PHOTONICS IN CONNECTICUT: HARNESSING THE POWER OF LIGHT

Photonics. Few people know what this field is all about—or even what the word itself means. Yet Connecticut has a number of manufacturers who are world leaders in photonics.

In photonics, photons—particles of light—are harnessed to perform a task, much as electrons do the work in electronics. Electronic equipment has become essential in today's world; yet just a hundred years ago, electrical power was a new concept. Today, we are in the early phases of another revolution—one that harnesses the power of light.

There are several companies in Connecticut that are actively making components, sub-systems, and systems based on photonics. This article is about them.

Why photonics and why now?

Two key inventions and developments are substantially responsible for the current, widespread application of photonics: the laser and the very-low-loss optical fiber.

The laser was invented 40 years ago and has undergone tremendous development since that time. A well-engineered, modern laser is capable of emitting an intense beam of laser light that has a very narrow optical bandwidth, excellent optical beam quality and excellent reliability. Lasers are key components in optical communication systems, several manufacturing processes, medicine, holography, measurement and instrumentation, and entertainment.

Optical fibers have also undergone tremendous development in the past 30 years. Current glass-based fibers are capable of transmitting a beam of light over very long distances (hundreds of kilometers) with very low loss and with very high optical bandwidth (equivalent to many, many television channels). These fibers, along with the proper lasers and other optical and electro-optical components and sub-systems, are responsible for the current revolution in telecommunications, Internet communications, optical networking, and related fields.

A Science Born in the Laboratory

The science of photonics was born in the laboratory, and was initially nurtured by engineers and scientists, graduate students, and hobbyists. Before long, particularly as laser power levels, reliability, and beam quality improved, the field attracted the interest of industry. Academy member and past president Anthony DeMaria, the “grand old man” of the Connecticut photonics industry and founder of Coherent*DEOS, explains, “The laser does in the photonics field what the transistor or the vacuum tube does in electronics. The transistor is the major workhorse for the electronics industry; the laser is the major one in the photonics industry. There's integrated optics and integrated opto-

electronics, electro-optics and crystal optics....there's a whole bunch of separate fields. All these fields are called 'photonics,' just like all the fields of transistors, microprocessors, computers, cell phones, pagers, CDs—even radars, microwave radars—fall under the term 'electronics.' Our company delivers lasers to scholars; one's going to be at the South Pole. We deliver lasers to the Air Force for military applications, and we deliver lasers to NASA. One of our lasers will be in an orbiting satellite for five years; it'll be measuring the radical OH (hydroxide) molecule concentration throughout the world to see what effects this has on the ozone layer. This laser must operate reliably for that entire period without any hands-on attention or servicing. Our biggest growth area is in industrial applications of our lasers."

Photonics in Connecticut

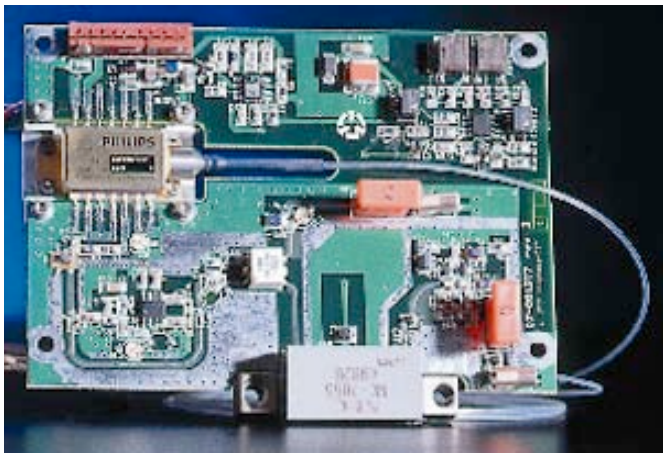
Connecticut is a world center of photonics manufacture, development and research, home to companies such as JDS Uniphase in Windsor, Coherent*DEOS in Bloomfield, TRUMPF Inc. in Farmington, Advanced Fuel Research in East Hartford, CiDRA in Wallingford, and Zygo in Middlefield. Photonics research is also being done at the University of Connecticut and at Yale.

JDS Uniphase, Coherent*DEOS, CiDRA and Advanced Fuel Research all began as spin-offs of United Technologies Corporation (UTC). Several of these have merged with and/or bought other related photonics enterprises. TRUMPF Inc. is the North American subsidiary of TRUMPF GmbH +Co. KG. (the TRUMPF Group), a privately owned German firm with worldwide plants; the one in Connecticut is its major US manufacturing and research facility. Zygo was founded over 30 years ago by a team that included Academy member Carl Zanoni.

Photonic-based telecommunications

Lasers and related optical and electro-optical components are essential elements in modern, optical-fiber based telecommunication systems.

JDS Uniphase (http://www.jdsu.com), a global company with annual sales of $2.1 billion, has approximately 400 employees in Connecticut. The Connecticut division manufactures high-speed external modulators and laser wavelength lockers. At other sites, the company manufactures ***a*** wide range of optical components for telecommunications systems, including semiconductor lasers, transmitters, couplers, multiplexers, circulators, tunable filters, optical switches, and isolators. Module and subsystem level products include amplifiers, transponders, transceivers, optical performance monitors, and dispersion compensation modules. The company also manufactures industrial lasers, advanced interference pigments such as those used on some currency and credit cards, optical display and projection products, and gas cluster ion beam surface equipment, and supplies test equipment for network installation and for system production applications.



JDS Uniphase's MDMT200 module, shown here, is used by Cable TV manufacturers. With powers up to +14 dBm, it is the highest power product in its class. It can include a hybrid amplifier, which is linearized along with the laser for maximum performance

(Photo courtesy of JDS Uniphase)

CiDRA (http://www.cidra.com) is also a significant manufacturer of telecommunications and optical networking equipment. According to their web site, "CiDRA Corporation designs, manufactures and markets component, module and subsystem products for dynamic routing, monitoring and conditioning of optical signals. Based on our proprietary technology platforms, CiDRA's family of AgileWave™ products are designed to bring a new level of flexibility, reliability and intelligence to the next generation of optical networks."

Photonics in manufacturing

Two Connecticut photonics companies, TRUMPF Inc. and Coherent*DEOS, make lasers and related systems that are used in manufacturing processes.

TRUMPF Inc. (http://www.us.trumpf.com), with headquarters and manufacturing facilities in Farmington, has about 500 employees in Connecticut and specializes in high power CO_2 and Nd:YAG lasers for material processing. These lasers have power levels of up to 20,000 watts.

TRUMPF's technologically advanced products include CNC laser cutting centers, punching machines, and press brakes. They also produce state-of-the art marking lasers, CAD/CAM software, punch and press brake tooling, and portable power tools. The speed, versatility, accuracy, and controllability of these systems greatly enhance the ability to do "just-in-time" manufacturing, resulting in lower inventory costs and ease of custom manufacture.

Seventy percent of TRUMPF's business is related to laser technology, and today the TRUMPF Group is the world's largest manufacturer and integrator of CO_2 and Nd:YAG laser resonators with total annual sales of $1.1 billion.

The TRUMPF TUBEMATIC™ uses a laser to accurately and precisely cut metal tubes and pipes. (Photo courtesy TRUMPF Inc.)

Coherent*DEOS, LLC (http://www.cohr.com), based in Connecticut and a subsidiary of Coherent Incorporated, manufactures lasers for many different applications. Coherent Incorporated had annual sales of $480 million in 2001, and Coherent*DEOS contributed significantly to that total. Coherent*DEOS manufactures CO_2-based lasers with power levels up to 300W, and plans to expand this product line to levels over 500W in a year or so. It should be noted that the world market for these low power CO_2 lasers is about $250 million annually; if one includes high power lasers, the total figure exceeds one billion dollars per year, providing ample opportunity for Coherent*DEOS to grow and expand.

*A photograph of a sealed, RF excited, 100W, air-cooled CO2 laser and its power supply manufactured by Coherent*DEOS, LLC, of Bloomfield, CT. This is the world's first 100W, air-cooled CO2 laser. (Photo courtesy: Coherent*DEOS)*

Photonics in Measurement and Instrumentation

Zygo (http://www.zygo.com) is a significant photonics player in the semiconductor, telecommunications, and industrial fields. Zygo is a leading supplier of metrology systems, macro-optics, and micro-optics. Zygo's TeraOptix division's products include precision micro-optics subcomponents and packaging. ZTO integrates precision optical subcomponents with customer-supplied elements onto a silicon optical bench using photolithographic and wafer fabrication techiques. Zygo's MicroLUPI™ interferometer is an advanced micro-optic metrology system which provides precise, automated high-speed optical testing of discrete or array-based micro-optical components, which provides non-contact 3-D surface measurement and analysis of highly curved, flat, or spherical components ranging from 20 microns to 3 millimeters in diameter. Their NewView 5000™ interferometer provides non-destructive, fast, accurate, repeatable surface texture measurement and analyses with no sample preparation required, which makes it useful in field conditions.

Example of a ZYGO system. The MicroLUPI™ is an advanced micro-optic metrology system that provides automated, precise, and high-speed optical testing of discrete or array-based micro-optical components. It is a fully integrated, micro-aperture, phase-shifting interferometer system that employs an innovative combination of optical technology and automation, enabling noncontact 3-D surface measurement and analysis of highly curved and nominally spherical, or flat, components ranging from 20□m to 3□m in diameter. (Photo courtesy: Zygo)

Advanced Fuel Research (http://www.afrinc.com) is also a significant manufacturer of equipment used in optical instrumentation and measurement. Much of the AFR photonics activity has been organized into a division called TurboSense. According to the company's web site, "TurboSense is a manufacturer and supplier of advanced process monitoring tools to the gas turbine engine industry and other combustion dependent industries. Our products are designed to provide for optimum operating efficiency, environmental compliance, and safety to the gas turbine engine industry for both electricity generation and propulsion, and energy-intensive process industries such as pulp and paper, chemicals, and petroleum refining. In addition, the products expedite test programs that will bring advanced engines and other combustion devices to production. TurboSense has positioned itself to be a dominant supplier of products by establishing working relationships with turbine engine manufacturing companies, turbine engine

testing companies, industrial process industries, environmental services companies, the U.S. Air Force, the U.S. Department of Energy and the U.S. Environmental Protection Agency."

A bright future

Lasers and photo-optical systems are critical to the development of modern technologies. They are found in CD players, computers and infrared sensors, and have applications in everything from telecommunications to medicine, the military, and manufacturing. From etching lot numbers and expiration dates on consumer and industrial goods to welding truck and auto bodies to precision cutting fabric and printed circuit boards, lasers have revolutionized manufacturing processes worldwide.

In the field of telecommunications, new products and applications for photonic instrumentation are in their infancy. In the field of medicine, lasers and photonic tools are used for corrective eye surgery and treatment for diabetic retinopathy and glaucoma. Fiber optics are used in sigmoidoscopies and colonoscopies, and the laser has become nearly as ubiquitous as the scalpel in the operating room.

Although still very young, the photonics industry is growing rapidly. Connecticut has a number of the world's leading manufacturers of photonic equipment and components, and, thanks to the presence of these companies as well as the state's university research centers, a reservoir of skilled workers and engineers.

It has been a mere 40 years since the first laser was built; 40 years from now, the use of photonics may well eclipse many electronic applications. Connecticut is ideally positioned to take advantage of this scenario. For the state's photonics industry, this means tremendous potential for growth—and a very bright future indeed. — *Jane Sibley, science writer, and George Foyt, executive editor, CASE Bulletin.*