2006-674: DEVELOPMENT OF AN ELECTRICAL ENGINEERING TECHNOLOGY PHOTONICS TRACK

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Development of an Electrical Engineering Technology Photonics Track

Abstract

In this paper, we will detail the development of a Photonics Track designed to meet the need for Photonics Technologists in industry. The degree concentration includes eight upper level photonics courses that were chosen to provide a well rounded education in all aspects of photonics. The details of each course and why it was included in the program will be discussed. The program has been offered for two years and the first degrees have now been awarded. An assessment of the success of these graduates will also be presented.

Introduction

Photonics is a broad term applied to all fields involving the generation, manipulation, and detection of light. Light has been an area of study for thousands of years but the use of photonics such as mirrors and lenses has only been applied in the last 700 years. It wasn't until 1960, with the first demonstration of the laser that the field of photonics began to mature. In the last three decades, photonics has begun to emerge from the laboratory to solve more common industrial and commercial problems. Examples would be the Compact Disc and Digital Versatile Disc players and recorders. Today, almost all commercial products involve some level of photonics technology from simple light emitters such as light emitting diodes to more complex holographic optical elements used to diffuse light in rear projection televisions. This recent exponential growth of photonic technologies has left a deficit of qualified human resources. Traditionally, photonics was only taught at the graduate level. As photonics has moved from the laboratory to commercial products the need for Associate and Baccalaureate graduates has subsequently increased.

In the past, photonics technologies were only used in what is considered high-technology systems. Today, photonics is used in the thousands of commonly used products to solve a variety of everyday problems. In the last few decades, new ways of transmitting and manipulating light or photons have been developed. The use of electrons for transmitting data across the world proved to be inadequate with the increased need for telecommunications for phone and Internet. Now most communication is made using thin glass fibers called fiber optics. Most technologists agree that the electron was the workhorse of the last century and the photon is the workhorse of the next century.[1]

The Center for Occupational Research and Development (CORD) is a national nonprofit organization providing innovative changes in education to prepare students for greater success in careers and higher education. In 2000 the National Science Foundation (NSF) funded CORD to complete a program called the Scientific and Technological Education in Photonics (STEP).[2] A major part of this program was the completion of a national survey of the need for Photonics Technicians. The goal of this survey was to predict the number of photonics technicians needed by the year 2005. The results of the survey showed that the need would grow by approximately 6000 technicians per year for a total of approximately 31,000 additional workers by 2005.

In 1999, Angelou Economic Advisors, an economic development consulting firm, developed the Metro Orlando Technology Strategy for the City of Orlando, Florida.[3] The goal of this strategy was aimed at marketing the Central Florida region for accelerated high-technology growth referred to as a high-tech boom. This strategy identified four industries, including Photonics, with existing strength that should be targeted for future growth.

The High-Tech Corridor, stretching from St. Petersburg to Melbourne is home to over 100 photonics related companies. Photonics companies currently contribute $4B to the state of Florida and $2.2B to Central Florida. The College of Optics and Photonics, at the University of Central Florida's, is a recognized leader in photonics research.

The Angelou study presented several critical factors for the successful economic development of the Central Florida region. The first and foremost of these was the ability to attract, train, and retain a technologically skilled workforce. The study showed that to do this would require a strong commitment by the higher educational system.

A second study conducted by ERISS Corporation for the Florida Photonics Cluster (FPC) showed that there is an immediate need for Photonics professionals.[4] The results of the study indicated that participating companies in what is known as the High-Technology Corridor needed employees with a technology degree specializing in Photonics.

These studies showed that there was an existing need for Photonics Technologists that would increase as a result of the Metro Orlando Technology Strategy. Unfortunately, there were no colleges in the state of Florida that were graduating the necessary people to fill the industry need.

The Department of Engineering Technology at the University of Central Florida formed an industry educational advisory board, in late 2001, to assess the needs of the local industry. These industry representatives wanted graduates with a 4-year technology degree with a strong foundation in electronics and a specialization in photonics. From these interactions, it was determined that a Photonics concentration could be added to the existing Electrical Engineering Technology four-year degree program (BSEET).

In this paper, we will discuss existing photonics programs currently only offered at the community college level. A detailed description and justification will be made for each of the courses included in our photonics concentration or track. Finally, observations of the programs success to date will be presented.

Existing Photonics Technology Programs

In the early stages of developing our BSEET-Photonics degree, research was performed to discover and evaluate existing photonics technology programs. The term "technology" is important since the program that we intended to develop was not an engineering program. Some of the existing programs that we found were 4-year Optical Engineering degrees. An example would be the B.S. in Optics degree offered by the University of Rochester. These engineering programs are not included in our discussion.

Cincinnati State Technical and Community College - Cincinnati, OH
Degrees Available: A.A.S. Laser Electro-Optics Engineering Technology
Accreditation: TAC/ABET
Total Credits Required: 120 hours

Photonics Related Courses:

Prefix	Number	Title	Credits
LOT	6715	Laser Safety	3
LOT	6720	Geometrical and Wave Optics	4
LOT	6730	Optical Components and Devices	4
LOT	6735	Industrial Laser Systems	4
LOT	6740	Applications of Lasers	4
LOT	6741	Introduction to Fiber Optics	4
LOT	6749	Laser Electro-Optic Project	2
LOT	6758	Laser Electronics	3
LOT	6745	Optical System Design	4
LOT	6750	Laser Electro-Optic Measurements	4
LOT	6768	Laser Maintenance	3

Queensborough Community College – Bayside, NY
Degrees Available: A.A.S. Laser and Fiber Optics Technology
Accreditation: TAC/ABET
Total Credits Required: 64

Photonics Related Courses:

Prefix	Number	Title	Credits
LOT	6715	Laser Safety	3
LOT	6720	Geometrical and Wave Optics	4
LOT	6730	Optical Components and Devices	4
PH	231	Fund. Lasers and Fiber Optics	4
PH	232	Lasers and Electro-optics Tech.	5
PH	233	Lasers/Electro-optics Devices	4
PH	234	Fiber Optic Devices	4
PH	235	Lasers/Electro-Optics Projects	3
PH	236	Intro. Computers in Electro-Optics	2

Texas State Technical College – Waco, TX
Degrees Available: A.A.S. Laser Electro-Optics Technology program
Accreditation: None
Total Credits Required: 72

Photonics Related Courses:

Prefix	Number	Title	Credits
LOTT	1241	Electro-Optic Components	2
LOTT	1301	Intro. to Fiber Optics	3
LOTT	1343	Geometrical Optics I	3
LOTT	1344	Fundamental of Lasers and Safety	3
LOTT	1372	Overview in Technology of Laser	3
LOTT	2332	Laser Maintenance and Repair	3
LOTT	2336	Wave Optics	3
LOTT	2339	Geometrical Optics II	3
LOTT	2341	Laser Optics Project	3
LOTT	2344	Pulsed Wave Lasers	3
LOTT	2346	Continuous Wave Lasers	3
LOTT	2349	Photonics	3
LOTT	2451	Laser Technology	4
SMFT	1211	Vacuum Principles	2
SMFT	2335	Vacuum Technology	3

Monroe Community College – Rochester, NY
Degrees Available: A.A.S. Optical Systems Technology
Accreditation: None
Total Credits Required: 68

Photonics Related Courses:

Prefix	Number	Title	Credits
OPT	131	Optical Elements and Ray Optics	4
OPT	135	Measurement and Analysis	4
OPT	151	Optical Instruments and Testing	4
OPT	153	Fiber Optics	3
OPT	211	Wave Optics and Apps	4
OPT	213	Optical Processes	4
OPT	215	Electro-Optic Devices and Systems	5
OPT	231	Lasers: Technology and Applications	4
PHO	201	Photo Science	4

Central Carolina Community College – Sanford, NC
Degrees Available: A.A.S. Lasers and Photonics Technology
Accreditation: None
Total Credits Required: 74

Photonics Related Courses:

Prefix	Number	Title	Credits
LEO	111	Principals of lasers	1
LEO	211	Photonics Technology	5
LEO	212	Photonics Applications	3
LED	223	Fiber Optics	3

Three Rivers Community College – Norwich, CT
Degrees Available: A.S. Photonics Engineering Technology
Accreditation: None
Total Credits Required: 66

Photonics Related Courses:

Prefix	Number	Title	Credits
PHO	K105	Laser Safety	0.5
PHY	K140	Intro. to Optics	4
PHY	K141	Applied Optics	4
PHO	K230	Laser Electronics	4
PHO	K240	Intro. to Lasers	4
EET	K2140	Telecommunications	3
EET	K2141	Telecommunications Lab	1.5
PHO	K250	Fiber Optics	4
PHO	K290	Advanced Laser Topics	3

Curriculum Developed for the UCF BSEET-Photonics Degree

The expected outcome of our students graduating with the photonics concentration is that they have a well-rounded understanding of the entire field. The objective of many of existing Associates Degree programs is to graduate students with a specialty geared towards a particular local industry. These programs are effective at providing particular companies with the human resources they require. However, as the industry focus shifts, these students will require additional training. It is the objective of the BSEET-Photonics program, to graduate students with an understanding of all aspects of the photonics field. These students can then fill the needs of a variety of photonics companies working in different specific areas. Ideally, this plan reduces the investment required by the company for training of their technicians. A graduate from our program will require only brief apprenticeship training since they have a broad educational foundation.

The basis for the Photonics Track is the ABET accredited B.S. in Electrical Engineering Technology degree. The courses described below are the Upper Level Required Courses that students must complete to obtain the BSEET-Photonics degree.

Upper Level Required Courses

Prefix	Number	Title	Credits
EET	4548	Power Systems	3
EET	3716	Network Analysis	3
EET	4158C	Linear Integrated Circuits	3
EST	3222	Intro. to Photonics Technologies	3
EST	3213	Photonics Simulation	3
EST	3211	Wave Photonics	3
EST	4236	Laser Systems Technology	3
EST	4227	Photonic Sensors and Devices	3
ETM	4225	Manufacturing of Photonics	3
EST	4256	Photonics Communication	3
ETG	4950	Senior Design - Photonics	3

Introduction to Photonics Technologies
This course will introduce engineering technology students to the field of Photonics. The course begins with the nature and properties of light and then progresses towards photonics devices and systems.

Photonics Simulation[5]
This course is a study of geometrical optics and optical system design. This course starts with lessons on thin and thick lens calculations. These calculations are then used to design real lenses and systems using a computer raytracing software program.

Wave Photonics[6]
The Wave Photonics course is centered on the mathematical wave nature of light historically referred to as physical optics. Students learn concepts such as light interference and diffraction. The course includes photonic devices that utilize the wave nature of light.

Laser Systems Technology[7]
This is a comprehensive course in laser technology. The course begins with laser theory and progresses towards existing laser systems currently employed in industry. The goal of the course is to familiarize students with laser operation, terminology, and an in-depth understanding of how lasers are used in industry.

Photonics Sensors and Devices
The objective of this course is to provide students with an understanding of how light is collected and detected using modern point and array detectors. Initially, mathematical concepts concerning the transfer of light energy to electrical energy are discussed. By the end of the course, students have a deep knowledge of how modern detectors are used in common systems such as digital cameras.

Manufacturing of Photonics
This course covers all aspects of the manufacturing of photonic components and photonic systems. Manufacturing issues such as tolerance, alignment, and troubleshooting are taught. Students get an in-depth view of how photonics are manufactured in both small and high volume in the photonics industry today.

Photonics Communication[8]
The main topic of this course is modern photonic communication systems such as fiber optics. The course covers topics from basic fiber optic operation to large scale communication systems currently employed in the modern world.

Senior Design - Photonics
The Senior Design course is the capstone course required by all graduation engineering technology students. Students enrolled in the BSEET-Photonics program are required to complete a project that utilizes photonics.

Conclusions

The BSEET-Photonics program was approved by the State of Florida in April 2003. In the Fall 2004 semester the program enrolled approximately 10 students. Since that time the program enrollment has increased to approximately 40 students. The first two students graduated in Spring 2005 with one additional graduate Fall 2005. These three students are now currently employed in the Orlando, Florida area by photonics based companies. The average starting salary of these students (although it is a small sample) is $50,000. This salary is equivalent to $65,000 in Boston Massachusetts or $72,000 in San Jose, California.

Currently, the feedback from employers has been good concerning the starting knowledge or our students. A true assessment of the impact of our program to local industry will not be possible for several years.

Our intent is to continually interact with local employers to keep our program valuable to the State. As more of our students enter the workforce, information concerning their strengths and weaknesses will be used to enhance the BSEET-Photonics program.

References

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6. Eugene Hecht, *Optics*, ISBN 0-8053-8566-5.
7. Jeff Hecht, Understanding Lasers, ISBN 0-7803-1005-5.
8. Gerd Keiser, Optical Communications Essentials, ISBN 0071412042.