Wednesday Morning Poster Sessions, October 4, 2000

Semiconductors
Room Exhibit Hall C & D - Session SC+EL+SS-WeP
Poster Session

SC+EL+SS-WeP1 Selectivity in Attachment of a Model pi-conjugated Organic Molecule to a Group IV Semiconductor Surface: Styrene on Si(001)*, **M.P. Schwartz**,* University of Wisconsin, Madison*; M.D. Ellison,* Wittenberg University*; S.K. Coulter, R.J. Hamers,* University of Wisconsin, Madison

The bonding of styrene to the Si(001) surface has been investigated as a model system for understanding selectivity in the attachment of conjugated pi-electron systems to semiconductor surfaces. Scanning tunneling microscopy images show one primary bonding configuration, slightly off-center from the middle of a dimer row. Infrared spectra using isotopically-labeled styrene establish that attachment occurs in a highly selective way, bonding through the external vinyl group and leaving the aromatic ring almost completely unperturbed. The implications for the high degree of selectivity in understanding attachment of other conjugated pi-electron systems are discussed.

SC+EL+SS-WeP2 Ferrocene and Decamethylferrocene Adsorption and Decomposition on Ag(100) and Si(111)*, **C.M. Woodbridge**, D.L. Pugmire,* University of Nebraska, Lincoln*; N.M. Boag,* University of Salford*; M.A. Langell,* University of Nebraska, Lincoln

Although metallocenes show potential as Chemical Vapor Deposition (CVD) source molecules, there is comparatively little known about their interactions with oriented substrates. We have investigated the adsorption and decomposition of ferrocene (FeCp@sub 2@) and decamethylferrocene (FeCp@sub 2@*) on Ag(100) and Si(111) using High Resolution Electron Energy Loss Spectroscopy (HREELS), Temperature Programmed Desorption (TPD), and X-ray Photoelectron Spectroscopy (XPS). For weakly-interacting systems such as those which occur with Ag(100), both FeCp@sub 2@ and FeCp@sub 2@* are adsorbed molecularly at 130 K. Monolayers of both FeCp@sub 2@ and FeCp@sub 2@* are oriented such that their molecular axes are perpendicular to the plane of the Ag(100) substrate; monolayer desorption occurs at approximately 250 K for both metallocenes. While FeCp@sub 2@ desorption is clean, FeCp@sub 2@* shows significant amounts of metallocene dissociation competing with molecular desorption. The Si(111)/metallocene systems also show molecular adsorption at 130 K but are more reactive to thermal decomposition upon heating and decompose primarily through hydrogenation and ligand-metal dissociation mechanisms. Specific information about the orientation of the adsorbed species and decomposition intermediates will be discussed.

SC+EL+SS-WeP3 Lowering of Processing Temperature due to a High Pressure Deuterium Anneal for Improved CMOS Hot Carrier Reliability*, **J. Lee**, K. Cheng, K. Hess, J.W. Lyding,* University of Illinois, Urbana*; Y.K. Kim, Y.W. Kim, K.P. Suh,* Samsung Electronics Co., Ltd.

The deuterium (D) isotope effect has been found to be very effective in reducing hot carrier induced degradation in CMOS transistors of numerous technologies. The magnitude of lifetime improvement (10x to 100x) varies from one technology to the other, but it directly correlates with D incorporation at the gate SiO@sub 2@/Si interface. Secondary ion mass spectrometry (SIMS) depth profiling has been used to make this determination. We have recently implemented high pressure D annealing to enhance its incorporation at the interface. By increasing the D pressure, the concentration at the interface can be increased for a fixed annealing temperature. Consequently, lower temperatures and shorter anneal times can achieve equivalent transistor reliability. This promises to be a technologically significant result for future CMOS production which requires a much lower thermal budget process due to the introduction of advanced materials (e.g. low k dielectrics) and increased number of metal layers. This high pressure annealing technique has been applied to one of the most recent CMOS technologies from Samsung Electronics. For these short-channel (0.18 µm) and low operating voltage (1.5V) devices, the isotope effect is substantially enhanced (700x). Rather than being scaled away, deuterium reduction of hot electron damage appears more relevant in future generations of CMOS integrated circuits. In the current work, the annealing temperature has been lowered from 450@degree@C to 350@degree@C. Although the lifetime improvement is not as great, we do observe a significant lifetime improvement (300x) just from changes in pressure. More experiments are in progress to maximize the D incorporation at the low annealing temperature. In addition, SIMS depth profiles are being determined for devices that were sintered at different annealing conditions.

SC+EL+SS-WeP4 Investigation of the Penetration of Atomic Hydrogen from the Gas Phase into a SiO@sub 2@/GaAs System*, **V.A. Kagadei**,* Research Institute of Semiconductor Devices, Russia*; E.V. Nefedtsev,* Tomsk University of Control Systems and Radioelectronics, Russia*; D.I. Proskurovsky,* Institute of High Current Electronics, Russia

Introduction of hydrogen into near-surface layers of semiconductor materials (hydrogenation) substantially varies their properties. In some cases hydrogenation improves the electrophysical parameters of the material and allows one to create devices with improved characteristics, while in other cases the penetration of hydrogen into a solid accompanies a technological process and causes unwanted changes in the parameters of the material. Therefore, it appears urgent to investigate the penetration of hydrogen into a semiconductor material, and a better understanding of this process will make it possible to optimize the technology of hydrogenation. The hydrogenation of GaAs samples coated with thin (5 nm) SiO@sub 2@ film was investigated. Samples were treated in a flow consisting of a mixture of atomic and molecular hydrogen produced by a source whose operation is based on a reflected arc discharge with a hollow cathode and a self-heating element. The hydrogenation time was 5 - 30 min, the hydrogenation temperature was 150 - 300 C, and the hydrogen pressure was varied from 10@super -1@ - 10@super -3@ Pa. It has been established that an increase in discharge current results in an increase in the concentration of atomic hydrogen in the gas phase, N, and in a decrease in the number of atoms penetrating into samples, and this is in contradiction with the usual notions about the penetration of hydrogen atoms into a solid. The data obtained suggest that the amount of hydrogen penetrating into samples is more dependent on the probability of the penetration of hydrogen atoms into a solid body, F, rather than on N. It has been proposed that F decreases substantially with decreasing the energy of the hydrogen atoms arriving at the solid surface. The energy of the atoms emerging from the reflected-arc-discharge-based source is estimated to vary between 0.1 and 10 eV. It is determined by the operating voltage of the discharge and decreases with increasing discharge current. Another possible cause of the observed phenomena is the formation of a near-surface diffusion barrier constituted by immobile hydrogen molecules, which occupy interstitials and retard the diffusion of atoms. The contribution of each of the proposed mechanism is discussed.

SC+EL+SS-WeP5 a-SiC:H Thin Films Fabricated by the High Rate Deposition Method*, **B.G. Budaguan**, A.A. Sherchenkov,* Moscow Institute of Electronic Technology, Russia*; A.A. Berdnikov, V.D. Chernomordic,* Institute of Microelectronics of Russian Academy of Science*; A.A. Aivazov,* UniSil Corp.

The a-SiC:H alloys are considered to be a perspective wide band gap material for different optoelectronic utilization. For the commercial application it is necessary to increase the deposition rate. However the increase of the growth rate results in the increase of structural inhomogeneity and in the deterioration of electronic properties of amorphous layers. Recently we have shown that deposition rate of a-Si:H films with high electronic properties can be increased with using of low frequency (55 kHz) glow discharge. In this work we investigated the growth mechanism and microstructure of a-SiC:H thin films fabricated for the first time by this method. The a-SiC:H films were deposited at different methane content from 0 to 100%, substrate temperatures T@sub s@ from 160 to 320 °C, and different discharge regimes: continuous wave and square wave modulated (SQWM). It was shown that the increase of the deposition rate of a-SiC:H films (5.3-11.1 Å/s depending on the methane content in gas mixture) in comparison with the standard deposition technology (3 Å/s for 13.56 MHz PECVD) is caused by the close position of a-SiC:H precursors formation to the growth surface. The joint analysis with using of infrared/optical spectroscopy and atomic force microscopy measurements showed that a-SiC:H films has the island type microstructure where the clustering of C atoms occurs at the island surfaces in the form of C-H@sub n@ bonds. The increase of C-H@sub n@ configurations on islands surfaces at high C content facilitate the relaxation of rigid a-SiC:H network through formation of flexible sp@super 2@-sites. The incorporation of Si-C bonds in the interior of islands determines the optical bandgap while the clustering of CH@sub n@ and SiH at the islands surface leads to the formation of graphite-like microstructure. It was shown that the suppression of formation of graphite-like microstructure at low T@sub s@ and in SQWM plasma allows to fabricate device quality alloys.

SC+EL+SS-WeP6 Mechanism for and Site of the Dissociative Chemisorption of XeF@sub 2@ on Si(100)2x1 Below 1 ML of Fluorine Coverage*, **J.R. Holt**, R.C. Hefty, M.R. Tate, S.T. Ceyer,* Massachusetts Institute of Technology

Upon exposure of a clean Si(100)2x1 reconstructed surface to a beam of xenon difluoride incident with an average kinetic energy of 0.9 kcal/mol, the XeF@sub 2@ dissociatively chemisorbs by atom abstraction solely on the Si dangling bonds up to a fluorine coverage of one monolayer (ML) before it begins to react with the Si-Si lattice bonds. This conclusion is based on the observations of scattered XeF and the preservation of the 2x1 dimer row reconstruction at 1 ML fluorine coverage. The scattered XeF is detected by a line-of-sight and differentially pumped mass spectrometer while the order of the surface is monitored by He diffraction. A clean Si(100)2x1 surface is characterized by three primary features in a He diffraction spectrum: a specular feature due to the smoothness and general order of the surface, a half-order feature due to diffraction perpendicular to the dimer rows, and a first order feature due to diffraction parallel to the dimer rows. The presence of the half-order feature at a fluorine coverage of 1 ML provides evidence that even the Si-Si sigma dimer bonds are undisturbed, preserving the original dimer rows. The reaction exothermicity of approximately 230 kcal/mol does not destroy the surface order. Molecular fluorine has previously been observed to react with a clean Si(100)2x1 surface in a similar manner by atom abstraction, saturating the Si dangling bonds at a coverage of 1 ML. The 2x1 periodicity is maintained. However, after saturation of the dangling bonds, F@sub 2@ ceases reacting with the surface while XeF@sub 2@ continues to deposit fluorine on the surface by its reaction with the Si-Si sigma dimer bonds and the Si-Si lattice bonds. The surface order is destroyed as a result of the continued fluorine deposition and ultimately etching occurs by the formation of volatile SiF@sub 4@.

SC+EL+SS-WeP7 STM Investigations of the Initial Ad- and Desorption Sites of Molecular Hydrogen on Si(001)*, **M. Dürr**,* Philipps University Marburg, Germany*; A. Biedermann, Z. Hu,* Columbia University*; U. Höfer,* Philipps University Marburg, Germany*; T.F. Heinz,* Columbia University

Whereas the extremely small sticking coefficients for dissociative adsorption of H@sub 2@ on Si surfaces indicate a high, the almost thermal energy distribution of the desorbing H@sub 2@ molecules points to a low barrier in the reaction channel. Recent molecular beam experiments have shown that this apparent contradiction is in full accordance with the principle of detailed balance and can be understood in terms of phonon-assisted sticking.@footnote 1@ To shed light on the underlying microscopic mechanisms, we have adsorbed H@sub 2@ on Si(001) at temperatures below the onset of H diffusion and investigated the site distributions with scanning tunnelling micrcoscopy (STM). The STM images show configurations of 4 adsorbed H atoms indicating a two-step process with an inter-dimer rather than the commonly assumed intra-dimer adsorption path as the relevant initial step. In the inter-dimer path, H@sub 2@ interacts with two dangling-bonds on adjacent Si dimers and forms a transition state with relatively large lattice distortion. Single-shot laser-induced thermal desorption experiments from nearly perfect hydrogen monolayers reveal distributions of unsaturated dangling bonds which indicate that the reverse path is also active in desorption. The influence of coverage, minority reaction channels as well as the consequences of the results on the reaction kinetics will be discussed. @FootnoteText@ @footnote 1@ M. Dürr, M. B. Raschke, and U. Höfer, J. Chem. Phys. 111, 10411 (1999).

SC+EL+SS-WeP8 Photoemission Study on Initial Oxidation of Si(001) Surfaces with Supersonic O@sub 2@ Molecular Beams*, **Y. Teraoka**,* Japan Atomic Energy Research Institute, Japan*; A. Yoshigoe,* Japan Atomic Energy Research Institute

We made a new surface reaction analysis apparatus at a soft x-ray beamline (BL23SU) in the SPring-8 (Super Photon ring-8GeV) to study incident energy effects for reactant chemisorption on semiconductor surfaces. As the first step, initial oxidation of Si(001) with O@sub 2@ has been investigated because that is not only interesting for surface reaction analysis but also important as electronic device development. The maximum incident energy was 3 eV in calculation. The clean Si(001) surfaces were irradiated by the supersonic O@sub 2@ molecular beams with various incident energy to achieve saturated adsorption. The oxygen amount on the surface was evaluated by measuring O-1s photoemission intensity. The intensity depended on the incident energy and two thresholds of 1.0 eV and 2.6 eV were found. These values are very resemble to the predicted values of 0.8 eV and 2.4 eV from the first-principles calculation, showing potential energy barriers for dimer backbond oxidation and oxygen insertion between the second and the third layer. Si-2p photoemission spectra were obtained at room temperature and 873 K by using high resolution soft x-rays from the beamline. In the case of room temperature, the maximum silicon oxidation number increased with increasing the incident energy from Si@super 2+@ to Si@super 4+@. Whereas a peak corresponding to SiO@sub 2@ was minor even in the case of 2.9 eV at room temperature, the peak was apparent in 873 K cases. Thermal energy may drive oxygen migration to form the SiO@sub 2@ structure. Even at such high temperature, incident energy affected in sub-oxide peak composition. The sub-oxide peak for Si@super 3+@ was increased with increasing the incident energy and was dominant in the case of 2.9 eV whereas the peak for Si@super 2+@ was primary in the case of 0.6 eV. The variation may be resultant from the Si@super 3+@ increase due to oxidation of dimer and sub-surface silicon atoms depending on the incident energy.

SC+EL+SS-WeP9 The Effect of Time and Moisture on the Adhesion Bond between Silica Particle and Silicon Oxide Substrate*, **J.W. Feng**, A.A. Busnaina,* Clarkson University

Adhesion of silica particles to silicon wafers is a problem that affects semiconductor manufacturing processes. The particle adhesion forces are greatly affected by the environment such as humidity, temperature and adhesion induced stress between the particle and the wafer following the particle deposition. The adhesion forces considered in the process include van der Waals, capillary force, double layer force and hydrogen bonding. In this study, silica particles are deposited onto wet and dry thermal oxide silicon wafers, then the samples are aged in different relative humidity environments. Results show that the largest increase in contact area between silica particles and thermal oxide wafers occur when the particle is first deposited on wet surface then aged in relative humidity above 55%. Higher humidity, results in higher adhesion force and lower removal efficiency. Results also indicate that adhesion force increases by more than two order of magnitude after the aging process. This suggests that hydrogen and covalent bonds are responsible for the increase in the adhesion force especially in humid environments.

SC+EL+SS-WeP10 Influence of Growth Direction on Order-Disorder Transition in (GaAs)@sub (1-x)@(Ge)@sub 2x@ Semiconductors*, A.G. Rodriguez, **H. Navarro-Contreras**, M.A. Vidal,* University, Mexico

We provide direct evidence of the dependence on the growth direction of the critical concentration of IV atoms at the order-disorder transition in ternary metastable (III-V)-IV, zincblende-diamond semiconductor alloys. The excellent agreement between the experimental and model predicted critical concentrations is evidence that the atomic ordering in these alloys is ruled almost entirely by substrate geometry. We report the observation of the critical concentration dependence on substrate orientation in (GaAs)@sub (1-x)@(Ge@sub 2@)@sub x@ metastable alloys, epitaxially grown on (001), (111), (112) and (113) GaAs. A different long-range order parameter behavior with Ge concentration is obtained for each growth direction, 0.36, 0.96, 0.59, and 0.50 ± 0.03, respectively, numbers that compare well with results of a Montecarlo simulation of the growth, 0.33, 1.0, 0.64 and 0.54, respectively.

SC+EL+SS-WeP11 Surface Electronic Structure of p-type GaN(000-1)*, **P. Ryan**, Y.C. Chao, K.E. Smith,* Boston University

Our investigation sought to describe the surface electronic characteristics of MBE grown (Mg-doped) wurtzite p-GaN (0001'). Four surface bands were mapped within the surface Brillouin zone. The peaks have been removed by atomic hydrogen exposure and three of the peaks show pz orbital configuration, the fourth an s orbital. The most interesting peak is a highly dispersing surface state which sweeps from the bulk valence band into the forbidden bulk band gap, approaches the Fermi level then returns to the bulk valence band. We compare this state to previously predicted mid-gap surface states.

SC+EL+SS-WeP12 Ultrafast Dephasing of Coherent Phonons by Lattice Defects in n-GaAs*, **M. Kitajima**, M. Hase, K. Ishioka,* National Research Institute for Metals, Japan*; K. Ushida,* RIKEN, Japan

GaAs is a key material for ultrafast switching and THz radiation because the carrier lifetime of low-temperature grown (defective) GaAs is ultrafast (sub-picosecond). In doped GaAs, the plasmon and the LO phonon form coupled modes through Coulomb interactions, and the frequencies of the LO phonon-plasmon coupled (LOPC) modes depend on the carrier density. We report the effect of active lattice defects on dephasing of coherent LOPC modes in He-ion irradiated n-GaAs by using a femtosecond pump-probe technique. The time-domain oscillations of the coherent LOPC modes in He@super +@ irradiated n-GaAs have been precisely measured for the different ion doses. The samples used were n-type GaAs with carrier density of ndop= 1.4x10@super 18@cm@super -3@. In order to examine the effect of point defects, 5 keV He@super +@ were irradiated to n-GaAs samples at doses of 9.4x10@super 12@ and 3.0x10@super 14@ He@super +@/cm@super 2@ in a UHV chamber with base pressure of 3x10@super -9@ Torr. The light source was a mode-locked Ti:sapphire laser with a pulse width of 25 fs. The anisotropic reflectivity change revealed coherent oscillations which shows beating pattern for the as-grown n-GaAs. This beating pattern in the time-domain data is due to an existence of the strong LO mode and the L@sub -@ mode. The mode beating changed clearly as increasing the ion dose, and the pattern of the Lmode disappeared at doses higher than 3.0x10@super 13@ He@super +@/cm@super 2@. The results suggest that defect-induced carrier trapping dominate annihilation of the coherent coupled modes. In addition we will also discuss on an anormalous behavior of dephasing of the coherent LO-phonon.

SC+EL+SS-WeP13 High Density Plasma Via Hole Etching In SiC*, **H. Cho,*** Miryang National University, South Korea*; K.P. Lee, P. Leerungnawarat,* University of Florida*; S.N.G. Chu,* Lucent Technologies, Bell Laboratories*; F. Ren,* University of Florida*; C.-M. Zetterling,* Royal Institute of Technology (KTH), Sweden*; S.J. Pearton,* University of Florida

Through-wafer vias ~100µm deep were formed in 6H-SiC substrates by Inductively Coupled Plasma etching with SF@sub 6@/O@sub 2@ at rates up to 0.8 µm·min@super -1@ and employing Al masks. Selectivies of @>@40 in SiC over Al were achieved. Electrical (C-V, I-V) and chemical (AES) analysis techniques showed that the etching produced only minor changes in reverse breakdown voltage, Schottky barrier height and near-surface stoichiometry of the SiC and had high selectivity over common front side metallization. The SiC etch rate and etch yield were measured as a function of plasma composition along with the selectivity over Al. This process is attractive for power SiC transistors intended for high current, high temperature applications.

SC+EL+SS-WeP14 RHEED Study of Ion-beam Induced Carbonization for 3C-SiC Heteroepitaxial Growth on Si(100)*, **N. Tsubouchi**, A. Chayahara, A. Kinomura, Y. Horino,* Osaka National Research Institute, Japan

3C-SiC heteroepitaxial film formation on a Si substrate is a very important when we consider compatibility with the silicon fabrication technology. So far, it has been reported that a carbonization process as buffer layer formation using various film-growth methods is effective for the heteroepitaxial film growth of 3C-SiC on Si while the lattice mismatch between 3C-SiC and Si is as large as 20 %. These methods reported for this reaction process, however, require high-temperatures ranging 700--1000°C, causing serious problems of redistribution of dopants and crystal defects such as dislocations and stacking faults especially at the heterointerface. In addition, carbonization reaction between provided gases including carbon atoms and Si substrates also results in promotion of defect formation in the Si-SiC interface. For solving these problems, a newly process, that is, ion-beam induced carbonization process of Si(100) with mass-separated energetic carbon ion species (e.g., @super 12@C@super -@, @super 12@C@sub 2@@super -@, @super 12@C@super +@ ions) was tried and investigated by RHEED measurements. The kinetic energies of ions and substrate temperatures were in the range 20-1200 eV and 400-700 °C, respectively. Such energetic species have possibility to lower a growth temperature inducing a decrease in defects and dislocations at the SiC/Si interface, in comparison with conventional methods. We report on the SiC growth condition during the carbonization process, i.e., ion-beam energy and substrate temperature dependence together with structural information.

SC+EL+SS-WeP15 Auger Depth Profile Analysis: Process Window Definition of 0.2 micron Aluminum RIE Interconnections*, **C. Dziobkowski**, L. Clevenger,* IBM Corporation*; M. Honda,* Toshiba, Japan*; R. Ramachandran,* Infineon Technologies

For fabrication of devices with dimensions of less than 0.2 microns, processing requirements become more demanding. New design requirements for the 256 Mbit DRAM also have higher aspect ratios. Process temperature control becomes very important because of the effects of temperature on the RIE etch, theta-Al2Cu precipitate distribution and texture. Eventually, even the electrical properties are affected resulting in device shorts and open circuits. This paper gives a description of the methodology developed to provide Auger depth profile analysis to characterize the copper distribution in the AlCu metallurgy. Copper segregation at the Al/Ti interface also affects the RIE process etching window. The information obtained from the Auger depth profiles can be used to define a window for VLSI devices with these small dimensions.

SC+EL+SS-WeP16 Epitaxial Growth of Cubic SiC Thin Films on Silicon Using New Single Molecular Precursors by MOCVD*, **J.-H. Boo**, S.-B. Lee,* Sungkyunkwan University, Korea*; K.-W. Lee, Yunsoo Kim, K.-S. Yu, S.H. Yeon, I.N. Jung,* Korea Research Institute of Chemical Technology, Korea

Heteroepitaxial cubic SiC thin films have been deposited on silicon substrates at temperatures in the range of 750 - 1000 ° C using newly developed single molecular precursors by MOCVD method. Single-crystalline, crack-free stoichiometric cubic SiC films were successfully grown on both Si(001) and Si(111) substrates without surface carbonization at as low as temperature of 920 ° C with 1,3-disilabutane (DSB), H@sub 3@Si-CH@sub 2@-SiH@sub 2@-CH@sub 3@, as a liquid single source precursor which contains silicon and carbon in 1:1 ratio. Cubic SiC thin films highly oriented in the [001] direction were also obtained on Si(001) using either a liquid mixture of 1,3,5-trisilapentane (TSP), H@sub 3@Si-CH@sub 2@-SiH@sub 2@-CH@sub 2@-SiH@sub 3@, and 2,4,6-trisilaheptane (TSH) at 980 ° C or 2,6-dimethyl-2,4,6-trisilaheptane (DMTSH), H@sub 3@C-SiH(CH@sub 3@)-CH@sub 2@-SiH@sub 2@-CH@sub 2@-SiH(CH@sub 3@)-CH@sub 3@ at 950 ° C without carrier gas. These growth temperatures were much lower than conventional CVD growth temperatures, and this is the first report of cubic SiC film growth using the single molecular precursors of trisilaalkanes.

SC+EL+SS-WeP17 Optical and Contact Properties of Indium Tin Oxide on p-GaN*, **D.W. Kim**, Y.J. Sung, J.W. Bae, G.Y. Yeom,* Sungkyunkwan University, Korea*; H.S. Kim,* University of Strathclyde, Scotland

Because Gallium nitride(GaN) is an attractive material which has an wide direct band gap, GaN-based optoeletronic devices such as light emitting diodes(LEDs) and laser diodes(LDs) in blue and ultraviolet wavelength regions have been studied intensively and fabricated successfully. However, the contacts to GaN-based LEDs are currently made by depositing metal layers on the top of GaN-based LEDs, therefore, significant optical loss is inevitable. In this study, we applied multilayers containing transparent conducting oxide such as indium tin oxide(ITO) to p-GaN and the effect of the optically more transparent contacts to p-GaN on the electrical and optical properties were investigated. As substrates, Mg-doped p-GaN layers were used. ITO thin films were deposited on p-GaN at room temperature using an oxygen radical assisted electron beam evaporator system. To improve the contact properties to p-GaN, various ITO/very thin metal multi-layer contact systems were also attempted and their electrical, structural, and optical properties were investigated. A semiconductor parameter analyzer and a four point probe were used to measure contact and electrical properties of ITO and mutilayer films on p-GaN. X-ray diffractometry(XRD) and Auger electron spectroscopy(AES) were used to investigate the structural properties of the contact during the annealing process, and an optical spectrophotometer was used to investigate the optical properties. The deposited ITO thin films showed the optical transmittance above 80 % at 420 nm(blue) with the sheet resistance of 40 ohm/sq. With ITO contact to p-GaN alone, Schottky contacts were generally obtained. However, depending on the applied very thin metal inter-layer and followed annealing conditions, different electrical and contact properties, which could be applicable to GaN devices, were obtained.

SC+EL+SS-WeP18 Visible Emission from Electroluminescent Devices using an Amorphous AlN:Cu, Mn, and Cr Thin Film Phosphor*, **M.L. Caldwell**, V.I. Dimitrova, M.E. Kordesch, H.H. Richardson, P.G. Van Patten,* Ohio University

Electroluminescence (EL) studies of AlN:Cu, Mn, and Cr alternating-current thin-film electroluminescent (ACTFEL) devices were performed at 300 K. Thin films of Cu, Mn, and Cr doped AlN, ~ 200 nm thick, were grown on p-doped silicon (111) substrates using RF magnetron sputtering in a nitrogen atmosphere. A transparent layer utilizing indium tin oxide was employed as the top layer contact. A strong bluish-green emission from the AlN:Cu films was observed under reverse bias due to electron impact excitation of the Cu atoms. The emission spectrum consisted of one broad peak in the visible region of 475 nm. a strong red emission from the AlN:Mn films was observed also under reverse bias due to electron impact excitation of the Mn atoms. There were two sharp emission peaks in the visible region at 680 nm and 700 nm. Studies of incorporationg the Cr@super +3@ ion will be performed to try to overcome the charge compensation problem. Temperature-dependent cathodoluminscence (CL) and photoluminscence (PL) studies will be performed between 30 - 450 K to determine the relationship of them to the EL results and show the optimum conditions for device performance.

SC+EL+SS-WeP19 Organic Contamination Removal on Silicon Substrate by Low Temperature Remote Plasma*, **H. Kang**, H. Soh, H. Seo, Y.C. Kim,* Hanyang University, Korea*; H. Jeon,* Hanyang University, Korea, South Korea

Organic contamination on silicon substrate deteriorates the film adhesion and forms deleterious decomposition during heating process. Organic impurities absorbed on the Si substrate surface generally desorbes in the form of volatile compounds by radio frequency (RF) remote oxygen and hydrogen plasma at relatively low temperatures. In this study, organic contamination removal and Si substrate surface microroughness by RF remote oxygen and hydrogen plasma will be described. The remote plasma system and analysis systems were connected by ultrahigh vacuum transfer system to avoid recontamination such as carbon absorption in the air. Organic impurity were intentionally contaminated and removed by hydrogen and oxygen remote plasma system. Surface contamination concentration and bonding state changes were analyzed by Auger electron spectroscopy (AES) and x-ray photoelectron spectroscopy (XPS). Surface morphology and microroughness were observed by scanning tunneling microscope (STM) and atomic force microscope (AFM). After remote hydrogen and oxygen plasma cleaning, carbon impurity was significantly reduced below detection limit of AES and the Si-C peaks of XPS were not observed. The surface microroughness generally degraded with increasing plasma power and exposure time.

SC+EL+SS-WeP20 Studies of the Surface Morphology, Chemical and Structural Changes of Ion Bombarded Silicon Carbide*, **P. McCarty**,* University of Alabama, Huntsville*; C.I. Muntele, I. Muntele,* Alabama A&M University*; M.A. George,* University of Alabama, Huntsville*; D. Ila,* Alabama A&M University*; D.B. Poker, D.K. Hensley,* Oak Ridge National Laboratory

Silicon carbide is gaining increasing interest for high temperature/harsh environment applications including miniature integrated sensors. In the past few years, efforts have been made toward controlling the defects and impurification that occur during various growth and fabrication processes. This work is intended to analyze the surface damage that occurs during ion implantation of silicon carbide, and the evolution of these defects. In order to correlate the effects that surface damage has on the sensing properties of ion implantation based silicon carbide gas sensors we have characterized these sensors under various conditions. We present the results of our investigation of the morphological, electrical and spectroscopic characteristics of ion implanted silicon-face 6H-SiC. In this work we have used He, O, Pd, and Au at energies between 100 keV to 8 MeV at fluences between 1 x 1015/Cm2 to 3 x 1017/Cm2. The ion bombardments were performed at both room temperature (300oK) and at elevated temperature (773oK). Atomic force microscopy, surface potential measurements and electric field microscopy was performed before and after ion implantation, as well as after the post-implantation high temperature annealing. This study is correlated with results obtained using micro-Raman, FTIR and Rutherford Backscattering Spectrometry. @FootnoteText@ We would like to thank Dr. David Larkin, NASA Glenn Research Center. Research sponsored by the NASA Grant No. NG3-2302, and partially by the Center for Irradiation of Materials, Alabama A&M University and the Division of Materials Sciences, U.S. Dept. of Energy, at the Oak Ridge National Laboratory, managed by UT-Battelle, LLC, for the U. S. Department of Energy under contract DE-AC05-00OR22725

SC+EL+SS-WeP21 Gallium Oxide Deposition and Radical Oxidation on GaAs(001)-(2x4) Investigated with STM*, **S.I. Yi**, P. Kruse, M. Hale, A.C. Kummel,* University of California, San Diego

Growth of metal oxide on GaAs with a low interface defect density is necessary for development of GaAs based metal oxide semiconductor field effect transistor (MOSFET). Vapor deposition of gallium oxide on GaAs(001) is emerging as a viable method for this objective. Using STM, we have investigated deposition of gallium oxide on GaAs(001)-(2x4) during the initial period and oxidation of the surface by atomic oxygen. Deposition of gallium oxide results in an atomically abrupt interface with the GaAs(001)-(2x4) surface, without disrupting the (2x4) surface order. In contrast, oxidation of GaAs(001)-(2x4) by atomic oxygen results in disordering of the surface characterized by formation of undimerized As surface atoms with half filled dangling bonds and As@subGa@ antisites. The stark difference in these two methods of oxide preparation has a profound implication for development of GaAs based MOSFET devices.

SC+EL+SS-WeP22 Density Functional Theory Studies of Semiconductor Surfaces*, G.S. Hwang,* California Institute of Technology*; **C.B. Shin**,* Ajou University, South Korea

Density functional theory (DFT) simulations have been proven to be a reliable and tractable tool in condensed matter physics. Indeed, these simulations are now successfully used to treat not only simple ordered solids but also complex systems such as surfaces and point-like/extended defects. We present the results of our recent pseudopotential based DFT studies which included: (i) the dynamics and configurations of Si(100) and (ii) the adsorption of hydrogen molecules on the surface. It is now rather well known that dimers on Si(100) are alternatively buckled at the ground state. However, the details of their geometry and dynamics at room temperature are still an issue of controversy. Our studies illustrate a tied flipping behavior of two consecutive dimers: the buckling of adjacent outer dimers becomes stronger while two inner dimers switch their orientations. Contrary to popular speculation, in most cases, the dimers undergo thermal fluctuations between two unequal energy minima, thereby preserving the 2x anticorrelation of dimer buckling along a row even at room temperature. Based upon such understanding of the dynamical behaviors of Si(100) at finite temperature, we have looked into dissociative adsorption of H@sub 2@ on Si(100), which is still ambiguous. This study reveals that intradimer @pi@-bonding disruption caused by thermal induced dimer stretching is mainly responsible for the anomalously strong surface temperature dependence of H@sub 2@ adsorption on the clean Si(100) surface.

SC+EL+SS-WeP23 Investigation of Polycrystalline Silicon Grain Structure by Single Wafer Rapid Thermal Chemical Vapor Deposition (RTCVD)*, **H. Bu**, C. Hu, M. Bevan, L. Tsung,* Texas Instruments*; L. Luo,* Applied Materials

It is known that the grain structure in poly-Si gate electrode can directly affect dopant activation and gate electrode depletion (GED). It is highly desirable to control the grain size and orientation during processing for improved IC device yield and reliability. This paper demonstrates the capability of tuning and generating a specific poly-Si grain structure with a lamp based and a heater based single wafer rapid thermal chemical vapor deposition (RTCVD) reactor at reduced pressure regime. Nitrogen gas is used as the carrier gas. The deposition temperature is varied from 650°C to 700°C. The effect of the concentration of intentionally added hydrogen during deposition is examined. Films deposited at various process conditions are characterized by TEM and XRD analysis. The results show that poly-Si grain size and orientation are sensitive to the hydrogen concentration. With a carefully selected process temperature and hydrogen concentration combination, the RTCVD technique is able to engineer the poly-Si grain size and orientation. The effect on poly-Si grain structure on electrical parameters such as electrical oxide thickness (EOT) and gate electrode depletion (GED) will be discussed.

SC+EL+SS-WeP24 Buried Low-Temperature (T@sub s@ <500 °C) Lateral Epitaxial Overgrowth of Si on SiO@sub 2@ Using Solid-Metal-Mediated Epitaxy*, **T. LaFave Jr.**, N. Lakshminarayana, A. Faik, M.-A. Hasan,* University of North Carolina

Buried lateral epitaxial overgrowth of Si on thin SiO@sub 2@ layers (<100 nm) using a thick solid Al layer as growth mediator was demonstrated using a newly developed solid-metal-mediated molecular beam epitaxy (SMM-MBE) method. The experiments were carried out at growth temperatures T@sub s@ < 500 °C using electron beam evaporation for Si and thermal evaporation of Al from an effusion cell. Si(100) wafers were thermally oxidized and patterned to provide seed/oxide strips ranging from 2/2 to 50/500 microns. Each seed/oxide strip was repeated within an area of ~ 1.25x2.00 cm@super 2@ and all patterns were placed on the same wafer. The wafers were then thermally etched at T@sub s@ = 900 °C under UHV conditions to desorb the remnant native oxide from the seed areas followed by deposition of Al at room temperature. Si deposited on the resulting structure at T@sub s@ < 500 °C re-grew epitaxially at the buried Al/Si interface and growth was extended laterally over the oxide layer. Initial TEM results demonstrated lateral growth of single crystalline Si over the oxide layer. This SOI method described above is based on SMM-MBE. In SMM-MBE, silicon grows epitaxially at a buried Al/Si interface during thermal evaporation of Si. Si atoms diffuse through the Al overlayer to the interface where low-energy atomic Si sites act as sinks for the diffusing Si atoms. This process is fundamentally different from surfactant assisted growth in which a small concentration of a metal (typically a fraction of a monolayer) is used to enhance epitaxial growth. In SMM-MBE, the Al layer can be thousands of monolayers thick (solid). The new findings may lead to new silicon-on-oxide fabrication method. Also, it provides a procedure for combined metallization and heavy p-type doping, e.g. in MOS device structure. Applications of this method in device fabrication will be discussed.

SC+EL+SS-WeP25 Field-Assisted Metal-Induced Crystallization of Amorphous Silicon Films, ***A. Khakifirooz,*** *S.S. Mohajerzadeh, S. Haji,* University of Tehran, Iran

Recently, metal-induced crystallization has gained special attention for low-temperature fabrication of polysilicon thin-film transistors. Metal-induced lateral crystallization, has been successfully utilized for obtaining high-performance TFTs. Very large silicon grains, free of metal contamination, are formed as a result of this lateral growth, providing a high carrier mobility. However, the lateral growth rate is still low and very long time annealing is required for practical applications. It has been reported that applying an electric field may enhance the growth rate. We have also observed this effect and the obtained results will be reported. Amorphous silicon films with a thickness of 1000Å are deposited on 50µm thick glass substrates via e-beam deposition. A 1000Å thick passivation oxide layer is subsequently deposited with e-beam and windows are opened for metal pads. A 1000Å thick nickel film is then deposited and patterned using photolithography. Samples are annealed on a hot plate while a DC voltage up to 100 V is applied between the pads. Growth rate is monitored using optical microscopy. SEM, TEM, and XRD are also used to investigate the crystalline structure of the films. A 300 µm crystallization was observed in samples annealed at 400°C for 30 min. when a 100 V/cm field applied. This is much higher than the previously reported growth rates. This may be explained by the fact that we have applied the field directly to metal pads, allowing a considerable current to pass through the a-Si film. Three regions with different crystalline structure are clearly observed in the laterally crystallized area when a high voltage is applied. The mechanism behind these phenomena will be discussed. In addition to filed-enhanced diffusion of Ni atoms, which has been supposed to be responsible for enhanced growth rate, we study the role of energetic electrons. Effect of impurities on the growth kinetics will be also reported.

SC+EL+SS-WeP26 Medium Range Order in Amorphous Silicon Films as a Function of Low-Energy Particle Bombardment During Growth, ***J.E. Gerbi,*** *J.R. Abelson,* University of Illinois at Urbana-Champaign; *P.M. Voyles,* University of Illinois and NEC Research Institute; *M.M.J. Treacy,* NEC Research Institute; *J.M. Gibson,* Argonne National Laboratory

Medium range order (MRO) refers to atomic correlations on a length scale of 1-2 nm. The recently developed TEM fluctuation microscopy technique@footnote 1@ is directly sensitive to MRO, as opposed to diffraction-based methods which are notably insensitive. In this work, we quantitatively compare the MRO in nominally amorphous hydrogenated Si thin films grown by significantly different vapor phase methods: plasma enhanced CVD, hot-wire (HW) CVD, and reactive magnetron sputtering (RMS). All films show significant MRO in the as-deposited state; the MRO decreases upon light soaking or thermal annealing, indicating the existence of a metastable state in the starting material. We investigate the roles of various particle bombardments in producing MRO with the RMS and HW-CVD growth processes. In previous work, we showed that bombardment by ions or neutrals promotes the formation of nanocrystalline or polycrystalline Si, depending on hydrogen addition and substrate temperature. We compare the MRO of a-Si:H, a-Si:D, and a-Si grown by RMS under high argon ion flux with that of a-Si:H grown by HW-CVD, which involves essentially no particle bombardment. We discuss how these bombardments affect the "structure" of a-Si in terms of MRO, and explain how this structure evolves during growth using the model of a frustrated polycrystalline growth surface which yields a highly strained, fine-grained "paracrystalline" structure. Such a structure looks amorphous in conventional diffraction methods, but is topologically crystalline. By contrast, the model of a continuous random network structure, as usually assumed for amorphous films, does not fit the data for as-deposited material. @FootnoteText@ @footnote 1@ J.M. Gibson, et al. Appl. Phys. Letts. 73 3093 (1998).

SC+EL+SS-WeP27 Cluster Deposition Study by Molecular Dynamics Simulation: Al Cluster and Cu Cluster, ***J.-W. Kang,*** *K.-S. Choi, E.-S. Kang, K.-R. Byun, H.-J. Hwang,* Chung-Ang University, Korea

Ionized cluster beam deposition for semiconductor interconnection technology has attracted much attention as a promising method for growing high-quality films at low substrate temperature. Therefore, it is important to understand the interaction between energetic cluster and substrate. In this work, we investigated energetic copper and aluminum clusters deposition and cluster-surface interactions. In the work, we used copper and aluminum clusters with the face centered cubic structure, a classical molecular dynamics simulation, and the second-moment approximation of tight-binding scheme. We simulated cluster deposition and investigated the variations of substrate temperature and the number of disordered atom as a functions of time, energy, and cluster size. The maximum substrate temperatures after energetic cluster impact on surface had linear relationship with total cluster energy and energy per atom, but we could not find any specific relationship with time taken for substrate temperature to reach its maximum. In this work, the correlated collisions between atoms in the cluster played a very important role in the impact on substrate surface and the correlated collision effect was proportional to the cluster size and kinetic energy per atom. For each impact angle and energy, we calculated the average properties such as sputter yield, sticking probability, average reflection angle of the impact cluster, and average emission angle of the sputter products. The calculated properties were compared with that of single atom deposition.

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