

# ***Competing for the Future:*** A Historical Review of NIST ATP Investments in Photonics and Optical Technologies

*"One of the great engines of our growing economy is our Nation's capacity to innovate. Through America's investments in science and technology, we have revolutionized our economy and changed the world for the better."*

President George W. Bush  
American Competitiveness Initiative

*"To promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life."*

—The NIST Mission

William Jeffrey  
NIST Director



**NIST**

**National Institute of  
Standards and Technology**  
Technology Administration  
U.S. Department of Commerce

# Competing for the Future: A Historical Review of NIST ATP Investments in Photonics and Optical Technologies

Throughout its 105 year history, NIST has sought to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life. The Advanced Technology Program (ATP) has helped NIST accomplish this vision by helping U.S. companies compete; by bridging the gap between the research lab and the marketplace to stimulate prosperity through innovation.

Between 1990 and 2004, ATP held 44 competitions resulting in the funding of 768 projects, involving 1,511 participants and an equal number of subcontractors. These innovative R&D projects included 218 joint venture and 550 single company awards, comprising \$4,371 million of high technical risk R&D – of which the ATP share is \$2,269 million and the industry share is \$2,102 million. Nearly **66% of all ATP awards** have been led by small companies.

In photonics and optical (P&O) technologies, ATP has stimulated **127 projects** and more than **\$774.4 million** of industry-defined, company executed innovative R&D. These cost-shared P&O awards directly sought the creation of new photonics and optical technologies, leading to new-to-the-market products, goods, and services.

## ATP Awards in Photonics and Optical (P&O) Technologies (1990-2004)

Total P&O Funded R&D	\$774.4 M	Total P&O Participants	199 Unique Entities
▪ ATP	\$396.5 M	Small Company	106
▪ Company	\$377.8 M	Medium Company	38
		Large Company	35
<b>Total P&amp;O Awards</b>	<b>127</b>	University	10
▪ Single Applicant	81	Non-profit	7
▪ Joint Venture	46	Federal Laboratory	3



ATP co-funded projects in photonics and optical technologies fall within two categories. Those that:

- Develop technologies for light-based products, or products based on other forms of radiant energy whose quantum unit is the photon (generally considered infra-red and shorter wavelengths), or
- Develop systems technologies, for a variety of commercial applications, which are enabled by the application of advancements in light-based technologies to solve a core technical problem.

*The market for optoelectronics components and enabled applications will surpass \$1 trillion by 2015.*

Dr. Michael Lebbey, President and CEO

## ***A History of Success***

The photonics and optical technologies industry within the U.S. is largely built upon the innovations and ideas that have emerged from within academic and laboratory entities across the country, and then brought to the market - typically by small and medium sized companies that may be located within photonics regional clusters<sup>1</sup>. Because of the complex nature of the innovation, expertise across multiple entities is often needed. These characteristics are reflected within ATP's funding history. Between 1990 and 2004, approximately 72% of all ATP projects in photonics and optical technologies have involved small or medium sized U.S. companies. On average, any one ATP P&O award involved in excess of 1.6 corporate, academic or laboratory entities. In addition, over 36% of all ATP P&O awards have involved teaming among multiple joint venture participants. Thus, funding by ATP in photonics and optical technologies has been especially successful in aiding the competitive foundation of the U.S. photonics and optics industry, has benefited small and medium sized entrepreneurs, and has stimulated teaming between corporations and needed partners.

The role of light in our lives has expanded enormously over the last several decades and will continue to expand as new challenges emerge. The projects that have been funded by ATP are the ideas of U.S. industry; their view of what innovative R&D is needed will translate, if successful, into large national economic benefits. As technology evolves or as matters of high national importance arise, optical based technologies will be an integral part of the solutions developed to meeting the challenge. Relative to topics of high national importance in today's world, ATP projects in photonics and optical technologies impact the following four areas: **Energy, Homeland Security, Manufacturing, Healthcare & Biotechnology, and Nanotechnology.**

### **Impact of ATP Photonics and Optical (P&O) Technology Awards on National Priority Areas**

<b>Technology Area</b>	<b>Total Number of P&amp;O Awards</b>	<b>Total Funding</b>
<b>Energy</b>	<b>16</b>	<b>Total Amount: \$ 68.3 M</b> ATP: \$ 36.5 M Company: \$ 31.8 M
<b>Homeland Security</b>	<b>14</b>	<b>Total Amount: \$ 71.1 M</b> ATP: \$ 37.1 M Company: \$ 34.6 M
<b>Manufacturing</b>	<b>78</b>	<b>Total Amount: \$490.6 M</b> ATP: \$ 246.7 M Company: \$ 243.8 M
<b>Healthcare &amp; Biotechnology</b>	<b>14</b>	<b>Total Amount: \$ 73.8 M</b> ATP: \$ 40.7 M Company: \$ 33.1 M
<b>Nanotechnology</b>	<b>5</b>	<b>Total Amount: \$ 39.5 M</b> ATP: \$ 20.7 M Company: \$ 18.8 M

*"Innovation will be the single most important factor in determining America's success through the 21st century."*

*Innovate America*  
Council on Competitiveness

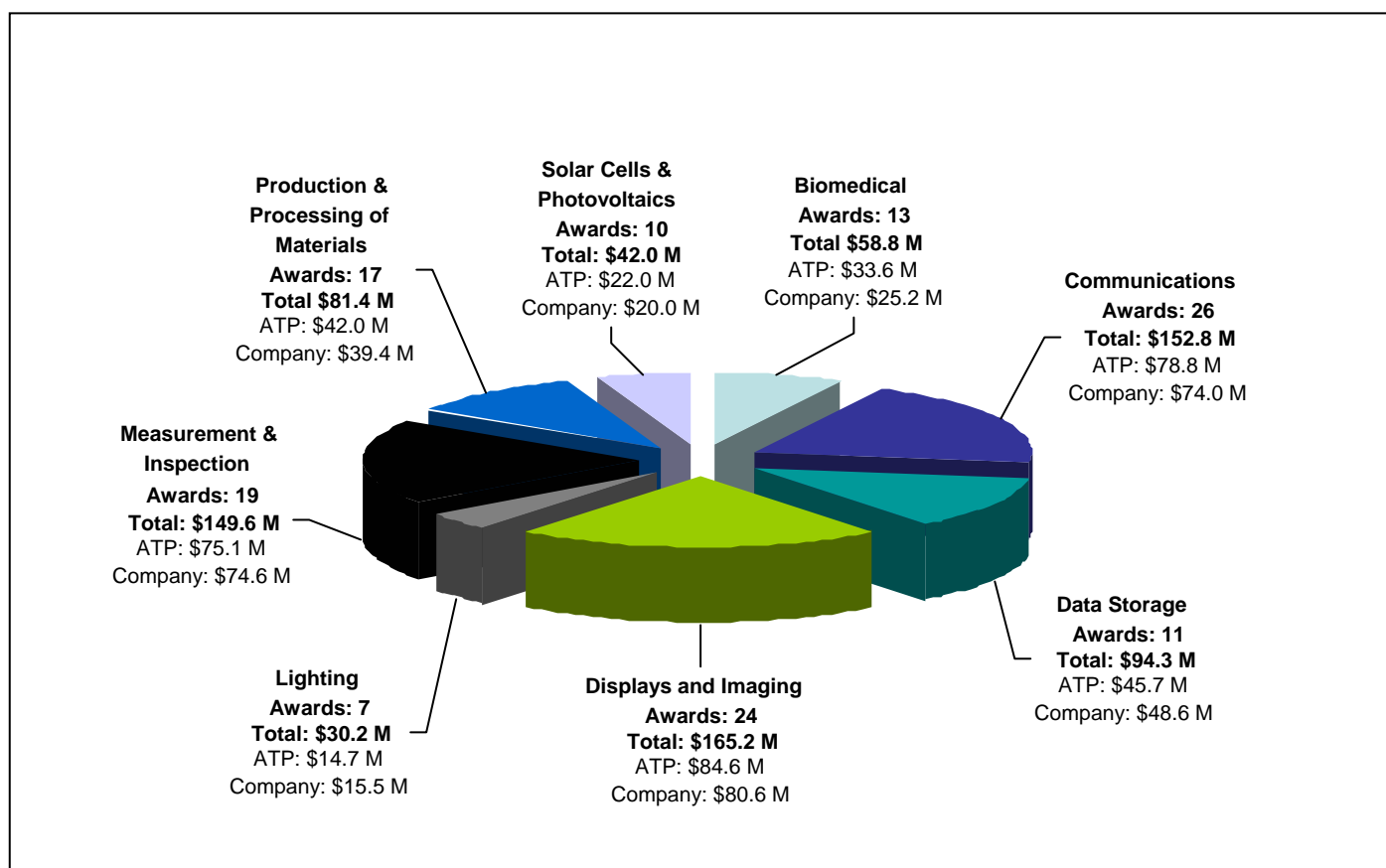
<sup>1</sup> The International Society for Optical Engineering (SPIE), <http://photonicsclusters.com/>, 2006.

## ***NIST Helps U.S. Industry Compete***

The 127 ATP funded projects in photonics and optical technologies can be grouped within eight application areas (Figure 1). Within these eight areas, two in particular - **Measurement & Inspection** and **Production & Processing of Materials** - impact across the U.S. manufacturing infrastructure, and illustrate the wide utility of optical technologies in solving manufacturing challenges. Combined, ATP investments in these two infrastructure areas represent approximately 30% of the total R&D funding in photonics and optical technologies stimulated by ATP, and approximately \$230 M of industry R&D.

ATP's funded projects in Measurement & Inspection have directly impacted a number of diverse end-use applications including semiconductor manufacturing, structural health monitoring, piece-part and discrete manufacturing, bio-manufacturing, and health and safety. NIST's funding by the ATP has led to innovative new technologies and equipment for measurement and inspection that has helped to strengthen U.S. metrology capabilities. This metrology is important not only for aiding U.S. manufacturing, but also in meeting matters of national importance including homeland security.

**Figure 1**  
**ATP & Industry Investments in**  
**Photonics and Optical Technologies**



The following is a brief look at some of the specific projects and results that have been accomplished as a result of ATP's funding in photonics and optical technologies.

**Ion Optics, Inc.**, of Waltham, MA, used ATP cost-share in 1999 to develop a MEMS infra-red photonic crystal sensor that can be tuned to accurately, reliably, and inexpensively measure trace gasses, including CO<sub>2</sub>, for medical and industrial uses.

- Commercial production of **SensorChip™** is targeted for 2006 with annual sales over the next 10 years expected to ramp up to 400,000 units for emergency medicine and up to 290,000 units for commercial building controls.
- Medical use of **SensorChip™** has the potential to prevent 112,000 deaths of trauma victims and critically ill patients on their way to U.S. emergency rooms.
- Cost savings from avoided medical treatments and energy savings from commercial building control are projected to result in net present values ranging from \$201 to \$245 million and public benefits of \$224 to \$298 for every ATP dollar invested.



**InPhase Technologies, Inc.**, of Longmont, CO, was co-funded in 2002 and 2003 to develop and demonstrate the use of rewriteable recording materials for holographic data storage systems, and to create a prototype optical data storage device that proves the viability of using holographic 3D techniques.

- InPhase demonstrated in April 2006 the highest data density of any commercial technology by recording 515 gigabits of data per square inch.
- The first generation drive has a capacity of 300 gigabytes on a single disk with a 20 megabyte per second transfer rate. The first product will be followed by a family ranging from 800GB to 1.6 terabyte (TB) capacity.
- On October 21, 2005 InPhase and Turner Broadcasting

System, Inc. recorded a promotional advertisement into InPhase's Tapestry™ holographic disk and holographic prototype drive. The ad was then aired at the scheduled time.

**X-Ray Optical Systems, Inc.**, of East Greenbush, NY, used ATP cost-share in 1992 to develop high transmission efficiency capillary optics for X-ray focusing and collimating. Commercial production started in the late 1990s. Economic benefits have been realized through cost and energy saving in the advanced materials and petroleum refining industries.

- Public returns on ATP's investments from 1994-2014 show net present values ranging from \$184 to \$233 million for every ATP dollar invested.
- Retroactive benefits from 1994-2003 indicate a realized net present values of \$7.40 million and realized benefit-to-cost ratio of \$4 of public benefits for every ATP dollar invested.



Under an existing award, **Actuality Systems, Inc.**, of Burlington, MA, is using ATP cost-share to advance holographic visualization technology from still images to full-motion full color images suitable for use in scientific visualization, medical evaluation, and entertainment. The company seeks to overcome challenges related to image resolution, data processing, and consumer-level pricing. Potential applications of affordable holographic video technology are many, especially in the \$22 billion visualization and simulation market. Earlier, Actuality Systems received a 2003 Photonics Circle of Excellence award from *Photonics Spectra* magazine for its early 3D system.

**Sage Electrochromics, Inc.**, of Faribault, MN, a 1993 ATP awardee, was a 2004 R&D 100 Award winner by R&D Magazine, a recognized journal for the nation's technology industry. Sage was recognized for their innovative "switchable" absorbing electrochromic window.

*"SageGlass allows the user to control the amount of incoming sunlight and solar heat with the push of a button. Applying a low DC voltage to the electrochromic device in its "clear" state causes the active electrochromic layers to darken; reversing the voltage polarity causes the layers to lighten. A house full of SageGlass windows takes less energy to run than a single 75 W incandescent light bulb."*



The following reports also document long-term results and economic benefits of earlier ATP co-funded P&O awards.

***Non-Contact Optical Metrology of Complex Surface Forms for Precision Industrial Manufacturing***

**Corning Tropel Corporation** (formerly Tropel Corporation)

Fairport, NY

<http://statusreports-atp.nist.gov/reports/95-01-0022.htm>

***Monolithic Multi-wavelength Laser Diode Array Spanning 430 to 1100nm***

**JDS Uniphase Corporation** (formerly SDL, Inc.)

San Jose, CA

<http://statusreports-atp.nist.gov/reports/91-01-0176.htm>

***X-Ray and Neutron Focusing and Collimating Optics***

**X-Ray Optical Systems, Inc.**

Albany, NY

<http://statusreports-atp.nist.gov/reports/91-01-0112.htm>

***Incoherent Combining of Radiation 2 dimensional Array of Semiconductor Lasers***

**Cynosure, Inc.**

Bedford, MA

<http://statusreports-atp.nist.gov/reports/92-01-0136.htm>

***IMOS Infrastructure for Photonics Manufacturing***  
**Digital Optics Corporation**

Charlotte, NC

<http://statusreports-atp.nist.gov/reports/98-02-0034.htm>

***Color Sequential Imaging***

**ColorLink, Inc.**

Boulder, CO

<http://statusreports-atp.nist.gov/reports/96-01-0263.htm>

***High Information Content Display Technology***

**Kopin Corporation**

Tuanton, MA

<http://statusreports-atp.nist.gov/reports/94-01-0304.htm>

***Holographic Graded-Index Non-Lambertian Scattering Screens and Components with Light-Shaping Capability***

**Physical Optics Corporation**

Torrance, CA

<http://statusreports-atp.nist.gov/reports/93-01-0205.htm>

***Robust, Fast 3-D Image Processing and Feature Extraction Tools for Industrial Automation Applications***

**Perceptron, Inc.**

Farmington Hills, MI

<http://statusreports-atp.nist.gov/reports/93-01-0071.htm>

***FLC/VLSI High-Definition Image Generators***

**Displaytech, Inc.**

Longmont, CO

<http://statusreports-atp.nist.gov/reports/94-01-0402.htm>



For information about the **Advanced Technology Program**, contact:

Phone: (800) ATP-FUND (800-287-3863)

Internet: <http://www.atp.nist.gov/>

E-mail: [atp@nist.gov](mailto:atp@nist.gov)

Fax: (301) 926-9524

Mail: Advanced Technology Program  
 National Institute of Standards and Technology  
 100 Bureau Drive, MS4700  
 Gaithersburg, MD 20899-4700

For further information on these and other ATP funded projects, visit the ATP website at [www.atp.nist.gov/](http://www.atp.nist.gov/)

May 8, 2006.