

Tuesday Afternoon, November 1, 2005

Surface Science

Room 206 - Session SS3-TuA

Ultrafast Surface Dynamics

Moderator: I. Harrison, University of Virginia

2:00pm **SS3-TuA1 Probing Molecular Motion Induced by Femtosecond Laser Pulses on a Site-by-Site Basis with Scanning Tunneling Microscopy**, *L. Bartels*, University of California, Riverside; *F. Wang, D. Moeller*, Columbia University; *E. Knoesel*, Rowan University; **T.F. Heinz**, Columbia University
INVITED

The fundamental time scale for nuclear motion and energy flow in surface dynamics lies in the femto- to picosecond range. With the on-going advances in laser technology, many powerful new approaches have been developed to explore the dynamics of elementary surface processes directly in the time domain. In this paper, we present an application of femtosecond laser radiation to examine the dynamics of the elementary process of surface diffusion. To this end, femtosecond laser irradiation is used to excite adsorbed CO molecules on a Cu(110) surface; the ensuing motion of individual molecules across the surface is characterized on a site-to-site basis by in-situ scanning tunneling microscopy (STM). Adsorbate motion both along and perpendicular to the rows of the Cu(110) surface occurs readily, in marked contrast to the behavior seen for equilibrium diffusion processes. In addition, STM permits us to determine the rate of the concurrent laser-induced desorption process. The experimental findings for the efficiency and direction of the molecular motion can be understood as a manifestation of strong coupling of the lateral degrees of freedom of the adsorbed molecules to the substrate electronic excitation produced by the femtosecond laser radiation. The overall efficiency for surface diffusion is modeled using data on the thermal diffusion of CO/Cu(110) in conjunction with a description of coupling of the frustrated translational mode to the electronic and lattice excitation of the substrate. The dominant role of the substrate electronic excitation emerges from this analysis. The experiment represents a successful combination of the capabilities of ultrafast laser radiation for accessing non-equilibrium phenomena and the capabilities of STM for accessing the atomic length scale. Possible future research directions will be discussed.

2:40pm **SS3-TuA3 Ultrafast Laser Modification of Single Crystal MgO Surfaces**¹, *J.T. Dickinson*, S.C. Langford, Washington State University; *W.P. Hess*, Pacific Northwest National Laboratory; *L.A. Boatner*, Oak Ridge National Laboratory

Interactions between wide bandgap insulators and nanosecond pulses of laser light at sub bandgap wavelengths often require defects for both absorption and emission. With ultrafast pulses, multiphoton absorption across the bandgap is much more probable and often yields exciton mediated decomposition. The doubly charged lattice of materials like MgO strongly inhibits exciton-induced decomposition. We compare the response of (100) MgO to 100 fs pulses at wavelengths of 800, 400, and 267 nm with our earlier studies using nanosecond pulses at 248 nm and 193 nm, where the latter interactions were clearly defect-mediated. Surfaces modified by femtosecond pulses show evidence for both photothermal and photoelectronic processes when examined by AFM and SEM. Some of these processes are clearly mediated by defects. ¹This work was supported by the Department of Energy.

3:00pm **SS3-TuA4 Wavelength-Dependent Infrared Laser Induced Hydrogen Desorption from a Si(111) Surface**, *Z. Liu*, University of Minnesota, Vanderbilt University; *P.I. Cohen*, University of Minnesota; *L.C. Feldman*, *N.H. Tolk*, Vanderbilt University; *Z. Zhang*, Oak Ridge National Laboratory

Wavelength-dependent infrared laser induced hydrogen desorption from a Si(111) surface hydrogen passivation on silicon surfaces is a bottleneck in low temperature Si homoepitaxy. We employ infrared laser radiation from the Vanderbilt Free-Electron Laser to desorb hydrogen from a Si(111) surface at a temperature below 300C where thermal effects are minimal. The vibrational mode of the Si-H bond was excited by the infrared laser to enhance hydrogen desorption. The cross-section of the coupling between the laser and the Si-H bonds has been measured as a function of laser wavelength and power, showing a resonant effect at the energy of the vibrational mode at 2087 cm⁻¹. The desorption rate was maximized when the polarization of the light was maximized along the Si-H bond direction. The vibrational energies of the Si-H bond are different at terrace sites and step sites. Thus this mechanism provides a way to

selectively desorb hydrogen atoms from different locations on the Si surface, and allows site-selective epitaxial growth of Si. To our knowledge this is the first report of wavelength-selective desorption of an adsorbate on a semiconductor surface. This project is partially supported by DARPA/SPAWAR grant N66001-04-1-8924 and DOE grant ER45781.

3:20pm **SS3-TuA5 Surface Plasmon Oscillation in Gold Nanocrystals of Different Shapes: Some Radiative and Nonradiative Ultrafast Properties**, *M. El-Sayed*, Georgia Institute of Technology
INVITED

The surface plasmon oscillation in gold nanocrystals will be introduced and its enhancement of the absorption, fluorescence and scattering properties will be discussed as a function of shapes. Excited with femtosecond lasers, the electronic oscillation rapidly relaxes into phonon excitation. The lattice oscillation can be detected optically as it modulates the surface plasmon absorption (the color) of the nanocrystals. The dependence of this oscillation on size, shape and interparticle coupling will be discussed

Author Index

Bold page numbers indicate presenter

— B —

Bartels, L.: SS3-TuA1, **1**

Boatner, L.A.: SS3-TuA3, **1**

— C —

Cohen, P.I.: SS3-TuA4, **1**

— D —

Dickinson, J.T.: SS3-TuA3, **1**

— E —

El-Sayed, M.: SS3-TuA5, **1**

— F —

Feldman, L.C.: SS3-TuA4, **1**

— H —

Heinz, T.F.: SS3-TuA1, **1**

Hess, W.P.: SS3-TuA3, **1**

— K —

Knoesel, E.: SS3-TuA1, **1**

— L —

Langford, S.C.: SS3-TuA3, **1**

Liu, Z.: SS3-TuA4, **1**

— M —

Moeller, D.: SS3-TuA1, **1**

— T —

Tolk, N.H.: SS3-TuA4, **1**

— W —

Wang, F.: SS3-TuA1, **1**

— Z —

Zhang, Z.: SS3-TuA4, **1**