribution The book is aimed at the semiconductor device physicist engineer and graduate student A knowledge of solid state physics on an elementary or introductory level is assumed Furthermore we have geared the book to device engineers and physicists desirous of obtaining an understanding substantially deeper than that associated with a small signal equivalent circuit approach We focus on both analytical and numerical treatment of specific device problems concerning ourselves with the mechanism that determines the constitutive relation governing the device the boundary conditions contact effects and the effect of the local circuit environment      *Selected Works of Professor Herbert Kroemer* C. K. Maiti, 2008 Information technology has changed our society radically Just as the integrated circuits have been the prime mover for electronics high speed transistors and semiconductor lasers based on heterostructures are now playing the same role in modern telecommunications Professor Kroemer's conceptual work on heterostructures began in the early 1950s as he was looking for a way to improve transistor speed and performance In the 1960s he applied the same principles to the development of lasers and light emitting diodes showing that they could achieve continuous operation at room temperature OCo something thought impossible at that time His deep fundamental scientific work has had a profound effect on technology and society transforming and improving our lives This reprint collection brings together Professor Kroemer's most important papers presenting a comprehensive perspective of the field It covers topics ranging from substrate materials electronic properties process technology and devices to circuits and applications This reprint collection will help the reader identify the key stages in the development of heterostructure devices and lasers from early research through to its integration in current manufacturing Devoted to R D engineers and scientists who are actively involved in extending the nano and microelectronics roadmap mainly via heterostructure engineering this volume may also serve as a reference for postgraduate and research students      Physics of Semiconductor Devices Simon M. Sze, Yiming Li, Kwok K. Ng, 2021-03-03 The new edition of the most detailed and comprehensive single volume reference on major semiconductor devices The Fourth

Edition of Physics of Semiconductor Devices remains the standard reference work on the fundamental physics and operational characteristics of all major bipolar unipolar special microwave and optoelectronic devices This fully updated and expanded edition includes approximately 1 000 references to original research papers and review articles more than 650 high quality technical illustrations and over two dozen tables of material parameters Divided into five parts the text first provides a summary of semiconductor properties covering energy band carrier concentration and transport properties The second part surveys the basic building blocks of semiconductor devices including p n junctions metal semiconductor contacts and metal insulator semiconductor MIS capacitors Part III examines bipolar transistors MOSFETs MOS field effect transistors and other field effect transistors such as JFETs junction field effect transistors and MESFETs metal semiconductor field effect transistors Part IV focuses on negative resistance and power devices The book concludes with coverage of photonic devices and sensors including light emitting diodes LEDs solar cells and various photodetectors and semiconductor sensors This classic volume the standard textbook and reference in the field of semiconductor devices Provides the practical foundation necessary for understanding the devices currently in use and evaluating the performance and limitations of future devices Offers completely updated and revised information that reflects advances in device concepts performance and application Features discussions of topics of contemporary interest such as applications of photonic devices that convert optical energy to electric energy Includes numerous problem sets real world examples tables figures and illustrations several useful appendices and a detailed solutions manual for Instructor s only Explores new work on leading edge technologies such as MODFETs resonant tunneling diodes quantum cascade lasers single electron transistors real space transfer devices and MOS controlled thyristors Physics of Semiconductor Devices Fourth Edition is an indispensable resource for design engineers research scientists industrial and electronics engineering managers and graduate students in the field

Handbook of Terahertz Technology Neil Sellers, 2018-01-21 Terahertz radiation also known as submillimeter radiation terahertz waves tremendously high frequency THF T rays T waves T light T lux or THz consists of electromagnetic waves within the ITU designated band of frequencies from 0.3 to 3 terahertz Wavelengths of radiation in the terahertz band correspondingly range from 1 mm to 0.1 mm Because terahertz radiation begins at a wavelength of one millimeter and proceeds into shorter wavelengths it is sometimes known as the submillimeter band and its radiation as submillimeter waves especially in astronomy The book presents information about Terahertz science Terahertz photodetectors and Terahertz Lasers A special emphasis is given to room temperature operation of long wavelength photodetectors based on novel quantum dots Moreover a complete analysis of systems based on Quantum Cascade structures to detect far infrared wavelengths is provided Finally the book presents Terahertz laser principles considering multi color lasers in this range of wavelengths It is written as a background for graduate students in the Optics field      *Microwave Semiconductor Devices* Sigfrid Yngvesson, 2012-12-06 We have reached the double conclusion that invention is choice that this choice is imperatively

governed by the sense of scientific beauty Hadamard 1945 Princeton University Press by permission The great majority of all sources and amplifiers of microwave energy and all devices for receiving or detecting microwaves use a semiconductor active element The development of microwave semiconductor devices described in this book has proceeded from the simpler two terminal devices such as GUNN or IMPATT devices which originated in the 1960s to the sophisticated monolithic circuit MESFET three terminal active elements of the 1980s and 1990s The microwave field has experienced a renaissance in electrical engineering departments in the last few years and much of this growth has been associated with microwave semiconductor devices The University of Massachusetts has recently developed a well recognized program in microwave engineering Much of the momentum for this program has been provided by interaction with industrial companies and the influx of a large number of industry supported students This program had a need for a course in microwave semiconductor devices which covered the physical aspects as well as the aspects of interest to the engineer who incorporates such devices in his designs It was also felt that it would be important to introduce the most recently developed devices HFETs HBTs and other advanced devices as early as possible

Explaining Jesus Benjamin Bennett-Carpenter, 2018-11-27 How exactly does one explain Jesus That is the central question of this book But the task of explaining Jesus is complicated For many nonbelievers skeptics or practitioners of non Jesus based religions or spiritualities it can be very strange to refer to a particular man who lived in the first century CE as someone who is still living Even for some believers this idea can be a difficult thing to understand even given the teachings of their faith Thus whether believer or nonbeliever or somewhere in between for the intellectually curious there is need for an explanation Explaining Jesus explores the possibilities of a secular interdisciplinary science based explanation for the phenomenon of Jesus

**Semiconductor Devices and Integrated Electronics** A. G. Milnes, 2012-12-06 For some time there has been a need for a semiconductor device book that carries diode and transistor theory beyond an introductory level and yet has space to touch on a wider range of semiconductor device principles and applications Such topics are covered in specialized monographs numbering many hundreds but the voluminous nature of this literature limits access for students This book is the outcome of attempts to develop a broad course on devices and integrated electronics for university students at about senior year level The educational prerequisites are an introductory course in semiconductor junction and transistor concepts and a course on analog and digital circuits that has introduced the concepts of rectification amplification oscillators modulation and logic and Switching circuits The book should also be of value to professional engineers and physicists because of both the information included and the detailed guide to the literature given by the references The aim has been to bring some measure of order into the subject area examined and to provide a basic structure from which teachers may develop themes that are of most interest to students and themselves Semiconductor devices and integrated circuits are reviewed and fundamental factors that control power levels frequency speed size and cost are discussed The text also briefly mentions how devices are used and presents circuits and

comments on representative applications Thus the book seeks a balance between the extremes of device physics and circuit design

*Nonlinear Dynamics in Solids* Harry Thomas, 2012-12-06 This volume contains the notes of lectures given at the school on Nonlinear Dynamics in Solids held at the Physikzentrum Bad Honnef 2-6 October 1989 under the patronage of the Deutsche Physikalische Gesellschaft Nonlinear dynamics has become a highly active research area owing to many interesting developments during the last three decades in the theoretical analysis of dynamical processes in both Hamiltonian and dissipative systems Research has been focused on a variety of problems such as the characteristics of regular and chaotic motion in Hamiltonian dynamics the problem of quantum chaos the formation and properties of solitary spatio-temporal structures the occurrence of strange attractors in dissipative systems and the bifurcation scenarios leading to complex time behaviour Until recently predictions of the theory have been tested predominantly on instabilities in hydrodynamic systems where many interesting experiments have provided valuable input and have led to a fruitful interaction between experiment and theory Fluid systems are certainly good candidates for performing clean experiments free from disturbing influences with fluids compared to solids it is simpler to prepare good samples the relevant length and time scales are in easily accessible ranges and it is possible to do measurements inside the fluid because it can be filled in after the construction of the apparatus Further the theory describing the macroscopic dynamics of fluids is well established and contains only very few parameters all of which have well known values

Survey of Semiconductor Physics Karl Wolfgang Böer, 1990 Taking up where the first volume left off this work provides coverage of the inhomogeneous semiconductor It deals mainly with Si and GaAs but also investigates other materials of theoretical and practical interest such as Ge other III-V and II-VI compounds and amorphous SiH Equipped with this source physicists semiconductor engineers device engineers and fabrication engineers will have access to a vast reservoir of practical information on the design production and operations of semiconductor devices

*Survey of Semiconductor Physics* Karl W. Böer, 2012-12-06 Any book that covers a large variety of subjects and is written by one author lacks by necessity the depth provided by an expert in his or her own field of specialization This book is no exception It has been written with the encouragement of my students and colleagues who felt that an extensive card file I had accumulated over the years of teaching solid state and semiconductor physics would be helpful to more than just a few of us This file updated from time to time contained lecture notes and other entries that were useful in my research and permitted me to give to my students a broader spectrum of information than is available in typical textbooks When assembling this material into a book I divided the topics into material dealing with the homogeneous semiconductor the subject of the previously published Volume 1 and the inhomogeneous semiconductor the subject of this Volume 2 In order to keep the book to a manageable size sections of tutorial character which can be used as text for a graduate level class had to be interwoven with others written in shorter reference style The pointers at the right hand page header will assist in distinguishing the more difficult reference parts of the book with the pointer to the right from the more

easy to read basic educational sections with the pointer tending to the left      *Advances in Electronics and Electron Physics*  
,1980-09-01 *Advances in Electronics and Electron Physics      Microwave, Radar & RF Engineering* Prakash Kumar

Chaturvedi,2018-06-20 This is a textbook for upper undergraduate and graduate courses on microwave engineering written in a student friendly manner with many diagrams and illustrations It works towards developing a foundation for further study and research in the field The book begins with a brief history of microwaves and introduction to core concepts of EM waves and wave guides It covers equipment and concepts involved in the study and measurement of microwaves The book also discusses microwave propagation in space microwave antennae and all aspects of RADAR The book provides core pedagogy with chapter objectives summaries solved examples and end of chapter exercises The book also includes a bonus chapter which serves as a lab manual with 15 simple experiments detailed with proper circuits precautions sample readings and quiz viva questions for each experiment This book will be useful to instructors and students alike      Nonequilibrium Phase

Transitions in Semiconductors Eckehard Schöll,2012-12-06 Semiconductors can exhibit electrical instabilities like current runaway threshold switching current filamentation or oscillations when they are driven far from thermodynamic equilibrium This book presents a coherent theoretical description of such cooperative phenomena induced by generation and recombination processes of charge carriers in semiconductors      **Mathematical Problems in Semiconductor Physics** P

A Marcati,P A Markowich,Roberto Natalini,1995-12-15 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      **Negative Differential**

**Resistance and Instabilities in 2-D Semiconductors** N. Balkan,B.K. Ridley,A.J. Vickers,2012-12-06 Instabilities associated with hot electrons in semiconductors have been investigated from the beginning of transistor physics in the 1940s The study of NDR and impact ionization in bulk material led to devices like the Gunn diode and the avalanche photo diode In layered semiconductors domain formation in HEMTs can lead to excess gate leakage and to excess noise The studies of hot electron transport parallel to the layers in heterostructures single and multiple have shown abundant evidence of electrical instability and there has been no shortage of suggestions concerning novel NDR mechanisms such as real space transfer scattering induced NDR inter sub band transfer percolation effects etc Real space transfer has been exploited in negative resistance PETs NERFETs and in the charge injection transistor CHINT and in light emitting logic devices but far too little is known and understood about other NDR mechanisms with which quantum well material appears to be particularly well endowed for these to be similarly exploited The aim of this book is therefore to collate what is known and what is not known about NDR instabilities and to identify promising approaches and techniques which will increase our understanding of the origin of these instabilities which have been observed during the last decade of investigations into high field longitudinal



transport in layered semiconductors The book covers the fundamental properties of hot carrier transport and the associated instabilities and light emission in 2 dimensional semiconductors dealing with both theory and experiment     *The Physics of Submicron Structures* Harold L. Grubin, 2012-12-06 Research on electronic transport in ultra small dimensions has been highly stimulated by the sensational developments in silicon technology and very large scale integration The papers in this volume however have been influenced to no lesser extent by the advent of molecular beam epitaxy and metal organic chemical vapor deposition which has made possible the control of semiconductor boundaries on a quantum level This new control of boundary conditions in ultra small electronic research is the mathematical reason for a whole set of innovative ideas For the first time in the history of semiconductors it is possible to design device functions from physical considerations involving nanoscale dimensions At the time the meeting was held July 1982 it was one of the first strong signals of the powerful developments in this area During the meeting important questions have been answered concerning ballistic transport Monte Carlo simulations of high field transport and other developments pertinent to new device concepts and the understanding of small devices from physics to function The committee members want to express their deep appreciation to the speakers who have made the meeting a success The USER project of DOD has been a vital stimulus and thanks go to the Army Research Office and the Office of Naval Research for financial support Urbana January 1984 K Hess Conference Chairman J R Brews L R Cooper Ex Officio D K Ferry H L Grubin G J Iafrate M I Nathan A F

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