

O 71: Metal substrates: Epitaxy and growth

Time: Thursday 15:00–18:00

Location: H31

O 71.1 Thu 15:00 H31

Interaction of gold with clean and oxygen-covered Re(10 $\bar{1}$ 0) surfaces — SEBASTIAN SCHWEDE, ●SUSANNE SCHUBERT, CHRISTIAN PAULS, and KLAUS CHRISTMANN — Freie Universität Berlin, Takustr. 3, 14195 Berlin

The structure, growth and morphology of thin Au films deposited on both clean and oxygen-covered rhenium (10 $\bar{1}$ 0) surfaces has been studied as a function of coverage Θ and temperature T using LEED, STM and thermal desorption spectroscopy (TDS). In the absence of oxygen, Au forms a variety of ordered ($1 \times n$) phases ($n = 3, 4, 5, 6$ and 1) with the Au adsorption energy increasing from ~ 320 kJ/mol at low Θ to ~ 380 kJ/mol near the bilayer (1×1) structure ($\Theta = 2$), where the heat of sublimation of bulk Au, ΔH_{sub} , is reached. Au wets the Re surface completely, for $\Theta > 2$, a simultaneous multilayer growth is observed. On the oxygen covered Re surface with its well-known (reconstructed) (1×3)-2O phase ($\Theta = 2/3$), however, Au deposition at 300 K causes immediate 3D clustering with rough and heterogeneous films pointing to a clear non-wetting behavior. Annealing of these films at 850 K gives the Au atoms sufficient mobility to coalesce to cylindrically shaped aggregates of ca. 50 Å diameter and 100 Å average length which are aligned parallel to the troughs of the Re surface. At elevated temperatures, Au desorbs first from the bulk phase ($E_{des} = \Delta H_{sub}$), only as oxygen desorption becomes competitive, Au atoms can diffuse to and interact with the bare Re sites and desorb with the characteristic energy.

O 71.2 Thu 15:15 H31

Study of the growth of bismuth thin film on graphite with STM and UPS at low temperature — FEI SONG, JUSTIN WELLS, MAGNE SAXEGAARD, ANNE BORG, and ●ERIK WAHLSTRÖM — Department of Physics, Norwegian University of Science and Technology (NTNU), Trondheim 7491, Norway

Bismuth, a novel semimetal material, which has been widely studied recently as topological insulator in the form of alloy with some other metals. In this talk, we will focus on the growth behaviour of Bi film from very thin coverage to thick layer at low temperature, in the light of scanning tunnelling microscopy (STM) and photoemission spectroscopy (PES), to have a close look at the interface morphology and electronic structure. Similar to other reports about Bi on Si substrate at critical coverage, interesting phenomenon, such as quantum well states will show up together with surface states which can be easily resolved from bulk states from the valence band.

O 71.3 Thu 15:30 H31

Structural analysis of Ag growth on Ni(111) — ●AXEL MEYER¹, JAN INGO FLEGE¹, SANJAYA SENANAYAKE², FAISAL ALAMGIR³, and JENS FALTA¹ — ¹Institute of Solid State Physics, University of Bremen, 28359 Bremen, Germany — ²Chemistry Department, Brookhaven National Laboratory, Upton, NY 11973-5000, USA — ³Georgia Institute of Technology, Atlanta, GA 30332-0245, USA

The growth structure and morphology of ultra-thin metal films on metallic substrates strongly influence the physical and chemical properties of the resulting bimetallic system. Therefore, a particular knowledge of these properties is crucial for creating functional materials with novel characteristics. In this contribution, a detailed study of the growth of ultra-thin silver films on the Ni(111) surface employing in-situ low-energy electron microscopy and diffraction (LEEM/LEED) is presented.

In the entire temperature range from 470 K to 850 K, silver is observed to grow in a Stranski-Krastanov mode with a wetting layer exhibiting a critical thickness of two atomic layers. For lower temperatures, the Ag films take on a collinear (7×7) structure or a 1° tilted ($\sqrt{57} \times \sqrt{57}$)R6.59° structure, respectively, the latter as predicted by Chambon et al. (Phys. Rev. B **79** 125412 (2009)). Elevated temperatures over 675 K lead to a ($\sqrt{52} \times \sqrt{52}$)R13.9° reconstruction with extended rotational domains on the Ni(111) surface, while Ag/Ni intermixing is not observed throughout the whole temperature range. Furthermore, by quantitative intensity-voltage analysis of the specular beam, layer-dependent surface relaxations were determined.

O 71.4 Thu 15:45 H31

Rare earth metals - Au surface compounds — ●MARTINA

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The high temperature reactive deposition of rare earths on Au(111) leads to the formation of surface compounds with extraordinary crystallinity. Gd on Au(111) is the most promising system we studied so far. Under specific growth parameters, we are able to obtain alloyed single- and double-layers whose optimum surface atomic structure corresponds to the GdAu₂ stoichiometry. Moreover, the lattice mismatch between the GdAu₂ layers and the Au substrate gives rise to a long-range periodic Moiré pattern, with a lattice parameter of 3.8 nm as detected by STM. We measured in detail with ARPES the electronic structure of the surface compound and based on theoretical calculations we identified the origin of the bands. This robust and highly ordered nanostructure is a perfect template to grow magnetic clusters. Co deposited at RT forms a regular network of homogeneously-sized dots that faithfully follow the underlying Moiré periodicity. By changing the Co coverage, we can obtain cluster arrays with areal densities up to 54 Teradots/inch² and remanent magnetization at 300 K.

O 71.5 Thu 16:00 H31

Small Pt adatom clusters on Pt(111): When fewer bonds are better than more — ●MICHAEL SCHMID¹, ANDREAS GARHOFER^{1,2}, JOSEF REDINGER^{1,2}, FLORIAN WIMMER¹, PHILIPP SCHEIBER¹, and PETER VARGA¹ — ¹Institut für Angewandte Physik, TU Wien — ²Center for Computational Materials Science, Wien, Österreich

Bonding of face-centered-cubic metals is usually characterized by a preference for high a coordination number of each atom. In sharp contrast to this picture, we find that small clusters of Pt adatoms on Pt(111) behave differently. Creating a high number of small Pt adatom clusters by pulsed laser deposition at low temperature, we find that up to 1/3 of all clusters are linear chains of Pt atoms with lengths of up to 9 atoms. This finding cannot be explained by a simple diffusion-limited-aggregation model. We have therefore analyzed the binding energies of Pt adatom clusters by density functional theory and found that bonding of such clusters does not follow the rule of “higher coordination is stronger bonding”. Instead, short linear chains are bound more strongly than some more compact configurations, explaining the preference for such structures observed experimentally. We ascribe the unusually low energies of short chains to strong bonding towards atoms at opposite sides, induced by d_{z^2} -like orbitals. We have also obtained time-lapse STM movies of diffusing Pt adatoms and their coalescence. The data show no strong long-range interaction between adatoms, which would otherwise provide a different route towards an explanation of the phenomena observed.

O 71.6 Thu 16:15 H31

Submonolayer growth of Cu on Cu(110) — ●GEORG CIOBOTEA, ANDREAS DOBLER, and THOMAS FAUSTER — Lehrstuhl für Festkörperphysik, Universität Erlangen-Nürnberg, Staudtstr. 7, 91058 Erlangen

The submonolayer growth of Cu on Cu(110) was investigated by scanning tunneling microscopy. Due to the geometry of the Cu(110) surface, diffusion in the $(1\bar{1}0)$ direction is expected to be dominant.

Island densities and shapes are measured after varying particle flux, coverage and temperature. Below 180 K, long and narrow islands of nearly constant width are found indicating a one-dimensional growth mode. At higher temperature island widths are strongly increasing. A comparison to nucleation theory is presented.

Thermal deposition and pulsed-laser deposition were compared at variable temperatures below 260 K. For pulsed-laser deposition, higher island densities are expected because of the high instantaneous particle flux. This behavior is found at low temperatures, where small adatom mobility is given.

O 71.7 Thu 16:30 H31

Pulsed-laser deposition of Cu on Cu(001) - the crucial role of

particle mobility and flux — ●ANDREAS DOBLER and THOMAS FAUSTER — Lehrstuhl für Festkörperphysik, Universität Erlangen-Nürnberg, Staudtstr. 7, 91058 Erlangen

Pulsed-laser deposition (PLD) provides for some μs up to 10^5 times higher particle flux than thermal deposition (TD). For homoepitaxial submonolayer growth, nucleation theory predicts island densities on the substrate scaling with a power law of flux F over the temperature-dependent diffusion coefficient D . Thus, significantly higher island densities are expected for PLD than for TD.

At 300 K, we found identical island densities for PLD and TD which were measured by scanning tunneling microscopy. Systematic variation of D (temperatures from 150 to 300 K) and F shows that this unexpected behavior is limited to low F/D values. At high F/D , the island density created by PLD is significantly higher than by TD. Nucleation is modeled by numerical integration of rate equations to explain this behavior.

O 71.8 Thu 16:45 H31

Anomalous Size-Dependent Reconstruction Behavior of Cu-Islands on Ag(100) — ●MICHAEL RIEGER¹, CHRISTOPHER ZAUM², KARINA MORGENSTERN², and KARSTEN REUTER^{1,3} — ¹Fritz-Haber-Institut, Berlin (Germany) — ²ATMOS Leibniz Universität Hannover, (Germany) — ³Technische Universität München, (Germany)

Fast-STM reveals an unusual structure and mobility of smaller Cu-islands on clean Ag(100) at room temperature. Small islands show a complex structure with Cu atoms also adsorbed in bridge sites, and a diffusivity and decay time that is significantly higher than any previously measured value. These observations are supported by our DFT calculations, which indicate a complex reconstructed structure of islands in this size range. Driven by the large lattice mismatch between Ag and Cu, this reconstruction enables shorter Cu-Cu bonds and thereby a stabilization through intra-island strain release. With the concomitantly weakened Cu-Ag bonds, the computed lower binding energy of reconstructed islands to the Ag(100) substrate is consistent with the measured higher diffusivity. In order to better explore the configuration space of island structures we validate an EAM potential for the Ag/Cu system against our DFT data set and employ it for an extensive structure search. The semi-empirical potential enables us to predict a critical island size for the reconstruction that is in perfect agreement with the experimental estimate for the shape turnover.

O 71.9 Thu 17:00 H31

Temporal evolution of Pb-islands on Ni(111) — ●TJEERD R.J. BOLLMANN, RAOUL VAN GASTEL, and BENE POELSEMA — MESA+ Institute for Nanotechnology, University of Twente, Enschede, The Netherlands

Low Energy Electron Microscopy (LEEM) allows real-time imaging of epitaxial growth of metals on metal substrates. We have used LEEM in combination with micro Low Energy Electron Diffraction to study the structure, size and height evolution of Pb islands on top of a Pb wetting layer on a Ni(111) surface, as well as the diffusion of islands across steps during epitaxial growth at elevated temperatures. Pb islands diffusing across nickel steps show remarkable self-organization in that they can half their surface area by doubling their layer in height. Concerted rapid coarsening of (larger) Pb islands within seconds is also observed. In both cases mass transport of Pb leads to new island equilibrium shapes with increased uniform (integer) heights. We present a systematic LEEM investigation of the effects that play a role in the area versus height evolution of Pb islands at elevated temperatures. The results are discussed in view of quantum size effect driven growth where specific heights are particularly stable.

O 71.10 Thu 17:15 H31

Adsorbate-induced segregation of C/Pt₂₅Rh₇₅(100): ab-initio predictions — ●TOBIAS KERSCHER, WOLFGANG LANDGRAF, and STEFAN MÜLLER — Universität Erlangen-Nürnberg, Lehrstuhl für Theoretische Physik 2, Staudtstr. 7, 91058 Erlangen, Germany

The segregation profile of alloy surfaces can strongly depend on the presence of adsorbates, a fact that is especially interesting for catalysts. The (100) surface of the alloy Pt₂₅Rh₇₅ provides an example: For the clean surface, the experiment [1] shows a strong Pt enrichment in the top atomic layer and a depletion underneath. Yet, even a small amount of carbon impurity (8% of a monolayer) leads to a considerable decrease in the Pt top layer concentration [1]. We use an ab-initio-based cluster-expansion in the framework of the UNCLE code [3] to efficiently model this adsorbate-induced change in segregation. The properties of the system are found to be controlled by two competing effects: the different segregation energies of Pt and Rh, and their individual binding energies to C. We discuss the substitutional ordering of the system as a function of C-coverage. Supported by Deutsche Forschungsgemeinschaft

[1] E. Platzgummer et al., Surf. Sci. **419** (1999), 236

[2] S. Müller, M. Stöhr, O. Wieckhorst, Appl. Phys. A. **82** (2006), 415 [3] D. Lerch et al, Modelling Simul. Mater. Sci. Eng. **17** (2009), 055003

O 71.11 Thu 17:30 H31

Oblique incidence ion impact pattern formation on Cu(001) along the [100] and [110] azimuthal directions — ●FRANK EVERTS, HERBERT WORMEESTER, and BENE POELSEMA — Solid State physics, MESA+ Institute for Nanotechnology, University of Twente, Enschede, The Netherlands

Oblique incidence sputtering is a versatile tool for nanopattern creation on different types of surfaces. Often ripple patterns are observed as a result of an erosion instability. The orientation of the ripples is governed by the polar angle of incidence of the ion beam. High resolution low energy electron diffraction reveal an unanticipated azimuth dependence for Cu(001) at 200 K. Near normal incidence sputtering along [110] gives rise to a diffraction pattern showing a fourfold symmetry of the etch structures. Surprisingly, a further increase of the polar angle shows that this surface imposed fourfold symmetry is preserved up to grazing incidence. In marked contrast are the results for sputtering along the [010] azimuth. Already for near normal incidence the fourfold symmetry in the diffraction pattern is broken, reflecting ripple formation. The orientation of these ripples changes with more oblique incidence sputtering. The explanation for this strong azimuth sensitivity is found by varying the ion energy, showing a strong dependence on the details of the ion substrate interaction.

O 71.12 Thu 17:45 H31

Surface structures of thin silver films on the Re(10 $\bar{1}$ 0) surface — ●VIKTOR SCHERF, LYRIA MESSAHEL, CHRISTIAN PAULS, and KLAUS CHRISTMANN — Freie Universität Berlin, Takustr. 3, 14195 Berlin

We have studied the growth of silver on the Re(10 $\bar{1}$ 0) surface in UHV between 300 and 700 K by means of MEED and LEED as well as with TPD. The phenomena depend strongly on coverage and temperature: At 300 K a (1 × 4) LEED phase exists in the large coverage range $0.1 < \Theta < 2$. For $T > 400$ K Ag forms a $c(2 \times 2)$ structure which reversibly transforms to the (1 × 4) phase upon cooling. *In-situ* MEED was performed during Ag deposition at various temperatures; grazing incidence ($\sim 2^\circ$) and off-Bragg scattering conditions provided high sensitivity with respect to surface electron reflectivity. At 700 K, we find a pronounced correlation between the (0,0) MEED beam intensity and the growth of the Ag phases which helps to calibrate the (local) Ag coverages. *Nominal* Ag coverages are obtained from Ag TPD peak areas. Systematic LEED intensity-temperature measurements at fixed Θ_{Ag} reveal optimum values of $\Theta = 1.3$ for the $c(2 \times 2)$ and $\Theta = 1.5$ for the (1 × 4) structure, respectively. Near the monolayer saturation a pseudomorphic (1 × 1) structure forms. According to dynamical LEED calculations, it contains two Ag atoms/unit cell and manifests $\Theta = 2$ for this bilayer, in which both troughs and ridges of the Re surface are covered by Ag atoms. The data are discussed and compared with the previously studied Au-on-Re(10 $\bar{1}$ 0) system.