Wednesday Morning, October 4, 2000

Surface Science
Room 209 - Session SS2-WeM

Stimulated Surface Processes
Moderator: R.M. Osgood, Columbia University

8:20am **SS2-WeM1 Enhanced Adatom Diffusion Using Glancing-Angle Ions**, *S.A. Barnett,* ***K.C. Ruthe,*** Northwestern University*; P.M. DeLuca,* Kopin

We describe the effects of glancing incidence (3°) 3-4 keV Ar ion bombardment on homoepitaxial growth on vicinal GaAs (001). The average adatom lifetime on surface terraces was measured during GaAs deposition using specular ion scattering. The lifetime was observed to decrease monotonically with increasing ion current density, e.g. from 1.8 to 0.8 s for a current density increased from 0.6 to 22 mA/cm2 at a temperature of 520C (GaAs miscut = 2.5). There was no measurable sputtering, and the results suggested that the Ga surface diffusivity was increased by the ions. The ion beam also suppressed scattered ion beam current oscillations, suggesting that the growth mode had changed from two-dimensional island nucleation to step-flow due to increased adatom surface diffusivity. The RMS roughness of 0.3 micron thick GaAs epitaxial layers, measured by atomic-force microscopy, showed a corresponding decrease from 0.5 to 0.25 nm due to ion bombardment. A simple model, involving direct momentum transfer from ions to adatoms parallel to the surface, is shown to be consistent with the measured diffusion enhancements.

8:40am **SS2-WeM2 Scattering of Hyperthermal O@super +@ Ions on a SiO@sub x@ Surface**, ***C.L. Quinteros,*** *T. Tzvetkov, D.C. Jacobs,* University of Notre Dame

Thin SiO@sub x@ films are grown on a Si(100) surface using a low current, hyperthermal (5-200eV) O@super +@ beam under UHV conditions. Scattered products are collected as a function of incident beam energy and angle, oxygen ion dose, temperature, and surface roughness. A rotatable quadrupole mass spectrometer detector resolves the energy-, mass-, and angular-distributions of the scattered species. Incident O@super +@ is efficiently neutralized, and both positively (Si@super +@, SiO@super +@) and negatively (O@super -@, O@sub 2@@super -@) charged products are formed. The product ion yields strongly increase with O@super +@ dose, as the oxide film develops. Individual features in the energy distributions of the scattered products are assigned to scattering events occurring at particular atomic sites on the surface. Product channel contributions originating from chemical reaction with incident O@super +@ and physical sputtering are differentiated.

9:00am **SS2-WeM3 Film Growth and Surface Modification by Low Energy Polyatomic Ions**, ***L. Hanley,*** University of Illinois at Chicago **INVITED**

Polyatomic ions with collision energies from 5 - 200 eV can be used to deposit films and modify surfaces in a highly controllable fashion. Low energy polyatomic ions are very surface selective, interact with surfaces via a unique collision dynamics, and can be used to transfer part or all of their chemical functionality to a surface. Ionization and mass-selection permits the facile preparation of a wide range of reactive species. Collision energy can be further used to control the final film properties. Examples discussed will include the deposition of 1) cross-linked fluorocarbon films on polystyrene by 25 - 100 eV CF@sub 3@@super +@ and C@sub 3@F@sub 5@@super +@ and 2) cross-linked organosiloxane films on Al by 15 - 100 eV Si@sub 2@O(CH@sub 3@)@sub 5@@super +@. Monochromatic x-ray photoelectron spectroscopy and contact angle measurements are used to determine film chemistry. Atomic force microscopy and x-ray reflectivity are used to determine film thickness and morphology. Oxidation and other aging processes are also examined for these films following air exposure for several weeks. Molecular dynamics simulations support the experimental results and compare the surface interaction process for different ion isomers. These results show that the size and structure of the depositing ion affects film formation via different chemical structure, reactivity, sticking probabilities, and energy transfer to the surface. These results also indicate that polyatomic ions and energetic neutrals likely play an important role in film deposition and surface modification during plasma polymerization, laser ablation of polymers, and sputter deposition of polymers.

9:40am **SS2-WeM5 Super-smooth Neutron Optical Surfaces By Gas Cluster Ion Beam Processing**, *L. Stelmack,* Epion Corporation and Northeastern University*;* ***L.P. Allen,*** Epion Corporation*; V. DiFilippo,* Epion Corporation and Tufts University*; J.A. Greer, D.B. Fenner, R. Chandonnet, J. Hautula, A. Kirkpatrick,* Epion Corporation

The neutron scattering research community has continuing need for advancing the technology required to produce improved neutron optical components, particularly in regard to increasing efficiency and reducing non-specular scattering from substrate surfaces and coating interfaces. A novel Ar gas cluster ion beam (GCIB) process was implemented in order to determine the effectiveness of the extreme GCIB surface smoothing technique as it applies to improving neutron optical component substrates and coatings. A matrix of GCIB smoothing conditions was applied on selected optical structures. Pre- and post-GCIB processed surfaces of Si, SiO2, Ni/Si, Ta, and Ni/Ta/ SiO2/Si substrates were examined with atomic force microscopy for surface roughness and overall film morphology. Silicon substrate surfaces coated with Ni were found to be consistently smooth to Ra ~1Å. In addition, results show that the Ni and Ta coated surfaces consistently achieved smoothness capable of supporting optical requirements for advanced neutron sources. The GCIB process parameters as applied to optical (SiO2, Ni/S, Al2O3), semiconductor (Si), and metallic (Cu, Ta, Ti, Ni) surfaces are shown to provide a predictable surface smoothness (Ra typically <3Å) for applications in a variety of material related fields.

10:00am **SS2-WeM6 Molecular Dynamics Simulation of Hyperthermal Ne@super +@ Scattering From Si(100)**, *J. Camden,* ***T. Tzvetkov,*** *C.L. Quinteros, D.C. Jacobs,* University of Notre Dame

An understanding of ion/surface energy transfer at hyperthermal energies is important to the semiconductor industry, where low-energy ion modification of surfaces is widely employed. In this paper, we present molecular dynamics simulations of Ne@super +@ scattering from Si(100) at hyperthermal energies (below 200eV). In the trajectory calculations, we use a Ne-Si potential consisting of pair-wise additive terms describing the repulsion between the projectile and all Si atoms within a slab, and a classical image charge attraction between Ne@super +@ and the bulk dielectric. The surface reconstruction is taken into account in the Si lattice simulation. A careful analysis of different trajectory contributions to the scattering signal is applied. The calculations for different surface conditions, including scattering from surface defects (steps, adatoms and vacancies), will be discussed. The calculations are compared to experimental results for Ne@super +@ scattering from Si(100) at energies ranging from 25 to 200 eV.

10:20am **SS2-WeM7 Laser Induced Reactivity of Ammonia on Silicon Surface**, ***T. Gonthiez,*** *P. Brault,* GREMI (University of Orleans-CNRS), France*; T. Gibert,* GREMI (University of Orleans), France

In the field of the growth of materials like Si@sub3@N@sub4@ or AlN, photochemical processes are of a great interest. A study of the reactivity of surface induced by laser of NH@sub3@ on Si(100) is undertaken. Laser fluence and NH@sub3@ pressure are low enough just to realize the first steps of the process. Experimental studies are performed in an ultra-high vacuum chamber. Gaz is introduce by a µ-leakage valve near the surface. A UV laser beam (266/355 nm) is used to activate reactions at gaz-surface interface or to desorb the surface for analysis. Due to initial surface contamination, reactions between NH@sub3@ and Si are self-limiting. Indeed O and C contaminant atoms tie up the surface dangling bonds leading to a passivation layer.@footnote1@ By Auger Electron Spectroscopy, we find that laser irradiation on Si cleans the surface and regenerates the dangling bonds. Analysis of the desorbed species during or after the reaction provides information on reactions at surface. The flying ionic species are directly detected by a quadrupolar mass spectrometer and the neutrals are postionized by a tunable laser. The resonant or non-resonant post-ionization techniques are useful to measure Time-of-Flight distribution of flying species by adjusting the delay between desorption and probe laser. TOF distributions can be fitted by suitable velocity distribution and this allows the determination of kinetic temperature.@footnote2@ This temperature has been shown to be the surface temperature during the laser interaction. Direct measurements of flying ions show several species and mainly Si@sub2@N, Si@sub2@NH, Si@sub2@NH@sub2@ and Si@sub2@NH@sub3@. Comparison between silicon TOF signal with and without NH@sub3@ is expected to give more insight in the nitride bond formation. @FootnoteText@ @footnote 1@Ph.Avouris, F.Bozso, RJ Hamers - J.Vac.Sci.Techno.B 5(5), Sept/Oct 1987;

1387-1392 @footnote 2@ T.Gibert, B.Dubreuil, MF.Barthe, JL Debrun-J.Appl.Phys 74, 3506 (1993).

10:40am **SS2-WeM8 Interaction of Laser Impulse with YBA@sub2@CU@sub3@O@sub7@ Target and Generation of Four Element Plasma**, ***I.Yu. Davletov***, Urganch State University, Uzbekistan; *M.R. Bedilov, R.M. Bedilov,* Tashkent State University, Uzbekistan

In this work the results of studies of interactions of laser radiation with HTSC-targets are presented. The experiments have been performed by using a laser mass-spectrometer and HTSC-materials in the from of tablets of 1,0 cm diameter and thickness 0,5 cm. It was established experimentally that along with heating, destroying and evaporation of the target under interaction of the laser radiation at q>10@super9@ W/cm@super2@ with HTSC-targets, the four element plasma has been formed. Mass, charge, velocity, time and energy spectra of ions emitted from HTSC-target were studied in a wide range of the laser power. It was revealed that mass-spectra of HTSC-target atom ionized by the laser radiation contained not only one-charged ion peaks of basic element of the target but also signals of multiply charged atoms of the elements. The experiment showed, that ions with Z>1 are emitted from the HTSC-target by one-electron mechanisms of ionization of the four-element target by the laser radiation in the range of 10@super8@ W/cm@super2@ - 10@super11@ W/cm@super2@ (branch feature). Note that the formation of target ions Y@super+1@ , Cu@super+1@, Ba@super+1@, O@super+1@ begins at the power density of the laser radiation q@super8@ W/cm@super2@, and Cu@super+2@, Y@super+2@ at q@super2@ W/cm@super2@. The charge and energy distributions of the multicharged ions of the HTSC-target are determined by processes of triple recombination and energy exchange of non. Coulombic collisions between them. The energety spectra of the HTSC-target ions are analogous to those of a mono-element target, but the decreasing of the maximal energy of the ions of each multiplicity resulted from energetic losses due to Coulombic collections. The influence of oxygen state in the HTSC-target is established.

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