

**Physics and Chemistry of Materials with Layered Structures**

**Volume I**

**Preparation  
and Crystal Growth  
of Materials with  
Layered Structures  
edited by R.M.A. Lieth**



SPRINGER-SCIENCE+BUSINESS MEDIA, B.V.

# Preparation And Crystal Growth Of Materials With Layered Structures

**Albert Furrer**



## **Preparation And Crystal Growth Of Materials With Layered Structures:**

Preparation and Crystal Growth of Materials with Layered Structures R.M.A. Lieth, 2013-06-29 The goal of the series Physics and Chemistry of Materials with Layered Structures is to give a critical survey of our present knowledge on a large family of materials which can be described as solids containing molecules which in two dimensions extend to infinity and which are loosely stacked on top of each other to form three dimensional crystals Of course the physics and chemistry of these crystals are specific chapters in ordinary solid state science and many a scientist hunting for new phenomena has in the past been disappointed to find that materials with layered structures are not entirely exotic Their electron and phonon states are not two dimensional and the high hopes held by some for spectacular dimensionality effects in superconductivity were shattered Nevertheless the structural features and their physical and chemical consequences singularize layered structures sufficiently to make them a fascinating subject of research This is all the more true since they are met in insulators and semiconductors as well as in normal and superconducting metals Although for the time being the series is intentionally limited to cover inorganic materials only the many known organic layered structures may well be the subject of future volumes Among the noteworthy peculiarities of layered structures we mention specific growth mechanisms and crystal habits Polytypism is very common and it is fascinating indeed to find up to 240 different polytypes in the same chemical substance

Preparation and Crystal Growth of Materials with Layered Structures R. M. A. Lieth, 2014-01-15      **Preparation of crystal growth of materials with layered structures**, 1977      Magnetic Properties of Layered Transition Metal Compounds L.J. de Jongh, 2012-12-06 In the last two decades low dimensional low d physics has matured into a major branch of science Quite generally we may define a system with restricted dimensionality d as an object that is infinite only in one or two spatial directions d 1 and 2 Such a definition comprises isolated single chains or layers but also fibres and thin layers films of varying but finite thickness Clearly a multitude of physical phenomena notably in solid state physics fall into these categories As examples we may mention Magnetic chains or layers thin film technology Metallic films homogeneous or heterogeneous crystalline amorphous or microcrystalline etc 1 d or 2 d conductors and superconductors Intercalated systems 2 d electron gases electrons on helium semiconductor interfaces Surface layer problems 2 d melting of monolayers of noble gases on a substrate surface problems in general Superfluid films of He or He Polymer physics Organic and inorganic chain conductors superionic conductors 1 d or 2 d molecular crystals and liquid crystals 1 d or 2 d ferro and antiferro electrics

*Photoelectrochemistry and Photovoltaics of Layered Semiconductors* A. Aruchamy, 2013-03-13 This volume aims at bringing together the results of extensive research done during the last fifteen years on the interfacial photoelectronic properties of the inorganic layered semiconducting materials mainly in relation to solar energy conversion Significant contributions have been made both on the fundamental aspects of interface characteristics and on the suitability of the layered materials in photoelectrochemical semiconductor electrolyte junctions and in solid state photovoltaic Schottky and p

n junctions cells New insights into the physical and chemical characteristics of the contact surfaces have been gained and many new applications of these materials have been revealed In particular the basal plane surface of the layered materials shows low chemical reactivity and specific electronic behaviour with respect to isotropic solids In electrochemical systems the inert nature of these surfaces characterized by saturated chemical bonds has been recognized from studies on charge transfer reactions and catalysis In addition studies on the role of the d band electronic transitions and the dynamics of the photogenerated charge carriers in the relative stability of the photoelectrodes of the transition metal dichalcogenides have deepened the understanding of the interfacial photoreactions Transition metal layered compounds are also recognized as ideal model compounds for the studies Involving surfaces photoreactions adsorption phenomena and catalysis scanning tunneling microscopy and spectroscopy and epitaxial growth of thin films Recently quantum size effects have been investigated in layered semiconductor colloids

### **Physics and Chemistry of Metal Cluster Compounds** L.J. de

Jongh, 2013-03-09 On Friday February 20 1980 I had the pleasure to be present at the inaugural lecture of my colleague Jan Reedijk who had just been named at the Chair of Inorganic Chemistry of Leiden University According to tradition the ceremony took place in the impressive Hall of the old University Academy Building In the course of his lecture Jan mentioned a number of recent developments in chemistry which had struck him as particularly important or interesting Among those was the synthesis of large metal cluster compounds and to my luck he showed a slide of the molecular structure of  $\text{Pt}_9\text{C}_4$  To my luck since at traditional Leiden University it is quite unusual to show slides at such ceremonies This constituted my first acquaintance with this exciting new class of materials I became immediately fascinated by this molecule partly because of the esthetic beauty of its fivefold symmetry partly because as a physicist it struck me that it could be visualized as an embryonically small metal particle embedded in a shell of CO ligands

### Carbyne and Carbynoid Structures R.B.

Heimann, S.E. Evsyukov, Ladislav Kavan, 2012-12-06 1 1 THE DISCOVERY OF CARBYNE Yu P KUDRYA VTSEV A N Nesmeyanov Institute of Organoelement Compounds Russian Academy of Sciences 117813 Moscow Russia Abstract The history of the discovery of carbyne is briefly recalled The existence of carbyne was first disclosed by Russian researchers in 1960 It was obtained for the first time via oxidative dehydropolycondensation of acetylene based on the Glaser coupling of ethynyl compounds 1 Introduction The polymeric nature of carbon was first pointed out by Mendeleev He wrote The molecules of coal graphite and diamond are very complicated and carbon atoms exhibit the capability of binding one to another to form complex molecules in all compounds of carbon None of the elements possesses an ability of complicating in such an extent as does carbon There is still no basis to define the polymerization degree of the coal graphite or diamond molecules One should believe however that they contain  $n$  species where  $n$  is a large value IJ Until the 1960s only two allotropic forms of carbon were known viz graphite and diamond including their polymorphous modifications For a long time amorphous carbon was also included among the simple forms Presently however the structure of amorphous and quasi

amorphous carbons such as carbon blacks soot cokes glassy carbon etc is known to approach that of graphite to various degrees 2J

**Nuclear Spectroscopy on Charge Density Wave Systems** T. Butz, 2013-04-17 Nuclear magnetic resonance NMR nuclear quadrupole resonance NQR time differential perturbed angular correlations TDPAC and the Mossbauer effect ME have been applied to the study of charge density wave CDW systems These hyperfine techniques provide unique tools to probe the structure and symmetry of commensurate CDWs give a clear fingerprint of incommensurate CDWs and are ideally suited for CDW dynamics This book represents a new attempt in the series Physics and Chemistry of Materials with Low dimensional Structures to bring together a consistent group of scientific results obtained by nuclear spectroscopy related to CDW phenomena in pseudo one and two dimensional systems The individual chapters contain the theory of CDWs in chain like transition metal tetrachalcogenides NMR NQR TDPAC and ME investigations of layered transition metal dichalcogenides NMR studies of CDW transport in chain like NbSe<sub>3</sub> and molybdenum bronzes multinuclear NMR of KCP high resolution NMR of organic conductors This book is of interest to graduate students and all scientists who want to acquire a broader knowledge of nuclear spectroscopy techniques applied to CDW systems

Electron Spectroscopies Applied to Low-Dimensional Structures H.P. Hughes, H. Starnberg, 2006-04-11 The effect of reduced dimensionality inherent at the crystallographic level on the electronic properties of low dimensional materials can be dramatic leading to structural and electronic instabilities including superconductivity at high temperatures charge density waves and localisation which continue to attract widespread interest The layered transition metal dichalcogenides have engaged attention for many years partly arising from the charge density wave effects which some show and the controlled way in which their properties can be modified by intercalation while the development of epitaxial growth techniques has opened up promising areas based on dichalcogenide heterostructures and quantum wells The discovery of high temperature superconducting oxides and the realisation that polymeric materials too can be exploited in a controlled way for various optoelectronic applications have further stimulated interest in the effects of structural dimensionality It seems timely therefore to draw together some strands of recent research involving a range of disparate materials which share some common characteristics of low dimensionality This resulting volume is aimed at researchers with specialist interests in the particular materials discussed but who may also wish to examine the related phenomena observed in different systems and at a more general solid state audience with broad interests in electronic properties and low dimensional phenomena Space limitations have required us to be selective as regards particular materials though we have managed to include those as dissimilar as polymeric semiconductors superconducting oxides bronzes and layered chalcogenides

**Two-Dimensional Electron Systems** E.Y. Andrei, 2012-12-06 Recent studies on two dimensional systems have led to new insights into the fascinating interplay between physical properties and dimensionality Many of these ideas have emerged from work on electrons bound to the surface of a weakly polarizable substrate such as liquid helium or solid hydrogen The research on this subject continues to be at the

forefront of modern condensed matter physics because of its fundamental simplicity as well as its connection to technologically useful devices This book is the first comprehensive overview of experimental and theoretical research in this exciting field It is intended to provide a coherent introduction for graduate students and non experts while at the same time serving as a reference source for active researchers in the field The chapters are written by individuals who made significant contributions and cover a variety of specialized topics These include the origin of the surface states tunneling and magneto tunneling out of these states the phase diagram collective excitations transport and magneto transport

**Neutron Scattering in Layered Copper-Oxide Superconductors** Albert Furrer, 2012-12-06 The phenomenon of superconductivity after its discovery in metals such as mercury lead zinc etc by Kamerlingh Onnes in 19 has attracted many scientists Superconductivity was described in a very satisfactory manner by the model proposed by Bardeen Cooper and Schrieffer and by the extensions proposed by Abrikosov Gorkov and Eliashberg Relations were established between superconductivity and the fundamental properties of solids resulting in a possible upper limit of the critical temperature at about 23 K The breakthrough that revolutionized the field was made in 1986 by Bednorz and Muller with the discovery of high temperature superconductivity in layered copper oxide perovskites Today the record in transition temperature is 133 K for a Hg based cuprate system The last decade has not only seen a revolution in the size of the critical temperature but also in the myriads of research groups that entered the field In addition high temperature superconductivity became a real interdisciplinary topic and brought together physicists chemists and materials scientists who started to investigate the new compounds with almost all the available experimental techniques and theoretical methods As a consequence we have witnessed an avalanche of publications which has never occurred in any field of science so far and which makes it difficult for the individual to be thoroughly informed about the relevant results and trends Neutron scattering has outstanding properties in the elucidation of the basic properties of high temperature superconductors

**Low-Dimensional Electronic Properties of Molybdenum Bronzes and Oxides** C. Schlenker, 2012-12-06 The history of low dimensional conductors goes back to the prediction more than forty years ago by Peierls of the instability of a one dimensional metallic chain leading to what is known now as the charge density wave state At the same time Frohlich suggested that an ideal conductivity could be associated to the sliding of this charge density wave Since then several classes of compounds including layered transition metal dichalcogenides quasi one dimensional organic conductors and transition metal tri and tetra chalcogenides have been extensively studied The molybdenum bronzes or oxides have been discovered or rediscovered as low dimensional conductors in this last decade A considerable amount of work has now been performed on this subject and it was time to collect some review papers in a single book Although this book is focused on the molybdenum bronzes and oxides it has a far more general interest in the field of low dimensional conductors since several of the molybdenum compounds provide from our point of view model systems This is the case for the quasi one dimensional blue bronze especially due to the availability of good

quality large single crystals This book is intended for scientists belonging to the fields of solid state physics and chemistry as well as materials science It should especially be useful to many graduate students involved in low dimensional oxides It has been written by recognized specialists of low dimensional systems

**2D Transition-Metal Dichalcogenides (TMDs): Fundamentals and Application** Abhay Kumar Singh, 2025-01-18 This book offers to reader a sound understating of two dimensional Transition Metal Dichalcogenides 2D TMDs materials detailing their physio chemical mechanisms and technological applications in various areas such as nanoelectronics and optoelectronics Moving from their invention to their modern developments including theoretical approaches experimental interpretations and their technical applications the book explores the basic concepts of 2D TMDs It will be of interest to undergraduate and postgraduate students researchers and scientists working in the area of 2D TMDs A key goal of this book provides a sound or clear idea about two dimensional Transition Metal Dichalcogenides 2D TMDs materials by providing their sound background fabrication approaches including interpretations of the inside physio chemical mechanism including technological applications in various significant areas such as nanoelectronics optoelectronics topological insulators biomedical

**Crystal Growth in Science and Technology** H. Arend, J. Hulliger, 2012-12-06 Science and art of crystal growth represent an interdisciplinary activity based on fundamental principles of physics chemistry and crystallography Crystal growth has contributed over the years essentially to a widening of knowledge in its basic disciplines and has penetrated practically into all fields of experimental natural sciences It has acted more over in a steadily increasing manner as a link between science and technology as can be seen best for example from the achievements in modern microelectronics The aim of the course Crystal Growth in Science and Technology being to stress the interdisciplinary character of the subject selected fundamental principles are reviewed in the following contributions and cross links between basic and applied aspects are illustrated It is a very well known fact that the intensive development of crystal growth has led to a progressive narrowing of interests in highly specialized directions which is in particular harmful to young research scientists The organizers of the course did sincerely hope that the program would help to broaden up the horizon of the participants It was equally their wish to contribute within the traditional spirit of the school of crystallography in Erice to the promotion of mutual understanding personal friendship and future collaboration between all those who were present at the school

*Crystallography and Crystal Chemistry of Materials with Layered Structures* F.A. Lévy, 2012-12-06 In the last ten years the chemistry and physics of materials with layered structures became an intensively investigated field in the study of the solid state Research into physical properties of these crystals and especially investigations of their physical anisotropy related to the structural anisotropy has led to remarkable and perplexing results Most of the layered materials exist in several polytypic modifications and can include stacking faults The crystal structures are therefore complex and it became apparent that there was a great need for a review of the crystallographic data of materials approximating two dimensional solids This second volume in the series Physics and Chemistry of Materials with Layered Structures has been

written by specialists of different classes of layered materials Structural data are reviewed and the most important relations between the structure and the chemical and physical properties are emphasized The first three contributions are devoted to the transition metal dichalcogenides whose physical properties have been investigated in detail The crystallographic data and crystal growth conditions are presented in the first paper The second paper constitutes an incisive review of the phase transformations and charge density waves which have been observed in the metallic dichalcogenides In two contributions the layered structures of newer ternary compounds are described and the connection between structure and non stoichiometry is discussed

*Biomedical Applications of Graphene and 2D Nanomaterials* Md Nurunnabi, Jason McCarthy, 2019-03-31  
Biomedical Applications of Graphene and 2D Nanomaterials provides a much needed reference on the biomedical applications of 2D nanomaterials as well as theoretical knowledge on their structure physicochemical properties and biomedical applications Chapters are dedicated to growth areas such as size and shape dependent chemical and physical properties and applications such as in diagnostic and therapeutic products The book also discusses the concept development and preclinical studies of 2D nanomaterials based biomedical tools such as biosensors artificial organs and photomedicine Case studies and reports form the core of the book making it an ideal resource on potential applications in biomedical science and engineering This timely resource for scientists and engineers in this rapidly advancing field features contributions from over 30 leaders who address advanced methods and strategies for controlling the physical chemical properties of 2D nanomaterials along with expert opinions on a range of 2D nanomaterials that have therapeutic and diagnostic applications Presents advanced methods and strategies for controlling the physical chemical properties of 2D nanomaterials Provides state of the art biomedical applications for 2D nanomaterials including graphene and boron nitride Includes key information from a broad selection of subject areas for researchers in both materials engineering and medicine

**Nanostructures and Thin Films for Multifunctional Applications** Ion Tiginyanu, Pavel Topala, Veaceslav Ursaki, 2016-04-02 This book is focused on recent advances in the development of thin films for photovoltaic applications TiO<sub>2</sub> WO<sub>3</sub> bilayers for applications with enhanced photocatalytic properties nanometer oxide and hydroxide films for anticorrosive coatings surface passivation in chemical industries micro and nanoelectronics trilayers of metglas and lead free piezoelectrics for magnetic field sensors current sensors spintronics microwave and read write devices Diluted ferromagnetic alloy films are also considered for superconducting spintronics based on superconducting spin valves Thermal properties of segmented nanowires are analyzed with respect to thermoelectric applications Recent advances in template production of nanocomposites are also reviewed with particular focus on technologies for template assisted formation of metal nanotubes Some elements related to abrasive flow machining AFM specifically state of the art elements of technological systems and construction of equipment are presented The book is written for researchers in materials science nanotechnologies PhD students and graduate student

**New Horizons in Low-Dimensional Electron Systems** H. Aoki, M. Tsukada, M.

Schlüter, F.A. Lévy, 2012-12-06 In *Bird of Passage* by Rudolf Peierls we find a paragraph in which he describes his Cambridge days in the 1930s. On these relativistic field theory problems my main contacts were Dirac and the younger theoreticians. These included in particular Nevill now Sir Nevill Mott perhaps the friendliest among many kind and friendly people we met then. Professor Kamimura became associated with Sir Rudolf Peierls in the 1950s when he translated with his colleagues Peierls's 1955 textbook *Quantum Theory of Solids* into Japanese. This edition to which Sir Rudolf himself contributed a preface benefitted early generations of Japanese solid state physicists. Later in 1974-5 during a sabbatical year spent at the Cavendish Laboratory Professor Kamimura met and began a long association with Sir Nevill Mott. In particular they developed ideas for disordered systems. One of the outcomes is a paper coauthored by them on ESR induced variable range hopping in doped semiconductors. A series of works on disordered systems together with those on two dimensional systems have served as building blocks for *Physics of Interacting Electrons in Disordered Systems* in the International Series of Monographs on Physics coauthored by Aoki and published in 1989 by the Oxford University Press. Soon after Professor Kamimura obtained a D Sc in 1959 for the work on the ligand field theory under the supervision of Masao Kotani his strong connections in the international physical community began when he worked at the Bell Telephone Laboratories in 1961-64.

**Defects in Two-Dimensional Materials** Rafik Addou, Luigi Colombo, 2022-02-14 *Defects in Two Dimensional Materials* addresses the fundamental physics and chemistry of defects in 2D materials and their effects on physical electrical and optical properties. The book explores 2D materials such as graphene hexagonal boron nitride h BN and transition metal dichalcogenides TMD. This knowledge will enable scientists and engineers to tune 2D materials properties to meet specific application requirements. The book reviews the techniques to characterize 2D material defects and compares the defects present in the various 2D materials e.g. graphene h BN TMDs phosphorene silicene etc. As two dimensional materials research and development is a fast growing field that could lead to many industrial applications the primary objective of this book is to review discuss and present opportunities in controlling defects in these materials to improve device performance in general or use the defects in a controlled way for novel applications. Presents the theory physics and chemistry of 2D materials. Catalogues defects of 2D materials and their impacts on materials properties and performance. Reviews methods to characterize control and engineer defects in 2D materials.

**New Research on Solid State Chemistry** James B. Veliotti, 2007 This book on solid state chemistry presents studies of chemical structural thermodynamic electronic magnetic and optical properties and processes in solids. Research areas include bonding in solids crystal chemistry crystal growth mechanisms diffusion epitaxy high pressure processes magnetic properties of materials optical characterisation of materials order disorder phase equilibria and transformation mechanisms reactions at surfaces statistical mechanics of defect interactions structural studies and transport phenomena.

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