APS SPIN-UP Workshop: Rutgers University, June 4-6, 2010

Undergraduate Research – The Start of a Career

Dr. Anthony M. Johnson, Director
Center for Advanced Studies in Photonics Research (**CASPR**)
Professor of Physics
Professor of Computer Science & Electrical Engineering
University of Maryland, Baltimore County (**UMBC**)
2002 President of the Optical Society of America (OSA)
Editor-in-Chief, *Optics Letters* (95-01)
NSF ERC MIRTHE Deputy Director & Materials Research Thrust Leader
amj@umbc.edu

Distinguished Member of Technical Staff (before January 1995)
Photonic Circuits Research Department, AT&T Bell Laboratories (now Alcatel-Lucent)
1995-2003 Chair, Physics Department, New Jersey Institute of Technology (**NJIT**)

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Early Bell Labs Undergraduate Research Internships and PhD Fellowship Programs for Minorities and Women

- The Cooperative Research Fellowship Program (CRFP) for Minorities, founded in 1972 was one of the first programs of its kind in the US to address the issue of under-representation of minorities at the PhD level in the fields of mathematics, science and engineering
- The Graduate Research Program for Women (GRPW) was founded in 1974 -- a companion program to CRFP to address the shortage of women scientists at Bell Labs
- To create a pool of undergraduate students eligible to enter the graduate CRFP and GRPW programs, the Bell Labs Summer Research Program for Minorities and Women (SRP) was established in 1974 – this 10-week summer program was for outstanding underrepresented minorities and women who have completed their Jr. year of undergraduate studies. The purpose of SRP was to provide a preview of the lifestyle of an R&D career to impact decisions to earn graduate degrees

Summer Research Program (SRP) For Minorities & Women (Est. 1974)

- Undergraduates who have completed 3 years of education in mathematics, science or engineering -- provisions include:
  - Summer employment – stipend
  - Housing arrangements – Rutgers University
  - Transportation
  - Individual research project with a Bell Labs scientist as mentor
  - In the early days approx. 60 slots were available across disciplines

Cooperative Research Fellowship Program (CRFP) For Minorities (Est. 1972)

- About 10 students enter each year and spend 5.5-6 years earning the PhD
- The program pays each Fellow's education expenses, including tuition, fees and books, conference attendance, summer employment and an annual stipend
- A mentor is assigned to each Fellow, with the objective of ensuring that Fellows have a substantive relationship with an experienced scientist in a related discipline, a professional who can provide guidance, nurturing, inspiration and advocacy during the doctoral training, and often beyond

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COMMENTS FROM PREVIOUS SRP STUDENTS

In answer to the question:
"How did you feel about the work assignment?"

"The work was intellectually stimulating and rewarding. It dealt with an area of . . . that is new and fertile. As a result of my contribution to this area, I will be co-author of two publications in technical journals."

"I feel I've learned more about my future field of interest than I have in years of school."

"To see theory actually working in an experiment makes it easier to understand and learn."

"For me one of the most interesting aspects of this summer was to actually see what sort of things a research position involves and how an advanced degree might be used. I think the things I learned this summer may give more direction to my studies and school work."

EXAMPLES OF 1992 UNDERGRADUATE STUDENT TALKS

IN THE COMMUNICATIONS SCIENCES RESEARCH DIVISION

- **Linewidth Measurements on Tunable DBR Lasers**

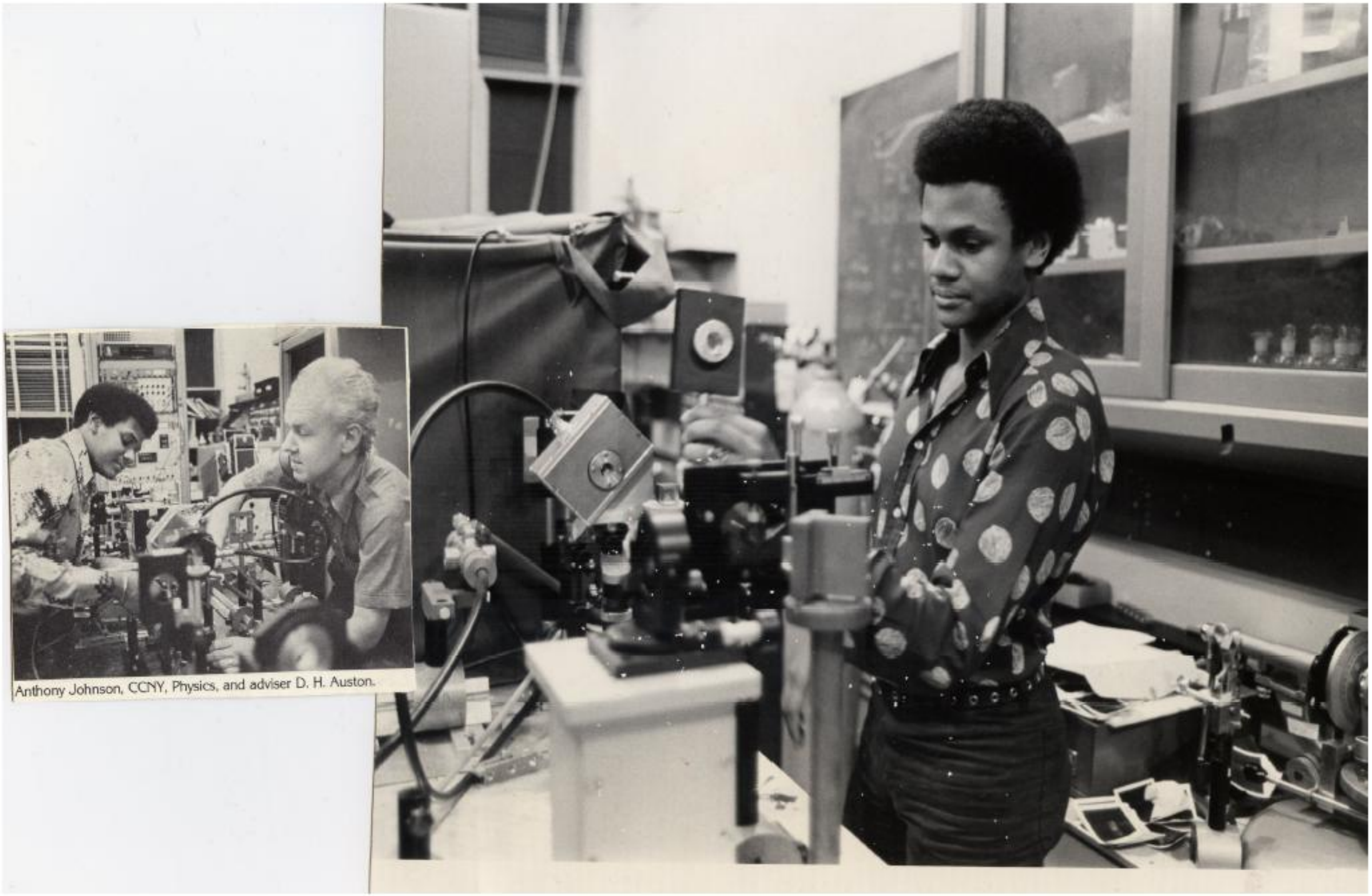
- **Surface Preparation Techniques for Selective Area Growth by MBE**

- **Flip-Chip Bonding Modulators onto Silicon Chips**

- **Computer Control of CBE Growth: Compositional Ramping**

- **Temperature Dependence of InP-HBT Parameters**

1974 Bell Labs Summer Research Program, Murray Hill, NJ



Anthony Johnson, CCNY, Physics, and adviser D. H. Auston.

David H. Auston – Lasers and Picosecond Optoelectronics – Past President, Kavli Institute -- UCSB

Robert Dynes – Low Temperature Physics and Superconductivity – Past President of UC -- UCSD

First scientific award:

Sigma Xi Undergraduate Research Award for Bachelor's Thesis (1975)

AN ABSTRACT

MICROWAVE SWITCHING
BY
PICOSECOND PHOTOCONDUCTIVITY

by

Anthony M. Johnson
Advisor: Hellmut J. Juretschke
Co-Advisor: Dave H. Auston

Submitted in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science (Physics)

June 1975

Bulk photoconductivity produced by the absorption of picosecond optical pulses in silicon transmission line structures has been used to switch and gate microwave signals. The technique permits the generation of microwave and millimeter wave pulses as short as a single cycle, and requires only a few microjoules of optical energy. The switching speed is essentially limited only by the duration of the optical pulses. The basic features of the device are illustrated with switching experiments at 1 GHz and 10 GHz, and the results are discussed with reference to the physical properties of the high density plasma responsible for the switching.

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[13] J. C. Dyment *et al.*, "Proton-bombardment formation of stripe-geometry heterostructure lasers for 300 K CW operation," *Proc. IEEE* (Lett.), vol. 60, pp. 726–728, June 1972.
[14] J. C. Dyment, C. J. Hwang, and A. R. Hartman, "Dependence of threshold current density and differential quantum efficiency of the stripe width of proton-bombarded double heterostructure lasers," unpublished.
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[16] A. W. Smith and J. A. Armstrong, "Intensity noise in multimode GaAs laser emission," *IBM Syst. J.*, vol. 10, pp. 225–232, May 1966.

IEEE Journal of Quantum Electronics, vol. QE-11, pp. 283-287, June 1975

Microwave Switching by Picosecond Photoconductivity

A. M. JOHNSON AND D. H. AUSTON

Abstract—Bulk photoconductivity produced by the absorption of picosecond optical pulses in silicon transmission-line structures has been used to switch and gate microwave signals. The technique permits the generation of microwave and millimeter-wave pulses as short as a single cycle, and requires only a few microjoules of optical energy. The basic features of the device are illustrated with switching experiments at 1 GHz and 10 GHz, and the results are discussed with reference to the physical properties of the high-density plasma responsible for the switching.

I. Introduction

In many cases, both for experimental purposes and for applications, it is desirable to have a capability for generating very short bursts of microwave and millimeter-wave signals of relatively high power. The current state of the art, however, is limited to switching speeds of approximately 1 ns [1]. Furthermore, at these speeds, the semiconductor p-i-n diodes which are used for this purpose are limited to powers of a few tens of watts. In this paper, we describe a simple optical technique for switching microwave signals which offers a significant improvement of both speed and power handling.

Although bulk semiconductor plasmas have received considerable attention as microwave switching devices [2], the use of high-density, optically generated plasmas has not been given serious consideration. Aside from the obvious speed capability, picosecond optical pulses have the additional advantage of enabling the generation of extremely high-density plasmas without damaging the material. Longer optical pulses are less efficient since they tend to produce more heating, and consequently are more likely to cause damage. It has recently been demonstrated [3] that plasma densities in excess of 10^{20} cm^{-3} can be readily generated by the absorption of single-picosecond optical pulses in semiconductors. Plasmas such as these are highly degenerate and have quasi-metallic properties. Their high conductivities make them ideal for bulk switching applications. The research reported in this paper is an extension of related work [4] in which switching and gating of dc signals was achieved with solid-state plasmas produced by picosecond pulses.

Manuscript received December 9, 1974.
A. M. Johnson was with Bell Laboratories, Murray Hill, N.J. 07974. He is now at the Polytechnic Institute of New York, Brooklyn, N.Y. 11201.
D. H. Auston is with Bell Laboratories, Murray Hill, N.J. 07974.

II. Optoelectronic Microwave Switching

An example of a microwave switch which utilizes the photoconductivity produced by picosecond optical pulses is illustrated in Fig. 1. It consists of a 50-Ω microstrip transmission-line [5] structure fabricated on a high-resistivity silicon substrate. The microstrip line consists of a uniform aluminum ground plane on the bottom and a narrow strip for an upper conductor in which there is a gap. Input and output microwave signals are coupled to the silicon chip by 3-mm coaxial-to-microstrip launchers. In a typical application, one side of the device would be connected to a microwave-signal source and the other to a load or test instrument. The switching action is produced by two optical pulses; one in the green region of the spectrum at $\lambda = 0.53$ μm, which is used to turn on the switch, and the other in the infrared at $\lambda = 1.06$ μm, which turns it off. The absorption constant at $\lambda = 0.53$ μm in silicon is 8×10^3 cm^{-1}, and consequently the effect of absorbing a green pulse in the microstrip gap is to produce a thin surface

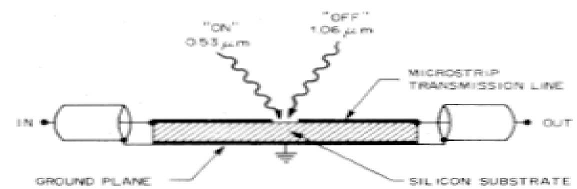
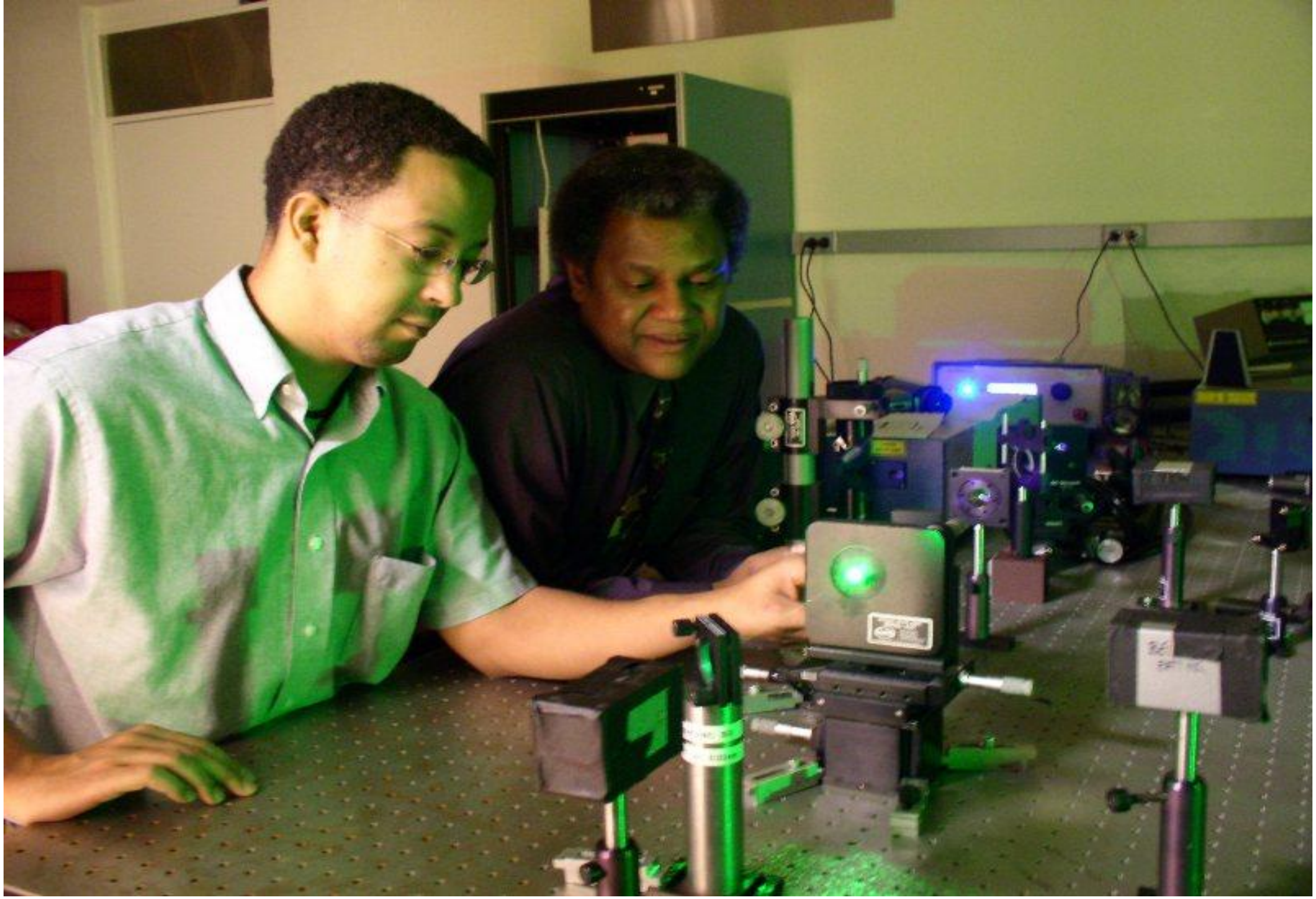


Fig. 1. An optoelectronic switch. The transmission of the switch is turned on by a surface layer of photoconductivity produced by the green pulse, and is turned off by volume photoconductivity produced by the infrared pulse, which shorts the device.



Robinson Kuis, Undergraduate Ronald E. McNair Scholar at NJIT – undergraduate research in modelocked lasers and nonlinear optics

Rob joined my group to pursue a PhD in Applied Physics at NJIT

Rob moved to UMBC to help build the CASPR Ultrafast Optics & Optoelectronics Lab

Rob completed his PhD in Applied Physics at UMBC December 2009

Rob is 1 of the typical 10-15 Latino-Americans in the US receiving a PhD in Physics in 2009

New Applied Physics PhDs

Dr. Robinson Kuis – Dec. 2009

Dr. Raymond Edziah – May 2010

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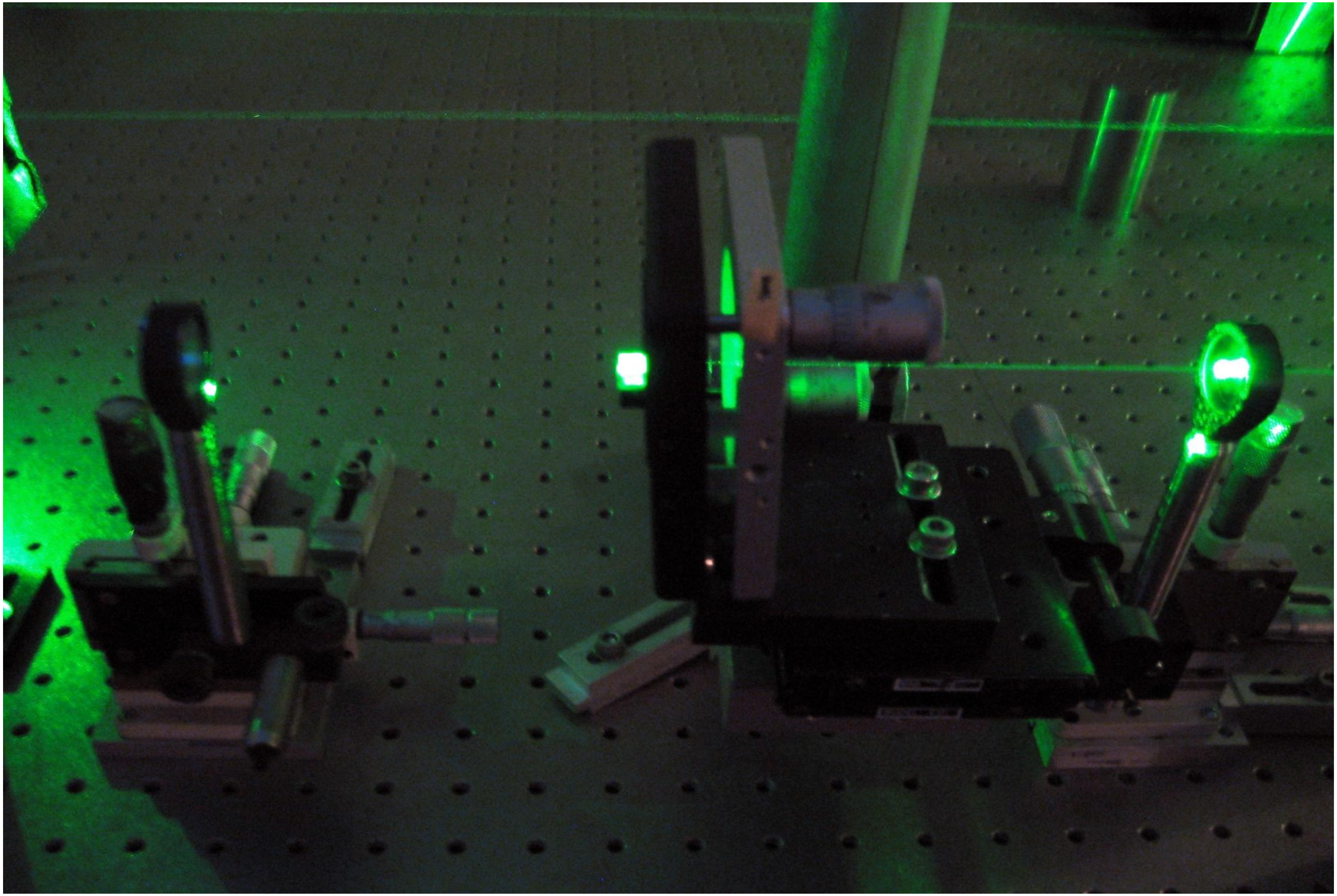
Robinson Kuis, PhD
Program Manager / Mid-IR fiber products
IRFlex
“The Mid-IR fiber devices Company”
Danville, VA
rob.kuis@irflex.com

A Modelocked and Frequency Doubled Nd:Vanadate Laser Using a KTP Crystal -- $\omega+\omega\rightarrow 2\omega$



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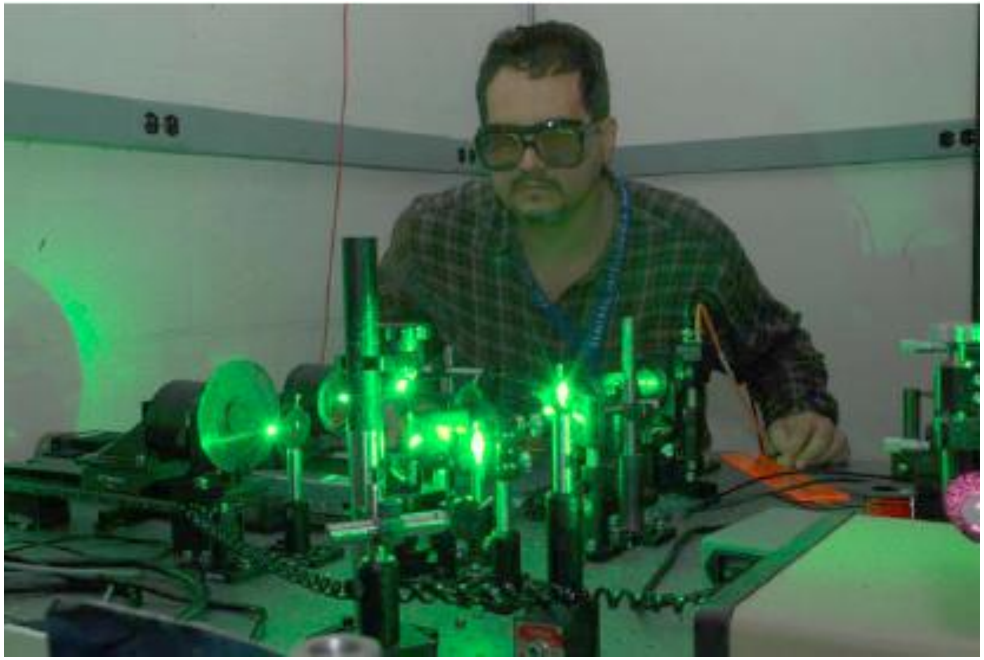
Victor Torres – 3rd Year PhD CSEE student, March 2008

Non-collinear background free autocorrelation of a 7ps frequency doubled SESAM modelocked Nd:Vanadate laser



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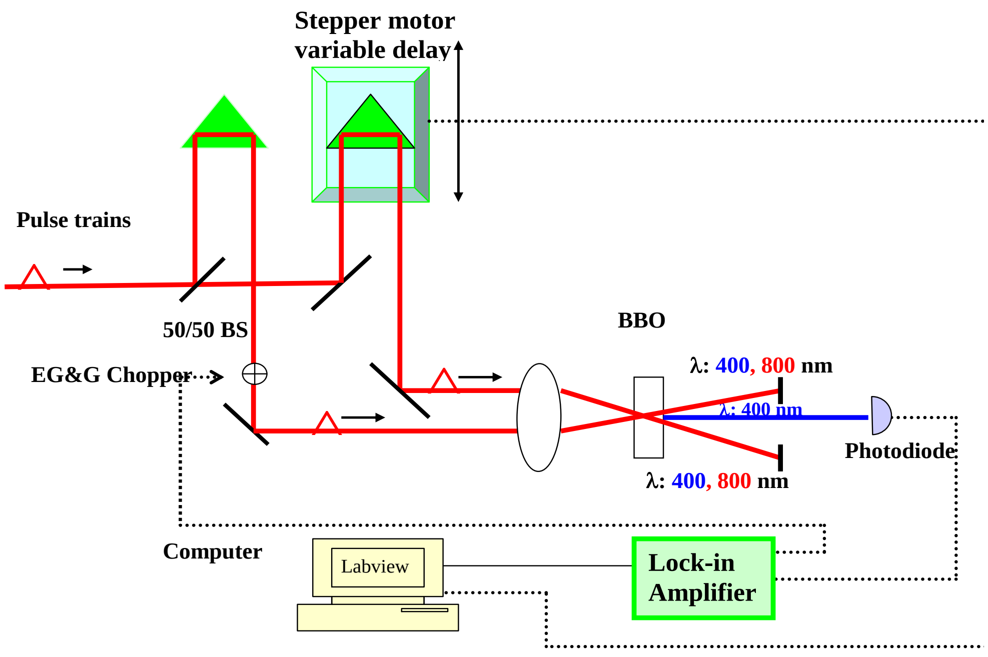
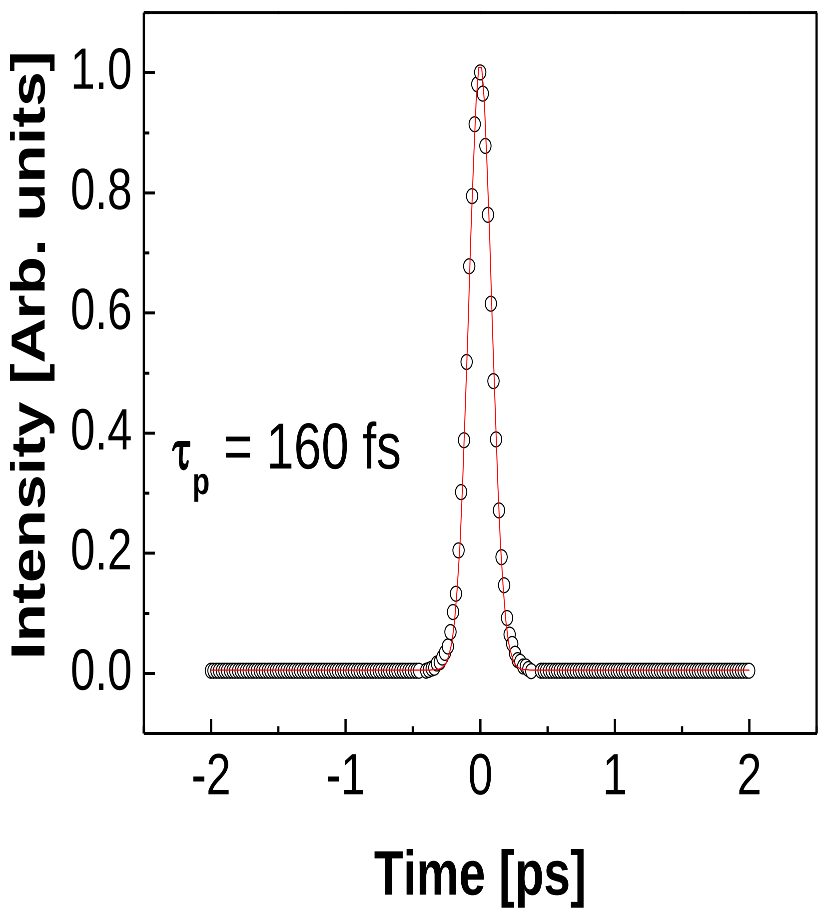
Nonlinear Optical Autocorrelation- Pulsewidth





BBO=Beta Barium Borate

$$G^{(2)}(\tau) = \int_{-\infty}^{\infty} E^*(t)E(t+\tau)E(t)E^*(t+\tau)dt$$

$$= \int_{-\infty}^{\infty} I(t)I(t+\tau)dt$$

d = ct

0.33 mm ⇔ 1 picosecond = 10^{-12} sec

0.33 μm ⇔ 1 femtosecond = 10^{-15} sec

Amplified Ti:Sapphire Laser, λ = 800 nm

$\tau_p = \tau_{auto}/\sqrt{2}$ (Gaussian Intensity Profile)

$\tau_{auto} = 226$ fs → $\tau_p = 160$ fs

Mid-Infrared Technologies for Health and the Environment

National Science Foundation – Engineering Research Center

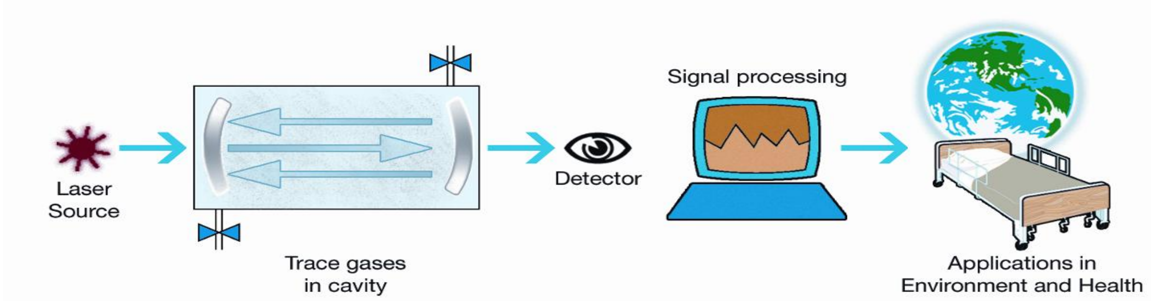
What / Who is MIRTHE ?

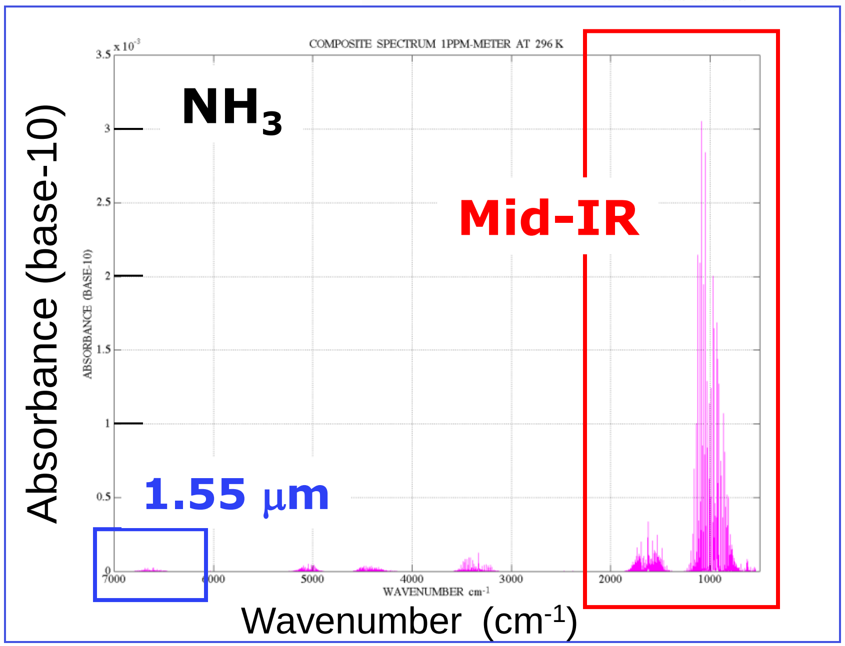
- World-class, interdisciplinary team of engineers, chemists, physicists, environmental and bioengineers, medical doctors, and educators, in academia and industry

Goals:

- Research, development, and technology transfer to industry of unprecedented mid-IR (3 – 30 μm) optical trace-gas sensing systems for environmental, homeland security, and medical applications.
- Formation of a vibrant community for learning and teaching, providing the best education with interdisciplinary breadth for a new generation of highly educated, practice-oriented, competitive, and diverse U.S. workforce.

Technology: Tunable "Diode" Laser Absorption Spectroscopy





- Molecules are uniquely identifiable through their mid-IR absorption spectra
- Strong resonance lines = Single-molecule or ppt (parts-per-trillion) sensitivity
- Non-destructive, non-invasive, with fast dynamic response.

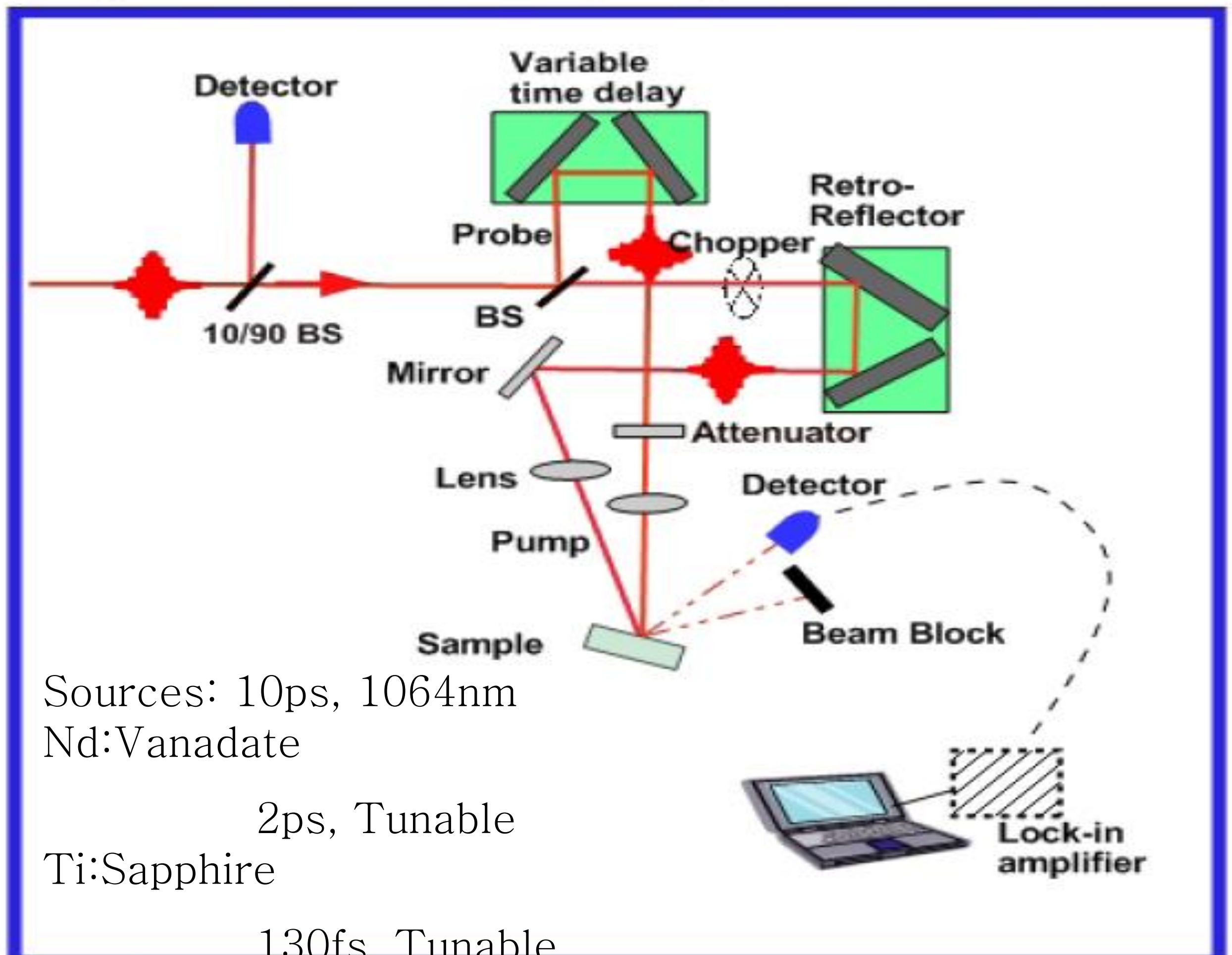
Graph: M. Taubman, PNNL

Time-Resolved Reflectivity of Mid-IR Materials -- UMBC-CASPR

•The photogenerated carriers contribute to changes in the refractive index of the material and thus changes in reflectivity through a combination of mechanisms such as free-carrier absorption, bandfilling and band-gap renormalization. Depending on the sample structure and its quality, these mechanisms may occur on a time scale as short as several picoseconds.

•We will compare the quality of MOCVD and MBE-grown III-V and MBE grown II-VI materials by studying the carrier dynamics and surface quality of the materials.

Pump-Probe Reflectivity Experimental Schematic



Sources: 10ps, 1064nm Nd:Vanadate

2ps, Tunable Ti:Sapphire

130fs, Tunable Ti:Sapphire

~150fs, 3-12um

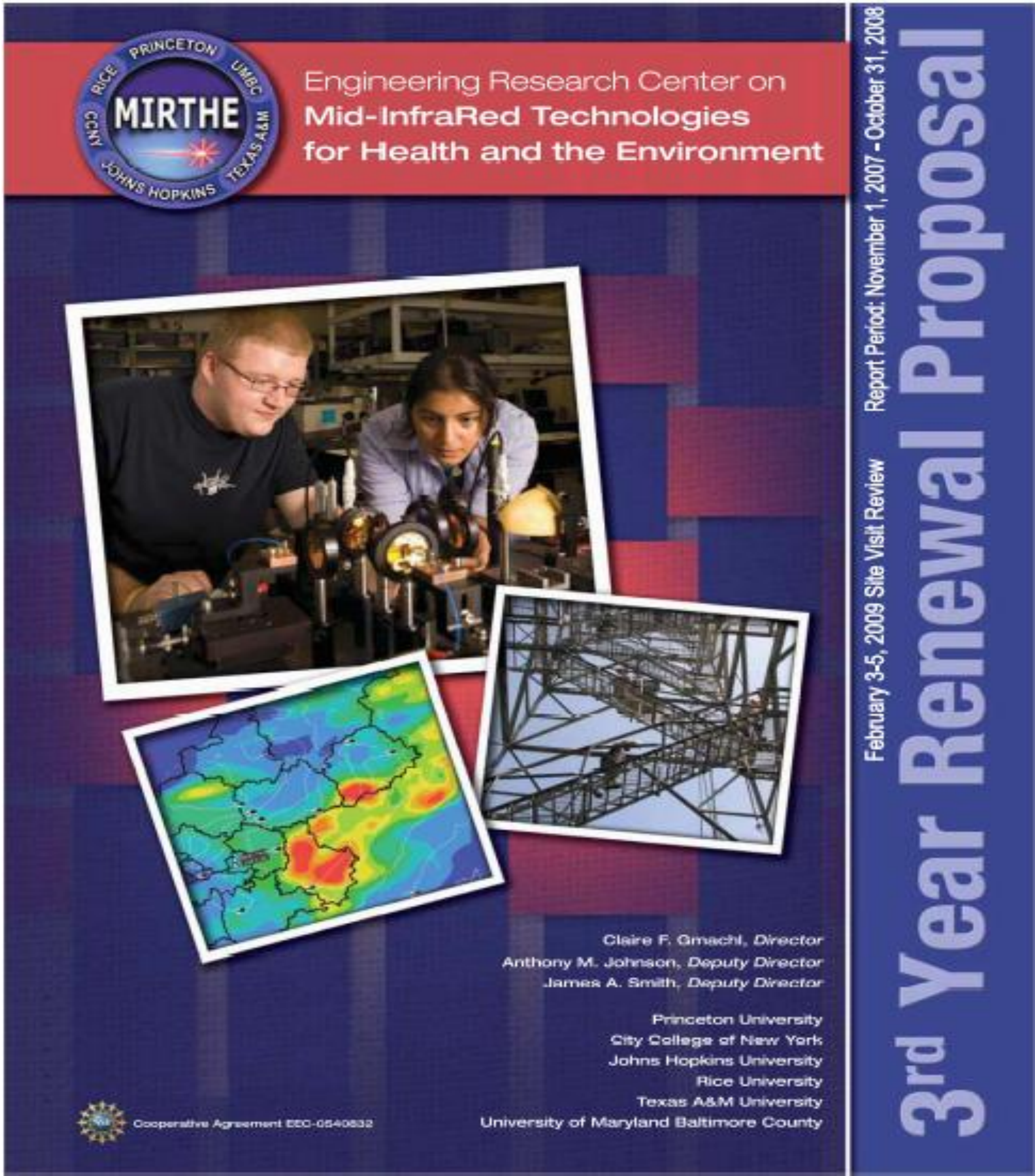
Bryan Bruce, Senior, CSEE

Meyerhoff Scholar, M17

Undergraduate Research at CASPR Lab, Fall & Spring Semesters ('07 – present) with NSF MIRTHE support – ultrafast optical phenomena in semiconductors, Raman spectroscopy and testing of quantum cascade lasers

Bryan graduated with a BS in May 2009 and is attending UMCP for graduate school

Photo → Bryan performing measurements on quantum cascade lasers during the NSF MIRTHE REU Program @ Princeton during Summer '08 in MIRTHE Director Claire Gmachl's lab



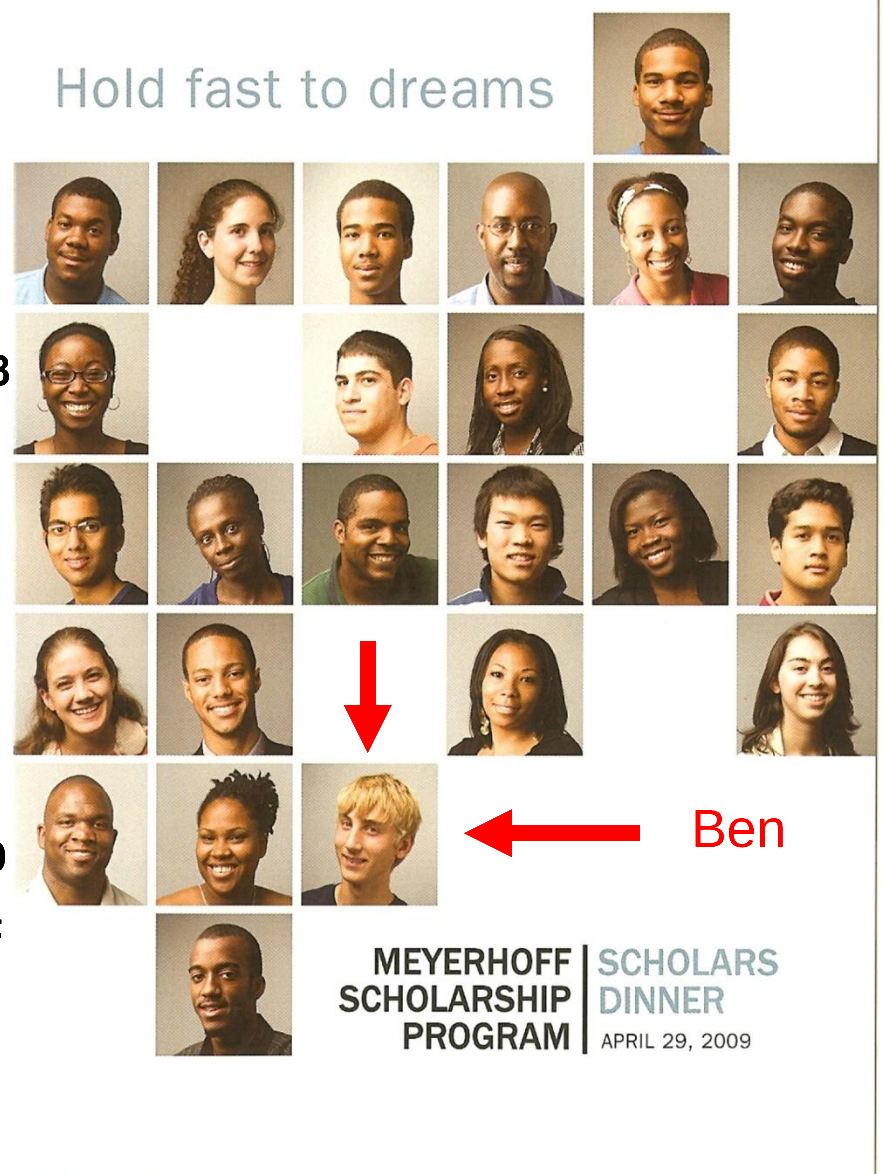
<u>Benjamin Ecker</u>, Sophomore (08), Physics

Meyerhoff Scholar, M19

Undergraduate Research Summer ’08 at CASPR in the NSF MIRTHE REU Program @ UMBC -- “Time-Resolved Reflectivity Measurements to Characterize Novel Semiconductor Materials”

Ben participated in the Summer Undergraduate Research Fellowship (SURF) Program at NIST in Gaithersburg, MD during Summer ’09

Ben will participate in the NIST SURF Program during Summer ’10. Ben’s project in THz spectroscopy will benefit from his ultrafast laser experience at CASPR/UMBC



Time-Resolved Reflectivity Measurements to Characterize Novel Semiconductors Materials

Benjamin Ecker, Robinson Kuis, Dr. Anthony Johnson, UMBC

What Seems to be the Problem??

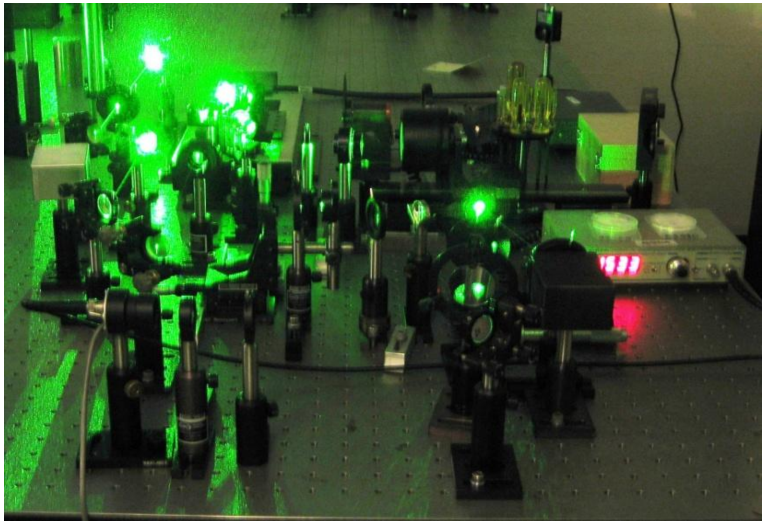
- MIRTHE wants to develop high quality but low cost sensing devices for health and environmental measurement which make use of QCL's

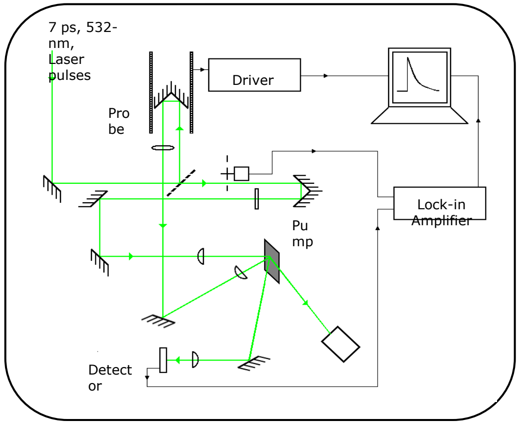
- In an attempt to optimize the QCL's at the core of the sensing devices, QCL Grower's are constantly trying new materials, different techniques, and varying compositions for QCL layers

- The problem is: how good are these new materials, techniques, and compositions??

What is the Solution??

- A measure of the quality of a semiconducting layer is the lifetime of optically generated carriers by short pulses of light
- A time-resolved reflectivity measurement is one method to determine the lifetime of the carriers

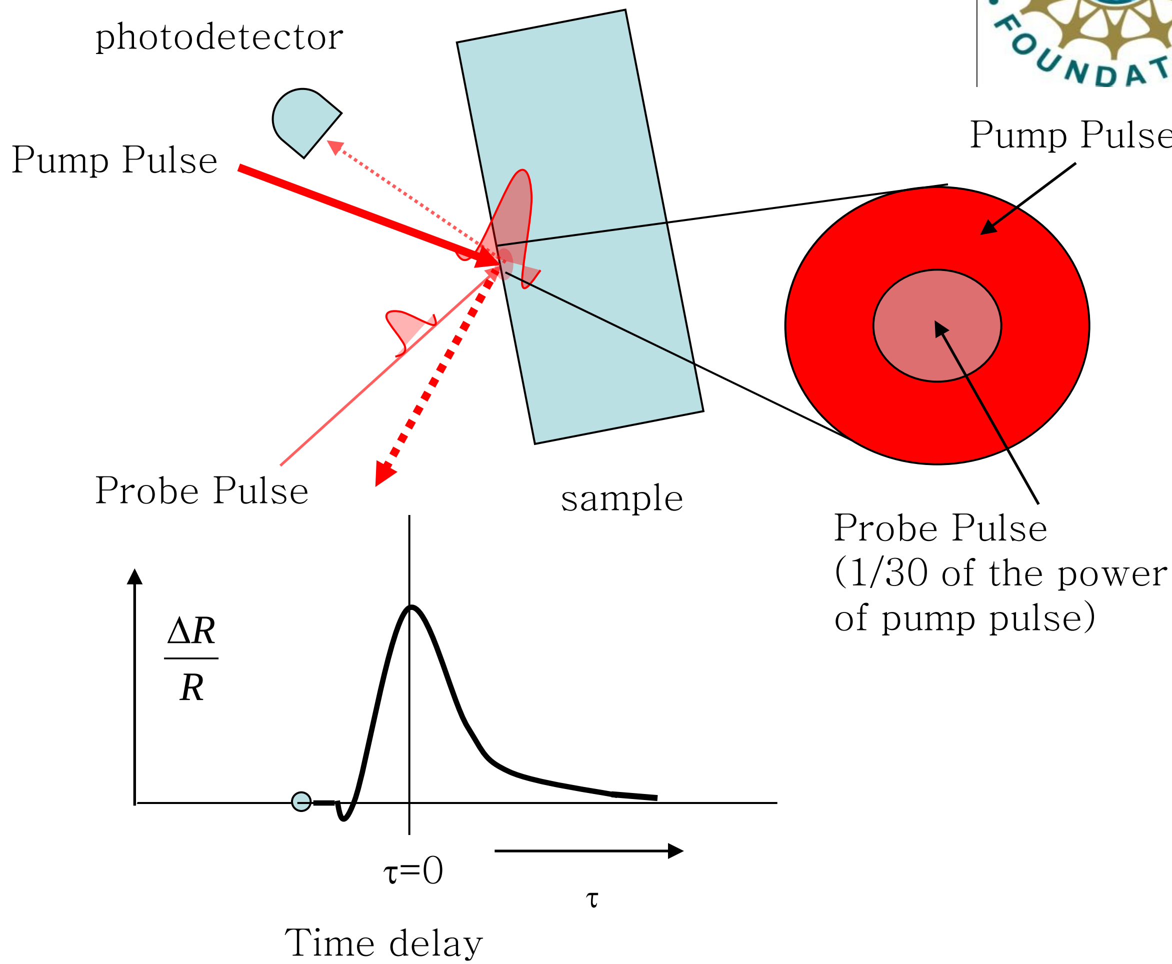




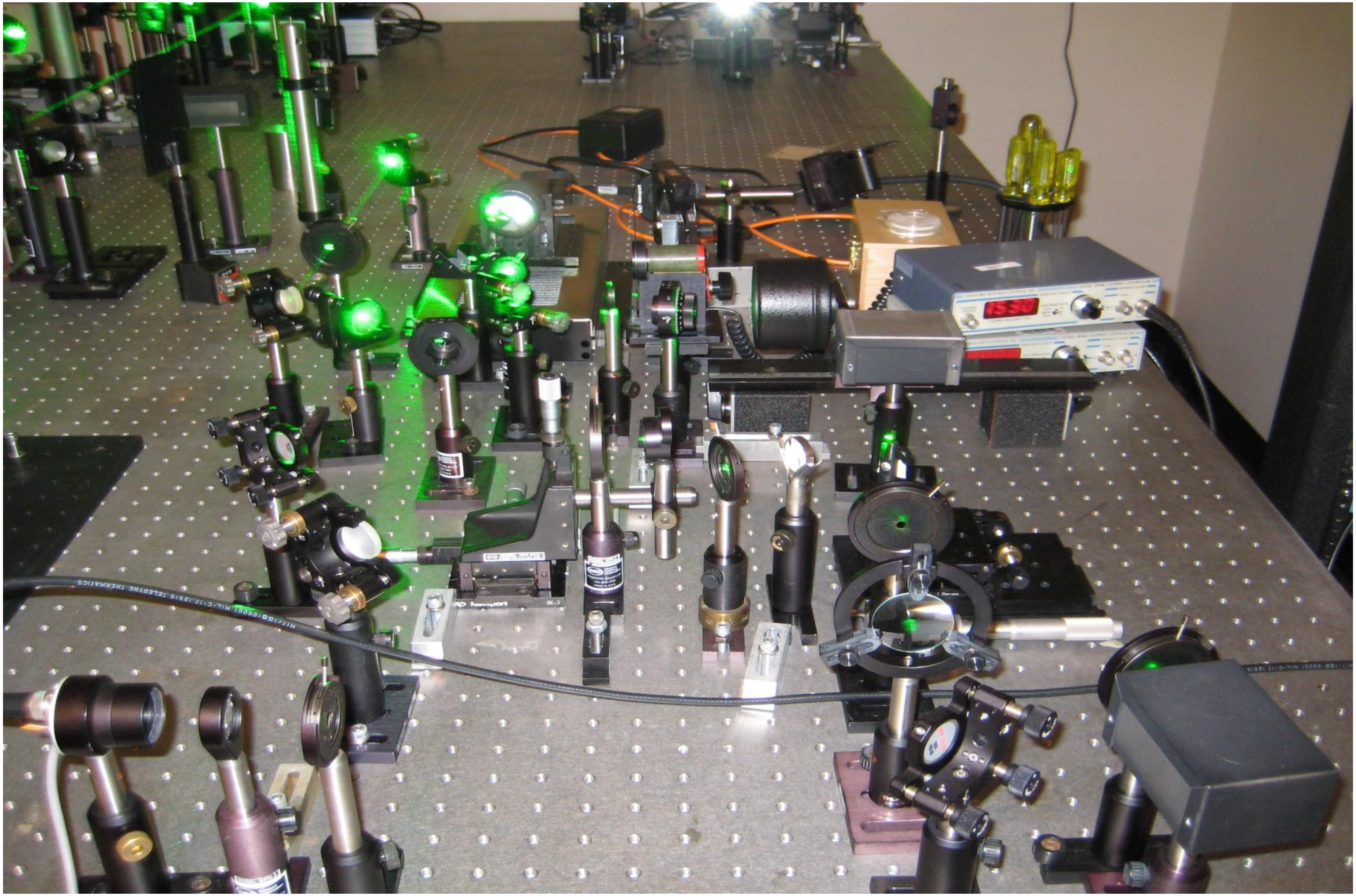
Pump-Probe Reflectivity

- **A strong pump pulse is focused onto the semiconductor sample and produces a distribution of photocarriers which results in a time-dependent refractive index change.**
- **A weak time-delayed probe-pulse is spatially overlapped with the pump pulse and the reflected signal is detected by a slow Si or InGaAs photodetector**
- **As the carriers recombine or get trapped by defects, the photocarrier density decays along with a decay in the refractive index change**

$$\frac{\Delta R}{R} \approx \frac{4\Delta n}{n^2 - 1}$$



Ben Ecker's Time-Resolved Reflectivity Setup



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Time-Resolved Reflectivity Measurements to Characterize Novel Semiconductor Materials

Benjamin Ecker[1], Robinson Kuis[1, 2], Dr. Anthony Johnson[1, 2, 3], UMBC

Motivation

•Problem:

One of the main goals of MIRTHE is to develop high quality but low cost trace gas sensing devices for health and environmental measurements which make use of Quantum Cascade Lasers (QCLs). The performance of the sensors depends upon the characteristics and quality of the semiconductor layers which make up the QCLs. Layers grown from new materials, different techniques, and varying compositions demand characterization.

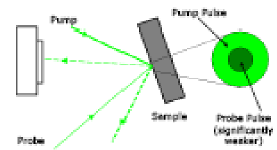
•Solution:

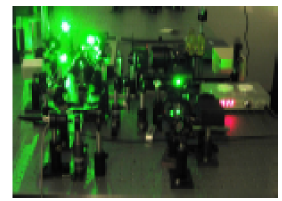
A measure of the quality of the semiconducting material is the lifetime of optically generated carriers excited by short pules of light. Typically, a short lifetime corresponds to a poor quality sample; the photo-excited carriers become trapped rapidly by defects in the sample. While a long carrier lifetime usually corresponds to a high quality sample. These lifetimes can be as short as several picoseconds (ps).

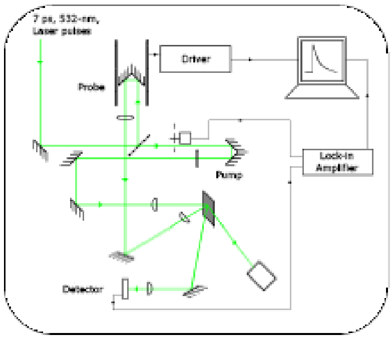
A time-resolved reflectivity measurement is one method to determine the lifetime of the photo-generated carriers. The carriers contribute to a small change in the refractive index and the reflectivity of the material. To perform a time-resolved reflectivity measurement, the pump-probe technique can be used to map out the small change in reflectivity, and thus determine the lifetime of the carriers and the quality of the semiconducting layer.

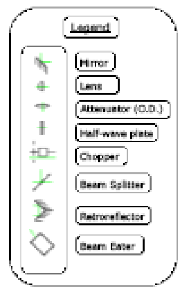
Theory Behind Pump-Probe Technique

- The pump pulse generates optically excited carriers in the sample.
- A small change in the refractive index and reflectivity of the semiconducting layer occurs with a significant carrier density created by the pump pulse.
- As the electron-hole pairs recombine or become trapped by defects in the sample, the photo-generated carrier density decreases resulting in a decrease in the change in the refractive index and reflectivity of the sample.
- The probe pulse after traveling through a variable time delay arrives at the sample, spatially overlapped with pump pulse.
- Depending upon the delay, a varying amount of the probe is reflected.
- By mapping out the delay and the amount reflected, it is possible to determine the lifetime of the carriers, and the overall quality of the semiconducting sample.



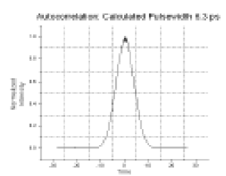


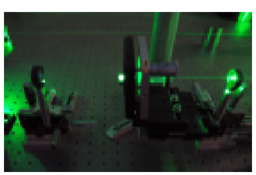




Source

- Nd:Vandate laser at wavelength 1064-nm
- SESAM (semiconductor saturable absorber modelocking) modelocked laser with nominal pulsewidth at 7 ps and a repetition rate of 76 MHz

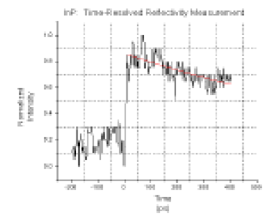




- The infrared wavelength of the laser was frequency-doubled to a visible wavelength of 532-nm (green) using a nonlinear optical crystal of potassium titanyl phosphate (KTP)

- Thanks to MIRTHE for financially supporting this research
- Thanks to the NSF who supports MIRTHE who support this research
- MANY, MANY, MANY THANKS to all those at CASPR for all their guidance, encouragement, and help with just about everything

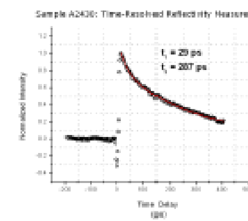
Experimental Data



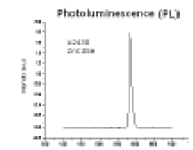
Pump Power: 100 mW
Probe Power: 3.5 mW

*Used to check validity of setup
*Expected to have exceeding long lifetime
*InP is a typical substrate used to grow QCLs layers on

Fitted InP Lifetime: 1263 ps



Fitted Sample A2430 Lifetime: T1 = 29 ps
T2 = 287 ps



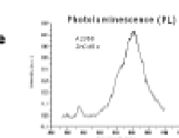
*Sample A2430 ZnCdSe
*Expected to have long lifetime
*Expected to be high quality sample due to narrow PL peak
*Sample grown from Molecular beam epitaxy (MBE)
*Sample could be used as a Quantum Well in a QCL

Sample Grown by Maria C. Tamargo's Group at City College of New York

Conclusions

The time-resolved reflectivity measurements produced good data. Measurements on Sample A2430 confirm that the sample is indeed of high quality and that it could make a very good II-VI semiconducting layer in a Quantum Cascade Laser.

**Future time-resolved reflectivity measurements will be performed on sample A2360 which is expected to be a poor quality sample because of a broad PL peak. It should produce carriers with an exceeding short lifetime.



CASPR

www.mirthecenter.org

[1] Department of Physics, University of Maryland Baltimore County, Baltimore, MD 21250, United States of America
[2] Center for Advanced Studies in Photonic Research, University of Maryland Baltimore County, Baltimore, MD 21250, United States of America
[3] Department of Computer Science and Electrical Engineering, University of Maryland Baltimore County, Baltimore, MD 21250, United States of America

MD middle school students visit the CASPR Ultrafast Optics & Optoelectronics Lab as part of the UMBC ESTEEM (Enhancing Science & Technology Education & Exploration Mentoring) summer camp program during the Summer ’05 – the OSA (Optical Society of America) sent a staffer to record the event and prepare an article for Optics & Photonics News (OPN)

OPN October 2005

OSA Past President Brings Lasers to Summer Camp

Patricia Daukantas

Anthony M. Johnson explains laser safety to middle school students in the ESTEEM program.

On one of the hottest afternoons of July, 25 middle school students witnessed some cool applications of laser technology. OSA 2002 president Anthony M. Johnson hosted the students for a couple of hours at his laser laboratory at the University of Maryland, Baltimore County (UMBC).

The middle schoolers, who live in Anne Arundel and Baltimore counties in Maryland, spent four weeks in a UMBC summer camp that is part of a program called ESTEEM (Enhancing Science and Technology Education and Exploration Mentoring). The camp, under the auspices of UMBC's Center for Women and Information Technology and Shriver Center, aims to stimulate girls' interest in technology careers; however, boys are welcome to attend as well, and several of this year's campers were boys.

The campers began their day learning about a fundamental aspect of the science of light: solar energy. In their morning session, they built small plastic toy carts powered by solar panels.

Campers use night-vision scopes to view infrared light.

In the afternoon, Johnson, who serves as director of UMBC's Center for Advanced Studies in Photonics Research (CASPR), told the youngsters that he became interested in lasers many years ago, thanks to a summer internship he did at Bell Laboratories—the site of many early innovations in the field.

He played for the campers an introductory OSA video, "Lasers as a Tool," which explains how the devices work and showcases numerous applications in the home, laboratory, factory and hospital. Apart from a few "ewwwws" when the camera zoomed in on surgical procedures, the students watched the video without squirming.

Johnson discussed how lasers are used in dentistry and ophthalmology as well as CD-ROM drives. He also explained that his own interests lie in the field of ultra-high-speed photonics, a topic that fits into UMBC's physics and electrical engineering departments, where he holds joint appointments.

The lasers in his lab, he said, give off pulses that are a million times shorter than a billionth of a second, and some that are even a thousand times shorter than that. "You can only do measurements that fast with light, because no electronics can do that," he told the students. His explanation of the lasers' intense speed increased the impact of his exhibition of his picosecond and femtosecond lasers.

Those lasers are included in a laboratory that Johnson calls the "million dollar

April 8, 2010 visit of 20 high school senior physics students from the Friends School of Baltimore to CASPR

Ms Shelly Watts – MS in Applied Physics July 2009 – Primary Physics Teacher at Friends School of Baltimore

CASPR
CENTER FOR ADVANCED STUDIES IN PHOTONICS RESEARCH

UMBC
AN HONORS UNIVERSITY IN MARYLAND

Dr. Elaine Lalanne, CASPR Research Associate, discusses the use of femtosecond optical pulses to study ultrafast processes in nanostructured materials, to senior high school physics students

CASPR

CENTER FOR ADVANCED STUDIES IN PHOTONICS RESEARCH

UMBC

AN HONORS UNIVERSITY IN MARYLAND

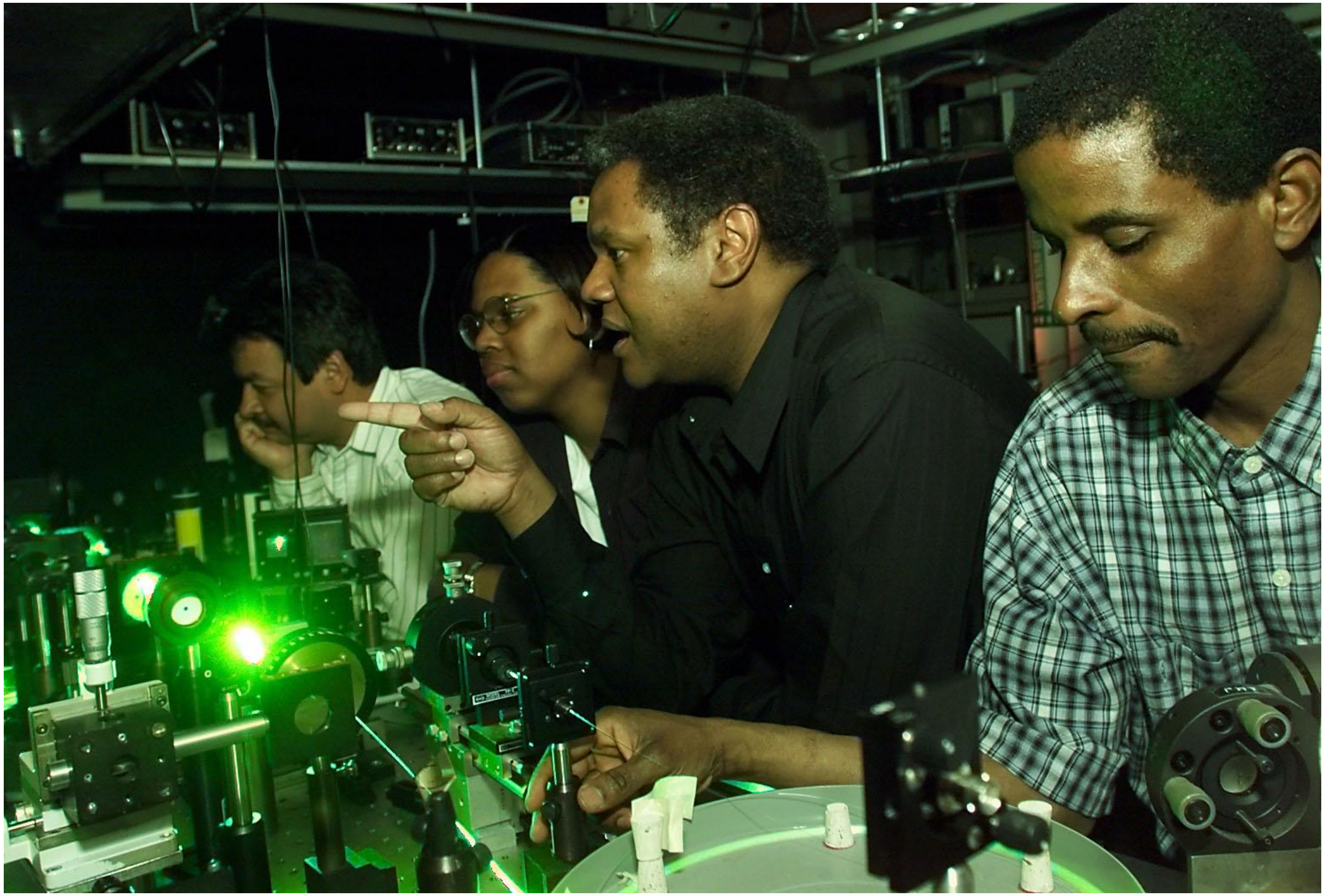
"My colleagues, kids and myself were really impressed and excited about our visit. I had so many questions on the way back about the research and especially as they got a chance to see me talk about my graduate work. My colleagues are really excited about this relationship we are forming and really hopes that it becomes part of our curriculum… As you heard, I am starting my lab from the ground up and I would like to invite you to my class at some time… FYI, today I realized how much I miss you guys, but thanks for preparing me for the future!"

-- Ms Shelly Watts, MS in Applied Physics, UMBC, July 2009

-- Primary Physics Teacher at the Friends School of Baltimore

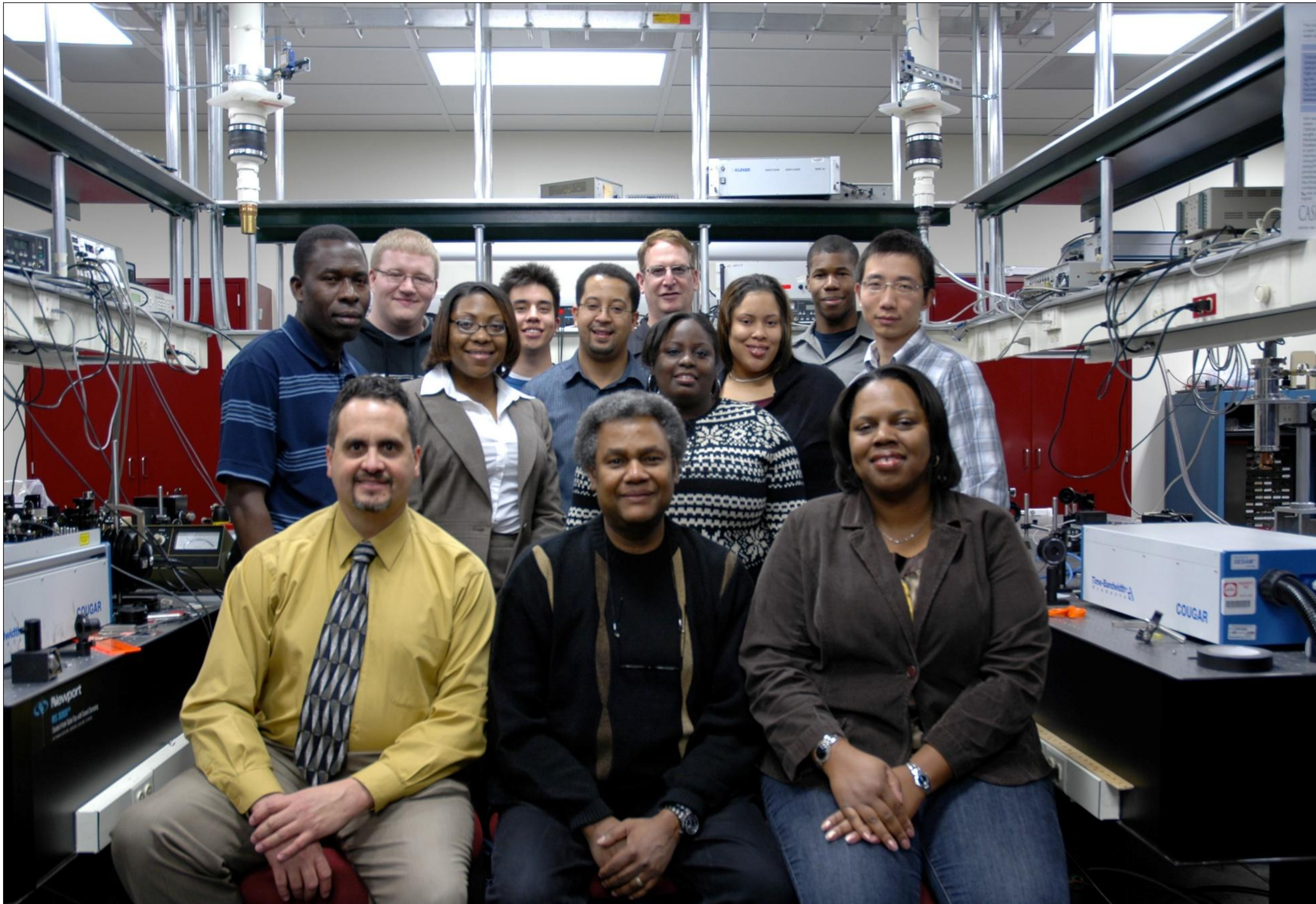
Beginning June 14, 2010, Ms Shelly Watts will spend the Summer at CASPR as part of the NSF MIRTHE (Mid-Infrared Technologies for Health and the Environment) ERC (Engineering Research Center) RET (Research Experiences for Teachers) Program

“Cultivating a field of dreams among a minority at NJIT”
by Caroline Brewer, Sunday Bergen Record
April 30, 2000, Living Section, page L-3



Former graduate students now Physics PhDs – Drs. Hernando Garcia, Elaine Lalanne and Ferdinand Oguama

The Ultrafast Optics and Optoelectronics Group (Feb. '08)



CASPR

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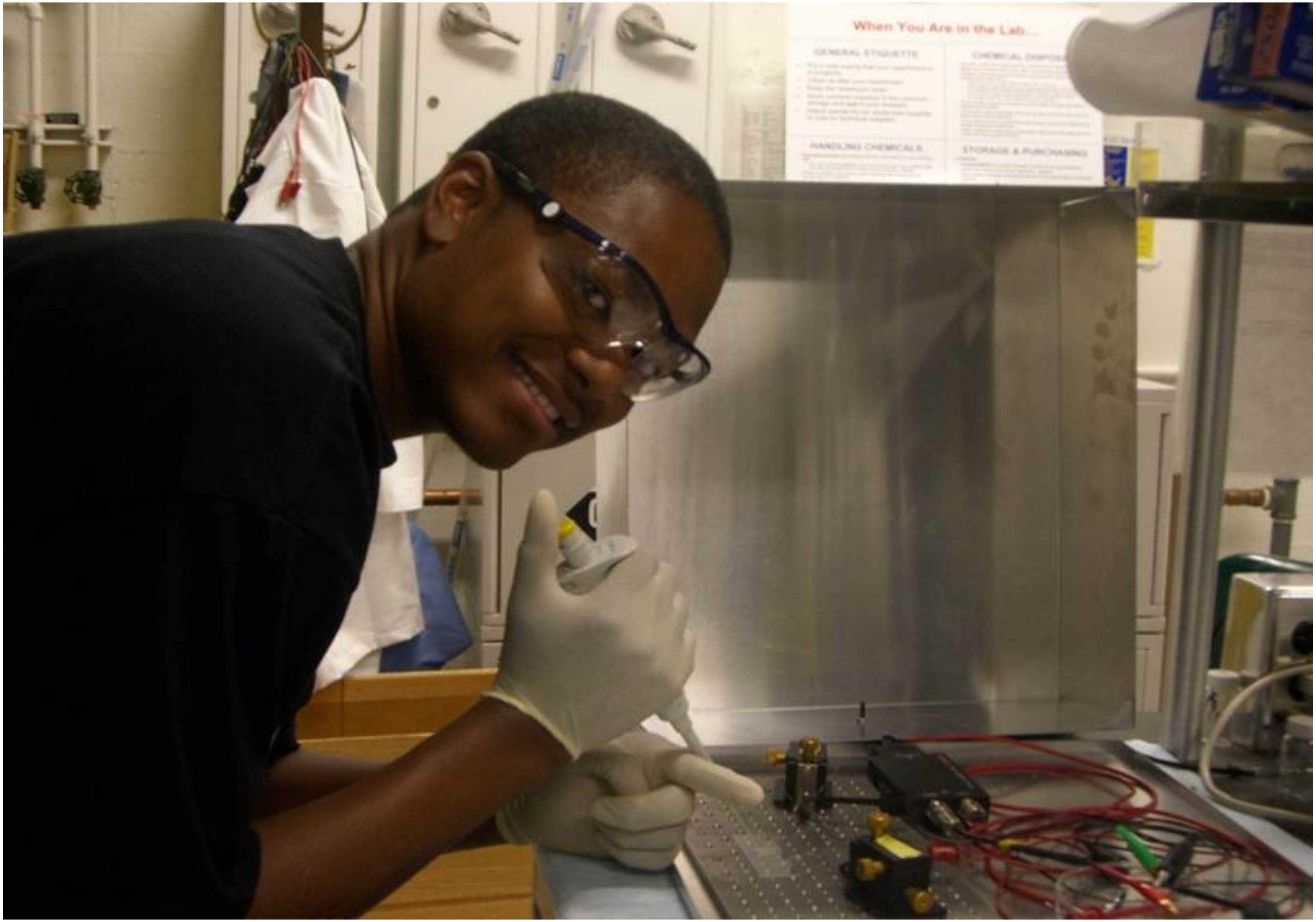
UMBC

AN HONORS UNIVERSITY IN MARYLAND

Brandon Johnson, BS Mechanical Engineering, Dec. 2008, Meyerhoff Scholar, M16

First Year graduate student at Stanford University on a Full Fellowship in Fall 2009



Summer 2006 Research Experience, UC Berkeley, Nanoengineering Lab of Dr. Arun Majumdar

Project: “An Exploration in Nanoengineering: Ion and Heat Transport in Nanostructures”

Observations and Lessons Learned

Due to a typically "sub-critical mass" of under-represented minority and women students, a supportive and nurturing environment is usually very important for retention. I have found that under-represented minority and women students gravitate towards research groups led by under-represented minorities and women. I am very fortunate to have a 100% retention rate.

In the case of foreign students there is typically a "critical mass" of students who will create a supportive environment whether or not the advisor or department provides one. One rarely hears about issues of retention in the case of foreign students. However, there appears to be a correlation between foreign students and foreign faculty.

Though initially I was skeptical of the concept of a "role model", when I left AT&T Bell Labs to join academia, I discovered that I attracted under-represented minorities to my research group in a department that had no such students before my arrival. My second PhD student, Dr. Elaine Lalanne was the only African-American woman to receive a PhD in Physics in 2003. I now believe that this concept of a "role model" works for both foreign and domestic students and of course women. It is therefore imperative to increase the number of under-represented minority and women faculty to have an impact upon the diversity of S&E graduate students.

Observations and Lessons Learned (Continued)

I have found that within an academic department, many students would "segregate" themselves along racial, ethnic and foreign status lines – unless the department made a concerted effort to provide a forum for interaction.

The ERCs provide a focus across academic departments and schools which fosters cooperation amongst foreign and domestic students. My group is largely Black and Hispanic and Prof. Fow-Sen Choa's group is largely Chinese. MIRTHE has brought our two research groups together to work on Quantum Cascade Lasers – a collaboration between under-represented minorities and foreign students that may not have occurred naturally without the MIRTHE ERC. – *Part of a presentation that I gave at the 2006 NSF ERC Annual Meeting*

Photonics has proven to be a wonderful "visual" medium to attract and fascinate young minds into science and engineering – it caught my attention some 30 years ago as a budding young scientist from Brooklyn, New York.


8th Annual National Conference of Black Physics Students
Georgia Institute of Technology
February 10 - 13, 1994

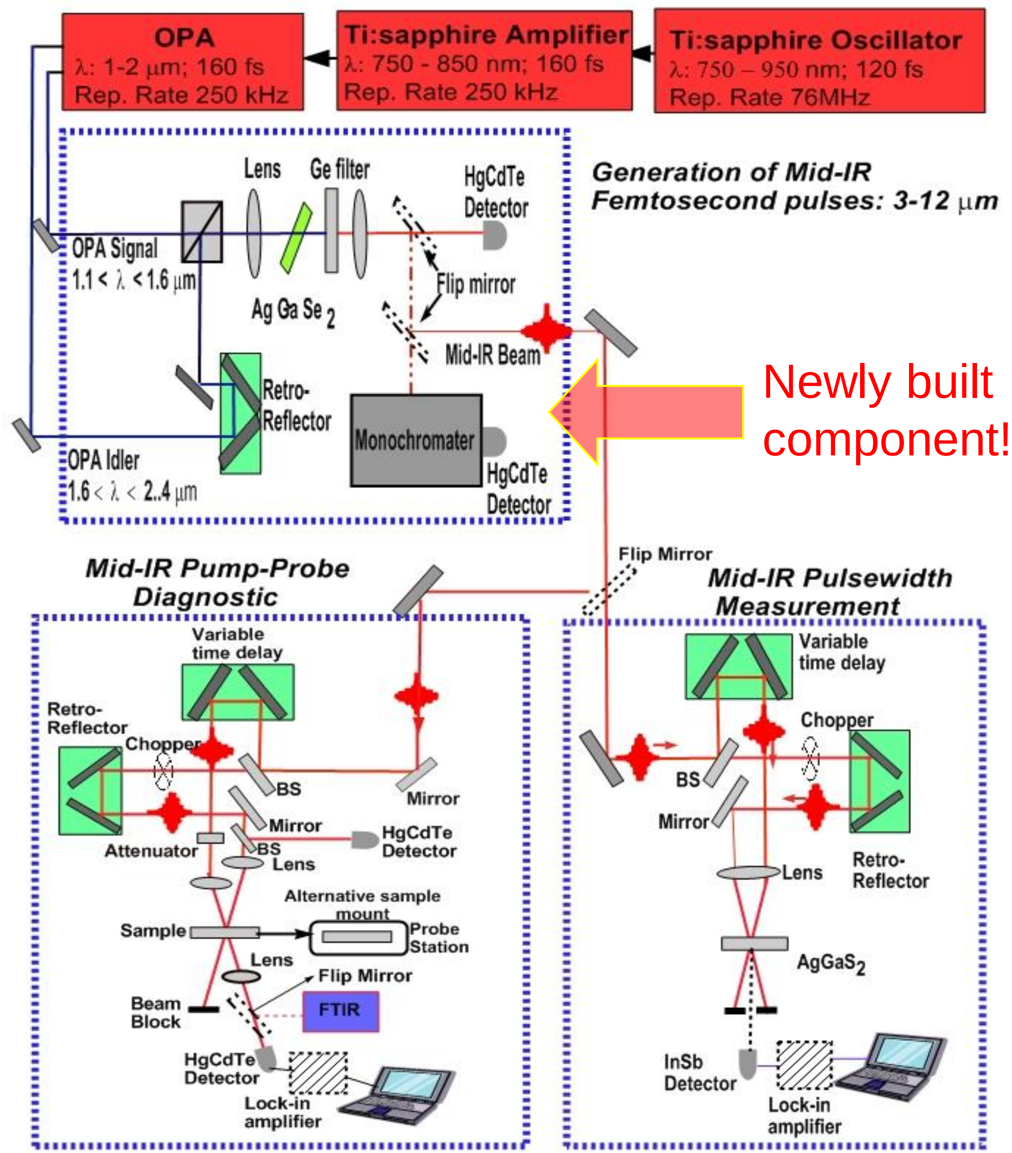
How many Black Physicists are there ?

This is a group picture of the joint meeting of the National Society of Black Physicists and the National Conference of Black Physics Students held at Stanford University March 28 through April 1, 2001

409 students and professional Physicists attended the meeting

Ultrafast Diagnostic Instrumentation for Mid-IR Materials at UMBC-CASPR

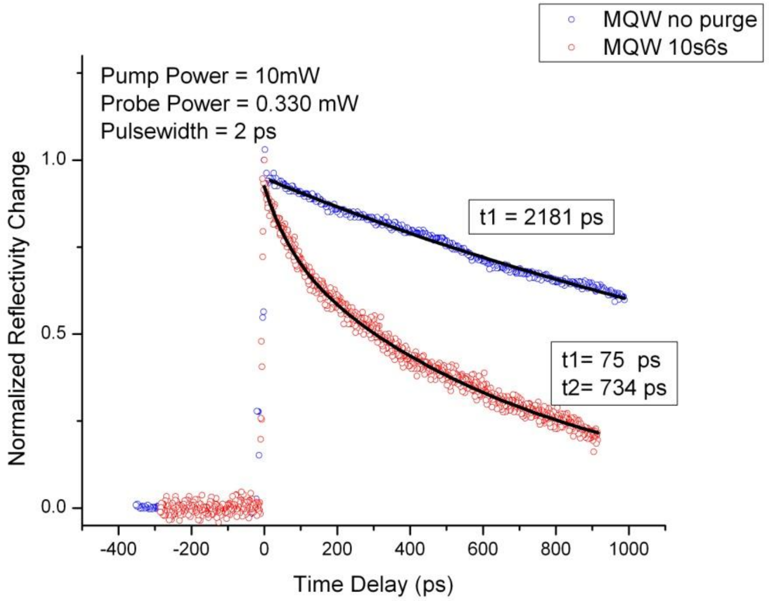
- Femtosecond time-resolved pump-probe spectroscopy with cryogenic probe station
  - Reflection, transmission, absorption, electroluminescence, photoluminescence
  - Near-IR:
    - Interband carrier dynamics
  - Mid-IR:
    - Intersubband carrier dynamics
- Time-resolved Raman scattering
  - Strain effects
- Comparison of growth methods
  - MBE vs. MOCVD
- Correlation of QC laser performance and material quality and growth parameters



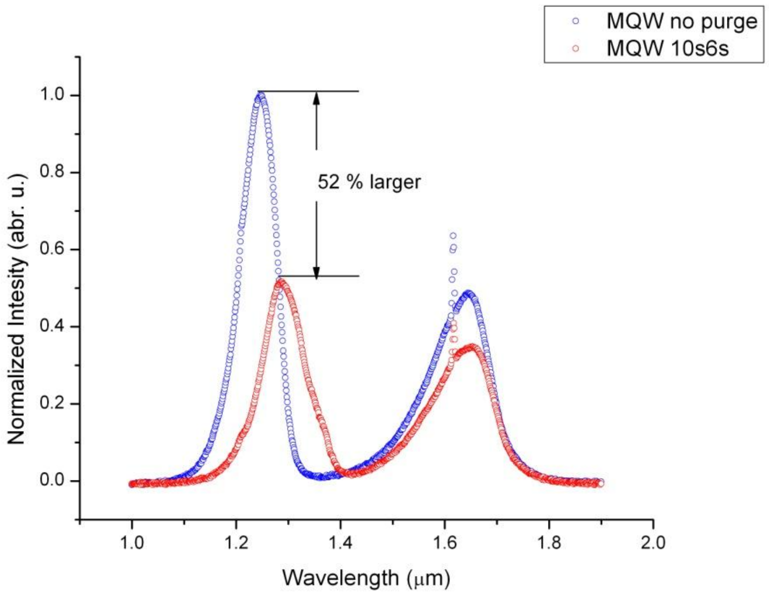
Partial support from NSF MRI Grant ECS-0619548

Pump-Probe Reflectivity and photoluminescence Data on Superlattice Structures

Pump-Probe Reflectivity



Photoluminescence



Photoluminescence data obtained from Dr. Fow-Sen Choa (umbc)

Introduction

- Pump-probe reflectivity can measure carrier lifetimes of semiconductors

- Carrier lifetimes are an indication of surface quality

- Pump-probe reflectivity has been used to measure surface quality of several InAlAs/InGaAs superlattice structures (having different purging times) grown by MOCVD (UMBC)

MICROWAVE SWITCHING

BY

PICOSECOND PHOTOCONDUCTIVITY

THESIS

Submitted in Partial Fulfillment

of the requirements for the

degree of

BACHELOR OF SCIENCE (Physics)

at the

POLYTECHNIC INSTITUTE OF NEW YORK

by

Anthony M. Johnson

June 1975

Approved:

May 16 1975

H. J. Juretschke

Head of Department

and Thesis Advisor

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