O 49 Epitaxie und Wachstum II

Zeit: Dienstag 15:45–18:30 Raum: TU EB407

O 49.1 Di 15:45 TU EB407

In-situ STM Measurements during MOVPE — •M. Breusing, B. Rähmer, M. Pristovsek, R. Kremzow, and W. Richter — TU-Berlin, Institut für Festkörperphysik, Hardenbergstr. 36, 10623 Berlin

Although numerous ex-situ and in-situ studies on nanostructures have been done the effects taking place on the surface during epitaxy are not completely understood. Most severe is the lack of in-situ tools for the Metal-Organic Vapour Phase Epitaxy (MOVPE) providing more information about the sample's topography then mean roughness.

Scanning Tunneling Microscopy (STM) is a technique which would directly give quantitative information about the topography and could work under a typical MOVPE reactor pressure of 100 mbar. However, an in-situ STM in a MOVPE growth environment has not been realized so far, because of many unsolved problems.

Indeed, the development of a STM for in-situ MOVPE measurements requires a completely new set-up. The limited space in the MOVPE reactor and the high temperatures during growth near the susceptor, caused by the thermal conductivity of the carrier gas, require a special design of the STM. On the other hand the influence of the STM on the growth (flow pattern in the reactor) must be minimized.

For these conditions we developed an in-situ STM which can resist sample-temperatures up to 550°C continuously. We were able to make the first STM measurements during InAs MOVPE growth on a GaAs stebpunching surface, showing resolution better than 4 nm vertically and 20 nm laterally.

O 49.2 Di 16:00 TU EB407

Modelling of ultrathin Si_xGe_{1-x} film growth on Si(111) by chemical vapour deposition — •Selvi Gopalakrishnan, H. Rauscher, and R.J. Behm — Abt. Oberflächenchemie und Katalyse, Universität Ulm, 89069

Experimental studies on step width, temperature and gas ratios established [1] that these properties are important factors for epitaxial growth by chemical vapour deposition (CVD). We investigated the effect of these factors on the sticking coefficients of the Si and Ge containing species and on the growth morphology of ultrathin Si_xGe_{1-x} films grown on the Si(111) substrate by CVD with Si_2H_6 and GeH_4 as precursor gases. The CVD films were grown from a 7:3 GeH_4:Si_2H_6 gas mixture at temperatures of 750K and 850K, a deposition pressure of 2.5 $\times 10^{-5}$ mbar and with wafers of differing terrace width of 1500A and 6000A, were investigated by STM and XPS. The data on the sticking coefficients of the Si and the Ge containing species and the total (STM) and the Ge (XPS) coverages were used to model the kinetics of the ultrathin Si_xGe_{1-x} film growth at low CVD deposition pressures. Ref:[1] H.Rauscher, J.Braun and R.J. Behm, Si_xGe_{1-x} ultrahigh-vacuum chemical vapour deposition on Si(111)-7×7 from GeH_4/Si_2H_6 mixtures. Appl. Phys. A. 76, 711-719(2003)

O 49.3 Di 16:15 TU EB407

Thin $CuInS_2$ films prepared by MOMBE: Interface and surface properties — •Carsten Lehmann[1], Christian Pettenkofer[1], and Wolfram Calvet[2] — [1]Hahn-Meitner-Institut, Glienicker Straße 100, 14109 Berlin — [2]SPECS GmbH, Voltastrasse 5, 13355 Berlin

$CuInS_2$ (CIS) films were prepared by MOMBE on Si (111) with TBDS as an organic sulfur source. Film properties were investigated in situ by LEED, XPS and UPS with respect to morphology, chemical composition and electronic structure. Film growth starts with a In-S bufferlayer on H-terminated Si(111) substrates. No carbon contaminations from the sulfur precursor are incorporated in the samples. Depending on the deposition conditions metallic In precipitations or Cu_2In phases were detected for the In rich film. A Cu_2S surface phase is found for Cu rich films. Cu to In rato and growth temperature were varied and optimised to obtain near stoichiometric CIS films. A bandalignment for the interface with respect to the bufferlayer and Si will be discussed.

O 49.4 Di 16:30 TU EB407

Facet and layer formation of II-VI semiconductors on GaSe van der Waals terminated Si(111) — •Bengt Jaeckel, Rainer Fritsche, Andreas Klein, and Wolfram Jaegermann — Darmstadt University of Technology, Surface Science Division, Department of Materials Science, Petersenstr. 23, 64287 Darmstadt

The growth of II-VI-semiconductors on GaSe terminated Si(111) is investigated with Scanning Tunneling Microscopy (STM) and Low Energy Electron Diffraction (LEED). CdS, CdSe, ZnS and ZnSe are evaporated from effusion cells filled with compound material. The growth temperature is varied from room temperature up to 300°C. Annealing steps are also performed to investigate reorganization phenomena.
Nucleation occurs preferred at step-edges or defect sites. On the bare terraces nearly no nucleation takes place. For higher temperatures larger clusters are observed which are better orientated to the substrate. Annealing of films deposited at room temperature leads to a reorganization and to an increased crystallinity with orientation to the GaSe passivated Si(111)-substrate surface.
Interestingly, during the annealing procedures of high temperature films the surface morphology passes through highly facetted surfaces with different kinds of facet-planes. In the case of CdS a closed (111)-orientated film is formed at higher annealing temperatures (300°C) and is also well oriented towards the GaSe:Si(111)-substrate.

O 49.5 Di 16:45 TU EB407

Real-time study of orientational transitions during organic thin film growth — •Stefan Kowarik[1], Alexander Gerlach[1], Stefan Sellner[2], Frank Schreiber[1], Leide Cavalcanti[3], and Oleg Konovalov[3] — [1]Physical and Theoretical Chemistry, Oxford University, United Kingdom — [2]Max-Planck-Institut für Metallforschung, Stuttgart, Germany — [3]European Synchrotron Radiation Facility, Grenoble, France

We study thin films of the semiconductor diindenoperylene on silica during organic molecular beam deposition (OMBD) using synchrotron surface X-ray scattering. The molecular orientation within the thin film and the related anisotropy in electrical conductivity is of practical relevance for electronic devices. Further, the molecular tilt angle is an additional and qualitatively new degree of freedom in growth compared to inorganic / atomic systems. To understand and therefore control growth in OMBD important alterations from inorganic growth have to be included in established growth models. For example, molecular tilt may change scaling laws, which relate surface roughness to lateral and vertical (film thickness) length scales (1). We report on our in-situ and real-time experiment during OMBD growth. It provides evidence for changes of the out-of-plane and in-plane lattice parameters with time, and, importantly, with changes of the molecular tilt angle. We discuss our findings on the orientational transition, combining structural knowledge from the real time measurements with post-growth information on film roughness and morphology.

1. A. C. Dürr et al., Phys. Rev. Lett. 90 (2003) 016104

O 49.6 Di 17:00 TU EB407

Mechanisms of grain growth, coarsening and texture formation in Ag-films on an amorphous Substrate — •Celia Polop[1], Christian Rosiepen[1], Enrique Rodriguez-Cañas[2], and Thomas Michely[1] — [1]I.Physikalisches Institut RWTH-Aachen — [2]Instituto de Ciencia de Materiales de Madrid, CSIC, Spain

In order to study grain growth and texture evolution of a polycrystalline thin metal film, a well defined substrate was carefully constructed. The Si(001) 2x1 surface was prepared under UHV conditions and subsequently amorphised by a dose of 1,4*E15 ions/cm2 of 5 keV Ne+. Then Ag was deposited at 300K. The thin film morphological evolution was investigated for films up to 32nm thickness. Analysing the film with scanning tunneling microscopy (STM) an x-ray diffraction (XRD), three distinct stages of grain growth, grain coalescence and film formation are quantitatively characterized by roughness and length scale determination. Key elements of film evolution are also identified directly in the STM topographs.

O 49.7 Di 17:15 TU EB407

Fe on GaN: Growth investigations — •Ralph Meijers[1], Raffaella Calarco[1], Hans Lüth[1], Matthias Buchmeier[2], and Daniel Bürgler[2] — [1]Institute of Thin Films and Interfaces (ISG1) and CNI - Centre of Nanoelectronic Systems for Information Technology, Research Center Jülich, 52425 Jülich, Germany — [2]Institute of Solid State Research (IFF) and CNI - Center of Nanoelectronic Systems for Information Technology, Research Centre Jülich, 52425 Jülich, Germany

Spintronics is a rapidly evolving research field, which aims to combine ferromagnets with semiconductors to develop devices with new functionality. One of the main goals is achieving an efficient spin-polarized carrier injection into semiconductors at room temperature. One method is to inject carriers from ferromagnetic metals into a semiconductor. The Fe/GaN hybrid system is an interesting layer system, since recent theoretical calculations predict a large spin lifetime in pure GaN. However the lattice mismatch between Fe and GaN is large. The crystalline quality of the heterostructure and the nature of the metal/semiconductor interface are very important.

The epitaxial relation of Fe to GaN was investigated using LEED and XRD together with simulations. The α-Fe(110) plane was found to be parallel to the GaN(0001) plane and formation of three equivalent domains, rotated 120^0 against each other, was observed. Using AFM and STM, the surface morphology was investigated and flat domains with sizes up to 500nm were found. SQUID measurements showed ferromagnetic behavior and good homogeneity of the magnetic properties was concluded from ferromagnetic resonance data.

O 49.8 Di 17:30 TU EB407

Growth of NiO on Ag(100) Studied by In-Situ X-Ray Scattering — •E. Schierle, E. Weschke, A. Gottberg, and S.R. Krishnakumar — Institut für Experimentalphysik, Freie Universität Berlin, Arnimallee 14, D-14195 Berlin, Germany

The growth of NiO on Ag was studied by specular x-ray diffraction *in situ* at ID 10 A of the European Synchrotron Radiation Facility, using a small UHV chamber mounted on the diffractometer. Films where prepared by Ni evaporation in oxygen atmosphere, with the substrate held at 500 K. In agreement with earlier results, we find that on Ag(111), layer-by-layer growth occurs only up to ≈ 6 monolayers, while extended growth is observed for Ag(100). On this surface, films were grown with thicknesses of up to 180 monolayers. Pronounced Laue oscillations of the (100) Bragg peak and rocking widths from 0.6 to 1.2 degrees indicate good crystalline quality of the films, particularly at film thicknesses below ≈ 30 monolayers. We observe a gradual change of the lattice parameter from a strained value to the bulk value of NiO.

This work was supported by DFG, Sfb 290 (TPA06).

O 49.9 Di 17:45 TU EB407

Growth and atomic structure of NiO and MnO films on Pt(111): In-situ STM experiments at elevated temperatures — •Christian Hagendorf, Henning Neddermeyer, and Wolf Widdra — Martin-Luther-Universität Halle-Wittenberg, FB Physik, Hoher Weg 8, D-06120 Halle (Saale)

Growth, atomic structure and phase transitions of NiO and MnO thin films on Pt(111) have been studied using scanning tunneling microscopy and spectroscopy (STM/STS), low-energy electron diffraction (LEED), and Auger electron spectroscopy (AES). Mn and Ni have been deposited in an O_2 atmosphere ($10^{-8} - 10^{-6}$ mbar) at substrate temperatures between $300 - 600$ K. In-situ STM experiments were performed at elevated temperatures during film growth.

Depending on the substrate temperature, one-dimensional network-like Ni/O adsorbate structures or islands with (7x1) and (4x2) reconstruction are formed during the initial stages of growth. These structures transform *reversibly* to a (2x2) reconstruction by varying the O_2 pressure between $1.5 - 2 * 10^{-6}$ mbar which has been followed by in-situ STM. After further reduction of the O_2 pressure to $< 10^{-10}$ mbar metallic Ni islands are obtained. At higher coverages (111) oriented NiO islands are stabilized in a 3-dimensional growth mode.

MnO grows on Pt(111) at 450 K in a layer-by-layer mode. Characteristic reconstructions are observed at different coverages which are stable after deposition. Structural changes can be induced by annealing to 600 K. The results will be compared to previous investigations of NiO and MnO on Ag(001).

O 49.10 Di 18:00 TU EB407

Bestimmung des Koinzidenzgitters eines Aluminiumoxidfilms auf $Ni_3Al(111)$ — •Stefan Degen, Aleksander Krupski, Marko Kralj, Andreas Langner, Conrad Becker, Moritz Sokolowski und Klaus Wandelt — Institut für Physikalische und Theoretische Chemie, Wegelerstr. 12, 53115 Bonn

Ein bei einer Temperatur von 1000 K in einer Sauerstoffatmosphäre auf einer $Ni_3Al(111)$-Oberfläche gewachsener doppellagiger Aluminiumoxidfilm [1] wurde mittels hochaufgelöster Elektronenbeugung (SPA-LEED) und Tieftemperaturrastertunnelmikroskopie (LT-STM) untersucht. Mit beiden Methoden findet man Überstrukturen mit Gitterkonstanten von 2,40 (Netzwerkstruktur) bzw. 4,16 nm (Punktstruktur). Die Punktstruktur ist eine $(\sqrt{3} \times \sqrt{3})R30^0$-Überstruktur der Netzwerkstruktur. Das gemessene Beugungsbild kann unter Berücksichtigung des Substrats und der gefundenen Einheitszellen der Oxidüberstrukturen sehr gut simuliert werden. Die Punktstruktur erweist sich als kommensurabel zum Substrat und die Überstrukturmatrix wurde bestimmt. Durch Variation der Tunnelparameter ist es möglich, mit dem Rastertunnelmikroskop sowohl durch den Film hindurch das Substrat mit atomarer Auflösung sowie an der gleichen Stelle die Oxidüberstrukturen aufzulösen. Aufgrund der hohen Driftstabilität des LT-STM (0,24 nm/Stunde) konnte so die laterale Position der Überstruktur relativ zum Substrat eindeutig bestimmt werden. Die bereits durch SPA-LEED bestimmten Überstrukturrelationen wurden bestätigt.

[1] A. Rosenhahn et al., J. Vac. Sci. Technol. A 18 (2000) 1923

O 49.11 Di 18:15 TU EB407

Formation, propagation and stability of stacking fault defects in Iridium thin films — •Sebastian Bleikamp[1], Celia Polop[1], Arne Thoma[1], Gerhard Pirug[2], and Thomas Michely[1] — [1]I. Physikalisches Institut, RWTH Aachen, 52056 Aachen — [2]Institut für Oberflächen und Grenzflächen, Forschungszentrum Jülich, 52425 Jülich

During homoepitaxial growth stacking fault islands are readily found on Ir(111). Upon coalescence defect structures are formed, which induce stacking fault propagation in subsequent layers.

To follow the fate of the twinned domains, a low energy electron diffraction (LEED) method is applied, which decomposes LEED I/V spectra into linear combinations of the non-equivalent first order diffraction peaks of the clean surface. The method was successfully calibrated versus STM measurements.

At 350K a film thickness of 50 monolayers is sufficient to create a nearly random mixture of twinned and untwinnned crystallites. Such films possess an impressive stability against thermal healing. Only at temperatures above 0.5 of the melting temperature, the fraction of twin crystallites gradually decreases. The stability of the faulted domains is discussed in relation to the structure of the twin boundaries formed.