O 11 Epitaxy and growth I

Time: Monday 15:00–17:30 Room: WIL A317

O 11.1 Mon 15:00 WIL A317

Steering induced growth anisotropy as a probe for long range interaction — •Herbert Wormeester, Frits Rabbering, Teun Warnaar, and Bene Poelsema — University of Twente, Enschede, The Netherlands

Grazing incidence homo-epitaxy of 0.5 ML on Cu(001) leads to anisotropic structures as determined with high-resolution LEED. This is the result of attractive forces between the surface and the incoming particle. The trajectory of an incoming particle changes so dramatically that a large deposition flux enhancement on protruding structures results [1]. Trajectory calculations based on an attractive Lennard-Jones potential were combined with a kMC simulation that treats the surface diffusions processes in order to investigate the evolution of the observed anisotropy. Modifications of this potential at short range distances only slightly influence the anisotropy, while modifications at long range has a significant influence on the anisotropy as observed during sub-monolayer growth. This enables to probe the long range interaction. The experimental feasibility of the detailed probing will be discussed. [1] S. van Dijken, L.C. Jorritsma and B. Poelsema, Phys. Rev. Lett. 82 4038 (1999)

O 11.2 Mon 15:15 WIL A317

Pulsed Laser Deposition of Fe on Cu Single Crystal Surfaces - Investigations by STM and Time-of-Flight Spectroscopy — •Georg Rauchbauer[1], Andreas Buchsbaum[1], Hannes Schiechl[1], Werner Rupp[1], Michael Schmid[1], Peter Varga[1], and Albert Biedermann[2] — [1]Institut für Allgemeine Physik, Technische Universität Wien — [2]Institut für Materialphysik, Universität Wien

In order to understand the influence of growth conditions on structure, morphology and properties we investigated ultrathin pulsed laser deposited Fe films on Cu. The main analysis technique employed was scanning tunneling microscopy (STM), allowing us to determine the structure of the surfaces. For measuring the energy distribution of the ablated species, a time-of-flight (TOF) spectrometer, applicable for ions as well as for neutrals, has been constructed. At low coverage, low laser fluence leads to bilayer island growth while higher laser fluences result in layer-by-layer growth. We observed intermixing of Fe and Cu in the films which is caused by implantation of Fe with high kinetic energy. With increasing laser fluence, an increasing number of Fe atoms is implanted. The TOF spectra show hyperthermal energies of the neutrals, high degrees of ionization up to several dozen percent and kinetic ion energies of 50 to 150 eV, depending on the laser fluence. The ion energies can be related to the different growth modes observed.

O 11.3 Mon 15:30 WIL A317

Initial growth of Cu islands on Cu(100) by pulsed laser deposition — •Andreas Dobler and Thomas Fauster — Lehrstuhl für Festkörperphysik, Universität Erlangen, Staudtstr. 7, D-91058 Erlangen

We investigated the initial growth of Cu islands on a Cu(100) surface for coverages below 0.3 monolayers with scanning tunneling microscopy. According to nucleation theory, the island density increases with the deposition flux F proportional to $F^{\frac{i}{i+2}}$. For thermal deposition at room temperature the critical nucleus i is about three atoms. Although the instantaneous flux of pulsed laser deposition is about 10^4 times higher than in the case of thermal deposition, the island density is of the same order of magnitude for both deposition methods. When the flux is increased due to higher laser intensity, the number of islands decreases which cannot be explained by nucleation theory.

O 11.4 Mon 15:45 WIL A317

Al-Enriched Surface Phases on NiAl(100) — •Roland Schurr, Andreas Klein, Lutz Hammer, and Klaus Heinz — Lehrstuhl für Festkörperphysik, Universität Erlangen-Nürnberg, Staudtstr. 7, D-91058 Erlangen

The thermal evolution of Al-films evaporated on the cold NiAl(100) surface was studied by means of LEED, STM and AES. Deposition of several monolayers of Al at 100 K on clean NiAl(100) leads to rather flat but poorly ordered epitaxial films with (111) orientation. With annealing at about 500 K reordering occurs within the films leading to both pseudomorphic (100) grains and epitaxially aligned (111) oriented grains of pure Al as identified by comparison with single crystal LEED intensity spectra. With increasing temperature Al dissolves into the bulk leading to a sequence of different Al-rich surface phases of NiAl(100). At first a $(\sqrt{5} \times \sqrt{5})$R26.6° phase at about 600 K appears, followed by a 1D-incommensurate superstructure at about 750 K. This can be tentatively ascribed to a transition state towards the then following structure, an Al-rich c$(\sqrt{2} \times 3\sqrt{2})$R45° phase (="(3×3)diag"), which develops at 800 K. Further annealing eventually produces a (1×1) structure which corresponds to the (100) surface of stoichiometric NiAl. At even higher temperatures (>1150 K) Al starts to desorb from the surface leading to another "(3×3)diag"phase of the Ni-enriched surface known since earlier [1]. LEED intensity spectra taken from both "(3×3)diag"phases differ completely proving the existence of two distinct phases with the same periodicity. [1] D.R. Mullins and S.H. Overbury, Surf. Sci. 199 (1988) 141

O 11.5 Mon 16:00 WIL A317

Growth and structure of ultrathin Ni-films on Ir(100)-(1×1) — •W. Meyer[1], B. Gumler[1], A. Klein[1], A. Schmidt[1], L. Hammer[1], S. Müller[1], K. Heinz[1], and J. Redinger[2] — [1]Festkörperphysik, Universität Erlangen-Nürnberg, Staudtstr. 7, D-91058 Erlangen — [2]Center for Computational Material Science, Vienna University of Technology, Gumpendorferstr. 1A, A-1060 Vienna

We report on the growth and atomic structure of epitaxial Ni-films on the metastable (1×1)-phase of Ir(100) in the coverage regime 1 - 4 ML using STM, quantitative LEED and first principle calculations. The lateral misfit for Ni on the Ir(100) substrate is +8.8% so that layer-by-layer growth should not be expected. The STM studies reveal flat growth of the first Ni-layer whilst the second film layer does not close completely but third layer islands start to grow. It comes as a surprise that the films return to an almost ideal layer-by-layer growth for the 3 and 4 ML coverages. Quantitative LEED was applied to determine the atomic structure of the surfaces. The Ni-films are heavily tetragonally distorted with an average contraction of 12.3% of the inner film layers and 14.4% for the top layer spacing relative to the Ni bulk value. The experimental observation can be understood in combination with the DFT calculations: The surface formation enthalpy for the 2 ML film is less favourable than a combination of 1 ML and 3 ML islands. For higher film thickness surface roughening does not yield a sizable energy gain. Hence, only formation of a 2 ML film is energetically hindered. The relaxed film structure calculated by DFT agrees well with the LEED results apart from the top layer spacing for which DFT predicts an enhanced contraction.

O 11.6 Mon 16:15 WIL A317

Large Film Stress of Fe, Co, and Ni monolayers on Ir(100) — •Z. Tian, C.S. Tian, D. Sander, and J. Kirschner — Max-Planck-Institut für Mikrostrukturphysik,

The mechanical stress of ferromagnetic monolayers(ML), which are deposited on different surface reconstructions of Ir(100) (1 × 1, 5 × 1-Hexagonal, 5 × 1-H) is measured with an optical bending beam technique during growth. Both Co and Ni show a large positive film stress of 17 and 15 GPa, respectively, during the initial stage of the growth(1-2ML). This stress corresponds to the calculated value based on continuum elasticity with a misfit strain of 8.8% for fcc-Co and 9.1% for Ni. The same magnitude of stress is measured irrespective of the surface reconstruction. A kink in the stress vs. coverage curve at 2 ML can be tentatively ascribed to the end of pseudomorphic growth. Ongoing deposition leads to a lower film stress, which relaxes to less than 2 GPa as the thickness increases above 10ML. The growth of Fe leads to a compressive film stress of -10 GPa in the thickness range 2-12 ML. This stress magnitude corresponds to the epitaxial misfit induced stress, if we take the lattice constant of bcc-Fe as a reference. We conclude that pseudomorphic growth of Fe ends around 12 ML. The results are discussed in view of film structure and morphology as obtained by in-situ LEED and MEED measurements and previous STM work[1]Lattice strain is often the decisive factor which determines the magnetic anisotropy of ferromagnetic monolayers (ML). [1] L. Hammer, W. Meier, A. Schmidt and K. Heinz: Phys. Rev. B **67**, 125422 (2003).

O 11.7 Mon 16:30 WIL A317

Two new phases of CO monolayers on Ag(100) — •Hans-Christoph Ploigt, François Patthey, Marina Pivetta, and Wolf-Dieter Schneider — Ecole Polytechnique Fédérale de Lausanne, Institut de Physique des Nanostructures, CH-1015 Lausanne, Switzerland

We used low-temperature scanning tunneling microscopy to characterise the growth mode of CO monolayers on a cold Ag(100) substrate. CO was dosed at substrate temperatures between 150 K and 250 K. The CO was adsorbed on the substrate and formed two new phases in the submonolayer regime which coexist in the studied temperature range. One is a slightly disordered hexagonal phase without translational symmetry. The average intermolecular distance is 440 ± 20 pm. The other one has a rectangular lattice unit cell with the dimensions $a = 1.62 \pm 0.12$ pm and $b = 0.83 \pm 0.06$ pm. For a substrate temperature above 250 K, CO desorption was observed.

O 11.8 Mon 16:45 WIL A317

A LEEM study of structure, morphology and composition of ultrathin Ag/films on Pt(111) — •Esther van Vroonhoven and Bene Poelsema — Solid State Physics; MESA+ Institute for Nanotechnology; University of Twente; P.O.Box 217; AE 7500 Enschede; The Netherlands

The growth of ultra-thin silver films on Pt(111) at 750 K has been studied in real time and - space using Low Energy Electron Microscopy, LEEM. Our results demonstrate that the system is considerably more complex than appreciated so far. The LEEM/LEED results reveal a highly mobile film-substrate system. In the sub-monolayer regime they exhibit an intriguing sequence of surface confined alloying up till $\theta(\mathrm{Ag}) = 0.5$ ML and de-alloying (both consistent with existing literature), phase separation, partial strain relieve at $\theta(\mathrm{Ag})$ ˜ 0.8 ML, reentrant alloying and accompanying build-up of strain as indicated by return of the monolayer film to the pseudomorphic state. During growth of the second layer more Pt is dissolved into the Ag-bilayer until the strain is finally relieved by the formation of wide trenches along <11-2> azimuth directions, in line with <1-10> being the soft direction under compressive strain. The full de-alloying and approach towards the bulk immiscibility of silver and platinum is reached only in third monolayer, accompanied by remarkable rearrangements at the interface.

O 11.9 Mon 17:00 WIL A317

Growth of different adatom systems on a Moiré superstructure induced by Pt deposition on WSe_2 — •Denys Makarov, Roger Pallesche, Günter Schatz, and Manfred Albrecht — University of Konstanz, Department of Physics, D-78457 Konstanz, Germany

The morphology and structure of Pt deposited on a $WSe_2(0001)$ van der Waals surface was investigated by reflection high energy electron diffraction (RHEED) and compared to scanning tunneling microscopy (STM) and spectroscopy (STS). The growth of Pt at 450 °C is characterized by an initial three-dimensional growth of (111)-orientated nanostructures followed by coalescence of the nanostructures. After a Pt thickness of about 3 nm a clear (4x4) superstructure appears, which is a result of strong Se diffusion towards the growth surface, forming mostlikely a $PtSe_2$ alloy on the top surface. Due to the lattice mismatch between the Pt(111) layers and the $PtSe_2$ top layer a Moiré pattern is created. The investigation of the Pt growth on WSe_2 at different deposition temperatures shows that the Moiré structure is established at about 300 °C. With the presence of the Moiré pattern the surface potential becomes a 2D periodical function of the local density of states near the Fermi level. Thus, the extrema of the local density of states can act as "pinning" sites for adatom nucleation. This approach for nanostructuring employing a self-organized Moiré pattern in the WSe_2/Pt system was attempted by the deposition of different adatom systems including metals (Co, Cr) and organic molecules (C_{60}).

O 11.10 Mon 17:15 WIL A317

Metastable and Stable Structures of In on W(110) — •Martin Gabl[1], Marek Trzciński[2], Norbert Memmel[1], Antoni Bukaluk[2], and Erminald Bertel[1] — [1]Institute of Physical Chemistry, University of Innsbruck, A-6020 Innsbruck, Austria — [2]Institute of Mathematics and Physics, University of Technology and Agriculture, Pl-85796 Bydgoszcz, Poland

The growth of indium on W(110) at submonolayer coverages was studied by low energy electron diffraction (LEED) and scanning tunnelling microscopy (STM). At room temperature with increasing coverage three indium-induced overlayer structures - (3x1), (1x4) and (1x5) - are observed. The (3x1) structure corresponds to an overlayer with 1 atom/unit cell of the In-overlayer and an ideal coverage of 0.33 ML. The (1x4) structure is essentially interpreted as a Moire-pattern between the W(110) substrate and a slightly distorted In(111) layer in Nishiyama-Wassermann orientation. The atom density in the (1x4) overlayer matches that of a close-packed In(111) layer within 2%. The (1x5) structure is interpreted as a compressed monolayer, where the areal density of In exceeds that of an In(111) monolayer by 8%. Upon annealing or aging at room temperature the In atoms of the (3x1) structure agglomerate into islands with the high-coverage (1x4) structure. Hence the (3x1) structure - although being ordered - is only metastable. This transition can also be induced by exposure to oxygen. Obviously oxygen first adsorbs onto the free W(110) surface and compresses In atoms into densely-packed islands of (1x4) periodicity rather than oxidizing the indium adlayer.