



# Condensed Systems of Low Dimensionality

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# Condensed Systems Of Low Dimensionality

**D. Baeriswyl, L. Degiorgi**



## **Condensed Systems Of Low Dimensionality:**

Condensed Systems of Low Dimensionality J.L. Beeby, P.K. Bhattacharya, P.Ch. Gravelle, F. Koch, D.J.

Lockwood, 2012-12-06 The NATO Special Programme Panel on Condensed Systems of Low Dimensionality began its work in 1985 at a time of considerable activity in the field. The Panel has since funded many Advanced Research Workshops, Advanced Study Institutes, Cooperative Research Grants and Research Visits across the breadth of its remit which stretches from self-organizing organic molecules to semiconductor structures having two, one and zero dimensions. The funded activities, especially the workshops, have allowed researchers from within NATO countries to exchange ideas and work together at a period of development of the field when such interactions are most valuable. Such timely support has undoubtedly assisted the development of national programs, particularly in the countries of the alliance wishing to strengthen their science base. A closing Workshop to mark the end of the Panel's activities was organized in Marmaris, Turkey, from April 23-27, 1990, with the same title as the Panel. Condensed systems of Low Dimensionality. This volume contains papers presented at that meeting which sought to bring together chemists, physicists and engineers from across the spectrum of the Panel's activities to discuss topics of current interest in their special fields and to exchange ideas about the effects of low dimensionality. As the following pages show, this is a topic of extraordinary interest and challenge which produces entirely new scientific phenomena and at the same time offers the possibility of novel technological applications. **Lower-Dimensional Systems**

**and Molecular Electronics** Robert M. Metzger, Peter R. Day, George C. Papavassiliou, 2013-11-11 This volume represents the written account of the NATO Advanced Study Institute Lower Dimensional Systems and Molecular Electronics held at Hotel Spetses, Spetses Island, Greece, from 12 June to 23 June 1989. The goal of the Institute was to demonstrate the breadth of chemical and physical knowledge that has been acquired in the last 20 years in inorganic and organic crystals, polymers and thin films which exhibit phenomena of reduced dimensionality. The interest in these systems started in the late 1960s with lower dimensional inorganic conductors, in the early 1970s with quasi one-dimensional crystalline organic conductors which by 1979 led to the first organic superconductors and in 1977 to the first conducting polymers. The study of monolayer films, Langmuir-Blodgett films, had progressed since the 1930s but reached a great upsurge in the early 1980s. The pursuit of non-linear optical phenomena became increasingly popular in the early 1980s as the attention turned from inorganic crystals to organic films and polymers. And in the last few years the term molecular electronics has gained ever increasing acceptance although it is used in several contexts. We now have organic superconductors with critical temperatures in excess of 10 K, conducting polymers that are soluble and processable and used commercially, we have films of a few monolayers that have high in-plane electrical conductivity and polymers that show great promise in photonics; we even have a few devices that function almost at the molecular level. **Optical Switching in Low-Dimensional Systems** Hartmut Haug, L.

Banyai, 2012-12-06 This book contains all the papers presented at the NATO workshop on Optical Switching in Low

Dimensional Systems held in Marbella Spain from October 6th to 8th 1988 Optical switching is a basic function for optical data processing which is of technological interest because of its potential parallelism and its potential speed Semiconductors which exhibit resonance enhanced optical nonlinearities in the frequency range close to the band edge are the most intensively studied materials for optical bistability and fast gate operation Modern crystal growth techniques particularly molecular beam epitaxy allow the manufacture of semiconductor microstructures such as quantum wells quantum wires and quantum dots in which the electrons are only free to move in two one or zero dimensions of the optically excited electron hole pairs in these low respectively The spatial confinement dimensional structures gives rise to an enhancement of the excitonic nonlinearities Furthermore the variations of the microstructure extensions of the compositions and of the doping offer great new flexibility in engineering the desired optical properties Recently organic chain molecules such as polydiacetylene which are different realizations of one dimensional electronic systems have been shown also to have interesting optical nonlinearities Both the development and study of optical and electro optical devices as well as experimental and theoretical investigations of the underlying optical nonlinearities are contained in this book Science and Engineering of One- and Zero-Dimensional Semiconductors Steven P. Beaumont, Clivia M. Sotomayor Torres, 2012-12-06 This volume comprises the proceedings of the NATO Advanced Research Workshop on the Science and Engineering of 1 and 0 dimensional semiconductors held at the University of Cadiz from 29th March to 1st April 1989 under the auspices of the NATO International Scientific Exchange Program There is a wealth of scientific activity on the properties of two dimensional semiconductors arising largely from the ease with which such structures can now be grown by precision epitaxy techniques or created by inversion at the silicon silicon dioxide interface Only recently however has there burgeoned an interest in the properties of structures in which carriers are further confined with only one or in the extreme zero degrees of freedom This workshop was one of the first meetings to concentrate almost exclusively on this subject that the attendance of some forty researchers only represented the community of researchers in the field testifies to its rapid expansion which has arisen from the increasing availability of technologies for fabricating structures with small enough sub  $\text{\AA}$  dimensions Part I of this volume is a short section on important topics in nanofabrication It should not be assumed from the brevity of this section that there is little new to be said on this issue rather that to have done justice to it would have diverted attention from the main purpose of the meeting which was to highlight experimental and theoretical research on the structures themselves Light Scattering in Semiconductor Structures and Superlattices D.J. Lockwood, Jeff F. Young, 2013-12-20 Just over 25 years ago the first laser excited Raman spectrum of any crystal was obtained In November 1964 Hobden and Russell reported the Raman spectrum of GaP and later in June 1965 Russell published the Si spectrum Then in July 1965 the forerunner of a series of meetings on light scattering in solids was held in Paris Laser Raman spectroscopy of semiconductors was at the forefront in new developments at this meeting Similar meetings were held in 1968 New York 1971 Paris and 1975 Campinas Since then

and apart from the multidisciplinary biennial International Conference on Raman Spectroscopy there has been no special forum for experts in light scattering spectroscopy of semiconductors to meet and discuss latest developments. Meanwhile technological advances in semiconductor growth have given rise to a veritable renaissance in the field of semiconductor physics. Light scattering spectroscopy has played a crucial role in the advancement of this field providing valuable information about the electronic vibrational and structural properties both of the host materials and of heterogeneous composite structures. On entering a new decade one in which technological advances in lithography promise to open even broader horizons for semiconductor physics it seemed to us to be an ideal time to reflect on the achievements of the past decade to be brought up to date on the current state of the art and to catch some glimpses of where the field might be headed in the 1990s.

***Excitons in Low-Dimensional Semiconductors*** Stephan Glutsch, 2013-04-17 Low dimensional semiconductors have become a vital part of today's semiconductor physics and excitons in these systems are ideal objects that bring textbook quantum mechanics to life. Furthermore their theoretical understanding is important for experiments and optoelectronic devices. The author develops the effective mass theory of excitons in low dimensional semiconductors and describes numerical methods for calculating the optical absorption including Coulomb interaction geometry and external fields. The theory is applied to Fano resonances in low dimensional semiconductors and the Zener breakdown in superlattices. Comparing theoretical results with experiments the book is essentially self contained it is a hands on approach with detailed derivations worked examples illustrative figures and computer programs. The book is clearly structured and will be valuable as an advanced level self study or course book for graduate students lecturers and researchers.

**Point and Extended Defects in Semiconductors** Giorgio Benedek, 2013-06-29 The systematic study of defects in semiconductors began in the early fifties. From that time on many questions about the defect structure and properties have been answered but many others are still a matter of investigation and discussion. Moreover during these years new problems arose in connection with the identification and characterization of defects their role in determining transport and optical properties of semiconductor materials and devices as well as from the technology of the ever increasing scale of integration. This book presents to the reader a view into both basic concepts of defect physics and recent developments of high resolution experimental techniques. The book does not aim at an exhaustive presentation of modern defect physics rather it gathers a number of topics which represent the present time research in this field. The volume collects the contributions to the Advanced Research Workshop Point Extended and Surface Defects in Semiconductors held at the Ettore Majorana Centre at Erice Italy from 2 to 7 November 1988 in the framework of the International School of Materials Science and Technology. The workshop has brought together scientists from thirteen countries. Most participants are currently working on defect problems in either silicon submicron technology or in quantum wells and superlattices where point defects dislocations interfaces and surfaces are closely packed together.

**Excitations in Two-Dimensional and Three-Dimensional Quantum Fluids** A.F.G. Wyatt, H.J.

Lauter,2012-12-06 The study of quantum fluids in three dimensions has been an important area for many years as it embraces Bose Einstein condensation superfluidity and macroscopic quantisation These are fundamental aspects of physics which can be studied in liquid  $^4\text{He}$  In contrast quantum fluids in two dimension is more recent and less developed Nevertheless it has shown many interesting phenomena including a rich variety of phases and the Kosterlitz Thouless transition Intermediate between these dimensions are the restricted geometries of micro porous materials into which He may be introduced The main quantum materials considered are  $^4\text{He}$   $^3\text{He}$   $\text{D}_2$   $\text{H}_2$   $\text{H}$  and electrons on the surface of  $^4\text{He}$  The superfluid phases of  $^3\text{He}$  were excluded except for superfluid film flow as  $^3\text{He}$  involves a separate set of problems These proceedings arise from a lively Advanced Research Workshop on Excitations in Two Dimensional and Three Dimensional Quantum Fluids held in Exeter 10 15 August 1990 Fifty scientists took part and each provided a written contribution Perhaps it is a testimony to the discussions that several papers were revised by the authors after the meeting The order of the chapters is the same as the presentations at the workshop This arrangement starts with  $^4\text{He}$  in three dimensions which establishes a base from which the two dimensional properties can be viewed At the end of each section there is a report on the discussion session These are interesting and useful chapters as they clarify points made in the papers and define the boundary of current understanding

*Low-Dimensional Systems* Tobias Brandes,2008-01-11 Experimental progress over the past few years has made it possible to test a number of fundamental physical concepts related to the motion of electrons in low dimensions The production and experimental control of novel structures with typical sizes in the sub micrometer regime has now become possible In particular semiconductors are widely used in order to confine the motion of electrons in two dimensional heterostructures The quantum Hall effect was one of the first highlights of the new physics that is revealed by this confinement In a further step of the technological development in semiconductor heterostructures other artificial devices such as quasi one dimensional quantum wires and quantum dots artificial atoms have also been produced These structures again differ very markedly from three and two dimensional systems especially in relation to the transport of electrons and the interaction with light Although the technological advances and the experimental skills connected with these new structures are progressing extremely fast our theoretical understanding of the physical effects such as the quantum Hall effect is still at a very rudimentary level In low dimensional structures the interaction of electrons with one another and with other degrees of freedoms such as lattice vibrations or light gives rise to new phenomena that are very different from those familiar in the bulk material The theoretical formulation of the electronic transport properties of small devices may be considered well established provided interaction processes are neglected

*Interacting Electrons in Reduced Dimensions* Dionys Baeriswyl,David K. Campbell,2012-12-06 As its name suggests the 1988 workshop on Interacting Electrons in Reduced Dimensions dealt with the wide variety of physical effects that are associated with possibly systems focused on strongly correlated electrons interacting in quasi one and quasi two dimensional materials Among the phenomena discussed were superconductivity magnetic ordering the metal

insulator transition localization the fractional Quantum Hall effect QHE Peierls and spin Peierls transitions conductance fluctuations and sliding charge density CDW and spin density SDW waves That these effects appear most pronounced in systems of reduced dimensionality was amply demonstrated at the meeting Indeed when concrete illustrations were presented they typically involved chain like materials such as conjugated polymers inorganic CDW systems and organic conductors or layered materials such as high temperature copper oxide superconductors certain of the organic superconductors and the QHE samples or devices where the electrons are confined to a restricted region of sample e g the depletion layer of a MOSFET To enable this broad subject to be covered in thirty five lectures and about half as many posters the workshop was deliberately focused on theoretical models for these phenomena and on methods for describing as faithfully as possible the true behavior of these models This latter emphasis was especially important since the inherently many body nature of problems involving interacting electrons renders conventional effective single particle mean field methods e g Hartree Fock or the local density approximation in density functional theory highly suspect Again this is particularly true in reduced dimensions where strong quantum fluctuations can invalidate mean field results

*Mechanisms of Reactions of Organometallic Compounds with Surfaces* D.J. Cole-Hamilton, J.O. Williams, 2013-11-11 A NATO Advanced Research Workshop on the Mechanisms of Reactions of Organometallic Compounds with Surfaces was held in St Andrews Scotland in June 1988 Many of the leading international researchers in this area were present at the workshop and all made oral presentations of their results In addition significant amounts of time were set aside for Round Table discussions in which smaller groups considered the current status of mechanistic knowledge identified areas of dispute or disagreement and proposed experiments that need to be carried out to resolve such disputes so as to advance our understanding of this important research area All the papers presented at the workshop are collected in this volume together with summaries of the conclusions reached at the Round Table discussions The workshop could not have taken place without financial support from NATO and donations were also received from Associated Octel Ltd STC Ltd and Epichem Ltd for which the organisers are very grateful The organisation of the meeting was greatly assisted by Mrs G MacArthur and Mr L R Dunley of the Chemistry Department St Andrews University

Evaluation of Advanced Semiconductor Materials by Electron Microscopy David Cherns, 2012-12-06 The last few years have seen rapid improvements in semiconductor growth techniques which have produced an expanding range of high quality heterostructures for new semiconductor devices As the dimensions of such structures approach the nanometer level it becomes increasingly important to characterise materials properties such as composition uniformity strain interface sharpness and roughness and the nature of defects as well as their influence on electrical and optical properties Much of this information is being obtained by electron microscopy and this is also an area of rapid progress There have been advances for thin film studies across a wide range of techniques including for example convergent beam electron diffraction X ray and electron energy loss microanalysis and high spatial resolution

cathodoluminescence as well as by conventional and high resolution methods Important developments have also occurred in the study of surfaces and film growth phenomena by both microscopy and diffraction techniques With these developments in mind an application was made to the NATO Science Committee in late summer 1987 to fund an Advanced Research Workshop to review the electron microscopy of advanced semiconductors This was subsequently accepted for the 1988 programme and became the NATO Advanced Research Workshop on the Evaluation of Advanced Semiconductor Materials by Electron Microscopy The Workshop took place in the pleasant and intimate surroundings of Wills Hall Bristol UK during the week 11-17 September 1988 and was attended by fifty five participants from fourteen countries

Resonant Tunneling in Semiconductors L.L. Chang, E.E. Mendez, C. Tejedor, 2012-12-06 This book contains the proceedings of the NATO Advanced Research Workshop on Resonant Tunneling in Semiconductors Physics and Applications held at Escorial Spain on May 14-18 1990 The tremendous growth in the past two decades in the field of resonant tunneling in semiconductor heterostructures has followed if not outpaced the expansion witnessed in quantum structures in general Resonant tunneling shares also the multi disciplinary nature of that broad area with an emphasis on the underlying physics but with a coverage of material systems on the one end and device applications on the other Indeed that resonant tunneling provides great flexibility in terms of materials and configurations and that it is inherently a fast process with obvious device implications by the presence of a negative differential resistance have contributed to the unrelenting interest in this field These proceedings consist of 49 refereed articles they correspond to both invited and contributed talks at the workshop Because of the intertwining nature of the subject matter it has been difficult to subdivide them in well defined sections Instead they are arranged in several broad categories meant to serve only as guidelines of emphasis on different topics and aspects The book starts with an introduction to resonant tunneling by providing a perspective of the field in the first article This is followed by discussions of different material systems with various band structure effects

**Spectroscopy of Semiconductor Microstructures** Gerhard Fasol, Annalisa Fasolino, Paolo Lugli, 2013-06-29 Proceedings of a NATO ARW held in Venice Italy May 9-13 1989

*Dynamics of Magnetic Fluctuations in High-Temperature Superconductors* George Reiter, Peter Horsch, Gregory C. Psaltakis, 2012-12-06 This NATO Advanced Research Workshop was held at a time when there was little consensus as to the mechanism for high temperature superconductivity in the context of a world undergoing major changes in its political alignments and sense of the possibility for the future It was characterized by generosity in the sharing of our uncertainties and speculations as was appropriate for both the subject matter and the context The workshop was organized of necessity around the experimental work as is this volume Where the theoretical work is directly relevant to particular experiments it is included in the appropriate sections with them Most of the participants felt strongly that magnetic fluctuations played an important role in the mechanism for high  $T_c$  although with the exception of the ILS R work reported by Luke showing results inconsistent with the anyon picture and the work on flux phases by Lederer the mechanism remained an issue in the



background A major focus was the phenomenological interpretation of the NMR data

**Physics Of Low-dimensional Systems - Proceedings Of Nobel Symposium 73** Stig Lundqvist, Nils Robert Nilsson, 1989-07-01 List of Contributors P W Anderson S Tanaka C W Chu Y H Kim T V Ramakrishnan G Wendin G Baskaran H Fukuyama Y Hasegawa A Zawadowski A A Abrikosov A I Buzdin V L Ginzburg S Barisic I Batistic E J Mele L Dzyaloshinskii L A Falkovsky J R Schrieffer D J Scalapino A I Larkin K W Becker P Fulde S A Trugman F C Zhang K A Chao G Z Wei D J Rome et al J Bardeen M Sinclair S M Girvin D P Arovas P B Wiegmann and others *Physics, Fabrication, and Applications of Multilayered Structures* Claude Weisbuch, 2013-06-29 Low dimensional materials are of fundamental interest in physics and chemistry and have also found a wide variety of technological applications in fields ranging from microelectronics to optics Since 1986 several seminars and summer schools devoted to low dimensional systems have been supported by NATO The present one Physics Fabrication and Applications of Multilayered structures brought together specialists from different fields in order to review fabrication techniques characterization methods physics and applications Artificially layered materials are attractive because alternately layering two or more elements by evaporation or sputtering is a way to obtain new materials with hopefully new physical properties that pure materials or alloys do not allow These new possibilities can be obtained in electronic transport optics magnetism or the reflectivity of x rays and slow neutrons By changing the components and the thickness of the layers one can track continuously how the new properties appear and follow the importance of the multilayer structure of the materials In addition with their large number of interfaces the study of interface properties becomes easier in multilayered structures than in monolayers or bilayers As a rule the role of the interface quality and also the coupling between layers increases as the thickness of the layer decreases Several applications at the development stage require layer thicknesses of just a few atomic layers

*Metallization and Metal-Semiconductor Interfaces* Inder P. Batra, 2012-12-06 This book represents the work presented at a NATO Advanced Research Workshop on Metallization and Metal Semiconductor Interfaces held at the Technical University of Munich Garching W Germany from 22-26 August 1988 The major focus of the workshop was to evaluate critically the progress made in the area of metal semiconductor interfaces The underlying theme was the mechanism of Schottky barrier formation and a serious assessment of the various models A significant fraction of the workshop time was also spent in discussing the interaction of alkali metals with semiconductors Alkali metals on semiconductors form ordered overlayers and the resulting system often exhibits one dimensional metallic properties The nature of their interaction has introduced new and exciting complexities and this was pursued at length during the lively discussions at the workshop A half a day was devoted to Scanning Tunneling Microscopy the emphasis being on its utility in providing structural and electronic character of low coverage regime The book should provide readers with the most current status of the research activity in the general area of metal semiconductor interfaces at an international level It should also serve as an excellent introduction to the field since sufficient review type of material has also been included The workshop

organizers Dr I P Batra Director mM Almaden Research Center San Jose Prof S Ciraci Bilkent University Ankara Prof C Y Pong University of California Davis Prof Dr F Koch Local Chairman Technical University Munich Garching Dr H *Strong Interactions in Low Dimensions* D. Baeriswyl, L. Degiorgi, 2007-09-29 This book provides an attempt to convey the colorful facets of condensed matter systems with reduced dimensionality Some of the specific features predicted for interacting one dimensional electron systems such as charge and spin density waves have been observed in many quasi one dimensional materials The two dimensional world is even richer besides d wave superconductivity and the Quantum Hall Effect perhaps the most spectacular phases explored during the last two decades many collective charge and spin states have captured the interest of researchers such as charge stripes or spontaneously generated circulating currents Recent years have witnessed important progress in material preparation measurement techniques and theoretical methods Today larger and better samples higher flux for neutron beams advanced light sources better resolution in electron spectroscopy new computational algorithms and the development of field theoretical approaches allow an in depth analysis of the complex many body behaviour of low dimensional materials The epoch when simple mean field arguments were sufficient for describing the gross features observed experimentally is definitely over The Editors aim is to thoroughly explain a number of selected topics the application of dynamical probes such as neutron scattering optical absorption and photoemission as well as transport studies both electrical and thermal Some of the more theoretical chapters are directly relevant for experiments such as optical spectroscopy transport in one dimensional models and the phenomenology of charge inhomogeneities in layered materials while others discuss more general topics and methods for example the concept of a Luttinger liquid and bosonization or duality transformations both promising tools for treating strongly interacting many body systems Science and Technology of Fast Ion Conductors Harry L. Tuller, M. Balkanski, 2012-12-06 The rediscovery of fast ion conduction in solids in the 1960 s stimulated interest both in the scientific community in which the fundamentals of diffusion order disorder phenomena and crystal structure evaluation required re examination and in the technical community in which novel approaches to energy conversion and chemical sensing became possible with the introduction of the new field of Solid State Ionics Because of both the novelty and the vitality of this field it has grown rapidly in many directions This growth has included the discovery of many new crystalline fast ion conductors and the extension to the fields of organic and amorphous compounds The growth has involved the extension of classical diffusion theory in an attempt to account for carrier interactions and the development of sophisticated computer models Diffraction techniques have been refined to detect carrier distributions and anharmonic vibrations Similar advances in the application of other techniques such as NMR Raman IR and Impedance Spectroscopies to this field have also occurred The applications of fast ion conducting solid electrolytes have also developed in many directions High energy density Na S batteries are now reaching the last stages of development Li batteries are being implanted in humans for heart pacemakers and solid state fuel cells are again being considered for future power plants The proliferation

of inexpensive microcomputers has stimulated the need for improved chemical sensors a major application now being the zirconia auto exhaust sensor being sold by the millions each year

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