O 24: Semiconductor Substrates: Epitaxy and Growth

Time: Tuesday 11:15–12:45 Location: H39

O 24.1 Tue 11:15 H39

Ultrafast Electron Diffraction of epitaxial Bi(111) films on Si(001) — •Anja Hanisch, Boris Krenzer, and Michael Horn-von Hoegen — Universität Duisburg-Essen, Experimentalphysik, 47057 Duisburg

Ultrafast time resolved electron diffraction experiments in a RHEED geometry allow the observation of the surface temperature evolution after laser excitation. Diffraction patterns of epitaxially Bi(111)-films grown on Si(001) taken at different delays between pumping laser pulses and probing electron pulses are converted to the transient surface temperature using the Debye-Waller effect. A rapid increase of the surface temperature from 80 K up to 190 K is followed by a slow exponential decay with a decay constant of 640 ps for 5,5 nm thin film [1], which is determined by the thermal boundary resistance at the interface between Bi and Si. While the decay constant is almost independent of the pump energy (fluence ramping from 0,33 mJ/cm2 to 3 mJ/cm2) we observe a linear dependence of the decay constant with the filmthickness for filmthicknesses between 6 nm and 12 nm. A detailed analysis shows that this linear behaviour cannot be explained in terms of existing models describing the thermal boundary resistance. In order to explain the observed behaviour the existing models have to be expanded which will be presented in this talk.

[1] A.Janzen et al., Surface Science 600, 4094 (2006).

O 24.2 Tue 11:30 H39

Lattice accommodation by a periodic array of interfacial misfit dislocations in Bi(111)/Si(001) heteroepitaxy — •Giriraj Jnawali, Hichen Hattab, Frank M. zu Heringdorf, Boris Krenzer, and Michael Horn von Hoegen — Fachbereich Physik, Universität Duisburg-Essen, Lotharstr. 1, 47048 Duisburg, Germany

Ultra-smooth Bi(111) films with very low defect density could be grown on Si(001) following a recipe published by Jnawali et al.[1]. Surprisingly the hexagonal Bi(111) lattice fits quite well with the rectangular Si(001) lattice with a low misfit in both the [110] and [1$\bar{1}$0] directions. A remaining lattice mismatch of 2.3 % is accommodated by the formation of a periodic array of misfit dislocations at the interface. The dislocations are generated during annealing of a 6 nm thick Bi(111) film from 150 K to 450 K while the film relaxes. The periodic one dimensional dislocation array is observed via its strain fields and the accompanied surface undulation by spot splitting in high resolution LEED (SPA-LEED). From the satellite spot intensity at different scattering phases, the amplitude Δh = 0.66 Å and the average length Γ = 200 Å of the wave-like periodic surface undulation is determined. Comparing these results with a continuum theory for elastic distortion by Springholz et al.[2] we conclude that the misfit dislocation at the interface is a full-dislocation with Burgers vector of b = $\frac{1}{2}[1\bar{1}0]$ defined by the surface lattice constant of the Si(001) surface.

[1] G. Jnawali, H. Hattab, B. Krenzer, and M. Horn von Hoegen, Phys. Rev. B, 74, 195340 (2006).
[2] G. Springholz, Appl. Surf. Sci. 112, 12 (1997).

O 24.3 Tue 11:45 H39

Symmetry breaking in the growth of 2D Ge islands on Bi/Si(111) — •Konstantin Romanyuk and Bert Voigtländer — Institute of Bio and Nanosystems (IBN 3), and cni - Center of Nanoelectronic Systems for Information Technology, Research Centre Jülich, 52425 Jülich, Germany

The threefold rotational symmetry of the Si(111) surface usually leads to the formation of threefold symmetric islands (triangular or hexagonal) in the initial stages of epitaxial growth. However, for Ge growth on the Bi($\sqrt{3}\times\sqrt{3}$)$R30°$ terminated Si(111) surface we find islands with a reduced symmetry. The Ge islands have a rhomb shape with only one mirror plane and are terminated by <1$\bar{1}$0> steps. We demonstrate that not only the bulk lattice symmetry but the symmetry of the combined substrate/island system is important to define the shape of the islands. It will be shown that the symmetry of the two level system is reduced due to the surface reconstruction to only one σ mirror reflection symmetry. The mirror plane run along small diagonal of the rhomb islands. The triangular symmetry of the Si(111) surface which includes 3 mirror planes leads to three different orientations of the rhomb shaped islands on the surface, as observed in the experiments.

O 24.4 Tue 12:00 H39

Epitaxial growth of Aluminium on Silicon (111) studied by SPA-LEED and STM — •Thomas Payer, Christian Wiethoff, and Michael Horn-von Hoegen — Universität Duisburg-Essen, FB Physik, AG Horn-von Hoegen, Lotharstraße 1 47057 Duisburg

We studied the epitaxial growth of Aluminium on Si (111) on Al-induced reconstructions as well as on the plain Si (111) (7x7) reconstruction. The film and surface morphology was studied in-situ by scanning tunnelling microscopy (STM). During deposition, the growth kinetics was observed by spot profile analyzing LEED (SPA-LEED). The deposition temperature varied between room temperature and 700K. On Si(111) Al grows in (111)-orientation. Both lattice constants of Al (111) and Si (111) fit in a 4 to 3 ratio with a small remaining mismatch of only 2%. Growth on top of the Al-induced ($\sqrt{3}\times\sqrt{3}$) reconstruction in a temperature regime of 500 - 550 K yields the smoothest films. Compared to films directly deposited on top of the Si (111) (7x7), the film roughness is reduced by a factor of five to 2nm rms roughness for a 20nm thick film. Growth on top of other Al-induced reconstructions do not provide any advantages in comparison to deposition on top of the clean Si (111) (7x7) surface. Instead, islands are formed and the films show an enhanced surface roughness. Growth at temperatures above 600K results in a Stransky-Krastanov mode with large Al islands on the Al-induced γ-reconstruction.

O 24.5 Tue 12:15 H39

Self-organized thickness engineering of Al thin films by alternation of dense and diluted atomic layers — •Ying Jiang[1,2], Kehui Wu[1], Zhe Tang[1], Philipp Ebert[2], and Enge Wang[1] — [1]Institute of Physics, Chinese Academy of Sciences, Beijing 100080, China — [2]Institut für Festkörperforschung, Forschungszentrum Jülich GmbH, 52425 Jülich, Germany

We studied the growth of Al on Si(111)-$\sqrt{3}$x$\sqrt{3}$ -Al substrates by scanning tunneling microscopy and low energy electron diffraction. We found that the Al film grown on an atomically sharp Al/Si interface exhibits of a superlattice structure of alternating densely-packed (1x1) and loosely-packed (likely $\sqrt{3}$x$\sqrt{3}$) atomic layers, at film thicknesses ¡ 0.9 nm. Above 0.9 nm Al starts to grow in the normal stacking of Al(111) layers. The phenomenon is explained within the theory of the quantum size effects in a jellium metal combined with strain effects.

O 24.6 Tue 12:30 H39

Untersuchung der Homoepitaxie auf GaAs(001) mit Molekularstrahlepitaxie und in-situ-STM — •Sylvia Hagedorn, Jan Grabowski, Holger Eisele und Mario Dähne — Technische Universität Berlin, Institut für Festkörperphysik, PN4-1, Hardenbergstraße 36, D-10623 Berlin

Mit einer UHV-Anlage zur Molekularstrahlepitaxie (MBE) mit den Komponenten Indium, Gallium und Arsen, die mit einem Rastertunnelmikroskop (STM) gekoppelt ist, wurde die Homoepitaxie von GaAs auf GaAs(001) untersucht. Ziel ist es, den Einfluss verschiedener Substratrekonstruktionen auf das Wachstum von InAs-Quantenpunkten zu studieren. Nach der Reinigung von GaAs(001)-Wafern durch Ionenbeschuss und Ausheilen (IBA-Zyklus) wurden grundlegende Wachstumsparameter wie Probentemperatur, Teilchenfluss und Wachstumsrate variiert, um verschiedene Oberflächenrekonstruktionen zu erzielen. Hierbei wurde die Homoepitaxie von GaAs auf GaAs(001) erfolgreich durchgeführt. Bei verschiedenen Präparationsbedingungen konnte die Präparation der GaAs(001) beta2(2x4)-Rekonstruktion sowie der GaAs(001) c(4x4)-Rekonstruktion durchgeführt und mit Reflektion hochenergetischer Elektronen (RHEED) kontrolliert werden. In STM-Untersuchungen mit atomarer Auflösung konnten weite defektarme Oberflächenbereiche beobachtet werden. STM-Untersuchungen des Wachstums von InAs-Quantenpunkten auf diesen GaAs(001)-Oberflächen stehen kurz bevor.