

SKI Conference Program
SLC, Utah (3/20-3/22)

Thursday (3/19) Evening:

7:00-9:00: Reception in the Guest House Conference Room A.

Friday (3/20) Morning: Atomic SKI at Commanders House

8:05-8:15: “Meeting opening and announcements” by Feng Liu

8:15-8:30: “Welcome” by Richard Brown, Dean of College of Engineering, University of Utah

Session I: Skiing over the “Moguls” (Chair: Feng Liu)

8:30-9:00: Max Lagally: Si Nanomembranes: Strain Engineering, Surfaces, and Interfaces

9:00-9:30: Matthias Scheffler: (to be decided)

9:30-10:00: John Venables: Modeling Facet Nucleation and Growth of Hut Clusters on Ge/Si(001)

10:00-10:30: Akihisa Inoue: (to be decided)

10:30-10:45: Coffee Break

Session II: Atomic view of SKI---1 (Chair: Hanno Weitering)

10:45-11:15: Harold Zandvliet: Playing Pinball with Atoms

11:15-11:45: Kotone Akiyama: Nano-scale lithography with frequency modulation AFM

11:45-12:15: Ziqiang Qiu: X-ray study of magnetic multilayers

Friday (3/20) Afternoon: Mountaineer SKI at Alta and Park City

12:30 pm -5:00 pm: shuttle will leave Guest House at 12:30 pm and leave Ski Resort at 5:00 pm

Friday (3/20) Evening: Banquet at La Caille

6:00 pm -9:30 pm: shuttle will leave Guest House at 6:00 pm

Saturday (3/21) Morning: Atomic SKI at Commanders House

Session I: Atomic view of SKI---2 (Chair: Kristen Fichthorn)

8:15-8:45: Oliver Schmidt: Surface interdiffusion during strained island growth

8:45-9:15: Peter Kratzer: Surface atomic structure of InAs nanowires as indicator of zincblende or wurtzite crystalline segments

9:15-9:45: James Evans: Epitaxial growth of metal films on NiAl surfaces: STM and KMC analysis

9:45-10:15: Talat Rahman: (to be decided)

10:15-10:30: Coffee Break

Session II: Huang's surface growth tricks (Chair: John Venables)

10:30-11:00: Huang, Hanchen: A Characteristic Surface Length Scale During Growth

11:00-11:30: Huang, Zhifeng: Phase Field Crystal Modeling and Amplitude Formalism for Strained Film Epitaxy

11:30-12:00: Hwang, Chanyong: Magnetism in Fe-Pt surface alloy

Saturday (3/21) Afternoon: Mountaineer SKI at Alta and Park City

12:30 pm -5:00 pm: shuttle will leave Guest House at 12:30 pm and leave Ski Resort at 5:00 pm

Saturday (3/21) evening: Atomic SKI at Commanders House

Session I: Christian's uphill and downhill techniques (Chair: Talat Rahman)

8:00-8:30: Kristen Fichthorn: Ab Initio Accelerated Molecular Dynamics of Thin-Film Epitaxy

8:30-9:00: Christian Teichert: Step edge barriers in organic thin film growth

9:00-9:30: Christian Ratsch: A Level-Set Method for Self-Organized Pattern Formation during Heteroepitaxial Growth

Session II: SKI Posters

9:30-10:30 (Commanders House)

Sunday (3/22) Morning: Atomic SKI at Commanders House

Session I: Quantum Effects in SKI (Chair: Yukio Hasegawa)

8:15-8:45: Hanno Weitering: Quantum stability and superconductive properties of atomically smooth ultrathin alloy films

8:45-9:15: Cai-Zhuang Wang: Quantum Size Effects in Thin Film Evolution

9:15-9:45: Michael Altman: Anomalous Mass Transport in the Pb Wetting Layer on the Si(111) Surface

9:45-10:00: Coffee Break

Session II: Quantum Effects in SKI---2 (Chair: Michael Altman)

10:00-10:30: Jinfeng Jia: New progresses on Si(111)/Pb system

10:30-11:00: Yukio Hasegawa: The screened potential and the Friedel oscillation observed by LT-STM

Sunday (3/22) Afternoon: Mountaineer SKI at Alta and Park City

12:00 pm -5:00 pm: shuttle will leave Guest House at 12:30 pm and leave Ski Resort at 5:00 pm

Abstract

001. Akihisa Inoue Japan

002. Cai-Zhuang Wang USA

Quantum Size Effects in Thin Film Evolution

C. Z. Wang

Ames Laboratory-USDOE and Department of Physics, Iowa State University, Ames Iowa 50011

Recent experiment showed that the kinetic behavior of coarsening and growth of Pb islands on Si(111) surface does not obey traditional classical kinetic model predictions [1]. We have developed a novel rate equation model to describe this unconventional and rapid coarsening and growth behavior [2,3]. In addition to the dependence of chemical potential on islands' curvatures as in the classical coarsening model, our model incorporates the dependence of the chemical potential on the island height and also the effects of the dense wetting layer between the islands. Extensive first-principles calculations are performed to determine the relevant chemical potentials in the theory. Incorporating these features, this theoretical model predicts the evolutions of island density and height distribution in good agreement with experiments.

Work done in collaboration with Maozhi Li, J. W. Evans, M. Hupalo, M. C. Tringides, T. L. Chan, and K. M. Ho.

[1] C. A. Jeffrey, E. H. Conrad, R. Feng P, M. Hupalo C. Kim, P. J. Ryan, P. F. Miceli, and M. C. Tringides, *Phys. Rev. Lett.* **96** 106105 (2006).

[2] Maozhi Li, J. W. Evans, C. Z. Wang, M. Hupalo, M. C. Tringides, T.-L. Chan, and K. M. Ho, *Surf. Sci. Lett.* **601** (23) L140-L144 (2007).

[3] Maozhi Li, C. Z. Wang, J. W. Evans, M. Hupalo, M. C. Tringides, and K. M. Ho, *Phys. Rev. B*, in press.

003. Chanyong Hwang Korea

Title: Magnetism in Fe-Pt surface alloy

Abstract : Fe-Pt alloys draws a lot of attention for their possible application in self-aligned media for data storage, in permanent magnet and in high-density recording media. We have shown lots of interesting surface-related phenomena at Fe/Pt(110) system. First, two types of an ordered Fe-Pt surface alloys could be formed on a Pt(110)-(1x2) surface by varying the substrate temperature. Detailed atomic structures of these alloys were identified by scanning tunnelling microscopy (STM) and core-level photoemission spectroscopy with the aid of first principles calculation. One can study the origin of surface reconstruction with this ordered surface alloy, which was also shown at the clean Pt(110) surface. Second, one of these alloy surfaces showed the exchange bias effect, which is shown up when the antiferromagnet is in contact with the ferromagnet. This system would give you an idea on the origin of the exchange bias in atomic scale. Third, magnetic properties of Fe/Pt(110) were studied using the surface magneto-optic Kerr effect(SMOKE). It reveals a strong magnetic anisotropy in plane, which is expected due to the difference of pinning site distribution in magnetization reversal. Fourth, this system showed interesting order-disorder phase transition

when the coverage of Fe was very small. It can be understood as the minimization of the free energy by increasing the entropy of the system. We will show our approach in thermodynamics by using the STM with the aid of first principles calculation.

004. Christian Ratsch USA A Level-Set Method for Self-Organized Pattern Formation during Heteroepitaxial Growth
A Level-Set Method for Self-Organized Pattern Formation during Heteroepitaxial Growth

It is well known that strain leads to the formation and self organization of nanostructures and quantum dots during heteroepitaxial growth. However, modeling these phenomena is a challenging task, because of the vastly different time and length scales involved, and the fact that elastic calculations are computationally expensive due to their long range.

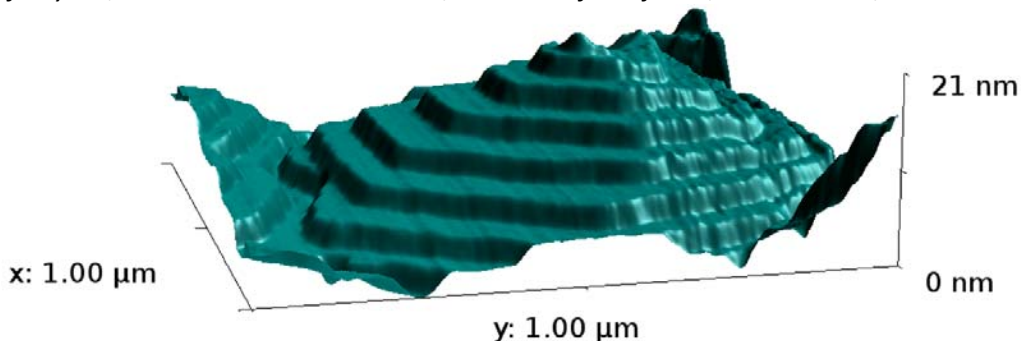
In this talk, we will discuss a model for heteroepitaxial growth that employs an island dynamics model with the level-set technique in combination with a fully self-consistent elastic model. Adatoms are described in a mean-field approach, and we solve a diffusion equation for the adatom concentration. At every timestep in the simulation, we solve the elastic equations for the entire system. At every lattice site strain then changes the local bonding, and thus the potential energy surface for adatoms and the microscopic parameters of the simulation, such as adatom diffusion, and the rate of detachment from island edges.

We will then present results for several growth phenomena: In the submonolayer regime, islands become smaller and more regular upon increasing strain, and the island size distribution narrows and sharpens. We will discuss how a spatially varying potential energy surface can be exploited for pattern formation. Such spatial variations are for example a result of defects or other features that are buried under the substrate. Another example is the growth of stacked quantum dots, where islands self-align on top of previously grown islands.

Step edge barriers in organic thin film growth

Christian Teichert

Institute of Physics, Montanuniversität Leoben, Franz Josef Straße 18, 8700 Leoben, Austria



In inorganic epitaxy it is well known that kinetically hindered interlayer mass transport due to the existence of an additional energy barrier at step edges - the so-called Ehrlich Schwoebel barrier (ESB) [1,2] - results in the formation of terraced mounds [3] instead of layer-by-layer growth. For the growth of rod-like para-sexiphenyl (6P) molecules on mica(001) we found by atomic force microscopy (AFM) that on a pre-ion-bombarded substrate indeed such mounds composed by almost upright standing molecules do form. Analysis of the mound cross sections showed that the layer distribution follows almost ideally a Poisson distribution indicating an absence of mass transport between adjacent layers. The observed deep trenches separating the mounds are in agreement with the predictions of the Zeno effect [4]. From the mound separation and the size of the top terraces, the ESB was estimated following a procedure developed originally for metal homoepitaxy [5]. The obtained value of 0.67 eV has been verified by transition state theory calculations which also revealed that the molecule bends during step edge crossing [6]. A careful analysis of the AFM measurements revealed in the first few monolayers a higher tilt angle of the molecules with respect to the surface normal (up to 43°) as compared to the bulk value observed in thicker films (17°). This leads to a lower value of the ESB of only 0.26 eV for the first layer. The reduction of the ESB could be explained by an interplay between different molecule orientations and necessary molecule bending during terrace edge crossing [6]. The observed level dependence of the ESB is a clear consequence of the anisotropy and complexity of the diffusing species in organic thin film growth.

- [1] G. Ehrlich, F. Hudda, *J. Chem. Phys.* **44** (1966) 1039.
- [2] R. Schwoebel, E. Shipsey, *J. Appl. Phys.* **37** (1966) 3682.
- [3] K. Meinel, M. Klaua, H. Bethge, *J. Cryst. Growth* **89** (1988) 447.
- [4] I. Elkinani, J. Villain, *Solid State Commun.* **87** (1993) 105.
- [5] T. Michely and J. Krug; *Islands, Mounds and Atoms* (Springer, Berlin 2004).
- [6] G. Hlawacek, P. Puschnig, P. Frank, A. Winkler, C. Ambrosch-Draxl, C. Teichert, *Science* **321** (2008) 108.

This work has been performed in collaboration with G. Hlawacek, P. Puschnig, C. Ambrosch-Draxl, P. Frank, and A. Winkler. Support in the framework of the Austrian Science Fund (FWF) within the National Research Network "Interface controlled and functionalized organic films" (S9707+S97014) is gratefully acknowledged.

006. Fukwo Men Taiwan

007. Hanchen Huang USA A Characteristic Surface Length Scale During Growth

008. Hanno Weitering USA

Title: Quantum stability and superconductive properties of atomically smooth ultrathin alloy films of thermodynamically immiscible elements

Abstract: Pb and Ga are immiscible in bulk form. However, atomically smooth ultrathin films of Pb $1-x$ Ga x alloy ($x=0.06$) can be stabilized on a Si(111)7x7 substrate through the quantum size effect. The quantum stability and superconductive properties of these films were investigated using scanning tunneling microscopy, x-ray photoemission spectroscopy, and superconducting quantum interference device (SQUID) magnetometry measurements. Quantum stabilized growth defects, consisting of deep holes extending to the film-substrate interface, act as pinning centers for vortices in the superconducting state. The pinning centers support an extraordinarily robust critical state with critical current densities in excess of 3 MA/cm² in 10 monolayer thick films. Anomalies in the dc magnetization and ac magnetic response below 2.5-3.5 K indicate a reduction of the flux pinning below these temperatures, which we attribute to the nature of the holes (deep holes as opposed to blind holes in!

pure Pb films). The present study highlights the possibility of growing new alloys beyond the solid solubility limit and controlling critical state properties in the quantum regime

009. Harold Zandvliet Netherlands

Title: Playing pinball with atoms

Abstract : We demonstrate the feasibility of controlling an atomic scale mechanical device by an external electrical signal. On a germanium substrate, a switching motion of pairs of atoms is induced by electrons that are directly injected into the atoms with a Scanning Tunneling Microscope (STM) tip. By precisely controlling the tip current and distance we make two atom pairs behave like the flippers of an atomic sized pinball machine. This atomic scale mechanical device exhibits six different configurations.

010. James Evans USA

Title: Epitaxial growth of metal films on NiAl surfaces: STM and KMC analysis

Abstract : First, we describe epitaxial growth of Ag(110) and NiAl(110), and Ag(100) and NiAl(100), which are lateral strain-free due to a perfect lattice match! Bilayer-by-bilayer growth is observed for Ag/NiAl(110) to quantum size effects. Growth of Ag/NiAl(100) is similar to Ag/Ag(100) homoepitaxy after the first couple of layers. Atomistic modeling* can elucidate growth kinetics

including the uphill mass transport even at low temperatures underlying bilayer growth in Ag/NiAl(110). Second, we briefly describe new studies of deposition of Al and Ni on NiAl(110) where growth behavior is dependent on complex kinetics rather than simple thermodynamics.

*Y. Han et al. PRL 100 (2008) 116105; Surf. Sci. 602 (2008) 2532.

011. Jinfeng Jia China New progresses on Si(111)/Pb system

Title: New progresses on Si(111)/Pb system

Abstract : Our recent results on Si/Pb system will be reported in this talk. First, high-resolution scanning tunneling microscopy images of a homogenous Pb terminated 1×1 phase on a Si(111) surface show a new hexagonal structure at room temperature (RT), which can be explained by the established T1 model, i.e., each Pb atom adsorbs directly on top of a Si atom located at the T1 site. Second, new evidences show that the epitaxial Pb films on Si(111) surface possess a hexagonal-closed-packed (hcp) structure, instead of a face-centered-cubic (fcc) one that has been considered before. The structure change is also caused by the quantum size effects (QSE). Third, the Si(111)-Pb SIC phase is found to be superconducting, which is the thinnest superconductor with only one layer Pb atoms. Pb films on SIC phase are also investigated and the 4ML Pb film is found to have the largest superconducting gap. The observed phenomena can be understood by the enhanced electron-phonon interaction at the Si-Pb interface and QSE.

In collaboration with Qikun Xue, Xucun Ma, Xi Chen, S.B. Zhang, S.L. He, S. Qiao and F. Liu. Supported by the Natural Science Foundation of China and Ministry of Science and Technology of China.

012. John Venables USA Modeling Facet Nucleation and Growth of Hut Clusters on Ge/Si(001)

Title: Modeling Facet Nucleation and Growth of Hut Clusters on Ge/Si(001)

Abstract : Recent STM observations of homogenous distributions of pyramid and hut clusters on Ge/Si(001) have shown that these clusters grow extremely slowly during annealing at intermediate temperatures, $T \sim 450$ oC, when there is a super-saturation of mobile ad-particles above and within the wetting layer. Data has been obtained on the absolute length of the clusters as a function of time $L(t)$, and thereby the evolution of the growth rate, over periods of order 100 hours [1]. We model this slow growth as a layer by layer (2D) facet nucleation and growth problem, in the presence of strain-induced energies both on and around the facets. All of these energies can markedly influence the nucleation rate of new facets. First, they justify the observation that facet nucleation occurs from the apex of the hut, as has been observed in several other studies [2, 3]. Second, they indicate a substantial slowing down of the nucleation rate, by many orders of magnitude, relative to the case when such energies are not present. Finally the need to undo the stable reconstruction on the $\{105\}$ facets as each new layer is formed contributes an extra energy of order 0.5 eV [4] to the energy of the critical nucleus. Inclusion of these effects, with experimental values of the Ge diffusion coefficient, provides a quantitative fit to the $L(t)$ data, and sets

bounds on step and facet energies appropriate to hut clusters. Such energies should be amenable to ab-initio calculation to compare with experiment.

1. M.R. McKay, J.A. Venables and J. Drucker, Phys. Rev. Lett. 101, 216104 (2008)
2. F. Montalenti et al., Phys. Rev. Lett., 93, 216102 (2004)
3. S. Cereda, F. Montalenti and L. Miglio, Surface Sci. 591, 23-31 (2005)
4. S. Cereda and F. Montalenti, Phys. Rev B 75, 195321 (2007)

013. Kotone Akiyama Japan

Nano-scale lithography with frequency modulation AFM

Kotone Akiyama^{1,2}, Masayuki Hamada³, T. Eguchi³, Y. Hasegawa³, T. Ono² and M. Esashi^{1,2}

¹WPI-Advanced Institute for Materials Research, Tohoku University

²Graduate School of Engineering, Tohoku University

³The Institute for Solid State Physics, The University of Tokyo

Using atomic force microscopy (AFM), one can deposit small amount of atoms from an AFM probe tip by field evaporation through voltage pulse application, and fabricate nano-size structures by repetitive dot formation on a substrate. The method called AFM lithography has been extensively studied because it enables us to draw desired nano-size structures directly on a substrate without using a resist, which is required in electron-beam lithography, and its drawing resolution may exceed that of e-beam lithography (~10 nm). So far, however, the best resolution of the AFM lithography is limited to ~25 nm. The reasons for the limited resolution are relatively large tip radius of the probe since the tip has to be coated with the metal to be deposited, and a usage of the amplitude-modulation mode of AFM, whose force sensitivity is not good as frequency-modulation (FM) AFM. In this study, we have developed a new AFM lithography method using a metal tip cantilever [1], whose tip apex is sharper than the coated tips, in FM-AFM mode with an aim of exceeding the drawing resolution of the present AFM lithography and e-beam lithography. For the FM AFM lithography, we used a quartz tuning fork as a force sensor [2]. A 10- μ m width Au wire is attached on one of the two prongs of the sensor, and the wire was sharpened by focused ion beam in the method reported in ref. [1]. The tip radius was characterized with TEM and found that the curvature radius of the tip is ~15 nm, much sharper than Au-coated tips by a factor of 5 to 10. Using the tip, we performed the AFM lithography on a Si substrate covered with the native oxide layer in a high vacuum and successfully obtained 10~20 nm diameter Au dots on the substrate. It turned out that the height depend on the applied voltage of the pulses; larger voltage produces larger height of dots. The voltage dependence indicates that field evaporation is a major mechanism of the dot formation. Through a repetitive voltage pulsing on designated sites, we drew wire structures and characters demonstrating the performance of the method.

[1] Kotone Akiyama, T. Eguchi, T. An, Y. Fujikawa, Y. Yamada-Takamura, T. Sakurai, and Y. Hasegawa, Rev. Sci. Instrum. 76, 033705 (2005).

[2] F.J. Giessibl, Appl. Phys. Lett, 71, 1470 (2000).

014. Kristen Fichthorn USA

Title: Ab Initio Accelerated Molecular Dynamics of Thin-Film Epitaxy

From: Kristen Fichthorn (fichthorn@psu.edu)

Abstract : I will discuss our recent studies using accelerated ab initio molecular dynamics to probe diffusion and growth in Al(110) homoepitaxy. For these studies, we developed an efficient parallel implementation of the Bond-Boost method to do accelerated ab initio molecular dynamics. We identified a number of important, new rate processes that govern the rise of huts when Al is deposited on Al(110) between 300 and 450 K. Using kinetic Monte Carlo, we

simulate the growth of the huts. If time permits, I will discuss our studies of the beta 2 (2x4) reconstruction of GaAs(001), where we have employed the Bond-Boost method to understand the temperature-dependent structure of this surface.

015. Matthias Scheffler Germany

016. Max G. Lagally USA Si Nanomembranes: Strain Engineering, Surfaces, and Interfaces

017. Michael Altman Hong Kong

Anomalous Mass Transport in the Pb Wetting Layer on the Si(111) Surface

An exceptionally fast and unusual mass transport behavior has been discovered in the dense Pb wetting layer on the Si(111) surface at temperatures as low as 150 K [1]. Mass transport is studied by observing non-equilibrium coverage profile evolution using low energy electron microscopy. The initial coverage step profile that is produced by laser induced thermal desorption propagates rapidly at a constant velocity and with unperturbed shape. This contrasts sharply with the profile broadening and gradual approach to equilibrium uniform distribution that is expected from classical considerations. The equilibration time also exhibits a dramatic coverage dependence that is characterized by an exceptionally sharp divergence below a critical coverage of 1.25 ML. A model is proposed that attributes this nonclassical equilibration behavior to the diffusion of thermally generated adatoms on top of the wetting layer. This model can account for the observed convection-like mass transport, as well as its dramatic dependence on Pb coverage. Such anomalous mass transport is believed to facilitate the remarkably efficient self-organization of uniform height Pb quantum islands on the Si(111) surface that was reported on widely in the past.

[1] K.L. Man, M.C. Tringides, M.M.T. Loy and M.S. Altman, Phys. Rev. Lett. 101, 226102 (2008).

018. Ming-huang Huang USA

019. Oliver Schmidt Germany Surface interdiffusion during strained island growth

Title: Surface interdiffusion during strained island growth

Author: Oliver G. Schmidt

Institute for Integrative Nanosciences, IFW Dresden, D-01069 Dresden, Germany

Abstract:

Surface interdiffusion plays a most significant role during formation of self-assembled quantum dots. As a prototypical material system we here consider SiGe strained islands on Si(001) substrate surfaces. We find that surface interdiffusion between deposited Ge and Si from the substrate is the driving force for alloying [1], motion [2] and shape/size oscillation effects [3]. In depth information about these phenomena is obtained by selective etching procedures [1,4] that allow us to derive the full 3D alloy profile of a single island [5], to reveal tree-ring like footprints left behind by dislocated islands [3] and to

“move” islands to predefined locations on in-situ patterned substrates [6]. These fundamental investigations are important to understand basic aspects of strained island growth as well as to apply and integrate SiGe islands into existing CMOS technologies [7].

[1] U. Denker et al., Phys. Rev. Lett. 90, 196102 (2003)

[2] U. Denker et al., Phys. Rev. Lett. 94, 216103 (2005)

[3] T. Merdzhanova et al., Phys. Rev. Lett. 96, 226103 (2006)

[4] O. G. Schmidt et al., Appl. Phys. Lett. 81, 2614 (2002)

[5] A. Rastelli et al., Nano Letters 8, 1404 (2008)

[6] G. Katsaros et al., Phys. Rev. Lett. 101, 096103 (2008)

[7] O. G. Schmidt and K. Eberl, IEEE Transactions on Electron Devices 48, 1175 (2001)

020. Peter Kratzer Germany

Title: Surface atomic structure of InAs nanowires as indicator of zincblende or wurtzite crystalline segments

Abstract : Nanowires of group-III-arsenides grown on (111)B-oriented substrates typically have hexagonal cross-sections. From crystallographic principles, one can deduce two possible orientations of the hexagon. For zincblende materials, the wire side facets either form from the $\{1 -1 0\}$ family of planes, or by alternation of $\{-2 11\}$ and $\{2 -1 -1\}$ facets. For wurtzite wires, these two possible orientations correspond to either $\{11 -20\}$ or $\{10 -10\}$ facets. In order to investigate the thermodynamic stability of the nanowires and to clarify the atomic structure of the side facets, we have performed electronic structure calculations using density functional theory. The surface energies of all relevant facets, both for InAs and GaAs, have been determined, and scanning-tunneling microscopic images have been simulated from the electronic structure data.

For zincblende wires, side facets of the $\{1-10\}$ type are found to be most stable. For wires with wurtzite structure, the analogous facet orientation, here called $\{11 -20\}$, has the lowest surface energy, too, and the absolute values are even lower than for the zincblende $\{1-10\}$ surfaces. However, the advantage in surface energy is too small to explain the occurrence of wurtzite wires in growth experiments on thermodynamic grounds, unless unrealistically thin wires would be considered. Interestingly, observation of wurtzite InAs surfaces by STM has become possible recently [1], by a special in vacuo cleaning procedure of CVD-grown wires using atomic hydrogen exposure at elevated temperatures. This is remarkable as wurtzite InAs, being metastable, cannot be synthesized as bulk crystal, and hence its surface structure had remained elusive up to now. The observed atomic structure of the $\{11 -20\}$ and the $\{10 -10\}$ surfaces agrees with the calculated structure predicted to have the !

lowest surface energy. Both surfaces do not reconstruct - there are only minor relaxations of the bulk-terminated atomic positions - nor do they display electronic surface states in the principal band gap.

[1] E. Hilner, U. Hoanson, L. E. Froerg, M. Karlsson, P. Kratzer, E. Lundgren, L. Samuelson, A. Mikkelsen, Nano Letters 8, 3978 (2008).

021. Talat Rahman USA

022. Yukio Hasegawa Japan

Title: The screened potential and the Friedel oscillation observed by LT-STM

From: Yukio Hasegawa (hasegawa@issp.u-tokyo.ac.jp)

Abstract : The electrostatic potential around a single charge in vacuum is described with the Coulomb potential. If it is situated in a metal, the potential is modified by electrons in the metals. The modification of the potential, called screening, is one of the fundamental phenomena in the condensed matter physics. Using low-temperature scanning tunneling microscopy / spectroscopy (STM/S) we have developed a method for measuring electrostatic potential in high spatial and energy resolutions and performed a real-space observation of the potential around external charges screened by two-dimensional surface electron system. In the potential mappings, characteristic decay and oscillation in the potential, so-called the Friedel oscillation, were clearly visible around the charges [1]. When the surface potential is spatially modified by, for instance, adsorbates and step edges on the surface, the energy level of the surface states shifts together with the potential. Therefore, by measuring the energy level of the surface states using STS, the potential can be measured and images of its spatial distribution can be obtained. As a sample having a two-dimensional (2D) electron system, we used the Si(111)- $\sqrt{3}\times\sqrt{3}$ -Ag surface. The electron standing wave patterns are observed in tunneling conductance (dI/dV) images and an obtained energy dispersion curve indicates free-electron like behaviors of the electron system. The obtained potential profiles around step edges, where Ag adsorbates are accumulated and thus positively charged, were fitted well with theoretically predicted screened potential profiles. We also observed oscillatory potential profiles whose period is the half Fermi wavelength of the two-dimensional electron system. The oscillator potential was well explained with the Friedel oscillation based on calculated results with the linear response theory. Differences between the Friedel oscillation and the standing waves are also discussed in the presentation.

References

[1] M. Ono et al., Phys. Rev. Lett., 96, 016801 (2006)

023. Zhi-Feng Huang USA

Title: Phase Field Crystal Modeling and Amplitude Formalism for Strained Film Epitaxy

Abstract : The formation and nonlinear evolution of surface nanostructures during strained film epitaxy are examined through a mesoscopic approach that we developed recently to incorporate both the film crystalline structure and standard continuum theory. It is based on the phase field crystal (PFC) modeling and the corresponding amplitude equation formalism, for both morphological and compositional profiles. Some of our recent efforts based on this new modeling technique will be described, including a universal scaling relation for strained island size, and the coupling between the film composition inhomogeneity and the evolution of surface nanostructures in alloy systems. Our results indicate the breakdown of conventional continuum approaches even at relatively large scales due to the discrete nature of the film crystalline structure.

024. Ziqiang Qiu USA

Title: X-ray study of magnetic multilayers

Abstract : In a magnetic multilayer structure, interesting properties often stem from the magnetic interaction between different magnetic layers. Therefore, an element-specific magnetic measurement would allow the identification of the magnetic interlayer coupling on the new magnetic properties. The recent development of the x-ray magnetic circular/linear dichroism (XMCD, XMLD) makes it possible to do element-specific measurement for ferromagnetic/antiferromagnetic materials with monolayer sensitivity. In particular, the combination of the XMCD/XMLD with electron microscopy allows element-specific magnetic domain imaging. In this talk, I will present some recent results from our group to illustrate the application of the XMCD/XMLD on magnetic multilayers.