O 4 Epitaxie und Wachstum I

Zeit: Freitag 10:45–13:00 Raum: TU EB202

O 4.1 Fr 10:45 TU EB202

Unidirectional patterning of transition-metal films on Ir(100) — •Chiara Giovanardi, Andreas Klein, Andreas Schmidt, Lutz Hammer, and Klaus Heinz — Lehrstuhl für Festkörperphysik, Universität Erlangen Nürnberg, Staudtstr. 7, D-91058 Erlangen

We report and compare the unidirectional patterning of Fe, Ni and Co ultrathin films deposited on the hydrogen-stabilized substrate Ir(100)-(5×1)-H. This template develops by exposure of the Ir(100)-(5×1)-hex phase to hydrogen and consists of long, regularly spaced and defect-free Ir monoatomic wires residing on the (1×1) structured Ir substrate. The space between the wires can be filled by deposition of the transition metals (TM) Fe, Co and Ni. We show by STM that this filling process is rather different for the three metals but eventually results, at 0.8 ML coverage, in lateral superlattices $\{TM_4Ir\}$. The crystallographic structure of the three compounds was determined by quantitative LEED, which also reveals that there is no intermixing of TM atoms with the Ir wires. By further TM deposition, the superlattice is covered by pure TM in a layer-by-layer growth mode. In the second and third layer, atoms deviate from the ideal quadratic arrangement as induced by the 1-dim. corrugated structure of the $\{TM_4Ir\}$ interface. The vertical buckling of the interface is imprinted in the TM film, with a maximum amplitude of e.g. 0.11 $\mathring{A}$ in the third Ni layer. Laterally, the atomic rows above the Ir chains of the interface have a larger separation and, under special conditions, can be decorated by further TM adatoms leading to well separated chain structures on top of the film.

O 4.2 Fr 11:00 TU EB202

Strain relaxation in ultrathin Ni films grown on Ir(100)-(1x1) and Ir(100)-(5x1)-H — •Andreas Klein, Bernd Gumler, Lutz Hammer, and Klaus Heinz — Lehrstuhl für Festkörperphysik , Universität Erlangen-Nürnberg, Staudtstr. 7, D-91058 Erlangen

We report on the growth of Ni films both on the metastable (1x1) phase and on the hydrogen-induced (5x1)-H phase of the Ir(100) surface in the coverage regime 4-10 monolayers (ML) applying STM and LEED. Whilst the (1x1) phase corresponds to the bulk-like truncated crystal, the (5x1)-H phase consists of long Ir wires of single atomic width which reside on this (1x1) phase in (on average) 5-fold lateral periodicity. On both templates an almost perfect layer-by-layer growth in the low coverage regime is followed by strain-relief controlled growth above 4 ML coverage. In this regime islands of 5 atoms width grow only one-dimensionally and eventually form irregular grids on the surface. Only with the completion of a layer the spaces within the grids are filled so that flat and homogeneous, but strained layers are formed. With film thicknesses in the range 6-8 ML the layerwise growth becomes less perfect and, at about 10 ML, dislocations are formed. For the (1x1) substrate the structures mentioned extend in both the [011] and [01-1] directions, whereas on the (5x1)-H phase the Ir wires at the film-substrate interface impose their unidirectionality on the higher coverage films. Only above a coverage of about 10 ML this differences between the two phases disappear and the nickel films exhibit similar patterns of strain relief.

O 4.3 Fr 11:15 TU EB202

Morphology and structure of pseudomorphic Ni-films grown on the Ir(100)-(1x1) surface — •Bernd Gumler, Andreas Schmidt, Andreas Klein, Lutz Hammer und Klaus Heinz — Lehrstuhl für Festkörperphysik, Universität Erlangen - Nürnberg, Staudtstr. 7, D-91058 Erlangen

Recent investigations of the epitaxial growth of Ni on the hexagonally reconstructed (100) surface of iridium, Ir(100)-(5x1)-hex, have shown that the reconstruction is lifted at very low Ni coverage leading to strong intermixing at the interface resulting in a rather limited order of the film. Therefore we used the surface's 1x1-structure, which can be prepared as metastable phase, as a template instead of the reconstructed phase. Scanning tunnelling microscopy (STM) and (quantitative) low-energy electron diffraction (LEED) were applied in the investigation. The Ni-Ir epitaxial misfit is as large as 8.2% so that layer-by-layer growth should not be expected. Indeed, we did not succeed to prepare a perfectly flat and closed 2 monolayers film. Surprisingly, yet, deposition of a third Ni layer yielded an almost ideal 3 layers film, i.e. the system seems to return to layer-by-layer growth. In fact, also the 4th layer grows accordingly. The films structures were determined and verified by excellent LEED theory-experiment fits. Structures were found to be tetragonally distorted with layer spacings of about 1.55 Å which are very close to the prediction of elastic theory. The structural influence of hydrogen adsorption on the films was investigated, too.

O 4.4 Fr 11:30 TU EB202

Nucleation in the presence of adatom insertion: Co / Pt(111) — •Philipp Buluschek, Stefano Rusponi, Mehdi El Ouali, Emmanuel Vargoz, Klaus Kern, and Harald Brune — Institute of the Physics of Nanostructures, Ecole Polytechnique Fédérale de Lausanne, CH-1015 Lausanne, Switzerland

We used variable temperature STM to study submonolayer nucleation of Co / Pt(111). Our experiments show that insertion of Co adatoms into the topmost layer of the Pt surface sets in at temperatures as low as 180 K. By relieving the tensile stress of the Pt surface, insertion leads to the formation of double partial dislocation lines. These take the shape of three branched stars.

With the insertion and the associated reconstruction, the Co / Pt(111) system makes a transition from homogeneous to heterogeneous nucleation. The behavior of the island density as a function of deposition temperature has been modeled in kinetic Monte-Carlo simulations. We show that the partial dislocations act as repulsive line defects with a diffusion energy barrier $E_d > 670$ meV. The comparison between simulations and experiment also enables access to the energy barriers for surface diffusion and the density of included adatoms in the surface.

O 4.5 Fr 11:45 TU EB202

Growth of Copper on Nickel (111) - a Scanning Tunneling Microscopy Study — •Florian Maier, Reinhard Lindner, and Hans-Peter Steinrück — Lehrstuhl Physikalische Chemie II, Universität Erlangen-Nürnberg, Egerlandstr. 3, D-91058 Erlangen

Controlled growth of bimetallic structures on a nanometer scale is of crucial interest in many fields. Therefore, the initial growth stage of copper on Ni(111) (0.05 ML $< \theta_{Cu} <$ 1.5 ML) as a model system was studied with scanning tunneling microscopy (STM). Copper was deposited using an electron beam evaporator that produced a flux of neutral atoms accompanied by a small fraction of ions. The latter was controlled by a countervoltage. The island size distribution was investigated as a function of substrate temperature (100 K or room temperature), concomitant copper ions, preadsorbed layers of water, and preadsorbed carbon monoxide.

In summary, room temperature promotes two-dimensional growth (due to kinetic effects), ion assisted deposition yields small islands (due to enhanced nucleation center formation), deposition on preadsorbed water layers results in a morphologie analogous to Stranski-Krastanov growth (due to "soft landing" of preformed copper clusters), and CO coadsorbtion prohibits island fusion (due to reduced diffusion length and/or step stabilisation).

O 4.6 Fr 12:00 TU EB202

Electronic structure of Zn on Pd(111) during growth and alloying — •Andreas Bayer, Ken Flechtner, Dieter Borgmann, Reinhard Denecke, and Hans-Peter Steinrück — Lehrstuhl für Physikalische Chemie II, Universität Erlangen-Nürnberg, Egerlandstr. 3, D-91058 Erlangen

Hydrogen as energy carrier can be produced by steam reforming of methanol over Pd/ZnO catalysts. The high activity and selectivity of the catalysts is attributed to the in-situ formation of Pd-Zn alloys as one of the active components [1]. Therefore, we investigated the growth of thin Zn layers (0-3 ML) on Pd(111) at 105 K and the changes in electronic structure during subsequent annealing to higher temperatures (up to 1000 K) by high-resolution X-ray photoelectron spectroscopy (XPS) with monochromized Al K_α radiation, ultraviolet photoelectron spectroscopy (UPS), and low energy electron diffraction (LEED). The formation of Pd-Zn alloys above 300 K can clearly be seen in XP spectra, as new Zn $2p_{3/2}$ and Pd $3d_{5/2}$ peaks evolve. The temperatures, at which these alloys form, strongly depend on the amount of adsorbed Zn. An ordered alloy was only observed for annealing 1 ML of Zn to 400-600 K. UPS measurements show a reduction in the density of states near the Fermi edge during alloying, explaining the Cu-like catalytic behaviour.

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[1] N. Iwasa, S. Masuda, N. Ogawa, and N. Takezawa, Appl. Catal. A 125 (1995) 145

O 4.7 Fr 12:15 TU EB202

Temperature dependent evolution of Au/Pd(110) structure — •Marko Kralj[1], Stefan Degen[1], Aleksander Krupski[1], Conrad Becker[1], Klaus Wandelt[1], Aude Bailly[2], Marie-Claire Saint-Lager[2], Pierre Dolle[2], and Robert Baudoing-Savois[2] — [1]Institut für Physikalische Chemie, Bonn, Germany — [2]Laboratoire de Cristallographie, Grenoble, France

Ultra thin gold films on Pd(110) are studied by surface x-ray diffraction (SXRD) and scanning tunneling microscopy (STM). The focus is set to a 2.5 atomic layers thick gold film. The evolution of the room temperature deposited film structure and morphology is investigated as a function of annealing temperature in the range of 300-580 K. With increasing temperature the film order increases and the surface plane exhibits a (1×2) missing row reconstruction. Also, after 500 K, a competitive process of alloying with the palladium substrate takes place. A diffuse component is observed when performing transverse SXRD scans along the (01L) crystal truncation rod. This diffuse intensity is present only in one direction and is thus induced by "defects" of anisotropic form. We propose a consistent model which clearly relates this effect to the STM data.

O 4.8 Fr 12:30 TU EB202

Bcc-like crystal structures in ultrathin "fcc"Fe films on Cu(111) — •Albert Biedermann, Werner Rupp, Michael Schmid, and Peter Varga — Institut für Allgemeine Physik, Vienna University of Technology, 1040 Vienna, Austria

Growing ultrathin Fe films on fcc substrates can stabilize the fcc structure of Fe. More often, however, distorted bcc-like structures are found instead. Fe/Cu(100) films are very flat and show relatively well defined fcc and bcc-like phases, among them a "nanomartensitic"bcc-like phase [1]. In contrast, Fe/Cu(111) films grown by thermal deposition are relatively rough, favoring Cu surface segregation and hampering standard LEED-I/V analyses. We have used atomically resolved STM and STS of clean and H-covered bi- and multi-layer islands together with XPD data by Kief and Egelhoff [2] to show the presence and conditions of stability of strained bcc-like phases in Fe/Cu(111) films. Our results are compared to published magnetic measurements [3] and first principles predictions [4], which favor an ideal fcc phase for very thin films.

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[2] M. T. Kief, W. F. Egelhoff, Jr, Phys. Rev. B 47 (1993) 10785

[3] P. Ohresser, J. Shen, J. Barthel, M. Zheng, C. V. Mohan, M. Klaua, and J. Kirschner, Phys. Rev. B 59, 3696 (1999).

[4] Spišák and J. Hafner, PRB 67 (2003) 134434

O 4.9 Fr 12:45 TU EB202

Growth and electronic structure of ultrathin chromium films on iridium(111) investigated by scanning tunneling microscopy and spectroscopy — •Felix Marczinowski, Kirsten von Bergmann, and Roland Wiesendanger — Institut für Angewandte Physik, Universität Hamburg

Magnetic materials are showing interesting properties when prepared as thin films. Bulk Cr has bcc structure and is antiferromagnetic. Instead, if grown as a hexagonal monolayer film, the antiferromagnetic alignment of neighbouring atomic moments is impossible and a frustrated spin-structure will be formed [D. Wortmann et al., Resolving Complex Atomic-Scale Spin Structures by Spin-Polarized Scanning Tunneling Microscopy, PRL(2001)]. To study this spin-structure on an atomic level, Cr films of various coverages were deposited on an Ir(111) substrate by means of molecular beam epitaxy (MBE). The growth up to three monolayers was studied by scanning tunneling microscopy and spectroscopy. Indeed, the Cr monolayers grow pseudomorphically on the Ir(111) substrate and hence have hexagonal symmetry. Interestingly, we find a coexistence of faulted and unfaulted Cr-monolayer areas with distinct morphology and slightly different electronic properties. For higher coverages, a modified Volmer-Weber growth mode is observed. For coverages above two monolayers the Cr film relaxes towards its bulk structure and shows an epitaxial relationship according to the Kurdjumov-Sachs orientation.