O 33: Symposium: Frontiers of Surface Sensitive Electron Microscopy I (Invited Speakers: James Hannon, Raoul van Gastel, Thomas Schmidt)

Time: Tuesday 13:45–16:15 Location: MA 005

Invited Talk O 33.1 Tue 13:45 MA 005

Dynamics at Strained Surfaces — •James B. Hannon — IBM T.J. Watson Research Center, Yorktown Heights, NY 10598, USA

It has long been recognized that surface stress influences surface morphology and kinetics. For example, stress can drive the spontaneous formation of periodic patterns. Analysis of the equilibrium configuration of stress domains can be used to determine surface thermodynamic parameters [1]. However, in many (if not most) systems, reaching equilibrium in experiment can be difficult. In this talk, I will describe experiments in which surface thermodynamic parameters are determined by analyzing the motion of stress domains far from equilibrium. In the first example, step motion on Si(100) is used to determine the strain pattern of a dislocation that intersects the surface [2]. In the second example, the rapid growth of isolated 7x7 domains on Si(111) is described. I show how certain generic features of the domain growth (e.g., faceting) are related to the orientational dependence of the domain boundary free energy.

Work performed with R.M. Tromp (IBM) and V.B. Shenoy (Brown Univ).

[1] Science 295 (2002) 299; Nature Materials 3 (2004) 95.
[2] Science 313 (2006) 1266.

Invited Talk O 33.2 Tue 14:15 MA 005

The role of long-range interactions in determining surface morphologies: a combined LEEM/SXRD study — •Raoul van Gastel — MESA+ Institute for Nanotechnology, University of Twente, Enschede, The Netherlands

LEEM has been used to study long-ranged elastic interactions that occur in metal heteroepitaxy. The elastic interactions are used to achieve shaping and sizing of nanostructures. Pb/Cu(111) is first used as an example to illustrate how LEEM is applied to quantify the thermodynamic parameters that are driving the self-assembly of two phases, a surface alloy phase and an overlayer phase. We show how those parameters can be manipulated to induce size and shape changes of individual domains.

For the similar Bi/Cu(111) system we have combined surface X-ray diffraction (SXRD) and LEEM to investigate the atomic structure and pattern formation. We investigate the structure of the different surface phases and pinpoint the origin of the morphological changes to the atomic structure of the different phases. The pattern formation and the dramatic changes that occur during the transitions are analyzed and the thermodynamic parameters that control the rich phase behavior in this system are quantified. Finally, a brief illustration is given of how electrostatic interactions can lead to similar effects in the self-assembly of organic molecules on metal substrates.

O 33.3 Tue 14:45 MA 005

Real Time Imaging of Surface Diffusion Fields during Island decay — •Dirk Wall[1], Kelly R. Roos[1,2], Kimberly L. Roos[1], Ingo Lohmar[3], Joachim Krug[3], Michael Horn-von Hoegen[1], and Frank-J. Meyer zu Heringdorf[1] — [1]Department of Physics and Center for Nanointegration Duisburg-Essen (CeNIDE) Universität Duisburg-Essen, D-47057 Duisburg, Germany — [2]Department of Physics, Bradley University, Peoria, IL 61625, USA — [3]Institut für Theoretische Physik, Universität zu Köln, 50937 Köln, Germany

Photoemission Electron Microscopy (PEEM) is used to study the thermal decay (650°C - 850°C) of Ag islands grown epitaxially on flat and vicinal Silicon surfaces. During island decay, bright quasi static Ag-reconstructed zones are formed around each of the islands. Micro Low Energy Electron Diffraction (μ-LEED) reveals that the photoemission contrast is caused by different reconstructions due to a coverage gradient that extends outward from the edge of the islands. A simple continuum model is presented explaining the dynamic decay of the islands. We additionally studied the diffusion anisotropy on numerous vicinal Silicon surfaces. The degree of diffusion anisotropy of the system is thereby revealed by the shape of the zones. We demonstrate that the imaging of these reconstructed "isocoverage-zones" constitutes a unique experimental method for directly imaging diffusion fields and diffusion anisotropy in epitaxial systems. The general applicability of this imaging technique is demonstrated by the decay of Indium islands on Silicon.

O 33.4 Tue 15:00 MA 005

Structural imaging of surface oxidation and oxidation catalysis on transition metal surfaces — •Jan Ingo Flege and Peter Sutter — Center for Functional Nanomaterials, Brookhaven National Laboratory, Upton, NY, United States

The oxides of 4d late transition metals (TM), such as ruthenium and rhodium, are a class of materials with desirable functional properties, e. g., for catalysis. However, the mechanism of initial oxidation of these materials and the nature of the structures produced by facile oxygen uptake into sub-surface layers have been notoriously difficult to investigate experimentally, primarily because of a lack of spatially resolving and structurally sensitive techniques adequate for identifying the initial nanometer-sized oxidation products under reaction conditions.

Here we use spatially and temporally resolved structural fingerprinting in connection with multiple scattering calculations to characterize surface oxidation as well as the catalytic properties of the resulting oxygen-rich structures on Ru(0001) and Rh(111). We will show that for both Ru and Rh the initial oxidation proceeds by initial formation of a O-TM-O trilayer. However, while in the case of Rh the thicker oxide structures emerge from the trilayer surface oxide, the bulk oxide RuO_2(110) islands grow independently from the trilayer, competing for surface area. Furthermore, individual phase-specific chemical reactivities for CO oxidation and cooperative effects during the catalytic cycle induced by the nanoscale heterogeneity will be discussed.

O 33.5 Tue 15:15 MA 005

Photoemission electron microscopy investigation of organic thin films — •Maria Benedetta Casu[1], Indro Biswas[1], Mathias Nagel[1], Peter Nagel[2], Stefan Schuppler[2], and Thomas Chassé[1] — [1]Institute of Physical and Theoretical Chemistry, University of Tuebingen, 72076 Tübingen, Germany — [2]Forschungszentrum Karlsruhe, Institut für Festkörperphysik, 76021 Karlsruhe, Germany

Organic electronic devices offer an interesting alternative to inorganic semiconductor electronics due to low-cost deposition methods, flexible substrates, and simple packaging. The organic molecules can be vapour deposited under vacuum, spin coated, dip coated or printed on the proper substrate. All these techniques are relevant for low cost electronics and their potentiality is still enormous. To favour further technical developments, the full understanding of electronic, structural, and morphological properties of organic materials plays a paramount role. Diindenoperylene (DIP) is a perylene-based molecule that shows a very high hole mobility already in thin films, good film forming properties and thermal stability, thus it may be considered as a promising molecule for electronics. In this work we present the results of photoemission electron microscopy (PEEM) investigations on DIP thin films deposited on polycrystalline gold. We focused on the different phases that may occur while growing a film on a given substrate. Based on the synergy of PEEM, X-ray photoemission, and nano near-edge X-ray absorption fine structure spectroscopy results, we propose a model for the growth of DIP thin film deposited with a relative low deposition rate (0.3 nm/min) on polycrystalline gold kept at room temperature.

O 33.6 Tue 15:30 MA 005

Characterization of nanosize buried defect in Mo/Si multilayer structure by EUV photoemission electron microscopy — •jingquan lin[1], jochen maul[2], nils weber[3], matthias escher[3], michael merkel[3], gerd schoenhense[2], and ulf kleineberg[1] — [1]Ludwig Maximilians University,Garching,Germany — [2]Mainz University, Mainz, Germany — [3]Focus-GmbH, Huenstetten-Kesselbach, Germany

Extreme ultraviolet lithography (EUVL) is one of the leading next-generation lithography candidates for the 32 nm node and below. The fabrication of defect-free masks including their inspection is a significant challenge for the implementation of EUVL. Here, we report experimental results of EUVL mask blank defects and patterned absorber inspection using photoemission electron microscopy (PEEM) technique. With EUV-PEEM, bump-type and pit type defects that buried under EUVL multilayer were investigated. In the case of bump-type defect we have demonstrated its sensitivity to a phase defects with lateral

size of 35 nm and height of 4 nm. We also investigated artificial microstructures with lateral size of several 100 nm in /on top of Mo/Si multilayer structure. The inspection results show that EUV-PEEM has ability of detecting an absorbing micro-structure and a closely-situated tiny defect in the multilayer structure simultaneously. In addition, a comparison detection of phase defect sample with different working wavelength was conducted.

Invited Talk O 33.7 Tue 15:45 MA 005

SMART - Spectromicroscopy with aberration correction for high resolution surface characterization — •Th. Schmidt[1,2], F. Maier[1], H. Marchetto[2], P. Lévesque[2], U. Groh[1], R. Fink[3], H.-J. Freund[2], E. Umbach[1,7], and SMART- Collaboration[1,2,3,4,5,6] — [1]University of Würzburg, EP II — [2]Fritz-Haber-Institute, Berlin — [3]University of Erlangen, PC — [4]TU Darmstadt — [5]TU Clausthal — [6]Carl Zeiss NTS GmbH — [7]Forschungszentrum Karlsruhe

Combining high-brilliance synchrotron radiation with a parallel imaging LEEM or PEEM allows a comprehensive characterization of surfaces, adsorbates, and ultrathin films. The SMART (Spectro-Microscope with Aberration correction for many Relevant Techniques), installed at BESSY, aims at a lateral resolution of 2 nm and an energy resolution of 100 meV, which can only be achieved by aberration correction and energy filtering. The actual lateral resolution of 3.1 nm is already the best for this kind of microscope. Using different sources (polarized x-rays, UV-light, electron gun) the SMART excels as a versatile instrument by imaging photo-emitted (XPEEM, UV-PEEM) and reflected electrons (LEEM) to study the morphology, chemical distribution, electronic state, molecular orientation, atomic steps, etc. Fast switching enables spectroscopy (nano-XPS, nano-NEXAFS, etc.) and (b) diffraction from small object areas (nano-PED = photoelectron diffraction, valence band mapping, LEED, etc). First experiments on the growth properties of organic thin films show the potential of the instrument and will be briefly presented. Funded by the BMBF, contract 05 KS4 WWB/4.