radius around an island where nucleation of another island is unfavorable. The process variables of alloy composition, substrate temperature, and growth rate influence 3-D island density through various mechanisms. We will discuss our results in the context of simple thermodynamic and kinetic models that may be used to engineer films with a desired 3-D island density. This work was supported by the NSF.

2:10 PM, H3+

Facet Formations in Selective Epitaxial Growth of SiGe/Si Heterostructures Grown By Gas-Source Molecular Beam Epitaxy: GREG D. U'REN[1]; Mark S. Goorsky[1]; Kang L. Wang[2]; [1]UCLA, Dept. of Materials Science & Eng., 420 Westwood Plaza, 6532 Boelter Hall, LA, CA 90095-1595 USA; [2]UCLA, Dept. of Electrical Engineering, 420 Westwood Plaza, Room 66-147, Engineering IV, LA, CA 90095-1594 USA

Gas-source molecular beam epitaxy was used to investigate facet formations occurring in the selective epitaxial growth of $Si_{1-x}Ge_xSi$ heterostructures ($x < 0.2$). We carried out experiments on nominal on-axis (100) Si substrates masked with 500-600 Å thermally grown SiO_2. Arrays 5 x 5 mm^2 of rectangular features 1-25 μm were defined by conventional photolithography techniques. Cross section transmission electron microscopy shows the development of {311} and {111} facets for a sidewall orientation parallel to the <110> directions. As growth proceeds and more importantly before lateral overgrowth, the {311} dominates. The combination of {111} and {311} facet growth leads to an overall lateral reduction of the (100) mesa top at an estimated rate of 2.2:1 [lateral reduction (x,y):epi thickness (z)]. The {311} facet grows approximately 3-4 times faster than the {111} facet, more quickly promoting the lateral reduction. With an appropriate Si buffer layer, the lateral dimension can be reduced beyond the original lithographic definition, which can be then used as a template for growth of SiGe heterostructures. Triple axis x-ray diffraction measurements of the selective epi determined that the crystalline quality is not compromised by the presence of facet growth nor subject to detectable additional strain relaxation mechanisms as a result of additional free surfaces for ≥ 1 μm structures. Also, from double axis x-ray measurements, no significant growth dependence as function of feature size was observed. The extent of reduction is determined by the oxide thickness. Lateral reduction continues until the epi thickness overcomes the oxide, at which point overgrowth occurs. For epitaxial overgrowth of SiGe, the {111} facet becomes dominant consuming the {311} facet. The results for lateral overgrowth of SiGe are consistent with overgrowth of Si.

2:30 PM, H4+

Complete Suppression of Oxidation Enhancement of Boron Diffusion Using Substitutional Carbon Incorporation: M. S. CARROLL[1]; C. L. Chang[1]; J. C. Sturm[1]; T. Buyuklimanli[2]; [1]Princeton University, Department of Electrical Engineering, Center for Photonics and Optoelectronic Materials, Princeton, NJ 08540 USA; [2]Evans East, Plainsboro, NJ 08536 USA

Boron diffusion and its enhancement via implant damage (transient enhanced diffusion, TED) and oxidation (oxidation enhanced diffusion, OED) are severe problems for the scaling of Si based devices. Recently, the suppression of boron diffusion and the reduction of its enhancement due to OED and TED mechanisms has been demonstrated through the incorporation of carbon in siliconll,2]. In this paper we show for the first time the ability, through introduction of a thin SiGeC layer, to completely filter interstitials injected by an overlying oxidizing surface, which results in the complete elimination of OED for underlying boron. Further, we also quantify the ability of the SiCeC to reduce normal thermal diffusion and OED in Si layers lying above the SiGeC layer. The test structures were grown using rapid thermal chemical vapor deposition (RTCVD), between 600 and 750°C using methysilane as the carbon source. A double peaked boron profile with and without a SiGeC or SiGe layer placed between the peaks was used to test the effect of the layer on boron diffusivities at different locations (above and below) with respect to the SiGe/SiGeC layer. Both boron peaks were approximately 250A thick and had a boron concentration of $5*10^{19}/cm^3$ centered 2000A and 3000A away from the surface respectively, while the 250A thick SiGeC layer was centered 2300A from the surface. As-grown samples were then cleaved and annealed in nitrogen and oxygen ambient atmospheres at 850°C for 30 minutes. Boron profiles were characterized using secondary ion mass spectroscopy (SIMS), and a commercially available process simulator (TSUPREM4 by TMA) was used to quantitatively compare boron profiles and obtain boron diffusivities. Silicon samples, oxidation at 850°C is observed to cause a 10 times enhancement of boron diffusivity, consistent with existing simulators. Unlike previous reports of partial OED suppressions, introduction of 0.5% substitutional carbon in SiGeC between the oxidizing surface and boron marker completely suppresses any oxidation enhanced diffusion, presumably by filtering out all interstitials injected at the surface by the oxidation process. Work is in progress to determine the critical density of susbtitutional carbon to suppress boron OED. A comparison of Si, SiGe, and SiGeC samples shows that substitutional carbon, not Ge, is critical for this result. Further, we report a boron diffusivity 33% of that in the annealed Si control sample layer -350A above the SiGeC layer (i.e. between the top surface and the SiGeC layer). This nonlocal suppression of boron diffusion, indicates that the SiGeC getters Si interstitials with an effective range of over ~350A in all cases including annealing in oxygen atmospheres. This work was supported by ONR (NO0014-96-1-0334), and AFOSR. References:1. L. D. Lanzerotti, et. al, Appl. Phys. Lett. vol 70, No 23, 9 June 972. Stolk, H. J. Gossmann, D. J. Eaglesham, J. M. Pate, Mat. Sci. & Eng. B36, 275-81, 96

2:50 PM, H5+

Effect of Low Carbon Levels on Boron Diffusion and Strain Relaxation in $Si_{1-y}C_y$ and $Si_{1-x-y}Ge_xC_y$ Alloys: ANDA C. MOCUTA[1]; Richard Strong[2]; David W Greve[1]; [1]Carnegie Mellon University, Department of Electrical and Computer Engineering, 5000 Forbes Ave. , Pittsburgh, PA 15213 USA; [2]Northrop Grumman, STC, 1350 Beulah Rd., Pittsburgh, PA 15235 USA

We report the growth of p-type $Si_{1-y}C_y$ and $Si_{1-x-y}Ge_xC_y$ epitaxial layers using Ultra High Vacuum Chemical Vapor Deposition (UHV/CVD). This is a novel application of UHV/CVD, a batch process epitaxial growth technique used in the commercial manufacture of Si-based integrated circuits. Silane, germane, and methylsilane were used as the source gases for Si, Ge, and C respectively. Boron doping was achieved both by (1) in-situ doping using diborane; and (2) B-implantation followed by annealing. Both doped and undoped layers were annealed at temperatures of up to 900 °C and analyzed using SIMS and high-resolution X-ray diffraction. For small concentrations (0.25%), carbon incorporation is completely substitutional in both $Si_{1-y}C_y$ and $Si_{1-x-y}Ge_xC_y$. These low carbon levels produce a significant enhancement in the thermal stability of SiGe alloys. Upon annealing at 900 °C for 1 hour, no significant strain relaxation occurs in SiGeC single layers or multiple quantum well structures while in similar SiGe structures with comparable strain and thickness strain relaxation is observed. The addition of carbon also greatly reduces the diffusivity of boron, regardless of whether the boron is implanted or incorporated during growth. For a 900 °C, 30 min anneal boron diffusion has been effectively inhibited in $Si_{1-y}C_y$ and a reduction in diffusion coefficient by at least a factor of 10 could be calculated. Sheet resistances of $Si_{1-y}C_y$ films with [B] ~ 10^{19} cm^{-3} are unaffected by low carbon levels; I/V characteristics of pn junctions show no increase in recombination current with the addition of 0.25% carbon. Fabrication of SiGe heterojunction bipolar transistors or p-channel MOSFETs involves both ion implantation and high temperature annealing steps. These results demonstrate that incorporating small amounts of substitutional carbon into films grown by UHV/CVD can have beneficial effects in processing devices by allowing a higher thermal budget.

3:10 PM Break

3:30 PM, H6

Effect of Growth Interruption on Si/SiGe Layers Using UHVCVD: JACK O. CHU[1]; Khaled Ismail[1]; Steve Koester[1]; [1]IBM T.J. Watson Research Center, Div 22/ Dept K4W, P.O. Box 218, MS 18-246, Yorktown Heights, NY 10598 USA

Si/SiGe modulation-doped layers have been harnessed to study the effect of growth interrupt on the epitaxial quality of layers grown by UHVCVD. Without any growth interruption, a mobility of about 1,900 cm^2/Vs (55,000 cm^2/Vs) is achieved at 300K (20K). The growth was interrupted at varying distance underneath the strain Si electron channel, while the wafers were pulled out to the load lock for 60 minutes. For an interrupt that is 200nm underneath the channel, there was no measurable effect on the mobility. However, interrupting the growth at 50nm, 10nm, and 0nm from the channel resulted in a mobility of 1,500, 1200, and 600 cm^2/Vs at room temperature, and 43,000, 8100 and 450 cm^2/Vs at 20K, respectively. The interrupt was associated with an oxygen spike in the SIMS profile amounting to a dose of 1 x $10^{13}cm^{-2}$. If, however, the wafers are cooled to 380C prior to growth interrupt while flowing SiH_4, the surface reamins hydrogen passivated, and the mobility increases from 600 cm^2/Vs to 1630 cm^2/Vs at 300K, and from 450 cm^2/Vs to 25,300 cm^2/Vs at 20K, for the case of interrupting the growth right underneath the channel. Thus the hydrogen passivation can be used as a valuable technique to interrupt the growth in case