

Lehigh University
Summer REU Program
2005
Student Abstracts

Ferroelectric Domain Inversion of LiTaO₃: Light Induced Effects, Raman Studies
Chad Althouse
Advisor: Prof. Volkmar Dierolf

The ferroelectric lithium tantalite (LiTaO₃) has become a material of interest for nonlinear and electro-optical devices due to the prospect to precisely engineer its ferroelectric domain structures and its good resistance to optical damage. With the goal to understand the structure of the domain wall and to find new techniques for domain engineering, we investigated the light induced effects for and performed Raman spectroscopy on samples with different composition and doping. This research was carried out at the University of Bonn, Germany and Lehigh University.

Scientific Results: Data was collected for three types of lithium tantalate crystals: congruent, stoichiometric, and near stoichiometric doped with 1 mol% magnesium oxide. The stoichiometric (VTE treated) sample had a close to perfect lithium content (49.97mol%, confirmed by absorption measurements). The stoichiometric and near stoichiometric doped with magnesium oxide samples were poled and current flow graphs recorded. Light aided poling was achieved on near-stoichiometric lithium tantalate samples doped with 1 mol% MgO; a reduction of coercive field by about 50% was caused by illumination at 305nm wavelength and an intensity of about 1W/cm². This observation suggests that light aided domain engineering is feasible. All these measurements were performed at the University of Bonn in the group of Prof. Buse. At Lehigh, we measured, using a confocal luminescence microscope, differences in the Raman spectra for as-grown, domain wall, and new domain regions of a partially poled congruent lithium tantalate crystal. Raman spectrum scans were taken across all three domain walls for a triangle shaped domain in a congruent lithium tantalite crystal. New peaks and peak shifts are present between the as-grown region and a newly grown domain as well as confined locally to the domain wall region.

My Experience in Germany: My research in Germany was part of a NSF research exchange program. I worked at the University of Bonn for a span of four weeks. The German graduate students were very helpful and motivated. I was also able to travel to Munich and visit the Max Plank Institute and a laser fair during a trip with our research group. I am grateful to have had the opportunity to participate in this program and the experience of working at the University of Bonn.

Vibrational Coupling and Molecular Structure of O-H, O-D Defects in MgO

In this paper we present a theoretical model for the Li:OH and Li:OD defects in MgO and ZnO. These defects have broad IR vibrational absorption spectra (Full Width at Half Maximum (FWHM) of about 209 cm^{-1} for O-H, and 64 cm^{-1} for O-D) in MgO at 300K, suggesting that the vibration is strongly coupled with another motion. In addition, since the FWHM is more than three times larger for O-H than O-D, the coupled motion must have a strong isotopic dependence when substituting D for H. Rotation of the defect itself is thus a good candidate for the coupling motion. The geometric structure as well as the potential surface as calculated by CRYSTAL2003 suggests that the simple model of a two dimensional quantum pendulum may give insight into the nature of these defects in MgO. We fully develop such a model, and we find that the complete spectrum of such a “generalized quantum pendulum” has not been completed correctly in the literature.

Since data in MgO exist only at 300K, we worked in collaboration with the solid state experimental group at Lehigh University on the same defect in the host crystal of ZnO. The temperature dependence of the FWHM and peak absorbance frequency were measured for the O-D defect between 4.8K and 294K. (The data for O-H in ZnO is in the literature.) One unanticipated result was the presence of two closely spaced absorption lines (about 0.18 cm^{-1} apart) at 4.8K. The integrated strengths of the two lines are in the ratio of about 13:1. The most consistent assignment of these two lines is to the two naturally occurring isotopes of Li, which are found in nature in approximately a 12:1 ratio. This proves that the geometrical model used for these defects is correct, and that these O-D and O-H defects are Li-related.

Finally, we fit a theoretical model to the temperature dependence of the FWHM and peak absorbance frequency for both O-H and O-D in ZnO. The model assumes that the defects are coupling to a harmonic “exchange mode” which in turn is coupled to the phonon bath of the crystal. We find a good fit to the experiment when we assume both O-H and O-D are coupled to an exchange mode of about 110 cm^{-1} . We conclude that in ZnO these defects are not coupling to rotation (since there is no isotope effect), and may be coupling to a local vibrational motion of the Zn atoms, or possibly to the phonon bath itself (in ZnO there is a strong density of phonon states around 100 cm^{-1}). We do not have enough experimental data to try a fit to MgO at present, but we believe that it is coupling to rotational motion. When the data becomes available, the basic structure of the theory, which has been worked out, can be applied.

Lehigh University Philip Blaney '06
Advisors: Dr. W. Beall Fowler
Dr. Kevin Martin

The Patch Clamp Project:

Instrumentation Amplifier circuit design and test results, modeling and analysis of the current-voltage characteristics for a planar MEMS Bio chip and experimental results for the formation of a gigaseal to enable reliable sensing of biochemical signals through ion channels.

Akwete Samkofi Bortei-Doku, Rajiv Mehrotra
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Funding: The Sherman Fairchild Summer Internship and the National Science Foundation

Abstract

Understanding ion channel behavior of biological cells is essential to gaining insight into certain disease characteristics. The method to record the ion channel current is performed by an electrophysiological experiment called "Patch Clamping". This technique involves the isolation of an ion channel by means of a glass micropipette, forming a tight seal with the cell to ensure no leakage currents and then amplification of the weak ion channel current obtained by a patch clamp low-noise instrumentation amplifier. In this paper, we discuss the formation of the gigaseal between the cell and the BioChip interface and present certain experimental results including current-voltage relationship between the chip and the cell. We also provide test results and redesign for the CMOS ultra-low noise instrumentation amplifier. We maintain the simulated figures of merit of a high gain of 2×10^{11} V/A from the amplifier.

SONOS NVSM Characterization Techniques with a Focus on their Analysis of SANOS Capacitors with Al₂O₃ as the Blocking Oxide

Matt Chabalko

August 4, 20005

Advisor: Marvin H. White

Graduate student advisor: Steven (Xiaonan) Wang

Acknowledgements: Steven (Xiaonan) Wang, Marvin H. White, National Science Foundation,
Sherman Fairchild Center

Abstract:

Today, among all Non-Volatile Semiconductor Memory devices, SONOS technology offers great opportunities for improving programming speed, retention, write/erase endurance, etc. A desirable feature of these devices would be to have a physically thicker blocking oxide, so as to improve programming speed, but maintain overall the effective thickness of the gate's triple-dielectric stack. Simulations indicated that Al₂O₃ as the blocking oxide may indeed meet these requirements, as it can be deposited thicker as the blocking oxide, but maintain gate effective thickness due to its high dielectric properties. Here, we introduce the electrical characterization techniques used to assess any SONOS device, but specifically those used in the characterization a SANOS capacitor fabricated using Al₂O₃ as the blocking oxide. We examine room temperature programming and erase speed, long term memory retention (extrapolated out to 10 years), and low frequency capacitance measurements, which allow measurement of the effective gate thickness and offers a means to measure the thickness of the nitride layer.

Annealing Study of Vibrational Lines of N-H₂ Complexes in GaPN¹

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Advisor: Michael Stavola, Lehigh University

Abstract

Hydrogen is an important impurity in semiconductors that is well known to passivate impurities and defects. In dilute III-V-N alloys, the addition of a few percent N decreases the band gap energy.^{1,2} The further addition of H eliminates the effect of N and increases the band gap energy to near the value of the N-free host.³ While it is common for H to affect the conductivity of semiconductors, it is unusual for H to modify the band gap energy. Understanding how N and H interact to modify the band gap energy is an interesting question in basis physics and is also important for the use of this material in future applications.

Theoretical calculations performed by several research groups suggested the formation of an H₂* complex in which one H atom is bonded to N and another is bonded to a Ga neighbor.⁴⁻⁷ It was suggested that this complex is stabilized by N and that its formation is what causes the band gap energy to shift. Previous experimental work on GaAsN:H used vibrational spectroscopy to probe the microscopic properties of N- and H-containing defects.⁸ In these studies, the dominant defect in hydrogenated GaAsN was found to contain two weakly coupled N-H modes. This assignment is inconsistent with the H₂* model suggested by theory because this defect should contain only one N-H bond.

The present experiments were performed to probe the vibrational properties of GaPN:H, an alloy with properties similar to GaAsN:H, to explore what defects might be formed in a different, related alloy system. We have found that the dominant N- and H-containing defects in GaPN:H also have two weakly coupled N-H bonds. The stretching and wagging vibrational lines associated with this defect all disappear together upon annealing at 350°C, consistent with their assignment to a single defect species. Our studies show that the vibrational properties of defects found in GaAsN:H are common also to GaPN:H and that a defect complex that contains two N-H bonds is responsible for the unusual properties of H in these materials.

¹ Supported by the National Science Foundation, Research Experiences for Undergraduates Program

Pure End Condition Problems in Elastodynamics

Steven Deutsch
Lehigh University
Advisor: Dr. Robert T. Folk

Abstract

The problem in elastodynamics that we considered was the problem of a slab with pure end conditions, meaning that we specify the stress tensors on the boundaries and as initial conditions. The mixed type problem in which you specify some component of stress and some component of displacement on the boundaries has already been solved analytically. Both of these problems have been worked on experimentally with good results but only the mixed problem has been previously solved analytically. Our goal is to solve the pure problem analytically. These problems result in coupled partial differential equations, and there are two standard methods to solve these problems. One is separation of variables and the other is by integral transforms. The mixed problem was solved by separation of variables and it worked quite well. For the pure problem separation of variables isn't so easy. In both types of problems, the eigenvalues of the solution are complex as opposed to real and this means that the operators are non self-adjointed, and so the Sturm-Louville theory does not apply. The way to proceed then is to use integral transforms. By transforming the equations using the Laplace and Fourier transforms we determined a system of coupled differential equations which we solved systematically and which gave us the desired solution.

TaN Metal Gate for Scaled SiO₂ and High-K Dielectrics

Brandon Eberly

August 5, 2005

Acknowledgements: National Science Foundation, Sherman Fairchild Center, Lehigh University, Dr. Marvin White, and Yijie Zhao

Abstract

The rapid scaling of the metal oxide semiconductor field effect transistor (MOSFET) has reduced the transistor's dielectric thickness to a point at which unacceptable leakage current (via tunneling) is imminent. A new dielectric must be found, but all candidates thus far are incompatible with the poly-silicon currently used as the gate in the MOSFET. For this reason, a search is underway for a material to be used as a gate in the next generation of MOSFETs, and TaN is a leading candidate. One of the strongest features of poly-silicon is that its work function can be changed via doping, allowing this material to be used in both nMOSFET and pMOSFET applications. It is of great interest to determine if the work function of TaN can also be tuned by some means, thereby eliminating the need to find two different materials to replace poly-silicon.

The research presented in this paper discusses methods that may be effective in tuning the work function of TaN. TaN-gated MOS capacitors are fabricated with SiO₂ thicknesses of 65, 130, and 185 angstroms. The TaN is deposited through sputtering, and two different argon-to-nitrogen flow rate ratios are used during this process. Also, half of the wafers are subjected to a forming gas anneal. Capacitance-voltage and current-voltage measurements are used to determine the work function and barrier height of each device. It is found that the forming gas anneal increases barrier height and work function, but further study will be necessary to form a direct correlation between the TaN work function and Ar:N₂ flow rate during sputtering.

Experimental Studies of Predissociating NaK Triplet States

Stephen Eckel*

Advisor: Professor John Huennekens

August 5, 2005

Abstract

The NaK $5^3\Sigma^+$ state and high-lying rovibrational levels of the $4^3\Pi$ state have never been observed using molecular fluorescence detection, despite extensive searches over the relevant energy regions. Because of this, we believe that the $5^3\Sigma^+$ predissociates to the Na(3P) + K(4S) separated atom limit, and that the high-lying $4^3\Pi$ levels similarly predissociate to the Na(3S) + K(3D) separated atom limit. To try to verify this, we have implemented a perturbation facilitated, optical-optical double resonance polarization spectroscopy experiment in our lab. Polarization spectroscopy is sensitive to the absorption step of the transition, and is therefore not dependent on fluorescence that takes place after the transition. Due to various complications, we have not yet been able to observe any $5^3\Sigma^+$ or $4^3\Pi$ levels with the polarization spectroscopy technique; however, we have demonstrated that the method works by using it to observe known $3^3\Pi$ and $1^3\Delta$ lines. We have also searched directly for the atomic dissociation products by attempting to detect potassium 3D \rightarrow 4P atomic fluorescence. Examination of known rovibrational states of the $4^3\Pi$ lying below the Na(3S) + K(3D) dissociation limit has revealed collisional processes that produce K(3D) atoms. In addition, increased populations of K(3D) atoms have been detected in the region of the $4^3\Pi$ above this dissociation limit using broadband laser scans, although predissociation has yet to be confirmed.

*Thanks to the National Science Foundation for Support



Structural and Micromechanical Properties of Endothelial Cells' Interiors: An Optical Tweezers Study

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Department of Physics, Lehigh University, Summer REU 2005

Abstract

The purpose of this study is to probe the micromechanical properties of bovine arterial endothelial cells. Optical tweezers (tightly focused laser beam) are used to trap granular structures in the cell's interior to explore the viscoelastic properties of that cell. This study seeks to determine the difference between the viscosity and elasticity of the cytoskeleton around granular structures in close vicinity of the nucleus and around the cell's edge. At the cell's edge, the value of the elastic modulus, G' , is approximately 1000 dyne/cm² while the value of the viscous modulus, G'' , is approximately 500 dyne/cm². In the vicinity of the nucleus, G' is approximately 500 dyne/cm², while the value of G'' is approximately 10 dyne/cm². This experiment was made possible by funding from the National Science Foundation and through the Lehigh University Research Experience for Undergraduates program.

Extraction of Thermal Resistance in HBTs

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Abstract — Thermal resistance (R_{th}) is an important parameter in heterojunction bipolar transistor (HBT) modeling. It describes the way a transistor thermodynamically reacts to internal power dissipation. The method for extraction of R_{th} examined here utilizes V_{BE} 's dependence on junction temperature. The measurements needed, as well as the step-by-step extraction from these measurements is explained. R_{th} in HBTs is not a constant value, showing dependence on internal power dissipation, as well as junction temperature. The magnitude of these dependencies can be related to the device size. Also examined is the effect of emitter resistance on the extraction technique.

Acknowledgments — Thanks to: James Hwang, Ph.D., Subrata Halder, and the rest of the ECE CSTL Lab for all the help with my, and the Sherman-Fairchild Scholarship and REU program for making this summer possible.

August 5, 2005

Optical Modes of Dipole-Lattice Shells

Brian O. Holder
Advisor: S. V. Rotkin

Abstract

We studied systems of dipole-lattice structures for the purpose of constructing optical resonators. Such systems can be formed by arrays of quantum dots arranged in the shape of a chain, cylinder, etc. Two systems were analyzed: the one-dimensional and circular chains. By using Fourier transformations and carrying out lattice sums in *Mathematica*, we were able to obtain dispersion curves for the case in which all dipoles were polarized in the same direction; and more general case: when polarization mixing was taken into account. Physically intuitive arguments were used to identify dispersion curves with the polarizations of the chains. For the one-dimensional chain there are one longitudinal and two degenerate transverse polarizations. For the circular chain there is one polarization perpendicular to the plane and two in-plane polarizations: radial and tangential.

The results obtained can be used to study the interaction of light with these systems of dipoles. Another possible direction of our research is to study more complicated lattice shells, such as a two-dimensional lattice of dipoles, cylindrical lattice, helical lattice, and spherical lattice. This provides us with sufficient background for developing applied models of electromagnetic wave amplification using dipole-lattice shells.

Surface Patterning and Neural Networks

Aziz Iqbal
Prof. Svetlana Tatic-Lucic and Gaoshan Jing

Abstract

Surface patterning with biological molecules has given rise to biologically integrated devices that are in the micron to the nanometer scale. These biosensors are currently used to facilitate the study of cells and tissue engineering applications. Several techniques such as local deposition of molecules using microcontact printing methods and photolithography is to be examined to create patterns of these biological molecules on surfaces for applications such as neuronal networks.

Neuronal cell patterning is an important step in understanding neuron-neuron and neuron-surface interaction. The culture, growth and patterning of neuronal cells on surfaces are made possible by the use of self-assembled monolayer (SAM).

A noticeably important aspect of neuronal cell patterning is the actual pattern that is created. Hippocampal neurons have been previously observed to grow axons and dendrites on certain pretreated surfaces. Our summer research was to examine the effects of various patterns and observe the ability for adjacent neuron cells to grow axons and dendrites within the constraints of these specific patterns. The research would also prove the efficiency of one SAM layer over another in the growth of neuronal cells.

Spin Orbit Coupling Constant Analysis for the $1^3\Delta$ and $3^3\Pi$ State of the NaK Molecule

Sucheta Jawalkar

July 29, 2005

Abstract

The Spin Orbit constant (A_v) for the $1^3\Delta$ and the $3^3\Pi$ states of NaK was analyzed using theoretical methods. The analysis was used to determine A_v as a function of internuclear distance (R) denoted by $A(R)$. A_v is an average over the internuclear distance where the vibrational wavefunction is large. Information about $A(R)$ gives more detailed information regarding the behavior of this constant. An analytic form for $A(R)$ was devised and analysed for the aforementioned states. The RMS deviation between the experimental A_v and the A_v obtained from the theoretical $A(R)$ was sought to be minimized. Good fitted curves were thus obtained with a low RMS and the same separated atom limit for both states.

Phase transition of the Hard Spheres

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Abstract: Monte Carlo techniques are used to determine the phase diagram of the hard sphere model. Our simulation results were consistent with the Carnahan-Starling equation of state and the cell-model equation of state. This enabled us to obtain the chemical potential for the liquid and solid phase, respectively. The simulation results predict a melting density of $\rho_m = 1.0602$ and a freezing density of $\rho_f = 0.93972$, which are in good agreement with prior studies.

Acknowledgment: This work is supported by the National Science Foundation, Research Experience for Undergraduates.

Testing Models in Simulations of Tokamaks

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Advisors

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5 August, 2005

The paleoclassical transport model [J.D. Callen, Phys. Rev. Lett. 94 (2005) 055002.] is tested together with neoclassical and flow-shear stabilized turbulence-driven transport in ASTRA simulations of the pedestal formation and ELM crashes at the edge of H-mode tokamak discharges [A.Y. Pankin *et al.*, Plasma Phys. Control. Fusion **47** (2005) 483]. Simulation results for the shape of the pedestal temperature profiles and the frequency of ELM crashes are compared with detailed experimental data from the DIII-D 98889 discharge. In this model, flow shear in the pedestal reduces the transport driven by ion drift modes, resistive ballooning modes, and the electron temperature gradient (ETG) mode, while flow shear does not affect the paleoclassical electron thermal transport or the neoclassical ion thermal transport. A limit on the pressure gradient triggers ELM crashes, which abruptly change the temperature profiles in a region that is wider than the pedestal at the edge of the plasma. The inclusion of the paleoclassical model has the effect of making the electron temperature pedestal wider and in closer agreement with experimental data, compared with previous simulations that used only the ETG mode for electron thermal transport in the pedestal.

Supported by NSF PHY 0353620 and DOE DE-FG02-92-ER-54141.

Measuring Dispersion Properties by a Coupled Cavity Laser Interferometer

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Funding Source: National Science Foundation, Research Experiences for Undergraduates (REU)

The coupled cavity laser interferometer (CCLI) operates by adding a reflector to a laser so that the laser beam is reflected back into the laser cavity. This coupled external cavity causes the intensity of the laser output to depend on the phase relationship of the returned beam with respect to the laser cavity field. Physical properties of the external cavity lead to path length changes, which can be determined by measuring how many times the laser output intensity oscillates between the maximum and minimum intensity. First, we have used the CCLI to measure the wavelength of the laser used, a He-Ne laser in this case, within half a percent of accuracy. Next, we inserted a long gas cell in the external cavity and determined the index of refraction of both nitrogen and carbon dioxide. There emerged a reliable method to determine the index of refraction of refrigerant R134a, a gas whose index of refraction is unknown. These measurements have allowed for the techniques to be developed so that they can be applied to measurement of the refractive index of plasma that is created by using a pulsed high-voltage discharge within the gas cell. The plasma's refractive index only depends on the electron density of the plasma, and therefore the electron density of the plasma can be measured for plasmas created under varying conditions. The CCLI fringes are affected, however, by the presence of two other competing effects: gas density changes within the gas cell due to heating; and the electromagnetic noises due to high current pulse of the discharge. We have successfully sorted out these extraneous components and found the electron density in the discharge plasma. Finally, we have examined the feasibility of using an imposed translation of the external mirror during a measurement run in attempt to determine whether the path length of the laser beam is being increased or decreased.

Fabrication and Optical Spectroscopy of Eu³⁺ and Pr³⁺ Doped LaBGeO₅ Crystallites inside a Glass Matrix

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August 5, 2005

Abstract

Rare-earth doped LaBGeO₅ is an attractive material for applications in integrated optics due to their excellent electrical-optical and nonlinear properties. LaBGeO₅ doped with Praseodymium and Europium was fabricated and their optical properties were investigated through confocal PL spectroscopy at room temperature. Both Praseodymium and Europium doped samples were pumped using argon laser at 363 nm, and expected a red emission. Emission was only observed from the Europium doped LaBGeO₅, and red emission between 560 and 720 nm was observed due to ⁵D₀ → ⁷F₂ transition of the Eu³⁺ ions. Emission from both the crystal and glass of the sample were measured, and observed that the emission from the crystal was greater than the emission from the glass.

Antibacterial Glasses

Heather Quantz

Faculty Advisors: Dr. Himanshu Jain and Dr. Derick Brown

4 August 2005

The two experiments attempted in this project are silver oxide doping of sodium borosilicate glass and the addition of various concentrations of titanium dioxide to a sample of silver doped sodium borosilicate glass. The purpose of these experiments is to study the effects of both silver oxide and titanium dioxide on the antibacterial properties of the glass. The first experiment doped the glass with .5 and 1 weight % silver oxide. The second added 5, 2, and 1.5 mol % titanium dioxide to a sample including 1 weight % silver oxide. The results of the first experiment are inconclusive. The stain used to observe the antibacterial properties in the first experiment did not function correctly, and under the time constraint, the experiment could not be repeated. Results of the second experiment were also not obtained because a uniform sample of glass containing titanium dioxide was never achieved.

Title: Creating Educational Resources in Glass

Author: Tara Schneider

Advisors: Dr. Bill Heffner and Professor Himanshu Jain

Abstract:

I fabricated and researched amorphous candy made of sugar (sucrose, $C_{12}H_{22}O_{11}$), corn syrup (mostly fructose, $C_6H_{12}O_6$ and glucose, $C_6H_{12}O_6$), and water (H_2O). Accompanied by Raina Jain, I drew candy fibers with a core and cladding using the double crucible method for demonstration purposes. Next I used Pfund's method to find the index of refraction of candy. A trend began to appear in the relation of the index of refraction to water content: The lower the water content (controlled by boiling time), the higher the refractive index of this amorphous candy.

Using videos and procedures from these two experiments with candy, I produced two PowerPoint slide shows entitled "Candy Glass: Fiber Drawing Using the Double Crucible Method" and "Pfund's Method for Finding the Index of Refraction of Amorphous Candy." The slide shows are intended for high school students and teach about the following concepts: glass transition temperature, amorphous solids, crystalline solids, a supercooled liquid, viscosity, Snell's law, total internal reflection, core and cladding, and fiber optics. At the end of each slide show are instructions on how to perform the two labs. These slide shows are available at www.lehigh.edu/imi.

I also recorded digital videos with Bill Heffner at the 17th University Conference on Glass Science and First International Materials Institute Workshop on New Functionality in Glasses at Pennsylvania State University in June of 2005. These lectures will be available through the IMI at Lehigh University in real media (.rm) format.

**THE FUSE AND IUE ULTRAVIOLET SPECTRA OF THE INTERACTING
BINARY RY PERSEI**

BY: Kathryn Washer, Moravian College

Advisor: Prof. George E McCluskey, Lehigh University

Thanks to the support of the NSF-REU program

ABSTRACT:

Thirty-nine ultraviolet spectra of the Algol-type semi-detached interacting binary RY Persei have been obtained from the International Ultraviolet Explorer (IUE) satellite data archive. In addition, four ultraviolet spectra of RY Per have been obtained from the Far Ultraviolet Spectroscopic Explorer (FUSE) satellite archive. The resonance lines of Al III, Mg II and Si IV are present in absorption in all IUE high resolution spectra while the C IV and N V lines are not present in absorption. The Al III, Mg II and Si IV absorption lines show a phase dependence in their strengths, implying the presence of absorbing gas of varying density within the system due to mass loss from the cooler companion. IUE low dispersion spectra taken during the totality phases of primary eclipse show emission lines due to Al II, Al III, C II, C IV, N V, Fe III, Mg II, Si III and Si IV which are attributed to a hot circumbinary plasma. The FUSE spectra obtained during totality reveal emission lines due to N II, N III, O VI, Si III and Si IV. The presence of O VI indicates a plasma temperature of over 100,000 K where it is formed. FUSE spectra taken outside of eclipse reveal a spectrum rich in interstellar lines and stellar absorption lines of C II, C III, N III, O III, Si II and Si III. Clearly, RY Per is a moderately active Algol-type binary with significant and variable mass flow both within and out of the system.

Lehigh University Summer REU

Isaac Wildeson

August 5, 2005

Acknowledgements: Yijie (Sandy) Zhao, Yanli (Esther) Zhang, Dr. Marvin H. White, National Science Foundation, Sherman Fairchild Center

Abstract:

Microelectronic devices' role in society is ever increasing as technology is scaled smaller and smaller. Extensive research is needed to understand how these devices operate at scaled dimensions. Two microelectronic devices that I have worked with this summer include an Erbium doped silicon light emitting device and a SONOS Nonvolatile Semiconductor Memory device. The goal behind the Erbium doped silicon light emitting device is to produce electroluminescence by pumping Erbium ions implanted within a silicon dioxide film. The particular wavelength of electroluminescence that is desired is 1540 nm because of its applications in telecommunications. The electroluminescence will be used to travel information from one device on a chip to another by means of an optical circuit. Integrated optical circuitry has received great attention due to its ability to transfer larger amounts of information at higher velocities than compared with electrical circuitry. My particular involvement in this research included setting up a new Power Meter to record the electroluminescence, as well as a Semiconductor Analyzer that is used to apply current through our device. I created a LabView program that runs both pieces of equipment simultaneously. We have set up a test station in which electroluminescence testing of the device can be made at different wavelengths. We are presently in the early stages of testing our devices.

Nonvolatile Semiconductor Memory (NVSM) devices are memory devices that do not require an outside power supply to store memory. NVSMs have a MOSFET like structure that allows them to store charge in their dielectric layer. The specific NVSM device I tested was a SONOS device. In these devices, the charge is stored within traps in the nitride layer. These devices have two states that are used to store information digitally. The device is either in the written state, where excess electrons are stored in the nitride, or in the erased state, where excess holes are stored in the nitride. I have carried out various tests on these devices. I performed tests of sweeping the device at varying voltages applied to the gate and drain. This informed us of many behavioral characteristics of the device. I also carried out numerous speed tests. These tests illustrate the minimal pulse width of time that is needed to properly write or erase the device. The final tests executed were retention tests. From these we saw how well the device retains information over a period of time, or literally, how well they hold electrons and holes within the nitride layer. Much knowledge was learned about the theory and experimental characteristics of these microelectronic devices.

Stability Analysis of GaAs-Based pseudomorphic High Electron Mobility Transistors (pHEMT)

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***Abstract* — When choosing source and load impedances for a transistor amplifier, it is important that the designer choose impedances that will not cause the transistor to behave in an unstable manner. Stability circles calculated from S-parameter measurements are often used to predict which source and load impedances will lead to oscillatory instability. This paper describes a method for calculating stability circles, and compares these predictions to the large-signal load-pull measurements taken on a 6 x 0.25 μ m x 90 μ m folded-structure GaAs pHEMT.**

The author would also like to thank the Sherman Fairchild Center for Solid State Studies for their generous funding of this project and the summer 2005 members of Lehigh University's ECE Compound Semiconductor Technology Lab

Light Assisted Waveguide Writing in LiNbO₃
Nathaniel Woodward
Adv: Prof. Dierolf

This summer was spent exploring the fabrication and characterization of waveguides in LiNbO₃. Waveguide fabrication was attempted using a novel direct writing method based on the work of [1]. The experimental setup used a 244nm UV laser to stimulate heat induced changes in concentration of Li within the crystal samples. It is speculated that changing the concentration effectively changes the index of refraction at the region of illumination. The UV beam (up to 13mW) was focused to a 2.5 micron spot size. The samples were placed on a translational stage with a .1 micron step size which allowed for the writing of uniform waveguides in the sample. The stages were controlled by a LabVIEW program that allowed control of the desired waveguide length, number of waveguides, spacing between waveguides, and stage speed. In order to ensure that the laser focus was at a constant position relative to the sample surface, I developed a LabVIEW program that performed a real-time “autofocus” function.. The whole writing set-up was tested using ink-covered glass slides as test objects. Very regular lines could be written, that due to local heating and melting of the glass, were transferred to micron-sized surface features on the glass substrate itself.

Despite multiple attempts using a variety of laser powers and fluences, we were unable to detect waveguides within both stoichiometric and congruent LiNbO₃ samples. We also searched without success for refractive index changes using microscopy, photoluminescence spectroscopy, and diffraction techniques. We suspect that the available UV power was too low.

Concurrently I worked on waveguide characterization. Our main interest was in measuring the attenuation coefficient of waveguides. We made use of a Fabry-Perot method by treating the waveguide as a Fabry-Perot etalon in which the waveguide facets from partially reflecting etalon mirrors. By sweeping through a range of wavelengths, the output will oscillate between maxima and minima. Their normalized differences give a contrast value that is a measure for the loss in the waveguide [2]. We used a DBR semiconductor laser and temperature tuning to sweep the wavelength by .4 nm, yielding about 10 maxima and minima. From the averaged contrast values we obtained we obtained reasonable loss values for our test sample. Presently we are analyzing experimental error and are incorporating polarization control into the loss setup. Overall I learned a great deal this summer about waveguides and their characterization and had an excellent time doing so.

References

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