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Morphological and Compositional Evolution of Heteroepitaxial Semiconductor Thin Films

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Morphological And Compositional Evolution Of Thin Films Proceedings

Vitaly Shchukin,Nikolai N. Ledentsov,Dieter Bimberg

Morphological And Compositional Evolution Of Thin Films Proceedings:

Morphological and Compositional Evolution of Thin Films: Volume 749 Michael J. Aziz,2003 The papers compiled in this volume were presented in Symposium W Morphological and Compositional Evolution of Thin Films held December 2 5 at the 2002 MRS Fall Meeting in Boston Massachusetts They are organized in the order that they were presented P xiii

Development of in situ methods for process monitoring and control and characterization of Cu-Zn-Sn-S based thin films Van Duren, Stephan,2019-06-03 In recent years kesterite Cu2ZnSnS4 CZTS has become an interesting alternative to copper indium gallium di selenide CIGS due to its non toxic and earth abundant constituents A variety of methods is being used to fabricate kesterite thin films such as coevaporation sputtering electrodeposition spray pyrolysis and others Most of them include an annealing step to stimulate elemental mixing and interdiffusion Although conversion efficiencies of kesterite solar cells have increased among different research groups the record value of 12 6% set by IBM in 2014 has not been broken yet Therefore experimental and theoretical studies are needed to predict the effect of the secondary phases and detrimental defects on the electronical properties of the CZTS based solar devices The work presented here studies non destructive techniques for in situ process control and monitoring With the aim to detect phases and phase transitions to optimize crucial processing steps such as pre annealing of metal precursors high temperature annealing and vacuum deposition of Cu Sn Zn S based thin films The research consists of three parts in which Raman spectroscopy X ray diffraction XRD and reflectometry are used to explore this objective In the first part Raman spectroscopy is investigated as an in situ monitoring technique during high temperature annealing of thin films It investigates whether the occurrence of CZTS can be monitored when it is created from annealing a Mo CTS ZnS layered thin film CuS SnS ZnS and CTS Cu Sn S films are prepared by physical vapor deposition The Raman scattering intensity was compared to investigate whether their specific vibrational modes can be distinguished from each other at room temperature Then the CTS film is annealed between 50 and 550 C in order to investigate whether CTS vibrational modes can be identified at elevated temperatures and to see which transitions take place within the thin film Also a CZTS reference film is annealed between 50 and 550 C for reference purposes The temperature dependence of the main CZTS modes is examined to investigate whether it can be used for in situ temperature control Finally a ZnS layer is deposited on the unannealed CTS film to obtain a Mo CTS ZnS layered film This film is used to study the conversion of CTS ZnS into CZTS at elevated temperatures It was found that Raman spectroscopy can successfully be used to monitor formation of CZTS by identifying its main vibrational mode during the annealing process The intensity of the CTS modes reduces at elevated temperatures At 450 C the main CZTS mode at 338 cm 1 can be clearly identified The second part also focuses on high temperature annealing However in this part the focus lies on annealing of the metal precursor films It is explored whether specific alloys benefit or hinder the formation of secondary phases during formation of the CZTS absorber films Also to what extent this influences solar cell performance In situ XRD was investigated

for in situ monitoring of the pre annealing process Cu poor metal precursor films are prepared by sputtering deposition The precursors are annealed at 150 C 200 C 300 C and 450 C in a three zone tube furnace The effect on the structural properties is analysed by XRD to study the formation mechanism of alloys The precursor films are then sulfurized in a three zone tube furnace The structural properties of the absorber are analysed and correlated with structures in the precursor It is found that formation of SnS2 in the absorber is proportional to the remaining Sn in the pre annealed precursor Also electron micrographs showed that pre annealing temperature influences grain growth and surface precipitation of Sn S and Zn S Pre annealed absorbers at 450 C did not exhibit these phases on the surface Solar devices are fabricated from the absorber films and best performing devices were obtained from pre annealed absorbers at 450 C They showed absence of Sn and SnS2 in respectively the precursor and absorber It could be concluded that SnS2 phases are detrimental to device efficiency and that SnS2 XRD peak intensity follows an inverse proportionality with device efficiency The third part explores reflectometry as a method to monitor a growing film during thermal evaporation in a physical vapor deposition PVD system A set of six CZTS absorbers is examined by ex situ Raman spectroscopy and reflectometry to study the influence of secondary phases CuS and ZnS on reflection spectra Composition strongly influences reflection spectra and CuS leaves a characteristic dip in the reflection spectrum at about 600 nm An integration method was used to analyze this phenomenon quantitatively Subsequently a reflectometry setup is designed developed and integrated in the PVD system Four different CZTS co evaporated and multi layered films are deposited Structural morphological and vibrational properties are investigated The reflection spectra are monitored during deposition and time dependent reflection spectra are analyzed for characteristic aspects related to properties such as thickness band gap and phase formation CuS could not be detected in the films by the integration method due to the superposition of the CuS dip with developing interference fringes during film growth However in multilayered CTS ZnS film it is found that the onset of ZnS deposition can be detected by increased reflection intensity due to reduced surface roughness Additionally the shifting onset of the interference fringes to lower photon energies can be used as a characteristic fingerprint during the deposition process In conclusion this work showed that Raman spectroscopy XRD and reflectometry could be successfully implemented for in situ process control and monitoring of high temperature annealing and vacuum deposition of Cu Sn Zn S based precursors and absorbers The application of these in situ techniques can lead to the optimization of thin film material properties and solar cells As such this study has paved the way for further improvement of Cu Sn Zn S based precursors and thin film absorbers Innerhalb der letzten Jahre hat sich Kesterit Cu2ZnSnS4 CZTS aufgrund seiner ungiftigen Bestandteile und deren hoher Verf gbarkeit zu einer interessanten Alternative zu Kupfer Indium Gallium di Selenid CIGS entwickelt Zur Herstellung von Kesterit D nnschichten wird eine Vielzahl von Methoden verwendet wie Ko Verdampfung Sputtern Elektrodeposition Spray Pyrolyse und andere Die meisten davon beinhalten einen Temper Schritt um die Durchmischung und Interdiffusion der Elemente zu stimulieren Obwohl der

Wirkungsgrad der Kersterit Solarzellen von verschiedenen Forschungsgruppen erh ht wurde ist der Rekordwert von IBM von 12 6 % noch nicht gebrochen worden Daher werden experimentelle und theoretische Studien ben tigt die den Einfluss von Fremdphasen und sch dlichen Defekten auf die elektronischen Eigenschaften der CZTS Solarzellen vorhersagen Die vorliegende Arbeit untersucht zerst rungsfreie Methoden f r die in situ Prozesskontrolle und berwachung Dabei ist das Ziel entscheidende Prozessschritte wie das Vortempern der Metall Vorl ufer sowie das Hochtemperatur Tempern und die Vakuum Abscheidung von Cu Sn Zn S basierten Schichten zu optimieren Die Untersuchung besteht aus drei Teilen in denen Raman Spektroskopie R ntgendiffraktion XRD und Reflektometrie benutzt werden um dieses Ziel zu erreichen Im ersten Teil wird die Ramanspektroskopie als in situ Methode zur berwachung des Hochtemperatur Temperns von D nnschichten betrachtet Es wird untersucht ob das Entstehen von CZTS beim Tempern von gestapelten Mo CTS ZnS D nnschichten beobachtet werden kann CuS SnS ZnS und CTS Cu Sn S Schichten werden durch physikalische Gasabscheidung hergestellt Die Intensit t der Raman Streuung wurde vergleichen um zu untersuchen ob die spezifischen Vibrations Moden bei Raumtemperatur voneinander unterschieden werden k nnen Dann werden die CTS Schichten zwischen 50 C und 550 C getempert um zu untersuchen ob die CTS Vibrations Moden bei h heren Temperaturen identifiziert werden k nnen und um festzustellen welche berg nge innerhalb der Schicht auftreten Au erdem wurde eine CZTS Referenzschicht zwischen 50 C und 550 C f r Referenzzwecke getempert worden Die Temperaturabh ngigkeit der CZTS Haupt Moden werden betrachtet um zu untersuche ob sie f r die in situ Temperatur berwachung verwendet werden k nnen Abschlie end wurde eine ZnS Schicht auf einem nicht getemperten CTS Film abgeschieden um eine gestapelte Mo CTS ZnS Schicht zu erhalten Diese Schicht wird verwendet um die Umwandlung von CTS ZnS zu CZTS bei erh hten Temperaturen zu untersuchen Es wurde festgestellt dass Raman Spektroskopie erfolgreich verwendet werden kann um die Bildung von CZTS zu berwachen indem die Haupt Vibrations Moden w hrend des Temperns identifiziert werden Die Intensit t der CTS Moden verringert sich bei h heren Temperaturen Bei 450 C kann die CZTS Hauptmode bei 338 cm 1 klar identifiziert werden Der zweite Teil konzentriert sich ebenfalls auf das Hochtemperatur Tempern In diesem Teil liegt der Fokus allerdings auf dem Tempern der Metal Vorl ufer Schichten Es wird erforscht ob bestimmte Legierungen die Entstehung von Fremdphasen w hrend der Entstehung der CZTS Absorberschichten beg nstigen oder hemmen und welchen Einfluss dies auf die Leistung der Solarzelle hat In situ XRD wird verwendet um die Prozesse des Vortemperns zu berwachen Kupfer arme Metall Vorl ufer Schichten werden durch Sputtern aufgetragen Die Vorl ufer werden bei 150 C 200 C 300 C und 450 C in einem Drei Zonen R hren Ofen getempert Die Auswirkungen auf die strukturellen Eigenschaften werden mit XRD analysiert um den Entstehungsmechanismus der Legierungen zu untersuchen Die Vorl uferschichten werden dann in einem Drei Zonen R hren Ofen sulfurisiert Die strukturellen Eigenschaften des Absorbers werden analysiert und mit der Struktur der Vorl ufer korreliert Es wurde festgestellt dass die Entstehung von SnS2 im Absorber proportional zum verbleibenden Sn im vorgetemperten Vorl ufer ist

Au erdem zeigen Bilder des Rasterelektronenmikroskops dass die Temperatur des Vortemperns das Kornwachstum und das Abschieden von Sn S und Zn S an der Oberfl che beeinflusst Bei 450 C vorgetemperte Absorber weisen keine dieser Phasen an der Oberfl che auf Solarzellen werden aus diesen Absorber Schichten hergestellt und die besten Zellen entstanden aus den bei 450 C vorgetemperten Absorbern Bei diesen traten Sn und SnS2 weder im Vorl ufer noch im Absorber auf Es konnte geschlussfolgert werden dass SnS2 Phasen sch dlich f r den Wirkungsgrad der Zellen sind und dass die Intensit t der SnS2 XRD Peaks invers proportional zum Wirkungsgrad der Zellen ist Der dritte Teil erforscht die Reflektometrie als Methode zur berwachung des Schichtwachstums w hrend des thermischen Verdampfens in einer Anlage zur physikalischen Gasabscheidung PVD Ein Satz aus sechs CZTS Absorbern wird mittels ex situ Raman Spektroskopie und Reflektometrie vermessen um den Einfluss der Fremdphasen CuS und ZnS auf die Reflexionsspektren zu untersuchen Die Zusammensetzung beeinflusst die Reflexionsspektren stark und CuS hinterl sst eine charakteristische Senkung bei 600 nm im Reflexionsspektrum Eine Integrationsmethode wurde verwendet um dieses Ph nomen quantitativ zu analysieren Anschlie end wurde ein Reflektometrieaufbau entworfen entwickelt und in die PVD Anlage integriert Vier verschiedene CZTS koverdampfte und Mehrschicht Filme wurden abgeschieden Strukturelle morphologische und Vibrationseigenschaften werden untersucht Die Reflexionsspektren werden w hrend des Abscheidens aufgenommen und zeitabh ngige Reflexionsspektren werden auf charakteristische Aspekte im Zusammenhang mit Eigenschaften wie Dicke Bandl cke und Entstehung von Phasen untersucht CuS konnte in den Schichten mit der Integrations Methode wegen der berlagerung der CuS Senkung mit dem entstehenden Interferenzmuster nicht detektiert werden Allerdings wurde in gestapelten CTS ZnS Schichten beobachtet werden dass der Beginn der ZnS Abscheidung durch eine ansteigende Intensit t der Reflektion aufgrund der verringerten Oberfl chenrauigkeit detektiert werden kann Zus tzlich kann die Verschiebung des Startpunkts der Interferenzen zu niedrigeren Photonenenergien als charakteristischer Fingerabdruck w hrend des Abscheidungsprozesses verwendet werden Zusammenfassend zeigt diese Arbeit dass Raman Spektroskopie XRD und Reflektrometrie erfolgreich als in situ Prozesskontrolle und berwachung bei Hochtemperatur Tempern und Vakuum Abscheidung von Cu Sn Zn S basierten Vorl ufern und Absorbern realisiert werden konnten Die Anwendung dieser in situ Techniken kann zu einer Optimierung der Eigenschaften von D nnschicht Materialien und von Solarzellen f hren Als solche hat diese Untersuchung den Weg f r weitere Verbesserung von Cu Sn Zn S basierte Vorl ufer und D nnschicht Absorber geebnet **Epitaxy of Nanostructures** Vitaly Shchukin,Nikolai N. Ledentsov,Dieter Bimberg,2013-03-09 The general trend in modern solid state physics and technology is to make things smaller The size of key elements in modern devices approaches the nanometer scale for both vertical and lateral dimensions Ultrathin layers or quantum wells had already gained broad acceptance for applications in micro and optoelectronics by the 1980s However the development of het erostructures with lower dimensionality quantum wires where carriers are confined in two directions and move freely in one

and quantum dots where carriers are confined in all three directions took longer It became clear that quantum wire and dot structures constitute the utmost technological chal lenge whilst providing enormous advantages At the beginning of the 1990s a few outstanding discoveries concern ing self organization phenomena at crystal surfaces for direct fabrication of nanostructures led to a change in the major paradigms of semiconductor physics and technology This new approach in epitaxy enables fast parallel fabrication of large densities of quantum dots or wires for almost unlimited material combinations and has become the basis for a powerful new branch of nanotechnology Quantum dots coherent inclusions in a semiconductor ma trix with zero dimensional electronic properties persistent up to room tem perature have demonstrated fascinating physical properties and given birth to a novel generation of optoelectronic devices and systems **Proceedings of the 5th International Conference on Metal Material Processes and Manufacturing** Dong-Won Jung,2024-03-21 This book the proceedings of International Conference on Metal Material Processes and Manufacturing is a comprehensive collection of research papers presented at a conference held on September 15 16 2023 in Jeju Island South Korea The book serves as a valuable resource for academics researchers and professionals in the field of metal material processes and manufacturing The book is organized into several chapters each covering a different topic related to metal material processes and manufacturing The chapters include Fundamentals of Metallurgical Processes Metallurgical Process Optimization Metal Matrix Composites Molten Metal Processing and Modeling Overall the proceedings of International Conference on Metal Material Processes and Manufacturing provides a comprehensive overview of the current state of research in the field of metal material processes and manufacturing It is an essential resource for anyone interested in staying up to date with the latest developments in this rapidly evolving field Index of Conference Proceedings British Library. Document Supply Centre,2003 Materials Science And Engineering - Proceedings Of The 2nd Annual International Workshop (Iwmse 2016) Roman Szewczyk,Jingyu Yang,2017-06-29 The 2nd Annual 2016 International Workshop on Materials Science and Engineering IWMSE 2016 was held in Guangzhou Guangdong China on August 12 August 14 2016 The main aim of IWMSE 2016 was to provide a platform for scientists and engineers to get together to share their research findings exchange ideas and identify the future directions of R D in materials science In this conference we have received over 272 high quality papers however only 160 articles are included in the proceedings covering topics such as ceramics and glasses amorphous materials nanomaterials and thin layers soft magnetic materials biomaterials polymers photovoltaic materials steels tool materials composites as well as functional and smart materials **Lateral Alignment of Epitaxial Quantum Dots** Oliver G. Schmidt,2007-08-17 This book describes the full range of possible strategies for laterally aligning self assembled quantum dots on a substrate surface beginning with pure self ordering mechanisms and culminating with forced alignment by lithographic positioning The text addresses both short and long range ordering phenomena and introduces future high integration of single quantum dot devices on a single chip Contributions by well known experts ensure

that all relevant quantum dot heterostructures are elucidated from diverse perspectives **Proceedings of the Fourth International Symposium of Process Physics and Modeling in Semiconductor Technology** G. R. Srinivasan,C. S. Murthy,Scott T. Dunham,1996 Research Perspectives on Functional Micro- and Nanoscale Coatings Zuzuarregui, Ana,Morant-Miñana, Maria Carmen,2016-04-11 Just as chemistry is a part of our daily lives functional coatings can be found in almost every object gadget or device you can see or touch However in the last 20 years the advances made in the preparation of different functional coatings with diverse compositions have allowed the development of nanoscale coatings that are more cost effective and environmentally conscious than traditional coatings Research Perspectives on Functional Micro and Nanoscale Coatings highlights critical research on preparation methods modification organization and utilization of functional coatings in micro nano and biotechnology Emphasizing emerging developments and global research perspectives this publication is a pivotal resource for engineers researchers and graduate level students interested in learning about emerging developments in functional coatings and nanotechnology **Diffuse Scattering and the Fundamental Properties of Materials** Rozaliya I. Barabash,Gene E. Ice,Patrice E. A. Turchi,2009 Annotation Beginning with a concise review of the physics and chemistry of polymers and their structure and morphology this book goes on to describe and explain the common methods of characterizing polymers including optical microscopy scanning electron microscopy and transmission electron microscopy among others Also covered are the characterization and modification of such surface properties as adhesion wetting tribology and surface thermodynamics **Block Copolymer Nanocomposites** Galder Kortaberria,Agnieszka Tercjak,2016-10-14 This book provides a comprehensive overview of the synthesis and characterization of nanocomposites based on block copolymers Because of the self assembly capability of block copolymers for the generation of nanostructures besides their ability to nanostructure thermosetting matrices such as epoxy and polyester binary or ternary nanocomposites can be prepared with different nanofillers such as nanoparticles and carbon nanotubes The book starts with a review on nanocomposites based on block copolymers and nanoparticles synthesized with the use of surfactants followed by a review on nanocomposites with metallic nanoparticles with polymer brushes and those with carbon nanotubes A chapter is devoted to binary systems based on block copolymers and nanoparticles synthesized by sol gel A review on nanocomposites based on thermosetting matrices nanostructured with block copolymers amphiphilic or chemically modified is also presented for both epoxy and polyester resins The work on ternary systems based on thermosetting matrices block copolymers and nanoparticles is presented next The book concludes with a discussion on nanocomposites based on epoxy and block copolymers with azobenzene groups for optical purposes **Evolution of Thin-Film and Surface Structure and Morphology: Volume 355** B. G. Demczyk,1995-07-18 The MRS Symposium Proceeding series is an internationally recognised reference suitable for researchers and practitioners **Material and Composition Screening Approaches in Electrocatalysis and Battery Research** Kai S. Exner,Jun Huang,Jianping

Xiao,Thomas Kadyk,Hideshi Ooka,2021-07-08 Nanostructured Surfaces and Thin Films Synthesis by Physical Vapor Deposition Rafael Alvarez,2021-04-22 This Special Issue deals with the synthesis of nanostructured surfaces and thin films by means of physical vapor deposition techniques such as pulsed laser deposition magnetron sputtering HiPIMS or e beam evaporation among others The nanostructuration of the surface modifies the way a material interacts with the environment changing its optical mechanical electrical tribological or chemical properties This can be applied in the development of photovoltaic cells tribological coatings optofluidic sensors or biotechnology to name a few This issue includes research presenting novel or improved applications of nanostructured thin films such as photovoltaic solar cells thin film transistors antibacterial coatings or chemical and biological sensors while also studying the nanostructuration mechanisms from a fundamental point of view that produce rods columns helixes or hexagonal grids at the nanoscale Ultrananocrystalline Diamond Olga A. Shenderova,Dieter M. Gruen,2006-08-10 Ultrananocrystalline Diamond Syntheses Properties and Applications is a unique practical reference handbook that brings together the basic science of nanoscale carbon structures particularly its diamond phase with detailed information on nanodiamond synthesis properties and applications Here you will learn about UNCD in its two forms as a dispersed powder made by detonation techniques and as a chemical vapor deposited film You will also learn about the superior mechanical tribological transport electrochemical and electron emission properties of UNCD for a wide range of applications including MEMS NEMS surface acoustic wave SAW devices electrochemical sensors coatings for field emission arrays photonic and RF switching biosensors and neural prostheses and more This Everything about Ultra nanocrystalline Diamond book with 16 chapters is written by leading experts worldwide It is for everyone who researches carbon nanostructures everyone who produces them everyone who characterizes them and everyone who builds devices using them *Recent Trends in Applied Physics and Material Science* Sudhir Bhardwaj,Manoj Singh Shekhawat,Bhuvneshwer Suthar,2025-10-22 It gives us immense pleasure to present the Conference Proceedings of the Second International Conference on Recent Trends in Applied Physics Material Science RAM 2024 held on November 15 16 2024 at Bikaner Rajasthan India This prestigious event was organized jointly by Bikaner Technical University Bikaner and the Condensed Matter Research Society Bikaner with the support of our esteemed publication partners CRC Press and the Journal of Condensed Matter RAM 2024 brought together over 400 participants both offline and online from across the globe reflecting the vibrant and growing international interest in the domains of Applied Physics and Material Science The conference featured plenary and keynote lectures by eminent experts oral presentations and poster sessions providing a stimulating platform for the exchange of knowledge and recent advances in the field **Polymer Morphology** Qipeng Guo,2016-05-16 With a focus on structure property relationships this book describes how polymer morphology affects properties and how scientists can modify them The book covers structure development theory simulation and processing and discusses a broad range of techniques and methods Provides an up to date comprehensive introduction to the principles and

practices of polymer morphology Illustrates major structure types such as semicrystalline morphology surface induced polymer crystallization phase separation self assembly deformation and surface topography Covers a variety of polymers such as homopolymers block copolymers polymer thin films polymer blends and polymer nanocomposites Discusses a broad range of advanced and novel techniques and methods like x ray diffraction thermal analysis and electron microscopy and their applications in the morphology of polymer materials *Nanoenergy* Flavio L Souza,Edson R Leite,2017-08-30 This book discuss the recent advances and future trends of nanoscience in solar energy conversion and storage This second edition revisits and updates all the previous book chapters adding the latest advances in the field of Nanoenergy Four new chapters are included on the principles and fundamentals of artificial photosynthesis using metal transition semiconductors perovskite solar cells hydrogen storage and neutralization batteries More fundamental aspects can be found in this book increasing the comparison between theory experimental achievements and latest developments in commercial devices

Elementary Processes in Organic Photovoltaics Karl Leo,2016-12-20 This volume presents the results of a multi year research programme funded by the Deutsche Forschungsgemeinschaft German Research Council which explains how organic solar cells work In this new promising photovoltaic technology carbon based materials are deposited by low cost methods onto flexible substrates thus allowing devices which open completely new applications like transparent coatings for building solar cells integrated into clothing or packages and many more The investigation of organic solar cells is an interdisciplinary topic covering physics chemistry and engineering The different chapters address topics ranging from the synthesis of new organic materials to the characterization of the elementary processes such as exciton transport and separation and the principles of highly efficient device design div **Interfaces, Adhesion, and Processing in Polymer Systems** Spiros Haralambos Anastasiadis,Alamgir Karim,Gregory S. Ferguson,2001

This book delves into Morphological And Compositional Evolution Of Thin Films Proceedings. Morphological And Compositional Evolution Of Thin Films Proceedings is a crucial topic that must be grasped by everyone, ranging from students and scholars to the general public. The book will furnish comprehensive and in-depth insights into Morphological And Compositional Evolution Of Thin Films Proceedings, encompassing both the fundamentals and more intricate discussions.

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mephistopheles will not answer this we see faustus becoming wracked with regret he finally cries the name of christ and at this lucifer and beelzebub join them faustus presumes they have come to fetch his soul they tell him that they have come to faustus dr faustus dr faustus dr faustus gce drama 2016 dr faustus

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