

Background

Contact: Kevin Lane at (412) 848-8345 or KLane85579@aol.com

Electro-Optics in the Pittsburgh Region

Subject matter experts available for comment on this topic include:

Karl Harris
Director
Electro-Optics Center

Dr. Edward G. Liszka
Director
Applied Research laboratory
The Pennsylvania State University

Francis Kramer
President and CEO
II-VI, Inc.

Dawn Rucker
Chief Executive Officer and COO
L-3 Communications Brashear

Dr. Pradeep Subrahmanyam
CEO
RAPT Industries

A technical definition of electro-optics describes a technology associated with components, devices and systems designed to interact between the electromagnetic and visible light spectrum and the electronic state. This definition states that electro-optics uses applied electrical fields to generate and control optical radiation.

In the simplest sense, electro-optics is a technology based around the conversion of electricity into light and light into electricity. Human sight is perhaps the closest model for the conceptual processes involved in electro-optics.

Two primary categories of electro-optics exist: outside-in mechanisms, which include imaging and sighting devices, and inside-out mechanisms, which typically involve lasers and laser applications. As a broader term, electro-optics also often is used to encompass laser, optics, fiber-optics and photonics technologies.

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Typical electro-optic devices include concave and convex mirrors, convergent and divergent lenses, prisms, beam-splitters, optical filters, resonators, sensors and lasers. Components include semiconductor diodes, light emitting diodes (LEDs), photodetectors, imagers, focal plane arrays, liquid crystal optics and multiplexers. Emerging fields within this cluster include fiber optic communications, which make up 40 percent of the total market, imaging acquisition products and optical disk storage.

The worldwide market for this industry cluster has been estimated at \$200 billion. Electro-optics technology (coupled with IT) increasingly has become of more interest to the DoD and DHS because of recent warfighting trends in communications, surveillance, unmanned systems and stand-off engagements.

The Army uses electro-optics for air defense systems, ground-based deep space surveillance equipment, night vision devices and a host of other optical tools. Powerful, small weapons-grade electro-optic lasers are being applied in military missile defense. For example, electro-optic uncooled sensors and flash lidar (laser radar) will improve weapons systems size, weight, power, costs and sensitivity. Flash lidar creates high-resolution three-dimensional images that enable robust target detection and identification with minimum collateral damage. Increasingly, our nation's defense depends on electro-optical components because of the distinct advantages they afford.

But the larger field of electro-optics has been growing over the past 20 years. Light emitting diodes used in video display screens are a recognizable application of electro-optics in the general public space. Other devices incorporating electro-optics include metalworking tools, surgery and medical devices, telecommunications equipment, night vision surveillance, art restoration and traffic lights. With LED technology, traffic bulbs will last 30 years and cost only 85 cents a month to operate, compared with five years and \$6.00 a month for conventional bulbs.

According to a National Research Council report, large companies do not dominate the industry. Certainly Kodak, AT&T, IBM and other large corporations are very involved in the electro-optics industry, as they tend to integrate electro-optics systems from many components, but small entrepreneurial companies comprise the bulk of the cluster. As a consequence, the EOC was established to assist the government with coordination and providing knowledge of these various smaller entities and to help focus efforts towards developing systems of DoD and DHS interest.

The Electro-Optics Center

Armstrong County in southwestern Pennsylvania is home to the Pennsylvania State University's Electro-Optics Center (EOC), the focal point for many of the nation's cutting-edge research initiatives, including products for the U.S. Departments of Defense (DoD) and Human Services (DHS) and U.S. industry. The Center assists the government with coordinating, providing

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knowledge of various smaller entities and helping to focus efforts towards developing systems of DoD and DHS interest. As such, it has become a formidable national and international resource. Formally established in 1999 as the U.S. Navy's Center of Excellence in Electro-Optics Manufacturing, the Freeport, PA-based Center is charged with ensuring excellence and world leadership in the emerging industry of electro-optics.

The EOC is managed by Pennsylvania State University and in 2005 received a five-year contract renewal under the Office of Naval Research Manufacturing Technology (ManTech) initiative. The Electro-Optics Center was recently recognized as one of the top 50 places to work in Western Pennsylvania.

The mission of the EOC is to serve as a national resource to advance electro-optics and related technologies by partnering with government and commercial customers for the primary benefit of the U.S. defense capabilities.

The four key services of the Electro-Optics Center include:

- **Technical Project Development and Management**, which includes assistance in the development of technical solutions for industry electro-optics manufacturing issues and requirements.
- **Manufacturing Technology Transfer and Deployment**, which develops resources and expertise that enable the transition from prototype demonstrations to production capability, resulting in the creation of new businesses or enhanced product lines.
- **Workforce Development and Education**, which encompasses programs that provide skill-based training and academic courses in basic and advanced electro-optics manufacturing technologies. This service also operates a teaching and demonstration facility, and conducts various outreach activities to heighten electro-optics awareness and opportunities.
- **Electro-Optics Technical Resources**, which includes technical oversight and consulting, proposal evaluation, program management, basic and applied research, prototype production demonstrations and acceptance tests.

Electro-Optics Center research projects generally have targeted laser technology, materials and fiber optics. But each year, EOC expands the number of research and development projects it coordinates and in which it directly participates. The year 2010 will mark the last year in a five-year, \$150 million contract for the Electro-Optics Center, in conjunction with Penn State University, to continue to serve as the Navy Manufacturing Technology Program Center of Excellence for electro-optics research. Since 2004, the EOC coordinated, managed and performed more than \$174 million in R&D funding under contract to various services within the DoD, including the Army, Navy, Air

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Force, Marines and SOCOM. More than \$60 million was subcontracted to Electro-Optics Alliance companies across the United States, including several firms in southwestern Pennsylvania. Projects included:

- advanced multiband optical surveillance system
- advanced silicon carbide crystal device technology
- avenger upgrade of the first generation FLIR
- aircraft missile warning sensors
- dual band detector imaging technology for Army (\$2.6 million) and for the Army's Special Operations Command
- high energy laser/missile for ship self-defense
- imaging system upgrade development
- infrared space sensors
- night vision

In conjunction with the National Center for Defense Robotics, now part of The Technology Collaborative, the EOC is funding several projects in two areas that address the growing intersection of electro-optics and "agile" robotics technologies, that being the use of electro-optic sensors on unmanned vehicles and use of agile robotics technology to manufacture electro-optics components.

Electro-Optics Alliance

The Electro-Optics Center is home to the Electro-Optics Alliance (EOA), with a roster of more than 360 member organizations spanning industry, university and government organizations. Some significant names include Lockheed Martin and Northrop Grumman. Regional firms include II-VI, Brashear, Chemicon and Plextronics.

New companies that have emerged in the area because of the EOC include Sabeus Federal Systems, Philips Applied Technologies, Boeing SVS, DRS and Rapt Industries.

The purpose of the Alliance is to advance Department of Defense critical electro-optics manufacturing science and technology and to promote U.S. preeminence in all areas of electro-optics. To that end, the Alliance creates an essential electro-optics infrastructure by promoting strategic partnerships among its members and by disseminating R&D findings to expand the electro-optics knowledge base and the commercialization of electro-optics technology. The EOC also shares resources within the Alliance with other entities in the Pittsburgh region, such as Catalyst Connection and the Latrobe-based National Center for Defense Manufacturing and Machining, to maximize leverage across southwestern Pennsylvania.

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Academic members of the Alliance reads like a who's who and includes Arizona State University, Boston University, Carnegie Mellon University, the University of North Carolina, the University of Illinois, Lehigh University, University of Massachusetts, the University of Pittsburgh, and of course The Pennsylvania State University.

Educational Outreach

Penn State Applied Research Laboratory (ARL) is located at State College and has demonstrated innovation and practicality in technology-based research through its involvement with the EOC. The Penn State ARL also maintains a facility at the university's Fayette campus where it supports companies in that county, like Argon ST, with regard to underwater defense research. Companies operating in that arena develop systems for signal intercept and identification, airborne imaging systems, threat warning systems, electronic intelligence, active electronic warfare systems, communications reconnaissance systems, torpedo countermeasures systems, imaging systems, communication systems, wireless networks and navigation systems.

Penn State ARL is one of just five other U.S. Navy academic research centers in the country known as university-affiliated research centers. The lab historically has served primarily as a center of excellence in undersea technology.

Penn State had ranked second in the nation for DoD research expenditures and third in the nation for industry-sponsored research expenditures. The university offers a graduate degree in electro-optics with specializations in non-destructive inspection, high-precision surface metrology and vibration and ultrasonic-guided wave monitoring.

The University of Pittsburgh's department of electrical engineering is the focal point for many electro-optics efforts in Pittsburgh. The department's areas of research and development include:

- optically based computing using reconfigurable processors and optical cache memory system-level modeling for free-space interconnects and optical micro-electro-mechanical systems (MEMS)
- erbium-doped waveguide optical amplifiers
- zero insertion-loss beam splitters
- optoelectronic packaging technologies for high speed optical communication
- integrated-optic ultraviolet detectors, based on wide band gap semiconductors.

Carnegie Mellon offers optics specialization in its electrical and computer engineering disciplines that focus on military target identification, Raman imaging and spectroscopy for environmental monitoring and polymer materials characterization for recycling.

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The EOC also has established partnerships which includes the sharing of facilities with both CMU and California University of Pennsylvania in robotics training.

Indiana University of Pennsylvania (IUP) also has forged a partnership with the EOC to further a new career-training program in electro-optics, including two-year degrees. To maximize its educational opportunities, IUP's educational facilities for electro-optics is housed in close proximity to the EOC at the Northpointe Technology Center in Armstrong County. Synergy with the EOC is creating unique student opportunities for advanced education and workforce training focused on emerging electro-optics technology.

The EOC also supports partnerships with the Armstrong Education Trust, the Armstrong Manufacturing Consortium, the Armstrong County Career Link, the Lenape Vocational-Technical School, area secondary and post-secondary schools with the objective of enhancing the region's workforce development efforts and to insure a viable workforce is available in the region upon which new companies can rely.

Private Sector

Many electro-optics companies are located in and around Armstrong County making it a prime location for future technology-cluster build-out. A short sampling of efforts at some of the prominent businesses illustrates the range of electro-optics activities already underway in southwestern Pennsylvania.

- II-VI (pronounced Two-Six) is a public company that manufactures optics equipment for a wide range of applications and industries, including military and medical use. The company's products include amber-colored lenses that focus intense laser light, radiation detectors for nationwide security and nuclear medicine, high-power electrical, electronic and microwave components. With more than 2,00 employees worldwide, II-VI Incorporated and its divisions and subsidiaries also have expertise in synthetic crystal materials growth, which is used to produce high-quality lenses and optics for lasers and telecommunications equipment. In fiscal 2008, company earnings increased more than 70 percent over the previous year, setting a company record with further growth expected. In 2008, II-VI made two acquisitions. The company completed the purchase in January of a 74.9 percent interest in German firm HIGHYAG Lasertechnologie GmbH, which makes automated equipment used in laser beam technology for cutting, drilling and welding. II-VI also acquired Pacific Rare Specialty Metals & Chemicals Inc., a Philippines-based company that produces and refines rare metals and components for electronic, industrial and other applications.

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- L-3 Brashear is recognized for world-class optics technology. The company designs and produces complex electro-optical and electro-mechanical systems and instrumentation for the commercial and defense markets. The company operates in six diverse, but complementary product areas: telescope systems, optical components, stabilized tracking systems, test range instrumentation, small arms fire control systems and laser beam directors. Brashear, under contract from Raytheon, recently manufactured 35 electro-optic systems for the Navy's Phalanx Weapon System, a computerized laser and gun. Brashear employs more than 160 scientists, engineers, opticians and support staff.
- SiMMtec, Inc. manufactures compact, high-power laser diode arrays for use in defense applications, like jet fighters. The company's proprietary design is based on the patented technology invented by Lawrence Livermore National Laboratory. Located in Allison Park, PA, SiMMtec maintains a 5,000 square-foot manufacturing facility that houses a class 10,000 and a class 100 clean room, processing area and state of the art testing laboratory.
- Optical Systems Technology, based in Freeport, PA, designs, manufactures and integrates high-performance, image-intensified, night vision scopes, stabilized gimballed optical platforms, large optical assemblies and fiber-optic illumination engines. Its products are marketed under the STAR*TRON brand name associated with the largest and fastest night vision catadioptric lenses in continuous production for more than 30 years. The company recently won a Marine Corps contract that could be worth \$39 million through 2011. The initial contract for 4,700 sniper mid-range night sights is worth \$6.9 million but could be extended to \$39 million through 2011 with options. Founded in 1995, Optical Systems Technology is the founding member of the OmniTech Partners Group, a conglomeration of electro-optical technology companies employing 65 people that occupies about 18,000 square feet in Freeport. Other members of the group are Keystone Applied Technologies Inc., a maker of surveillance systems and FrigLite Inc., a maker of lighting for refrigerated display cases.

The region also has key companies that either use electro-optic technology in their products or have compatible products. They include Draeger Safety, Mine Safety Appliances, ChemImage, Bridge Semiconductor and Westinghouse Electro-Mechanical Division, among others.

Regional Growth Efforts

The Electro-Optics Initiative is a program developed to combine the efforts of industry, education, community and government to make opportunities available for electro-optics companies to locate in and around Armstrong County's Northpointe Industrial Park .

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Since 2004, seven new companies established operations in Armstrong County, among them Caracal, Boeing SVS, DRS Technologies, Dynamic Manufacturing, RAPT Industries and Sabeus Sensor Systems. Such development plans are positive indicators of electro-optic clustering in the region and help to further establish and expand wider incentives for future growth.

Sabeus Sensor Systems, a division of California-based Sabeus Photonics, manufactures fiber optic sensors. In 2003, Sabeus began development work on a new sensor in its Freeport facility. In 2005, the company expanded its operations and moved into a new facility in the Northpointe Industrial Park, and it now has about 20 employees at that location.

DRS Technologies Inc. in Armstrong County focuses on upgrading infrared technology used by the United States Armed Forces. The company has been awarded a contract to manufacture pre-production hardware for the Avenger and the AN/TAS-4 systems that will provide low cost imaging technology upgrades. The company's electro-optical systems group provides electro-optical sensors technology, components and systems for both the domestic and international military markets.

RAPT Industries specializes in a patented process called reactive atom plasma used for polishing and shaping optical, ceramic and semiconductor components. The RAPT system provides for non-contact work and can remove subsurface damage due to traditional polishing and grinding.

Boeing SVS combines a strong core competence in controls, electro-optics, simulation and image processing, and is a leader in the design and development of specialized target acquisition, tracking and precision delivery systems. Aside from its new Armstrong County facilities, Boeing SVS employs more than 200 engineers, scientists and technicians at its Albuquerque, New Mexico headquarters, in addition to operations in Hawaii, Colorado, Massachusetts, Maryland and California.

Caracal has designed and implemented a new process for growing silicon carbide, which has properties that make it a superior semiconducting material for power devices operating at high voltages. After an extensive R&D effort, a new bulk growth method was discovered by Caracal scientists in 2005 lowers the required growth temperature and thermal gradient, which puts less strain on the materials, resulting in lower defects. The degradation rate of the graphite crucible is also reduced. The net effect is higher purity silicon carbide of greater boule length. The company has applied for three different patents covering both the process and apparatus of this new growth technique.

As an industry, electro-optics requires access to precision machinists, casting makers, computer engineers and other specialized talent to help develop it further. Some 30 companies in the Pittsburgh region, such as Spark Technologies, specialize in the manufacture of custom components for electro-optics. Workforce development programs at the EOC also aggressively have striven to develop the talent pool.

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Northpointe

The presence of the Electro-Optics Center has generated business growth throughout Armstrong County, which is the latest county to be added to the current seven-county Pittsburgh metropolitan statistical area. To better serve and foster this growth, Armstrong County developed a state-of-the-art business and technology park, called Northpointe in South Buffalo township. The park serves as a site for expanded partnerships between academic, industrial and government organizations in electro-optics and other areas.

Due to its own technical growth and workforce development advances, the Electro-Optics Center now occupies three facilities: a 45,000 square-foot facility in Northpointe; an 18,000 square-foot facility in Freeport, Pa. and a 3,600 square-foot facility at the Jimmy Stewart Airport in Indiana, Pa. Within these sites, the Electro-Optics Center has approximately 25,000 square feet dedicated to laboratory space.

ARMTech

Each year, the EOC joins forces with the Armstrong County Regional Manufacturing Initiative to host the ARMTech Showcase, a national trade show that draws national defense and aerospace contractors, medical researchers, regional electro-optics companies and advanced manufacturers. More than 90 interactive exhibits are featured at ARMTech each year. Local, regional and national industry representation in advanced manufacturing, medical research and defense related industries participated. The Public Showcase displayed thermal imaging video cameras, combat helmets with night vision capabilities and body armor protection systems.

The Department of Defense has played, and will continue to play, an important role in the development and funding of the region's electro-optics industry cluster. Many items the DoD uses are fairly easy to purchase commercially, however with electro-optical equipment, there usually are sophisticated modifications required for military use.

With military applications as a source of contracts and funding, the region's electro-optics industry represents a promising emerging cluster. The penetration of electro-optics devices into the medical and industrial markets also will continue to add to the cluster's growth.

Visit: www.electro-optics.org

www.arl.psu.edu/capabilities.html

www.armstrongmfg.org

www.ii-vi.com

www.l-3com.com/Brashear

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