**Shedding Some More Light on Photonics**[1]

***April 2009 Research Brief***

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Photonics involves the process of generating and harnessing light and other forms of radiant energy whose basic unit is the photon,[2] which carries electromagnetic radiation of all wavelengths including gamma rays, X-rays, ultraviolet light, visible light, infrared light, microwaves and radio waves.[3] The field of study includes light emission, transmission, deflection, amplification and detection, lasers, fiber optics, electro-optical instrumentation and electronics.[4]

Prior to the use of the photon in photonics, electrons dominated the landscape in electronics. Technology in the 20th century was dependent on the development of electronics, which includes the control, manipulation, transfer and storage of information using electricity. The ability to conduct electricity over metal wires has been fundamental in the development of the transistor and microprocessors, which has led to many advances with computers and automation.[5]

Photonics is similar to electronics in that it involves the control, manipulation, transfer and storage of information. But instead of utilizing electricity, photonics use light. Optical fibers are used to transmit the light and information.

Research with photonics was first conducted in the 1950s, but the experiments with sunlight and mercury arc lamps were not successful. The discovery and use of lasers in the 1960s brought some advancement,[6] "and its impact in telecommunications was enabled by the perfection in the late 1970s of low signal loss optical fibers for long haul undersea and terrestrial communications."[7] A major breakthrough came in 1999 when a

[1] Based on CERC's April 2008 *Research Brief*, this summary looks at components of the photonics industry and changes that occurred during 2008.
[2] The Photonics Dictionary, Laurin Publishing
[3] http://en.wikipedia.org/wiki/Photon
[4] http://www.photonics.com/directory/dictionary/lookup.asp?url=lookup&entrynum=3996&letter=p
[5] http://www.answers.com/topic/electronics?cat=technology
[6] Encyclopedia of Emerging Industries, Grey House Publishing
[7] http://www.lightexpress.soton.ac.uk/photonics.php

"laser time division multiplexing system" was created that quadrupled information transmission sent over a fiber-optic cable, making data transmission much faster and inexpensive.[8]

It is not surprising that an area expected to have many applications for photonics in the 21st century is in telecommunications, particularly optical fiber systems.[9] Other possible applications, based on recent developments in the industry, include biochips, neuroscience, pharmaceuticals, cytometry (sorting microscopic particles in a fluid stream), orthopedics, gene chips, prosthetic devices, ceramics, computer processing, imaging and printing.[10] The application of photonics varies from energy generation to detection to communications and information processing.[11]

What are some exciting photonics developments on the horizon?

- The area of optoelectronics is a potential application, which involves photonics and microelectronics. Products using optoelectronics include advanced liquid crystal displays, high efficiency silicon solar cells and medical eye surgery devices.
- The transition from copper wires to fiber optic cables is expected to occur on a much larger scale once transmission of information is needed to exceed 10 Gbit/s[12] -- telecommunications industries would see changes at that time.[13]
- Optical storage technology has grown considerably since the 1980s and has the potential to grow further. Spintronics is a new field that incorporates photonics, electronics and magnetism, and may have the capability of making computer processing faster.[14]
- Video displays have been changed dramatically by electro-optics – the flat panel display has revolutionized the television and computer monitor industries. Other applications may involve high-definition television with two-way communications.[15]
- Photonics research is also underway to discover military applications. Weapons systems based on light may be more reliable in battle conditions.[16]

[8] Encyclopedia of Emerging Industries, Grey House Publishing
[9] Encyclopedia of Emerging Industries, Grey House Publishing
[10] Encyclopedia of Emerging Industries, Grey House Publishing, according to Insight Research Corporation
[11] http://www.photonics.com/directory/dictionary/lookup.asp?url=lookup&entrynum=3996&letter=p
[12] gigabit per second
[13] Kevin Krewell, Electronics News, 11/1/05.
[14] Encyclopedia of Emerging Industries, Grey House Publishing
[15] Encyclopedia of Emerging Industries, Grey House Publishing

The U.S. is a large consumer of photonics technologies, in addition to researching its applications for approximately 50 years. Since photonics has many applications in many industries, there is no single set of industry codes (SIC or NAICS[17]) that encompass the sector in its entirety. And many activities are still emerging and do not have industry codes assigned to them. However, a number of industries can be analyzed that encompasses most of the photonics activities, although the industry definition may not be comprehensive.[18]

Figure 1 shows that there were more than 18,000 photonics establishments in the U.S. in March 2009, up from almost 15,000 in 2008 Q2. Connecticut had 287 photonics establishments in 2009, up 16 percent from the same time last year. Connecticut's establishments comprised 1.6 percent of all the photonics companies in the nation. These companies employed almost 4,300 workers, which was an increase of 14 percent from the year before. Three of the 15 states listed in Figure 1 lost employment in photonics industries (Minnesota, Pennsylvania and Arizona) while the U.S. and the other states had gains.

On a per capita basis, Connecticut's photonics employment was slightly above the national average, and was the 12th highest in the nation. In fact, seven of the nine Northeastern states are listed in the top 15 according to photonics employment per one million population (New Hampshire, Rhode Island, Massachusetts, New York, New Jersey, Pennsylvania and Connecticut).

Even though the global recession is impacting virtually every industry in the U.S., the photonics industries as a whole have seen establishment and employment growth. And two of the three "rising star" companies noted by PhotonicsOnline are Connecticut Optics and Photonics Association (CTOPA) members based in Connecticut: Newport-Oriel in Stratford and Andor Technology in South Windsor.[19] Newport-Oriel produces light sources, FT-IR spectrometers, monochromators, spectrographs and solar simulators.[20] Andor Technology works on the design and manufacture of specialty

[16] Encyclopedia of Emerging Industries, Grey House Publishing
[17] Standard Industrial Classification or North American Industry Classification System
[18] See Appendix A for a list of the SIC codes used in this analysis.
[19] "Growing Optics Industry," *Hartford Business Journal*, March 23, 2009.
[20] http://www.newport.com/oriel/

cameras and other products for scientific imaging, microscopy and spectroscopy applications. [21]

**Figure 1: Photonics Establishment and Employment in the U.S. and Top States, 2008-2009**

| | Establishments | | Estabs 08-09 | | % Total Estabs | | Employment | | Emp 08-09 | | Emp per 1Mil Pop | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2008 | 2009 | # | % | 2008 | 2009 | 2008 | 2009 | # | % | 2008 | 2009 |
| Minnesota | 299 | 369 | 70 | 23% | 2.0 | 2.0 | 18,667 | 18,219 | -448 | -2% | 3,591 | 3,490 |
| New Hampshire | 131 | 164 | 33 | 25% | 0.9 | 0.9 | 3,728 | 4,322 | 594 | 16% | 2,833 | 3,285 |
| Rhode Island | 57 | 59 | 2 | 4% | 0.4 | 0.3 | 2,983 | 3,286 | 303 | 10% | 2,820 | 3,127 |
| Massachusetts | 532 | 609 | 77 | 14% | 3.6 | 3.3 | 14,200 | 14,763 | 563 | 4% | 2,202 | 2,272 |
| California | 2,985 | 3,541 | 556 | 19% | 20.0 | 19.3 | 61,641 | 70,260 | 8,619 | 14% | 1,686 | 1,911 |
| New York | 1,034 | 1,262 | 228 | 22% | 6.9 | 6.9 | 33,832 | 34,636 | 804 | 2% | 1,753 | 1,777 |
| New Jersey | 544 | 675 | 131 | 24% | 3.7 | 3.7 | 10,954 | 12,333 | 1,379 | 13% | 1,261 | 1,420 |
| Oregon | 221 | 270 | 49 | 22% | 1.5 | 1.5 | 4,301 | 5,188 | 887 | 21% | 1,148 | 1,369 |
| Pennsylvania | 513 | 632 | 119 | 23% | 3.4 | 3.4 | 16,990 | 16,558 | -432 | -3% | 1,367 | 1,330 |
| Maryland | 237 | 306 | 69 | 29% | 1.6 | 1.7 | 6,106 | 7,209 | 1,103 | 18% | 1,087 | 1,280 |
| Indiana | 254 | 307 | 53 | 21% | 1.7 | 1.7 | 7,600 | 8,013 | 413 | 5% | 1,198 | 1,257 |
| Connecticut | 247 | 287 | 40 | 16% | 1.7 | 1.6 | 3,749 | 4,270 | 521 | 14% | 1,070 | 1,220 |
| U.S. | 14,898 | 18,353 | 3,455 | 23% | 100.0 | 100.0 | 327,850 | 355,088 | 27,238 | 8% | 1,087 | 1,168 |
| Michigan | 420 | 496 | 76 | 18% | 2.8 | 2.7 | 10,136 | 11,590 | 1,454 | 14% | 1,006 | 1,159 |
| Arizona | 364 | 445 | 81 | 22% | 2.4 | 2.4 | 7,274 | 7,254 | -20 | 0% | 1,148 | 1,116 |
| Wisconsin | 216 | 258 | 42 | 19% | 1.4 | 1.4 | 4,343 | 6,264 | 1,921 | 44% | 775 | 1,113 |

Source: D&B Zapdata, 2008 Q2 and March 2009

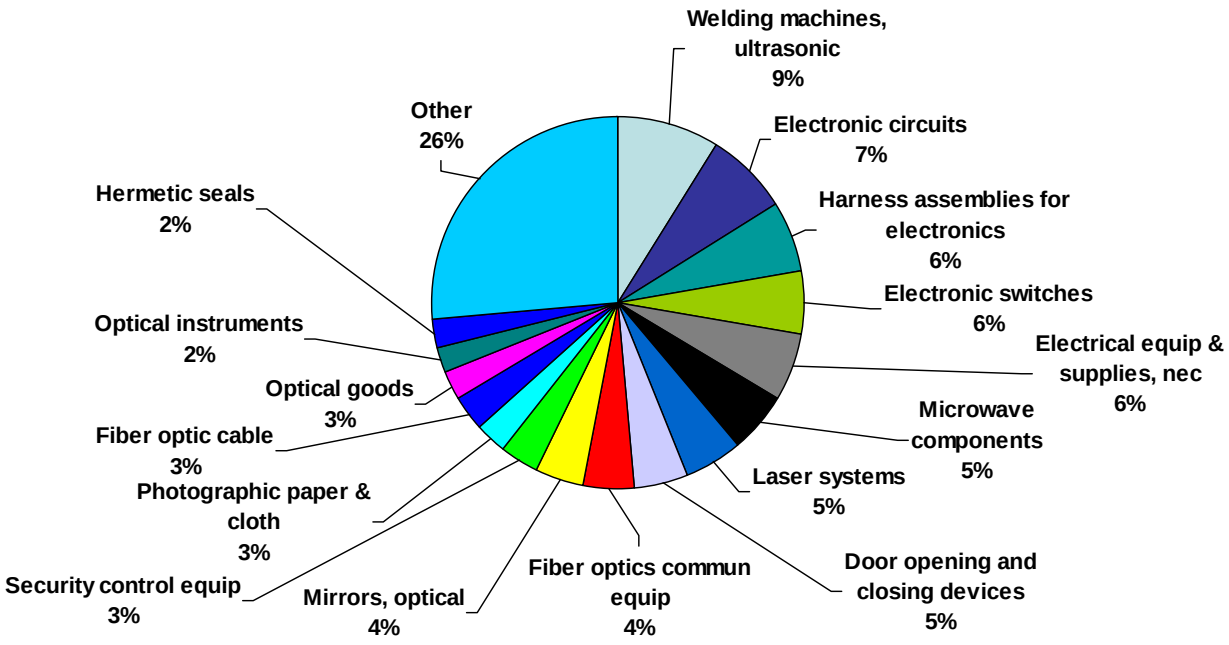
The Optoelectronics Industry Development Association (OIDA) estimates that the global optoelectronics market for 2008 was $356 billion, with green photonics comprising 8.1 percent or $28.9 billion. The 2009-2020 compound annual growth rate for global optoelectronics is forecasted to be 3.1 percent, which translates into $493 billion in revenue by 2020. Near term, the overall global optoelectronics market is forecast to decline by 1.4 percent in 2009.[22]

Figure 2 shows the distribution of photonics employment in Connecticut by industry. Nine percent of the 4,270 photonics employees work in the industry related to ultrasonic welding machines and equipment, with another seven percent involved with electronic circuits. All of the industries listed in Figure 2 employ at least 100 people.

[21] http://www.andor.com/

[22] www.businesswire.com/portal/site/home/permalink/?ndmViewId=news_view&newsId=20090227005738&newsLang=en

**Figure 2: Photonics Employment in Connecticut by 8-Digit SIC Industry, 2009**




Source: D&B Zapdata, March 2009

The Connecticut Optics and Photonics Association (CTOPA) was founded in October 2007 and was incorporated as a non-profit 501(c)(6) trade association in April 2008 to promote the industry in the state. A number of companies have already joined this group along with higher education institutions and nonprofit organizations. A selection of companies involved in CTOPA besides Andor and Newport include ASML-Optics, OFS Specialty Photonics, RSL Fibersystems, Ciencia, Fairfield Crystal and others. Photonics companies in Connecticut are involved in, but not limited to, fiber optic manufacturing/assembly, fiber optic illumination, lithography, biotechnology, lasers and material processing. [23]

The objectives of the CTOPA include marketing, networking, strategic partnering, education and representation.[24] An educational summit meeting was held with the support of Congressman Joe Courtney, who is a member of the U.S. House Education

[23] Anastasios Maurudis, CTOPA
[24] http://www.ctopa.org/

and Labor Committee. A committee formed from the meeting will develop a more integrated approach with middle schools, high schools, higher education institutions and companies to facilitate a better match between the local workforce skills and business needs in this industry.[25] Anastasios Mauridis, a biomedical/electrical engineer and founder of CTOPA, agrees that by bringing together the local firms, Connecticut could grow the optics/photonics industry, including generating new optics businesses and promoting the commercialization of research at higher education institutions.[26]

In summary, the photonics industry has a growing presence in Connecticut and the potential for product development and business creation is positive. Even though the state and nation are in the midst of a recession, a number of photonics companies are growing in terms of their research and employment opportunities. Many research applications are being developed and have yet to be discovered within this interesting field of science.

[25] Anastasios Maurudis, CTOPA
[26] Jonathan G. Fox, "Focusing On Commerce Like A Laser Beam," *Hartford Business Journal*, 11/26/07, http://www.hartfordbusiness.com/news3780.html

**Appendix A: SIC Industries Involved in Photonics**

3671 Electron tubes
3699 Electrical equipment and supplies, nec
3827 Optical instruments and lenses
3861 Photographic equipment and supplies

3211-00 Flat glass
3211-01 Transparent optical glass, except lenses
3211-02 Strengthened or reinforced glass
3229-02 Optical glass
3229-03 Industrial-use glassware
3674-03 Light sensitive devices
3679-00 Electronic components, nec
3679-01 Electronic circuits
3679-04 Electronic crystals
3679-05 Electronic switches
3679-99 Electronic components, nec
3826-01 Spectroscopic and other optical properties measuring equipment
3826-02 Analytical optical instruments
3826-06 Instruments measuring magnetic and electrical properties
3841-01 Ophthalmic instruments and apparatus

3229-0401 Fiber optic strands
3357-0102 Fiber optic cable (insulated)
3541-9904 Electron-discharge metal cutting machine tools
3559-9910 Electron tube making machinery
3559-9918 Optical lens machinery
3559-9938 Fiber optics strand coating machinery
3577-0503 Optical scanning devices
3652-9901 Compact laser discs, prerecorded
3661-9908 Fiber optics communications equipment
3674-9908 Optical isolators
3679-0203 Recording and playback heads, magnetic
3679-0204 Recording heads, speech and musical equipment
3695-9901 Optical disks and tape, blank
3821-0113 Laser beam alignment devices
3825-0209 Electron tube test equipment
3826-9904 Colorimeters (optical instruments)
3826-9909 Laser scientific and engineering instruments
3826-9911 Particle size analyzers
3826-9912 Perimeters (optical instruments)
3841-0420 Surgical lasers
3845-9901 Laser systems and equipment, medical
5049-0104 Optical goods
7374-9905 Optical scanning data service
7699-0106 Optical instruments repair