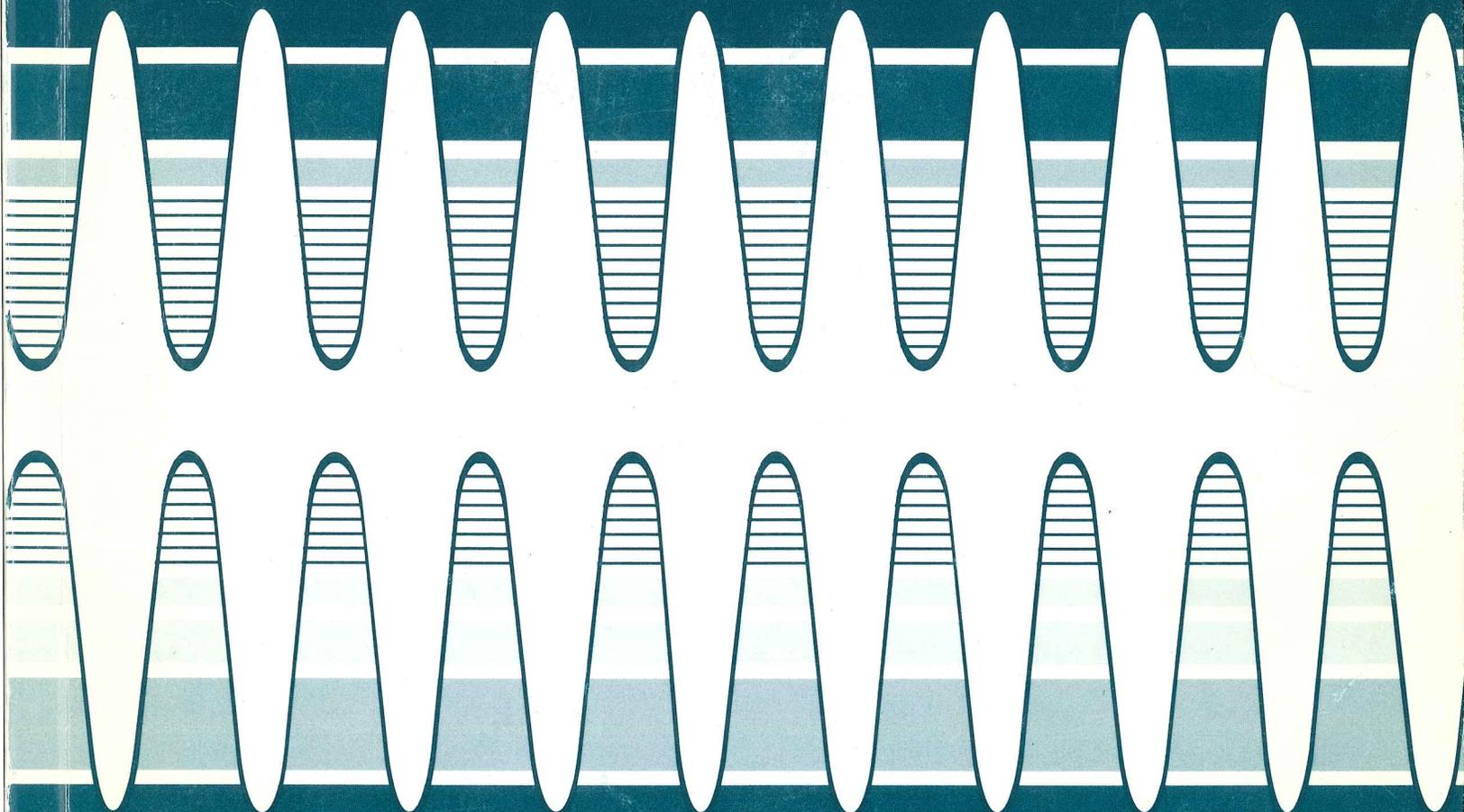


TMS
Minerals • Metals • Materials

University of Virginia
Charlottesville, Virginia
June 21-23, 1995



1995 ELECTRONIC

MATERIALS

CONFERENCE

Technical Program with Abstracts

TEM is used to confirm the superlattice structure. Absorption measurements indicated that the absorption coefficient, α , at 1.3mm is $6 \times 10^{13}/\text{cm}$. The experimental value for α shows agreement with the theoretical value of $8 \times 10^{13}/\text{cm}$, which was determined by calculating the effects of strain on the Ge rich layer of the superlattice. The results of the optical absorption measurements indicate that the SiGe strained layer superlattice would be suitable for a 1.3mm photodetector.

11:20AM, U9+

Electroluminescence from Polymer Blends of Poly(3-*n*-butyl-*p*-pyridyl vinylene) and Poly(9-vinylcarbazole): C.C. Wu, J. Tian, J.C. Sturm, M.E. Thompson, and R.A. Register, Princeton University, Advanced Technology Center for Photonic and Optoelectronic Materials, Princeton, NJ 08544

In this work, we study LEDs made from polymer blends composed of a hole-transporting polymer, poly(9-vinylcarbazole) (PVK) and the conjugated poly(3-*n*-butyl-*p*-pyridyl vinylene) (Bu-PPyV). The high solubility of Bu-PPyV and PVK allows the fabrication of LEDs from their blends of various ratios. Through blends of these two luminescent polymers, we show that it is possible to modify the electrical and optical properties of the polymers in ways not possible with pure materials, and also to identify the origin of the emission in pure Bu-PPyV. The electroluminescence (EL) of the pure Bu-PPyV thin film is in the orange-red range of the spectrum, with its peak position beyond 600 nm. Furthermore, Bu-PPyV is of special interest because in its protonated form it can be used for the electrostatic self-assembly of polymer monolayers. The LEDs made from the pure PVK emit violet light, with its peak around 420 nm. The EL from the blends exhibits new emission features between 500 and 600 nm, which are not present in either the pure Bu-PPyV or PVK. When the content of Bu-PPyV in the blend is high, the new feature is detectable but weak in comparison with the EL features characteristic of pure Bu-PPyV. As the content of Bu-PPyV decreases, the new feature dominates the emission and gradually shifts to the blue until it reaches about 500 nm. The origin of the new feature was identified by comparing it with the concentration-dependent luminescence of Bu-PPyV in organic solvents. The orange-red emission in pure Bu-PPyV corresponds to emission from Bu-PPyV excimers. The new feature in the blend with low Bu-PPyV content is then thought to be from isolated Bu-PPyV chromophores in the PVK rich environment, accounting for its large blue shift. In addition to the emission color, the EL efficiency of the LEDs made from the blends are also found to have a dependence on the content of the Bu-PPyV in the blend. The data shows that the new emissive species has higher radiative efficiency than the excimers. It may be due to the localization of excitons on isolated Bu-PPyV chromophores by the wide band-gap PVK, which would cause a lower probability for migration of excitons to quenching sites.

The incorporation of the PVK into the blend also changes the electrical properties of the thin film. To reach the same level of current, pure Bu-PPyV requires an electric field two times higher than that required in PVK. The blends lie between these two limits, with those having higher Bu-PPyV contents requiring a higher electric field. Therefore, the excellent hole transport properties of the PVK improve the carrier injection into the blend, reducing the voltage needed to operate the device.

11:40AM, U10

Late News

Friday, June 23, 1995, AM

Session V: Materials and Structures for Infrared Detectors and Emitters

Session Chairman: Robert M. Biefeld, Sandia National Laboratories, Albuquerque, NM 87185-0601

Co-Chairman: L. Ralph Dawson, Sandia National Laboratories, Albuquerque, NM 87185-0601

8:20AM, V1

Heterostructures with Biaxially Compressed InAsSb for Midwave Infrared Emitters*: S. R. Kurtz and R. M. Biefeld, Sandia National

Laboratories, Albuquerque, New Mexico 87185-0601

Frequently, the Auger-1 process (i.e. An electron and hole recombine by scattering a second electron up into the conduction band.) dominates radiative recombination in narrow bandgap III-V semiconductors, and as a result, the wavelength of diode lasers operating at room temperature has been limited to ≈ 2.1 - $2.3 \mu\text{m}$. In a biaxially compressed III-V layer, the $|3/2, \pm 3/2\rangle$ hole ground state can result in an increased threshold energy for Auger-1. Therefore, midwave infrared (2 - $6 \mu\text{m}$) emitters with biaxially compressed active regions may exhibit improved performance and higher temperature operation.

InAsSb/InGaAs strained-layer superlattices (SLSs) and InAsSb quantum wells, both with biaxially compressed InAsSb layers, were characterized using magneto-photoluminescence and compared with unstrained InAsSb and InAs alloys. In InAsSb quantum wells with thick InAs barriers, large quantum size shifts were observed, demonstrating that electrons are confined in the InAsSb layers in these heterostructures. In all heterostructures with biaxially compressed InAsSb, the holes exhibited a decrease in effective mass, approaching that of the electrons, and we show that the holes are also confined to the InAsSb layers. The biaxially compressed InAsSb heterostructures have a type I band offset, and the unexpectedly low photoluminescence energies of As-rich, InAsSb heterostructures is traceable to a bandgap anomaly observed for the InAsSb alloys. Analysis of the magneto-exciton in these heterostructures indicates that the hole mass may be quite small ($m_h^* \approx 0.02$). In the 2-dimensional limit, a large increase in the Auger-1 threshold energy accompanies the strain-induced change in valence-band symmetry in InAsSb heterostructures. Correspondingly, the activation energy for nonradiative recombination in the SLSs displayed a marked increase compared with that of the unstrained alloys. We have constructed lasers and light-emitting diodes with InAsSb SLS and quantum well active regions. The performance of these emitters will be summarized.

*Work supported by the U.S. Dept. of Energy under Contract DE-AC04-94AL85000.

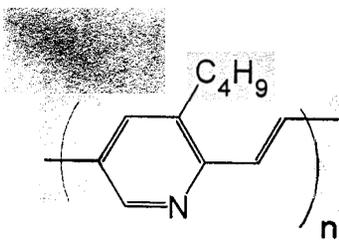
8:40AM, V2

Growth and Characterization of InAsSb/InGaAs Strained-Layer Superlattices and GaAsSb and AlAsSb Alloys Using Trimethylaminealane, Trisdimethylaminoantimony, and Triethylgallium*: R. M. Biefeld and S. R. Kurtz, Sandia National Laboratory, Albuquerque, NM 87185-0601

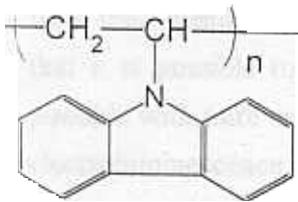
We have prepared InAsSb/InGaAs strained layer superlattices (SLS's) using metal-organic chemical vapor deposition (MOCVD) and the novel sources trisdimethylaminoantimony and triethylgallium for use in 3 - $5 \mu\text{m}$ emitters and detectors. Using these new sources we were able to reduce the growth pressure to 77 torr and increase the V/III ratio from 10 to 60. These superlattices have been grown over a temperature range of 475 to $550 \text{ }^\circ\text{C}$ using growth rates of 0.5 to $1.0 \mu\text{m}/\text{hour}$. Initial photoluminescence and double crystal x-ray characterization of these SLS's indicate that they are at least as good as the SLS's grown using standard methyl sources. As for the SLS's prepared using methyl-sources, the optically determined bandgap was smaller than accepted values for the InAsSb alloys. This InAsSb bandgap anomaly indicates that compositional ordering is occurring in these samples resulting in a bandgap reduction. This conclusion has been confirmed by transmission electron diffraction for the methyl-source SLS's.

We are also investigating alternate organometallic Sb and Al sources to obtain improved Al(Ga)AsSb characteristics compared to those grown using trimethylaluminum, trimethylgallium, and trimethylantimony. A major problem with AlAsSb grown with the methyl-sources has been the presence of carbon at concentrations $> 10^{18} \text{ cm}^{-3}$. We are exploring the growth of GaAsSb and AlAsSb alloys, for use as confinement materials in 3 - $5 \mu\text{m}$ emitters, using the novel sources trisdimethylaminoantimony, triethylgallium, and trimethylaminealane. Using these new sources we were able to grow GaAsSb and GaSb at a growth pressure of 77 torr at 500 - $600 \text{ }^\circ\text{C}$. The alloys were grown lattice matched to InP or InAs. The V/III ratio had to be maintained close to one to avoid the formation of Sb or Ga crystals on the surface for the growth of GaAsSb. Lattice matched GaAsSb appeared, in some instances, to be phase separated. Double crystal x-ray diffraction and Hall

FRIDAY, AM



poly(3-*n*-butyl-*p*-pyridyl vinylene)
Bu-PPyV



poly(9-vinylcarbazole)
PVK

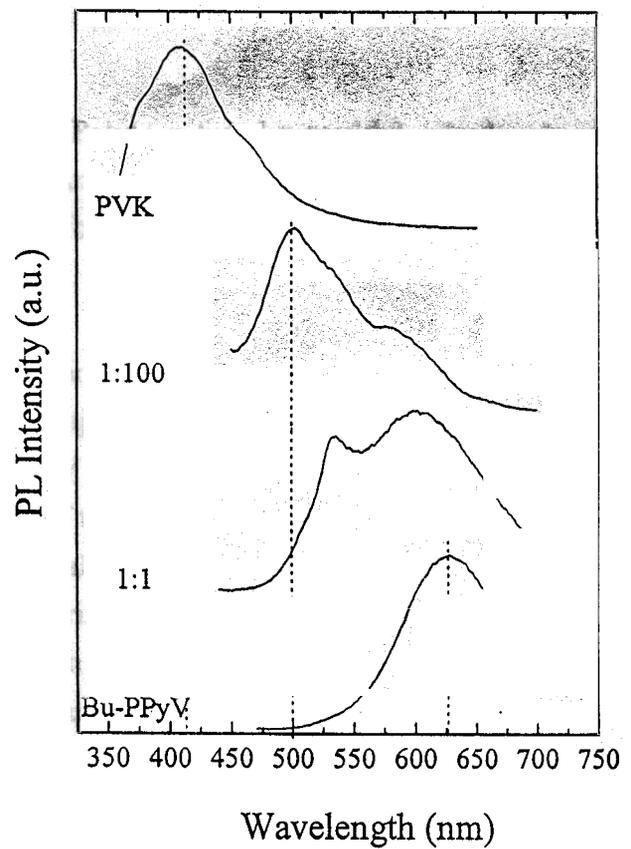


Fig. 2 The photoluminescence spectra of the Bu-PPyV, PVK and Bu-PPyV:PVK (wt:wt) blends.

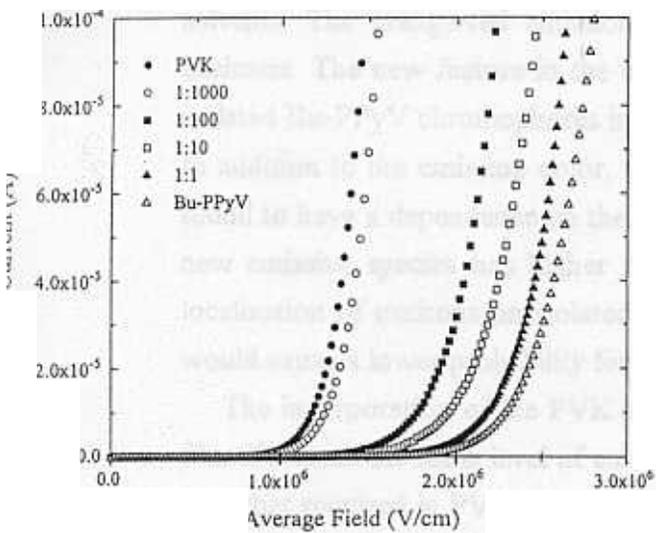


Fig. 3 The current vs. the average electric field characteristics of the LEDs made from the Bu-PPyV:PVK (wt:wt) blends.

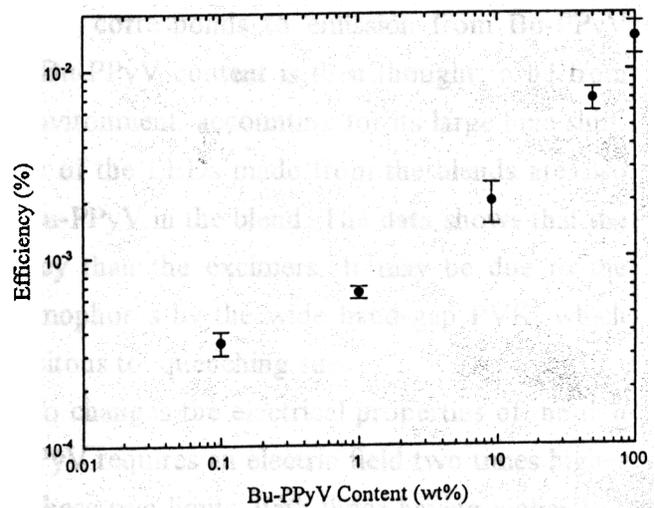


Fig. 4. EL efficiency vs. content of Bu-PPyV in blends