

Lehigh University
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Student Abstracts

ANALYSIS OF IUE DATA FOR THE SPECTROSCOPIC BINARY V 373 CAS

CHRISTINA ARAGONA

Department of Physics, Drew University

AND

GEORGE E. MCCLUSKEY, JR.

Department of Physics, Lehigh University

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ABSTRACT

A study of the IUE spectra for the spectroscopic binary V373 Cas was undertaken to obtain information concerning the presence of mass flow in the system. Lyubimkov et al. (1997), determined spectral types of B0.5 Ib-II and B0.5 III for the primary and secondary, corresponding to temperatures of $23,200 \pm 200\text{K}$ and $26,800 \pm 1500\text{K}$ respectively. In our study, one long wave spectra and the four available short wave spectra for the star were analyzed. The portion of the long wave spectra studied covered a range from 2000\AA to 3000\AA , while the short wave spectra covered a range of 1150\AA to 2000\AA . The spectra available at the IUE site had a resolution of $0.1\text{-}0.2\text{\AA}$. P Cygni features were found for N V, Si IV, and C IV. The C IV lines yielded a mean velocity of -1140 km s^{-1} . Both the N V and Si IV features showed evidence of absorptions at two distinct velocities. The N V lines indicated mean velocities of -1223 km s^{-1} and -442 km s^{-1} ; the Si IV lines yielded mean velocities of -1165 km s^{-1} and -460 km s^{-1} . The C IV doublet is almost completely blended and saturated so that the lower velocity wind component was not detected. The two distinct stellar wind velocities could either indicate that the primary's stellar wind has two components, or that the slower velocity is the result of a stellar wind from the secondary. The mid-ultraviolet spectra showed only interstellar lines, as expected for stars of this temperature. The mass loss rate appears to be normal for a B0.5 Ib-II supergiant.

Simulation of Biological Ion Channels as Nanodevices

Akwete Bortei-Doku, Santosh Pandey, Marvin H. White

16A Memorial Drive East, Department of Electrical Engineering,
Lehigh University, Bethlehem, PA-18015, USA

Abstract

In this paper, we describe how a TCAD solid-state device simulator is used to model the biological KcsA ion channel. The I-V characteristics of these channels have been studied extensively by many researchers but the need to acquire a better knowledge of the electrical properties of the ion channel has led to various simulation approaches that can accurately model the ion channel. This TCAD simulator is typically used by electrical engineers to simulate the process flow and electrical characteristics of solid-state devices. With this software, we have been able to study the possible electrical behavior, which includes the potential distribution through the channel, the ion concentration distribution along the channel, as well as the effect of surface charges present at the protein-water interface on the carriers' transport mechanism. Models of cylindrical and KcsA channel are built using the TCAD simulation tools and self consistent solutions of the axial potential and the ion fluxes are obtained. The simulation results are compared with the reported experimental results in the literature to verify the efficacy of our model.

Characterizing High-k Dielectric Films for CMOS Devices and SONOS NVSM Devices

Andrew J. Bronczyk, Yijie Zhao, Marvin H. White

Sherman Fairchild Center, Lehigh University
16A Memorial Drive East, Bethlehem, PA 18015

Abstract

High-k dielectric films such as HfO_2 and Al_2O_3 have been extensively studied in search of a new insulating material which will allow the MOSFET industry to continue scaling towards sub 100nm device structure sizes. The devices considered in this paper consist of a $\text{SiO}_2/\text{HfO}_2$ gate stack or an $\text{Al}_2\text{O}_3/\text{Si}_3\text{O}_4/\text{SiO}_2$ gate stack. Multiple tests such as capacitance-voltage (CV), linear voltage ramp (LVR), stress measurement, and write-erase measurement were conducted as to better characterize these devices. Such properties as film high-k values, charge trapping, and flat-band shifts were also analyzed.

Spectra Changes of Pr³⁺ Ions Across Ferro- electric Domain Walls in LiNbO₃: Domain Wall Imaging & Crystal Field Analysis

Kaia Buhl

Advisor: Dr. Volkmar Dierolf

August 6, 2004

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Dr. Dierolf and Research Group

Lehigh University

Abstract

Confocal luminescence microscopy was used to image the domain walls of Pr³⁺ in Lithium Niobate (LiNbO₃). There is a strong interest in Pr³⁺ due to its large range of wavelengths from near ultraviolet to infrared. The domain walls were observed to be very clear under particular transitions. This was especially true for portions of the transitions where there were definite shifts and/or bumps in the spectra from the domain inversion. We speculate the shifts to indicate an electric field change between the domain inverted and as grown part of the sample and the bumps to represent sites changing between the two. Some of the transitions showed evidence of the ferroelectric dipole changing while the defect dipole remained unchanged in the domain wall. This suggests that the crystal-field parameters appear to influence the changes during the domain inversion.

MEMS Design and Fabrication

Aziz Iqbal, Svetlana Tatic-Lucic, Wenyue Zhang
16A Memorial Drive East, Department of Electrical Engineering
Lehigh University, Bethlehem, PA 18015

Abstract:

Design and development of a mask to validate claims made by Alcatel Vacuum Technologies of etching with very high aspect ratio, high etch rate and low roughness on Silicon using their AMS 100 SE Deep reactive Ion Etcher. Initially, geometrically valid layouts are produced using a CAD program such as Conventorware. The fabrication of each layout is modeled using a 3-D simulation of the etch process. The 3-D model resulting from the simulation are compared to desired 3-D shapes and sent to mask making foundry in GDS and CIF formats for actual fabrication. The fabricated mask will then be used to test and finalize purchase of the AMS 100 SE.

Nonadiabatic Effects in $3^3\Pi$ and $4^3\Pi$ states of NaK

David O. Kashinski and A. P. Hickman

Department of Physics, Lehigh University, Bethlehem, PA, 18015

Abstract

We have investigated non-adiabatic coupling between the $3^3\Pi$ and $4^3\Pi$ states of NaK using a formalism applicable to the case that these electronic states can be obtained as the eigenvalues of a known diabatic 2×2 electronic Hamiltonian. Assuming that the R dependence of the adiabatic electronic wave function arises entirely from the R dependence of the of the mixing angle θ for the diabatic states, we are able to derive exact expressions for the matrix elements of the full nuclear kinetic energy operator. We developed a computer code to evaluate these matrix elements by numerical integration, using diabatic states determined by a fitting program also developed in this laboratory. The results indicate that the non-adiabatic coupling can be significant, sometimes as large as two or three tens of cm^{-1} . In general, the effects appear to be too large to apply the model only to two ro-vibrational states at a time. Continued work will be necessary to include a large number of ro-vibrational levels (of the same angular momentum J) in the calculation. The $3^3\Pi$ and $4^3\Pi$ states of Na appear to be an interesting example where effects of the breakdown of the Born-Oppenheimer approximation may be visible.

Evaluation of CHISEL Programming Technique and an Modeling new techniques for Retention Extrapolation

Bilal M. Khan

August 6, 2004

Acknowledgements: Rajiv Mehrotra, Steve Wrazien, Marvin H. White, National Science Foundation, Sherman Fairchild Center

Abstract:

Nonvolatile Semiconductor Memories are MOSFET like transistors that have the ability to store information without the presence of external power. However, once a memory state has been programmed into the device, due to the presence of electric fields charge begins leak out of the storage layers thereby reducing the reliability of the device. As time passes, charge leaves and causes a decrease in threshold voltage. The difference between the write and erase threshold voltages is indicative of how reliable the storage device is. A new method is explored of extrapolating the difference in threshold voltage out to ten years and beyond. This new technique shows that the actual memory window at 10 years may be at least five times greater than previously anticipated.

“Refurbishment of an UHVCVD Machine.”

R. Longenecker

M. K. Hatalis

5 August, 2004

Lehigh University Sherman Fairchild Center
Research Experience for Undergraduates

Special thanks to:
Army Research Labs
Sharp Labs of America

Abstract:

“The Semiconductor Industry has been one of rapid growth, both in technology and size. One could expect nothing less from an industry that has grown from relatively nothing to a market value of half a trillion dollars in half a century. With a modern fabrication plant priced in the billions, the semiconductor production and equipment industry has seen its own growth as well. With this in mind, it may be of great profit for one to gain insight and experience in this highly specialized area. This paper will examine the refurbishment of an Ultra High Vacuum Chemical Vapor Deposition (UHVCVD) machine at Lehigh University and give a small glimpse into the components and systems involved.”

Calibration of Model for Tokamak H-mode Pedestal and ELMs

Chris MacDonald

Advisors

Glenn Bateman

Arnold Kritz

Lehigh University Physics Department, Bethlehem, PA 18015

5 August, 2004

Experimental data is used to calibrate a model for predicting the pedestal and Edge Localized Modes (ELMs) implemented in the ASTRA integrated code. The input data and the models used in the ASTRA code are documented. Tools are developed to prepare experimental data for input into ASTRA and to analyze output. New models for the stability criterion used to trigger ELM crashes and the profile following an ELM crash are developed and implemented. The model is then calibrated to predict the frequency of the ELMs and the height of the electron and ion temperature pedestals just before each ELM crash. Detailed comparisons are made with experimental data from the DIII-D 98889 discharge, in which the noise in the data was reduced by overlaying the plasma profiles from a sequence of consecutive, nearly identical ELM cycles. The model includes neoclassical transport and transport driven by ion drift modes, resistive ballooning modes, and the electron temperature gradient mode. The criterion for triggering ELM crashes allows for access to second stability. The calibration is carried out by adjusting: (1) The flow shear rates for individual modes of long wavelength turbulent transport; (2) the stability criterion that is used to trigger ELM crashes; and (3) the shapes of the plasma profiles and plasma energy lost after each ELM crash. The calibration is presented as well as the sensitivity of ELM cycle period and pedestal heights to the changes in the coefficients in the model.

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Development of Nitride Films and Extraction of dielectric constants for electric field considerations and SONOS applications

Rajiv Mehrotra
August 6, 2004

Acknowledgements: Bilal M. Khan, Steve Wrazien, Marvin H. White, National Science Foundation, Sherman Fairchild Center

Abstract:

Due to its attractive endurance, reliability and the ability to withstand 10-100k program cycles, SONOS technology has become a leading competitor for operation in the Nonvolatile Semiconductor Memory devices. The principle performance of these devices takes place in the nitride layer where the charge is stored in discrete traps. The devices operate in the Modified Fowler-Nordheim Tunneling regime whose lower electric field bound is greatly dependant on the nitride layer properties. This study presents the characterization of three types of such nitride films – stoichiometric Si_3N_4 , silicon rich SiN and oxy-nitride SiO_xN_y layers. We extract parameters such as the dielectric constants of each film, the effective thickness of the nitride and the gate capacitance. The effect of these parameters on the electric fields produced in the devices is demonstrated and studied and future work in these footsteps is proposed.

Programming Microcontrollers to Generate Moving Patterns for Flexible Displays

8/05/2004

Rebecca Merola

Grad. Student Adviser Abbas Jamshidi Roudbari, Prof. Miltiadis Hatalis
Display Research Laboratory, ECE Dept., Lehigh University, Bethlehem, PA 18015

Funded by

Center for Optical Technologies through the "Flexible Display Project"
from the Army - Lehigh Research Cooperation Program.

National Science Foundation Research Experience for Undergraduates

Abstract

In conjunction with the Digital Research Laboratory at Lehigh University, my work this summer focused mainly on software to test and run their flexible displays. The Digital Research Laboratory is currently working on active-matrix, OLED Flat Panel displays on flexible metal substrates. Future applications of this research are in consumer, automotive, medical, and military markets. Some devices that may soon be using flexible displays are cell phones, PDAs, Tablet PCs, e-books, and some wearable equipment. A number of tests need to be performed on these displays to make sure they are running properly and to test what they are capable of. My work addressed one of the ways the displays need to be tested. By creating programs to generate moving patterns, one can test whether or not the display actually shows the proper information. My work focused on programming microcontrollers to generate these moving patterns to be used as a tool in testing these displays.

Calculation of elastic constants from parallel molecular dynamic simulations

M. T. Meyers

Undergraduate in Department of Materials Science and Engineering, Lehigh University, Bethlehem, Pennsylvania 18015

Acknowledgements

J. M. Rickman

Department of Materials Science and Engineering, Lehigh University, Bethlehem, Pennsylvania 18015

T. J. Delph

Department of Mechanical Engineering and Mechanics, Lehigh University, Bethlehem, Pennsylvania 18015

Financial support provided by:

National Science Foundation, Research Experience for Undergraduates Program

Abstract

Molecular Dynamic Simulations are often used to model different atomic level interactions. In molecular dynamics Newton's force equations are integrated in order to determine positions and velocities of individual atoms. With today's supercomputing capabilities, parallel machines are often utilized to increase the timescale for which simulations can be run. Also, the number of atoms in these simulations can be increased to make the trials more realistic, and in turn increase predictability and accuracy in the results.

Initially a simulation environment of 125 FCC Cu unit cells, each of side length 3.62 angstroms were established with 500 Cu atoms residing at their appropriate lattice positions. Simulations were conducted on a Beowulf parallel computing cluster that contained 96, 1 GHz processors. The simulations were run at a constant volume of 5919.92 cubic angstroms, a constant temperature of 100 K, and with periodic boundary conditions. Atom positions were tabulated and examined for long trials in order to eventually extract the three elastic constants of Cu in the solid state, along the [100], [110], and [111] directions. The intent of this study was to evaluate the fluctuation method for calculation of elastic constants of solids.¹ It has been asserted by L. R. Pratt, but never numerically demonstrated, that the elastic constant tensor can be found from a Fourier analysis of the second-rank tensor of displacement correlations. Trial simulations along with numerical calculations should confirm this work.

Electrical Extraction of Physical Parameters of Submicron Transistors

Wayne Miller, Yu Wang, and Marvin H. White

Sherman Fairchild Center, Lehigh University
16A Memorial Drive East, Bethlehem, PA 18015

Abstract

This article reviews and compares various methods to extract threshold voltage and effective channel length. The various extraction methods are compared using current-voltage characteristics of submicron LD(S/D) n-channel ONO transistors. The influence of drain voltage on the reviewed effective channel length extraction methods is also scrutinized.

Resistance of Flexible Displays

Jarrett Moyer

Advisor: Professor Hatalis

Acknowledgements:

Army Research Labs

Sharp Electronics Corporation

National Science Foundation – Research Experience for Undergraduates

Abstract

Flexible displays will completely change the display industry in the near future and many different organizations are performing research on these displays. Since no one knows the best method of creating a flexible display, many different types of flexible displays being proposed. The different substrates being used in these displays are either plastic or stainless steel the images are created with either electronic ink or organic light emitting diodes (OLED). Lehigh University is developing an active-matrix flexible display that uses a stainless steel substrate and OLED's. Prior research has widely covered the area of how thin-film transistors (TFT) react under curvature stress, but only a small amount of research has been performed on the resistance of wires across a bending, flexible display. Our research has concluded that the resistance of wires increases when the display is bent convexly and the resistance decreases when the display is bent concavely. Cracks in the glass insulating layer between in the stainless steel substrate and the wires were the main problems in our test samples. These cracks will cause the wires to be shorted and greatly affect the performance of the display.

Experimental Studies of the NaK $b^3\Pi_2$ state

By

Uloma Ogba

Supported by NSF and the Center for Optical Technologies, Lehigh University,
Bethlehem, PA

Abstract

Nearly degenerate levels of the $A^1\Sigma^+$ (v_A, J) and the $b^3\Pi_0$ (v_b, J) states, with the same rotational quantum number J couple together by the spin-orbit interaction creating singlet-triplet mixed levels, $A^1\Sigma^+$ (v_A, J) \sim $b^3\Pi_0$ (v_b, J), which act as “window” levels to higher lying triplet states. Pat Burns has studied $A^1\Sigma^+$ (v_A, J) \sim $b^3\Pi_0$ (v_b, J) windows extensively. $b^3\Pi_2$ levels are difficult to study because there is only a weak indirect coupling between the $b^3\Pi_2$ and the $A^1\Sigma^+$ states. We predicted the locations of these window levels by plotting the energies of the $A^1\Sigma^+$ (v_A, J) and $b^3\Pi_2$ (v_b, J) rotational levels vs. $J(J+1)$ and studying the observed crossings. A fitting program, LSQ was used to diagonalize the Hamiltonian matrix. Using the perturbation facilitated optical-optical double resonance technique (PFOODR) we found two $A^1\Sigma^+ \sim b^3\Pi_2$ levels at $v_A=19$, $v_b=17$ for $J=45$ and $v_A=23$, $v_b=20$ for $J=32$ by probing to the $1^3\Delta$ and $3^1\Pi$ states. We measured the hyperfine structure of these mutually perturbing ro-vibrational levels of the $b^3\Pi_2$ and the $A^1\Sigma^+$ states of the NaK molecule by co-propagating the pump and probe lasers in a singlet \rightarrow (mixed singlet/triplet) \rightarrow singlet pump/probe configuration. We also used these perturbed levels to determine the energies of high lying $3^3\Pi_2$ levels which gives us information about the fine structure splitting of this state.

Using Fluorescence to Measure Particle Displacement and Phase Shift for Optical Tweezers

Marissa An Ohira
Advisor: Dr. Daniel H. Ou-Yang
REU Summer 2004, Lehigh University

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Dr. Daniel H. Ou-Yang,
and his research group:
Dr. Chuan Pu, Olga Latinovic, Anil Kumar, Meron Mengitsu, Huseyin C. Yalcin

Abstract

In most experiments using optical tweezers, a particle suspended in a medium is trapped and given an applied force. Information about particle displacement and phase shift from this applied force can be used to extract properties of the medium, such as the energy storage and loss modulus. Current methods of measuring particle displacement for optical tweezers, such as the split photodiode, take time and patience. In order to achieve accurate data, the equipment must be correctly aligned. In this paper, I discuss research to develop a new method of measuring particle displacement and phase shift by using fluorescence. Advantages of this method include ease of set-up and measurement, applications with biological research using optical tweezers, and the possibility of using smaller particles, such as quantum dots.

Photoinduced Changes of Optical and Physical Properties in Chalcogenide Glasses

Corisma Robinson

Abstract

Thin films from bulk samples of As-Se based chalcogenides were deposited by vacuum thermal evaporation. Photoresist masks were produced from As-Se compositions of As_2Se_3 , $\text{As}_{50}\text{Se}_{50}$, and As_4Se_3 . In the first half of the experiment, the goal was to produce a negative photoresist. For a negative photoresist to occur, an organic etching bath was used. In order to compare the selectivity of etching against each As-Se system, the same concentration of the same solvents was used on all films. To check the selectivity of etching, the films were cut into small squares and exposed by a halogen light source at various times. Each piece of film was then timed while being etched until all of the film had dissolved. For the concentration of the etching bath used, $\text{As}_{50}\text{Se}_{50}$ had the highest selectivity. In the second half of the experiment, virgin films of the three As-Se systems were characterized during an insitu photodarkening experiment in which the films were exposed using a laser diode (660 nm) while measurements were taken. It was determined that the photodarkening increased as the amount of As in the film increased and the band gap decreased.

Raman Tweezer Application in Photonic and Biological Systems

Greg Stone

Advisor: Dr. Volkmar Dierolf

Funding: National Science Foundation, Research Experiences for Undergraduate and Center for Optical Technologies, Lehigh University

An experimental setup was constructed to combine the particle-trapping ability of optical tweezers with the investigative measurements of Raman spectroscopy. This setup is based around a scratch-built confocal luminescence microscope, which includes a high NA objective (needed for tweezing) and a laser-blocking notch filter (for measuring Raman signal). Glass beads of 1mm in diameter were used to test the tweezing capabilities and LiNbO₃ was separately used to test the Raman capabilities. Beta-Carotene was then studied as a test model for the combined tweezing and Raman measurements. We also examined poled samples of LiNbO₃ by scanning across the domain wall looking for changes in the Raman signal.

Organic Light Emitting Diodes:

An Investigation with Pulsed Photoconductivity

Natalie Terry

Advisors: Dr. Ivan Biaggio and Dr. Hikmet Najafov

Lehigh University, Bethlehem, PA 18015

July 2004

Funding: National Science Foundation, Research Experience for Undergraduates.

Abstract:

The diagnostics and characterization of organic light emitting diodes (OLEDs) by short-pulse-induced charge-carrier photoexcitation has been investigated in PPV-based systems. The measurement of the photoinduced charge accumulation on the electrodes of an OLED with an applied reverse bias voltage and after illumination with a short light pulse of variable wavelength has been demonstrated to be an effective method to obtain information on the photoexcitation mechanisms and charge transport in packaged OLEDs. The amplitude and time-dynamics of the observed resistivity change can be related to microscopic material parameters such as the mobility and lifetime of the photoinduced charge carriers. Even though the majority of the resistivity change occurs within less than a microsecond after illumination with picosecond pulses, charge carriers continue to move in PPV up to 100 microseconds afterwards. The dynamics of this slow charge-carrier drift could be detected by observing the corresponding charge accumulation on the OLED contacts in an effectively open circuit configuration. We found that its decay time is clearly dependent on the size of the applied electric field. This dependence can be tentatively assigned to the electric-field dependent transit times of the charge carriers towards the contacts. Under this assumption we determined hole-mobility value of the order of $1e-5 \text{ cm}^2/(\text{Vs})$. This value is higher than what has been determined by time-of-flight in PPV, which we assign to the fact that in our case the PPV thickness, and thus the transport length, was 50nm, in contrast to the time-of-flight measurements, which required micrometer-thick samples.

Vibrational Spectroscopy of Hydrogen-Containing Defects in Semiconductors

Quinn Thomas – 2004 Summer REU Program

The problem of identifying defects in semiconductors that contain hydrogen has been the subject of many experimental and theoretical studies. Vibrational spectroscopy has proved to be a powerful tool for probing materials to study these defects.

One defect that has been studied with vibrational spectroscopy is the interstitial H₂ molecule in Si. A challenging question has been, "Is H₂ a free rotator when trapped in the Si lattice?" First experiments performed at Imperial College in London were interpreted in terms of a static H₂ defect; however, a subsequent experiment at Lehigh University showed that H₂ is indeed a free rotator. A stress experiment is planned for HD in Si to confirm the nature of the vibrational transitions. The vibrational line for HD in Si is extremely weak, making it difficult to fabricate suitable samples for stress experiments. New methods to introduce H and D into Si samples were investigated and these samples were tested by IR spectroscopy to see if sufficiently strong signals were produced. The signal to noise ratio of IR measurements for HD will have to be increased by an additional factor of ~5 to make stress experiments feasible.

GaPN is another semiconductor material that has attracted much recent attention. When N is added to GaP, the band gap energy is reduced. When H is then added to GaPN, the band gap energy returns to its original value. This effect of H was first studied for GaAsN, and a defect structure was proposed by several theoretical groups that might account for these findings. The proposed structure has one N-H bond and one Ga-H bond. Studies of hydrogenated GaAsN by vibrational spectroscopy showed that the dominant defect contains two N-H bonds which is not consistent with the structure proposed by theory. In our experiments, we studied hydrogenated GaPN to investigate whether it would show vibrational properties similar to those seen previously for GaAsN. Our experiments showed N-H vibrational lines for hydrogenated GaPN that were very similar to those seen previously in GaAsN, suggesting a similar bonding structure for the N and H containing defects that are responsible for the band gap shifts observed for this material.

Utilizing the Fourier Series in Determining the Orbital Elements of Detached Visual Binary Star Systems

Peter Tupa
Hiram College
2004 NSF-REU
Advisor: Dr. Gary DeLeo

Abstract

In this paper we continue the work done by Quirin (2002) to construct a procedure to determine the orbital elements of detached visual binary stars. A Fourier representation is fit to observational data and then used to extract the orbital elements eccentricity, semi major axis, time of periastron passage, and the orientation angles for the plane of the orbit. The procedure was refined and applied to orbits used by Quirin (Xiboo, 51 Tau, 24 Aquarii, Bu 738) and new test cases (HIP 2552, WDS 13320-6519, WDS 17221-7007, HIP 110893, WDS 19456+3337). Further work is needed for BD +195116, WDS 14189+5452, 14373-4608, WDS 07294-1500, and WDS 00321-6715.

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Vibrational Calculations on an NH₂ Model for an N-H

Defect in GaAs

Kathryn Washer for the NSF, REU 2004 Program

Advisors: Dr. W. Beall Fowler

Dr. Kevin Martin

An important N-H defect in gallium arsenide (GaAs) consists of two hydrogen atoms and one, possible two, nitrogen atoms, but its detailed structure is unknown. We specifically looked at a proposed NH₂ configuration and compared this to an H₂O molecule. Looking at the normal modes of vibration for H₂O (asymmetric, symmetric, and wagging), and using G matrix theory, as well as some basic classical mechanics, we were able to match the vibrational spectra and determine the force constants (or “spring” constants) between the hydrogen and nitrogen. Also, we were able to predict where a “missing” frequency for an NDH defect might be found.