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Spring94 MRS San Fran meeting

## 9:30 A.M. POSTERS

### ‡E6.4

DOPANT CONCENTRATION AND As/Ga FLUX RATIO INFLUENCE ON ELECTRICAL AND OPTICAL PROPERTIES OF LT-GaAs, S.P O'Hagan and M. Missous, University of Manchester Institute of Science and Technology, Manchester, Electrical Engineering and Electronics, United Kingdom.

GaAs layers have been grown by molecular beam epitaxy at 250°C - undoped and doped with Si, Be, Se and the isoelectronic dopant In to $\sim 10^{19}cm^{-3}$ - with $As_4$/Ga flux ratios ranging from As-rich to stoichiometry. Layers have been characterised by Hall effect, photoluminescence, infra red absorption and x-ray diffraction. Undoped layers grown under As-rich conditions show a lattice mismatch due to excess As incorporation, however layers grown close to stoichiometry show no mismatch and improved properties. Maintaining high flux ratio and introducing Si at $10^{19}cm^{-3}$ also suppresses excess As incorporation and improves the optical and electrical quality of the layers. Improvement is only observed with Be under stoichiometric conditions. We believe such high impurity concentrations affect the dissociation of the $As_4$ molecule. Reducing flux ratio in the presence of high dopant concentration further betters electrical and optical performance. We attribute this to a reduction in compensating defects - As antisites in p-type and Ga vacancies in n-type material.

### ‡E6.5

**Variable Wavelength Femtosecond Probe-Probe Measurements of LT-Grown GaAs Near the Band Edge, H. B. Radousky, A. F. Bello, D. J. Erskine, L. N. Dinh, M. J. Bennahmias, M. D. Perry, T. R. Ditmire and R. P. Mariella Jr., Lawrence Livermore National Laboratory, Livermore, CA 94550.**

Low-temperature (LT)-grown GaAs has a sub-picosecond optical response time, and so is being considered for a variety of ultrafast opto-electronic devices. We have studied the optical response of a LT-grown GaAs sample which was deposited at 300 C on a Si substrate, and then annealed at 600 C. The Si was etched away to leave a 1 micron free standing GaAs film. Femtosecond transmission measurements were made using an equal pulse (probe-probe) technique at wavelengths, between 800-900 nm (corresponding to 1.55 and 1.48 eV). The pulses were generated from a Ti-Sapphire laser, with 15 mW of power applied to the sample in a 10 micron diameter beam. For all wavelengths used, which are near the 1.43 eV GaAs band gap, we observe a two component spectrum, consisting of a short relaxation (< 100 fs), and a component which is several picoseconds in duration. These results will be compared to bulk GaAs results performed in the same wavelength regime and discussed in terms of the band structure and defect structure of the LT-grown GaAs sample.
Work at LLNL performed under the auspices of the U.S. D.O.E. under contract number W-7405-ENG-48.

### ‡E6.6

**UNIFORM AND DELTA CARBON AND SILICON DOPING IN GAAS BY ELECTRON BEAM EVAPORATION IN SOLID SOURCE MBE, D. Sato, X.Liu, J. Juniper, F.J. Szalkowski, and H.P. Lee, University of California at Irvine, Department of Electrical and Computer Engineering, Irvine, CA.**

A compact, rod-fed electron beam evaporator integrated with a solid source III-V MBE apparatus has been used for the first time in the growth of both uniformly-doped and δ-doped GaAs structures. Both p-type (graphitic Carbon) and n-type (Silicon) structures have been fabricated and evaluated. The room temperature Hall mobility vs. carrier concentration measurements compare well with Be doped samples and closely match empirical data[1] up to $p = 6 \times 10^{19}/cm^3$, see Fig.1. This closely approaches the highest hole carrier concentration of C-doped GaAs layers reported in a solid source MBE system but avoids the deleterious effects of heated graphite filaments used in previous experiments[2]. Single and double δ-doped structures have also been attempted. Room temeprature mobility enhancement from 178 $cm^2/V\text{-}s$ at sheet carrier concentration of $5.5 \times 10^{11}/cm^2$ (single δ-doped) to 185 $cm^2/V\text{-}s$ at $1.9 \times 10^{12}/cm^2$ (double δ–doped) due to the spatial separation of the carriers and ionized acceptors is observed. The effect of $C_2$ and $C_3$ incorporation, in addition to monomeric C, at hole concentrations beyond $10^{20}/cm^3$ is currently under study and will be reported. Delta doping of Si in GaAs using the same high flux e-beam source (previously used in the epitaxial growth of GaAs-Si alloys[3]).has also been studied. Room temperature mobilities of 1033 $cm^2/V\text{-}s$ and 1086 $cm^2/V\text{-}s$ at sheet carrier concentrations of $1.0 \times 10^{13}/cm^2$ and $2.0 \times 10^{13}/cm^2$ for single and double δ-doped structures were measured respectively. These result compared extremely well with previous δ-doped structures using coventional effusion cells[4]. The results demonstrate that e-beam sources can be effectively used for the evaporation of low vapor pressure dopants such as Si and C in solid source MBE.

### ‡E6.7

TEMPERATURE DEPENDENCE OF CARBON INCORPORATION IN $Al_xGa_{1-x}As$ GROWN BY MOCVD' D.V.Forbes and J.J.Coleman, Materials Research Laboratory and Microelectronics Laboratory, University of Illinois, Urbana,IL 61801

The dependence of carbon concentration on growth temperature and V/III ratio for high composition $Al_xGa_{1-x}As$ ($x>0.40$) grown by metalorganic chemical vapor deposition using trimethyl sources has been investigated. The carbon concentration exhibits at least two temperature regimes having different trends with temperature. In the region of 600-675°C, the carbon concentration decreases with temperature, while in the range of 700-800°C, the carbon concentration increases with temperature. This profile is independent of V/III ratio and was observed in samples grown in two separate reactors. The results are qualitatively explained in terms of the chemical reactions and surface kinetics that may occur during the growth of GaAs or $Al_xGa_{1-x}As$.

### ‡E6.8

**THE USE OF TETRAETHYLTIN AS AN N TYPE DOPANT SOURCE FOR GAAS, ALGAAS, AND ALAS FOR LASERS AND BRAGG REFLECTORS GROWN BY MOCVD** C. J. Pinzone; AT&T Bell Laboratories, 600 Mountain Avenue, Murray Hill, NJ 07920; J. G. Neff, R. V Chelakara, K. Fertita, and R. D. Dupuis; Microelectronics Research Center, University of Texas at Austin, 10100 Burnet Road, Austin, Texas 78758

Tetraethyltin (TESn) was investigated as an n-type dopant source in low pressure metal organic chemical vapor deposition (LPMOCVD) of AlGaAs alloys. It was found that a wide range of dopant incorporation was obtained as a linear function of dopant mole fraction for GaAs and AlGaAs alloys. The increasing interest in photonic devices which utilize a quarter wave Bragg reflector consisting of a semiconductor superlattice of alternating AlAs or $Al_xGa_{1-x}As$ and GaAs layers led us to investigate the dopant incorporation of Sn in AlAs and high Al content $Al_xGa_{1-x}As$. For constant TESn mole fraction in the reactor, it was found that the amount of active carriers decreased with increasing Al fraction in the alloy.. AlAs/GaAs Bragg reflectors with high reflectivity were grown with Sn doping used to reduce series resistance in these structures. The behavior of Sn incorporation across a broad spectrum of doping and Al fraction will be presented. Results for doping of Bragg Reflectors will also be presented.

## 9:45 A.M. POSTERS

### ‡E6.9

**A STUDY OF TRAPS IN SEMI-INSULATING III-V EPITAXIAL FILMS BY ZERO BIAS TRANSIENT CURRENT SPECTROSCOPY, W. S. Lau, C. H. Goo, T. C. Chong and C. T. Tan, Centre for Optoelectronics, Faculty of Engineering, National University of Singapore, 10 Kent Ridge Crescent, Singapore 0511.**

Semi-insulating $Al_xGa_{1-x}As$ epitaxial films grown by molecular beam epitaxy have been proposed as gate insulators in GaAs MISFETs and also as buffer layers to suppress backgating. The quantitative characterization of traps in this category of material should have both technological and scientific significance. However, conventional capacitance DLTS (Deep Level Transient Spectroscopy) is not suitable because this category of material is semi-insulating. Here, we propose