TMS
Minerals • Metals • Materials

Jim Sturm

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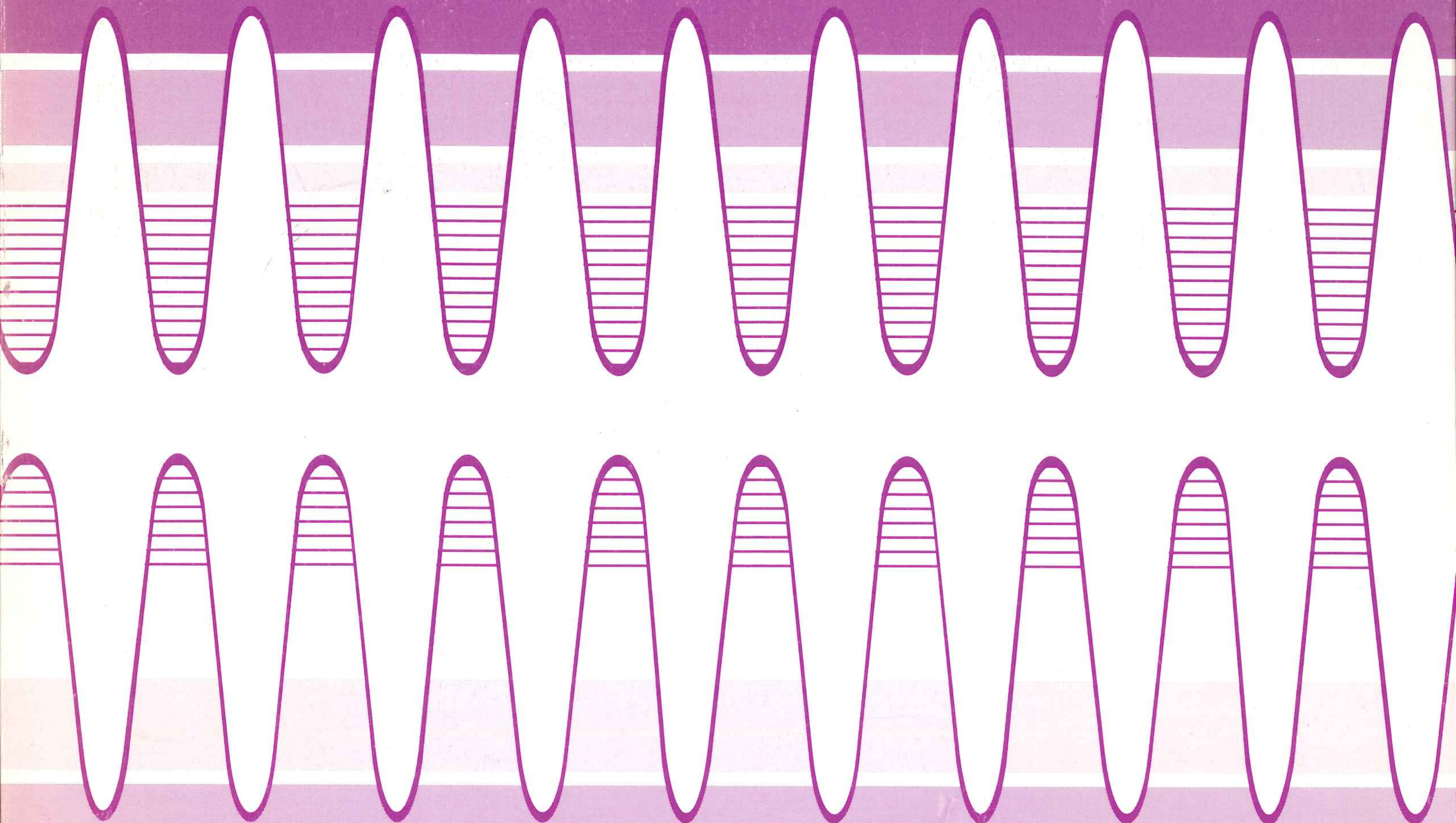

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Technical Program with Abstracts

multiplication regions were relaxed and therefore the data represent results for unstrained alloys. Multiplication coefficients for electrons and holes were obtained from the measured photocurrents of mesa-shaped diodes under pure (electron or hole) injection and a and b were derived from these coefficients. In $Si_{0.91}Ge_{0.09}$ we measured a = 3 x 10^3 cm^{-1} and a/b = 2.5 at 1/E = 1 x 10^{-5} cm/V. Similar measurements are in progress for other alloy compositions and will be presented. This work was supported by AFOSR and the Materials Research Lab at Wp.AFB.

11:20 AM, F9 +

Infrared Absorption in Ge_xSi_{1-x}/Si Quantum Wells: R. Misra, D. W. Greve and T. E. Schlesinger, Department of Electrical & Computer Engineering, Carnegie Mellon University, Pittsburgh, PA 15213

P- type quantum well infrared photodetectors (QWIP) are promising for infrared detector array applications because they are sensitive to normally incident radiation, and when implemented in the Ge/Si system may be easy to integrate with the signal processing electronics. There have been reports of Ge_xSi_{1-x} QWIPs published, in which the absorption has been attributed to various different mechanisms. We have conducted an extensive study of infrared absortion in Ge_xSi_{1-x} multiple quantum well structures over a range of well widths, well doping and well composition. In this talk we will present the results of our experiments on infrared absorption in UHV/CVD grown Ge_xSi_{1-x} layers and quantum wells.

All structures in this study were grown at 600°C in a UHV/CVD system, using silane as the source gases. For this study, multiquantum well structures with germanium concentrations of 16%, 24%, 26% and 28% were grown, with well widths ranging from 24Å to 64Å and well doping between 4 x 10^{18} and 2 x 10^{19} cm^{-3}. All samples had ten such wells grown on a silicon buffer layer, while the undoped silicon barriers between the wells were about 300Å thick. The entire structure was capped with a silicon layer. Infrared absorption measurements were performed using a Nicolet 5DXB FTIR instrument. We have used a single pass normal incidence configuration for these measurements in order to simplify determination of absorption per well. All absorption measurements were conducted at room temperature.

We have observed two types of absorption features: a monotonically increasing (with wavelength) component, and a peaked component. We believe that the monotonically increasing component is related to free carrier absorption by holes in the quantum wells, while the peaked component arises as a result of inter- subband transitions in the quantum wells. We have used a simple one dimensional quantum well model to predict peak locations for the possible transitions in the Ge_xSi_{1-x} wells. At the high doping levels in the samples considered in this study, many body effects such as exchange correlation and depolarization are expected to shift these peak locations. However, models that include some of these corrections predict transition energies that are only a few meV from the values predicted by the simple model. In either case, the predicted transitions are about 100meV away from the experimentally observed peaks. These observations are consistent with results reported for MBE grown samples.

11:40 AM, F10 +

Low Temperature Chemical Vapor Deposition of SiGeC alloys on (100) Si Substrates: C.W. Liu, A. St. Amour and J.C. Sturm Dept. of Electrical Engineering, Princeton University, Princeton, NJ 08544

Due to the wide bandgap (5 eV) and the small lattice constant (50% smaller than Si) of diamond, the substitutional incorporation of carbon into SiGe may provide a material complementary to SiGe for bandgap engineering of Si-based heterojunctions. The epitaxial growth of SiGeC alloys have been previously studied by Molecular Beam Epitaxy and Rapid Thermal Chemical Vapor Deposition (RTCVD) (using tetramethylsilane or tetraethylsilane as a carbon source) at relatively low growth temperature (≤ 625°C) to avoid the thermodynamically favored formation of silicon carbide. In this paper, we report the growth of SiGeC alloys at 550° by RTCVD using methylsilane as a carbon source with germane and dichlorosilane (DCS) or silane.

The SiGeC films were deposited on 4 in. Si (100) substrates by RTCVD at a growth temperature of 550°C. Methylsilane (0.1-12 sccm) was added to a DCS/germane mixture (or a silane/germane mixture) in 6 torr hydrogen routinely used to grow SiGe alloys. The crystal structure was investigated by Double Crystal X-ray diffraction (DCXRD) and Fourier Transform Infrared Spectroscopy (FTIR). For DCS growth, the DCXRD indicates that single crystalline SiGeC alloys can be grown with C concentration up to 0.7% in a $Si_{0.75}Ge_{0.24}C_{0.007}$ layer. For higher methylsilane flow, or higher temperature growth (625°C), the films became amorphous. At the highest methylsilaneflow, a (111) SiC peak was seen, indicating possible precipitation of silicon carbide. For silane growth, single crystalline SiGeC grown at 550°C could be achieved only for a C concentration of 0.1%, and the growth rate was 4 times that of DCS growth. Higher flows of methylsilane also lead to amorphous growth. Three distinct types of FTIR spectra were observed for DCS growth, depending on the methylsilane flow. At low flow (≤ 0.3 sccm), the FTIR showed a sharp vibration at 600 cm^{-1} characteristic of substitutional C in silicon. At high flow (12 sccm), there were two silicon-carbide like absorption peaks at 800 cm^{-1} (TO phonon) and 960 cm^{-1} (LO phonon). At intermediate flow (1.5sccm), a broad peak from 600 to 840 cm^{-1} was observed and very similar to the absorption spectrum of amorphous silicon carbide. Silane growth had similar types of FTIR spectra but with different ranges of methylsilane flow. In general, the FTIR results are consistant with the transitions observed by XRD from single crystalline alloys to amorphous materials and then to polycrystalline silicon carbide with increasing methylsilane flow.

In conclusion, we have successfully fabricated single crystalline SiGeC alloys with C content up to 0.7% by RTCVD. The DCS growth is more favorable than silane growth for incorporation of a large amount of substitutional C. The FTIR spectra of these films exhibited a substitutional carbon vibration at 600 cm^{-1}, with no indication of silicon carbide precipitation. The assistance of G.-J. Shiau and P. Rangarajan for XRD and the support of ONR are gratefully acknowledged.

Thursday, June 23, 1994, AM

Session G: MOCVD of Strained Materials

Room: Chemistry Building, Room 140

Session Chairman: P. Daniel Dapkus, Department of Electrical Engineering, University of Southern California, 504 Powell Hall of Engineering, Los Angeles, CA 90089-0271

Co-Chairman: Robert M. Biefeld, Sandia National Laboratories, P.O. Box 5800, Albuquerque, NM 87183-0601

8:20AM, G1+

Effects of Crystal Growth Parameters and Substrate Orientation on the Evolution of Highly Strained 2-D InAs Layers and 3-D InAs Islands Deposited via MOVPE on (100) and (111)B GaAs Substrates: R. E. WELSER and L.J. Guido, Center for Microelectronic Materials and Structures; Yale University, P.O. Box 208284, New Haven, CT 06520-8284

Earlier investigations of heteroepitaxial growth in highly-strained material systems, such as InAs/GaAs (~7.2% lattice-mismatch), have shown that the observed thin-film surface morphology and defect structure is strongly dependent upon the detailed kinetic pathways of nucleation, growth and strain relaxation. A complete theoretical description of heteroepitaxy which combines these various kinetic processes is necessary in order to fully optimize conventional strained-layer heterostructures, as well as to realize novel quantum structures of reduced dimensionality via strain-induced island growth tendencies. With these objectives in mind, we have investigated the effects of MOVPE growth parameters on the early stages of development of 2-D InAs layers and 3-D InAs islands deposited on (100) and (111)B GaAs substrates.

More specifically, we report here a matrix of experiments in which susceptor temperature, TMIn flux, and AsH_3 flux have been varied over a wide range of conditions. Scanning electron microscopy, atomic force microscopy, and electron microprobe analysis have been employed to determine the 3-D InAs island density, size orientation, and geometry, and to characterize the transition from a 3-D to a 2-D growth mode. In cases of 3-D growth, activation energies and power-dependent expo