O 7: Semiconductor substrates

Time: Monday 11:15–13:00 Location: SCH A315

O 7.1 Mon 11:15 SCH A315

Electronic structure of the cleaved non-polar GaN(1$\bar{1}$00) surface — •P. Löptien[1], M. Bertelli[1], M. Wenderoth[1], R.G. Ulbrich[1], A. Rizzi[1], J. Malindretos[1], M.C. Righi[2], A. Catellani[3], A. Ferretti[2], and L.C. Samos[2] — [1]IV. Phys. Inst., Univ. Göttingen, Germany — [2]Dip. Fisica, Modena, Italy — [3]CNR, Parma, Italy

The non-polar GaN(1$\bar{1}$00) surface (m-plane) has recently gained importance due to the demonstration of high-efficiency LEDs and LDs. A thorough microscopic understanding of this surface is therefore of great interest. Up to now the existence of surface states within the bandgap at the $\overline{\Gamma}$ point of the Brillouin zone is an open question. We performed cross-sectional scanning tunneling microscopy and spectroscopy (XSTM/XSTS) and ab initio DFT-LDA simulations of this surface. Our calculations suggest an unreconstructed surface and no surface state bands inside the gap at $\overline{\Gamma}$. The Ga derived empty surface state band is found to be degenerate with the CB minimum. In experiment, the unintentionally n-doped GaN(0001) samples grown by HVPE were thinned to $\sim$100 μm. They were cleaved in UHV along the m-plane and measured in-situ at room temperature. The experiments confirmed clearly the unreconstructed surface. The current measured by STS at different voltages can be explained with tip-induced band bending (TIBB). Conduction band states are addressed both at positive and negative bias voltages. This is confirmed by a simulation with a one-dimensional Poisson equation solver. We conclude that the Fermi-level is not pinned on clean cleaved surfaces. It follows that the bandgap has no intrinsic surface states at the $\overline{\Gamma}$ point of the BZ.

O 7.2 Mon 11:30 SCH A315

Impurity induced charge density oscillations in the π-bonded chains of the Si(111)-2×1 surface — •Karolin Löser[1], Martin Wenderoth[1], Thomas K. A. Spaeth[1], Jens K. Garleff[2], and Rainer G. Ulbrich[1] — [1]IV. Phys. Inst., Georg-August Univ. Göttingen, Germany — [2]PSN, Eindhoven University of Technology, the Netherlands

The π-bonded chain in the Si(111)-2×1 reconstructed surface behaves in many respects like a quasi 1-d electronic system. Investigating such chains in P-doped Si with a low-temperature STM (6-8 K) we found extended 1-d electronic contrast induced by the substitutional Phosphorus atom. The presence of the point defect modifies the electronic properties of the chains and causes localization of electron density. The contrast feature occurs at a bias voltage of about -0.5 V and has a length of 10 nm. Depending on the lattice site of the P-atom, it is confined to either one or two neighbouring π-bonded chains.

STS data on the π-bonded chains show a Coulomb Gap in the differential tunneling conductance at E_F. The Coulomb Gap has a width of up to 150 meV, depending linearly on the reciprocal length of undisturbed chain. The Coulomb Gap vanishes for undisturbed chain lengths of several hundred nm. We recently succeeded in preparing large surface areas ($>$ 600 nm)^2 without steps or domain boundaries cutting the chains. Scanning these areas we discovered that the P-atoms induce long range spatial oscillations of the LDOS along the π-bonded chains in addition to the well-known LDOS-feature. These oscillations have a wavelength of about 15 nm at a bias voltage of -0.5 V.

O 7.3 Mon 11:45 SCH A315

Epitaxial growth of micrometer-sized Cu-pyramides on Silicon — •Susanne Seyffarth and Hans-Ulrich Krebs — Institut für Materialphysik, Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

Studying the morphology of thin metallic films is very important regarding the properties of these films. Therefore thin Cu films on Si(111) and Si(100) substrates were prepared using pulsed laser deposition (PLD) in ultra high vacuum. At elevated substrate temperatures above 200 °C epitaxial growth of three dimensional pyramides with edge lengths of about five micrometers and heights up to 500 nanometers is observed using scanning electron microscopy (SEM) and atomic force microscopy (AFM). The base area of these islands is a triangle for Si(111) and a square for Si(100) depending on the orientation of the substrate. Epitaxial relationships with the Si substrates were studied using x-ray diffraction analysis (XRD). Furthermore periodic alignments of the pyramidal islands was achieved. The shape of the pyramidal islands was influenced by alloying Ni during deposition process. Additionally the decomposition of the Cu-islands was examined.

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MOVPE preparation of Si(100) surfaces for III-V hetero epitaxy — •Henning Döscher, Peter Kleinschmidt, Sebastian Brückner, Anja Dobrich, Christian Höhn, and Thomas Hannappel — Helmholtz-Zentrum Berlin für Materialien und Energie, Glienicker Str. 100, 14109 Berlin

The epitaxial growth of III-V semiconductors on silicon substrates is a major challenge for the integration of opto- and micro-electronic devices. But still, there is little experience in the preparation of the crucial Si(100) surface with metal-organic vapor phase epitaxy (MOVPE) and the respective interfaces to III-V materials.

In many ways the applied process environment common for the opto-electronic industry differs from the ultra high vaccuum (UHV) conditions typical in surface science - e.g. by the distinct presence of hydrogen as precursor residue and as process gas. For the desired growth of polar materials on non-polar substrates, the hetero-interface represents a source of highly corruptive anti-phase disorder. Ideally, this effect may be surpressed by the preparation of a completely double-stepped substrate surface with only one reconstruction domain.

Here, the preparation of clean Si(100) surfaces by MOVPE growth is investigated with regard to the requirements of hetero-epitaxial GaP growth. A contamination free transfer mechanism to UHV enabled X-ray photoelectron spectroscopy (XPS), low energy electron diffraction (LEED), scanning tunnelling microscopy (STM) and Fourier-transform infrared spectroscopy (FTIR) charaterization of the prepared surfaces, while reflectance anisotropy spectroscopy (RAS) was applied in-situ.

O 7.5 Mon 12:15 SCH A315

Ge nanoisland growth on the In/Si(112)-"(3.5 × 1)"surface — •Moritz Speckmann, Thomas Schmidt, Jan Ingo Flege, Torsten Wilkens, and Jens Falta — Institute of Solid State Physics, University of Bremen, 28359 Bremen

In this work we investigated the adsorption of In on Si(112) and the subsequent growth of Ge islands using a variety of different surface sensitive techniques. The unstable Si(112) surface consists of (111)- and (337)-like facets in [1$\bar{1}$0] direction (Baski et al., PRL, **74** (1995) 956). The surface is smoothened due to the adsorption of metals, such as Ga or In (Snijders et al., PRB, **72** (2005) 125343).

In LEED images we find an incommensurate "(3.5 × 1)"reconstruction for the In/Si(112) surface. We determine the number and the positions of the In atoms inside one unit cell using XPS and X-Ray Standing Waves (XSW). With these results it is, for the first time, possible to propose a structural model based on direct structural data.

By means of Low Energy Electron Microscopy (LEEM) and Photoemission Electron Microscopy (PEEM) we monitored the growth of Ge on the In/Si(112) surface. First a smooth wetting layer is formed and after a few MLs islands start to grow. The observed islands are triangularly shaped with a longer edge along the [1$\bar{1}$0] direction. The island density is higher compared to the growth on bare Si(112). Moreover no arrangement or preferential direction is visible for Ge islands on the bare Si(112) surface. The corresponding LEED patterns reveal a (4×1) reconstruction with additional facet spots which are attributed to the Ge islands.

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Structural properties of sub-monolayer InAs-coverages on GaAs(001) — •Christopher Prohl, Britta Höpfner, Jan Grabowski, Holger Eisele, and Mario Dähne — Institute of Solid State Physics, Technical University Berlin, Germany

Even if InAs/GaAs is the model system for III-V-semiconductor quantum dots, the growth and dot formation is still not understood in detail. In this work, we investigated low InAs coverages in the sub-monolayer range to understand the growth of InAs on GaAs and to receive a databasis, also for further investigation of quantum dots and their capping. Molecular beam epitaxy (MBE) was used to prepare different samples with increasing sub-monolayer InAs-coverages on a GaAs(001) wafer. The growth was performed on both As-rich reconstructions, the c(4x4) and the β2(2x4). Using in-situ scanning tun-

neling microscopy (STM) with atomic resolution, the formation of an InAs/GaAs- layer was investigated step by step, from the clean GaAs surface up to about one monolayer coverage of InAs. It was found that InAs first grows directly on boundaries of different c(4x4) domains. Further on, it then sticks to the hollow sites of perfectly c(4x4) reconstructed areas of GaAs(001). Continuing growth leads to a complete monolayer but with a new reconstruction for both the c(4x4) and the β2(2x4) reconstructed surface. The authors thank K. Jacobi and the MPG for providing the experimental set-up. This work was supported by project Da 408/12 of the DFG.

O 7.7 Mon 12:45 SCH A315

Structural properties of the InAs/GaAs system before and after quantum dot formation. — •Britta Höpfner, Christopher Prohl, Jan Grabowski, Holger Eisele, and Mario Dähne — Institute of Solid State Physics, Technical University Berlin, Germany

The structure of the wetting layer prior to quantum dot formation and the shape of just formed quantum dots are of high interest for the understanding of the quantum dot growth mechanisms. To understand growth and properties of InAs layers on GaAs step by step a molecular-beam epitaxy-system (MBE) including reflection high energy electron diffraction (RHEED) and attached scanning-tunneling microscope (STM) was used. In this work, GaAs(001) surfaces covered with increasing InAs coverages beginning with about one monolayer up to the formation of quantum dots were prepared. In order to study the influence of the surface reconstruction on the growth, both As-rich GaAs(001) c(4x4) and β2(2x4) reconstructed surfaces were used. Atomically resolved STM images of different coverages and an analysis of the growth behavior will be presented. Structural changes during closing of the first monolayer will be shown.

The authors thank K. Jacobi and the MPG for providing the experimental set-up. The work was supported by project Da 408/12 of the DFG.