

## Sym. H : The Surface, Interface & Nano-structure of Materials NANO-STRUCTURE

### B-THU-02

SILICON NANO-STRUCTURES VIA SELECTIVE SURFACE CHEMICAL REACTIONS UNDER ULTRAHIGH VACUUM, WAN SOO YUN, JEONG SOOK HA, KANG-HO PARK, and EL-HANG LEE (Basic Research Laboratories, ETRI, Taejeon 305-600, Korea)

We have investigated the formation of silicon nano-structures by nitridation and oxygen etching of silicon surface using STM and LEED. Silicon nitride islands with diameters of 6-15 nm were formed by dosing low energy nitrogen ions onto Si(111)-7x7 surface. These islands sustained oxygen exposure at high temperatures between 700 and 800 °C, while the bare silicon surface area was selectively etched away, leading to the formation of silicon nano-pillars as high as 2-3 nm. The atomic structures as well as the passivated I/V characteristics of the silicon nitride islands remained unchanged after reaction with oxygen gas at high temperatures. This result suggests that only a monolayer-thick silicon nitride islands can be used as successful masks for oxygen etching. In addition, the formation of silicon nitride islands via thermal nitridation of Si(111) surface by N<sub>2</sub> gas exposure at temperatures between 600 and 950 °C was investigated and the underlying growth mechanism was envisioned. Furthermore, these thermally grown silicon nitride islands were used as masks for oxygen etching and this was compared with the case of nitrogen ion dose. This study implies a high potential of surface chemical reactions for application to the formation of silicon nano-structures such as dots, pillars, and wires.

### B-THU-03

Crystal Growth Study Using Combination of Molecular Dynamics and Monte Carlo, MASAO DOYAMA (Teikyo University of Science & Technology, Uenohara, Yamanashi 409-0193 Japan) Atomic diffusion on a surface is much easier than that in bulk. In bulk, a vacancy has to come to one of the nearest neighbor sites of the atom to move. The activation energy for the diffusion of add-atom is much lower than that of self-diffusion. Consider the (111) surface of a face centered cubic metal. There are two kinds of atomic sites for an add-atom on the (111) plane. One is a face centered site (F) which forms a face centered lattice and the other is a hexagonal site (H) which forms a hexagonal lattice. The activation energy for the motion of an add-atom from an F site to an H site  $E_{FH}$  is higher than that from an H site to an F site  $E_{HF}$ . This process comes alternatively. An add-atom diffuses until forming an add-atom cluster. After forming a cluster, the motion becomes much slower.

### B-THU-04

Na-INDUCED 3x1 RECONSTRUCTION OF THE Ge(111) SURFACE STUDIED BY SCANNING TUNNELING MICROSCOPY, Geun Seop Lee (Material Evaluation Center, KRISS, Taejeon, 305-600, Korea), Jong Geol Kim (Univ. of Utah, Salt Lake City, UT, USA), and R. F. WILLIS (Pennsylvania State Univ., University Park, PA, USA)

A scanning tunneling microscopy (STM) has been used to study the Na-induced (3x1) reconstruction of the Ge(111) surface. Both filled- and empty-state images of Ge(111) 3x1-Na consisted of zigzag chain-like double rows of atoms. In particular, the empty state image of the Na-induced 3x1 reconstruction with atomic resolution is for the first time presented. While the filled state image of Ge(111)3x1-Na is very similar to that reported for Si(111) 3x1-Na, the empty state image shows the distinct difference. The dual-polarity images taken simultaneously revealed detailed characteristics, a lateral shift and phase reversal of the rows upon polarity reversal. They are attributed to the evidence for a  $\pi$ -bonded Si(111)-2x1 and also proposed in theoretical model structures of 3x1 reconstruction. The interpretation of the images in comparison with existing models will be discussed.

### B-THU-05

SURFACE GLASS TRANSITION BEHAVIORS OF AMORPHOUS POLYMER FILMS ON THE BASIS OF SCANNING FORCE MICROSCOPY, T. KAJIYAMA and A. TAKAHARA (Department of Materials Physics and Chemistry, Graduate School of Engineering:Kyushu University; Hakozaki, Higashi-ku, Fukuoka 812-8581, Japan)

Surface molecular motions of amorphous polymeric solids have been directly measured on the basis of scanning viscoelasticity microscopic(SVM) and lateral force microscopic(LFM) measurements. SVM and LFM measurements of the monodisperse polystyrene (PS) films at room temperature revealed that in the case of the number-average molecular weight,  $M_n$  less than ca.30k, the surface was in a glass-rubber transition state even though the bulk glass transition temperature,  $T_g$  was far above room temperature, resulting in that the surface molecular motion was fairly active compared with the bulk one. LFM measurement of the monodisperse PS films at various scanning rates and temperatures revealed that the time-temperature superposition was applicable to the surface mechanical relaxation behavior and also, the surface  $T_g$  was depressed in comparison with the bulk one even though the magnitude of  $M_n$  was fairly high as 140k. The active thermal molecular motion at the polymeric solid surface can be interpreted in terms of excess free volume near the surface region induced by the surface localization of chain end groups. The chain end group localization at the air/PS interface was directly verified from the dynamic secondary ion mass spectroscopic analysis of the end-labeled PS film.