

The University of North Carolina at Charlotte

Department of Physics and Optical Science

Master of Science in Optics
Request for Authorization to Establish

THE UNIVERSITY OF NORTH CAROLINA
Request for Authorization to Establish a New Degree Program

INSTRUCTIONS: Please submit five copies of the proposal to the Senior Vice President for Academic Affairs, UNC Office of the President. Each proposal should include a 2-3 page executive summary. The signature of the Chancellor is required.

Date: April 19, 2002

Constituent Institution: The University of North Carolina at Charlotte

CIP Discipline Specialty Title: Optics

CIP Discipline Specialty Number: 40.0807 Level: B M 1st Prof D

Exact Title of Proposed Program: Master of Science in Optics

Exact Degree Abbreviation (e.g. B.S., B.A., M.A., M.S., Ed.D., Ph.D.): M.S.

Does the proposed program constitute a substantive change as defined by SACS? Yes No

a) Is it at a more advanced level than those previously authorized? Yes No

b) Is the proposed program in a new discipline division? Yes No

Proposed date to establish degree program (allow at least 3-6 months for proposal review):

month January year 2003

Do you plan to offer the proposed program away from campus *during the first year of operation*?

Yes No

If so, complete the form to be used to request establishment of a distance learning program and submit it along with this request. Not applicable

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EXECUTIVE SUMMARY

Overview

The proposed degree program is an interdisciplinary program involving six science and engineering departments [Physics and Optical Science, Chemistry, Mathematics, Electrical and Computer Engineering, Mechanical Engineering and Engineering Science, and Computer Science], the Center for Optoelectronics and Optical Communications, and the Center for Precision Metrology. The program will be administered through the Department of Physics and Optical Science. The purpose of the program is to educate scientists and engineers who will lead research necessary to develop the next generation of optical technology. The program, central to the success of UNC Charlotte's Center for Optoelectronics and Optical Communications and the Charlotte Institute for Technology Innovation, will support the explosive growth of optics-related industry in the Charlotte region.

During the last decade UNC Charlotte has been building infrastructure that allows it to take advantage of emerging optical technologies. The buildup has taken place primarily in the Department of Physics and Optical Science and the College of Engineering. The current program in optics at UNC Charlotte is very active, strongly interdisciplinary, and growing rapidly. The new degree program is proposed in response to the continuing growth of optics activities within the University and the greater optics community. A 1998 report by the National Research Council states that optics is rapidly becoming an important focus for new business in the global economy, with both large and small businesses emerging as significant players. Optics-related companies in the U.S., now totaling more than 5,000, have a net financial impact that exceeds \$50 billion annually. A ten-fold growth in the optical communication industry is predicted over the next five years. Optical technology is riding the wave of economic expansion in the Southeast. A high technology corridor has emerged from the Research Triangle Park in eastern North Carolina to Atlanta, Orlando, and Huntsville. At the heart of this corridor is the city of Charlotte, which is now a global center for banking and finance and is becoming a major participant in the optics and optical technology revolution. The region served by UNC Charlotte is rapidly becoming a world center for optical fiber technology with major facilities operated by Corning, Alcoa, Alcatel, and Seicor. Several smaller, but important, optics companies are also located in the region. Medical Optical Imaging, Waveguide Solutions, and Digital Optics Corporation are all recent spin-offs from UNC Charlotte's optics program. Several ongoing research programs could lead to products and new companies in a short time, but an expanded program is certain to lead to a significant expansion in the number of start-ups in the future. The proposed new program will fulfill the critical need of providing a centralized academic program that addresses the research, educational, and service needs being generated by the rapid growth of optoelectronics and optical communications.

Notification of intent to plan the proposed program was posted June 12, 2001. The proposed date for implementation is January, 2003. North Carolina has no other programs leading to an M.S. in Optics.

Program Objectives

The educational objectives of the proposed program are:

- To provide students with educational opportunities in pure and applied optical science and technology culminating in an interdisciplinary research-based M.S. in Optics

- To increase the supply of highly skilled scientists and engineers so badly needed by optoelectronics and optical communications companies. The M.S. is often the degree of choice for such workers
- To support and increase the base of technology in the rapidly growing optoelectronics and optical communications industry in the Charlotte region, in North Carolina, and across the nation
- To enhance the educational experience in science and engineering for all students, graduate and undergraduate, at UNC Charlotte
- To support activities of the UNC Charlotte Center for Optoelectronics and Optical Communications and the Charlotte Institute for Technology Innovation

The research objectives are:

Research In:

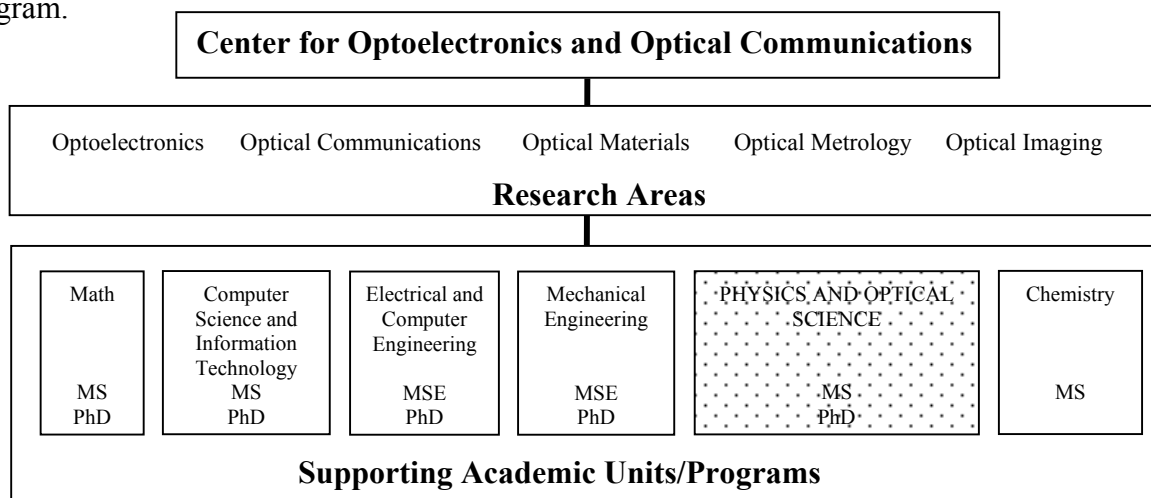
- *Optoelectronic devices and sub-assemblies*
- *Devices for telecommunications, sensors, and characterization*
- *Optical materials (semiconductors, polymer-organic and crystalline)*
- *Optical metrology*
- *Optical imaging*
- *Optical communication networks*

Applications In:

- *Optical telecom and data-com*
- *High efficiency, tunable narrow bandwidth laser sources and detectors*
- *Smart structures for distributed sensing*
- *Wireless technologies for communications and remote sensing*
- *Materials and surface characterization*
- *Nanostructured optical devices*
- *Microelectronics Medical diagnostics*

Relationship of Proposed New Program to Existing Programs

Optics is an interdisciplinary field of study that, when most successful, integrates relevant engineering disciplines with basic science and mathematics as depicted by the following diagram.



The proposed new degree program at UNC Charlotte clearly establishes this unique connection and has been designed to accommodate students and faculty from a variety of disciplines. Graduates of the program will be clearly identifiable as optical scientists/engineers. Student demand at UNC Charlotte for the proposed program has been steadily building over the past decade. Currently, 33 faculty and approximately 50 graduate students in six academic departments at UNC Charlotte work in areas of applied optical science and technology. About half of these 50 students are enrolled in the M.S. in Applied Physics program. Implementation of the proposed program will allow students seeking an optics education a degree option that has an appropriate label. We are already receiving inquiries from prospective students as news of the proposed program spreads by word of mouth. There is no question as to future student demand for the proposed program. The demand exists now.

Special Conditions in Support of Proposed Program:

Two major initiatives at UNC Charlotte support establishment of the proposed new program at this time. The first of these, The Charlotte Institute for Technology Innovation, is a University/Industrial/Community initiative recently developed by UNC Charlotte in cooperation with leaders of Advantage Carolina. The purpose of this initiative is to strengthen the region's technology and infrastructure by taking steps to accelerate UNC Charlotte's development as a research university and fortify its role as the region's high technology engine. To launch this initiative, UNC Charlotte is developing a new research and technology campus, the Charlotte Institute. Critical to the success of the Charlotte Institute is a second major initiative, establishment of the Center for Optoelectronics and Optical Communications. The Center for Optoelectronics and Optical Communications will join the Center for Precision Metrology as the first two components of the Charlotte Institute of UNC Charlotte as soon as construction of the first two buildings, currently in the planning stage, is completed in 2004. Implementation of the proposed new degree program is crucial to the success of these initiatives.

Budgetary Considerations

Start-up costs for the proposed program are modest, particularly for a program of this type. For more than a decade UNC Charlotte, particularly the College of Arts and Sciences and the College of Engineering, has been building infrastructure needed to implement the proposed program. Administration of the program will be through an existing department. No additional funds will be required to administer the program. UNC Charlotte has recently established its Center for Optoelectronics and Optical Communications. All members of the Optics Faculty will have joint appointments in this Center and access to its research facilities. Association with the Center will significantly reduce the amount of start-up funding needed to support new faculty lines requested for the proposed program.

The current UNC Charlotte Optics Faculty is sufficient to teach existing courses in the curriculum. The proposed program will generate enrollment increase funds (\$243,000) and new external funding (\$300,000) that, together with a reallocation of institutional resources (\$124,000), are needed to fund new faculty lines, teaching and research assistantships, and expand library holdings during the first three years of the proposed program.

Concluding Remarks

Establishment of the proposed new program undoubtedly will result in a substantial increase in

the number of graduate and undergraduate students working in the critical areas of optoelectronics and optical communications. These uniquely skilled people are urgently needed today and into the foreseeable future. Having these skilled people locally will attract business to our community and state. Also, establishment of the proposed program will result in an increase in the number and quality of our research laboratories that will in turn attract faculty and students from the United States and abroad to create a major intellectual resource for North Carolina and the greater Charlotte region.

I. DESCRIPTION OF THE PROGRAM

The proposed degree program emphasizes applied optical science and technology. It is an interdisciplinary program involving six science and engineering departments [Physics and Optical Science, Chemistry, Mathematics, Electrical and Computer Engineering, Mechanical Engineering and Engineering Science, and Computer Science], the Center for Optoelectronics and Optical Communications, and the Center for Precision Metrology. The program will be administered through the Department of Physics and Optical Science. The purpose of the proposed program is to educate the scientists and engineers needed to support expansion of the next generation of optical technology. The program will emphasize basic and applied interdisciplinary education and research in areas that include (1) active and passive photonic devices and sub-assemblies, (2) fiber-optic devices for telecommunications and sensors, (3) integrated optics and packaging of optical devices, (4) optical materials, (5) optical metrology, (6) optical communication networks, and (7) optical imaging. The program, central to the success of UNC Charlotte's Center for Optoelectronics and Optical Communications and the Charlotte Institute for Technology Innovation, will support the explosive growth of optics-related industry in the Charlotte region.

The notification of intent to plan the proposed new program was posted June 12, 2001.

A. Description of the Program

During the last decade UNC Charlotte has been building infrastructure that allows it to take advantage of emerging optical technologies. The buildup has taken place primarily in the Department of Physics and Optical Science and the William States Lee College of Engineering. The Physics and Optical Science Department has positioned itself to become an optics, laser, and optical technology resource for the Southeast region. Ongoing research focuses on fiber optic devices and sensors, optoelectronic and photonic devices for optical communication, adaptive optics, spectroscopy, and near-field microscopy. In addition, the enabling program in Precision Metrology at UNC Charlotte has assembled a research team that has developed an international reputation. Ten faculty members in Mechanical Engineering, and more than a dozen participants from other campus units, work in high precision manufacturing and metrology, including optical metrology. Our NSF-recognized Industry/University Cooperative Research Center in Precision Metrology has 11 corporate partners and supports over 35 graduate students. The Department of Electrical and Computer Engineering (ECE) has grown in the areas of microelectronics, communications, and computer engineering. These areas are strategically identified as major research components in the ECE Department. New high-speed electronic and optical devices are being developed by the ECE faculty for applications in communications and biomedical fields.

The Department of Chemistry is working to synthesize and characterize organic optoelectronic materials for use as optical waveguides, laser dyes, and organic light emitting diodes (OLEDs), currently a \$3 million market expected to rise to a \$714 million market by 2005. Optics research in the Department of Mathematics addresses problems related to medical imaging (detection of breast tumors using laser sources) and computational combustion simulations for detonations and chemical lasers. Faculty members within the Department of Computer Science are involved primarily with image processing, optical networking architecture, protocols, and security issues.

The current program in optics at UNC Charlotte is very active, strongly interdisciplinary, and growing rapidly in response to demand by industry. However, it does not presently have a centralized academic program that addresses the research, educational, and service needs being generated by the rapid growth of optoelectronics and optical communications. The proposed new program will fulfill this critical need.

B. Objectives of the Proposed Program

The educational and research objectives of the proposed program are:

B.1. Educational Objectives

- To provide students with educational opportunities in pure and applied optical science and technology culminating in an interdisciplinary research-based M.S. in Optics
- To increase the supply of highly skilled scientists and engineers so badly needed by optoelectronics and optical communications companies. The M.S. is often the degree of choice for such workers
- To support and increase the base of technology in the rapidly growing optoelectronics and optical communications industry in the Charlotte region, in North Carolina, and across the nation
- To enhance the educational experience in science and engineering for all students, graduate and undergraduate, at UNC Charlotte
- To support activities of the UNC Charlotte Center for Optoelectronics and Optical Communications and the Charlotte Institute for Technology Innovation

B.2. Research Objectives

The objectives of the research program are:

Research In:

- *Optoelectronic devices and sub-assemblies*
- *Devices for telecommunications, sensors, and characterization*
- *Optical materials (semiconductors, polymer-organic and crystalline)*
- *Optical metrology*
- *Optical imaging*
- *Optical communication networks*

Applications In:

- *Optical telecom and data-com*
- *High efficiency, tunable narrow bandwidth laser sources and detectors*
- *Smart structures for distributed sensing*
- *Wireless technologies for communications and remote sensing*
- *Materials and surface characterization*
- *Nanostructured optical devices*
- *Microelectronics/Medical diagnostics*

C. Relationship of Proposed New Program to Existing Programs

The relationship between existing programs, the proposed new program, and the Center for Optoelectronics and Optical Communications is depicted in Figure 1. The Center's research program will emphasize pure and applied optical science and engineering research in each of

the research focus areas. The Optics M.S. program is designated specifically to support the Center’s research programs. Graduates of the program will be well qualified to assume positions in industry.

Optics is an interdisciplinary field of study that, when most successful, integrates relevant engineering disciplines with basic science and mathematics. Dr. M. J. Soileau, University of Central Florida Center for Research and Education in Optics and Lasers (CREOL), depicts an academic program in optics by the diagram shown in Figure 2. Most disciplines, engineering for example, are organized horizontally as depicted in the diagram. Mathematics, physics, and chemistry can be similarly envisioned in a College of Arts and Sciences. Optics is a unique blend of these disciplines and best organized along the vertical line in the diagram connecting mathematics and science with engineering. The proposed new degree program at UNC Charlotte clearly establishes this unique connection and has been designed to accommodate students and faculty from a variety of disciplines. Graduates of the program will be clearly identifiable as optical scientists/engineers.

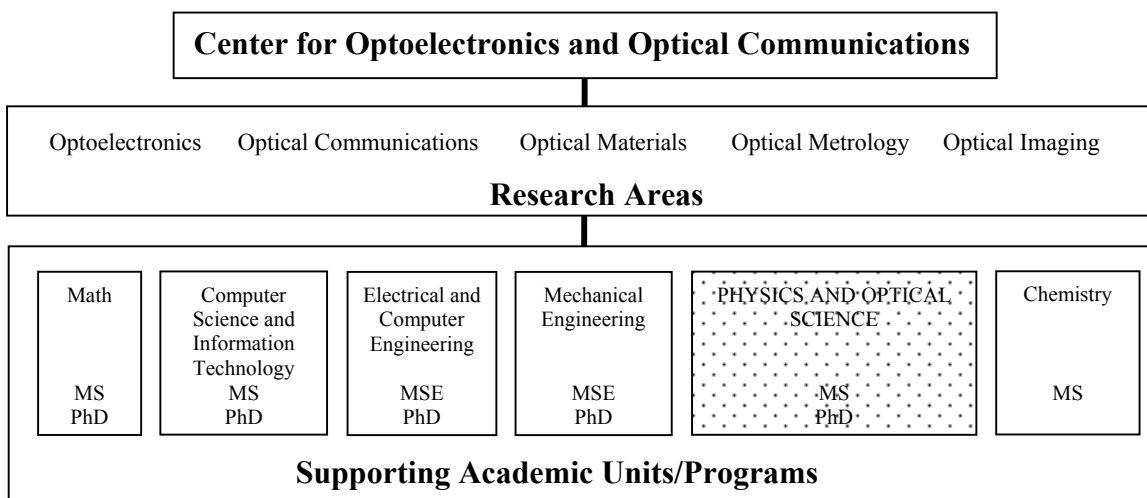


Figure 1. Diagram depicting the relationship between the Center for Optoelectronics and Optical Communications, the proposed new program, and current degree programs at UNC Charlotte having an optics component. The proposed program in optics will be the cornerstone academic program that supports Center activities. (CS-IT = Computer Science and Information Technology)

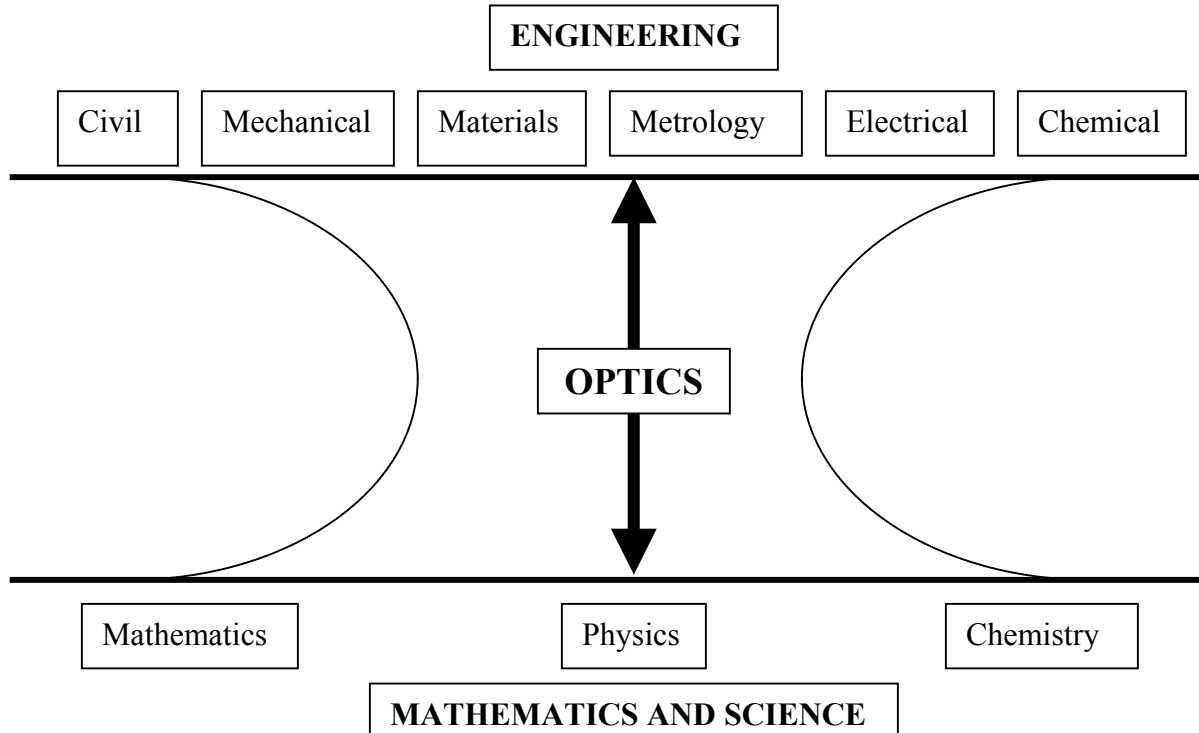


Figure 2. Diagram depicting the relationship between the optics discipline and traditional academic units in engineering, science, and mathematics.

The degree program gives its graduates an identity by means of an optics core common to all students in the program. The core program has been designed to accommodate students and faculty from the relevant disciplines without significant retooling. Ensuing coursework provides depth in the optics field necessary to give students the foundation needed for the various research thrusts. A schematic diagram illustrating the structure of the proposed program is presented in Figure 3.

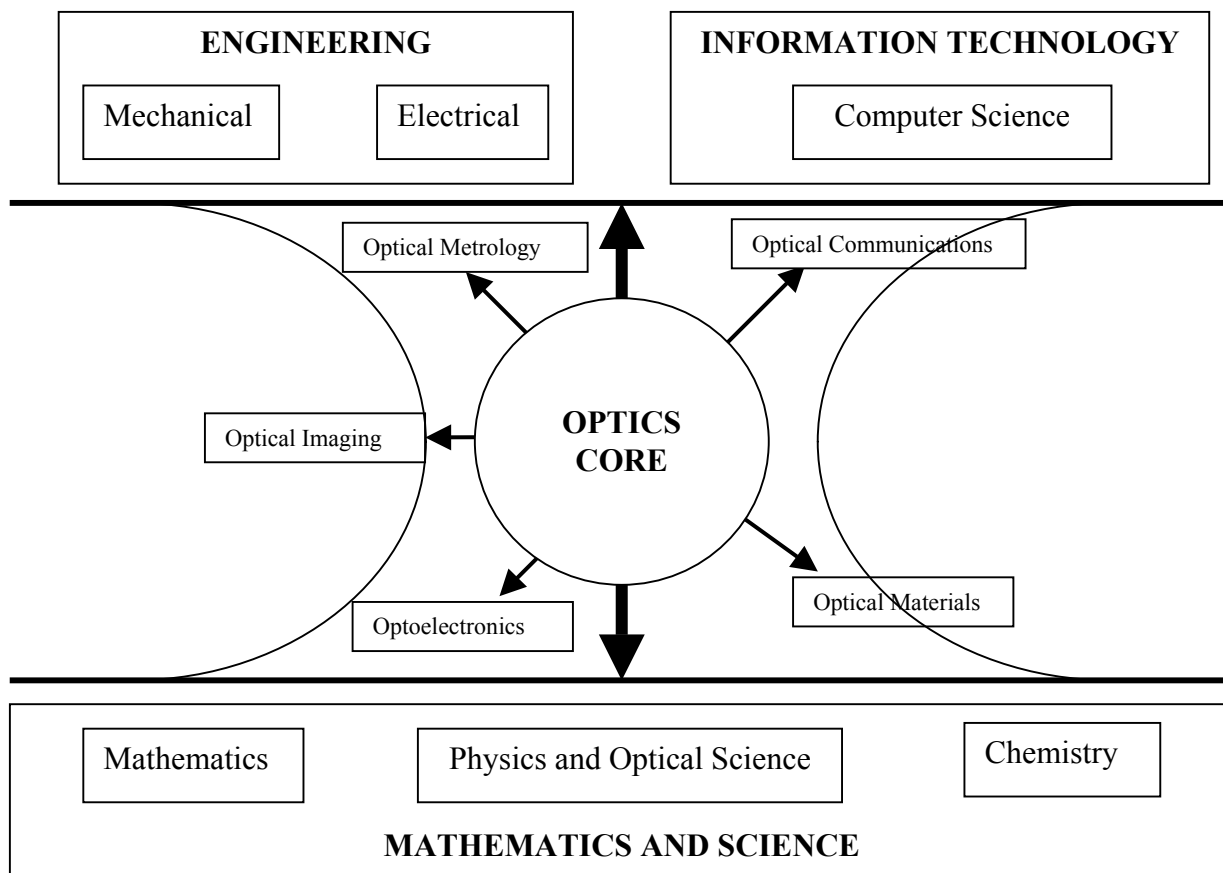


Figure 3. Diagram illustrating the relationship between the optics core program, the supporting academic units, and the research areas supported by the Center for Optoelectronics and Optical Communications.

In Figure 3, spokes (smaller arrows) emerging from the core program represent study and research concentrations within the overall optics program. The core program will be offered through the Department of Physics and Optical Science. All academic units participating in the optics degree program will contribute to the curriculum in the five concentration areas.

II. JUSTIFICATION FOR THE PROPOSED NEW PROGRAM

A.1. Relationship of Proposed Program to Institutional Mission and Strategic Plan

Following is a statement of institutional mission for UNC Charlotte.

MISSION STATEMENT

UNC Charlotte is the only major public Doctoral/Research University - Intensive in the Charlotte region, fully engaged in the discovery, dissemination, synthesis, and application of knowledge. It provides for the educational, economic, social, and cultural advancement of the people of North Carolina through on- and off-campus programs, continuing personal and professional education opportunities, research, and collaborative relationships with private, public, and nonprofit institutions. UNC Charlotte has a special responsibility to build the intellectual capital of this area. As such it serves the research and doctoral education needs of the greater Charlotte metropolitan region.

The primary commitment of UNC Charlotte is to extend educational opportunities and to ensure success for qualified students of diverse backgrounds through informed and effective teaching in the liberal arts and sciences and in selected professional programs offered through Colleges of Architecture, Arts and Sciences, Business Administration, Education, Engineering, Information Technology, and Nursing and Health Professions, and through programs and services designed to support students' intellectual and personal development. The University offers an extensive array of baccalaureate and master's programs and a number of doctoral programs.

With a broad institutional commitment to liberal education as the foundation for constructive citizenship, professional practice, and lifelong learning, UNC Charlotte is prepared to focus interdisciplinary resources to address seven broad areas of concern to the Charlotte region: 1) Liberal Education; 2) Business and Finance; 3) Urban and Regional Development; 4) Children, Families, and Schools; 5) Health Care and Health Policy; 6) International Understanding and Involvement; and 7) Applied Sciences and Technologies.

The proposed program emphasizing applied optical science and technology is consistent with the Mission Statement. It will expand the array of programs offered by UNC Charlotte at the master's level. The proposed interdisciplinary approach will foster collaborative educational and research efforts with existing graduate and undergraduate programs, and will attract students and generate funding such that the University's growth and stature will be enhanced. Of no less importance are the prospects the proposed program has to build intellectual capital in this region. Having, as it does, an emphasis in optoelectronics and optical communications, the proposed program will allow us to become a major player in one of the most economically important technologies of the new millennium. The proposed program will, through its educational programs, serve the region by preparing the highly skilled graduates in optical science and technology who are so badly needed by industry, and will, through its research programs, develop new technology necessary to support the explosive growth of the information technology superhighway. Active collaborations with existing and

future high technology industry will benefit Charlotte, the surrounding region, and the State. All factors described are key elements of UNC Charlotte's strategic plan.

A.2. Student Demand for Proposed Program

Student demand at UNC Charlotte for the proposed program has been building steadily over the past decade. Currently, 33 faculty and approximately 50 graduate students in six academic departments at UNC Charlotte work in areas of applied optical science and technology. (See Appendix A for faculty listing.) About half of these 50 students are enrolled in the M.S. in Applied Physics degree program. In the 2000-01 academic year seven students receiving an M.S. in Applied Physics presented theses on an optics topic. All of these students would have elected the proposed program were it available. Most of the remaining students studying optics at UNC Charlotte are enrolled in M.S. or Ph.D. programs in either the Department of Electrical and Computer Engineering or the Department of Mechanical Engineering and Engineering Science. The proposed program would support these students as well.

Not only will implementation of the proposed new program expand opportunities for student participation in the UNC Charlotte Optics Program, it will allow students seeking an optics education a degree option at UNC Charlotte that has an appropriate label. We are already receiving inquiries from prospective students as news of the proposed new program spreads by word of mouth. There is no question as to future student demand for the proposed program. The demand exists now.

UNC Charlotte is well positioned to offer the proposed new program. Current optics researchers at UNC Charlotte have a record of research funding and publications that includes support from both private sources and federal agencies. Over the past seven years, these 33 faculty and their students have generated external optics-related funding of more than \$7.3 million, licensed 15 faculty/student-developed products to industries around the United States, and patented 27 inventions. In the past two years they have published more than 60 articles in archival journals. Greater visibility afforded by the proposed new program will attract even more outstanding students, increase industrial partnerships, and lead to increased external funding for optical science and technology.

A.3.1. Societal Need for Proposed Program

The new degree program is proposed in response to the continuing growth of optics activities within the University and the greater optics community. A 1998 report by the National Research Council states that optics is rapidly becoming an important focus for new business in the global economy, with both large and small businesses emerging as significant players. Optics-related companies in the U.S., now totaling more than 5,000, have a net financial impact that exceeds \$50 billion annually. A ten-fold growth in the optical communication industry is predicted over the next five years. Optical technology is riding the wave of economic expansion in the Southeast. A high technology corridor has emerged from the Research Triangle Park in eastern North Carolina to Atlanta, Orlando, and Huntsville. At the heart of this corridor is the city of Charlotte, which is now a global center for banking and finance and is becoming a major participant in the optics and optical technology revolution. The region served by UNC Charlotte is rapidly becoming a world center for optical fiber technology with major facilities operated by Corning, Alcoa, Alcatel, and Seicor. Smaller,

but important, optics companies in the region include USCONEC, CommScope, Litton Airtron, Digital Optics Corporation, Solutions Technology, Medical Optical Imaging, INC., Waveguide Solutions, and Solectron. Medical Optical Imaging, Waveguide Solutions, and Digital Optics Corporation are recent spin-offs from UNC Charlotte's Departments of Mathematics, Physics and Optical Science, and Electrical and Computer Engineering, respectively. New optical technology companies locate in the region annually. Several research programs are ongoing that could lead to products and companies in a short time, but an expanded program is certain to lead to a significant expansion in the number of start-ups in the future.

Establishment of the proposed new program will result in a substantial increase in the number of graduate and undergraduate students working in the critical areas of optoelectronics and optical communications. These uniquely skilled people are urgently needed today and into the foreseeable future. Having these skilled people locally will attract business to our community. Also, establishment of the proposed program will result in an increase in the number and quality of our research laboratories that will in turn attract faculty and students from the United States and abroad to create a major intellectual resource for the greater Charlotte region.

Demand for the proposed program is documented in a recent report titled, "*Help Wanted*," published by SPIE, one of two international optics societies. Selected excerpts from this article are presented here. "There has been a consistent decline in the number of science and engineering degrees awarded in the U.S., and there is stiff competition for the qualified optical technicians and engineers currently working in this field." "The consensus among those in science and technology fields is that the U.S. will become less competitive in critical technology sectors unless industry, academia, and the government make a concerted effort to promote and attract people to these fields." "The price for this shortage (skilled personnel) is being paid--literally--by the optics industry, via increased salaries, pay-to-stay deals, and large hiring bonuses." Now, some good news. "Despite the current situation, there is cause for some cautious optimism. For starters, the shortage of science and technology workers is finally being regarded as a priority issue." Vicki Hoffman, Director of Human Resources at Coherent (a major supplier of laser technology), spoke about a strategy that company is using to ensure a future supply of qualified employees. Other initiatives are being planned. The proposed new program is designed to address the need for skilled professionals in the optoelectronics and optical communications fields. A complete copy of the SPIE document is presented in Appendix B.

Optical technology companies are growing at a significant rate, both in the U.S. and abroad. Demand for skilled professionals exists at all levels. This is documented in letters (see Appendix C) written in support of the proposed new program. Jeff Conley, General Manager of Photonics at Alcoa Fujikura Ltd., writes, and we paraphrase, "while the number of Ph.D.s needed at his company might not be high (currently 3 -5), it would be ideal to have new grads at the M.S. and B.S. levels to fill the 100 current optics vacancies in that company. The proposed new Ph.D. program would act as a catalyst for increased optics professionals at all levels." Robert Smythe, Vice President of Engineering at Zygo Corporation, says, and again we paraphrase, "The lack of optical engineering talent is a national problem that we feel in all regions; from northeast to southwest and even Silicon Valley. Zygo sees UNC Charlotte as a source of new talent and would be very interested in UNC Charlotte students as potential

employees." He goes on to say that Zygo hired over 50 new optical engineers (BS to Ph.D.) this past year. Eric Buckland, Chief of Staff of Optical Networking Devices at Corning, writes, "I believe this program can be valuable to Corning and to North Carolina." The competition for talent to address the technical and commercial challenges associated with bringing next-generation optical solutions to market is intense. At OFC in Baltimore the ratio of open jobs to jobseekers was on the order of 10:1. While it is impossible for me to project the numbers of graduates that Corning would hire out of a UNC Charlotte applied optics program, it is clear that the optical communications industry -- a key industry targeted by the UNC Charlotte program -- is still in its infancy. A well-structured applied optics program at UNC Charlotte would be a welcome source for future recruiting." Corning has hired seven graduates of UNC Charlotte's physics and engineering programs during the past two years.

All writers of letters supporting establishment of the proposed new program echo this same theme.

The University of Arizona has one of the premier optics programs in the U.S. A recent check of their web site shows the level of demand for trained optics professional at all levels. A copy of job openings posted on this web site is presented in Appendix D.

Understandably, there might be some concern about the present state of the photonics business world. Between January and October 2000, stocks in companies such as Juniper Networks, Ciena, Corning, Nortel, SDL and JDS Uniphase lost between 20% and 54% of their value (see USA Today, Money Section B, "Was it just an optical illusion?", Thursday October 26th, 2000, page 1B). Competition was driving prices down as dozens of companies were working in the same kind of business. At the same time (and to this day) many companies were and are seeking programs in optics and there is a continued shortage of people with a basic knowledge of optics. In Photonics Spectra (April 2001, page 100, "Jobs in Photonics" by Brent D. Johnson) the article begins "Layoffs and Wall Street notwithstanding, photonics is booming – and so is the job market. It's hard to ignore what appears to be contrary evidence." Companies were laying off at that time but still shipping. From April layoffs increased while at the same time those skilled in optics were still being hired. The layoffs were primarily affecting lower-level manufacturing personnel rather than those with more advanced skills. The optics press seems to characterize what we are seeing as a temporary pullback after an unusually rapid expansion

Particularly important to note is the continued demand for people with optics skills at all levels. While in April 2001 some 20,000 layoffs of high-tech workers were described, the same issue of Photonics Spectra (see page 115) identified the need for 32,000 more individuals degreed in photonics. This was described as a need for 6,400 additional optics employees per year until 2005. This needed group of individuals should have "both an understanding of photonics and a 'renewed' foundation in science and mathematics." These numbers were revised upwards in the September 2001 issue of Photonics Spectra to an identified need for 62,000 photonics-skilled individuals by 2005.

Evidence that we are seeing a repositioning or perturbation to the optical networking industry, rather than any fundamental downturn, is evidenced by the recent Optical Fiber Conference (OFC 2001), the major annual event for this industry. It broke all records (see Optics and Photonics News, May 2001, by Jeff Hecht, page 48). It was record breaking in the number of attendees (38,000 compared with 17,000 the year before) and in the

technological breakthroughs reported (e.g. 10 Tbit/sec over a single fiber: a new world record). With 970 exhibitors occupying 270,000 square feet, it was calculated by Hecht that given the opening hours of the exhibit he had only 1.5 minutes to visit each exhibitor's stand.

Another point of confusion is over the current capacity of the already installed networks. The New York Times reported in July 2001 that there was a glut of fiber. And that in the last two years 100 million miles of fiber had been laid worldwide. [Contrast this New York Times report with the September 2001 piece in Lightwave (page 63, "Impact of the ongoing fiber shortage", by Mack and Sarkar) which documents the shortage of fiber affecting many fiber and cable manufacturers since 1999.] There is indeed a lot of fiber laid for the long haul information pipelines, but this only serves to drive the R & D efforts into lower cost, higher performance local access equipment, or "edge" equipment as it is called. A comparison is made with the glut of railways after 1870. The difference, of course, is that fiber can and will come into each and everybody's home, providing essentially unlimited bandwidth for our global and ubiquitous connectivity. Lower cost, integrated photonic devices with built in intelligence will further revolutionize the IT age and UNC Charlotte is well positioned to be a major player in this effort.

A.3.2. Special Conditions in Support of Proposed Program

Two major initiatives at UNC Charlotte support establishment of the proposed new program at this time. The first of these, The Charlotte Institute for Technology Innovation, is a University/Industrial/Community initiative recently developed by UNC Charlotte in cooperation with leaders of Advantage Carolina. The purpose of this initiative is to strengthen the region's technology and infrastructure by taking steps to accelerate UNC Charlotte's development as a research university and fortify its role as the region's high technology engine. To launch this initiative, UNC Charlotte is developing a new research and technology campus, the Charlotte Institute. Initial areas of concentration on this campus will include Precision Metrology, Optoelectronics and Optical Communications, and Software and Information Technology.

Critical to the success of the Charlotte Institute is a second major initiative, establishment of the Center for Optoelectronics and Optical Communications. The Center for Optoelectronics and Optical Communications will join the Center for Precision Metrology as the first two components of the Charlotte Institute of UNC Charlotte as soon as construction of the first two buildings, currently in the planning stage, is completed in 2004. The Director of the Center for Optoelectronics and Optical Communications has been hired effective January 14, 2002. Implementation of the proposed new degree program is crucial to the success of these initiatives.

Press releases describing the Advantage Carolina initiative recently published in the Charlotte Observer are presented in Appendix E.

A.4. Impact on Existing Programs

The proposed new program will significantly enhance instructional and research programs at UNC Charlotte at both the undergraduate and graduate levels. The program will be interdisciplinary with active participation initially by six academic departments [Physics and Optical Science, Chemistry, Mathematics, Electrical and Computer Engineering, Mechanical

Engineering and Engineering Science, and Computer Science], the Center for Optoelectronics and Optical Communications, and the Center for Precision Metrology. The program will expand to include other units with interest and application in optical technology as that occurs. Increased visibility provided by the proposed program will better allow UNC Charlotte to attract and retain highly qualified students and faculty. The ensuing increased level of external support will allow the University to provide more and better opportunities and programs for students choosing optics as a field of study. The result will be skilled workers to support a rapidly growing optics industry in the region and the nation and, through its research programs, new knowledge, materials, devices, and systems.

A.4.1. Impact on Undergraduate Program

Existing opportunities for undergraduate students to pursue studies in optics range from their electing to take one or more courses and laboratories in optics to participation in funded research programs. Establishment of the proposed new program will enhance these opportunities by bringing increased visibility to the optics programs and by providing broader and more numerous opportunities for participation.

The Department of Physics and Optical Science and supporting academic units in the Colleges of Engineering, Arts and Sciences, and Information Technology currently offer in excess of 70 lecture and laboratory courses that support the proposed program. Additional courses are being planned to meet current and future needs. Many of these courses are available to undergraduate students electing an optics concentration in their major field of study. These courses allow studies in basic electromagnetic theory, fundamental optics, modern optics, optoelectronics, lasers, optical materials, and optical networks. Opportunities for undergraduates to participate in optics research currently exist at UNC Charlotte. Students in physics and engineering regularly elect an optics-related topic for their senior thesis projects. Results obtained from this work are routinely presented at professional society meetings and university symposia. Financial support is often available for these students through external research funding, on a part-time basis during the academic year and a full-time basis during the summer. The Center for Precision Metrology has research fellowships for students wishing to pursue studies in optical metrology relating to manufacturing. Students may also participate in the NSF-sponsored Research Experiences for Undergraduates (REU) Program through the Center for Precision Metrology. The proposed new program will result in an expansion of these opportunities to more students.

UNC Charlotte has a growing international option that allows international students an opportunity to study in the U.S. and UNC Charlotte students an opportunity to study abroad. Arrangements are in place at numerous European universities. We regularly have students from England, France, Germany, and The Netherlands who spend a year or two at UNC Charlotte to pursue study in optics. With the advent of the proposed new program others will follow.

A.4.2. Impact on Graduate Program

With one exception, the proposed program will serve to benefit existing graduate programs at UNC Charlotte. Because the proposed program will, due to its interdisciplinary nature, be inclusive to accommodate faculty and graduate students from the departments in the Colleges of Engineering, Information Technology, and Arts and Sciences, existing programs in these

areas will be afforded new and expanded opportunities. Existing programs within current participating units already have M.S. degree programs allowing for thesis work in applied optics. Implementation of the proposed new program will enhance opportunities for studies in optics for students in these programs.

Three departments [Electrical and Computer Engineering, Mechanical Engineering and Engineering Science, and Mathematics] have interdisciplinary Ph.D. programs that support work in optoelectronics and optical technology related fields. In many cases students and faculty are already engaged in team projects that span departmental and college boundaries. The interdisciplinary nature of the proposed program will serve to strengthen existing collaborations in academic programming and in research. The addition of a program leading to a M.S. in Optics is necessary to properly reflect the field of optics in students' records and on diplomas for students electing that option. Implementation of the proposed program will have a positive benefit on these programs by allowing more opportunities than currently exist.

Implementation of the proposed new program will result in a significant reduction in the number of students graduating with an M.S. in Applied Physics, at least in the short term. More than 80 percent of the students graduating from this program present theses describing research in an optics area. However, the expectation is that over time the enhanced stature attained by the Department of Physics and Optical Science resulting from implementation of the proposed program, and the Ph.D. Program in Optics currently being planned, will result in growth of the physics program as well. Such growth has occurred at other institutions implementing new optics programs similar to the one proposed here.

In summary, the proposed new program will focus the now diversified studies in optical science and technology, and will formally integrate the academic program with the program of research to be undertaken by the Center for Optoelectronics and Optical Communications. This Center will support basic and applied interdisciplinary research in the areas of (1) active and passive photonic devices and sub-assemblies, (2) fiber-optic devices for telecommunications and sensors, (3) integrated optics and packaging of optical devices, (4) optical materials, (5) optical metrology, (6) optical communication networks, and (7) optical imaging. The Center's program will stress productive applications oriented M.S. thesis work that prepares highly skilled people for the work force. The research program at the Ph.D. level will emphasize pure and applied optical science and engineering research in each of the focus areas. Graduates of the proposed new program will be well qualified to assume prominent positions in industry.

B. Potential Program Duplication and Competitiveness

B.1. Similar Programs in North Carolina

Seven universities in North Carolina offer a M.S. program in Physics. None offer an M.S. in Optics. We are proposing to establish an interdisciplinary program of pure and applied education and research in areas of optoelectronics and optical communications unique to the State that has the following education and research themes.

Research and Education In:

- *Optoelectronic devices and sub-assemblies*
- *Devices for telecommunications, sensors, and characterization*
- *Optical materials (semiconductors, polymer-organic and crystalline)*
- *Optical metrology*
- *Optical imaging*
- *Optical communication networks*

Applications In:

- *Optical telecom and data-com*
- *High efficiency, tunable narrow bandwidth laser sources and detectors*
- *Smart structures for distributed sensing*
- *Wireless technologies for communications and remote sensing*
- *Materials and surface characterization*
- *Nanostructured optical devices*
- *Microelectronics*
- *Medical diagnostic*

No university or research center in the U.S. has this comprehensive theme. Duke University has recently established the Fitzpatrick Center for Photonics and Communications Systems. The Fitzpatrick Center will emphasize systems and should mesh well with the UNC Charlotte initiative emphasizing materials, components, and devices. There are individuals and small groups that work on some aspects of what is proposed here, but only the comprehensive approach can address the needs of today’s industries and enable us to become a leader in developing the next generation of optical technology.

The universities in North Carolina offering the M.S. in Physics are located at the following distances from UNC Charlotte.

<u>Institution</u>	<u>Miles from UNC Charlotte</u>
UNC Chapel Hill	125
NC State University	150
Duke University	140
Wake Forest University	60
East Carolina University	190
Appalachian State University	120
North Carolina A and T State University	90

B.2. Similarity to Other Programs in State

There are no other programs leading to a M.S. in Optics in North Carolina.

C. Enrollment

No other UNC institution offers a program leading to a M.S. in Optics. Presented below (C.1.) are enrollment statistics available on web sites maintained by three similar programs in other states. Enrollments shown are optics program totals and include students at both M.S. and Ph.D. levels. The UNC Charlotte program is expected to achieve a similar enrollment

when it achieves steady state. The enrollment projection for the proposed M.S. program is presented in C.2.

C.1. Enrollment Statistics for Three Similar Programs

Institution: The University of Central Florida
 Program Title: The School of Optics Enrollment: ~ 100
 M.S. and Ph.D. Graduates by Year: 60 in 1999 54 in 2000

Institution: The University of Arizona
 Program Title: Optical Sciences Center Enrollment: ~ 180 (52 new in 2001)
 Graduates: Not Available on the Web

Institution: The University of Rochester
 Program Title: The Institute of Optics Enrollment: Limited to ~70
 Graduates: Not Available on the Web

C.2. Projected Enrollment in Proposed Program for First Four Years

	Year 1 (2002-03)	Year 2 (2003-04)	Year 3 (2004-05)	Year 4 (2005-06)
Full-time	10	15	20	25
Part-time	3	4	5	6
TOTALS	13	19	25	31

C.2.1. Basis for Projections

Enrollment in the current M.S. in Applied Physics Program has averaged approximately 25 students over the past three years. Many of these students would have enrolled in the proposed program were it available. There is no question this program will be in demand. The demand exists now.

Enrollment is projected to increase by six students each year. UNC Charlotte's Center for Optoelectronics and Optical Communications will occupy its new facilities in 2004 and will begin to achieve its expected potential by 2007. The presence of the Center will significantly enhance our ability to attract student support from external sources. Enrollment in the proposed program should increase significantly after 2007.

C.2.2. Steady-state Head Count

We do not expect to reach steady state in four years. Following is our estimate of the steady-state headcount enrollment in the proposed program by the year 2010.

Full-time 50 Part-time 10 Total 60

After maturation of the proposed program we would expect the steady-state enrollment to approximate the steady-state headcount in the three programs listed in C.1. above.

C.3. Student Credit Hour Production for First Four Years

Year 1 (1/2 year)	Student Credit Hours		
Program Category	UG	Master's	Doctoral
Category I			
Category II			
Category III		117	
Category IV			

Year 2	Student Credit Hours		
Program Category	UG	Master's	Doctoral
Category I			
Category II			
Category III		264	
Category IV			

Year 3	Student Credit Hours		
Program Category	UG	Master's	Doctoral
Category I			
Category II			
Category III		414	
Category IV			

Year 2	Student Credit Hours		
Program Category	UG	Master's	Doctoral
Category I			
Category II			
Category III		522	
Category IV			

III. PROGRAM REQUIREMENTS AND CURRICULUM

A. Program Planning

A.1. Institutions With Similar Offerings

Three programs in the United States considered to have model programs leading to a Ph.D. in Optics are:

- a. The School of Optics/CREOL at The University of Central Florida; Orlando, Florida
- b. The Optical Sciences Center at The University of Arizona; Tucson, Arizona
- c. The Institute of Optics at The University of Rochester; Rochester, New York

A.2. Institutions Visited or Consulted

Faculty members in the UNC Charlotte optics program are quite familiar with the three programs listed above. Several of our Optics Faculty have visited one or more of the three institutions. Dr. M. J. Soileau, immediate past Director of the School of Optics at CREOL

and current Vice President for Research at the University of Central Florida, visited UNC Charlotte in September of 2001. During his visit he met with the Chancellor, Provost, Dean of the College of Arts and Sciences, Dean of the College of Engineering, other administrative officials, and several of the Optics Faculty for the purpose of advising UNC Charlotte relating to possible structures for the proposed new program and its relation to the Center for Optoelectronics and Optical Communications. His advice is reflected in this document.

B. Admission

B.1. Admission Requirements for Proposed Program

The minimum admission requirements for the program are:

- a. A baccalaureate degree in Physics, Chemistry, Mathematics, Engineering, Optics, Computer Science, or a related field with a minimum undergraduate GPA of 3.0 overall and 3.0 (A = 4.0) in the major
- b. A minimum combined score of 1000 on the verbal and quantitative portions of the GRE, and satisfactory scores on the analytical and discipline specialty sections of the GRE
- c. A minimum score of 220 (computer-based test) or 550 (paper-based test) on the TOEFL if the previous degree was from a country where English is not the official language
- d. Positive letters of recommendation
- e. May be required to take undergraduate courses determined by the Optics Program Committee on an individual basis. Such courses will be specified at the time of admission into the program

B.2. Documents to Be Submitted for Admission

- a. Official transcripts from all colleges and universities attended
- b. Official GRE scores
- c. Official TOEFL scores (if the previous degree was from a country where English is not the official language)
- d. The UNC Charlotte application for graduate admission form
- e. A minimum of three letters of reference
- f. An essay detailing the applicant's motivation and career goals

C. Degree Requirements

Recipients of the Master of Science in Optics degree should demonstrate mastery of relevant subject matter, present an acceptable thesis based upon research performed, and demonstrate potential for a successful career following graduation.

C.1. Total Hours Required

The minimum requirement for the M.S. in Optics degree is 32 credit hours beyond the baccalaureate degree that includes a minimum of nine credit hours of thesis research, two credit hours of seminar (OPTI 6110), and a minimum of 21 credit hours of formal course work. The program of study must include at least 15 credit hours in approved courses having an OPTI prefix. The remaining six credit hours of required coursework may be selected from the listing of approved optics, engineering, and sciences electives.

C.2. Proportion of Courses Open Only to Graduate Students in the Program

At UNC Charlotte courses having 5000 numbers are open to graduate students and advanced undergraduate students. Courses with 6000, 7000, and 8000 numbers are open only to graduate students. A minimum of 16 credit hours presented toward the M.S. in Optics degree must be in courses having a 6000 or 7000 number. Courses having an 8000 number are open only to Ph.D. students.

C.3. Grades Required

A student in the M.S. in Optics degree program must maintain a minimum GPA of 3.0 in all coursework attempted for the degree. An accumulation of two *C* grades will result in termination of the student's enrollment in the program. A grade of *U* earned in any course will result in termination of the student's enrollment in the program.

C.4. Transfer Credit Accepted

Up to six credit hours of approved coursework may be transferred from other accredited master's and doctoral programs. Only courses in which the student earned a grade of *B* or better (or its equivalent) can be transferred. No more than six credit hours of approved coursework taken as a post-baccalaureate student may be applied toward the degree. Credit for thesis research cannot be transferred.

C.5. Other Requirements

a. Thesis Advisor and Advisory Committee:

Each student in the program must have a Thesis Advisor and an Advisory Committee before being admitted to candidacy. The Thesis Advisor serves as Chair of the Advisory Committee and must be a member of the Optics Faculty at UNC Charlotte. Composition of the Advisory Committee must be approved by the Optics Program Director.

b. Qualifier and Admission to Candidacy:

The qualifier consists of three parts.

- (1) All graduates of the program must demonstrate competency in the Core Curriculum. A comprehensive examination on subject matter in each of the five courses of the Core Curriculum is required for all students entering the program. Students may demonstrate competency in the subject matter of a specific course of the Core Curriculum by earning a grade of *Pass* on that section of the comprehensive examination. Students failing to receive a grade of *Pass* on a section of the comprehensive examination must enroll in the core course for that section. Students demonstrate competency in the core curriculum by earning a grade of *B* or better in those core courses not passed during the comprehensive examination.
- (2) All students must prepare a Plan of Study before the end of the second semester following admission to the program. The Plan of Study must be approved by the Advisory Committee.

- (3) After successful completion of the Core Curriculum requirement and approval of the Plan of Study, the student will prepare a Thesis Research Plan that is evaluated by the Advisory Committee.

After successfully demonstrating competency in the Core Curriculum, approval of the Plan of Study, and approval of the Research Plan by the Advisory Committee, the student is admitted to candidacy. The qualifier, as described, must be completed by the end of the second year following admission to the program. A full-time student is normally expected to complete the qualifier before the end of the third semester following admission to the program.

c. Thesis Requirement:

Each student will complete a minimum of nine credit hours of Thesis Research. The student must present a written thesis to the Advisory Committee. The student must defend the thesis at a presentation before the Optics Faculty. Upon approval of the written thesis and oral presentation by the Advisory Committee, the student has successfully completed the thesis requirement. The thesis must be written using a format acceptable to the Graduate School.

d. Seminar Requirement:

Each student is required to take two credit hours of Seminar (OPTI 6110).

e. Residence Requirement:

The student must satisfy the residence requirement for the program by completing 12 credit hours of continuous enrollment in coursework/thesis-research credit. Residence is considered continuous if the student is enrolled in one or more courses in successive semesters until 12 credit hours are earned.

f. Language Requirement:

The program has no language requirement.

g. Time Limit for Completion of Program Requirements:

All program requirements must be completed within four calendar years from the date the student is admitted into the program.

D. The Curriculum

Required courses are indicated by *; new courses are indicated by ^N.

CORE CURRICULUM

- *^N**OPTI 6101. Mathematical Methods of Optical Science and Engineering. (3)** Prerequisite: Admission to the Optics M.S. program. Topics include: matrix theory, series and Frobenius methods of solutions to ordinary differential equations, special functions, Fourier analysis, separation of variables techniques for partial differential equations, selected boundary value problems, and complex analysis. Topical coverage will emphasize applications specific to the field of optics. Three lecture hours per week. (Fall)

- *^N**OPTI 6102. Principles of Geometrical and Physical Optics. (3)** Prerequisite: Admission to the Optics M.S. program. Ray analysis of common optical elements (mirrors, lenses and systems of lenses, prisms). Reflection and refraction at plane and spherical surfaces, thin and thick lenses, lensmaker's equation, field of view, and numerical aperture. Wave properties of light, superposition of waves, diffraction, interference, polarization, and coherence. Optics of thin films. Three lecture hours per week. (Fall)
- *^N**OPTI 6103. Light Sources and Detectors. (3)** Prerequisite: Admission to the Optics M.S. program. The nature of light, blackbody radiation. Quantized energy levels, photons, emission and absorption of light. Introduction to condensed media. Semiconductor quantum wells. Continuous wave and pulsed (mode-locked, Q-switched) lasers. Optical resonators and selected solid-state lasers. Common laser systems. Light detection, thermal and quantum detectors, imaging and non-imaging detectors, photomultiplier tubes, and diode detectors. Noise in light sources and detectors. Optical spectrum analysis. Three lecture hours per week. (Fall)
- *^N**OPTI 6104. Electromagnetic Waves. (3)** Prerequisite: OPTI 6101. Maxwell's equations, the electromagnetic wave equation, and electromagnetic wave functions. Waves in dielectric and conducting media, dispersion. Reflection, refraction, transmission, internal reflection, and evanescent waves at an interface. Intensity. Introduction to guided waves. Three lecture hours per week. (Spring)
- *^N**OPTI 6105. Optical Properties of Materials I. (3)** Prerequisite: Admission to the Optics M.S. program. Photophysical and photochemical processes in materials. Linear and nonlinear optical properties of materials. Optical properties of semiconductors and crystals. Optical transmission, absorption, and reflection. Fluorescence of organic and inorganic materials. Chiral molecular systems. Three lecture hours per week. (Spring)
- *^N**OPTI 6110. Seminar. (1)** Prerequisite: Admission to the Optics M.S. program. Discussion and analysis of topics of current interest to the field of optics. May be repeated for up to two hours of credit. Seminar is required of all students during their first two semesters of residence. Two semester hours of seminar are required. (Fall/Spring)

THESIS RESEARCH

- *^N**OPTI 6991. Thesis Research. (1 – 3)** Prerequisite: Admission to candidacy. Research for the thesis. May be repeated for a total of 12 credit hours. Graded Pass/Fail. (Fall/Spring/Summer)
- ***OPTI 6999. Masters Residence. (1)** Prerequisite: OPTI 6991. Required of all Optics M.S. students who have completed all requirements for the degree except the thesis defense and are taking no other courses. May be repeated for credit. Credit for this course does not count toward the degree. Graded Pass/Fail. (Fall/Spring/Summer)

APPROVED OPTICS ELECTIVES⁺⁺

- ^N**OPTI 6000. Selected Topics in Optics. (3).** Prerequisite: Consent of Optics Program Director. Selected topics in optics from areas such as medical optics, adaptive optics, and all optical networks. May be repeated for up to six hours of credit with consent of the Optics Program Director. (Fall/Spring/Summer)

- OPTI 6201. Fourier Optics. (3)** Prerequisite: OPTI 6102. Principles of scalar diffraction theory. Fourier analysis applied to optical system design, imaging systems, optical filtering, optical data processing, correlation techniques, and holography. Three lecture hours per week. (Alternate years)
- ^NOPTI 6205. Optical Properties of Materials II. (3)** Prerequisites: OPTI 6102, OPTI 6104, and OPTI 6105 or ECGR 6133. Microscopic theory of absorption, dispersion, and refraction. Real and imaginary parts of the optical constant. Non-linear optical material properties. Light scattering mechanisms, including Rayleigh, Raman, and Brillouin scattering. Photoelectron spectroscopy. Ultra-short optical pulse propagation. Four-wave mixing. Three lecture hours per week. (Alternate years)
- OPTI 6211. Introduction to Modern Optics. (3)** Prerequisites: OPTI 6102, OPTI 6103, and OPTI 6104. Propagation of rays and beams in free space, non-linear materials, and fiber. Optical resonators. Theory of laser oscillations. Second harmonic generation and parametric oscillation. Electrooptic modulation of laser beams. Detection of optical radiation. Interaction of light and sound. Three lecture hours per week. (Alternate years)
- ^NOPTI 6212. Integrated Photonics. (3)** Prerequisites: OPTI 6211 or ECGR 4125. Study of basic principles and fabrication of optical waveguides. Optoelectronic materials growth and processing. Photonic devices and circuits. Integration techniques for multifunctional sub-assemblies. Three lecture hours per week. (Alternate years)
- OPTI 6221 Optical Communications I. (3)** Prerequisite: Prerequisites: OPTI 6102, OPTI 6104, and OPTI 6105, or ECGR 5165. Introduction to optical communications. Optical waveguides (attenuation, dispersions, etc.). Basic communication blocks such as lasers, optical modulators, and optical transceivers. Passive and active photonic components such as tunable lasers, optical amplifiers, SOAs, λ -converters, and filters. Coherent and incoherent detection. Signal processing, photonic switching, and point-to-point connections. Three lecture hours per week. (Alternate years)
- ^NOPTI 6222. Optical Communications II. (3)** Prerequisite: OPTI 6221. Elements of optical networks. Optical signal coding. Optical transport and networking (optical-layer). Optical multiplexing and de-multiplexing. Time-domain medium access (TDM and SONET), wavelength-division multiplexing (WDM and DWDM). Optical add-drop multiplexing, switching and routing topologies. Wavelength conversion. Dispersion management. Optical clock and timing recovery. Broadband ISDN concepts. Access, metro, and long-haul network topologies. Three lecture hours per week. (Alternate years)
- ^NOPTI 6241. Optical System Function and Design. (3)** Prerequisite: OPTI 6102. Advanced study of telescopes, microscopes, cameras, off-axis imaging systems, stops, apertures, multiple lenses, use and selection of ray trace computer codes. Three lecture hours per week. (Alternate years)
- ^NOPTICS 6244. High Speed Photonics and Optical Instrumentation. (3)** Prerequisite: OPTI 8103 and OPTI 8104. Study of instrumentation used for generation, detection, and manipulation of light in optical circuits. Topics include electrooptic modulators, selective polarizers, optical switches, amplifiers, multiplexing and mixing schemes, application of CCD and CMOS cameras and detectors. Three lecture hours per week. (Alternate years)

OPTI 6281. Modern Optics Laboratory. (3) Prerequisite: OPTI 6102. Selected experiments in areas of modern optics such as fiber optics, interferometry, spectroscopy, polarization, optical metrology, and holography. Six laboratory hours per week. (Spring)

^NOPTI 6691. Research Seminar. (1 - 3) Prerequisite: Consent of Optics Program Director. A seminar in which independent study may be pursued by the student, or a group of students, under the direction of a professor. (Fall/Spring/Summer)

⁺⁺ Additional existing approved electives are listed according to research concentration areas in Appendix F. Some courses in this listing are shown under more than one concentration area. Complete descriptions of these courses are available in the current *UNC Charlotte Graduate Catalog*.

IV. FACULTY

A. Faculty Directly Involved in Proposed Program

Any member of the University's Graduate Faculty with an interest in optics, significant published scholarship in the field, and a willingness to teach in the program or serve on dissertation committees may become involved in the proposed program. Only members of the Optics Faculty will have direct supervision of the proposed program. Current members of the Optics Faculty are listed below, grouped according to their research specialization. Members will be added to the Optics Faculty from new hires and from current UNC Charlotte faculty as they meet criteria for Optics Faculty membership to be defined later. The Optics Faculty listed below includes only current members of the UNC Charlotte Faculty who have participated actively in development of the proposed program.

Table 1. The Optics Faculty

Optoelectronic Devices and Sub-Assemblies

Raphael Tsu -- Electrical and Computer Engineering
Mohamed-Ali Hasan -- Electrical and Computer Engineering
Stephen Bobbio -- Electrical and Computer Engineering
Vasily Astratov -- Physics and Optical Science

Optical Communications

Yasin Raja -- Physics and Optical Science
Faramarz Farahi -- Physics and Optical Science
Patrick Moyer -- Physics and Optical Science
Teresa Dahlberg -- Computer Science

Devices and Systems for Sensors and Characterization

Terrill Mayes -- Physics and Optical Science
Jordan Poler -- Chemistry

Optical Materials

Kasra Daneshvar -- Electrical and Computer Engineering
Ken Gonsalves -- Chemistry
Wade Sisk -- Chemistry

Optical Metrology

Bob Hocken -- Mechanical Engineering and Engineering Science
Steve Patterson -- Mechanical Engineering and Engineering Science
Angela Davies -- Physics and Optical Science

Optical Imaging

Michael Fiddy -- Physics and Optical Science and Electrical and Computer Engineering
Robert Tyson -- Physics and Optical Science
Tom Lucas -- Mathematics
Taghi Mostafavi -- Computer Science

Please see Appendix L for abbreviated faculty vita and Appendix M for full faculty vita.

B. Need for Additional Faculty

For the proposed new program to achieve international recognition in the focus areas of optoelectronics and optical communications, additional faculty in relevant teaching/research areas will be needed at both junior and senior ranks. The program's optics focus primarily affects the Departments of Physics and Optical Science, Chemistry, Electrical and Computer Engineering. New faculty appointees will occur in these units. Faculty members specializing in the enabling technologies for optoelectronics and optical communications can be appointed to the Department of Mathematics, the Department of Mechanical Engineering and Engineering Science, and the College of Information Technology. Current optics activity at UNC Charlotte is centered in the Department of Physics and Optical Science, as developments leading to significant advances in optoelectronics and optical communications

require a fundamental understanding of optics basics normally obtainable through the study of physics. Advances must occur both at the device and component level where basic physics applies before the situation changes to the engineering of optical systems. This area, therefore, has the greatest need for new faculty lines.

C. New Faculty Positions

New faculty positions to support growth of the proposed new program will occur through normal university allocations.

D. Impact of Proposed New Program on Faculty Activity

Implementation of the proposed program will have no adverse impact on faculty activity. Faculty involved in the program will simply continue what they currently do. All members of the Optics Faculty are already fully engaged in activities necessary to support the proposed program. The only anticipated impact will be positive in that the levels of scholarly research and public service activity resulting from the proposed program are likely to see a significant increase.

V. LIBRARY

Consultation with library staff was initiated on December 18, 2001. The evaluation by Barbara Tierney of the library staff was completed on January 16, 2002. Her complete assessment is shown in Appendix G. In summary, Barbara concluded, "Library holdings are adequate." The proposed new program will, however, generate approximately \$17,000 for library materials from enrollment increase money. These funds will be used to improve Atkins Library's optics journal and monograph collection. A listing of monographs to be purchased is being generated.

Titles of new optics journals to be considered for purchase by the third year of the program are:

<u>Title</u>	<u>Cost Estimate</u>
Journal of Nonlinear Optical Physics and Materials	\$636
Journal of Optics A	\$850
Journal of Optics B	\$700
Microelectronic Engineering	\$1,752
Microwave and Optical Technology Letters	\$1,690
Optical Communications	\$5,246
Optical Engineering	\$525
Optics Express	Free
Optical Fiber Technology	\$341
Optics and Lasers in Engineering	\$1,552
Optics Letters	\$1,291
Optical Materials	\$836
Optical and Quantum Optics	\$1,351
Optical Review	\$628

Optika 1 Spektroskopia	\$516
Optik	\$1,028
Photonics Spectra	\$122
Photonic Network Communications	\$397
Physical Review A (on-line only)	\$1,660
Journal of Imaging Science and Technology	\$145
Optics and Spectroscopy	\$2,255

The Atkins Library provides access to a wide and in-depth collection of print and electronic services that are mostly available from on-campus workstations as well as from off-campus via the University's proxy server. Materials not available from this service can be obtained via interlibrary loan.

VI. FACILITIES AND EQUIPMENT

A. Description of Facilities Available for the Proposed New Program

Current facilities are adequate to support the proposed program during its first three years. During the past decade, the University has developed a significant infrastructure to support research in optoelectronics and optical communications. An inventory of major equipment available is presented in Appendix H. Infrastructure facilities currently available to support optoelectronics and optical communications research activity include a 3000 sq. ft. Class 1000 clean room with Class 10 or better conditions under individual laminar flow work stations, and a 1400 sq. ft. Metrology Laboratory with 0.1 degree temperature control and a class 10,000 environment. Deposition capabilities within the clean room include molecular beam epitaxy and UHV chemical vapor deposition for group III-Nitrides and II-VI optoelectronic materials. In addition, two machine shops and an electronics shop are available to support optics activities. These shops have broad capabilities for construction of experimental hardware and troubleshooting electronic instrumentation. Capabilities include conventional and CNC machining, electrical discharge machining, and printed circuit fabrication. Each shop has a professional staff.

Current activity in optoelectronics and optical communications at UNC Charlotte is largely concentrated in the Department of Physics and Optical Science (housed in the Burson Building), the Center for Precision Metrology and the Department of Computer Science (housed in the Cameron Applied Research Center), and the Department of Electrical and Computer Engineering (housed in the Smith Building). Space currently available to support optics activities in these three locations is as follows.

General-purpose lab space	35,000 sq. ft.
Office space (faculty and students)	7,200 sq. ft.
Metrology lab space	12,000 sq. ft.
Clean room space	<u>3,000 sq. ft.</u>
Total space	57,200 sq. ft.

This space is utilized by the people listed below.

Current faculty	36
Current staff	6
Current undergraduates	200
Current graduate students	120

B. Facilities to Become Available by 2004

While present space and personnel are adequate to support the proposed program during its first two to three years, additional space and personnel will certainly be needed to accommodate anticipated growth. Fortunately, the proposed new program is accompanied by a significant expansion in both facilities and personnel made available as a result of the recent establishment of UNC Charlotte's Center for Optoelectronics and Optical Communications and the Charlotte Institute for Technology Innovation. Space will become available in two buildings tentatively scheduled for completion in 2004. Funding to construct these buildings was obtained through the November 2000 bond referendum for capital construction approved by the voters of North Carolina. UNC Charlotte is busy planning an approximately 92,000 sq. ft. building to house the Department of Physics and Optical Science and the Center for Optoelectronics and Optical Communications. An additional 98,000 sq. ft. of space will be available in an office/classroom/laboratory building that will house the Department of Mechanical Engineering and Engineering Science and UNC Charlotte's Center for Precision Metrology. These buildings are currently in the architectural design stage. Additional space to become available upon completion of the 92,000 sq. ft. building designed to house UNC Charlotte's optical science and engineering program include (1) a fully equipped 3800 sq. ft. class 10,000 clean room, (2) research laboratories and office to accommodate as many as 50 research faculty and 100 graduate students, (3) four classrooms, and (4) six additional infrastructure facilities to be described below. Space in the adjacent 98,000 sq. ft. building will accommodate instruments and electronic shops that will support the proposed new program. Availability of this new space should provide adequate physical facilities for the optical science and engineering program at UNC Charlotte through 2010. University planning already underway calls for an addition to this space in anticipation of the success of the proposed new program.

C. Information Technology Services Needed for Proposed New Program

Information technology services currently provided by UNC Charlotte are more than adequate to support the proposed new program during its first three years of operation. The UNC Charlotte campus is fully networked with the latest Ethernet technology. An upgrade of the network was recently completed. This network is maintained by University Computing Services that operates campus servers and provides user assistance to those connected to their servers. The Mosaic Laboratory, housed in the College of Engineering, operates additional servers. Although operating out of the College of Engineering, the Mosaic Laboratory makes its services available to other campus users. The 92,000 sq. ft. building that will house the proposed program is being designed to provide space for a network room for use by University Computing Services and a server room for Mosaic Laboratory. An additional 1500 sq. ft. of space in this building is being designed to accommodate a 4-processor Onyx infinite reality graphics workstation, a PC cluster workstation, and a FakeSpace data wall. Video and data servers, scanners, digitizers, video capturing equipment, etc. will also be available. Information

technology services currently available and planned are more than adequate to support the research and teaching activities associated with the proposed new program.

D. New Facilities and Equipment

UNC Charlotte's Center for Optoelectronics and Optical Communications is an integral part of the proposed new academic program. The Center will operate seven major infrastructure facilities.

CENTER FACILITIES

- Optoelectronic and Optical Device Fabrication Facility
- Optical Characterization and Measurement Facility
- Optical Metrology Facility
- Optical Communication Infrastructure Facility
- Clean Room Facility
- Optical Imaging and Visualization Facility
- Education and Training Facility

These facilities will be fully available to support research activities of the proposed program. Past efforts to obtain funding needed to equip the seven facilities are being rewarded. The major part of the estimated \$10.3M needed to build the Center infrastructure comes from federal and private sources. The first \$2.0M of the estimated \$10.3M needed to build the Center infrastructure is already in hand. A complete description of these facilities and a listing of instrumentation to be purchased to equip the facilities are presented in Appendix I.

VII. ADMINISTRATION

The Department of Physics and Optical Science

The interdisciplinary Master of Science Program in Optics will be administered through the Department of Physics and Optical Science. The Chair of the Department of Physics and Optical Science has administrative responsibility for all programs administered through that department. The Optics Faculty is a subgroup of the Faculty of the Department of Physics and Optical Science. Membership on the Optics Faculty is restricted to those having an interest in optics, significant published scholarship in the field, and a willingness to teach in the program or serve on dissertation committees. Members of the Optics Faculty having primary appointments in other academic units, *e.g.* Electrical and Computer Engineering, will have either adjunct or dual appointments in the Department of Physics and Optical Science.

Organizational Chart

The organizational chart for administration of the master's program in optics is shown in Figure 4. On the recommendation of the Optics Faculty, the Chair of the Department of Physics and Optical Science will recommend an "Optics Program Director" to the Dean of

the College of Arts and Science. On the recommendation of the Optics Program Director, the Chair of the Department of Physics and Optical Science will appoint an “Interdisciplinary Optics Program Committee” from among the Optics Faculty.

The Optics Faculty

In accordance with the criteria developed for each graduate program or unit and approved by the Graduate Council, and upon recommendation of the appropriate department chair, the Dean of the Graduate School appoints Graduate Faculty members for renewable five-year terms. Members of the Graduate Faculty offer courses and seminars and supervise research and dissertation at an advanced level of scholarship.

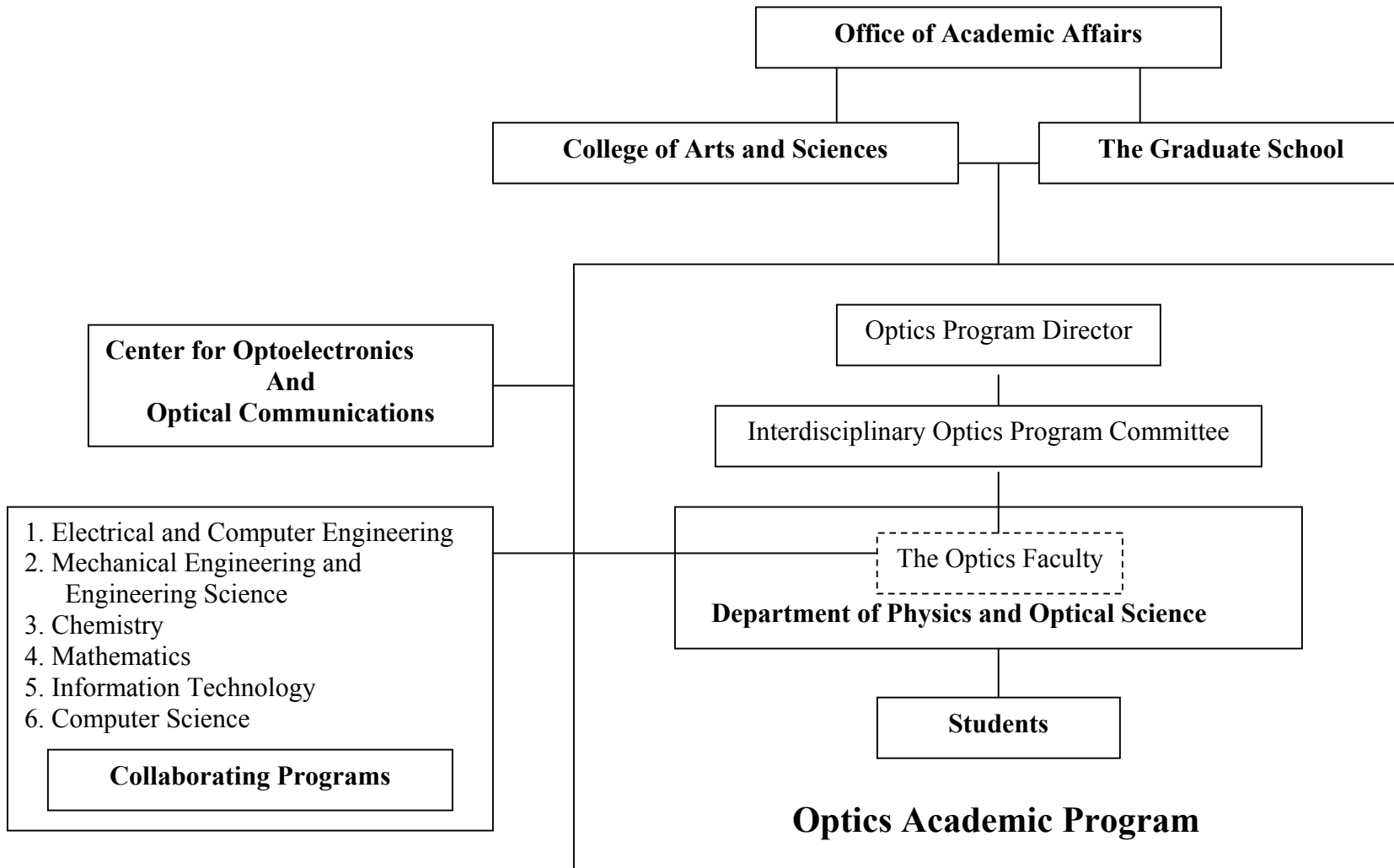
Any member of the Graduate Faculty with an interest in optics, significant published scholarship in the field, and a willingness to teach in the program or serve on dissertation committees may apply to the Interdisciplinary Optics Program Committee for membership in the Optics Faculty. Appointments will be for five-year terms with reappointment made according to the guidelines established by the Interdisciplinary Optics Program Committee, approved by the Graduate Council, and administered by the Dean of the Graduate School. The program faculty will serve as the constituency of the program for matters appropriate for faculty governance and will meet as appropriate to vote on such issues.

Interdisciplinary Optics Program Committee

The Interdisciplinary Optics Program Committee will have at least one representative from each of the departments having representation on the Optics Faculty. The Director of the Center for Optoelectronics and Optical Communications and the Chair of the Department of Physics and Optical Science will have ex officio membership on the committee. At least four members of the Committee will have their primary faculty appointments in the Department of Physics and Optical Science. Membership will be for a two-year period. Recommendations on admission to the program and admission to candidacy will be made by the Interdisciplinary Optics Program Committee, chaired by the Optics Program Director. The Committee works with the Optics Program Director to set policy and:

- Recommends to the Graduate School applicants for admission to the program
- Approves the student’s advisory committee and thesis topic
- Assures that the comprehensive exam is administered appropriately
- Assures that the qualifier is administered appropriately
- Recommends to the Graduate School qualified candidates for the degree
- Assures that all requirements are fulfilled by each candidate
- Recommends course additions and alterations as appropriate
- Approves participation of faculty in the program
- Appoints search committees for new faculty for the program
- Plans and evaluates the program

**Figure 4. Organizational Chart
For Administration of
Doctoral Program in Optics**



Director of the Optics Program

Direct responsibility for administration of the program will rest with the Optics Program Director in consultation with the Interdisciplinary Optics Program Committee, the Director of the Center for Optoelectronics and Optical Communications, and the Chair of the Department of Physics and Optical Science under the direction of the Dean of the College of Arts and Sciences. The Optics Program Director will have a primary faculty appointment in the Department of Physics and Optical Science. The duties of the Director include:

- Curriculum and conduct of the program
- Recommending operating budgets and supervising expenditures
- Chairing meetings of the Interdisciplinary Optics Program Committee
- Communicating assessment of the program and personnel to the chairs of all participating departments and programs and the Deans of Arts and Sciences and Graduate School
- Overseeing recruitment efforts for the program
- Recommending budget allocations for travel, equipment, communication, and supplies to the Chair of the Department of Physics and Optical Science
- Coordinating scheduling of courses among the cooperative departments and programs
- Assuring proper maintenance of graduate student records
- Scheduling dissertation defenses
- Representing the program to external constituencies

The College of Arts and Sciences

The Department of Physics and Optical Science is one of 22 departments in the College of Arts and Sciences. The Dean of that College has administrative responsibility for the supervision of all departments and programs housed within the College.

The Graduate School

At the University of North Carolina at Charlotte, the Dean of the Graduate School is the administrative officer with primary responsibility for the supervision of graduate programs. The Dean is responsible for the executive and administrative affairs of the Graduate School in accordance with policies determined by the UNC Charlotte Graduate Council, the Graduate Faculty, and the Faculty Council. The Graduate School is responsible for monitoring the quality of graduate programs, the final admission of graduate students, appointments to the Graduate Faculty, and supporting the enhancement of research activities essential to the conduct of graduate programs.

The Graduate Dean's main duties include the following:

- Admission of students
- Appointment of dissertation and thesis committees
- Approval of programs of study
- Admission of students to candidacy
- Final approval of dissertations

Student's Advisory Committee

Before the beginning of the third semester following admission to the Master of Science in Optics Program, the student must form an Advisory Committee. The Thesis Advisor serves as Chair of the Advisory Committee and must be a member of the Optics Faculty at UNC Charlotte. The committee should be constituted to complement the proposed plan of study and to reflect the interdisciplinary focus of the program. The Advisory Committee will consist of a minimum of four members, including the Committee Chair. A majority of committee members must be on the Optics Faculty at UNC Charlotte. The student, in consultation with the Thesis Advisor, selects two members of the Advisory Committee. The Optics Program Director appoints the fourth member. Composition of the Advisory Committee must be approved by the Optics Program Director.

Subject to the approval of the Dean of the Graduate School, the functions of the committee are to:

- Approve the student's plan of study
- Evaluate the student's academic progress
- Administer the qualifier
- Evaluate the thesis research plan
- Administer the thesis defense
- Certify the candidate's qualifications for the degree subject to the approval of the Dean of the Graduate School

VIII. ACCREDITATION

There is no agency that accredits graduate programs in optics at this time.

IX. SUPPORTING FIELDS

The proposed program is interdisciplinary, and as such involves curriculum and research activity in six academic departments housed in three colleges, the Center for Precision Metrology, and the Center for Optoelectronics and Optical Communications. Supporting academic departments include:

1. The Department of Physics and Optical Science, the Department of Chemistry, and the Department of Mathematics in the College of Arts and Sciences,
2. The Department of Mechanical Engineering and Engineering Science and the Department of Electrical and Computer Engineering in the College of Engineering, and
3. The Department of Computer Science in the College of Information Technology.

Faculty strength in these areas is adequate to implement the program. Table 2 lists the current 20 members of the Optics Faculty by home department and research specialization. The

interdisciplinary nature of the proposed program is evident from the mix of disciplines represented by members of the Optics Faculty. Each has a Ph.D. in a relevant discipline.

Table 2. The Optics Faculty by Home Department

Department of Physics and Optical Science

Optical Imaging--Michael Fiddy and Robert Tyson
Optical Communications--Yasin Raja, Faramarz Farahi, and Patrick Moyer
Optical Sensors and Characterization--Terrill Mayes
Optical Metrology--Angela Davies
Optoelectronic Devices--Vasily Astratov

Department of Electrical and Computer Engineering

Optoelectronic Devices--Ray Tsu, Stephen Bobbio, and Mohamed-Ali Hasan
Optical Materials--Kasra Daneshvar

Department of Mechanical Engineering and Engineering Science

Optical Metrology--Bob Hocken and Steve Patterson

Department of Chemistry

Optical Materials--Ken Gonsalves and Wade Sisk
Optical Characterization--Jordan Poler

Department of Computer Science

Optical Imaging--Taghi Mostafavi
Optical Communications--Teresa Dahlberg

Department of Mathematics

Optical Imaging--Tom Lucas

Support from the academic units listed above is essential to the success of the proposed program since subject matter taught within these academic units is needed to support the research concentration areas of the proposed program. Optics, an emerging discipline, spans traditional departmental boundaries. Some universities, The University of Central Florida for example, have created separate optics departments to house their programs. UNC Charlotte has opted to use expertise developed over the past decade in existing departments rather than create a new Department of Optics. The economy of this as related to staffing needs is self-evident. Although more difficult to administer than a program housed in a single department, the interdisciplinary approach as outlined makes sense for UNC Charlotte at this time in that it will take advantage of optical expertise wherever it exists. All participating departments have agreed to devote present and future resources needed to develop the proposed program into one having an international reputation for excellence.

The close relationship of the proposed program to research programs in the Center for Precision Metrology and the Center for Optoelectronics and Optical Communications is another major strength of the proposed program. The Center for Precision Metrology has established a national reputation for excellence of its research program in optical metrology. Optical metrology will be an important component of the research program of the Center for Optoelectronics and Optical Communications. As stated previously, UNC Charlotte, the Charlotte region, and the State are united and fully committed to the success of the optics

initiative at UNC Charlotte that has the proposed program, an optics center, and a metrology center as its cornerstones. The Department of Physics and Optical Science, as well as other supporting departments, accepts the challenge and welcomes the opportunity it affords to develop bridges between sister institutions such as Western Carolina University, Clemson University, the Fitzpatrick Photonics Center at Duke University, and the optics industry, both present and emerging.

The exploitation of all of these relationships is necessary if the program is to achieve its full potential. Current resources are adequate to initiate the program. Realization of its full potential awaits coming resources needed to strengthen the areas listed above. UNC Charlotte is committed to providing these resources.

X. ADDITIONAL INFORMATION

There is no additional information pertinent to the review of the proposed program.

XI. BUDGET

Start-up costs for the proposed program are relatively modest. For more than a decade UNC Charlotte, particularly in the College of Arts and Sciences and the College of Engineering, has been building infrastructure needed to implement the proposed program. Administration of the program will be through an existing department. No additional funds will be required to administer the program. UNC Charlotte has recently established its Center for Optoelectronics and Optical Communications. All members of the Optics Faculty will have joint appointments in this Center and access to its research facilities. Association with the Center will significantly reduce the amount of start-up funding needed to support new faculty lines requested for the proposed program.

The 20 current members of the UNC Charlotte Optics Faculty can teach existing courses in the curriculum. However, new faculty lines are needed to teach the five core courses and eight elective courses new to the optics curriculum, serve as thesis advisors, and participate in the research programs of the Center for Optoelectronics and Optical Communications. Resources needed to fund the new faculty lines, the three new graduate teaching assistantships, and 10 new graduate research assistantships will be generated by enrollment increase funds (\$243,000), reallocation of institutional resources (\$124,000), and external funding (\$300,000). Only one new faculty line is requested for this program, as additional faculty lines will be generated through a new optics program leading to a Ph.D. Permission to plan the Optics Ph.D. program was obtained November 9, 2001. A request to establish the Ph.D. program is being submitted concurrent with this program request.

A detailed budget statement is presented in Appendix J.

XII. EVALUATION PLANS

A. Criteria for Evaluation of Proposed Program

Criteria to be used to evaluate the quality and effectiveness of the proposed program include:

- Number of graduates from the program
- Successful placement of graduates in positions in government laboratories and industry
- Publication of thesis research in scientific and engineering journals
- Transfer of technology developed through research programs to the private sector
- Level of external funding obtained to support the research programs

B. Measures for Evaluation of Proposed Program

Measures to be used to evaluate the quality and effectiveness of the proposed program include:

- In steady state we expect to have as many as 60 students enrolled in the program, 50 of them full time. Expected time to degree is 2 ½ years beyond the baccalaureate degree. We would expect to graduate 15-20 students/year from the program when steady state is reached in approximately 10 years.
- The program will be deemed successful if graduates pursue successful careers in government laboratories and industry.
- A major goal of the proposed program is thesis research that adds to the knowledge base in the optics fields. Such research, even at the M.S. level, is often publishable. The program will be deemed successful in this arena if results of thesis results research produce publications in science and engineering journals.
- Technology transfer is measured by patents. We would expect the research programs to produce a steady supply of patents.
- The proposed program is strongly research based. Research in university science and engineering departments is largely conducted by graduate students supported by graduate research assistantships. We would expect most of the graduate students in the program to be supported by graduate research assistantships in steady state.

C. Projected Productivity of Proposed Program

	Year 1 (2002-2003)	Year 2 (2003-2004)	Year 3 (2004-2005)	Year 4 (2005-2006)	TOTALS
B					
M		5	6	10	21
I/P					
D					

D. Recommended Reviewers of Proposed Program

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E. Evaluation Plan

Maturation of the proposed program is expected to take about 10 years. Similar programs at other institutions have actually taken much longer to mature, but they began at a lower level than the UNC Charlotte program. The measures for evaluating program success, listed above, will not be realized in four years. Evaluation of the program must, therefore, assess progress toward the steady-state goals. Fourth year milestones are listed below.

1. During the fourth year of the proposed program enrollment will be assessed to determine if it is meeting projections. Full-time enrollment in the program should approach 50 by the fourth year.
2. During the fourth year of the proposed program grant activity by the Optics Faculty will be assessed. New external funding generated annually by the Optics Faculty should exceed \$1.0M. External funding should be supporting a minimum of 15 graduate research assistants.
3. The program should have produced approximately 20 graduates by the fourth year of operation.
4. A panel composed of a subgroup of program reviewers, listed in D above, will be invited to the UNC Charlotte campus to assess the overall success of the program. The report prepared by this panel will be reviewed by the Optics Program Director, the Optics Program Committee, the Dean of the College of Arts and Sciences, the Dean of the College of Engineering, the Director of the Center for Optoelectronics and Optical Communications, and the Provost.
5. Changes in the proposed program will be implemented as necessary to allow achievement of program goals.

XIII. REPORTING REQUIREMENTS

Institutions will be expected to report on program productivity after one year and three years of operation. This information will be solicited as a part of the biennial long-range planning revision.

XIV. STARTING DATE AND INSTITUTIONAL APPROVAL

Proposed date of initiation of proposed degree program: January, 2003

This proposal to establish a new M.S. in Optics at UNC Charlotte has been reviewed and approved by the appropriate campus committees and authorities.

Chancellor _____

APPENDIX A

FACULTY PARTICIPANTS

CENTER FOR OPTOELECTRONICS AND OPTICAL COMMUNICATIONS

- Chaired Professors: Robert Hocken – Metrology, Nanotechnology
Steve Patterson – Precision Machining, Interferometry
Raphael Tsu – Semiconductor Lasers
- Professors: Stephen Bobbio – Microelectromechanical Devices
Farid Tranjan - Microelectromechanical Devices
Wei Cai – Computational Electromagnetics
Kasra Daneshvar – Non-linear Optics, Lasers
Tom DuBois – Chiral Molecules for Polarization Control
Faramarz Farahi – Fiber Optics, Interferometry
Michael Klibanov – Applied Mathematics, Inverse Problems
Tom Lucas – Applied Mathematics, Numerical Analysis, Inverse Problems
Craig Ogle – Chiral Materials
Boris Vainberg – Mathematics of Wave Propagation
Ken Gonsalves – Organic Optical Materials
- Associate Professors: Banita Brown – Organic Optical Materials
Bernadette Donovan-Merkert – Chiral Materials
Terrill Mayes – Interferometry, Optical Sensing
M. Yasin A. Raja – Semiconductor Lasers, Optical Communications
Robert Tyson – Adaptive Optics, Diffraction Theory
Mohamed-Ali Hasan – Optoelectronic Materials and Devices
Patrick Moyer – Near-field Optics
Wade Sisk – Organic Optical Materials and Devices
Jordan Poler – Surface Analysis and Surface Self Assembly
Taghi Mostafavi – Image Processing
- Assistant Professors: Brian Cooper – Ultrasensitive Fluorescence Detection
Teresa Dahlberg – Telecom Network Protocol and Security
Essam El-Kwae – Image Processing
Irvin Jones – Computer Aided Design of Digital Optical Systems
Asis Nasapuri – Fiber Networks, Wireless Networking
K. R. Subramanian – Image Processing
Susan Trammell – CCD Imaging Devices
Tom Weldon – Communication Systems, Medical Image Processing
Angela Davies – Optical Metrology
Vasily Astratov – Optoelectronic Materials and Devices

APPENDIX B

HELP WANTED

SPIE ARTICLE

SPIE Web CAREER SERVICES

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"Help wanted"

Coalition for Photonics and Optics holds meeting about worker shortage

This article appeared in the August 2000 issue of OE Reports.

by Greg Friedman

In late June, the Coalition for Photonics and Optics held a meeting in Washington, D.C. to discuss the worker shortage in the U.S. optics industry, and to explore possible remedies. Representatives from government, industry, academia, and several optics associations, including SPIE, attended the meeting.

The bad news

The facts presented at the meeting paint a discouraging picture. Fewer grade-school students demonstrate an interest in science and math; there has been a consistent decline in the number of science and engineering degrees awarded in the U.S.; and there is stiff international competition for the qualified optical technicians and engineers currently working in the field.

The price for this shortage is being paid-literally -- by the optics industry, via increased salaries, pay-to-stay deals, and large hiring bonuses. Many companies are resorting to robbing each other of employees and clever out-manuevering tactics to gain an advantage with new sources.

The consensus among those in science and technology fields is that the U.S. will become less competitive in critical technology sectors unless industry, academia, and government make a concerted effort to promote and attract people to these fields. Bureau of Labor statistics indicate that between 1992 and 1999, high-tech employment in the U.S. grew by approximately 1.5 million jobs. At the same time, however, the number of science and technology degrees awarded by U.S. institutions has steadily decreased. For example, the U.S. Dept. of Education reports that the number of bachelors degrees awarded in electrical engineering declined 46 percent between 1987 and 1997.

Angela Kupps, human resource director at E-Tek Dynamics, Inc., (San Jose, CA) spoke at the meeting about E-Tek's experiences finding qualified workers. She said the company grew from 1000 to 3000 employees in one year, adding 200 engineers. The average time to fill a vacant position was three to four months; due to the scarcity of qualified U.S. workers, 75 percent of the new employees are Asian with more than 100 sponsored on H1B visas (which allow certain foreign professionals to work in the U.S. for up to six years).

Scott Lockledge, Science Fellow in Congressman Vernon Ehler's office, spoke about some of the inadequacies in the federal education resources earmarked for science and math. For example, he said the fees generated by H1B visas will provide about \$200 million in 2001 for science and math education -- which sounds like a lot, but is actually only a drop in the bucket, representing about one-tenth percent of all the money spent on K-12 programs. Other federal education funds are derived from the Elementary and Secondary Education Act. Once again, however, only a small percentage is targeted at science and math.

The good news

Despite the current situation, there is cause for some cautious optimism. For starters, the shortage of science and technology workers is finally being regarded as a priority issue.

Vicki Hoffman, director of human resources at Coherent, spoke about a strategy the company is using to ensure a future supply of optical technicians. Coherent, along with Spectra-Physics, is collaborating with Yuba Community College in Sacramento, California, on an optical technician program (see "Training tomorrow's technicians at Yuba Community College," *OE Reports*, May 2000). The program is designed to prepare students to go directly into industry and require a minimum of supervision and training. The curriculum, which began in August 1999, includes an interning component at Coherent or Spectra-Physics. Coherent is pleased with the strategy, and Hoffman recommended that other companies follow their lead.

Many schools and organizations have established or are planning outreach programs designed to raise young people's interest in science. Bob Phillippy of Newport Corp. and president of the Laser and Electro-Optics Manufacturers' Association spoke about a presentation for high-school seniors and college freshmen his company is developing. The project, which is also sponsored by SPIE, OSA, LEOMA, and IEEE/LEOS, will be a presenter-led multimedia PowerPoint demonstration that spotlights optical engineering.

SPIE has developed a number of resources and programs to stimulate students in optics, including the SPIE K-12 Optics Outreach Kit, and SPIE's annual \$250,000 scholarships and grants program. In addition, SPIE, in collaboration with OSA and other groups, is in the process of applying for an NSF grant that would enable the organization to engage in education outreach on a much larger scale.

Other programs specifically target grade-school children, such as an optics outreach kit developed by Steve Jacobs at the Center for Optics Manufacturing that focuses on where color comes from.

Government, too, is taking proactive steps to encourage careers in science. For example, the National Science Foundation (NSF) is expecting a significant budget increase for 2001 to \$2.8 billion -- an increase of \$675 million. The NSF, through new and existing programs, will devote resources to everyone from grade schoolers to graduate students.

In addition, several bills introduced to Congress are geared toward improving science and math education in public schools. The provisions in the bills range from providing grants and scholarships to creating after-school science day-care programs to establishing tax credits for science teachers.

In the short-term, allowing more skilled foreign workers into the U.S. would help fill the void. Congress is considering raising the cap on legal foreign workers from 115,000 to 195,000 through 2002.

The future

An important part of promoting science among young people is to ensure that under-represented groups in engineering and the sciences are targeted. According to a White-House report conducted by the National Research Council, if the gender and racial make up of the engineering profession does not change, the U.S. will experience a 9 percent drop in the number of engineering degrees awarded over the next 50 years.

Gloria Putnam of Pixel Vision and chair of SPIE's Education Committee and Women in Optics working group said women are the largest under-represented group, comprising 50 percent of the population but only 10 percent of the engineering profession. One strategy that would help change this situation is to address girls as early as the second grade, which is when a far greater number of girls than boys say they don't like math.

To attract people to optical engineering, Putnam said professional societies

must raise the visibility of optics as a distinct profession. She said an important step is developing a pamphlet as a resource for high-school students, so they know what courses to take and the things they need to do to become optical engineers. Just as important are classroom visits by professionals, career information delivered via the web (which is part of SPIE's grant proposal), and efforts to inform K-12 teachers and counselors about opportunities for their students in the field.

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APPENDIX C

LETTERS OF SUPPORT FROM INDUSTRY



envision integrated photonic solutions™

February 7, 2001

Terrill W. Mayes
Graduate Committee
Physics Department
UNC Charlotte
Charlotte, NC 28223


photonic chips™

I am writing in support of a new Ph.D. program in Applied Optics at UNC Charlotte. I am proud to be part of a rapidly growing company, Digital Optics Corporation that finds itself favorably positioned in the exploding optoelectronics industry. I am certain that you realize that Internet usage is fueling the demand for higher and higher transmission speeds - this will only be achieved through advances in both optics and the integration of optics with electronics. (For example, just the high-speed routing market alone is expected to have a CAGR of >75% over the next 4 years, resulting in a market of ~ \$12 billion in 2004¹). Research in this area is a fundamental requirement for the technological and product development necessary to support these advances. A Ph. D. program in Applied Optics at UNC Charlotte working in conjunction with Electrical Engineering, Precision Metrology, Chemistry, Mathematics and Computer Science would not only provide the advances required in optics, but the foundation for integration as well.

A Ph.D. program in Applied Optics at UNC Charlotte would also be a source of talent for this industry. There is a current feeding frenzy in this market for talent as outlined in an article in today's Wall Street Journal. Dr. Michael Feldman reminds me routinely that there are very few doctoral programs in applied optics nationally - this would put UNC Charlotte in very good company. So the impact of a Ph.D. program in Applied Optics at UNC Charlotte would have national if not international impact. I would expect a significant impact regionally as well. Other regionally based companies such as Alcatel, CommScope, BFGoodrich, and Corning would be potential employers. Digital Optics Corporation currently has technologists that hold 4 Ph.D.'s in Physics, 7 M.S. in Physics, and 9 B.S. in Physics. We have been very successful in hiring exceptional talent from UNC Charlotte as currently we have 19 technologists with UNC Charlotte degrees.

I would further expect that Digital Optics Corporation, those regional companies listed above and a multitude of other companies in this market would seek collaboration with research institutions that specialize in the field of optics. I fully endorse the proposed Ph.D. program in Applied Optics at UNC Charlotte and wish you the best of luck in your efforts.

Respectfully yours,


Kevin M. Drehmer

¹ Source: Ryan, Hankin & Kent



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February 5, 2001

Terrill Mayes
Graduate Committee
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UNC Charlotte
Charlotte, NC 28223

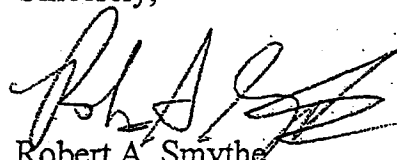
Dear Dr. Mayes,

It has come to my attention that UNCC, Department of Physics, is considering establishing a Ph.D. program in Applied Optics. The establishment of such a program could not come at a better time. There is a tremendous need for high quality applied optical engineers of all levels (Ph.D., MS and BS) in industry today. A major need exists for optical systems engineers who can create and develop optical systems encompassing a broad range of technologies. These technologies include software, electronics, precision mechanics and of course optics. A physics department based optics program is best suited for this type of broad training. Physics is the foundation of all these disciplines and applied physics training naturally cuts across these areas.

The lack of optical engineering talent is a national problem that we feel in all our regions from northeast to southwest and even Silicon Valley. Zygo sees UNCC as a source of new talent and would be very interested in your students as potential employees. Zygo has added over 50 new engineers (BS to Ph.D.) this last year and we plan to be very aggressive in our growth. Zygo is hiring from around the world and sees UNCC as a local source.

I encourage UNCC to move forward with this program. Optics is a ripe field both commercially and intellectually. UNCC could be an important link in the advancing the field and training new talent so badly needed.

Sincerely,



Robert A. Smythe
Vice President Engineering
Zygo Corporation

CLEMSON UNIVERSITY

February 12, 2001

Dr. Terrill Mayes
Graduate Committee
Department of Physics
UNC Charlotte
Charlotte, NC 28223

Dear Dr. Mayes,

I was thrilled to hear of your Department's consideration of implementing a graduate program in Applied Optics. Given your centralized geographic location to the world's largest optical fiber production facilities in Wilmington, NC (soon to be Concorde, NC when that plant comes fully on-line) as well as the Lucent facility in Norcross, GA, the Alcatel plant in , and the myriad of smaller optics-based companies in the Charlotte area, your decision could not be more timely nor more towards meeting the economic development needs of your State and Nation. Optical telecommunications continue to proliferate globally at rates heretofore unrealized by any other technology, save perhaps the transistor. Despite this record growth the vast majority of scientists working to continually advance the state-of-the-art come to the field from a diverse range of educational backgrounds that is unfortunately light on physicists. This is partly due to the fact that there do not exist very many PhD-level programs in optics; particularly towards the application of the technology (i.e., applied optics). I feel that your program, based on my impressions and interactions with your faculty, will become a centerpiece for optics education in the country bringing added publicity to UNCC and, likely, industrial growth to your region.

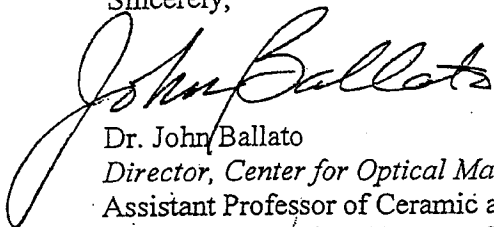
Speaking from the experience of graduating and placing into the optical communications industry numerous students over the past few years, I can say that there is no shortage in necessity for people skilled in applied optics. We at Clemson have never had a problem placing



any graduates in the field and I expect that trend to continue for all academic institutions graduating well-educated students. The need exists and, with the planned levels of growth (e.g.; Corning-Wilmington is presently doubling their size as is Corning-Concorde with a third expansion to Concorde already being planned), that need will continue. Without question, companies all across the nation will actively pursue any person graduating with any degree – undergraduate or graduate - in optics.

In summary, the optical communications industry is in great need of people educated in applied optics. There is no foreseeable short fall in the need for skilled employees in this area and your graduate program could not be more timely nor better focused on an area of technology critical to the economic development of the region and the Nation.

Sincerely,

A handwritten signature in cursive script that reads "John Ballato". The signature is written in black ink and is positioned to the left of the typed name and title.

Dr. John Ballato

Director, Center for Optical Materials Science and Engineering Technologies

Assistant Professor of Ceramic and Materials Engineering

Clemson University, Clemson, SC 29634-0907

Phone: (864) 656-7881; Fax: (864) 656-1453

Email: john.ballato@ces.clemson.edu



Alcoa Fujikura Ltd.

Telecommunications Division

Post Office Box 3127
Spartanburg, South Carolina 29304-3127
(864) 433-0333

February 13, 2001

Terrill Mayes
Graduate Committee
Department of Physics
UNC Charlotte
Charlotte, NC 28223

Dear Dr. Mayes,

As a bit of background, Alcoa Fujikura, Ltd is a fiber optics company with 17 years of history. AFL is headquartered in Brentwood, Tennessee, but the main operations are located in Spartanburg, SC, about 90 minutes from UNCC. The main products include aerial cable, connectorization products, fusion splicers, optical components and modules. AFL has manufacturing plants and key customers in a number of areas, but there is a concentration on the East Coast.

UNCC has a number of programs which are of interest to AFL. We have had the opportunity for some joint overviews that have opened dialog between the technical groups. This type of collaboration is critical for our success. The Applied Optics program being proposed by UNCC would be ideal because it would:

1. create a local source of talent for future job needs,
2. establish research programs on critical optical components, and
3. provide advanced equipment and analytical capabilities for special needs.

The world of fiber optics is growing rapidly and evolving rapidly. It is critical for companies, such as AFL, to be tied closely to research activities that will provide the next step changes in optical component integration, process improvements, or basic understanding.

Our need for new graduates continues to grow. While the numbers of PhD's might not be high (3-5), we also have a large need for M.S. and B.S. graduates with experience in optics. I am sure that a strong PhD program will not only provide the PhD needs, but also foster a strong M.S. and B.S. optics program. If the clock could be advanced a bit, it would be ideal to have new grads available today to fill our more than 100 open professional positions!

Dr. Mayes, AFL has already enjoyed the relationship which we have with UNCC. The proposed PhD program in Applied Optics would only strengthen this relationship. This new program would provide a catalyst for increased optical expertise in the Carolina's, which is needed by companies such as AFL. We wish you success in the approval of this program!

Sincerely,



Jeff Conley
General Manager, Photonics, AFL

Eric Buckland, PhD
Chief of Staff
Optical Networking Devices

112 Mariner's Point Lane
Hickory, NC 28601

March 15, 2001

Terrill Mayes
Graduate Committee
Department of Physics
UNC Charlotte
Charlotte, NC 28223

Dear Dr. Mayes,

I am writing this letter in support of an Applied Optics Ph.D. program at UNC-Charlotte. I believe this program can be valuable to Corning and to North Carolina as the optical communications industry sector continues its phenomenal growth.

The competition for talent to address the technical and commercial challenges associated with bringing next-generation optical solutions to market is intense. At OFC 2000 in Baltimore the ratio of open jobs to job seekers was on the order of 10:1. It was a job hunters paradise. There is simply too much work and not enough available talent.

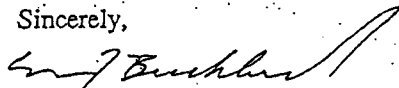
The range of optical technologies important to the communications industry is rapidly broadening. Today, a range of technologies including active devices, EDFAs, high data rate fibers, fiber Bragg gratings and thin film filters, are enabling the capacity growth of optical communication networks. Added to the mix, increasingly complex integrations of optical materials, electronics, and opto-mechanics are being applied to devices and subsystems that are increasing the functionality and intelligence of the optical layer.

Interestingly, North Carolina with its large manufacturing base in optical fibers and cables, strong industrial base in communications software and electronics, and strong academic base in solid state physics and electrical engineering, has only weak participation – academic or commercial – in the optical technologies that are driving growth in the optical communications industry. A UNCC Applied Optics program complementarily designed with the recently announced Photonics program at Duke could play an influential role in enhancing North Carolina's role in the optical communications sector.

Corning recognizes a long-term need for creative talent to invent, develop, manufacture, and commercialize new optical technologies for next-generation communications systems. Corning has hired a number of students out of the UNCC Physics and EE programs over the last couple of years who are now valued contributors in market development and applied research roles. While it is impossible for me to project the numbers of graduates that Corning would hire out of a UNCC Applied Optics program, it is clear that the optical communications industry – a key industry targeted by the UNCC program – is still in its infancy. A well-structured Applied Optics program at UNCC would be a welcome source for future recruiting.

I would therefore like to express my personal support for the development of this Ph.D. program at UNCC.

Sincerely,




Eric Buckland
Chief of Staff

cc: Pat Moyer

Boeing Commercial Airplane Group
P.O. Box 3707
Seattle, WA 98124-2207

March 20, 2001
6-2000-M3-010001

Terrill Mayes
Graduate Committee
Department of Physics
UNC Charlotte
Charlotte, NC 28223

 Dear Dr. Mayes:

It is with pleasure that I write to support your plan to establish an interdisciplinary Ph.D. program in Applied Optics at UNC Charlotte. There is a great need in industry for the new technology and broadly trained professionals such a program would supply. The interdisciplinary aspect, involving Physics, Engineering, Metrology, and Chemistry, will produce professionals that can operate over a broad range of technologies. Shortage of professionals in this area is acute at all educational levels and is occurring nationally. A program with this emphasis is very timely. Such a program would have national impact.

Boeing has considerable interest in optics ranging from optical metrology systems used in aircraft and missile assembly to a new generation of optical sensors for aerospace applications. Our association with the Center for Precision Metrology at UNC Charlotte has been very productive. We at Boeing look forward the increased opportunities the new program will afford.

I fully endorse UNC Charlotte's effort to expand its program in this area. The Ph.D. program in Applied Optics is an essential component for the success of the Center for Optoelectronics and Optical Communications currently being established. We at Boeing wish you success in your efforts, even though at this time we are unable to provide any financial support.

Sincerely,



Richard P. White P. E.
Manager
Manufacturing Research and Development
Quality Assurance, Measurement Research and Development
Phone: (425) 234-5721

Bell Labs

Innovations for Lucent Technologies

Lucent Technologies101 Crawfords Corner Rd.
Holmdel, NJ 07733
March 26, 2001Terrill Mayes
Graduate Committee
Department of Physics
UNC Charlotte
Charlotte, NC 28223

Dear Dr. Mayes,

I am pleased to learn that the formation of an optics degree program is being pursued at UNC Charlotte. As you are aware, there is a critical shortage of professionals with technical expertise in the area of optics. This situation is true for all degree levels: Bachelors, Masters and Doctoral. As an example, you might consider that while the current slowdown in the telecommunications industry has forced many organizations to reduce their workforces, at the same time all of these organizations continue to aggressively recruit technical people educated in optics and related areas. This scenario is certainly true here at Lucent Technologies. Many indicators suggest that this shortage will persist well into the next decade, and even worsen if our educational sector does not respond to this need. Your new degree program together with the Center for Optoelectronics and Optical Communications will put UNC Charlotte in a leading position for a growing national trend. I expect that within the next decade the optics degree will be a vital part of most major technical universities. I view your efforts in this direction to be a natural step for a university that is poised to become a major educational force in the Southeast region.

A doctoral program in optics will be especially important at UNC Charlotte. Today the PhD is no longer reserved for the educational elite. It is an essential degree for technical professionals in this rapidly changing high-tech marketplace. Many companies are building their core businesses around technology that is still in the research phase or not yet even invented. The self-directed, laboratory-based education provided by the doctoral degree is critical in this environment. Competition for professionals with doctoral degrees has risen to the point that companies are forced to locate their facilities around the people. This circumstance strengthens the advantage of expanding the optics activity at UNC Charlotte. One only needs to look at cities such as Orlando, Atlanta, and Tucson to see the benefits of strong university programs in optics on the regional economy. Optics centers and degree programs (particularly at the doctoral level) in these cities have stimulated the growth of new companies, and the draw of a strong workforce has attracted established companies. The positive impact that your efforts will have on the Charlotte region cannot be underestimated.

Sincerely,

Dr. Daniel C. Kilpet

BFGoodrich

The BFGoodrich Company
Four Coliseum Centre
2730 West Tyvola Road
Charlotte, NC 28217-4578
Tel: (704) 423-7561
Fax: (704) 423-5838
e-mail: jlee@corp.bfg.com

Dr. Jerry S. Lee
Senior Vice President
Technology and Innovation

February 22, 2001

Dr. Terrill Mayes
Graduate Committee
Department of Physics
UNC Charlotte
Charlotte, NC 28223

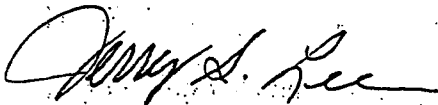
Dear Dr. Mayes:

I am delighted to learn that you are proposing a Ph.D. program in Applied Optics at UNC Charlotte and that this program will be well integrated with the new Center for Optoelectronics and Optical Communications. From a BFGoodrich perspective, this is a critical and powerful combination. Applied optics research and high caliber graduates fit remarkably well with BFGoodrich's technology and business strategies.

Through its Advanced Sensors Technical Center, BFGoodrich is actively developing optically based sensors for ice detection on aircraft, ice detection on roadway, non-intrusive air data measurement systems for aircraft, clear air turbulence detection systems, high reliability fire detection systems, and obstacle detection and avoidance systems for helicopters. BFGoodrich is also investing strongly in MEMS-based optical switching for high-speed communications. Near the end of 2000, BFGoodrich acquired a premier Optical Systems business from Raytheon. Thus, our need for optical technology is growing and our need for people skilled in applied optics is growing. We have businesses throughout the United States; however, for optical experts the most probable employment locations are Connecticut, Ohio, and Minnesota.

Over the next decade, I estimate that we will have positions for up to 5 people at the Ph.D. level, 10-15 at the M.S. level, and 10-15 at the B.S. level. In addition, we encourage collaborative, Ph.D.-level research with universities. Please keep this in mind as you proceed with the Ph.D. program.

Sincerely,



Jerry S. Lee

APPENDIX D

OPTICS JOB POSTINGS

UNIVERSITY OF ARIZONA

APPENDIX D

Copy of Recent Job Postings on the Web Site

of

The University of Arizona Ph.D. in Optical Sciences

Jobs:

The optics industry is experiencing a shortage of skilled optical engineers and scientists, and have asked us to "grow the program" to produce more graduates. The University of Arizona has targeted our BS degree program for expansion and we are actively working on increasing the scope and breadth of the program to attract more students. In the near future, we'll be offering the BS degree in optics with concentrations in electrical and computer engineering, astronomy, mechanical engineering, materials science and physics -- and the same high-quality education to prepare graduates for careers in optical design, optical fabrication and testing, lasers, optical detectors, optical instrumentation and optical fiber communication.

Salaries in the optics industry are extraordinarily high and jobs are plentiful. Every week we receive an average of five or six messages from colleagues in academia and industry telling us about job openings and asking us to circulate those messages to our soon-to-graduate students and to our alumni.

New Job Openings posted within past 5 weeks.

January 4, 2001. Optical engineers. On behalf of Corning, Inc., a recruiting company is searching for several optical engineers in the area of measurement and design, including one supervisory position. If interested, contact: Christopher Rule, Consultant, Kenexa (Formerly TalentPoint), by email at <mailto:chris.rule@kenexa.com>. For information about Kenexa, please visit <http://www.kenexa.com>.

January 4, 2001. Optical engineer. Symbol Technologies, Inc., winner of the National Medal of Honor and the maker of barcode laser scanners, handheld computers and wireless LAN, is currently seeking a candidate interested in optical engineering. The Optical Engineer contributes to the analysis, engineering experimentation and documentation for the design of optical instruments. Degree: MS or PhD (preferred). Major: Optics or Opto-Electronics with training in Opto-mechanics. Knowledge and deep understanding of physics, geometrical and diffraction optics completed by practical design and experience in

laser containing optical devices is needed for position. Knowledge of all related to opto-electronics and mechanics signal transfer function analysis, as well as capability to apply it to developing systems is essential. Solid knowledge and experience is required regarding optical laboratory instrumentation, experimentation techniques, optical metrology and measuring methodology is required. Applicant should demonstrate solid background in the area of opto-electronics related to patents, inventions and other unconventional technical ideas. Laboratory Experience: Optical Laboratory, Instrumentation, Experimentation Techniques, Optical Metrology and Measuring Methodology GPA: 3.5+ Location: Long Island (Holtsville), NY. Email your resume to <mailto:college@symbol.com>.

January 4, 2001. Multiple openings. On behalf of client companies, Sze Sze Tobias (pronounced as "ZZ") is searching for candidates to fill the following openings: VP of Marketing, CA . For a fiber optics, telecommunications start-up company, dealing with passive components, DWDMs, pump combiners, etc. Company anticipates going public Q3 or Q4 of next year. Marketing Director/VP, CA . This person will report to the CEO. Preferred credential: senior marketing experience at telecom and broadband industry. Whether the person is a director or VP will depend on his/her experience and background. competition § Establish and maintain leading edge expertise

January 4, 2001. Multiple openings. CENIX Inc., based in Allentown, Pennsylvania and Irvine, California, is advancing state-of-the-art technology for high-speed opto-electronic interfaces. We are focused on the design and automated manufacture of next generation 10 Gb/s and 40 Gb/s integrated subsystems. Our objective is to be the world's premier independent supplier of high functionality, highly integrated optical subsystems to network equipment suppliers. Our turnkey optical line card solutions will be plug and play ready for use by customers interfacing Routers, Switches and Transport Systems. We currently have opportunities to participate on an integrated team that includes product design, automated process and test equipment design and development, manufacturing process development, and manufacturing engineering and quality. **Optical Device Design Engineer:** Description: Design of optoelectronic chip components that meet requirements for automated manufacturing and performance specifications of 10 Gbit/s to 40 Gbit/s modules and subsystems. Successful candidates will work closely with module designers, module manufacturing and wafer fabrication engineers to create leading edge solutions for low-cost and high performance products. Requires BS/Ms/PhD in an appropriate field and extended knowledge of laser and/or detector chip design and reliability qualification. **Project Manager:** Description: Technology oriented Project Manager leading a high energy and diverse team through rapid product development and manufacture ramp. Position will work across multiple technology disciplines including electrical, optical, and mechanical. Involves running regular project meetings, tracking progress, resolving interface issues, and providing clear and timely documentation. Requirements: BS in Engineering, 3-5 years experience in technology oriented company. Position requires excellent communication skills, staying highly organized and focused in a fast paced environment, establishing clear objectives and plans, tracking details, and fluency in MS project, MS office or similar tools. Experience in communications equipment design and/or manufacture preferred. **Sr. MCM Engineer.** Work with High-Speed electrical and mechanical engineers as part of a leading-edge development group to create compact, integrated, fiber optic subsystems. Design and analysis of multichip modules and high-

density SMT assemblies. The design and package of MCM's and SMT assemblies operating from 10 Ghz to 40 Ghz. Analysis involves thermal, mechanical and circuit analysis of MCM's. Interface with Production. Interface with customers from the design concept phase through design reviews. Limited component engineering and project management duties. Requirements: BS Electrical Engineering or equivalent experience 3-5 years of relevant industrial experience with emphasis on hybrid and multichip modules. Experience and knowledge using CAE tools required. Specific experience with Cadence design tools is desired. RF module design is a plus. Working knowledge in processing of MCM-L, -C and -D modules desired. Experience with laminate substrates, BGA packaging, Flip chip assembly, Chip Scale packaging and other newer technologies is also desired. Opto-electronics experience is also a plus. RF/Microwave Design. Description:

January 4, 2001. Computer specialists. The Chandra X-ray Center Science Mission Planning team (at Harvard) is looking for two bright and motivated computer specialists (data aides). Needed: basic knowledge of astronomy and demonstrated computer skills, including experience with UNIX, and coding/scripting languages such as C, Perl, IDL, etc. If interested, contact Pat Slane at <mailto:slane@cfa.harvard.edu> or Mike Garcia at <mailto:garcia@cfa.harvard.edu>.

January 4, 2001. Research scientist. The Eppley Laboratory, Inc. Located in Newport, Rhode Island, the Eppley Laboratory (EPLAB) has been a leading manufacturer of scientific instruments for precision measurements since 1917. Eppley manufactures and calibrates pyranometers, pyrheliometers, pyrgeometers and radiometers for the precise measuring/monitoring of Solar & Atmospheric Radiation. An immediate position is available for Research Scientist. Experience in Atmospheric Earth Sciences; knowledge of Thermal Radiation Applications (Detectors and Sources); Computing Skills (Basic, DOS, Windows); and familiarity with design, operation and calibration of Radiometric Instrumentation required. Graduate or Doctorate Degree preferred. Immediate responsibilities include operation/calibration of AHF Absolute Cavity Radiometers and Automatic Solar Trackers as well as research on improving calibration techniques, data taking and instrument design & construction. For additional information, please contact: The Eppley Laboratory, Inc., Attention: Tom Kirk, PO Box 419 - 12 Sheffield Avenue, 401-847-1020 - 401-847-1031 (fax). [Mailto:eplab@mail.bbsnet.com](mailto:eplab@mail.bbsnet.com). <http://www.eppleylab.com>.

January 4, 2001. Multiple openings. Baynet Optics is a fast growing start up company, a provider of high precision fiber optic modules, and passive components for intelligent fiber optical network and telecommunication industries. You will be key engineering members in the design and characterization of high-precision optic modules and passive components for use in Optical Networking, and Telecommunications. Your experience with Bellcore standards is a plus. Fiber Optic Lab Technician: AA / AS in physics, EE, or related scientific discipline, with hands on fiber optics and tooling experience. Fiber Optic Process Engineer: BS in Optics (MS & PhD preferred) or related scientific discipline, with fiber optics alignment, assembling, and process development experience. Fiber Optic Testing Engineer: BS in EE (MS & PhD preferred) or related scientific discipline, with fiber optical testing, equipment setup, and procedure development experience. Understanding Bellcore testing and setup is a Plus. Electronic Engineers. Board level

analog system design, analog IC design. Interface with vendors and customers on requirements. At least 2-5 years of experience. BS/MS EE degree required. Familiar with analog circuit design tools, such as PCAD, Cadence or equivalent. Electro-optical Engineers :

January 4, 2001. Scientist. Applications are invited for a Scientist in the Light Microscopy/Optical Properties Characterization Laboratory of 3M's Corporate Analytical Technology Center. The Laboratory supports the development, production, and protection of all 3M products. This is a state of the art light microscopy laboratory that utilizes most of the classical and many of the advanced light microscopies to solve problems of importance to most 3M divisions. Applicants should have broad experience in optical microscopy such as: bright field, dark field, differential interference contrast, phase contrast, polarized light, and interference microscopy

January 4, 2001. Multiple openings: Gemfire Corporation is a dynamic, pre-IPO photonics company developing cost-effective solutions for the telecommunications industry. Specifically, we are innovating integrated optics components for fiber optic network systems. By providing high performance, low cost planar light circuits and laser products, we are confident of substantial market share in this explosive and fast growing market. Our novel approach to integrated photonics promises great rewards with reduced risk. Gemfire has just closed a significant round of funding including support from premier telecom, datacom, optical component and electronic chip companies. This is an ideal time to join a company that's part of the optics revolution! Gemfire employees are a team of highly motivated, creative individuals who are committed to developing cutting-edge technology in this exciting industry. Located in Palo Alto, we offer a fast-paced, fun work environment, competitive compensation, generous benefits and stock options

December 14, 2000 -- Multiple Openings. On behalf of a client company, MRI-RTP is searching for several candidates. **Principal Optical Engineer—Metrologist.** Reference 1403D. Responsibilities: Define tests to measure optical parameters of components (surface figure, vertex location, surface roughness etc.) Implement setups and perform tests and alignment procedures. Work closely with lens design, mechanical//structural (for metrology mounts/brackets) and technician support groups. Education/experience: The Optical Metrologist should have a strong background in optical testing, data reduction (as it applies to optical testing) and knowledge of optical fabrication techniques. Experience with optical component testing, optical alignment, lens design, stray light analysis and optical mounting techniques. **Principal Optical Systems Engineer.** Reference: 1328D. Description: Systems level programs include optical telescopes and aerial based camera systems. The telescopes fall into two main areas, large ground based astronomical and large deployed space systems. Aerial cameras encompass multi/hyperspectral imaging cameras on both aircraft and satellite platforms and strategic high performance aircraft cameras used by the military. Responsibilities: The system engineer will provide technical leadership in the pursuit, design, fab and test of these systems; interact with customers to ascertain specifications and performance standards of desired system and respond with a proposal. At the beginning of a program the system engineer will lead functional discipline experts in defining the design and detailing test plans and verification steps, then consult during the manufacturing phase. During testing the system engineer

will assume the lead technical role. Special skills: The system engineer must have broad technical knowledge in the normal functional areas such as mechanical, structural, thermal, electrical, controls, optical, manufacturing, etc. such that flow down of requirements to these different disciplines can be made. It is anticipated that no one will have sufficient knowledge in all areas and provision will be made to provide further expertise in deficient areas. Education/experience: MS in Engineering/Physics required plus 5-6 years experience in optics, optical systems, test development, manufacturing and systems engineering of optical systems. **Opto-Mechanical Lead Engineer.** Reference: 1327D. Responsibilities: Manage a small optics prototype shop supervising 3 opticians. Optics and coatings production or procurement for multiple products. Engineering lead for small instrumentation projects for leading-edge astronomical instruments. Lead systems level flow down of engineering requirements from scientific requirements. Project management experience a plus. Education/experience: Bachelors' degree in Mechanical or Optical Engineering; plus at least 10 years related experience or an MS and 7 years experience. Experience should include opto-mechanical design, knowledge of geometric optics, optical fabrication and test methods, use of Zemax and CAD design packages. **Director, Thin Film Tech/Optical Coating.** Reference: 1318D. Leading producer of OEM custom optics, systems and crystal components is seeking a senior optical coatings professional to head its optical coating team. Responsibilities: The Director will manage the optical coating group, expand the group's capacity and capabilities including the planning and implementation of a second shift coating operation. The manager will provide technical and managerial leadership for process engineering, new coating process development, production yield improvement, employee recruitment, development, and certification, selecting and bringing new capital equipment on line, meeting quality requirements, and provide customer technical support. Special skills: Experience in e-beam deposition required, UV through IR, evaporative IR and IAD experience is highly desirable. Management experience in team based environment required. Education/experience: BS Optics Engineering, Physics or other related degree. Advanced degree a plus. 8-12 years experience in the design of optical coatings and operation of vacuum coating equipment. **OEM Optics Sales Account Manager.** Reference: 1319D. General Description: Develop and cultivate new accounts and markets. Service and support existing accounts. Provide multi-level support to customer base including technical support, on-site visits and liaison with manufacturing. Responsibilities: Sales and support of custom OEM optics, optical assemblies, including non-linear optical components for laser systems. Direct account management to include a maintenance of existing accounts and development of new domestic and international accounts. Identify and cultivate new product and market areas. Provide technical support to OEM accounts and end users to meet their application and technical requirements. Manage and coordinate quote and order process with applicable internal resources. Monitor and maintain complete competitive product analysis. Coordinate trade shows. Special skills: Approximately 25% travel. Education/experience: BS or higher in Optics, Physics or related engineering. Minimum 5 years of high level sales and technical support experience in the photonics or optics industry, OEM and custom optics experience preferred. Proven ability to cultivate and develop new markets. Strong consultative customer sales and support skills. Ability to effectively interface with all levels of customers and INRAD staff. Strong account management, presentation and negotiation skills. Please contact David Bradley, MRI--

Research Triangle Park by email at <mailto:dab@mri-rtp.com>. Telephone 919-572-2292.
Web <http://www.mri-rtp.com>.

December 14, 2000 -- Multiple Openings. Corning has a number of position vacancies as follows: **Design Manager – Photonic Products.** This is a hands-on photonics product development engineering position, supervising up to eight engineers / designers. Ideal candidate has a BSME or MSME plus experience in the design and development of high technology products. Good people skills are a necessity. Electronic packaging a plus. Familiarity with Systems Engineering and a broad range of Engineering tools (3-D CAD, DFMA, Configuration Management, FEA). **Optical Project Leader.** Experience in telecommunications, EDFA's or optical components, MS or Ph.D. in Optics, Physics or EE. **Electronic Design Engineer.** Analog/ Digital, PS, detectors, sensors or signal conditioning. Versilog, Pads. BS or MS EE. **Optical Science Modeling.** Profiling, Waveguides, Rare Earth elements, or vapor deposition, BS, MS or Ph.D. in Materials or Chemistry. **Mfg. Project Leader.** Electronics, PCB's, Prototypes to Mfg., Hands-on, BS to Ph.D. **Optical or Modeling Group Leader.** BS to Ph.D. in Engineering, Math, Physics or Statistics. **Sr. Electronic Tech.** Embedded controls, Component level troubleshooting, DSP software, (optics is not needed). To apply, please send a resume using MS Word via email to: Tom Minahan, Corning Inc., Science & Technology at <mailto:minnihanit@corning.com>.

December 14, 2000 -- Optical Engineer. Bayer Diagnostics, currently the 3rd largest supplier to the worldwide diagnostics market, is seeking a candidate for new instrument development and current product support. Incumbent will be involved in all phases of optical engineering from requirements analysis and preparation of specifications to design/development of spectroradiometers for measurement of sample reflectance and transmission, prototype testing, documentation and product maintenance. The work scope will include selection of electro-optical components and reference standards, optical component design, and optical systems synthesis and layout. Position Requirements: BS in optics (MS desired) or physics with emphasis in applied optics. Experience with LED's, photomultipliers, photodiode detectors, CCDs. Familiarity with ray tracing software (LightTools, Zmax). Must be able to work in team based environment. Hands-on. The Company: Bayer Diagnostics is a \$1.8B division of Bayer AG a \$32B multinational life sciences and industrial chemical corporation. Bayer Diagnostics is currently the 3rd largest supplier to the worldwide diagnostics market. The Near Patient Testing business segment researches, develops, manufactures and supports equipment used for the diagnosis and treatment of patients both in a critical care setting as well as in other health care facilities and physician office/labs. Near Patient Testing's headquarters and primary development center is located in Medfield, MA. Further information can be found at <mailto:www.bayerdiag.com>. The Products: Urinalysis. A comprehensive line of instruments are developed and produced for a variety of health-care settings. Analyte concentration is obtained by measurement of spectral reflectance from a test strip. Some of the test analytes measured are Leukocytes, Ketone, Protein, Nitrite, Blood, Glucose, etc. CO-oximetry: CO-oximetry is the sophisticated measurement of total hemoglobin and specific fractions of hemoglobin in whole blood. Used in the care of critically ill patients. Measurement is done by the fractionation of collimated light transmitted through the sample onto a photo-diode detector array. Futures: Research efforts now underway

focus on new urine tests, fluorescence measurements and incorporation of chemiluminescence measurements into new products. Contact: Peter Prescottanno, HR Representative, by telephone at 508-359-3820 or by email at <mailto:peter.prescottano.b@bayer.com> or Richard Schoon by telephone at 508-359-3143 or by email at <mailto:richard.schoon.b@bayer.com>. The application deadline is February 1, 2001.

December 14, 2000 -- Fiber Optic Engineer. Lightel Systems Corporation in Chantilly, Virginia is seeking an MS or PhD with graduate level lab or industry experience in DWDM R&D engineering and design as a telecommunication product developer. About Lightel: Lightel is a pre-IPO company dedicated to the R&D of the fiber optic industry's first design that consists of unique arrangements of high-speed fiber communications aligned with computing intelligence in end-to-end systems. Lightel's patent-pending innovative design incorporates unique wavelength mapping techniques to create a new architecture and high performance network topologies. This approach distinguishes Lightel's products in creating the highest performing systems at the lowest risks and costs. Competitive compensation includes base salary, significant participation in the stock option program, as well as industry comparable benefits. Contact Lightel's Staffing Consultant: Chris Allison, at early_stage@att.net or by telephone at 540-888-3991.

December 7, 2000 -- Multiple Openings. The Aegis Technologies Group, Inc. has two immediate openings in support of the Kinetic Kill Vehicle Hardware-in-the-loop facility. These jobs are full-time and located at Eglin AFB in Ft. Walton Beach, Florida. Electro-Optical Engineer. Requirements include a BS in physics, optical engineering, computer science, or electrical engineering. An MS is preferred. Experience in one or more of the following areas is preferred: hardware-in-the-Loop; IR and LADAR scene projection; optical design and performance metrics; IR and visible sensors; MATHCAD, MATLAB, and KHOROS; software development in C, C++, and FORTRAN. Software Engineer. Requirements include a BS in electrical engineering or computer science. Experience in the following areas is preferred: Win NT, Sun, SGI, and Concurrent Highhawk; C, C++, FORTRAN; real-time implementation, data visualization and management, configuration control; hardware drivers; distributed interactive simulation and high level architecture. Aegis offers very competitive salaries and generous benefits intended to promote the personal well-being and professional development of every employee. To apply, please submit a resume and cover letter in confidence to: ATTN: Human Resources Manager, The Aegis Technologies Group, Inc., 6703 Odyssey Drive, Suite 200, Huntsville, Alabama 35806. E-mail <mailto:hr@AegisTG.com>. Fax 256-922-0904.

December 7, 2000 -- Optical Engineers. Axon Photonics, a startup company in Fremont, California, develops modules and subsystems for optical networking. They currently have openings in their Component Development, Testing and packaging area. For engineers to work with other fiber optics engineers to develop testing and fiber attachment process for OE components and subsystems. Ideal candidates are MS or BS degree graduates in optical sciences, physics, or optical engineering with zero to five years of experience in testing and handling optical fiber, pigtailling active or passive components, or connectorizing optical fiber. Good communications and computer skills are necessary. Axon Photonics offers competitive salaries, excellent benefits and stock options. Please

send a resume to Jacob Sun, Vice President for Operations, at <mailto:jsun@axonphotonics.com> or to Saurav Das, Optical Engineer (OSC MS 1999), at sdas@axonphotonics.com.

December 7, 2000 -- Software Engineer - Fluent in Mandarin. On behalf of a client company in San Diego, California, Tanis Tech Recruiters is searching for an engineer to support the development of imagery and information systems business unit for the model 486, Taiwan Remote-Sensing Ground Station program. Software engineers typically support requirements analysis and definition, object oriented database and software design and development, test plan development, unit and integration testing, configuration management, and document preparation. Software development in C++/Unix environment. Must have the following: Three or more years of software engineering, image processing systems is highly desirable. Experiences with OOD, C++, and Unix are required. Knowledge of CORBA, current national remote sensor systems, image processing techniques, ClearCase experience, and Rational tools and process methodology are highly desirable. Candidate must be fluent in Mandarin. A BS in Computer Science, Engineering, Mathematics, or applied sciences with a software emphasis is required due to the highly math and scientific intensive software development environment. Information technology programs such as Computer Information Systems, High Tech Management, Information Decision Sciences, etc. focus more on business applications and are not a good match for this position. U.S. citizenship is required. No security clearance. Please forward a resume (preferably in WordDoc) to: <mailto:gary@tanistechrecruiters.com>. Tanis Tech Recruiters, 2440 North Shannon, Tucson, Arizona 85745.

December 7, 2000 -- Multiple Openings. On behalf of a client company in San Diego, California, MRI-RTP is searching for candidates to fill four openings. Laser Applications Engineer. Provide applications engineering support and follow up to customers. Help define customer specification for manufacturing and engineering. Design or redesign product configuration based on customer needs. Writes technical notes for customers, manufacturing and engineering. Provide suggestions for product improvement and proposes new products for development. Reports to Director of Engineering. BS degree or equivalent and a minimum of 3 years of experience with laser systems. Large Optics Coating Facility Manager. Responsible for the business development and bottom line profits for the Large Optics coating facility. This facility is currently coating the laser optics for the Air Borne Laser (ABL) and Space Borne Laser (SBL) programs. The candidate will be the direct interface between our customers and the coating engineers & technicians. He/She will also schedule the manpower and facilities to meet customer delivery requirements. The candidate will design and develop coatings for high power laser applications in direct response to our customers' requirements. Experience in the design and analysis of infrared, and laser systems coatings, along with thin film optical metrology is necessary. Reports to Director of Engineering. BS degree or equivalent and a minimum of 10 years of experience with thin film design software (FilmStar preferred) and Program Management/Scheduling software. Optical Engineer. Design lenses and optical systems in response to customer inquiries. Develop lens drawings for manufacturing and engineering. Responsible for the development and test of prototype systems as well as null lenses and computer generated holograms. Experience in the design and analysis of infrared, and laser systems along with optical metrology is highly

desirable. Reports to Director of Engineering. BS degree or equivalent and a minimum of 3 years of experience with optical design software (Zemax preferred) and CAD systems. Thin Film Engineer. Design and develop optical coatings in response to customer inquiries. Deposit and test prototype thin film coating processes for manufacturing. Process experience with high vacuum deposition systems necessary. Experience in the design and analysis of infrared, and laser coatings along with thin film metrology is highly desirable. Reports to Director of Engineering. BS degree or equivalent and a minimum of 3 years of experience with optical coatings software (FilmStar preferable) and continuous process improvement programs. To apply, please contact Neil Lasky by telephone at 919-572-2292 or by email at <mailto:nlasky@mri.rtp.com>.

December 7, 2000 -- Faculty Position in Experimental Condensed Matter Physics.

The Department of Physics at Case Western Reserve University has an opening for a faculty appointment to begin in the 2000-2001 academic year. Significant startup and laboratory resources will be made available to the successful candidate. This appointment will be made at a level commensurate with experience. Candidates are sought in the areas of optical/biological physics, mesoscopic or nanoscopic physics, and soft condensed matter physics. These areas complement and strengthen current experimental and theoretical programs in optics/optical materials, soft condensed matter physics, semiconductor physics, surface physics, quantum wires and dots, quantum transport, quantum computing, low-dimensional physics, electronic structure, and medical imaging. Interested individuals should send their applications, including a CV and a list of references, to: CME Search C/O Lawrence Krauss, Chair; Case Western Reserve University; Department of Physics; 10900 Euclid Avenue; Cleveland, Ohio 44106-7079.

APPENDIX E

ADVANTAGE CAROLINA

PRESS RELEASES



University of North Carolina at
Charlotte

NEWS

Office of Public Relations

September 14, 2000

Initiative to Expand Region's Economy and Enhance Research Partnerships at UNC Charlotte Unveiled

CHARLOTTE— Leaders of the Advantage Carolina initiative introduced plans today to strengthen the region's technology and research infrastructure by taking steps to accelerate UNC Charlotte's development as a research university and fortify its role as the region's high-technology engine.

"If North Carolina is to prosper in the years to come, Charlotte must develop a foundation that fosters high-tech business and industry development," said Russell M. Robinson II, chair of the Advantage Carolina UNC Charlotte/Research University steering committee. "While the Charlotte region has enjoyed remarkable economic growth in the last decade, it trails many comparable cities in terms of high-tech industry development. It is critical that we reverse this trend and build upon the strengths of our region, starting with UNC Charlotte, who has already proven successful in the technology research and development arena."

To launch this initiative, UNC Charlotte is proposing the development of a new research and technology campus — the Charlotte Institute for Technology Innovation (CITI). On 100 acres of the UNC Charlotte campus, adjacent to Highway 29, the University will develop multiple research facilities that will achieve a number of objectives:

- Further advance the scale and depth of research conducted at UNC Charlotte;
- Build on current research strengths to fuel the development of high-technology companies to enhance the competitiveness of the regional economy;
- Expand the intellectual capital the University already brings to the region; and
- Raise the national and international visibility and reputation of the University.

"As a joint partnership between corporate Charlotte and the University, the Charlotte Institute will help create intellectual capital through technology research and development," said UNC Charlotte Chancellor James Woodward. "Supported by star faculty and students, the Charlotte Institute will draw technology industries to the region. These companies will, in turn, bring economic benefits to Charlotte and the state."

Woodward said CITI will grow from a plan that emphasizes strategic focus, the university's research strengths and competitive advantages, and relevance to the region's economy. The initial areas of concentration will include:

- Precision Metrology and Intelligent Manufacturing;
- Opto-electronics and Optical Communication; and
- Software and Information Technology.

UNC Charlotte's Center for Precision Metrology and Intelligent Manufacturing, located in the C.C. Cameron Applied Research Center, specializes in the measurement of physical dimensions, achieving resolution and accuracy at one billionth of a meter — subatomic increments. The center is nationally recognized, attracting research funding from the National Science Foundation and corporations like 3M, Boeing, Caterpillar and Lockheed-Martin. It consists of more than 20 faculty members from multiple university departments, including mechanical engineering, electrical and

computer engineering, computer science, physics, chemistry and business administration. In addition to metrology, the group also conducts precision research in the areas of high-speed machining, manufacturing, optics and standards.

Opto-electronics involves using optics for computing and networking — transmitting data at the speed of light. Opto-electronics research at UNC Charlotte is multidisciplinary and well established, with faculty members from seven departments and \$4.5 million in funding. The Charlotte region has become a center for fiber optics manufacturing, with companies like Corning, located in Cabarrus County and Hickory, and Alcatel Telecommunications in Claremont. At the same time, Charlotte is home to several cutting-edge opto-electronics companies. Among these are Litton Airtron Synoptics, Unifi Technology and Digital Optics Corporation, a company born out of UNC Charlotte research.

Adding to the University's strengths in precision metrology and opto-electronics is UNC Charlotte's newly established College of Information Technology. UNC Charlotte is the only institution in the Carolinas with a college solely devoted to the study and advancement of information technology.

In early 1998, the Charlotte Chamber commissioned the Advantage Carolina strategic plan to help ensure that Charlotte's economy continues to grow while the community remains uniquely livable. The acceleration of UNC Charlotte to a top-tier research university to support the economy was named as one of the 16 flagship initiatives for the program.

Because of the critical importance to the future economy and global competitiveness of the region and North Carolina, Advantage Carolina looked to the international management and consulting firm McKinsey & Company Inc., for expert analysis. Under the direction of Peter Sidebottom, a managing partner in McKinsey and Co.'s Charlotte office, the firm took a close look at the region's technology and research infrastructure and areas of potential growth.

The firm found that while the Charlotte region has enjoyed remarkable economic growth in the last decade, it now faces far more imposing competitors in the global economy. Charlotte trails competitors such as Boston, Houston, Los Angeles, New York, Phoenix, San Francisco and Seattle in several economic measures, including research concentration, technology business development and number of patents issued per number of workers in region.

UNC Charlotte is the only institution in the region offering master's and doctoral degrees in the technology fields of mechanical engineering, electrical engineering, information technology, mathematics and biology. In the early 1990s, UNC Charlotte built the C.C. Cameron Applied Research Center. This marked a first step by the University to develop high-technology research programs. Today, the nationally recognized facility is filled to capacity and conducts more than \$5 million annually in externally funded research. Additionally, four high-technology companies have grown from Cameron Center research programs.

"Given UNC Charlotte's experience and expertise, reaching the level of a top-tier research university would be a significant cue to the world," Sidebottom said. "The technology research area is a relatively new, untapped frontier among major universities, including other institutions in the Carolinas. This would set UNC Charlotte apart and gain the region national attention for achievements in research."

Advantage Carolina's plans call for UNC Charlotte to become a major research university in 8 to 10 years. Regional and university leaders hope development of CITI will begin in early 2001. Ultimate approval must come from the UNC system Board of Governors. Funding for the initiative will come

from several sources. UNC Charlotte's growing enrollment and recent reclassification to a doctoral/research university will bring an additional \$9 million a year in state funds. Officials also hope the \$3.1 billion bond referendum for the state's universities and community colleges, appearing on the Nov. 7 ballot, wins voter approval. UNC Charlotte stands to receive \$190 million, enough to build eight new classroom and laboratory buildings. The university also will look for community support.

"We envision the Charlotte Institute as a partnership between the region's leaders, corporations and UNC Charlotte," Woodward said. "The Charlotte Institute provides a clear opportunity to address a compelling need of the region and state. Leveraging Charlotte's existing strengths and better positioning UNC Charlotte as a major research university are crucial if Charlotte is to develop and attract the high-technology and research interests it desperately needs.

"To ensure the success of this essential plan, we will need the abiding support of our corporations and community. Investment in the region's and state's technology infrastructure must become a priority," Woodward added.

-END-

UNC Charlotte contact: Jeff Lowrance, 704-687-4385, jclowran@email.uncc.edu

McKinsey & Company Inc. contact: Betty Hillyard for Peter Sidebottom, 704-954-5064

Advantage Carolina contact: Janice Mauney for Russell Robinson, 704-350-7111



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The University of North Carolina at Charlotte

University of North Carolina at
Charlotte**NEWS**

Office of Public Relations

December 4, 2000

University Gears Up To Launch Construction Projects

CHARLOTTE — Following passage of the Higher Education Improvement Bonds Nov. 7, UNC Charlotte is launching a building program that will change the look of its campus dramatically and enable the university to grow from 17,000 students to approximately 25,000.

The university is preparing to construct 15 new buildings in the next six to eight years. Ground will be broken for at least four new structures during the upcoming year.

North Carolina voters spoke in unison last month when 73 percent statewide voted in favor of the Higher Education Improvement Bonds. The measure passed in all 100 counties, gaining no less than 60 percent of the vote in each county.

The \$3.1 billion bond package included \$190 million for construction projects at UNC Charlotte. The university will use the bond money to build seven new classroom and laboratory buildings and modernize two existing academic buildings. At the same time, UNC Charlotte will use funds from other sources to build new residence halls, student life buildings and parking decks.

Projects scheduled to begin in 2001 are a \$21.4 million Humanities and performing arts building, a \$33.2 million science and technology building, a \$4.5 million administrative building to house UNC Charlotte's admissions offices, and a new \$8.25 million parking deck for 800 vehicles.

Work could begin as early as next February on the administrative building and in April on the Humanities building. Early May is the projected start date for the science and technology building. The university will break ground for the new parking deck in February or March.

The other buildings to be constructed from bonds money and their projected start dates are:

General Classroom Building
\$26.1 million
Spring 2002

Graduate Engineering Complex
\$14.7 million
Fall 2002

Research Laboratory Building
\$8.4 million
Summer 2002

College of Nursing and Health Professions
Building
\$34 million
Spring 2004

College of Education Building
\$25 million
Fall 2002

The university will be using funds generated from research programs, residence hall rental fees, parking permit fees, bookstore and conference facilities revenues and student fees to build a number of other buildings in the next six to eight years. These include a \$14.5 million residence hall, a \$26 million research facility, a \$24 million student union and bookstore, a \$4.8 million expansion of the Brocker Student Health Center, an \$8.7 million parking deck, and new physical plant facilities.

In addition to these, the university is raising funds through private gifts to build a 20,000-square-foot alumni center and recently broke ground on a 30,000 square-foot addition to the Barnhardt Student Activity Center, also being funded through private donations.

Construction also will begin in 2001 on a new Chancellor's Residence on campus. The new home will be paid for from proceeds of the sale of the current Chancellor's Residence in the Morocroft neighborhood.

This construction activity will represent the largest and most aggressive building program in UNC Charlotte's history. Total academic space, including classrooms and laboratories, will nearly double from 1.2 million square feet to 2.2 million square feet.

-END-

Media Contact: Jeff Lowrance, 704-687-4385, jclowran@email.uncc.edu



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University of North Carolina at
Charlotte

NEWS

Office of Public Relations

February 16, 2001

Charlotte Institute Board Introduced, Priory to Chair

CHARLOTTE— Taking another major step toward creating a new research campus to spur high technology business development, corporate and community leaders today introduced the newly formed board of directors of the Charlotte Institute for Technology Innovation.

The board, which includes six corporate presidents/CEOs, a former governor, and a former mayor, will be chaired by Richard Priory, Duke Energy chairman, president and CEO.

Last September, UNC Charlotte and the Charlotte Chamber, through its “Advantage Carolina” initiative, announced plans to establish the Charlotte Institute for Technology Innovation. The Charlotte Institute will be developed on 100 acres of the UNC Charlotte campus, adjacent to U.S. 29, and will contain multiple research facilities. The research complex promises to achieve a number of objectives critical to UNC Charlotte’s and the region’s future, said university and chamber leaders. These include:

- Further advance the scale and depth of research conducted at UNC Charlotte
- Build on current research strengths to fuel the development of high technology companies to enhance the competitiveness of the regional and state economy;
- Expand the intellectual capital the university already brings to the region;
- Raise the national and international visibility and reputation of the university.

“The Charlotte Institute for Technology Innovation is without a doubt one of the more important endeavors in the Charlotte region and the state today,” said Priory during a morning news conference. “It’s a bold step and a smart choice in achieving the destiny to which we aspire for this region and state.

“The global economy is driven by intellectual capital and intangible assets. The ability to produce intellectual capital will determine which regions grow and which ones decline. The Charlotte Institute will produce and attract intellectual capital,” Priory added.

Joining Priory on the Charlotte Institute board are:

- Crandall C. Bowles, Chairman and CEO, Springs Industries Inc.
- David L. Burner, CEO, Chairman and President, BF Goodrich
- Norman R. Cohen, President and CEO, UNITEC Inc.
- Kevin M. Drehmer, President, Digital Optics Corporation
- Harvey B. Gantt, Partner, Gantt Huberman Architects

- James G. Martin, Corporate Vice President, Carolinas HealthCare System
- James H. Hance Jr., Vice Chairman and CFO, Bank of America
- Anna Spangler Nelson, Partner, The Wakefield Group
- Russell M. Robinson II, Senior Partner, Robinson, Bradshaw & Hinson
- Peter J. Sidebottom, Partner, McKinsey & Company
- G. Kennedy Thompson, President and CEO, First Union Corporation

The Charlotte Chamber commissioned the “Advantage Carolina” initiative in 1998 to help ensure that the region’s economy continues to grow while the community remains uniquely livable. The acceleration of UNC Charlotte to a top-tier research university to support the economy was named as one of the 16 flagship initiatives for the program.

Because of the critical importance to the future economy and global competitiveness of the region and North Carolina, the international management consulting firm McKinsey & Company Inc., conducted a pro bono analysis of the region’s industries and identified potential areas of growth.

The firm found that while the Charlotte region has enjoyed remarkable economic growth in the last decade, it now faces far more imposing competitors in the global economy. The Charlotte region trails competitors such as Boston, Houston, Los Angeles, New York, Phoenix, San Francisco and Seattle in several economic measures, including research concentration, technology business development and number of patents issued per number of workers in region.

Further, McKinsey & Co. identified UNC Charlotte as the most powerful and logical technology engine in the region. UNC Charlotte is the only institution in the region offering master’s and doctoral degrees in the technology fields of mechanical engineering, electrical engineering, information technology, mathematics and biology. In the early 1990s, UNC Charlotte built the C.C. Cameron Applied Research Center. Today, the nationally recognized facility is filled to capacity and conducts more than \$5 million annually in externally funded research. Additionally, four high-technology companies got their start from Cameron Center research programs.

UNC Charlotte Chancellor James Woodward has said that the Charlotte Institute will grow from a plan that emphasizes strategic focus, the university’s research strengths and competitive advantages, and relevance to the region’s economy.

The initial areas of concentration will include:

- Metrology and Intelligent Manufacturing;
- Opto-electronics and Optical Communication; and
- Information Technology, relating to data privacy and security in e-commerce.

At the news conference, Woodward reported on the progress made relating to the Charlotte Institute since last fall. In November, North Carolinians overwhelmingly voted in favor of the N.C. Higher Education Improvement Bonds. The \$3.1 billion bond package includes \$190 million for UNC Charlotte to construct seven new classroom and laboratory buildings. Two of these buildings will be located in the Charlotte Institute complex.

The university has established a tax-exempt corporation for the operation of the Charlotte Institute

and has included the complex in its newly revised master plan for campus development. UNC Charlotte also has sought and received approval from the UNC Board of Governors to plan a Center for Optoelectronics and Optical Communication. Funding for the center is included in the Board of Governors' biennial budget request, submitted to the General Assembly.

The commitment of each member to serve on the Charlotte Institute board indicates the importance of the enterprise, Woodward added. "This distinguished board represents a new model of engagement in the support of higher education, research and economic development," he said. "The members' service and support and that of the institutions they represent underscore the opportunity presented to UNC Charlotte – to lead in enhancing the research and technology infrastructure of the region.

"UNC Charlotte eagerly accepts this important challenge and welcomes the guidance of this truly stellar board of directors," Woodward said.

The Charlotte Institute for Technology Innovation board of directors will meet for the first time next month.

-END-

Media Contacts:

UNC Charlotte -- [Office of Public Information, 704-687-4286, pubinfo@email.uncc.edu](mailto:pubinfo@email.uncc.edu)

Duke Energy – Scott Carlberg, 704-373-7930, sccarlbe@duke-energy.com



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APPENDIX F

EXISTING APPROVED ELECTIVE COURSES BY RESEARCH CONCENTRATION

The chart below shows approved existing electives. Concentration areas for which each course is approved are indicated by •. Complete descriptions of these courses are available in the UNC Charlotte Graduate Catalog. Concentration designations are as follows: Optoelectronics – Opto; Optical Communications – Comm; Optical Metrology – Mtgy; Optical Materials – Mats; Optical Imaging – Imag

Concentration Area	Opto	Comm	Mtgy	Mats	Imag
CHEM 6082 Surfaces & Interfaces of Materials				•	
CHEM 6147 Photochemistry				•	
CHEM 6155 Polymer Synthesis				•	
ECGR 5124 Digital Signal Processing					•
ECGR 5138 Electronic Thin Film Materials and Devices	•			•	
ECGR 5140 Introduction to VSLI Processing	•				
ECGR 5197 Fundamentals of Optical Engineering			•		
ECGR 5231 Materials for Electro-Optical Engineering				•	
ECGR 6111 Systems Theory					•
ECGR 6118 Applied Digital Image Processing			•		•
ECGR 6121 Advanced Theory of Communications I		•			
ECGR 6122 Advanced Theory of Communications II		•			
ECGR 6125 Optoelectronics Information Processing	•	•			
ECGR 6132 Advanced Semiconductor Device Engineering I	•				
ECGR 6133 Advanced Semiconductor Device Engineering II	•				
ITCS 6132 Performance Analysis of Communication Networks		•			
ITCS 6134 Digital Image Processing			•		•
ITCS 6152 Computer Vision			•		•
ITCS 6153 Neural Networks					•
ITCS 6166 Computer Communications & Networks		•			
ITCS 6168 Wireless Communication Networks		•			
ITCS 6186 Micro System Design and Simulation			•		•
ITCS 6220 Pattern Recognition			•		•
ITCS 6222 Bio Signal Processing					•
ITCS 6224 Bio Image Processing					•
MATH 5165 Numerical Linear Algebra					•
MATH 5176 Numerical Methods for Partial Differential Equations					•
MATH 7143 Real Analysis I					•
MATH 7144 Real Analysis II					•
MATH 7147 Applied Functional Analysis					•

MATH 7175 Inverse Problems					•
MEGR 6181 Engineering Metrology			•		
MEGR 7182 Machine Tool Metrology			•		
MEGR 7283 Advanced Coordinate Metrology			•		
MEGR 6166 Mechanical Behavior of Materials I				•	
MEGR 7167 Mechanical Behavior of Materials II				•	
MEGR 7284 Advanced Surface Metrology			•		
PHYS 6131 Classical Electromagnetism I			•		
PHYS 6132 Classical Electromagnetism II			•		
PHYS 6141 Quantum Theory I	•			•	
PHYS 6142 Quantum theory II	•			•	
PHYS 6271 Solid State Physics	•			•	
Concentration Area	Opto	Comm	Mtgy	Mats	Imag

APPENDIX G

ATKINS LIBRARY CONSULTATION REPORT

**J. MURREY ATKINS LIBRARY
LIBRARY CONSULTATION FOR
COURSE AND/OR CURRICULUM PROPOSAL**

Date: January 16, 2002

To: Dr. Terrill Mayes, Chair
Physics Department

From: Barbara Tierney, Library Liaison to Physics Department

Re: Optics MS Program (New Program)

The adequacy of library holdings to support the above proposal when it is implemented is evaluated by the Reference Librarian as follows:

1. Holdings are superior:
2. Holdings are adequate: X Please see below comments
3. Holdings are adequate only if department purchases additional materials:
4. Holdings are inadequate: _____

Comments:

I believe that the UNC Charlotte Atkins Library currently has adequate relevant library resources (indexes and databases, journals and serials, and monographic materials) to support a new Optics MS Program, although it is recommended that the Department continue to augment and update its monographic materials and journal and serial titles, as appropriate.

Specifically I find that:

The UNC Charlotte Atkins Library currently has adequate print and electronic indexes and databases to support a new Optics MS Program. These index and database resources include:

Applied Science and Technology Index
Cambridge Scientific Abstracts
Chemical Abstracts
Compendex
MathSci Net
Optics Index
Science Direct
Springer-Verlag Link
Web of Science
Academic Search Elite (Ebscohost, NCLIVE)
ASAP (Infotrac, NCLive)

In addition, the UNC Atkins Library currently provides adequate relevant journal and serial titles, either from institutional subscriptions or from publisher or aggregator databases (such as Science Direct, Springer-Verlag Link, Ebscohost, or Infotrac) to support a new MS in Optics Program. The Atkins Library currently subscribes to many publications originating from the OSA (Optical Society of America), the SPIE (Society of Photo-Optical Instrumentation Engineers), the IEEE (Institute of Electrical & Electronics Engineers), the IOP (Institute of Physics), and others.

To give reviewers an idea of how the UNC Charlotte Atkins Library journal and serial holdings compare to "Journal Citation Report" listings of leading journals in the areas of Optics, Imaging, and Spectroscopy-- as well as to the journal and serial holdings of the University of Arizona Library (an institution that currently supports an Optics Ph.D. program that the UNC Charlotte Physics Department identifies as "one of the premier graduate Optics programs in the U.S.")--- I prepared the following three tables (for Optics, Imaging and Spectroscopy journals and serials) to illustrate comparative holdings.

Column One of each table shows "Journal Citation Reports" listing the most frequently cited scholarly and technical journals and serials in the fields of Optics, Imaging, and Spectroscopy. ("Journal Citation Reports" is a comprehensive resource for journal evaluation, using citation data drawn from over 8,400 scholarly and technical journals worldwide. Coverage is both multidisciplinary and international, and incorporates journals from over 3,000 publishers in 60 nations. The JCR is the only source of citation data on journals, and includes virtually all specialties in the areas of science and technology. The Science Edition of "JCR" contains data from roughly 5,000 journals in the areas of science and technology.)

Column Two of each table shows journal and serial holdings of the University of Arizona Library in the subject areas of Optics, Imaging, and Spectroscopy. (The University of Arizona has been identified by the UNC Charlotte Physics Department as having "one of the premier graduate level Optics programs in the U.S.")

Column Three of each table shows current UNC Charlotte Atkins Library journal and serial holdings in Optics, Imaging, and Spectroscopy

LEADING OPTICS JOURNALS (JOURNAL CIT. REPTS.)	UNIV.ARIZ.	UNCC
ADVANCED MATERIALS FOR OPTICS AND ELECTRONICS	YES	YES
ADVANCES IN ATOMIC, MOLECULAR, AND OPTICAL PHYSICS	YES	YES
APPLIED OPTICS	YES	YES
APPLIED PHYSICS. B, LASERS AND OPTICS	YES	YES
DISPLAYS	NO	YES
FIBER AND INTEGRATED OPTICS	YES	YES
IEEE P-OPTOELECTRON	NO	NO
IEEE JOURNAL OF SELECTED TOPICS IN QUANTUM ELECTRONICS	YES	YES
IEEE PHOTONICS TECHNOLOGY LETTERS	YES	YES
IMAGE AND VISION COMPUTING	NO	NO
INFRARED PHYSICS AND TECHNOLOGY	YES	YES
INTERNATIONAL JOURNAL OF IMAGING SYSTEMS AND TECHNOLOGY	NO	NO
INTERNATIONAL JOURNAL OF INFRARED AND MILLIMETER WAVES	YES	NO
INTERNATIONAL JOURNAL OF MICROGRAPHICS AND OPTICAL TECHNOLOGY	NO	NO
INTERNATIONAL JOURNAL OF OPTOELECTRONICS	YES	YES
JOURNAL OF ELECTRONIC IMAGING	YES	YES
JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY	YES	YES
JOURNAL OF INFRARED AND MILLIMETER WAVES	NO	NO
JOURNAL OF LASER APPLICATIONS	YES	NO
JOURNAL OF LIGHTWAVE TECHNOLOGY	YES	YES
JOURNAL OF LUMINESCENCE	YES	YES
JOURNAL OF MODERN OPTICS	YES	YES
JOURNAL OF NONLINEAR OPTICAL PHYSICS AND MATERIALS	NO	NO
JOURNAL OF OPTICS A-PURE AND APPLIED OPTICS	YES	NO

OPTICS JOURNALS CONT'D	UNIV.ARIZ.	UNCC
JOURNAL OF OPTICS B-QUANTUM AND SEMICLASSICAL OPTICS	YES	NO
JOURNAL OF THE OPTICAL SOCIETY OF AMERICA A, OPTICS AND IMAGE SCIENCE	YES	YES
JOURNAL OF THE OPTICAL SOCIETY OF AMERICA B, OPTICAL PHYSICS	YES	YES
JOURNAL OF OPTICAL TECHNOLOGY	YES	YES
JOURNAL OF OPTOELECTRONICS AND ADVANCED MATERIALS	NO	NO
JOURNAL OF PHYSICS B, ATOMIC, MOLECULAR AND OPTICAL PHYSICS	YES	YES
JOURNAL OF RUSSIAN LASER RESEARCH	NO	NO
JOURNAL OF SYNCHROTON RADIATION	NO	NO
LASERS IN ENGINEERING	NO	NO
LASER FOCUS WORLD	YES	YES
LASER PHYSICS	NO	NO
MICROELECTRONIC ENGINEERING	YES	YES
MICROWAVE AND OPTICAL TECHNOLOGY LETTERS	YES	NO
OPTICA APPLICATA	NO	NO
OPTICS COMMUNICATIONS	YES	YES
OPTICAL ENGINEERING	YES	YES
OPTICS EXPRESS	NO	YES
OPTICAL FIBER TECHNOLOGY	YES	NO
OPTICS AND LASERS IN ENGINEERING	YES	NO
OPTICS AND LASER TECHNOLOGY	YES	YES
OPTICS LETTERS	YES	YES
OPTICAL MATERIALS	NO	YES
OPTICAL AND QUANTUM ELECTRONICS	YES	NO
OPTICAL REVIEW	NO	NO
OPTIKA I SPEKTROSKOPIYA	NO	NO
OPTIK	NO	NO
PHOTONICS SPECTRA	YES	NO
PHOTONIC NETWORK COMMUNICATIONS	YES	NO
PHYSICAL REVIEW A	YES	YES
PROGRESS IN OPTICS	YES	YES
QUANTUM AND SEMICLASSICAL OPTICS	YES	NO

LEADING IMAGING JOURNALS (JOURNAL CIT. REPTS.)	UNIV. ARIZ.	UNCC
EARTH OBSERVATION AND REMOTE SENSING	NO	NO
IEEE TRANSACTIONS ON MEDICAL IMAGING	YES	YES
IMAGING SCIENCE JOURNAL	YES	NO
INTERNATIONAL JOURNAL OF MICROGRAPHICS AND OPTICAL TECHNOLOGY	NO	NO
INTERNATIONAL JOURNAL OF REMOTE SENSING	YES	NO
ISPRS JOURNAL OF PHOTOGRAMMETRY AND REMOTE SENSING	YES	YES
JOURNAL OF ELECTRONIC IMAGING	YES	YES
JOURNAL OF IMAGING SCIENCE AND TECHNOLOGY	YES	NO
JOURNAL OF INFORMATION RECORDING	NO	NO
PHOTOGRAMMETRIC ENGINEERING AND REMOTE SENSING	YES	YES
PHOTOGRAMMETRIC RECORD	NO	NO
REMOTE SENSING OF ENVIRONMENT	YES	YES
SMPTE JOURNAL	YES	NO
ZHURNAL NAUCHNOI I PRIKLADNOI FOTOGRAFII	NO	NO

LEADING SPECTROSCOPY JOURNALS (JOURNAL CIT. REPTS.)	UNIV. ARIZ	UNCC
ANNUAL REPORTS ON NMR SPECTROSCOPY	YES	YES
APPLIED MAGNETIC RESONANCE	NO	NO
APPLIED SPECTROSCOPY	YES	YES
APPLIED SPECTROSCOPY REVIEWS	YES	YES
ASIAN JOURNAL OF SPECTROSCOPY	NO	NO
ATOMIC SPECTROSCOPY	YES	YES
BIOSPECTROSCOPY	NO	NO
CANADIAN JOURNAL OF ANALYTICAL SCIENCES AND SPECTROSCOPY	NO	NO
CONCEPTS IN MAGNETIC RESONANCE	NO	NO
EUROPEAN JOURNAL OF MASS SPECTROMETRY	NO	NO
INTERNATIONAL JOURNAL OF MASS SPECTROMETRY	YES	YES
JOURNAL OF THE AMERICAN SOCIETY FOR MASS SPECTROMETRY	YES	YES
JOURNAL OF ANALYTICAL AND APPLIED PYROLYSIS	YES	NO
JOURNAL OF ANALYTICAL ATOMIC SPECTROMETRY	YES	NO
JOURNAL OF BIOMOLECULAR NMR	YES	NO
JOURNAL OF CHEMICAL CRYSTALLOGRAPHY	YES	NO
JOURNAL OF ELECTRON SPECTROSCOPY AND RELATED PHENOMENA	YES	YES
JOURNAL OF MASS SPECTROMETRY	YES	NO
JOURNAL OF MOLECULAR SPECTROSCOPY	YES	YES
JOURNAL OF QUANTITATIVE SPECTROSCOPY AND RADIATIVE TRANSFER	YES	YES
JOURNAL OF RAMAN SPECTROSCOPY	YES	YES
MAGNETIC RESONANCE IN CHEMISTRY	YES	NO
MASS SPECTROMETRY REVIEWS	NO	NO

LEADING SPECTROSCOPY JOURNALS CONT'D	UNIV.ARIZ	UNCC
NMR IN BIOMEDICINE	YES	NO
NUCLEAR INSTRUMENTS AND METHODS IN PHYSICS RESEARCH, SECT. A	YES	YES
NUCLEAR INSTRUMENTS AND METHODS IN PHYSICS RESEARCH, SECT. B	YES	YES
OPTICS AND SPECTROSCOPY	YES	NO
PROGRESS IN NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY	YES	YES
RAPID COMMUNICATIONS IN MASS SPECTROMETRY	YES	NO
SOLID STATE NUCLEAR MAGNETIC RESONANCE	NO	NO
SPECTROCHIMICA ACTA PART A MOLECULAR AND BIOMOLECULAR SPECTROSCOPY	YES	YES
SPECTROCHIMICA ACTA PART B ATOMIC SPECTROSCOPY	YES	YES
SPECTROSCOPY LETTERS	YES	NO
SPECTROSCOPY AN INTERNATIONAL JOURNAL	NO	NO
SPECTROSCOPY	NO	YES
VIBRATIONAL SPECTROSCOPY	YES	YES
X-RAY SPECTROMETY	YES	NO

Results: Out of a total of 55 leading Optics journals identified by "Journal Citation Reports" ---the University of Arizona Library provides a total of 37 titles (67 %) to support its optics program; the UNC Charlotte Atkins Library currently provides a total of 29 titles (53%).

Out of a total of 14 leading Imaging journals identified by "Journal Citation Reports"—the University of Arizona Library provides a total of 9 titles (64 %) to support its optics program; the UNC Charlotte Atkins Library currently provides a total of 5 titles (36 %).

Out of a total of 37 leading Spectroscopy journals identified by "Journal Citation Reports"—the University of Arizona Library provides a total of 27 titles (73 %)to support its optics program; the UNC Charlotte Atkins Library currently provides a total of 17 titles (46 %).

Although there clearly is room for the UNC Charlotte Atkins Library to increase its journal and serial resources (especially to support a Ph.D in Optics Program), I believe that current journal and serial resources are adequate to support a new Masters in Optics Program.

A comparative search of the online library catalogs of the University of Arizona and the Library at UNC Charlotte (using the following Library of Congress Subject Headings or keywords) reveals the following holdings for each institution (with regard to relevant monographic literature--books and documents-- currently in the collections). The following is not meant to be exhaustive, but rather indicative of library holdings and title availability.

Note: The first number under each institution gives the total number of titles in the subject or keyword area; the number in parentheses gives the number of titles dated 1995 or newer.

LC Subject Headings or Keywords	Univ. Of Ariz.		UNC Char.	
	No. of titles		No. of titles	
Optical Communications (subj.head.)	166	(61)	68	(11)
Optical Imaging (keywords)	28	(23)	64	(16)
Optical Instrumentation (keywords)	4237	(2074)	111	(5)
Optical Materials (subj.head.)	32	(12)	8	(0)
Optical Measurements (keywords)	162	(63)	67	(19)
Optical Metrology (keywords)	19	(16)	11	(4)
Optical Propagation (keywords)	7	(3)	25	(0)
Optical Properties Materials (subj.head.)	8	(1)	5	(1)
Optoelectronic Devices (subj.head.)	86	(36)	28	(8)
Adaptive Optics (keywords)	40	(25)	10	(7)
Electromagnetic Wave Propagation (keywd)	86	(8)	18	(3)
Fiber Optics (subj.head.)	256	(49)	94	(12)
Integrated Photonics	6	(4)	4	(2)
Laser Technology (keywords)	73	(26)	54	(20)
Medical Optics (keywords)	79	(50)	4	(0)
Optical Networks (keywords)	40	(36)	16	(10)
Photoelectron-spectroscopy (keywords)	79	(25)	16	(1)
Stochastic Processes (subj.head)	496	(107)	208	(28)
Wireless Communication Systems (subj.head.)	125	(117)	52	(46)

Although it is recommended that the Physics Department continue to purchase additional current monographic titles in the above listed subject and keyword areas and to subscribe to additional relevant journals and serials—I find that current Library holdings are adequate to support a new Masters in Optics Program.

I would be happy to assist your department in selecting additional library resources, using catalogs provided by the Optical Society of America, the Society of Photo-Optical Instrumentation Engineers, the Institute of Electrical & Electronics Engineers, the Institute of Physics, and other relevant selection tools..

Barbara D. Jurney, Librarian
 Evaluator's Signature

Jan. 16, 2002
 Date

APPENDIX H

LISTING OF CURRENT MAJOR EQUIPMENT

A. CAMERON APPLIED RESEARCH CENTER CLEAN ROOM

- 3000 square feet
- Class 1000 clean room with class 10 or better conditions under individual laminar flow work stations
- 18 megohm deionized water throughout the clean room
- Complete chemical cleaning/etching capability with fume exhaust and laminar air flow
- High temperature operations including gate and field-oxides with TCA gettering, n-type, and p-type doping using Corso-Gray, Thermco, and Lindberg furnaces
- Photolithography using a HTG contact mask aligner and Solitec and Headway spin coaters
- Pattern generation on masks or substrates with a Research Devices optical pattern generator
- Etching with a RIE (reactive ion etch) tool designed by IBM
- Plasma operations using a Technics Micro-Plasma 900 plasma deposition tool
- Thin film evaporation using a Cooke thermal evaporator, Cooke e-beam evaporator, Varian 3125 4 pocket e-beam evaporator, or a CHA Mark 50 rf induction evaporator
- Sputtering using a CVC AST-601 3 target sputtering tool
- Thin film profiles using an Alpha Step 200 or Dektak IIA
- Thin film thickness measurements using a Nanometrics Nanospec AFT 200 automatic film thickness tool
- Inspections with a Cambridge SEM (scanning electron microscope) and optical microscopes with both video and digital video cameras
- 4 MBE (molecular beam epitaxy) systems – 1 Physical Electronics and 3 VG Scientific for the fabrication of II-V and II-IV compound semiconductors
- SiC (silicon carbide) PECVD system
- Electrical measurements using a Micromanipulator probe station and Tektronix 576 curve tracer
- Substrate cutting using a Microautomation 1100 diamond dicing saw
- Wire bonding using a K&S 4125 gold wire ball bonder

The microelectronics fabrication laboratory has 3000 square feet of class 1000 clean room space. This laboratory includes all of the necessary facilities to fabricate complex devices and integrated circuits. A recirculating deionized water system supplies the lab with high purity water. Purge and process gases are plumbed throughout the lab. Complete chemical cleaning and etching capabilities are included

The fabrication laboratory includes 8 high temperature furnaces manufactured by Corso-Gray, Thermco, and Lindberg. These furnaces are used for high purity silicon oxidations, n and p type doping and diffusion, and high temperature anneals. The lab has complete photolithography capability including wafer spin coating, direct contact mask exposure with a HTG contact mask aligner, and developing facilities. Etching is accomplished with either wet chemical etching or plasma techniques using a Technics Micro-Plasma series 900 plasma system or an IBM designed reactive ion etch tool. Metal thin films can be vacuum deposited with a Cooke thermal

evaporator, Cooke e-beam evaporator, Varian 3125 4 pocket e-beam evaporator, a CHA Mark 50 rf induction evaporator, or a CVC AST-601 3 target sputtering tool. The lab includes various inspection microscopes and measurement tools including a Nanometrics Nanopsec AFT 200 automatic thickness tool, Tencor Alpha Step 200 surface profiler, and a Dektak IIA surface profiler. A K&S 4125 gold wire ball bonder is also available. A Micromanipulator probe station with Tektronix 576 curve tracer is available for electrical measurements.

Four MBE (molecular beam epitaxy) systems are used for advanced materials research. The MBE systems are pumped by either cryogenic or turbomolecular high vacuum pumps and have various deposition sources for individual or co-deposition operations. III-V and II-IV materials are currently under investigation.

Two SEM (scanning electron microscopes), a TEM (transmission electron microscope), an AFM (atomic force microscope), and a Raman spectrometer are available for advanced analysis.

B. CAMERON APPLIED RESEARCH CENTER CENTER FOR PRECISION METROLOGY

- Nanoscope II, Tencor AFM, Omicron STM
- Renishaw, HP and Optodyne stabilized lasers and metrology systems
- OGP optical CMM
- Werth Inspector Optical CMM
- Tropel CM25 Cylindrical Interferometer
- Wyko RST surface interferometer
- Zygo Axiom Interferometer Specialized High Speed Metrology System
- Zygo Mark IV Flatness Interferometer
- Zygo Maxim 3-D Surface interferometer
- Zygo White Light Scanning Interferometer
- Precitech Nanoform 250 Diamond Turning Machine (Optics Manufacture)

C. LASERS AND ELECTRONIC INSTRUMENTATION PHYSICS AND ENGINEERING

- Picosecond Ti:Sapphire Laser (mode-locked) 600 mW average power, 100 MHz rate with a 5W Ar⁺- Ion pump laser,
- Intra-cavity frequency-doubled Ar⁺-UV- laser (8 W fundamental), 12 mW UV
- High peak power Nd:YAG laser with 2nd , 3rd , and 4th Harmonic generation, and tunable dye-laser
- High-resolution spectrometer,
- Fiber-Optic Spectrometer,
- dual channel 1GHz digital Oscilloscope, and high-speed digital pulse generators,
- Optical Spectrum Analyzer (HP Model 71450B),
- Near-field scanning optical microscope
- VCSEL Characterization Station, mounting & positioning hardware and optical components, Probe-station and microprobes, CCD-cameras and accessories
- Laser drivers, Low-noise power supplies, Optical power meters, Nonlinear crystals, filters, assortment of optical and electronic components & accessories.
- Lasers: Argon , YAG, Nd. YVO4, Xenon

- Electronic and optical measuring devices: Spectrum analyzers, amplifiers, OTDR, etc.
- Vibration isolation tables, He-Ne lasers, lenses, etc.

APPENDIX I

PLANNED INFRASTRUCTURE FACILITIES

CENTER FOR OPTOELECTRONICS AND OPTICAL COMMUNICATIONS

The Center for Optoelectronics and Optical Communications
UNC Charlotte

INFRASTRUCTURE BUDGET

Total Cost: \$10.3 million

Optoelectronic and Optical Device Fabrication Facility \$1.0 million

Optoelectronic components and sub-assemblies are the building blocks of almost all appliances we use today, including watches, calculators, computers, cellular phones, palm pilots, and remote controllers. The backbone and the front end of contemporary data-com and telecom equipment, systems, and networks all utilize devices such as photodetectors, semiconductor lasers, light-emitting diodes, waveguides, optical fibers, lenses, prisms, micro-switches, *etc.* The fabrication of such devices with added functionality and intelligence requires the integration of processes that combine microelectronics, micro-optics, and quantum phenomena on the microscopic and nanoscale level. The Center, as part of its mission, will develop new materials, novel devices, integration, and packaging process technology. As part of such an effort, the fabrication facility will be a key part of the centers program, where faculty, graduate students, and post-doctoral fellows will conduct research to implement and test innovative concepts and ideas. In turn they will acquire new expertise and training to develop new optoelectronic devices and subassemblies. Equipment in the Optoelectronic and Optical Device Fabrication Facility will include a rapid sol-gel system, sub-micron precision mask alignment system, reactive ion-etching system, flip-chip bonding machine, rapid thermal annealing stations, and a packaging machine.

Optical Characterization and Measurement Facility \$2.5 million

Applications and the range of usefulness of optical materials and devices are determined by many parameters that need to be established before the materials can be used in any device development. The primary goal of the Optical Characterization and Measurement Facility is to use dedicated analytical instruments to allow researchers to test and measure major optical properties by destructive and non-destructive methods. These properties include surface morphology, crystal structure, purity, diffusion depth, and index distribution. The facility will contain dedicated experimental stations to determine optical coefficients of material and devices including optical gain, loss, quality factors, and other optical constants. The laboratory will house instruments to measure electro-optic, magneto-optic, acousto-optic, transmission, absorption, and nonlinear factors. Such characterization will be used to evaluate and establish the limitation and usefulness of materials for optical applications and is essential for the development of any new optical devices. The laboratory will be equipped with an intense UV source, X-ray source, ion beam devices, tunable lasers, scanning Auger electron spectrometer, scanning probe microscope, spectrum analyzer, and related electronic and optical test equipment.

Optical Metrology Facility

\$1.7 million

Optical metrology is a broad, enabling technology spanning large machine vision systems used for on-line inspection of manufactured parts and the determination and characterization of physical features at the micron and sub-micron level. UNC Charlotte already operates the leading university precision metrology laboratory in the U.S., and one of the leading laboratories in the entire world. This facility will significantly extend those capabilities. Optical metrology will continue to enable advances in communication, electro-optics, and information technology as well as increase the quality and capability of more familiar products like automobiles and aircraft. The Optical Metrology Facility will include the following instrumentation together with supporting database systems: scanned probe microscope system, biological AFM, scanning near-field microscope, scanning laser confocal microscope, scanning electron microscope, and x-ray interferometer test stand.

Optical Communication Infrastructure Facility

\$1.0 million

Optical communication techniques, including fiber optics and lasers, are the workhorses of the Internet and high-capacity computing. Meeting the computing and telecommunications needs of next two decades will require advances across a broad front of R&D, including optical signal generation, transmission, switching and routing, data storage and displays, and intelligent and seamless networking. Although institutions and companies have access to such rapidly growing, high-speed global telecommunication networks, the infrastructure is not yet in place to provide the individual user access that fully exploits the power of light. Additional research is necessary to be able to further develop optical communications at cost effective and high reliability levels. The Optical Communications Infrastructure Facility will include tunable communication laser systems, fiber fusion splicing system, network analyzers, optical spectrum analyzers, optical fiber measurement and characterization systems, optical spectrum analyzers, and supporting instrumentation and subsystems.

Clean Room Facility

\$2.0 million

A class 1000 clean room is the minimum required for all microelectronic memory fabrication. Class 10 is what is currently required for the manufacturing of the Pentium chip at Intel. In one cubic foot, there are ten 0.5-micrometer size particles for a Class 10 clean room. In comparison, a regular clean office has about 700,000 such particles. The proposed clean room for the Center for Optoelectronics and Optical Communication will include a class 1000 environment, with class 10 or better conditions under individual laminar flow workstations. A portion of the facility will be class 10,000 for experimental work with less stringent requirements. Total space will be approximately 10,000 sq. ft. The clean room includes necessary facilities, such as advanced lithography and processing, for the fabrication of complex optoelectronic devices and integrated circuits. High purity water is provided by a recirculating deionized system. Purge and process gases are plumbed throughout the facility.

Optical Imaging and Visualization Facility

\$1.1 million

The various design and characterization activities of the Center will generate large amounts of data, images, and video. The Imaging and Visualization Facility will serve all of the activities of the Center and will handle image processing, analysis, storage, and large-scale data visualization of multi-dimensional or multi-parameter geometric models derived from raw data. Graphics and large-scale data visualization will be handled by multi-processor workstations supplemented by a cluster of workstations and PCs. To facilitate collaborative research and applications, the visualization output will be fed to a large data display. A data and video server will also provide fast access to stored data.

Education and Training Facility

\$1.0 million

The rate of technological change in optics and in manufacturing has reached the level that practitioners can no longer rely on their previous education to remain competitive and productive. Through the development of tutorials, short courses, hands-on seminars, and computer-aided instruction, the Center for Optoelectronics and Optical Communications will provide numerous continuing educational opportunities for workers in optics and optoelectronics fields. The Center's training facility will prepare students for work in the Center's specialized facilities and will supplement students' classroom instruction. It will also provide research opportunities for undergraduates and provide students with opportunities for cooperative research and product development with industry while pursuing graduate degrees. This facility will include laboratories and experimental stations to allow individual and group participation and will contain test, measurement, and development facilities flexible enough to provide a wide range of training in optoelectronics and optical communication.

**The University of North Carolina at Charlotte
Center for Optoelectronics and Optical Communication
Infrastructure Budget**

[Budget Total = \$10.3M]

Optoelectronic and Optical Device Fabrication Facility Total \$ 0.98 M

Optical Waveguide Design Software	\$50K
Polymer Ink-jet OEIC Fab Machine	\$180K
Electronic and Computing Equipment	\$150K
Pulsed Excimer (UV) Laser System	\$100K
Optical Fiber Fabrication Unit	\$500K

Optical Characterization and Measurement Facility Total \$2.17 M

Phase Contrast Microscope with High Resolution Camera	\$50K
Prism Coupler for Integrated Optical Systems	\$60K
Visible Spectrometer & Detector	\$75K
IR Spectrometer & Detector	\$85K
Raman EDFA	\$125K
Tunable Ti:Sapphire Laser System	\$200K
Biological AFM	\$160K
Critical Dimension Microscope (AFM)	\$200K
Flatness Interferometer	\$450K
General Purpose Microscopes (2)	\$40K
Scanned Probe Microscope System	\$215K
Scanning Fabry Perot Interferometer	\$15K
Scanning Laser Confocal Microscope	\$186K
Scanning Near field Microscope	\$184K
OPO-Nd-YAG System UV-IR	\$125K

Optical Metrology Facility Total \$1.45 M

Data Base Storage	\$160K
Ellipsometer	\$135K
Lapping/Polishing Equipment	\$30K
Metallurgical Microscope	\$50K
Miscellaneous Optics	\$20K
Multi-sensor CMM	\$250K
Network Hardware	\$43K
Optical Benches (4)	\$50K
Refractometer/Excel	\$25K
SEM	\$172K
Software	\$85K
Wavelength Trackers	\$7K
Workstations	\$210K
X-Ray Interferometer Test Stand	\$214K

Optical Communication Infrastructure Facility Total \$1.14 M

Network Analyzer (Consisting of DCA Wide-Bandwidth Oscilloscope and 11 Plug-in Modules)	\$175K
Tunable Communication Laser System (Consisting of Sources, Converters, optical Isolators, Filters, etc.)	\$125K
High Temperature Micro-optic Fabrication Machine	\$50K
Multifiber Fusion Splicing System	\$50K
Transceiver Module OC48	\$20K
Transceiver Module OC192	\$30K
C & L Band Erbium Doped Fiber Amplifier	\$50K
Multichannel Optical Spectrum Analyzer	\$350K
High Resolution RF Spectrum Analyzer	\$100K
Lasers & Detectors	\$40K
Electronic and Computing Equipment	\$150K

Clean Room Facility Total \$ 2.93 M

Photolithography System (< 1 μ)	\$950K
High Temperature Oxidation/Diffusion System	\$225K
Research Size Sputtering Tool	\$150K
Research Size Dual Gun e-beam System	\$187K
CVD Deposition Tools	\$230K
RIE Etch Tool	\$188K
Epitaxial Reactor	\$250K
Rapid Prototyping-Optical Integrated Circuit System	\$300K
Flip-chip Bonding and Packaging Machine	\$450K

Optical Imaging and Visualization Facility Total \$1.10 M

4-Processor SGI Onyx Infinite Reality Version 3 Graphics Workstation, PC cluster	\$350K
FakeSpace Data Wall	\$150K
Video and Data Server (Tape, DVD, RAID systems)	\$150K
Scanners, digitizers, video capturing equipment	\$200K
Image processing, analysis, and modeling software	\$150K
	\$100K

Education and Training Facility Total \$0.53 M

Optical Metrology Training Laboratory Equipment	\$250K
Optoelectronics Training Laboratory Equipment	\$280K

APPENDIX J

BUDGET SCHEDULE FOR PROPOSED PROGRAM

**Projected Funding for New Degree Program
M.S. in Optics
Regular Term 2002-2003
(Based on 2001-2002 Change in Student Credit Hours)**

Program Category	Change in Student Credit Hours			Instructional - Position Funding Factors			Instructional Positions Required		
	Undergrad	Masters	Doctoral	Undergrad	Masters	Doctoral	Undergrad	Masters	Doctoral
Category I				643.72	171.44	138.41	0.000	0.000	0.000
Category II				487.37	249.94	146.74	0.000	0.000	0.000
Category III				364.88	160.93	122.95	0.000	0.000	0.000
Category IV				230.52	102.45	70.71	0.000	0.000	0.000

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0

Fringes for faculty salaries

FICA @ 7.65%;	\$0
Retirement @ 9.71%	\$0
Medical @ \$2,933	\$0
	<hr/>
	\$0

Total Positions Required	0.000
Instructional - Position Salary Rate (FY 02)	\$61,786
<i>101-1310</i> Instructional Salary Amount	\$0
Other Academic Costs 44.89300%	0
<i>Purpose 101</i> Total Academic Requirements	\$0
<i>Purpose 151</i> Library 11.48462%	0
<i>Purposes 152, 160, 170 180</i> General Instit Support 54.04980%	0
Neg Adj Factor 50.00000%	n/a
In-state SCHs 0	
Financial Aid (in-state) 67.99800%	0
Total Requirements	\$0

SUMMARY OF ESTIMATED ADDITIONAL COSTS FOR PROPOSED PROGRAM/TRACK

Institution UNC Charlotte Date May 6, 2002
 Program (API#, Name, Level) 40.0807, Physical Sciences (Optics), M.S.
 Degree(s) to be Granted Master of Science in Optics Program Year 2002-2003

ADDITIONAL FUNDING REQUIRED - BY SOURCE

	Reallocation of Present Institutional Resources	Enrollment Increase Funds	Federal/State or Other Non-state Funds (Identify)	New Allocations	Total
101 Regular Term Instruction					
1310 EPA Academic Salaries	99,000		150,000		249,000
Assistant Professor 1 - COAS	60,000				
3 Graduate Teaching Assistants (GTA)	39,000				
5 Graduate Research Assistants (GRA) (GRAs from federal and industry funds)			150,000		
1810 Social Security	7,574				7,574
1820 State Retirement	5,826				5,826
1830 Medical Insurance	11,732				11,732
2000 Supplies and Materials					0
2300 Educational Supplies					
2600 Office Supplies					
3000 Current Services					0
3200 Communications					
3400 Printing & Binding					
5000 Capital Outlay (Equipment)					0
5100 Office Equipment					
5200 EDP Equipment					
TOTAL Regular Term Instruction	\$124,132	\$0	\$150,000	\$0	\$274,132
151 Libraries					
TOTAL Libraries	\$0	\$0	\$0	\$0	\$0
189 General Institutional Support					
TOTAL General Inst. Support	\$0	\$0	\$0	\$0	\$0
TOTAL ADDITIONAL COSTS	\$124,132	\$0	\$150,000	\$0	\$274,132

NOTE: Accounts may be added or deleted as required.

**Projected Funding for New Degree Program
M.S. in Optics
Regular Term 2003-2004
(Based on 2002-2003 Change in Student Credit Hours)**

Program Category	Change in Student Credit Hours			Instructional - Position Funding Factors			Instructional Positions Required		
	Undergrad	Masters	Doctoral	Undergrad	Masters	Doctoral	Undergrad	Masters	Doctoral
Category I				643.72	171.44	138.41	0.000	0.000	0.000
Category II				487.37	249.94	146.74	0.000	0.000	0.000
Category III		117		364.88	160.93	122.95	0.000	0.727	0.000
Category IV				230.52	102.45	70.71	0.000	0.000	0.000

Total Positions Required	0.727
Instructional - Position Salary Rate (FY 02)	<u>\$61,786</u>
101-1310 Instructional Salary Amount	\$44,920
Other Academic Costs 44.89300%	<u>20,166</u>
Purpose 101 Total Academic Requirements	\$65,086
Purpose 151 Library 11.48462%	7,475
Purposes 152, 160, 170 180 General Instit Support 54.04980%	35,179
Neg Adj Factor 50.00000%	n/a
In-state SCHs 0	
Financial Aid (in-state) 67.99800%	<u>0</u>
Total Requirements	<u>\$107,740</u>

<i>Fringes for faculty salaries</i>	
<i>FICA @ 7.65%;</i>	\$3,436
<i>Retirement @ 9.71%</i>	\$4,362
<i>Medical @ \$2,933</i>	<u>\$2,132</u>
	<u>\$9,930</u>

SUMMARY OF ESTIMATED ADDITIONAL COSTS FOR PROPOSED PROGRAM/TRACK

Institution	UNC Charlotte	Date	May 6, 2002
Program (API#, Name, Level)	40.0807, Physical Sciences (Optics), Master of Science		
Degree(s) to be Granted	M.S. in Optics	Program Year	2003-2004

ADDITIONAL FUNDING REQUIRED - BY SOURCE

	Reallocation of Present Institutional Resources	Enrollment Increase Funds	Federal/State or Other Non-state Funds (Identify)	New Allocations	Total
101 Regular Term Instruction					
1310 EPA Academic Salaries	0	44,920	60,000		104,920
		44,920			
2 Graduate Research Assistants (GRA) (GRAs from federal and industry funds)			60,000		
1810 Social Security		3,436			3,436
1820 State Retirement		4,362			4,362
1830 Medical Insurance		2,132			2,132
2000 Supplies and Materials		3,000			3,000
2300 Educational Supplies		1,500			1,500
2600 Office Supplies		1,500			1,500
3000 Current Services		3,000			3,000
3100 Travel		1,000			
3200 Communications		1,000			
3400 Printing & Binding		1,000			
5000 Capital Outlay (Equipment)		4,236			4,236
5100 Office Equipment		2,000			
5200 EDP Equipment		2,236			
TOTAL Regular Term Instruction	\$0	\$65,086	\$60,000	\$0	\$125,086
151 Libraries					
5000 Capital Outlay (Equipment)		7,475			7,475
5600 Library Book/Journal		7,475			
TOTAL Libraries	\$0	\$7,475	\$0	\$0	\$7,475
189 General Institutional Support					
2000 Supplies and Materials		10,000			10,000
2600 Office Supplies		10,000			
3000 Current Services		10,000			10,000
3200 Communications		5,000			
3400 Printing & Binding		5,000			
5000 Capital Outlay (Equipment)		15,179			15,179
5100 Office Equipment		7,500			
5200 EDP Equipment		7,679			
TOTAL General Inst. Support	\$0	\$35,179	\$0	\$0	\$35,179
TOTAL ADDITIONAL COSTS	\$0	\$107,740	\$60,000	\$0	\$167,740

NOTE: Accounts may be added or deleted as required.

**Projected Funding for New Degree Program
M.S. in Optics
Regular Term 2004-2005
(Based on 2003-2004 Change in Student Credit Hours)**

Program Category	Change in Student Credit Hours			Instructional - Position Funding Factors			Instructional Positions Required		
	Undergrad	Masters	Doctoral	Undergrad	Masters	Doctoral	Undergrad	Masters	Doctoral
Category I				643.72	171.44	138.41	0.000	0.000	0.000
Category II				487.37	249.94	146.74	0.000	0.000	0.000
Category III		147		364.88	160.93	122.95	0.000	0.913	0.000
Category IV				230.52	102.45	70.71	0.000	0.000	0.000

Total Positions Required		0.913
Instructional - Position Salary Rate	(FY 02)	<u>\$61,786</u>
101-1310 Instructional Salary Amount		\$56,438
Other Academic Costs	44.89300%	<u>25,337</u>
Purpose 101 Total Academic Requirements		\$81,775
Purpose 151 Library	11.48462%	9,392
Purposes 152, 160, 170 180 General Instit Support	54.04980%	44,199
Neg Adj Factor	50.00000%	n/a
In-state SCHs	0	
Financial Aid (in-state)	67.99800%	<u>0</u>
Total Requirements		<u>\$135,366</u>

<i>Fringes for faculty salaries</i>	
<i>FICA @ 7.65%;</i>	\$4,317
<i>Retirement @ 9.71%</i>	\$5,480
<i>Medical @ \$2,933</i>	<u>\$2,679</u>
	<u>\$12,477</u>

SUMMARY OF ESTIMATED ADDITIONAL COSTS FOR PROPOSED PROGRAM/TRACK

<i>Institution</i>	UNC Charlotte			<i>Date</i>	May 6, 2002
<i>Program (API#, Name, Level)</i>	40.0807, Physical Sciences (Optics), Master of Science				
<i>Degree(s) to be Granted</i>	M.S. in Optics			<i>Program Year</i>	2004-2005
ADDITIONAL FUNDING REQUIRED - BY SOURCE					
	Reallocation of Present Institutional Resources	Enrollment Increase Funds	Federal/State or Other Non-state Funds (Identify)	New Allocations	Total
101 Regular Term Instruction					
1310 EPA Academic Salaries	0	56,438	90,000		146,438
		56,438			
3 Graduate Research Assistants (GRA) (GRAs from federal and industry funds)			90,000		
1810 Social Security		4,317			4,317
1820 State Retirement		5,480			5,480
1830 Medical Insurance		2,679			2,679
2000 Supplies and Materials		4,000			4,000
2300 Educational Supplies		2,000			
2600 Office Supplies		2,000			
3000 Current Services		4,000			4,000
3100 Travel		1,500			
3200 Communications		1,500			
3400 Printing & Binding		1,000			
5000 Capital Outlay (Equipment)		4,860			4,860
5100 Office Equipment		2,000			
5200 EDP Equipment		2,860			
TOTAL Regular Term Instruction	\$0	\$81,775	\$90,000	\$0	\$171,775
151 Libraries					
5000 Capital Outlay (Equipment)		9,392			9,392
5600 Library Book/Journal		9,392			
TOTAL Libraries	\$0	\$9,392	\$0	\$0	\$9,392
189 General Institutional Support					
2000 Supplies and Materials		14,000			14,000
2600 Office Supplies		14,000			
3000 Current Services		14,000			14,000
3200 Communications		7,000			
3400 Printing & Binding		7,000			
5000 Capital Outlay (Equipment)		16,199			16,199
5100 Office Equipment		8,000			
5200 EDP Equipment		8,199			
TOTAL General Inst. Support	\$0	\$44,199	\$0	\$0	\$44,199
TOTAL ADDITIONAL COSTS	\$0	\$135,366	\$90,000	\$0	\$225,366

NOTE: Accounts may be added or deleted as required.

APPENDIX K

PROGRAM CATALOG COPY

CATALOG COPY

Department of Physics and Optical Science

101 Burson Building

(704) 687-2536

www.physics.uncc.edu

Degree

M.S. in Optics

Optics Program Coordinator

(To be appointed)

Optics Program Committee

(To be appointed)

Program of Study

The M.S. program in Optics is interdisciplinary involving six science and engineering departments [Physics & Optical Science, Chemistry, Mathematics, Electrical & Computer Engineering, Mechanical Engineering & Engineering Science, and Computer Science], the Center for Optoelectronics & Optical Communications, and the Center for Precision Metrology. The program is administered through the Department of Physics & Optical Science. The purpose of the program is to educate scientists and engineers who will develop the next generation of optical technology. The program emphasizes basic and applied interdisciplinary education and research in areas of optics that include:

- Optoelectronic devices and sub-assemblies
- Devices for telecommunications, sensors, and characterization
- Optical materials (semiconductors, polymer-organic and crystalline)
- Optical metrology
- Optical imaging
- Optical communication networks

Applications of this research include:

- Optical telecom and data-com
- High efficiency, tunable narrow bandwidth laser sources and detectors
- Smart structures for distributed sensing
- Wireless technologies for communications and remote sensing
- Materials and surface characterization
- Nanostructured optical devices
- Microelectronics
- Medical diagnostics

Additional Admission Requirements

All applicants seeking admission into the Optics M.S. program must fulfill the university's general requirements for graduate admission at the M.S. level. Additional requirements for admission into the program are:

- a. A baccalaureate or masters degree in Physics, Chemistry, Mathematics, Engineering, Optics, Computer Science, or a related field with a minimum undergraduate GPA of 3.0 overall and 3.0 (A = 4.0) in the major.
- b. A minimal combined score of 1000 on the verbal and quantitative portions of the GRE, and satisfactory scores on the analytical and discipline specialty sections of the GRE.
- c. A minimum score of 220 (computer-based test) or 550 (paper-based test) on the TOEFL if the previous degree was from a country where English is not the official language.
- d. Positive letters of recommendation.
- e. Students may be required to take undergraduate courses determined by the Optics Program Committee on an individual basis. Such courses will be specified at the time of admission into the program.

Documents to Be Submitted for Admission

- a. Official transcripts from all colleges and universities attended.
- b. Official GRE scores.
- c. Official TOEFL scores (if the previous degree was from a country where English is not the official language).
- d. The UNC Charlotte application for graduate admission form.
- e. A minimum of three letters of reference.
- f. An essay detailing the applicant's motivation and career goals.

Degree Requirements

The degree of Master of Science in Optics is awarded for completion of scholarly research that advances the knowledge base in the field of that research. Evidence of this is demonstrated by a successful thesis defense. Additionally, recipients of this degree should demonstrate mastery of relevant subject matter and a potential for success, usually in a position with government or industry.

The minimum requirement for the M.S. in Optics degree is 32 credit hours beyond the baccalaureate degree that includes a minimum of 9 credit hours of thesis research, 2 credit hours of seminar (OPTI 6110), and a minimum of 21 credit hours of formal course work. The program of study must include at least 15 credit hours in approved courses having an OPTI prefix. The remaining 6 credit hours of required coursework may be selected from the listing of approved optics, engineering, and sciences electives.

Grade Requirement

A student in the Optics M.S. program must maintain a minimum GPA of 3.0 in all coursework attempted for the degree. An accumulation of two C grades will result in termination of the student's enrollment in the program. A grade of U earned in any course will result in termination of the student's enrollment in the program.

Transfer Credit Accepted

Up to 6 credit hours of approved coursework may be transferred from other accredited masters and doctoral programs. Only courses in which the student earned a grade of B or better (or its equivalent) can be transferred. No more than 6 credit hours of approved coursework taken as a post-baccalaureate student may be applied toward the degree. Credit for thesis research cannot be transferred.

Thesis Advisor and Advisory Committee

Each student in the program must have a Thesis Advisor and an Advisory Committee before being admitted to candidacy. The Thesis Advisor serves as Chair of the Advisory Committee and must be a member of the Optics Faculty at UNC Charlotte. Composition of the Advisory Committee must be approved by the Optics Program Director.

Qualifier and Admission to Candidacy

All graduates of the program must demonstrate competency in the Core Curriculum. A comprehensive examination on subject matter in each of the five courses of the Core Curriculum is required for all students entering the program. Students may demonstrate competency in the subject matter of a specific course of the Core Curriculum by earning a grade of Pass on that section of the comprehensive examination. Students failing to receive a grade of Pass on a section of the comprehensive examination must enroll in the core course for that section. Students demonstrate competency in the core curriculum by earning a grade of B or better in those core courses not passed during the comprehensive examination.

All students must prepare a Plan of Study before the end of the second semester following admission to the program. The Plan of Study must be approved by the Advisory Committee.

After successful completion of the Core Curriculum requirement and approval of the Plan of Study, the student will prepare a Research Plan for the thesis that is approved by the Advisory Committee. The Research Plan must demonstrate: (a) the student's knowledge of the relevant literature base, and (b) a research plan that, if successfully completed, will lead to an approved thesis. The student must present a written plan to the Advisory Committee. The student must also make an oral defense of the Research Plan at a presentation before the Advisory Committee.

After successfully demonstrating competency in the Core Curriculum, preparation of an approved Plan of Study, and approval of the Research Plan by the Advisory Committee, the student is admitted to candidacy. The qualifier, as described, must be completed within two years following admission to the program. A full-time student is normally expected to complete the qualifier prior to the end of the third semester following admission to the program.

Thesis

Each student will complete a minimum of 9 credit hours of thesis research. The student must present a written thesis to the Advisory Committee. The student must defend the thesis at a presentation before the Optics Faculty. Upon approval of the written thesis and oral presentation by the Advisory Committee, the student has successfully completed the thesis requirement. The thesis must be written using a format acceptable to the Graduate School.

Residency Requirement

The student must satisfy the residence requirement for the program by completing 12 credit hours of continuous enrollment in coursework/dissertation credit. Residence is considered continuous if the student is enrolled in one or more courses in successive semesters until 12 credit hours are earned.

Language Requirement

The program has no language requirement.

Time Limit for Completion of Program Requirements

All program requirements must be completed within 4 calendar years from the date the student is admitted into the program.

The Optics Faculty

Optoelectronic Devices and Sub-Assemblies

Raphael Tsu -- Electrical & Computer Engineering
Mohamad Ali-Hasan -- Electrical & Computer Engineering
Stephen Bobbio -- Electrical & Computer Engineering
Vasily Astratov -- Physics & Optical Science

Optical Communications

Yasin Raja -- Physics & Optical Science
Faramarz Farahi -- Physics & Optical Science
Patrick Moyer -- Physics & Optical Science
Teresa Dahlberg -- Computer Science

Devices and Systems for Sensors and Characterization

Terrill Mayes -- Physics & Optical Science
Jordan Poler -- Chemistry

Optical Materials

Kasra Daneshvar -- Electrical & Computer Engineering
Ken Gonsalves -- Chemistry
Wade Sisk -- Chemistry

Optical Metrology

Bob Hocken -- Mechanical Engineering & Engineering Science
Steve Patterson -- Mechanical Engineering & Engineering Science
Angela Davies -- Physics & Optical Science

Optical Imaging

Michael Fiddy -- Physic & Optical Sciences and Electrical & Computer Engineering
 Robert Tyson -- Physics & Optical Science
 Tom Lucas -- Mathematics
 Taghi Mostafavi -- Computer Science

SUGGESTED SCHEDULE

A student will normally complete the core curriculum, shown below, during the first year of residence. Courses taken after completion of the core curriculum are elective but must be approved by the student's Thesis Advisor and Advisory Committee.

Year 1

Fall

OPTI 6101	Mathematical Methods of Optical Science and Engineering
OPTI 6102	Principles of Geometrical and Physical Optics
OPTI 6103	Light Sources and Detectors
OPTI 6110	Seminar

Spring

OPTI 6104	Electromagnetic Waves
OPTI 6105	Optical Properties of Materials I
OPTI 6110	Seminar

COURSES IN OPTICS

CORE CURRICULUM

OPTI 6101. Mathematical Methods of Optical Science and Engineering. (3) Prerequisite: Admission to the Optics M.S. program. Topics include: matrix theory, series and Frobenius methods of solutions to ordinary differential equations, special functions, Fourier analysis, separation of variables techniques for partial differential equations, selected boundary value problems, and complex analysis. Topical coverage will emphasize applications specific to the field of optics. Three lecture hours per week. (Fall)

OPTI 6102. Principles of Geometrical and Physical Optics. (3) Prerequisite: Admission to the Optics M.S. program. Ray analysis of common optical elements (mirrors, lenses and systems of lenses, prisms). Reflection and refraction at plane and spherical surfaces, thin and thick lenses, lensmaker's equation, field of view, and numerical aperture. Wave properties of light, superposition of waves, diffraction, interference, polarization, and coherence. Optics of thin films. Three lecture hours per week. (Fall)

OPTI 6103. Light Sources and Detectors. (3) Prerequisite: Admission to the Optics M.S. program. The nature of light, blackbody radiation. Quantized energy levels, photons, emission and absorption of light. Introduction to condensed media. Semiconductor quantum wells.

Continuous wave and pulsed (mode-locked, Q-switched) lasers. Optical resonators and selected solid-state lasers. Common laser systems. Light detection, thermal and quantum detectors, imaging and non-imaging detectors, photomultiplier tubes, and diode detectors. Noise in light sources and detectors. Optical spectrum analysis. Three lecture hours per week. (Fall)

OPTI 6104. Electromagnetic Waves. (3) Prerequisite: OPTI 6101. Maxwell's equations, the electromagnetic wave equation, and electromagnetic wave functions. Waves in dielectric and conducting media, dispersion. Reflection, refraction, transmission, internal reflection, and evanescent waves at an interface. Intensity. Introduction to guided waves. Three lecture hours per week. (Spring)

OPTI 6105. Optical Properties of Materials I. (3) Prerequisite: Admission to the Optics M.S. program. Photophysical and photochemical processes in materials. Linear and nonlinear optical properties of materials. Optical properties of semiconductors and crystals. Optical transmission, absorption, and reflection. Fluorescence of organic and inorganic materials. Chiral molecular systems. Three lecture hours per week. (Spring)

OPTI 6110. Seminar. (1) Prerequisite: Admission to the Optics M.S. program. Discussion and analysis of topics of current interest to the field of optics. May be repeated for up to 2 hours of credit. Seminar is required of all students during their first two semesters of residence. Two semester hours of seminar are required. (Fall/Spring)

THESIS RESEARCH

OPTI 6991. Thesis Research. (1 - 3) Prerequisite: Admission to candidacy. Research for the thesis. May be repeated for a total of 12 credit hours. Graded Pass/Fail. (Fall/Spring/Summer)

OPTI 6999. Masters Residence. (1) Prerequisite: OPTI 6991. Required of all Optics M.S. students who have completed all requirements for the degree except the thesis defense and are taking no other courses. May be repeated for credit. Credit for this course does not count toward the degree. Graded Pass/Fail. (Fall/Spring/Summer)

APPROVED OPTICS ELECTIVES

OPTI 6000. Selected Topics in Optics. (3). Prerequisite: Consent of Optics Program Director. Selected topics in optics from areas such as medical optics, adaptive optics, all optical networks, etc. May be repeated for up to 6 hours of credit with consent of the Optics Program Director. (Fall/Spring/Summer)

OPTI 6201. Fourier Optics. (3) Prerequisite: OPTI 6102. Principles of scalar diffraction theory. Fourier analysis applied to optical system design, imaging systems, optical filtering, optical data processing, correlation techniques, and holography. Three lecture hours per week. (Alternate years)

OPTI 6205. Optical Properties of Materials II. (3) Prerequisites: OPTI 6102, OPTI 6104, and OPTI 6105 or ECGR 6133. Microscopic theory of absorption, dispersion, and refraction. Real and imaginary parts of the optical constant. Non-linear optical material properties. Light scattering mechanisms, including Rayleigh, Raman, and Brillouin scattering. Photoelectron spectroscopy. Ultra-short optical pulse propagation. Four-wave mixing. Three lecture hours per week. (Alternate years)

OPTI 6211. Introduction to Modern Optics. (3) Prerequisites: OPTI 6102, OPTI 6103, and OPTI 6104. Propagation of rays and beams in free space, non-linear materials, and fiber. Optical resonators. Theory of laser oscillations. Second harmonic generation and parametric oscillation. Electrooptic modulation of laser beams. Detection of optical radiation. Interaction of light and sound. Three lecture hours per week. (Alternate years)

OPTI 6212. Integrated Photonics. (3) Prerequisites: OPTI 6211 of ECGR 4125. Study of basic principles and fabrication of optical waveguides. Optoelectronic materials growth and processing. Photonic devices and circuits. Integration techniques for multifunctional sub-assemblies. Three lecture hours per week. (Alternate years)

OPTI 6221 Optical Communications I. (3) Prerequisite: Prerequisites: OPTI 6102, OPTI 6104, and OPTI 6105, or ECGR 5165. Introduction to optical communications. Optical waveguides (attenuation, dispersions, etc.). Basic communication blocks such as lasers, optical modulators, and optical transceivers. Passive and active photonic components such as tunable lasers, optical amplifiers, SOAs, λ -converters, and filters. Coherent and incoherent detection. Signal processing, photonic switching, and point-to-point connections. Three lecture hours per week. (Alternate years)

OPTI 6222. Optical Communications II. (3) Prerequisite: OPTI 6221. Elements of optical networks. Optical signal coding. Optical transport and networking (optical-layer). Optical multiplexing and de-multiplexing. Time-domain medium access (TDM and SONET), wavelength-division multiplexing (WDM and DWDM). Optical add-drop multiplexing, switching and routing topologies. Wavelength conversion. Dispersion management. Optical clock and timing recovery. Broadband ISDN concepts. Access, metro, and long-haul network topologies. Three lecture hours per week. (Alternate years)

OPTI 6241. Optical System Function and Design. (3) Prerequisite: OPTI 6102. Advanced study of telescopes, microscopes, cameras, off-axis imaging systems, stops, apertures, multiple lenses, use and selection of ray trace computer codes. Three lecture hours per week. (Alternate years)

OPTICS 6244. High Speed Photonics and Optical Instrumentation. (3) Prerequisite: OPTI 8103 and OPTI 8104. Study of instrumentation used for generation, detection, and manipulation of light in optical circuits. Topics include electrooptic modulators, selective polarizers, optical switches, amplifiers, multiplexing and mixing schemes, application of CCD and CMOS cameras and detectors. Three lecture hours per week. (Alternate years)

OPTI 6281. Modern Optics Laboratory. (3) Prerequisite: OPTI 6102. Selected experiments in areas of modern optics such as fiber optics, interferometry, spectroscopy, polarization, optical metrology, and holography. Six laboratory hours per week. (Spring)

OPTI 6691. Research Seminar. (1 - 3) Prerequisite: Consent of Optics Program Director. A seminar in which independent study may be pursued by the student, or a group of students, under the direction of a professor. (Fall/Spring/Summer)

APPROVED ELECTIVES IN THE RESEARCH CONCENTRATIONS

The chart below shows approved existing electives. Concentration areas for which each course is approved are indicated by •. Complete descriptions of these courses are available in the UNC Charlotte Graduate Catalog. Concentration designations are as follows: Optoelectronics – Opto; Optical Communications – Comm; Optical Metrology – Mtgy; Optical Materials – Mats; Optical Imaging – Imag

Concentration Area	Opto	Comm	Mtgy	Mats	Imag
CHEM 6082 Surfaces & Interfaces of Materials				•	
CHEM 6147 Photochemistry				•	
CHEM 6155 Polymer Synthesis				•	
ECGR 5124 Digital Signal Processing					•
ECGR 5138 Electronic Thin Film Materials and Devices	•			•	
ECGR 5140 Introduction to VSLI Processing	•				
ECGR 5197 Fundamentals of Optical Engineering			•		
ECGR 5231 Materials for Electro-Optical Engineering				•	
ECGR 6111 Systems Theory					•
ECGR 6118 Applied Digital Image Processing			•		•
ECGR 6121 Advanced Theory of Communications I		•			
ECGR 6122 Advanced Theory of Communications II		•			
ECGR 6125 Optoelectronics Information Processing	•	•			
ECGR 6132 Advanced Semiconductor Device Engineering I	•				
ECGR 6133 Advanced Semiconductor Device Engineering II	•				
ITCS 6132 Performance Analysis of Communication Networks		•			
ITCS 6134 Digital Image Processing			•		•
ITCS 6152 Computer Vision			•		•
ITCS 153 Neural Networks					•
ITCS 6166 Computer Communications & Networks		•			
ITCS 6168 Wireless Communication Networks		•			
ITCS 6186 Micro System Design and Simulation			•		•
ITCS 6220 Pattern Recognition			•		•
ITCS 6222 Bio Signal Processing					•
ITCS 6224 Bio Image Processing					•
MATH 5165 Numerical Linear Algebra					•
MATH 5176 Numerical Methods for Partial Differential Equations					•
MATH 7143 Real Analysis I					•
MATH 7144 Real Analysis II					•
MATH 7147 Applied Functional Analysis					•
MATH 7175 Inverse Problems					•
MEGR 6181 Engineering Metrology			•		

MEGR 7182 Machine Tool Metrology			•		
MEGR 7283 Advanced Coordinate Metrology			•		
MEGR 6166 Mechanical Behavior of Materials I				•	
MEGR 7167 Mechanical Behavior of Materials II				•	
MEGR 7284 Advanced Surface Metrology			•		
PHYS 6131 Classical Electromagnetism I			•		
PHYS 6132 Classical Electromagnetism II			•		
PHYS 6141 Quantum Theory I	•			•	
PHYS 6142 Quantum theory II	•			•	
PHYS 6271 Solid State Physics	•			•	
Concentration Area	Opto	Comm	Mtgy	Mats	Imag

APPENDIX L

CURRICULUM VITAE FOR OPTICS FACULTY

Curriculum Vitae: Vasily N. Astratov

Personal Information:

Birth March 24, 1958. Leningrad, USSR. Russian citizenship. UK Permanent Resident 2001.
Home 7903 University Ridge Drive, Apt#304, Charlotte, NC 28213.
Work Department of Physics, University of North Carolina at Charlotte, Charlotte, NC 28223.

Major Research Interests:

Optics of photonic crystals: photonic band structure and light-matter interaction effects, control of emission, light scattering and localization, polaritons and plasmons.

Novel materials: opals, patterned waveguides and semiconductor microcavities; on-chip integration of self-assembled elements, composite and functional photonic crystals.

Applications: optical nonlinearity and switching, superprism effect and lasing.

Degrees

- 1986 **Ph.D., Experimental Physics**, Solid State Optics Department, A.F. Ioffe Physical-Technical Institute, St. Peterburg, Russia.
Dissertation: *Dynamics of Electric Field Screening in $Bi_{12}SiO_{20}$ and $Bi_{12}GeO_{20}$ Crystals* (supervised by Prof. A.A. Kaplyanskiy).
- 1981 **Diploma, Experimental Physics**, corresponds to B.Sc.&M.Sc. in Physics, Department of Physics, St. Peterburg State University, Russia.

Positions Held

- 07.2002- **Assistant Professor**, Department of Physics, University of North Carolina at Charlotte.
- 01.02-07.02 **Visiting Assistant Professor**, Department of Physics, The University of North Carolina at Charlotte.
- 1997-01 **Postdoctoral Research Fellow**, Department of Physics and Astronomy, University of Sheffield, UK. Led the research group, see: <http://www.shef.ac.uk/uni/academic/N-O/phys/people/vastratov/>
- 1992-97 **Senior Lecturer** (part time), Department of Industrial Electronics, Northwestern Polytechnic Institute, St. Peterburg, Russia.
Lectured courses on optoelectronics and electronic devices.
- 1981-97 **Senior Member of Research Staff** (1997), **Member of Research Staff**, Solid State Optics Department, A.F. Ioffe Physical-Technical Institute, St. Peterburg, Russia. Created (1992) and headed the "Photonic Band Gap Group".

Honors and Awards

- 1996 **Royal Society and Russian Academy of Sciences Fellowship**, Exchange Programme.
- 1993 **Award for research excellence**, A.F. Ioffe Physical-Technical Institute.
- 1985 **FIRST award**, A.F. Ioffe Physical-Technical Institute.

Research Grants

- 2000- *EM Properties, Band Structure and Light Matter Interaction in Semiconductor Photonic Crystals*
EPSRC grant GR/M72951 (in the UK)
Major contributions to this proposal, 100% effort, Total £162,000
- 1995-97 *Photonic Band Gaps in Opals*

Russian Fund for Basic Research grant 960217928
PI, 100% effort, Total \$20,000

1992-94 *Optical Spectroscopy of Near-Surface Quantum Wells*
Russian Ministry of Science funded
PI, 100% effort, Total \$3,000

Professional Experience

a) Research visits

2001 (8 days), University of Pavia, Italy, host: L.C. Andreani.
1996 (60 days), University of Sheffield, UK, host: M.S. Skolnick.
1996/1994 (10 days), Instituto Metodologie Avanzate Inorganiche, Roma, host: A.D' Andrea.

b) Seminars

20 invited seminars and lectures (last 3 years)

c) Conference presentations

12 talks at the international conferences including 2 invited talks (last 3 years)

d) Graduate students (acted as a supervisor or co-supervisor)

Y.A. Vlasov (Ph.D. 1995), O.Z. Karimov (Ph.D. 2000), R.M. Stevenson (Ph.D.2000), M. Emam-Ismail (Ph.D. 2002), A.M. Adawi (Ph.D. 2002) and A.D. Bristow.

Additional Professional Activities

2000- Member of the International Expert Panel on Priority Programme "Photonic Crystals" in Germany (DFG Projekt Photonische Kristalle).
1995- Reviewer for a number of journals: Science, Applied Physics Letters, et al.

Publications

65 papers in internationally refereed journals and 7 patents

List of five significant recent publications

- 1. Heavy Photon Dispersions in Photonic Crystal Waveguides**
V.N. Astratov, R.M. Stevenson, I.S. Culshaw, D.M. Whittaker, M.S. Skolnick, T.F. Krauss, and R.M. De La Rue
Appl. Phys. Lett., v.77, No.2, 178-180 (2000).
- 2. Photonic Band Structure Effects in the Reflectivity of Periodically Patterned Waveguides**
V.N. Astratov, D.M. Whittaker, I.S. Culshaw, R.M. Stevenson, M.S. Skolnick, T.F. Krauss, and R.M. DeLaRue
Phys. Rev. B **60**, No.24, R16255-16258 (1999).
- 3. Continuous Wave Observation of Massive Polariton Redistribution by Stimulated Scattering in Semiconductor Microcavities**
R.M. Stevenson, V.N. Astratov, M.S. Skolnick, D.M. Whittaker, M. Emam-Ismail, A.I. Tartakovskii, P.G. Savvidis, J.J. Baumberg, and J.S. Roberts
Phys. Rev. Lett. **85**, No.17, 3680-3683 (2000).
- 4. Opal Photonic Crystals Infiltrated with Chalcogenide Glasses**
V.N. Astratov, A.M. Adawi, M.S. Skolnick, V.K. Tikhomirov, V. Lyubin, D.G. Lidzey, M. Ariu, and A.L. Reynolds
Appl. Phys. Lett., v.78, No.26, 4094-4096 (2001).
- 5. Manifestation of Intrinsic Defects in Optical Properties of Self-Organized Opal Photonic Crystal**
Y.A. Vlasov, V.N. Astratov, A.V. Baryshev, A.A. Kaplyanskii, O.Z. Karimov, and M.F. Limonov
Phys. Rev. E **61**, No.5, 5784-5793 (2000).

Stephen M. Bobbio: Brief CV

Research Interests:

Microelectronics, optoelectronics, advanced packaging, and microstructures (design, fabrication, optical and biomedical applications)

Contact Information:

Address: The University of North Carolina at Charlotte, Department of Electrical Engineering,
9201 University City Blvd, Charlotte, NC 28223-0001
Telephone: 704-547-2668, Fax: 704-547-2352, email: smbobbio@uncc.edu

Education:

The College of William and Mary, Ph.D., 1972, Atomic and Molecular Physics

Professional Experience:

- 1993 to present: The University of North Carolina at Charlotte; Professor in Electrical Engineering
Research in plasma tool development, novel photoresist applications (3D processing), and microactuators. Acts a senior faculty liaison to the university cleanroom (provide financial support and equipment)
- 1994 to present: Integrated Electronic Innovations (IEI); President
Development and sale of equipment, process, and materials for advanced packaging
- 1985 to 1993: MCNC; Member of the Technical Staff and Principal Investigator for Plasma Research
Responsible for research programs in plasma processing (etch and deposition, process and equipment), plasma – resist interaction. Also supported the clean room staff when there was a problem in any of these areas.
- 1984 to 1985: Materials Research Corporation; Manager of Plasma Etching.
Responsible for plasma equipment and process R&D, the applications lab, and customer support.
- 1979 to 1984: Allied Signal; Research Physicist, Senior Research Physicist, Research Associate
Responsible for programs in plasma etch gas compositions and equipment, surface analysis, plasma – photoresist interaction. Also helped design and fit-up a small cleanroom in the facility.
- 1974 to 1979: The University of Georgia; Assistant Professor in Chemistry
- 1972 to 1973: Brown University; Postdoctoral Research Associate

Professional Activities and Awards:

- Member of the SRC Roadmap Committee for Plasma Etching, 1988-1989
Conference Co-Chair, SPIE Plasma Etching Symposium, 1989.
Two Best-of-Conference Awards, 1993 and 1995.
Governor's New Product Award to IEI for Fluxless Soldering Equipment, 1994.
R&D 100 Award to MCNC for Fluxless Soldering Process, 1996.
Surface Mount Technology Vision Award to IEI for Fluxless Soldering Equipment, 1996.
Program Committee, Session Chair for the SPIE Symp. on Smart Electronics and MEMS, 1996 to present.

Approximately 65 Technical Papers and 27 Issued Patents in the areas of Microelectronics Process, Process Equipment, and Materials as well as in Advanced Packaging and Microstructures.

Teresa A. Dahlberg

Department of Computer Science
University of North Carolina at Charlotte,
9201 University City Blvd., Charlotte, NC 28223
<http://www.cs.uncc.edu/~tdahlber>

Professional Preparation

University of Pittsburgh	Electrical Engineering	B.S. 1984
North Carolina State University	Computer Engineering	M.S. 1990
North Carolina State University	Computer Engineering	Ph.D. 1993

Appointments

- Assistant Professor, Computer Science, University of North Carolina at Charlotte, August 2000 – present.
- Assistant Professor, Electrical and Computer Engineering, University of North Carolina at Charlotte, August 1995 – August 2000.
- Assistant Professor, Computer Science, Winthrop University, August 1994 – August 1995.
- Staff Engineer, IBM Corp., Charlotte, NC, May 1987 – August 1994.
- Engineer, IBM Corp., Research Triangle Park, NC., May 1984 – May 1987.

Publications

Most Relevant

1. T. Dahlberg, J. Jung, "Survivable Load Sharing Protocols: A Simulation Study," *ACM/Baltzer Science Wireless Networks Journal (WINET)*, May 2001.
2. T.A. Dahlberg, K.R. Subramanian, "Visualization of Mobile Network Simulations," *Simulation, The Journal of the Society for Computer Simulation International*, September/October 2001.
3. D. Tipper, T. A. Dahlberg, H. Shin, C. Charnsripinyo, "Providing Fault Tolerance in Wireless Access Networks," *IEEE Communications Magazine*, January 2002.
4. T. Dahlberg, K.R. Subramanian, "Visualization of Real-time Survivability Metrics for Mobile Networks", *Proc. Mobile and Wireless Simulation Workshop (MsWIM)*, Aug. 2000.
5. T. Dahlberg, S. Ramaswamy, D. Tipper, "Issues in the Survivability of Wireless Networks", *Proc. IEEE Mobile and Wireless Communication Networks Workshop (MWCN97)*, May 1997.

Other Related

1. B. Heybruck, T. Dahlberg, "Survivability Analysis of Mobile Networks", *Proc. IEEE Workshop on Local and Metropolitan Area Networks (LANMAN)*, Boulder, Colorado, March 2001.
2. K.R. Subramanian, T. Dahlberg, "Congestion Control in Mobile Networks", *IEEE Symposium on Information Visualization 2000 (InfoVis 2000)*, Oct. 2000, IEEE Computer Society.
3. J. Jung, T.A. Dahlberg, "Geographical based simulation of survivable mobile networks", *Proc. Of The Advanced Simulation Technologies Conference (ASTC 2000)*, April, 2000.

4. T.A. Dahlberg, J. Jung, "Load Sharing Protocols for Radio Level Resilience", *Proc. International Teletraffic Congress (ITC-16)*, June 1999.
5. T. Dahlberg, J. Jung, "Teletraffic Modeling for Mobile Communications", *Proc. International Conference on Communications (ICC98)*, June 1998.

Synergistic Activities

1. Served as program chair for Modeling, Analysis, and Simulation of Wireless and Mobile Systems (MSWiM2001) workshop, July 21, 2001, in Rome, Italy, and will do the same for MSWiM2002 in Atlanta in 2002.
2. Serving as program chair for tools session of IEEE/ACM Int'l Symposium on Modeling, Analysis and Simulation of Computer and Telecommunications Systems (MASCOTS2002).
3. Serving as a co-editor for a special issue of Wireless Networks Journal (WINET) on Modeling and Simulation of Mobile Networks, to appear in 2002.
4. Working with researchers in the Real Time Systems Lab (RTSLAB) at Linköping University in Linköping, Sweden. Addressing coordinated middleware and networking layer solutions for fault tolerant mobile systems.
5. Participated in the National Security Agency sponsored Wireless Interconnect Network and Reconfigurable Systems (WINARS) project. Developing networking architectures and protocols for high speed millimeterwave communications. Focus on reconfigurable, scalable architectures and adaptive protocols. 1996-1998.

Collaborators and Other Affiliations

Collaborators

K.R. Subramanian, UNC Charlotte; Kayvan Najarian, UNC Charlotte; David Tipper, University of Pittsburgh; Simin Nadjm-Tehrani, Linköping University.

Graduate Advisors

Dharma Agrawal, University of Cincinnati; Arne Nillson, North Carolina State University; Ionnis Viniotis, North Carolina State University

Thesis Advisees

Bing Cao, UNC Charlotte; Bill Elderidge, UNC Charlotte; Bill Heybruck, IBM, Charlotte, NC; Jinwie Jung, Motorola, Phoenix, Arizona; Surekha Pangamamula, UNC Charlotte; Axay Shah, location unknown; Karan Sood, UNC Charlotte; Amit Suratkar, UNC Charlotte, Vinod Namboodiri, UNC Charlotte, Shirisha Thummala, UNC Charlotte.

Kasra Daneshvar

Professor, Electrical and Computer Engineering Department
University of North Carolina, Charlotte, NC 28223
Email: daneshvar@uncc.edu
Phone: 704-687-4145

Education

Louisiana State University	Electrical Engineering	BS	1970
University of Illinois	Electrical Engineering	MS	1972
University of Illinois	Physics	MS	1975
University of Illinois	Physics	Ph.D.	1979
University of Pennsylvania	Physics (Post-Doctoral Fellow)		1979-81

Appointments

Professor: Electrical and Computer Engineering Department, University of North Carolina, Charlotte, NC, 1992-present
Associate Professor: Electrical Engineering Department, University of North Carolina, Charlotte, NC, 1987-91
Assistant Professor:
Electrical Engineering Department, Auburn University, AL, 1984-87
Assistant Professor: Physics Department, Auburn University, AL, 1981-84
Senior Research Associate: Physics Division, Argonne National Lab. Argonne, IL, 1975-79

Publications (samples)

1. K. Daneshvar, M. Raissi, and S. M. Bobbio, Laser Rapid Prototyping in Nonlinear Medium, *Journal of Applied Physics*, 88 (5), 1 Sept 2000, 2205-2210.
2. K. Daneshvar and D. Kang, A Novel Method for Laser-Induced Periodic Domain Reversal in LiNbO₃, *IEEE Journal of Quantum Electronics*, 36 (01), January 2000, 85-88.
3. K. Daneshvar, E. A. Giess, D. Kang, J. R. Williams, D. Dawes, Rb Ion-exchange Profile in Potassium Titanyl Phosphate (KTP), *Optical Materials*, 12 (4), Sept 1999, 453-457.
4. K. Daneshvar, Integrating Optical and Electrical Engineering Courses, *IEEE Transactions on Education*, 42 (2), May 1999, 124-128.
5. K. Daneshvar, E. A. Giess, A.M. Bacon, D. G. Dawes, L.A. Gea, and L.A. Boatner, Ion Exchange in Potassium Titanyl Phosphate, *Applied Physics Letters*, 71 (6), 11 August 1997, 756-758
6. J. F. T. Wang, and K. Daneshvar, Numerical Calculation of the Effective Second - Order Nonlinear Coefficient along Collinear Phase-matching Directions inside Nonlinear Crystals in Three-wave Interaction, *IEEE Journal of Quantum Electronics*, 32(2), Feb. 1996, 183-191.
7. K. Daneshvar, B.Z. Li, P. Liu, G. B. Jiang, W. N. Huang, X Lu, and R. G. Aitken, Electrical Transport Properties of CoSi₂ and Co(SixGe_{1-x})₂ Films Formed by Different Methods, *Journal of Applied Physics*, 70 (10), pt.1, 15 November 1991, 5427-5432.
8. K. Daneshvar, High Current Pulse Generator for Gain Switching Semiconductor Lasers, *International Journal of Electronics*, 69(3) Sept. 1990, 379-384.
9. B-Z Li, R. G. Aitken, K. Daneshvar, R. Y. Kwor, and T.S. Kalkur, Hall Effect of the High T_c Superconducting Bi-Sr-Ca-Cu Thin Film, *Journal of Applied Physics*, 68 (1), 1 July 1990, 218-222.

10. K. Daneshvar, R. G. Aitken, and G. Singco, Silicon Detector for Low-Energy Electron Spectroscopy, *Review of Scientific Instruments*, 61 (5), May 1990, 1464-1467.

Patents

1. Electro-optical Method and Apparatus for Testing Integrated Circuits U.S. Patent No.: 5,216,359 Issue Date June 1, 1993.
2. Field Emitter Flat Panel Display Device and Method for Operating Same, U.S. Patent No.: 5,698,942, Issue Date Dec. 16, 1977.

Synergistic Activities

1. Used small ion accelerator for material analysis. Development of research facilities for depth profile (Rutherford Back Scattering, RBS, Proton Induced X-ray emission, PIXE), Auburn University, Physics Dept. AL. 1981-1984. (Served as the director of the center).
2. Developed a program in Optoelectronics and Quantum Electronics courses and research facilities in the Electrical Engineering Department, Auburn University, AL, 1984-1988
3. Spearheaded the optical engineering program in the Electrical and Computer Engineering Department, University of North Carolina, Charlotte. This includes courses and curriculum, research facilities, and undergraduate laboratories. 1988-present.
4. Participated in summer faculty programs at the U.S. Army Missile Command, Redstone, Huntsville AL, 1985; U.S. Naval Research Laboratory, Washington DC, 1988; Continuous collaboration with Material Group of Oak Ridge National Laboratory,

Collaborators & Other Affiliations

(i) Collaborators (during the last 48 months).

L.A. Boatner, Oak Ridge National Laboratory, S. M. Bobbio, University of North Carolina, Charlotte, R. Coleman, University of North Carolina, Charlotte, D. Dawes, Litton Airton, E. A. Giess, Retired, R. F. Greene, University of North Carolina, Charlotte, D. Kang, U.S. Patent Office, J. Williams, Auburn University, Auburn Alabama

(ii) Graduate and Postdoctoral Advisors

D. Kovar, Argonne National Laboratory (Ph.D.) DOE, Div. Nuclear Physics/Director
D. Balamuth, University of Pennsylvania (Post Doctoral)

(iii) Thesis Advisor and Postgraduate-Scholars Sponsors (while at UNCC)

M. Raissi, General Electric, Greensboro, NC (Ph.D.),
D. Kang, Lucent, Research Triangle Park NC. (Ph.D.)
T. Dogaru, Just Graduated (Ph.D.)
Total of 23 MS. and 12 Ph.D. students (including other universities)

ANGELA D. DAVIES

Physics Department, University of North Carolina at Charlotte, Charlotte, North Carolina 28223-0001
TEL: (704) 687-2505, FAX: (704) 687-3160, adavies@unc.edu

PROFESSIONAL PREPARATION

B.S. Physics, University of Oregon with Departmental Honors, 1988.

Ph.D. Physics, Cornell University 1994, Advisor: H. G. Craighead.

APPOINTMENTS

2001-present Assistant Professor, University of North Carolina at Charlotte
1998-2001 Project Leader, Manufacturing Engineering Laboratory, National Institute of Standards and Technology
1994-1998 Physicist, Physics Laboratory, National Institute of Standards and Technology

PUBLICATIONS

5 most closely related

- A. Davies and M. Levenson, "Estimating the RMS of a Wavefront and Its Uncertainty" *Applied Optics*, **40**, 6203-6209 (2001).
A. Davies, C. Tarrío, and C. J. Evans, "Advanced Optics Characterization" *Optics & Photonics News*, **12**, 34-38 (2001).
C. J. Evans, A. Davies, T. Schmitz and R. E. Parks, "Interferometric figure metrology; enabling in-house traceability" *SPIE Conference Proceedings*, SPIE's 46th Annual International Symposium on Optical Science and Technology, July (2001).
T. L. Schmitz, A. Davies, and C. J. Evans, "Uncertainties in interferometric measurements of radius of curvature" *SPIE Conference Proceedings*, SPIE's 46th Annual International Symposium on Optical Science and Technology, July (2001).
C. J. Evans, R. E. Parks, L. Shao, T. Schmitz, and A. Davies, "Interferometric Testing of Photomask Blank Flatness" *SPIE Conference Proceedings*, SPIE's 26th Annual International Symposium Microlithography, February (2001).

5 other publications

- D. T. Pierce, A. Davies, J. A. Stroschio, D. A. Tulchinsky, J. Unguris, and R. J. Celotta, "Non-collinear exchange coupling in Fe/Mn/Fe (001): Insight from scanning tunneling microscopy" *Journal of Magnetism and Magnetic Materials*, **222** (1-2), 13-27 (2000).
D. T. Pierce, A. Davies, J. A. Stroschio, and R. J. Celotta, "Polarized light emission from the metal-metal STM junction" *Applied Physics A*, **66**, S403-S406 (1998).
A. Davies, J. A. Stroschio, D. T. Pierce, J. Unguris, R. J. Celotta, "Observations of alloying in the growth of Cr on Fe(001)" *Journal of Magnetism and Magnetic Materials*, **165**, 82-86 (1997).
A. Davies, J. A. Stroschio, D. T. Pierce, R. J. Celotta, "Atomic-scale observations of alloying at the Cr-Fe(001) interface" *Physical Review Letters* **76**, 4175-4178 (1996).
J. A. Stroschio, A. Davies, D. T. Pierce, R. J. Celotta, "Tunneling spectroscopy of bcc(001) surface-states" *Physical Review Letters*, **75**, 2960-2963 (1995).

SYNERGISTIC ACTIVITIES

Member of the Education Committee for the American Society of Precision Engineering from 1998 to present; member of the Research Advisory Committee at NIST from February 1999 to April 2001; co-organizer of a topical discussion (workshop) for wafer flatness at NIST January 2001; assisted with the planning and implementation of Take Our Daughters to Work Day at NIST in 1997.

COLLABORATORS and OTHER AFFILIATIONS

Collaborators

J. Ballato (Clemson University), M. A. Davies (UNC Charlotte), C. J. Evans (Zygo Corporation), R. J. Hocken (UNC Charlotte), P. D. Knight (Digital Optics Corporation), J. W. Kolis (Clemson University), M. Levenson (U.S. Consumer Product Safety Commission), T. W. Mayes (UNC Charlotte), P. J. Moyer (UNC Charlotte), R. E. Parks (Optical Perspective Group), T. L. Schmitz (NIST), Ms. L. Shao (ASML Optics), D. W. Smith, Jr. (Clemson University), K. S. Smith (UNC Charlotte), C. Tarrío (NIST), R. K. Tyson (UNC Charlotte), R. G. Wilhelm (UNC Charlotte).

Graduate and Postdoctoral Advisors

Dr. G. Craighead, Cornell University, thesis advisor.

Dr. J. A. Stroschio, NIST, postdoctoral advisor.

Thesis Advisor

Total number of graduate students supervised = 2.

Katherine Medicus, UNC Charlotte, Ph. D. In Mechanical Engineering, expected graduation May 2005.

Devendra Karodkar, UNC Charlotte, M. S. in Mechanical Engineering, expected graduation May 2002.

Total number of postdoctoral scholars supervised = 0.

Faramarz Farahi
Professor of Physics
The University of North Carolina at Charlotte

Education: Ph.D. University of Kent at Canterbury, Thesis on Fiber Optic Sensors 1988.
M.Sc. Applied Mathematics & Theoretical Physics, University of Southampton, 1978.
B.Sc. Physics, Aryamehr University of Technology, 1976.

PROFESSIONAL SUMMARY

(1994-present) Professor of Physics, The University of North Carolina at Charlotte, Charlotte, NC 28223, USA.
(1990-1994) Associate Professor of Physics, The University of North Carolina at Charlotte.
(1989-1990) Assistant Professor, Physics Department, University of Kent, Canterbury, UK.
(1988-1989) Post-doctoral Research Fellow, Fiber Optic Group, University of Kent, UK.
(1984-1988) Research Assistant, Fiber Optic Group, University of Kent, UK.
(1978-1984) Lecturer in Physics, University of Gilan.

RESEARCH INTERESTS

Research interests include laser and white light interferometry utilizing optical fiber for precision measurement of displacement, vibration, strain, pressure, and other physical quantities. Also interested in using fiber optic gratings, and integrated optics technology to develop novel optical sensors and devices for telecom applications.

PATENTS & PUBLICATIONS

Holds several international patents. Has more than 100 publications. A few sample publications are:

"Multiplexed fiber-optic interferometric sensing system: combined frequency and time division," with J.D.C. Jones, D.A. Jackson, Selected Papers on Interference, Interferometry, and Interferometric Metrology, P. Hariharan, D. Malacara, Editors, SPIE Milestone Series 110, p. 580 (1995).

"Simultaneous measurement of displacement and temperature using low finesse cavity and a fiber Bragg grating" L.A. Ferreira, A.B. Lobo Ribeiro, J.L. Santos, IEEE Photonics Tech. Lett, 8, 1519 (1996).

"Photocurrent and optical limiting studies of C₆₀ films and solutions" with W. Sisk, Dong Hee Kang, M.Y.A. Raja, Int. J. Optoelectronics, 11, 325 (1997).

"Frequency Modulated Multimode Laser Diode for Fiber Bragg Sensors " with L.A. Ferreira, E.V. Diatzikis, J.L. Santos, J. Lightwave Tech., 16, 1620 (1998).

"Dynamic Range Enhancement in Fibre Bragg Grating Sensors Using a Multimode Laser Diode" with P.J. Moreira, L.A. Ferreira, J.L. Santos, IEEE Photonics Tech. Lett., 11, 703 (1999).

"Demodulation of Fiber Bragg Grating Sensors Based on Dynamic Tuning of Multimode Laser Diode" with L.A. Ferreira, E.V. Diatzikis, J.L. Santos, Applied Optics, 38, 4751(1999).

"Simultaneous Measurement of Strain and Temperature Using Interferometrically Interrogated Fiber Bragg Grating Sensors" with L.A. Ferreira, F.M. Araújo, J.L. Santos, Journal of Optical Eng. 39, 2226 (2000).

BIOGRAPHICAL SKETCH

Michael A. Fiddy

a. List of the Individual's Undergraduate and Graduate Education and Postdoctoral Training as Indicated below:

Ph. D. University of London, January 1977

B. Sc. Physics, First Class Honors, University of London, 1973

b. Appointments

2002	Director, Center for Optoelectronics and Optical Communications, UNCC Professor, Physics & Electrical Engineering Department, UNCC
1994-2001	Head of Department of Electrical & Computer Engineering
1991-	Professor, Department of Electrical Engineering, UML
1987-1991	Associate Professor, Department of Electrical Engineering, UML
1985-86	Visiting Associate Professor in Mathematics Department, Catholic University of America, Washington, D. C.
1984-1987	Lecturer in Physics, Kings College, London University (tenured).
Summer 1982 and 1983	Visiting Associate Professor, Institute of Optics, U. of Rochester
1979-1984	Lecturer in Physics, Queen Elizabeth College, London University

Fellow of the Optical Society of America (member since 1979),

Fellow of the Institute of Physics (member since 1977),

Fellow of the Society of Photo-Optical Engineers (since 1988),

Senior Member IEEE Lasers and Electro-optics Society (since 1988),

Member of the Electromagnetics Academy since January 1990

Member of the American Society for Engineering Education, ASEE, (since 1994)

Member of Sigma Xi (since 1994)

c. Publications

i. List of up to publications most closely related to the proposed program.

Testorf, M. and M. A. Fiddy, "Imaging from real scattered field data using a linear spectral estimation technique", Inverse Problems, Vol. 17, no 6, pp 1645-1658, 2001.

Testorf, M. and M. A. Fiddy, "Algorithms for data evaluation applied to the detection of buried objects", Waves in Random Media, Vol 11, pp 535-547, 2001.

Fiddy, M. A., D. Kalluri and J. D. Sanchez, "Effective University-Industry Partnerships", chapter in Approaches to Sustainable Development: The Public University in the Regional Economy, Ed. R. Forrant and J. Pyle, UMass Press, Amherst, 2001.

Testorf, M., A. Morales-Porras and M. A. Fiddy, "Imaging of strongly scattering targets based on signal processing algorithms", submitted to special issue of IEICE on Problems of Random Scattering and Electromagnetic Wave Sensing, IEICE Trans. Electron. Vol E83-C, December 2000, pp 1905 -1911.

Testorf, M. and M. A. Fiddy, "Simulation of light propagation in planar-integrated free-space optics", Optics Communications 176, pp 365-372, 2000

Schwarze, C.R., D.A. Pomet, G. Flynn and M. A. Fiddy, "Enhancement of X^3 in nanoparticle composite media exhibiting electrostriction and quantum confinement", Waves in Random Media 10, pp 43 - 52, 2000.

Testorf, M and M. A. Fiddy, "Diffraction tomography based on McCutchen's theorem" J.Opt. Soc. Amer. A. 16, pp 1806-1813, 1999.

Sanchez-de-la-Llave, D and M. A. Fiddy, "Incoherent to coherent conversion and square law transmission based on photinduced birefringence in bacteriorhodopsin films", Applied Optics, 38, pp815-821, 1999.

Malley, L.E., D.A. Pomet and M.A. Fiddy, "Optically induced ordering in microparticle suspensions", J. Opt. Soc. B, 15, 1590-1595, 1998.

BIOGRAPHICAL SKETCH

ii. List of other publications, whether or not related to the proposed program

Editor: Inverse Problems in Scattering and Imaging, SPIE San Diego, July 1992,
Inverse Optics III, Orlando April 1994
Experimental and numerical methods for solving ill-posed problems: medical and nonmedical applications, with Barbour, R.L. and M. J. Carvlin, San Diego, 1995.
Experimental and numerical methods for solving ill-posed problems: medical and nonmedical applications II with Barbour, R.L. and M. J. Carvlin, San Diego, 1997
Proceedings Optical Society of America Topical meeting on *Signal Recovery and Synthesis VI*, held June 1998, Kona Surf Hawaii.
Image reconstruction from incomplete data, SPIE San Diego, with R. Millane, July 2000

d. Synergistic Activities

Editor, *Waves in Random Media*, since Jan 1996; Editorial board member since 1991.
Topical Editor for *Signal and Image Processing*, Optical Society of America, 1994-2001.
Area Editor for *Electro-optics and Lightwave Systems*: CRC Press Dictionary of Electrical Engineering
Associate Editor of the *Multidimensional Systems and Signal Processing* (Kluwer).
UMass Lowell Outstanding Graduate Educator of the year, 1990/91.

Recent training activities

Courses in optics have been taught at both the undergraduate and graduate level at Raytheon, Lucent and SierraCom.

Graduate students who have completed doctoral theses since 1997: D. Sanchez, V. Kholi, A.J. Noushin, A. Morales

Graduate students who have completed MS theses since 1997: Y-T. Chao, D. Canton, M. Sy, J. Shenck, O. Akinwale, J. Wankel, C. Gomez, S-Y Hong, T. Markos, J. Rentz, M. Adams, J. Cole, E. Meidunas, C. Beaudoin

Courses taught during the last three years:

16.100/101 Introduction to Electrical Engineering	16.111 Digital Information World
16.364 Engineering Mathematics	16.699 Res. methods in Elec. & Comp. Eng
16.499 Capstone project	16.590 Fiber optics and networks
16.511 Digital image processing	16.568 Electro- and fiber optics
16.610 Optics for Information Processing	17.201 Introduction to Fiber Optics
17.202 Introduction to Optical Systems	59.101 Values and creative thinking

Activities conducted in collaboration with K-12 schools or other educational organizations

Organized and taught (residential) High School Scholars Camp in E.E. 1998, 1999 and 2001

e. Collaborators & other Affiliations

Collaborators (during last 48 months) (include collaborators on this proposal)

Dr. C.L. Byrne, Mathematics: Superresolution techniques
Dr. J. Canning, Computer Science: Parallel Implementation of Algorithms
Dr. W. Goodhue, Physics, MEMs based SLMs
Dr. W. Lazonick, Regional Economic & Social Development Dept: Lucent Technologies
Dr. Carl Lawton, Chemical Engineering: Quantum Dots
Dr. R. V. McGahan, AFRL: Radar Foliage Penetration Studies
Dr. Babs Soller, UMass Medical Center: Retinal Spectroscopy
Dr. Jan Stecchi, Dean of the College of Health Professions: Medical Translator
Dr. M. Testorf, ECE Department: Optical Processing and Imaging
Dr. J. Waldman and Dr. R. Giles, Physics: Radar Data Processing

Kenneth E. Gonsalves PhD

Celanese Acetate Distinguished Professor of Polymer Chemistry
Department of Chemistry &
Cameron Applied Research Center
University of North Carolina
Charlotte, NC 28223

Academic:

PhD in Chemistry; University of Massachusetts at Amherst 1980-84
Postdoctoral : MIT 1984-85
MS Chemistry, Boston College
BS(Honors) Delhi University
Research Assistant, Materials Res. Lab. University of Massachusetts at Amherst 1981-84.

Experience:

Assistant Professor Stevens Inst. of Technology NJ, 1986-1990.
Assistant Professor University of Connecticut at Storrs, Sept. 1990 to May 1994.
Associate Professor University of Connecticut at Storrs, Sept. 1994
Professor, University of Connecticut at Storrs, Aug. 99-00
Visiting Professor Harvard University 1997
Visiting Scientist US Army Research Lab. Natick MA 1997-99
Scientific Visitor ININ Mexico 1997-98
Associate Faculty member microelectronics, optoelectronics, Dept. of Electrical Engineering, UCONN 1998-00

Professional Societies:

American Chemical Society:

Inorganic Division; Polymer Division; Polymer Materials Science & Engineering Division

Materials Research Society

Research Interests:

Materials Synthesis: Organic Polymer Chemistry, organometallic polymers, polymer and molecular precursors for ceramics and intermetallics; nanostructured materials/composites; biomaterials; novel resists for nanolithography; nanofabrication and nanopatterning of biomaterials.

Graduated over 15 PhD and postdoctoral students plus 3 MS students in polymer science and chemical engineering; mentored undergraduate students under the NSF REU and Young Scholars Programs

INTERNATIONAL HONORS/AWARDS

Invited by the French Ministry of Foreign Affairs under the VIP Scientist Program to the University of Limoges FRANCE summer 1997.

Publications

Over 150 publications in refereed journals, editors of 1 ACS & 3 MRS Technical Proceedings.
Several invited book chapters and reviews, especially in nanostructured materials and technology
Four US patents and one US and International patent in nanotechnology applied for.
Several invited lectures both nationally and internationally.
Editor of 3 Materials Research Soc. Symp. Proceedings and an American Chemical Society Symp. Proc.
Organizer of 3 MRS and 1 ACS symposia.

Organizing a symposium on "Nanopatterning: from Ultralargescale Integration to Biotechnology" supported by the Whittaker Foundation for Biomedical Engineering students, Fall MRS Boston 2001.

Recent selected publications

1. Organic-inorganic Nanocomposites: Unique Resists for Nanolithography" **Adv. Mater.** May, **2001**, **13(10)**, 703-714 (**invited review**); with L. Merhari, H. Wu and Y. Hu.
2. "New Advances in Resist System for Next Generation Lithography" **SPIE Proc. 2001**; with Y. Hu, W. He and L. Merhari.
3. "Nanocomposite Resists for Electron Beam Lithography" **Microelectronic Engineering**, Summer **2001**; with Y. Hu and L. Merhari.
4. "High Resolution Resists for Next Generation Lithography: The Nanocomposite Approach" **MRS Proc. 2001 (invited review)**; with H. Wu, Y. Hu and L. Merhari.
5. "Incorporation of Polyhedral Oligosilsesquioxane (POSS) in CA Resists to Improve their RIE Resistance" **JVST B June/July 2001**; with H. Wu and M. Jose-Yacamán.
6. "Functionalized Copolymers and their Composites with Polylactide and Hydroxyapatite", **J. Mater. Sci. Mater. Med.(10)**, 363 (1999); with S. Jin.
7. "Synthesis and Characterization of Poly(L-lactide-co-serine) and its Graft Copolymers with Polyethylene Glycol" **Polymer 39(21)**, 5155 (1998); with S. Jin.
8. "Synthesis and Characterization of Functionalized Poly(ϵ -caprolactone) Copolymers by Free Radical Ring Opening Polymerization", **Macromolecules 31(4)**, 1010 (1998) with S. Jin.
9. ""Synthesis and Properties of Degradable Polyamides and Related Polymers" **TRIP 4(1)**, 25 (1996); with P. M. Mungara(**invited review paper**).

M.-A. Hasan

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University of North Carolina
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Tel: (704) 510-6414, Fax: (704) 547-2352
E-mail: mhasan@uncc.edu

Home Address

5211 Basswood Dr.
Concord, NC 28025
Tel. (704)795-1707

Education:

- Licentiate of Engineering (2 to 3 years program after the Master degree), Department of Physics and Measurement Technology, Linköping Institute of Technology, Sweden, 1987.
- Ph.D. in Materials Physics, Department of Physics and Measurement Technology, Linköping Institute of Technology, Sweden, Sept. 1990.

Awards and Scholarships:

- Postdoctoral fellowship from the Swedish Natural Science Research Council (NFR: Naturvetenskapliga forskningsrådet), 1992-1993.
- Welch Scholarship Award from the International Union of Vacuum Science, Technique and Applications (IUVSTA), 1991-1992
- Postdoctoral fellowship from the Swedish Natural Science Research Council (NFR: Naturvetenskapliga forskningsrådet) 1991-1992.
- Postdoctoral fellowship from the Sweden-America Foundation (Sverige-America Stiftelsen), 1991-1992
- Student Travel Award from the Electronic Materials and Processing Division of the American Vacuum Society, 1990. (Toronto Meeting)
- Student Travel Award from the Thin Film Division of the American Vacuum Society 1986. (Baltimore meeting)
- Postgraduate Scholarship Award from Sabah Al-Salem Al-Sabah foundation (Kuwait) for partly supporting my Ph.D. study in Sweden. 1985-1987
- Deutscher Akademischer Austauschdienst (DAAD) [German Academic Exchange Service] scholarship, KFA (Nuclear Research Center) Jülich GMBH, Germany, July-September (During the third year of my undergraduate study).
- Top-Ten Award: during all four years of my undergraduate studies.

Publications: More than 34 refereed articles in scientific journals, 52 contributions to international and national conferences, 8 patent disclosures, and 11 manuscripts in preparation.

Proposals and Funding:

- ~\$900,000 has been awarded. The research areas can be summarized in the following:

- A. Fabrication and characterization of power devices and radiation detectors based on wide bandgap materials, mainly SiC and group-III nitrides (AlN, GaN, InN). This project includes a new method for the fabrication of SiC substrates (funded)
- B. Solid-metal Mediated Molecular Beam Epitaxy (SMM-MBE): Recently, we have developed SMM-MBE a process that is both a dramatic technological advance, and a deeply interesting scientific phenomenon. In SMM-MBE, defect free single crystalline silicon is formed at a buried solid-metal/Si interface at low growth temperatures ($T_s < 400$ °C). This process occurred during deposition from the vapor phase on the metal/Si heterostructure without measurable delay between deposition on the free metal surface and regrowth at the buried interface. The method combines epitaxial metallization and doping of Si in a single processing step. It has the potential for altering the current CMOS fabrication methods and can provide solutions to the challenges facing submicron device fabrication. Recently, we have used the method to grow SOI structures (funded).
- C. Development, characterization, and testing of a new family of cold cathode emitters based on group II-VI semiconductor and lanthanum monosulfide (a low work-function semimetallic compound). These emitters would be suitable as compact, efficient, low-voltage cathodes for microwave tubes and flat panel displays (funded).

Positions Held:

- Associate Professor, Department of Electrical Engineering, University of North Carolina, Charlotte, Spring 2000-present
- Assistant Professor, Department of Electrical Engineering, University of North Carolina, Charlotte, Fall 1995-Fall 99
- Research Assistant Professor, Electronic Materials Division, Coordinated Science Laboratory, Dept. of Materials Science and Engineering, University of Illinois at Urbana-Champaign (UIUC), USA, Sept. 1991- Aug. 1995
- Senior Research Assistant (forskning assistent), Department of Physics and Measurements Technology, Linköping Institute of Technology, Sweden, Oct.-Jan. 1990 and April-Aug. 1991.
- Visiting Scholar, Coordinated Science Laboratory, Dept. of Materials Science and Engineering, University of Illinois at Urbana-Champaign (UIUC), USA, Feb.-April, 1991
- Research and teaching assistant, Department of Physics and Measurements Technology, Linköping Institute of Technology, Sweden, July 1985-Sept. 1990.
- Research assistant, Department of Physics and Measurements Technology, Linköping Institute of Technology, Sweden, 50% May 1984- June 1984, 80% July 1984 - June 1985.

Robert J. Hocken
Norvin Kennedy Dickerson Jr. Distinguished Professor of Precision Engineering
Director, Center for Precision Metrology
Department of Mechanical Engineering and Engineering Science
The University of North Carolina at Charlotte

Areas of Specialization

Present research efforts include the areas of nanotechnology, electro-optical instrumentation, atomic force microscopy and optical stethoscopy, and dimensional metrology for manufacturing.

Professional Experience

Director, NSF (I/UCRC) Center for Precision Metrology, University of North Carolina at Charlotte (1998-present)
Norvin Kennedy Dickerson, Jr., Distinguished Professor in Precision Engineering, University of North Carolina at Charlotte (1988 – present)
Chief, Precision Engineering Division, Center for Manufacturing Engineering, National Institute of Standards and Technology [formerly National Bureau of Standards] (1985 – 1988)
Chief, Automated Production Technology Division, Center for Manufacturing Engineering, National Bureau of Standards [NBS] (1980 – 1985)
Various research and management positions, NBS, Dept. (1983 – 1985)
Visiting Professor, Cranfield Institute of Technology, Bedford, England (1985)
Invited Lecturer, University of Tianjin, China (1983)
Visiting Professor, University of Maryland (1982)

U. S. Patents

No. 4,714,339 "Three and Five Axis Tracking Systems," Dec. 1987

Education

NBS-NRC Postdoctoral Fellow (1974-75)
Ph.D., Physics, State University of New York at Stony Brook (1973)
M.A., Physics, State University, New York at Stony Brook (1969)
B.A., Mathematics, Oregon State University (1968)
B. A., Physics, Oregon State University (1968)

Honors, Awards and Accomplishments

Summa Cum Laude, Oregon State University, 1968
NSF Fellow, 1971
Silver Medal, Dept. of Commerce, NBS, 1978
F. W. Taylor Medal, International Institute for Production Engineering Research, Paris, France (1979)
IR 100 Award, Instrument for Large Scale Stereo Triangulation, 1980
NBS Applied Science Award, Developments in 3-Dimensional Metrology, 1980
IR 100 Award (Division), "Drill Up," 1983
F. W. Taylor International Research Award (Medal), Society for Manufacturing Engineers, 1985
Charter Fellow, Society for Manufacturing Engineers, 1986
IR 100 Award (Division), "Space Beads" (first space manufacturing product), 1986
Gold Medal, Department of Commerce, 1987
Presidential Executive Award, 1987
Alcoa Award for Outstanding Faculty at the Graduate Level, 1992
First Citizens Bank Scholar's Medal, 2000
ASPE Lifetime Achievement Award, 2000

Professional and Honorary Societies

American Physical Society; Society for Manufacturing Engineers (Senior Member, Fellow); B-89 Committee, American Society for Mechanical Engineers (ASME); Active Member, International Institute for Production Engineering Research (CIRP); American Society for Precision Engineering Board; B-5 Committee, ASME, Machine Tool Performance Standards

Selected Recent Publications

Authored over 80 publications including journal reports, invited lectures and presentations. A sample of recent

publications:

- Phan, S., Keanini, R., Smith, S., **Hocken, R.** "Resonance Based Force Measurement: Prelude to High-resolution Anemometry for Liquid Metal Flows." *Proceedings of the ASME Heat Transfer Division, International Mechanical Engineering Congress & Exposition*, Vol. 4, ASME 1999, November 14-19, 1999, p. 3.
- Holmes, M., Trumper, D., and **Hocken, R.** "Magnetically-suspended Stage for Accurate Positioning of Large Samples in Scanned Probe Microscopy." *Proceedings of the MAG '98 Industrial Conference and Exhibition on Magnetic Bearings*, pgs. 23-32, 1998.
- Hocken, R. ASME/ANSI, "Methods for the Performance Evaluation of CNC Lathes and Turning Centers." New Standard B5.57M, approved by B5 Committee of ASME, October 1997.
- Holmes, M. **Hocken, R.**, Trumper, D., "A Long-range Scanning Stage," *Proceedings of the ASPE*, Volume 16, pg. 474, 1997.
- Hocken, R., Namperumal, R., Pereira, P., Lovingood, J., Edgeworth, R., Sharma, A., Holmes, M., and Muralikrishnan, B., "Design of a Second Generation Nanometric Cutting Instrument," *Proc. of the ASPE*, Volume 16, pg. 386, 1997.
- Babu, U., Raja, J. **Hocken, R.**, and Chen, K. "Sampling Methods and Substitute Geometry Algorithms for Measuring Cylinders in a Coordinate Measuring Machine." *Transactions of NAMRI/SME*, Volume XXV, pp. 353-358, 1997.
- Boudreau, B.D., Raja, J., **Hocken, R.J.**, Patterson, S.R., and Patten, J. "Thermal Imaging with Near-field Microscopy." *Rev. Sci. Instruments*, Vol. 68, pp. 3096-3098, 1997.
- Wilhelm, B., S. Srinivasan, F. Farabaugh, and **Hocken, R.**, "Prediction of Part Form Errors from Machine Tool Measurements: Experimental Summary", *NAMRI/SME*, Vol. XXV, page 317, May 1997.
- Hocken, R. and Wilhelm, R., "Frontiers in Precision Manufacturing - Metrology." *International Journal for Manufacturing Science and Production*, 1997.
- Evans, C., **Hocken, R.** And Estler, W. "Self-Calibration: Reversal, Redundancy, Error Separation, and 'Absolute Testing'," *Annals of the CIRP*, Vol. 45/2, 1996.
- Badami, V., Smith, S., Raja, J., and **Hocken, R.**, "A Portable Three-Dimensional Stylus Profile Measuring Instrument." *Precision Engineering*, 18, April/May, 1996.
- Miller, J. **Hocken, R.**, Smith, S., Harb, S., "X-Ray Calibrated Tunneling System Utilizing a Dimensionally Stable Nanometric Positioner." *Precision Engineering*, 18, April/May, 1996.
- Holmes, M., Trumper, D., and **Hocken, R.J.**, "Atomic-Scale Precision Motion Control Stage (The Angstrom Stage)," *CIRP Annals*, Vol. 44, January 1995.
- Boudreau, B.D., Raja, J., Patten, J. and **Hocken, R.J.**, "Scanning Near-Field Infrared Microscopy," *Proceedings of the 1995 NSF Design and Manufacturing Grantees Conference*, La Jolla, California, January 4-6, 1995.
- Cloninger, T.L., Balasubramaniam, S., Boudreau, B. Raja, J., and **Hocken, R.J.**, "A Simple Technique for Screening Near-field Probes," *Ultramicroscopy* 57 (1995).
- Hocken, R.J., *An American National Standard: Methods for Performance Evaluation of Coordinate Measuring Machines*, ANSI/ASME B89-4-1995, Standard for ASME, 1995.
- Badami, S.T. Smith, J. Raja, and **R.J. Hocken**, "Design of a Three-Dimensional Surface Profiler," *Proceedings of 1994 ASPE Annual Meeting*, October 1994.
- Hocken, R., J. Raja, and U. Babu, "Sampling Issues in Coordinate Metrology," *Manufacturing Review*, December, 1993.
- Howard, L.P., and **Hocken, R.J.**, "An Interferometric Instrument for the Metrology of Micromechanisms." *Proc. ASPE 1991 Annual Conference*, Santa Fe, NM, October 1991.
- Hocken, R., et. al., "Methods for Performance Evaluation of Computer Numerically Controlled Machining Centers," ANSI/ASME B5.54-1991, Standard for ASME, 1991.
- Miller, J.A. and **Hocken, R.J.**, "STM Bit Making on Highly Oriented Pyrolytic Graphite: Initial Results," *Journal of Applied Physics*, July 1990.

THOMAS R. LUCAS
PRINCIPAL INVESTIGATOR

Department of Mathematics
University of North Carolina at Charlotte, Charlotte, NC 28223
Phone: (704) 687-4571, Fax: (704) 687-6415, e-mail: trlucas@uncc.edu

EDUCATION:

Ph.D. in Applied Mathematics, Georgia Institute of Technology, 1970
M.S. in Mathematics, University of Michigan, 1962
B.S. in Mathematics, University of Florida, 1961

FIELD: Applied Mathematics, Numerical Analysis for Partial Differential Equations, Inverse Problems

PROFESSIONAL EXPERIENCE:

Department of Mathematics, Professor, University of North Carolina at Charlotte, 1969-Present (lesser rank during 1969-83)
David Taylor Naval Research Center, Summers 1983-88
Martin-Marietta (Orlando), Senior Engineer, 1962-65

PUBLICATIONS MOST CLOSELY RELATED TO THE PROPOSED PROJECT:

1. R.M. Frank, M.V. Klibanov and T.R. Lucas, A fast and accurate imaging algorithm in optical/diffusion tomography, *Inverse Problems*, 1997, v. 13, 1341-1361.
2. M.V. Klibanov and T.R. Lucas, Numerical solution of the parabolic inverse problem in optical tomography using experimental data, *SIAM J. Appl. Math.*, 1999, v. 59, 1763-1789.
3. Y.A. Gryazin, M.V. Klibanov and T.R. Lucas, GMRES computation of high frequency electrical field propagation in land mine detection, *J. Comp Phys.*, 2000, v. 158, 98-115.
4. Y.A. Gryazin, M.V. Klibanov and T.R. Lucas, Numerical solution of a subsurface imaging inverse problem, *SIAM J. Appl. Math.*, 2002, v. 62, 664-683 (available electronically).
5. Y.A. Gryazin, M.V. Klibanov and T.R. Lucas, Two novel numerical methods for an inverse problem for the 2-D Helmholtz equation, *Journal of Computational Physics*, submitted 2001, 25pp.

OTHER SIGNIFICANT PUBLICATIONS:

1. T.R. Lucas and G.W. Reddien, Some collocation methods for nonlinear boundary value problems, *SIAM J. Numer. Anal.*, 9 (1972), 341-356.
2. Y.H. Kim and T.R. Lucas, Nonlinear ship waves, in *Proc. of 18th Symposium on Naval Hydrodynamics*, (1990), 439-452, Ann Arbor, Michigan.

3. T.R. Lucas and H.S. Oh, The method of auxiliary mapping for the finite element solutions of elliptic boundary value problems containing singularities, *J. Comp. Phys.*, 108 (1993) 327-342.
4. M.V. Klibanov and T.R. Lucas, Method and Apparatus for Detecting an Abnormality Within a Host Medium, U.S. Patent 5,963,658, granted October 5, 1999.
5. M.V. Klibanov and T.R. Lucas, Elliptic systems method in diffusion tomography using back-reflected data, *Inverse Problems*, 2000, v. 16, 199-221.

SYNERGISTIC ACTIVITIES:

- National Award in Computational Science Education, Ames Laboratory, 1994.
- Was part of a NC team to select a supercomputer for the forthcoming NC Supercomputer Center (late 80's) and later served as a member of the Advisory Board of the Supercomputer Center.
- Was a founder of a company, Medical Optical Imaging, to develop new approaches to the diagnosis of female breast cancer using diffusion tomography.
- As Co-PI under a grant from the ARO, I developed methodologies related to the detection of mine-like targets in soil using ground penetrating radar.
- Currently serving on a small panel to develop a Center for Optoelectronics and Optical Communications and a related new Ph.D and Masters interdisciplinary program at UNC Charlotte. (This is heavily supported by both the local and state administrations with 8 figure amounts and fast tracking.)

CITIZENSHIP: U.S. Citizen

COLLABORATORS IN THE PAST 48 MONTHS:

Michael V. Klibanov, Department of Mathematics of the University of North Carolina at Charlotte; and Yuriy A. Gryazin previously from the Department of Mathematics of the University of North Carolina at Charlotte, now at Idaho State University, Department of Mathematics.

Thesis Advisor to Robert Frank

Thesis Advisor: Dr. William Kammerer, Georgia Institute of Technology.

BIOGRAPHICAL SKETCH: TERRILL W. MAYES

University of North Carolina at Charlotte
Department of Physics
Charlotte, NC 28223
(704) 547-4516
Fax: (704) 547-3160
E-mail: twmayes@uncc.edu

EDUCATION:

Ph.D., Physics, 1967 - Vanderbilt University
Thesis Title: *Spectroscopic Determination of the State of a High Pressure Plasma*
Thesis Advisor: J.P. Barach
M.S., Physics, 1965 - Vanderbilt University
Thesis Title: *Efficiency of High Pressure Electric Shock Tubes*
Thesis Advisor: J.P. Barach
B.S., Physics, 1963 - Western Kentucky State College

PROFESSIONAL EXPERIENCE:

University of North Carolina at Charlotte, 1967 - Present
Interim Chair of Physics, 2001-
Associate Professor of Physics, UNC Charlotte, 1974 - Present
Assistant Professor of Physics, UNC Charlotte, 1967 - 74
Graduate Coordinator, Physics Department, 1991 - 99
Vanderbilt University, 1964 - 67
Research Associate, Summer of 1967
AEC Fellow, 1964 - 67

PROFESSIONAL ORGANIZATIONS:

Charlotte Chapter of the American Optical Society
American Physical Society
American Optical Society
American Association of Physics Teachers

PUBLICATIONS:

FIVE PUBLICATIONS MOST CLOSELY RELATED TO PROPOSED RESEARCH

1. J. P. Barach and T. W. Mayes, *Spectroscopic Measurements of Electric Shock Tube Flow*, Phys. Fluids **11**, pp 89-95 (1968).
2. T. W. Mayes, *Polar Intensity Profile of Elliptically Polarized Light*, Am. J. Phys. **44**, pp 1101-03 (1976).

3. T. W. Mayes and F. Farahi, *Demonstration of Logic Operations Using Fiber Optic Interferometry*, Am. J. Phys. **62**, pp 467-69 (1994).
4. T. W. Mayes and B. F. Melton, *Fraunhofer Diffraction of Visible Light by a Narrow Slit*, Am. J. Phys. **62**, pp 397-403 (1994).
5. B. F. Melton, V. L. Pollak, T. W. Mayes, and B. L. Willis, *Condition for Sudden Passage in Earth's Field NMR Technique*, J. Magnetic Resonance, **117**, pp 164-170 (1995).

FIVE ABSTRACTS MOST CLOSELY RELATED TO PROPOSED RESEARCH

1. *An Investigation of the Faraday Effect for Advanced Physics Undergraduates*, Abstract, APS Bulletin, Nov. 1993.
3. P.M. Brinegar, T. W. Mayes, F. Farahi, and R. J. Hocken, *Interferometric Frequency Stabilization of 670 nm Diode Lasers*, Abstract, Bull. Am. Phys. Soc. Vol 39, No. 8, 1994.
4. W. Xu, T. W. Mayes, and F. Farahi, *Fiber Optic Based Detection of NO_x Concentration Using Absorption Lines in the Visible Optical Range*, Abstract, Vol. 39, No. 8, 1994.
5. C. M. DePriest, F. Farahi, and T. W. Mayes, *Optical Fluid Velocimetry Exploiting the Fresnel Drag Effect*, Abstract, Bull. Am. Phys. Soc., Vol. 39, No. 8, 1994.
6. M. S. Riley, K. Edward, P. J. Moyer, T. W. Mayes, and R. J. Hocken, "Phase imaging in the near field", Optics in the Southeast, Clemson, 2001.

RECENT FUNDING

1. *Modern Optics Laboratory*, NSF, \$39,602, 1991-93 (Co-PI With F. Farahi and S. P. Almeida).
2. *Fiber Optic Sensors for Gas Emission Monitoring*, Duke Power Company, 1993-95, \$175,564 (Co-PI With F. Farahi).
3. *Extension of Fiber Optic Sensors for Gas Emission Monitoring*, 1994-96, \$36,250 (Co-PI With F. Farahi and W. Sisk).
4. *Second Extension of Fiber Optic Sensors for Gas Emission Monitoring*, 1996-97, \$17,625 (PI).
5. *A Near-field Scanning, Phase Contrast Microscope*, NSF, \$264,999, 2000-03, (Co-PI with B. Hocken and P. Moyer)

C. COLLABORATORS: Dr. Bob Hocken, UNC Charlotte, Dr. Pat Moyer, UNC Charlotte

D. STUDENTS:

1. Mike Riley & Kert Edward, *A Near-field Scanning, Phase Contrast Microscope*, Current
2. Andrew Woodfin, *Phase Contrast NSOM*, (With P. Moyer) MS, 1998.
3. Barry Etter, *Continuous Flow Rate Monitor for Emission From Coal Fired Stacks*, MS 1996 (With F. Farahi).
4. Paul Brinegar, *Stabilization of Diode Laser for Precision Position Determination*, MS 1995 (With F. Farahi).
5. Weidong Xu, *Continuous Gas Emissions Monitor for Coal Fired Stacks*, 1995.

Curriculum VITA
M. Taghi Mostafavi

Education:

Ph.D. Electrical and Computer Engineering with Minor in Computer and Information Science, Oklahoma State University, May 1986

M.S. Electrical Engineering, Oklahoma State University, May 1982

B.S. Computing and Information Sciences OK-State, December 1980

Professional Experience:

UNC-Charlotte, Associate Professor, 1993-present

UNC-Charlotte, Assistant Professor, 1986-Fall 1993

OK-state, ECE Department, Teaching Assistant, 1984-1986

OK-State AE Department, System Analyst Programmer, 1980-1986

Research Interest:

Computer and biomedical Engineering, Imaging and Computer Vision, Vision Metrology and High Speed Inspection; Computer and VLSI Architecture.

Consulting Activities:

Microelectronics Center of North Carolina: VLSI Design and Simulation, Test and CAD Development, 1988-1989

Selected Funded Research:

- "Interactive 3D Visualization of Intravascular Ultrasound Images," Mostafavi (CO-PI) and K. R. Subramanian (CO-PI), **American Heart Association**, \$54K, 1998-2000.
- "A high Speed Vision System for Precision Inspection," Mostafavi (PI), **National Science Foundation**, ~\$49,000, matching, 1994-1996
- "Acquisition, Processing and Analysis of Discrete Data for Imaging/Visualization Applications," Mostafavi (CO-PI) and K. R. Subramanian (CO-PI), **National Science Foundation**, \$31,632, matching, 1996-1998.
- "Equipment for Precision Engineering," with Hocken (PI) and other UNC-Charlotte Faculty, **National Science Foundation**, \$1.099 million, 1994-1999.
- "A Unified Framework for Computer System Engineering" Mostafavi (PI) and B. Wilkinson, Tektronix contribution toward purchase of engineering equipment, \$64,000, matching, 1994-1995,
- "A Custom Integrated Circuit for Real Time Image Processing," **Mostafavi (PI)**, **Microelectronics Center of North Carolina**, \$51,000, 1993.
- "A high Speed Vision System for Precision Inspection," Mostafavi (PI), **National Science Foundation**, \$157,094, 1992-1994
- "Optical Threshold Control Technique for Detection of Physical Failure in MOS Devices," Mostafavi (PI) and F. Farahi, **National Science Foundation**, \$49,895, 1992-1993
- "A parallel Processing Model for Fast Image Processing in Automated Manufacturing," Mostafavi (PI), **NCSC**, \$130,000, computing support, 1991-1992
 - "A Custom Integrated Circuit for Real Time Image Processing," Mostafavi (PI), **Mostafavi (PI)**, **Microelectronics Center of North Carolina**, \$117,000, 1989-1992.

Selected Refereed Publications Since 1990:

- T. Mostafavi, S. Vishin, and W. Dettloff, "A parallel Processor ASIC Design for Real Time Pattern Recognition," IEEE International Conference of EURO ASIC 90, Paris, France, pp 306-309, May 29 1990.
- K. Ashenayi, T. Heng, M.R. Sayeh and T. Mostafavi, "Single-Layer Perceptron Capable of Classifying 2N+1 Distinct input Patterns," Journal of Modeling and Simulation, Vol. 10, No. 4, pp 124-128, 1990.
- T. Mostafavi, "Specialized Interconnected Architecture for VLSI Implementation of Neural Network Models," Intelligent Engineering Systems Through Artificial Neural Networks, pp 67-72, Vol. 2, Nov. 1992.
- T. Mostafavi, "A High Speed Vision System for Precision Inspection and Metrology," Proceeding of the 1994 NSF Design and Manufacturing Grantees Conference, MIT, pp 75, Jan, 1994.
- T. Mostafavi, "Image Processing System and Methods for Precision Metrology," "Proceeding of the 1995 NSF Design and Manufacturing Grantees Conference, UC San-Diego, pp 131, Jan, 1995.
- Mostafavi, T., "Image Processing Research for Non-Contact Measurement," 1996 NSF Design and Manufacturing Grantees Conference, UNM, Sandia National Laboratories, Albuquerque, NM, Jan. 1996.
- M. Taghi Mostafavi and Satish Pragalsingh, "An Optical Calibrating Technique for Non-Contact Metrology," Proceeding of ASEP, Monterey, California, Nov. 1996, pp 196-201.
- M. Taghi Mostafavi, "Results From Optical Calibration Using A template Matching Technique," The 1997 NSF Design and Manufacturing Grantees Conference, University of Washington, Seattle, Washington Jan. 1997. pp 255--256.
- K.R. Subramanian, D. M. Lawrence, M.T. Mostafavi, "Interactive Segmentation and Analysis of Fetal Ultrasound Images", Springer Verlag, November 1997.
- K.R. Subramanian, M. J. Thubrikar, M.T. Mostafavi, B. Fower, "Evaluating the Accuracy of 3D IVUS Reconstruction", Biomedical Engineering Society, 1999 Annual Fall Meeting, Atlanta, Georgia, Oct 13-19, 1999.
- K.R. Subramanian M.J.Thubrikar, M.T.Mostafavi, B. Fowler, "Accurate 3D reconstruction of curved coronary vessels from intravascular ultrasound images," Journal of Medical Engineering and Technology.
- Heba N. Saba, Essam A. El-Kwae, and Taghi Mostafavi, "Automated Object Segmentation from X-Ray Images," ISDA Medical Imaging Conference, August 2001

Patent:

- M. Taghi Mostafavi, "Specialized Image Processing System Architecture and Method for Image Data Arrays," U.S. Patent No. 5,642,444, June 24, 1997.

Invited Talk:

- T. Mostafavi, "Linear Interconnection Architecture in Parallel Implementation of Neural Network Models," SPIE Conference, Neural Networks session, Rosemont Illinois, 1990
- T. Mostafavi, "VLSI Design of a Parallel Processor for Real-Time Pattern Recognition," 22nd Pittsburgh Conference on Modeling and Simulation, May 2-3, 1991.
- K.R. Subramanian, D. M. Lawrence, M.T. Mostafavi, "Interactive Segmentation and Analysis of Fetal Ultrasound Images", 8'th Eurographics Workshop on Visualization in Scientific Computing, Boulogne sur Mer, France, April 28-30, 1997.
- K. Davis, K. Najarian, E. El-Kwae, T. Mostafavi (presenter), and S. Shirani, "Robust and efficient watermarking using a non-linear model of the human visual system," SCI word conference, Orlando, Florida, July 2001.

1

Patrick J. Moyer
Brief Curriculum vita

EDUCATION

- B.S. Physics, 1986, Moravian College, Bethlehem, PA
M.S. Physics, 1988, Saint Bonaventure University, Olean, NY
Ph.D. Major: Physics, 1993, North Carolina State University, Raleigh, NC

WORK EXPERIENCE

- May 2001 – present
Director, Photonic Development, **Waveguide Solutions, Inc.**, Charlotte, NC
- July, 2001 – present (currently on leave of absence)
Associate Professor (with tenure), **The University of North Carolina at Charlotte**, Department of Physics, Charlotte, NC
- August, 1996 – June, 2001
Assistant Professor (tenure track), **The University of North Carolina at Charlotte**, Department of Physics, Charlotte, NC
- April, 1998 - August, 1998
Invited Guest Professor, **The Technical University of Dresden**, Institute for Applied Photophysics, Dresden, Germany
- August, 1995 - August, 1996
Assistant Professor (tenure track), **Brooklyn College of the City University of New York** and **The Graduate Center of the City University of New York**, Department of Physics, Brooklyn, NY
- March 1, 1993 - August 1995:
Staff Scientist, **TopoMetrix Corporation**, Santa Clara, CA

SELECT REFEREED PUBLICATIONS

- Patrick J. Moyer, Timothy Martin, Andy Pridmore, Jan Schmidt, Thomas Hasche, and Lukas Eng, "Dependence of radiative lifetimes of porous silicon on excitation intensity and wavelength", *Appl. Phys. Lett.* **76**, 2683 (2000).
- Patrick J. Moyer, Jan Schmidt, Lukas Eng, Alfred J. Meixner, Gunther W. Sandmann, Hartmut Dietz, and Waldfried Plieth, "Surface enhanced Raman scattering spectroscopy of carbon domains on individual Ag nanoparticles on a 25 millisecond time scale", *J. Am. Chem. Soc.* **122**, 5409 (2000).
- Patrick J. Moyer, Todd L. Cloninger, James L. Gole, and Lawrence A. Bottomley, "Experimental evidence for molecule-like absorption and emission of porous silicon using near-field and far-field optical spectroscopy", *Phys. Rev.* **B60**, 4889 (1999).
- P.I. James, L.F. Garfias-Mesias, P.J. Moyer, and W.H. Smyrl, "Scanning Electrochemical Microscopy with Simultaneous Independent Topography", *J. Electrochem. Soc.* **145**, L64-L66 (1998).
- Michael A. Paesler and Patrick J. Moyer, *Near-field Optics: Theory, Instrumentation, and Applications*, Wiley-Interscience, 1996.

Patrick J. Moyer and Stefan Kammer, "High resolution imaging using near-field scanning optical microscopy and shear force feedback in water", *Appl. Phys. Lett* **68**, 3380-3382 (1996).

Patrick J. Moyer, Stefan Kämmer, Karsten Walzer, and Michael Hietschold, "Investigations of liquid crystals and liquid ambients using near-field scanning optical microscopy", *Ultramicroscopy* (NFO3 Proceedings) **61**, 291 - 294 (1995).

Patrick J. Moyer, Karsten Walzer, and Michael Hietschold, "Modification of the optical properties of liquid crystals using near-field scanning optical microscopy", *Appl. Phys. Lett.* **67**, 2129-2131 (1995).

SELECT CONFERENCE CHAIRS

Session Organizer, Near-field Optical Spectroscopy Symposium, 1996 Pittsburgh Conference, Chicago, March 1996.

Chairman, Scanning Probe Microscopy Sessions I, II, and III, Microbeam Analysis Society 1995 Annual Meeting, August 6-11, Breckenridge, CO, USA.

Co-Chairman, Near-field Scanning Optical Microscopy Session, SPIE 1995 Conference, July, San Diego, CA, USA.

SELECT INVITED TALKS

SPIE BIOS 2000, "Single molecule structure determination using near-field and far-field microscopy and spectroscopy", San Jose, January 2000.

Max-Born-Institut (Berlin, Germany), Institute Seminar, June 1999.

BioNanoTechnology Workshop, Brandenburg Economic Development Corporation (Potsdam, Germany), June 1999.

Technical University of Chemnitz (Germany), Institute of Physics Seminar, July 1998.

"Photoluminescence spectroscopy of porous silicon using near-field scanning optical microscopy", 1997 Southeast Section of the American Physical Society, Nashville, TN, November 1997.

1996 IEEE Lasers and Electro-Optics Society Annual Meeting, Boston, November 1996.

1996 Pittsburgh Conference for Analytical Chemistry, "Surface modification on a nanoscale using near-field scanning optical microscopy", Chicago, March 1996.

SELECT GRANTS AND CONTRACTS

"Development of a phase-contrast, near-field scanning optical microscope", National Science Foundation, June 2000, **\$260,000**, Prof. Robert Hocken (Mech. Eng.) is PI and Prof. Moyer and Prof. Terrill Mayes are co-PI's.

"Determination of the Light Emission Mechanism of Porous Silicon Using Near-Field Scanning Optical Microscopy and Spectroscopy", Research Corporation, June 1998, **\$26,000**.

"High Spatial Resolution Fluorescence Energy Transfer Studies of Intact Membrane Proteins Using NSOM", North Carolina Biotechnology Center, July 1997, **\$39,000**.

Steven Robert Patterson
Distinguished Professor of Precision Engineering
Mechanical Engineering and Engineering Science Department
University of North Carolina at Charlotte

Professional Preparation

Ph.D., Applied Science, University of California at Davis, 1987.
M.S., Applied Science, University of California at Davis, 1982.
B.S., Physics, California Institute of Technology, 1970.

Appointments

University of North Carolina at Charlotte, 1993 to present
United Dominion Industries Distinguished Professor of Precision Engineering,
Lawrence Livermore National Laboratory, 1979-1993
Project Manager, National Ignition Facility, 1993.
Program Leader, Brilliant Pebbles Test Program, 1991-1993.
Division Leader, Materials Fabrication Division, 1987-1991.
Associate Program Leader for Research, Precision Engineering Program, 1985-1987.
Section Leader, Fabrication Technology, 1983-1985.
Deputy Project Leader, Large Optics Diamond Turning Machine, 1979-1983.
Air Force Weapons Laboratory, 1977-1979.
Chief, Optical Physics Group, Laser Development Division.

Publications (related)

1. P.D. Knight, S. Patterson, "Repeatability and Calibration of a Grazing Incidence Cylindrical Interferometer," *Proceedings of the 12th Annual Meeting of the American Society for Precision Engineering*, 106-109 1997
2. Knight, P. D. and Patterson, S. R., "Sensitivity analysis of a cylindrical interferometer," *Proceedings of the 14th Annual Meeting of the American Society for Precision Engineering*, 436-439, 1999.
3. P. D. Knight, S. Patterson, "Simulation of a cylindrical interferometer for comparison to stylus measurement techniques," *Proceedings of the 13th Annual Meeting of the American Society for Precision Engineering (ASPE)*, St. Louis, MO, 17, 542-545, 1998.
4. V. Badami, S. Patterson, "A Frequency Domain Method for the Measurement of Nonlinearity in Heterodyne Interferometry," accepted, *Precision Engineering*, 1999.
5. S. Patterson, J. Beckwith, "Reduction of systematic errors in heterodyne interferometry," *Proceedings of the 8th International Precision Engineering Seminar, Compiègne, France*, pp 101-104, 1995

Publications (other)

1. V. Badami, S. Patterson, "A Frequency Domain Method for the Measurement of Nonlinearity in Heterodyne Interferometry," accepted, *Precision Engineering*, 1999.
2. A. Meinel, M. Meinel, J. Stacy, S. Patterson, T. Saito, "Wavefront correctors by diamond turning," *Applied Optics* 25,6, 824-825, 1986.

3. S. Patterson, D. Schmidt, "Precision roll measurement using a polarization reference," *Proceedings of the American Society for Precision Engineering 1994 Annual Meeting*, pp 80-83, 1994.
4. S. Patterson, J. Beckwith, "Reduction of systematic errors in heterodyne interferometry," *Proceedings of the 8th International Precision Engineering Seminar, Compiègne, France*, pp 101-104, 1995.
5. R. Schenz, R. Donaldson, D. Owens, S. Patterson, "Comparison of optical figure measurements by mechanical and interferometric methods," *Proceedings of the Seventh Annual Meeting of the American Society for Precision Engineering*, 1992

Jordan C. Poler, Ph.D.
Associate Professor
Department of Chemistry
University of North Carolina at Charlotte
Charlotte, NC 28223
jcpoler@email.uncc.edu

State University of New York, Brockport	B.S.	1987 Chem. & Physics (Math Minor)
University of North Carolina, Chapel Hill	Ph.D.	1992 Physical Chemistry/Materials Science
Princeton University	Postdoc.	93-95 Materials Science /Molecular Biology

Research Appointments:

7/01 - Associate Professor, University of North Carolina at Charlotte, Charlotte NC
8/95 - 6/01 Assistant Professor, University of North Carolina at Charlotte, Charlotte NC
2/93 - 8/95 NIH Postdoctoral Fellow, Princeton University, Princeton NJ
8/87 - 2/93: MCNC Research Fellow, University of North Carolina at Chapel Hill, Chapel Hill NC
5/90 - 9/90: Graduate Student Intern at the T. J. Watson Research Center, IBM, Yorktown NY
(Wickramasingh)
5/85 - 9/85; 5/86 - 9/86; 12/86 - 1/97; 5/87 - 8/87: Student Internships at the T. J. Watson Research Center,

IBM, Yorktown NY (Kovack and Buchwalter, advisors)

Administrative Appointments:

7/00 - Graduate Studies Coordinator

Fellowships:

9/93 - 8/95 National Institute of Health (NIH) Postdoctoral Fellowship
9/89 - 2/93 Semiconductor Research Corporation (SRC) Fellowship
Spring '89 Department of Education (DoE) Fellowship
Fall '88 Dobbins Fellowship (UNC-CH)
Spring '88 Microelectronics Center of North Carolina (MCNC) Fellowship
Fall '87 C. N. Reilley Fellowship (UNC-CH)

Affiliations:

American Chemical Society (ACS), American Physical Society (APS), Materials Research Society (MRS), American Association for the Advancement of Science (AAAS), American Vacuum Society (AVS), Charter Member of *ALPHA CHI* National Honors Scholarship Society

Relevant publications:

1. Poler, J.C., W.S. Woodward and E.A. Irene. Novel charge integrating pulsed I(V) technique: A measurement of Fowler-Nordheim currents through thin SiO₂ films. Rev. Sci. Instrum. 64, 781-787, (1993).
2. Poler, J.C. and E.A. Irene, Pump-probe charge integrating technique: A study of trap emission kinetics, Appl. Phys. Lett. 62(24), 3123-3125, (1993).
3. Martin, Y., J.C. Poler and H.K. Wickramasinghe. Sidewall profiling using scanning force microscopy. U.S. Patent, IBM No. Y09,91,162 (Feb. 1, 1994).

4. Poler, J.C., K.K. McKay and E.A. Irene, Characterization of the Si/SiO₂ interface morphology from quantum oscillations in Fowler Nordheim tunneling currents, *J. Vac. Sci. Technol. B* 12(1), 88-95, (1994).
5. Poler, J.C., and E.A. Irene, Investigation of trap emission kinetics in MOS capacitors using a pump-probe charge integrating technique, *J. Appl. Phys.* 75(5), 2555-63, (1994).
6. Poler, J.C., R.M. Zimmermann and E.C. Cox, Scanning Thermopower Microscopy of Guanine Monolayers, *Langmuir* 11, 2689-2695, (1995).
7. Ye, W., B. Drozd, M.A. Hasan and J. C. Poler, Cross Sectional AFM of Oxidized Porous Silicon, Atomic Resolution Microscopy of Surfaces and Interfaces, Mater. Res. Soc. Proc., 466 pp. 63-66 (1997).
8. Poler, J.C., R.M. Zimmermann and E.C. Cox., Scanning Thermopower Microscopy: a technique for organic and biological molecules complementary to STM in Procedures in Scanning Probe Microscopies edited by Richard Colton, Andreas Engle, Jane Frommer, Hermann Gaub, Andrew Gewirth, Reinhard Guckenberger, Wolfgang Heckl, Bruce Parkinson and Jürgen Rabe., John Wiley and Sons: New York, , pp 55-60 (1998).
9. Poler, J.C., Surface Oxidation Kinetics: A Scanning Tunneling Microscopy Experiment, *J. Chem. Educ.* 77, 1198-1200, (2000)
10. J. C. Poler and David Schiraldi, Atomic Force Microscopy of Polymers, Invited Review (In Press) for Encyclopedia of Polymer Science and Engineering, Set. 3rd Ed., Wiley Interscience, Jacqueline I. Kroschwitz (Editor-in-Chief)

Synergistic Activities

Undergraduate advising and Mentoring
 Undergraduate Research Education
 Science "Pen-pal" activities with local high school students
 Undergraduate Curriculum Reform
 Development of new undergraduate physical chemistry laboratory experiments
 Project Chem Lab, (Annotations of J. Chemical Education articles)

Recent Collaborators:

Prof. Ken Gonsalves	UNC Charlotte
Prof. Patrick Moyer	UNC Charlotte
Dr. David Schiraldi	Kosa Research
Prof. Wade Sisk	UNC Charlotte

Advisors

Eugene Irene, UNC Chapel Hill (Doctoral Advisor)
 Edward C. Cox, Princeton University (Postdoctoral Advisor)

Graduate Advisees	Total number of graduate students advised	6
Ms. Deborah Crombez	(MS)	
Ms. Weijun Ye	(MS)	
Mr. Jody Kendrick	(MS)	
Mr. Titus Faulkner	(MS)	
Mr. James Michael Luther	(MS)	
Mr. Scottie Mickey	(MS)	

Curriculum Vitae

NAME: M. Yasin Akhtar Raja

RANK: Associate Professor

SPECIALIZATION / EXPERTISE: Design and Characterization of VCSELs, High Speed Photonic Devices, Modules and Sub-systems; Optical Components for Telecom and Data-Com; Fiber Lasers and Optical Amplifiers, All-Optical Networks, High Power Lasers.

SKILL SUMMARY:

- *Published* over 70 papers, delivered 14 invited talks and 5 patents disclosures. supervised 18 Graduate Thesis, in addition 3 MS and 4 BS Projects, and served on 35 thesis committees.
- *Photonic Devices for Optical Communication:* Study of Er:Yb co-doped fiber lasers and amplifiers and design of gain-flattened optical amplifiers, tunable DWDM filters, and design and simulation of optical network components. Polarization mode dispersion compensation (PMDC); Study of polarization effects, and short-pulse generation in VCSELs, other optoelectronic active and passive devices; Semiconductor laser arrays and amplifiers (SOA)
- *Software knowledge:* Photonics design tools (EDFAs, and Raman Amplifiers) and Network simulations, Design simulations of transceivers and DWDM modules (OC192 and OC768), C-band and L-band EDFAs Mux/de-Mux and gain-equalization, Waveguides and “holley fibers”.
- *High Power Lasers:* Design and fabrication of Nd:YAG, Ti:Sapphire and Nd: Vanadate Lasers, High Power Semiconductor and Fiber Lasers / Amplifiers

EDUCATION:

Ph.D. in Laser Physics /Optoelectronics[†], University of New Mexico, Albuquerque, USA, 1988
M. Phil in Laser Physics, Quaid-i-Azam University, Islamabad, Pakistan, 1979

PROFESSIONAL SUMMARY:

Associate Professor of Physics, UNC Charlotte, NC, USA, 1996-present.

Assistant Professor of Physics, UNC Charlotte, NC., USA, 1990-96.

Senior Research Associate, Center for High Technology, Electrical Engineering Department, University of New Mexico, Albuquerque NM., USA, 1988-89.

Research Assistant, Center for High Technology, Electrical Engineering, Department, University of New Mexico, Albuquerque NM, USA, 1984-88.

Senior Scientific Officer, Electronics Division, PINSTECH, Islamabad, Pakistan, 1979-83

➤ **Patents:**

Sole or co-inventor of the following inventions:

Invention Disclosure UNC-Charlotte:, “Dynamic Polarization Mode Dispersion Compensator (Technique and Apparatus Design)”, (initial appl. Nov. 19, 2001)

US. Patent No. 5,920,390: “Fiber-optic Interferometer and Associated Method for analyzing Tissue”, (Joint with Drs. Splinter & Farahi; July 1999).

Invention Disclosure UNC-Charlotte: “Novel Design for Ultra-Short Pulse VCSELs”, (Joint with Dr. D. C. Kilper & G. D. Dorazio; 1998) (*Filed provisionally*)

Invention Disclosure UNC-Charlotte:, “Ultra-short Laser Pulse Generator”, (July 28, 1995)

U.S. Patent No. 4,881,236: “Wavelength Resonant Surface-Emitting Semiconductor Laser (VCSEL)”, Joint with Brueck et. al. (Nov. 1989).

† Ph.D. Dissertation title: “*Optically Pumped, Wavelength-Resonant Surface-Emitting Semiconductor Laser*”, It was a pioneer work on VCSELs.

➤ **Other Areas:**

Professional Affiliations: Member of The Optical Society of America (OSA) since 1986; The Institute of Electrical and Electronics Engineers (IEEE); since 1988; ComSoc since 1996; The International Society for Optical Engineering (SPIE) since 1996; The National Physics Honor Society (Sigma Pi Sigma) 1990

Reviewer/Referee for Professional Journals, Electronics Letters, Optical Engineering, Applied Physics Letters, Journal of Quantum Electronics, Optics communications, Photonics Technology Letters, Solid State Electronics, Annals of Biomedical Engineering, Journal of Applied Physics.

RECENT / SELECTED PUBLICATIONS :

i) Articles in Refereed Journals and Proceedings:

- M. Y. A. Raja, A. Al-Dwayyan, Y. Cao, and C. X. Wang, "Polarization and Spatial-Mode Behavior of Short-Wavelength VCSELs" (*in press*) J. Optics and Laser Technology, 2001
- M. Y. A. Raja, A. Al-Dwayyan, Y. Cao, and C. X. Wang, "Polarization and Spectral Properties of Ion-implanted and Oxide-confined VCSELs" , (*in press*) J. Optical Engineering, 2001
- A. Al-Dwayyan, Y. Cao, M. Y. A. Raja, and C. X. Wang, "Low-Frequency Pulsation in VCSELs Coupled to a Long External Cavity", (*in press*) IEE Proc. Optoelectronics, 2001
- R. Splinter, R. Ramaiah, H. Deshmukh, M. Y. A. Raja, "3-D interactive visualization of light-tissue interaction using Java", 'Applications of Photonic Technology IV' ICAPT2000 – Photonics North, SPIE Proc. Vol. 4087 pp.1067-78 (2000)
- K-S Kang, W.N. Sisk, M.Y.A. Raja, and F. Farahi, "Field-Enhanced Degradation of Pyromethene Dye" J. Photochem. & Photobiol. A: Chemistry 121, 133-140 (1999).
- W.N. Sisk, D. H. Kang, M.Y.A. Raja, and F. Farahi, "Photocurrent and Optical Limiting Studies of C₆₀ Films and Solutions" Int. J. Optoelectronics Vol. 11, 325 (1997).
- M.Y.A. Raja, M. Yousaf, and D. Allen, "In Search of Photon's Elementary Axial Magnetostatic Field", Appl. Phys. B Vol. 64, 79(1997).
- M.Y.A. Raja, D. Allen, and W. Sisk, Room-Temperature Inverse Faraday Effect in Terbium Gallium Garnet", Appl. Phys. Lett. 67, 2123(1995).

ii) Articles in Conference Proceedings:

- M. Samara, M. Y. A. Raja, and S. K. Arabasi, "High-Gain Short-Length Phosphate Glass Er-Yb-Doped Fiber Amplifier", OSA, Symp. Optical Devices, Components & Systems, OPTO S. E. Clemson SC, Oct. 4-5, 2001.
- S. K. Arabasi, M. Y. A. Raja, and A. M. Samara, "Simulations of Polarization Mode Dispersion Phenomena and Compensation using VPI⁺ Software Package", OSA Symp. Optical Devices, Components & Systems, *ibid*
- D. C. Kilper, K. Croussore, E. Rowell, and M. Y. A. Raja, "Polarization Dependent Intensity Noise in Er/Yb co-doped Fiber Lasers", CLEO'2001, Baltimore, MD, USA. 2001.
- Dwayyan, Y. Cao , M. Yasin Akhtar Raja , and C. X. Wang, "Low Frequency Pulsation in the VCSEL Coupled to a Long External Cavity" presented in SIOE'2001, "Semiconductor and Integrated Optoelectronics" Conf. in Cardiff , UK 2001.

FUNDING:

- "High-Density Three-dimensional Packaging Technology for Giant Magnetoresistive Memory Devices", Leading PI for multi-institutional consortium with UNC Charlotte as Leading institution (others include TC, RTP, NC, College of William and Marry, NC A&T University, and University of Florida; Requested Funds **\$1.685 million** including subcontracts for one-year and program extends over 3 years with similar additional budget figures. (in the process of being finalized)
- "Microsphere Stabilized Lasers for Metrology", from 'Precision Metrology Center Affiliates Fund', March'1998-01, **\$161,500 for 3+ years** (Joint with Dr. C. Kilper).
- *Past accumulative Grants: \$ 885,590 as \$101,590 from* the Charlotte-Mecklenburg Health Services Foundation, Inc (with R. Splinter); \$59,000 from Whitaker Foundation, and \$ 725,000 from DARPA (with M. Feldman and I. Turlik).

Honors and Awards: Fellowship for *Ph.D.* (Institute of Modern Optics, UNM, Albuquerque, NM, USA) 1984.: 4.0 Grade Point Average (on scale of 4) in graduate school (UNM, Albuquerque, NM, USA) 1987: Fellowship for *M. Phil.* (Pakistan National Science & Technology) 1976-79: Merit Scholarship for *M. Sc.* (University of Islamabad) 1974-75.

CURRICULUM VITAE

Dr. Wade Napoleon Sisk
Department of Chemistry
University of North Carolina Charlotte
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Charlotte, NC 28223-0001
E-mail: wsisk@email.uncc.edu

PROFESSIONAL PREPARATION

University of Iowa, Iowa City, IA	Chemistry	B.S. 1984
University of California, Berkeley, CA	Physical Chemistry	Ph.D. 1990
Tokyo Institute of Technology, Tokyo, Japan	Gas Phase Photochemistry Japan Society for the Promotion of Science, Postdoctoral research fellow.	1990-1991
Hitachi Research Laboratory, Hitachi-Shi, Japan	Organic Photoconductors postdoctoral researcher	1991-1992
Brookhaven National Laboratory, Upton, NY	Diode Laser Spectroscopy postdoctoral researcher	1992-1993

APPOINTMENTS

University of North Carolina at Charlotte	Chemistry Assistant Professor	1993-present
The Institute of Physical and Chemical Research RIKEN	Science and Technology Visiting Researcher	1997-1998

PUBLICATIONS

A. Organic Photonics Publications

1. M. Mackey and W. N. Sisk, "Photostability of Pyrromethene 567 Laser Dye Solutions via Photoluminescence Measurements" *Dyes and Pigment* **51** (2001) 79.
2. K. Kang, W. N. Sisk, M. Y. A. Raja, and F. Farahi, "Field-enhanced Photodegradation of Pyrromethene Dye Films," *J. of Photochem. and Photobiol. A: Chemistry* **121** (1999) 133.
3. W. N. Sisk, D. Kang, M. Y. A. Raja, and F. Farahi, "Photocurrent and Optical Limiting Studies of C₆₀ Films and Solutions," *Int. J. Optoelectronics* **11** (1997) 325.
4. Z. Cao, B. Lee, W. Sisk, W. Samuels, and G. J. Exharhos, "Photoresponse of Tb⁺³ Doped Phosphosilicate Thin Films," *Materials Research Bulletin* **32** (1997), 1285
5. W. Sisk, K. Kang, M. Y. A. Raja, and F. Farahi, "Matrix and Donor/Acceptor Dependence of Polymer-Dispersed Dye Photoconductivity," *Int. J. Optoelectronics* **10** (1995) 95.

B. Other Publications

1. S. N. Henegar, H. Bui, S. F. Bush, and W. N. Sisk, "Nitric Oxide Chemiluminescence Enhancement by Substituted Benzenes" *J. of Photochem. and Photobiol. A: Chemistry* **135** (2000) 91.

2. W. N. Sisk, N. Sarkar, S. Ikeda, and H. Hayashi, "Influence of Large Magnetic Fields on Fluorescence of Gaseous CS₂ Excited through Several V Bands," *J. of Phys. Chem. A* **103** (1999) 7179.
3. W. N. Sisk, K. Kang, F. Farahi, and M.Y.A. Raja, "Electric Field Induced Photodegradation of Pyrromethene Dye Films," *Polym. Prepr.* **39** (1998) 1061.
4. Kang, W. N. Sisk, F. Farahi, and M. Y. A. Raja, "Photodegradation Studies of Fullerene-Doped Polymer Films," *Proc. International Symposium on the Science and Technology of Atomically Engineered Materials* Nov. 1995.
5. K. Kang, W. Sisk, F. Farahi, and M. Y. A. Raja, "Photocarrier Generation Efficiency of Pyrromethene-Doped Polymers," *Proc. Organic Thin Films Photonic Appl. Topical Meeting*, Sept. 1995, MD12-1.

SYNERGISTIC ACTIVITIES

Judge for the North Carolina Louis Stokes Alliance for Minority Participation (NCLSAMP), Raleigh, NC, April 20, 2001 and Winston-Salem State University, April 14, 2000.

Utilized TopClass On-line software to create 10 tutorials and on-line lectures for freshmen chemistry (CHEM 1251).

Served as the Science Coordinator for the University Transition Opportunities Program (UTOP), summer 1996. Authored the program's science teaching manual containing over 150 math and science problems.

Regional Treasurer, American Chemical Society (1996).

Participated as a mentor to Tabarius Smith (1994) and Jerrell Brown (1999) in the federally funded Ronald E. McNair Post-Baccalaureate Achievement Program, for preparing minority college students for graduate/ professional studies.

COLLABORATORS & OTHER AFFILIATIONS

(i) Collaborators.

Dr. Mamoun Bader, Assistant Professor of Chemistry, Penn. State University, Pennsylvania.
 Dr. S. Fowler Bush, Professor of chemistry, The University of North Carolina Charlotte
 Dr. Faramarz Farahi, Professor of Physics, The University of North Carolina Charlotte.
 Dr. Kenneth Gonsalves, Professor of Chemistry, The University of North Carolina, Charlotte
 Dr. Harold Freeman, Ciba-Geigy Professor, Department of Textile Engineering,
 Chemistry and Science, North Carolina State University, Raleigh, NC
 Dr. Hisaharu Hayashi, Director of the Molecular Photochemistry Group, The
 Institute of Physical and Chemical Research (RIKEN), Japan.
 Dr. Shigeru Ikeda, Research Chemist, The Molecular Photochemistry Group, RIKEN
 Dr. Yasin Raja, Associate professor of physics, The University of North Carolina Charlotte
 Dr. Nilmoni Sarkar, Indian Institute of Technology, Kharagpur, West Bengal, India
 Dr. Nobuaki Tanaka, Assistant professor of chemistry, Shinshu University, Nagano, Japan

(ii) Graduate and Postdoctoral Advisors.

Doctoral thesis advisor: Professor Harold Johnston, Chemistry Department, University of California y
 Postdoctoral Research Advisor: Professor Kinichi Obi, Tokyo Institute of Technology, Tokyo, Japan
 Postdoctoral Research Advisor: Dr. Toshiro Saito, Hitachi Research Laboratory, Ibaraki-ken, Japan
 Postdoctoral Research Advisor: Dr. Ralph Weston Jr., Brookhaven National Laboratory, Upton, NY

(iii) Thesis Advisor for the following.

Graduate students = 3: Kwang-Sun Kang (MS & Ph.D.), Dong Hee Kang (M.S.), and Stacey Henegar (M.S.).

RAPHAEL TSU, DISTINGUISHED PROFESSOR, ECE, UNC-Charlotte, Charlotte, NC 28223

Education BS - U of Dayton, 1956; M S. - Ohio State U, 1957; Ph. D - Ohio State, 1960

Experience: Dr. R. Tsu started his professional career at the Bell Telephone Laboratories, Murray Hill, NJ, working on the theory and experiments related to electron-phonon interaction in piezoelectric solids. He played a major role in the understanding of stimulated phonon emission when a solid state ultrasonic amplifier was invented at BTL. He became a close collaborator of Leo Esaki (Nobel Laureate in 1973) at IBM T.J. Watson Research Center where he joined in 1966. He was involved with the theory and experiments of optical and transport properties, band structures, luminescence and Raman scattering, tunneling and material characterization. A man-made semiconductor superlattice and modulation doping were conceived jointly with Esaki, in 1969. His work on the superlattices and resonant tunneling through a quantum well, led to his outstanding contribution award from IBM Research in 1975 and later in 1985, to sharing the International New Materials Prize of the American Physical Society with Esaki and Chang. In 1979, he became the head of materials research at Energy Conversion Devices, Inc., in charge of the study on the formation and structure of amorphous silicon. His major contributions involve the determination of bond angle distribution and conductivity percolation. In 1985, he became the head of the amorphous silicon research group at the Solar Energy Research Institute (now NREL) as a principal scientist, working on amorphous Si/Ge and Si/C alloys. In 1975, as the recipient of the Alexander von Humboldt award, he took a year sabbatical at Max Planck Institute for Solid State Physics in Germany. In 1977, he took a year of sabbatical at the Physics Institute, Campinas, Brazil. While at ECD, he took a sabbatical at the University of Sao Paulo, Brazil, teaching solid state physics and established a deposition laboratory. Since 1988, he has been a professor at University of North Carolina at Charlotte, and directing research on the physics of quantum confinement, nanoscale particles and optoelectronic devices. Since 1996, he became the Distinguished Professor of the Department of Electrical Engineering. His most recent work involves a new type of semiconductor-atomic superlattice particularly in silicon, and cooling of electronic devices by field emission into the vacuum.

Honors: Am. Phys. Soc. International New Materials Prize - 1985; Fellow of Am. Phys. Soc. - 1980; Patent awards - IBM 1973 and 1979; Outstanding Contribution Award -IBM 1975; Alexander von Humboldt Award - 1975.

Most Relevant List of Publications

- 126 Silicon Quantum Well with Strain-Layer Barrier, R. Tsu, Nature **364**, 19 (1993).
- 132 Doping of a Quantum Dot, R. Tsu and D. Babic, Appl. Phys. Lett. **64**, 1806 (1994).
- 145 A Simple Model For The Dielectric Constant Of Nanoscale Silicon Particle, R. Tsu, D.Babic, and L.Ioriatti, J. Appl. Phys. **82**, 1327(1997)
- 151 Silicon Epitaxy on Si(100) with Adsorbed Oxygen, R. Tsu, A.Filios, C.Lofgren, K.Dovidenko, and C.G.Wang, Electrochem. & Solid State Lett. **1**, 80 (1998).
159. R. Tsu, ECS Proc. **98-19**, 3 (1999)
162. R. Tsu and R.F.Greene, Inverse Nottingham Effect Cooling, Electrochem and Solid State Lett. **2**, 645 (1999)
163. Ultra-stable Visible Electroluminescence from c-Si/O Superlattice, Q.Zhang, A.Filios, C.Lofgren and R. Tsu, Physica-E, North Holland, **8** (4),365-368,(2000)

Current Federal Grants

DARPA : HERETIC - PI, involves 5 universities and one Corporation, 1999-2002
ARO: Semiconductor-Atomic Superlattice, 1999-2002
NSF : LED with Si/O Superlattice, 1999-2000

Robert K. Tyson

Education:

- Ph.D. Physics, West Virginia University, 1978
Dissertation: *The Anger Gamma Camera Point Spread Function: Calculation and Applications*. Advisor: Sharad R. Amtey, Ph.D.
- M.S. Physics, West Virginia University, 1976
Thesis: *Problems in Resolution Measurement of Radiographic and Nuclear Imaging Systems*. Advisor: Sharad R. Amtey, Ph.D.
- B.S. Physics, Pennsylvania State University, 1970

Employment History:

- Associate Professor, Department of Physics and Optical Science, The University of North Carolina at Charlotte, August 1999 – present.
- Senior Scientist, Schafer Corporation, Chelmsford, MA 1987- 1999. Optical system development including adaptive optics systems for imaging, laser communications, and optical remote sensing, Technology development of micromachined adaptive optics, wavefront sensing techniques, and the study of atmospheric turbulence.
- Senior Project Engineer, United Technologies Optical Systems, West Palm Beach, FL, 1978 - 1987. Technical Director for a number of development programs including coherent optical phasing of multiple apertures, the first magnetostrictive-actuator deformable mirror, and the first infrared laser used in surgical anastomosis (tissue welding).

Recent Publications:

- R. K. Tyson, B. W. Frazier, "Microelectromechanical programmable aberration generator for adaptive optics," *Appl. Opt.* **40** 2063, 2001.
- R. K. Tyson, "Bit-error rate for free-space adaptive optics laser communications" *J. Opt. Soc. Am. A* (accepted for publication) 2002.
- Robert K. Tyson, *Introduction to Adaptive Optics*, SPIE Eng. Press, 2000.
- Robert K. Tyson, Editor; *Adaptive Optics Engineering Handbook*, Marcel Dekker, New York, 1999
- Robert K. Tyson, *Principles of Adaptive Optics*, 2nd Ed., Academic Press, Boston, 1997.
- Robert K. Tyson, Chapter 1: Introduction; *Adaptive Optics Engineering Handbook*, Marcel Dekker, New York, 1999
- R. K. Tyson, "Performance assessment and applications of MEMS adaptive optics," *Proc. 2nd Intl. Workshop on Adaptive Optics for Industry and Medicine*, World Scientific, Singapore, 2000.
- R. K. Tyson, "Adaptive optics and ground-to-space laser communications," *Appl. Opt.* **35**, 3640, 1996.
- R. K. Tyson, "Adaptive optics compensation of atmospheric turbulence: the past, the present, and the promise." Invited Paper; *Proc. SPIE* **2222**, 404, 1994.

Recent External Funding:

The University of North Carolina at Charlotte

Xinetics Inc. (2000-2002) \$169,027

North Carolina Space Consortium (2001) \$10,000

North Carolina Space Consortium (2000) \$2,000

SPIE – The Optical Engineering Society (2001) \$2,000

Schafer Associates

U. S. Naval Air Warfare Center (1999) \$600,000

U. S. Naval Air Warfare Center (1997-1998) \$140,000