Surface Science
Room 210C - Session SS2-TuA

Welch Award Symposium: Nucleation and Growth
Moderator: P.J. Feibelman, Sandia National Laboratories

1:20pm **SS2-TuA1 Real-Time Microscopy of Second Order Phase Transitions on Pb/Ge(111)**, ***Y. Sato***, *S. Chiang,* University of California, Davis

Using the Low Energy Electron Microscope (LEEM), we have studied phase transitions that occur on the Pb/Ge(111) surface. We have observed a very unusual second order phase transition with strong fluctuations at coverages above 1ML. The Pb layer forms two stable (@sr@3x@sr@3)R30° phases on the surface, a low-density @alpha@ phase and a dense @beta@ phase. It is well known that the critical temperature of the phase transition from @beta@ to (1x1) depends strongly on the coverage. The transition occurs at 180C for coverage below 1ML and at 270C for coverages above 1.33ML. LEEM data clearly show this difference in the critical temperature derives from the different mechanisms of the transformation. For coverages between 0.33ML and 1ML, where the @alpha@ phase coexists with the @beta@ phase below the critical temperature and with the (1x1) phase above it, the reversible phase transformation from @beta@ to (1x1) shows typical second order phase transition behavior, i.e., the intensity of the @beta@ phase gradually changes with temperature. On the other hand, for coverages above 1 ML, where the surface is either the low temperature @beta@ phase or the higher temperature (1x1) phase, the system shows an unusual second order phase transition. As the sample is heated through the critical temperature, the (1x1) phase appears as small domains over the surface. The domains appear and disappear until they are stabilized in the new phase. The transition is reversible, and similar behavior is observed upon cooling. The frequency analysis of the critical fluctuations will be presented, and the different mechanisms for both of the second order phase transitions mentioned above will be discussed.

1:40pm **SS2-TuA2 Dislocation-Driven Surface Dynamics on Solids**, ***S. Kodambaka***, *S.V. Khare, J. Bareno, W. Swiech, I. Petrov, J.E. Greene,* University of Illinois at Urbana-Champaign

Using low-energy electron microscopy, we investigate the near-equilibrium dynamics of surface-terminated dislocations. We observe, in real time, the thermally-driven (1500-1700 K) nucleation and shape-preserving growth of spiral steps rotating at constant temperature-dependent angular velocities (@omega@(T)) around cores of dislocations terminating on TiN(111) in the absence of applied external stress or net mass change. We measure @omega@ as a function of spiral geometry, N@sub2@ partial pressure, annealing time, and temperature. We find that @omega@ is independent of the local environment and ambient, and decreases linearly with time. From the temperature-dependent @omega@ data, we obtain an activation barrier of 4.9±0.3 eV for the growth of spirals. This phenomenon, attributed to point-defect migration from the bulk to the surface along dislocation lines, is both qualitatively and quantitatively different from step curvature-driven surface dynamics and "standard" Burton-Cabrera-Frank (BCF) spiral growth.@footnote 1@ Our results demonstrate that dislocation-mediated surface roughening can occur even in the absence of deposition or evaporation, and provide fundamental insights into mechanisms controlling nanostructural stability. We expect that this process is general and that it occurs in other materials.@footnote 1@ S. Kodambaka, S.V. Khare, W. Swiech, K. Ohmori, I. Petrov, and J.E. Greene, Nature, May 6th issue, 2004.

2:00pm **SS2-TuA3 Probing the Kinetics of Nanoscale Self-Assembly on Surfaces**, ***G.L. Kellogg***, Sandia National Laboratories, US **INVITED**

Pb atoms deposited on Cu(111) form a Pb-poor surface-alloy phase and a Pb-rich overlayer phase which spontaneously order into nanoscale domain patterns.@footnote 1@ The thermodynamic forces responsible for the self-assembly have been determined in previous studies with the LEEM.@footnote 2@. In this talk I will describe recent studies of the atomic mechanisms underlying the remarkable cooperative motion that allows these patterns to form and evolve. For example, the ordering of Pb overlayer islands occurs by islands containing 10's of thousands of atoms moving 100's of nm's is a few minutes. To help understand the atomic processes responsible for such motion, we measured the thermal decay of pure Cu, Pb-overlayer, and Pb/Cu surface-alloy islands using both STM and LEEM.@footnote 3@ The results indicate that the diffusion of Cu atoms over the Pb-Cu surface alloy is rate-determining for the decay both Pb overlayer and Pb-Cu alloy islands and that slower diffusion on the surface alloy is due to path blocking by embedded Pb atoms. Additional LEEM studies of Cu island nucleation within the Pb overlayer strongly suggest that the large-scale mobility of overlayer islands is accomplished by fast migration of Cu atoms within the overlayer. Thus, the rapid self-assembly in this system can, surprisingly, be traced to the existence of a low energy Cu thermal defect within the Pb overlayer. Sandia is operated by Sandia Corporation, a Lockheed Martin company, for the U. S. Department of Energy under Contract #DE-AC04-94AL85000. @FootnoteText@ @footnote 1@ R. Plass, J. A. Last, N. C. Bartelt, and G. L. Kellogg, Nature 412, 875 (2001).@footnote 2@ R. van Gastel, R. Plass, N. C. Bartelt, and G. L. Kellogg, Phys. Rev. Lett. 91, #55503 (2003); R. van Gastel, N. C. Bartelt, P. J. Feibelman, Francois Leonard, and G. L. Kellogg, Phys. Rev. B, submitted.@footnote 3@ M. L. Anderson, N. C. Bartelt, P. J. Feibelman, G. L. Kellogg, and B. S. Swartzentruber, in preparation.

2:40pm **SS2-TuA5 Medard Welch Award Presentation: Growth and Epitaxy of Thin Pentacene Films**, **INVITED**

Pentacene (Pn) is the highest mobility organic semiconductor known. It is a crystalline organic solid that can be deposited on a substrate by either vacuum sublimation, or by spin coating of a suitable soluble precursor followed by mild annealing. In this talk I will focus on studies of Pn thin film growth in vacuum, studies by in-situ Low Energy Electron Microcopy, Scanning Tunneling Microscopy, and Photo Electron Spectroscopy. We find that the molecular orientation in the growing film, as well as the nucleation density depend strongly on the choice and preparation of the substrate. For instance, grain sizes can vary from 0.1 micrometer to over 0.1 millimeter. Molecules can orient in-plane or out-of-plane, depending on the electronic structure of the substrate. On most substrates, grains show random azimuthal orientation, but recently we have succeeded in growing epitaxial pentacene films on a number of different substrates that hold promise for the fabrication of epitaxial organic thin film transistors with improved transport properties. In this talk I will review our results and recent progress.

3:20pm **SS2-TuA7 Growth Dynamics of Organic Semiconductors**, ***F. Schreiber***, Oxford University, UK **INVITED**

We will review our recent work on the growth dynamics of molecular semiconductors by organic molecular beam deposition (OMBD), with emphasis on growth studies beyond the first monolayer, i.e. the evolution of the film structure and morphology. After briefly discussing general issues related to growth modes, correlation functions, dynamic scaling, and growth exponents, we will try to identify the general features that distinguish organic from inorganic systems, such as the different interaction potentials and the internal degrees of freedom of organic molecules.@footnote 1@ We will then discuss selected case studies of perylene-derivatives (in particular diindeno-perylene (DIP)@footnote 2@ and 3,4,9,10-perylenetetracarboxylic dianhydride (PTCDA)@footnote 3@), with results on the dynamic scaling exponents and real-time studies of the growth. Finally, we will briefly discuss the implications for organics-based heterostructures and the improvement of device performance. @FootnoteText@@footnote 1@F. Schreiber, Phys. Stat. Sol. (a) 201 (6) (2004) 1037 @footnote 2@A. C. Dürr et al., Phys. Rev. Lett. 90 (2003) 016104 @footnote 3@B. Krause et al., Europhys. Lett. 65 (3) (2004) 372

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