PHOTONICS: LIGHTING OUR FUTURE

WHAT IS PHOTONICS?

Look around you – your phone, computer, TV – all are modern-day technologies made possible largely by photonics.

Optics and photonics are the science and application of light. Specifically, photonics generates, controls and detects particles of light to advance manufacturing, robotics, medical imaging, next-generation displays, defense technologies, biometric security, image processing, communications, astronomy and much more.

Simply put, photonics technology is lighting our future by addressing and solving the challenges of a modern world. It enhances our quality of life; safeguards our health, safety and security; and drives economic growth, job creation and global competitiveness.

A LESSON IN HISTORY

A 1998 report prepared by the research arm of the National Academy of Science presented a comprehensive view of the potential impact of optics and photonics on health care, manufacturing, defense, communication and many other industries.

Since the release of the “Harnessing Light” report, many countries have significantly increased their national commitments to the optics and photonics industries. For example, in 2011, Germany committed nearly €1 billion ($1.3 billion in USD) to photonics research and development (R&D) over 10 years; China began funding several programs targeting photonics supply chains; and the European Commission, as part of its new Horizon 2020 program, has directed €1.6 billion (over $2 billion in USD) to photonics-related R&D over the next seven years, and has designated photonics as one of only five key enabling technologies for future prosperity.

Historically, the US has been a leader in photonics R&D; but the current US share of the global photonics industry is only 17 percent – behind Japan and with increasing competition from Europe, South Korea, Taiwan and China. Global competition is putting at risk our nation’s leadership position, which is causing a substantial loss of global market share to overseas competitors as well as thousands of US jobs.

THE NATIONAL PHOTONICS INITIATIVE

Now is the time for the United States to make photonics a national priority. In 2012, the National Research Council released a sequel to “Harnessing Light” that called for a National Photonics Initiative (NPI) to increase collaboration and coordination among US industry, government and academia to identify and further advance areas of photonics critical to regaining US competitiveness and maintaining national security.

New opportunities in these fields — including high-efficiency lighting, genome mapping, high-tech manufacturing, nuclear threat identification, cancer detection and new optical capabilities vital to supporting the Internet’s growth — offer the potential for even greater societal impact in the next few decades. The NPI advocates for US investment in photonics to grow our economy, protect and improve the lives of our people, and position the United States as a global technology leader. The time is now to light our future.
PHOTONICS: LIGHTING OUR FUTURE WITH INNOVATIVE APPLICATIONS

DEFENSE & NATIONAL SECURITY

Optics and photonics greatly enhance the United States’ ability to gather intelligence, defend its citizens and protect its troops in the field. Optical sensing technology makes surveillance and reconnaissance possible, and it identifies chemical, biological and nuclear threats to the homeland. Photonics makes laser-guided weapons more accurate, provides lasers for critical missile defense capabilities and permits personalized use of flexible display technology, which allows our men and women in uniform to remain informed and safe during operations with night vision, GPS and physiological feedback. Coordinated investment and associated technology development in remote sensing, photonic integrated circuit manufacturing, high-power lasers and cybersecurity will ensure military and economic security.

HEALTH CARE & MEDICINE

From laser eye surgery to CT scans, photonics is responsible for medical advances that save and dramatically improve millions of US lives. Photonics plays a key role in next-generation health care, both in enhancing the ability to observe and measure symptoms and the capability to treat patients earlier with less invasive, more cost-effective methods. Photonics-based health care tools offer sensitivity, precision, speed and accuracy, which enable rapid diagnosis and effective therapy — key ingredients for high-quality, cost-effective care. Further investment in biophotonics will result in smaller, more portable, automated, point-of-care diagnostic devices that have the potential to improve outcomes and the ability to reach patients who lack access to health care.

COMMUNICATIONS & INFORMATION TECHNOLOGY

The next time you send an e-mail, Skype with your family or post on Twitter, remember that without photonics, the Internet as we know it would not exist. Optics and photonics increased the capacity of the Internet by nearly 10,000-fold over the past two decades. Bandwidth demand is expected to grow another 100-fold, and possibly more, over the next 10 to 20 years. Without improvements to address the cost, power consumption, data rate and size, demand will outstrip capacity, which may lead to higher costs and possibly even constrain the greater US and global economy. Those countries that invest in solving these challenges will gain a sizeable national security advantage by advancing the infrastructure that enables our Internet-based economy.

ENERGY

Photonics increases the efficiency and safety of US energy production and consumption. The renewable energy sector is an area of potentially significant job growth and a space in which photonics research can help lower US energy consumption and reduce our reliance on foreign oil, thus strengthening national security and revitalizing the US economy. The oil and gas industry increasingly uses optical systems to monitor wells, thereby increasing production and mitigating risks. Additionally, solid-state lighting, such as LEDs, developed through photonics research, could cut US lighting electricity usage by about 45 percent by 2030, with forecasted energy savings of $30 billion dollars at today’s energy costs and a reduction of greenhouse gas emissions equivalent to 40 million cars. Global demand for new energy sources represents a significant growth opportunity for US manufacturers and producers. US companies will need continued research and development investments and structural support to lead the world into a clean, secure, efficient energy future.
ADVANCED MANUFACTURING

Advanced manufacturing is vital for the economic well-being of the country; it is a sector in which substantial job growth is possible. Though the majority of display and photonics component manufacturing has moved overseas, the United States can be a leader in new and innovative areas of manufacturing involving a new generation of high-power and low-cost ultrashort pulsed lasers, as well as 3D printing. 3D printing allows machines to make a range of customized products directly from electronically transmitted designs, saving costly material in the process. These advanced printers can create objects ranging from prosthetic limbs and functional human tissue to jet engine parts and shoes. While the United States may struggle to compete successfully in high-volume, labor-intensive, low-cost manufacturing, our nation can be a strong competitor in custom, precision and high added-value manufacturing.

EDUCATION & WORKFORCE DEVELOPMENT

Hands-on problem solving has made the US globally dominant in technology commercialization throughout our history. By invigorating technical education through hands-on learning, the US will foster an education pipeline that will better prepare the optics and photonics workforce and improve the translation of research results into innovative commercial applications for the benefit of the nation’s economy, security, health and competitiveness. The current demand for hands-on learning at the community college and undergraduate levels will increase dramatically with the application of optics and photonics technologies in next generation products and services across economic sectors. Investment in programs that provide hands-on experiences for students pursuing post-secondary degrees and certificates will invigorate technical education in the US.

QUANTUM SCIENCE & TECHNOLOGY

A global quantum revolution is currently underway. Quantum science and technology (QST) will open new scientific, technological and economic avenues. It will improve security and privacy in digital communications systems that connect our world; enhance navigation in demanding environments; advance sensors for geological resource exploration; and, drive superior computational capabilities for complex simulations and modeling of new pharmaceutical drugs and solar-energy-harvesting materials. Research and development (R&D) in optical science continues to develop new enabling technologies for a wide range of basic studies and applications in quantum science. Many quantum innovations rely on photonics-enabled technologies. Support for such enabling technologies has a two-way benefit: commercial products will drive the development of quantum technologies, and the developing quantum arena will provide market space for these products.
Continued Federal Support Critical to Study, Application of Optics and Photonics in Public and Private Sectors

Key Programs Need Sustained Support

The NPI thanks Congress for its recent show of support for federal research and development agencies and programs in the Consolidated Appropriations Act, H.R. 1625. Optics and photonics – the science and application of light – benefit greatly from federal research and development (R&D) investments and, in turn, contribute to innovations that reach beyond scientific discovery. Photonics generates, controls and detects particles of light to advance manufacturing, robotics, medical imagining, next-generation displays, defense technologies, biometric security, image processing, communications, astronomy and much more.

Now more than ever, it is important to maintain meaningful federal investments in photonics research to expand innovation, competitiveness and economic opportunity. The NPI encourages Congress to oppose cuts and support, at a minimum, 4 percent growth over inflation in funding for the nation’s science research.

Several science agencies and programs of interest to the NPI include:

NIST - The National Institute of Standards and Technology (NIST) was created to ensure America’s scientific and economic competitiveness throughout the world. Promoting innovation and advancement in measurement, standards and technology, NIST has enhanced U.S. economic markets and everyday lives for more than a century. NIST is the lead agency for two key manufacturing programs: the Manufacturing Extension Partnership Program (MEP) and National Network for Manufacturing Innovation (NNMI).

President’s FY19 Budget Proposal - $629 million for NIST FY18 Omnibus - $1.2 billion

MEPs – Manufacturing Extension Partnerships (MEPs) are public-private partnerships that foster innovative collaborations among industry, academia and state and local governments to provide small- and medium-sized manufacturers in all 50 states access to resources that help them identify growth opportunities and tools and services to improve their processes and create new products.

President’s FY2019 Budget Proposal - eliminates MEPs FY18 Omnibus - $140 million

DOE Office of Science - The Department of Energy’s (DOE) Office of Science is the nation’s largest funder of research in the physical sciences and plays a dominant role in underwriting engineering, mathematics and computer research. It supports discoveries in new fields such as biotechnology, nanotechnology and supercomputing – enabled by optics and photonics – and is critical to our nation’s economy and competitiveness. The Office of Science has provided grants to researchers and facilities in all 50 states and the District of Columbia, to DOE’s national laboratories and to more than 300 higher education institutions. The president has also proposed eliminating critical programs such as the Advanced Research Projects Agency-Energy (ARPA-e).

President’s FY19 Budget Proposal - $5.4 billion FY18 Omnibus - $6.26 billion
NIH - The mission of NIH is to seek fundamental knowledge about the nature and behavior of living systems and the application of that knowledge to enhance health, lengthen life and reduce illness and disability. NIH is the lead agency for cancer research and the BRAIN Initiative, which is authorized to fund increases over the next decade through the enacted 21st Century Cures Act.

President’s FY19 Budget Proposal - $34.8 billion FY18 Omnibus - $37.3 billion

NSF – The National Science Foundation (NSF) is a key funder of optics and photonics research. An example is the Laser Interferometer Gravitational-Wave Observatory (LIGO), which recently measured gravitational waves from a binary black hole merger. This discovery, enabled by photonics, confirms Einstein’s Theory of General Relativity. Another example is work being done by researchers to make solar cells that can be used on almost any surface, including windows, walls, computer bags and clothing.

President’s FY19 Budget Proposal - $7.47 billion FY18 Omnibus - $7.8 billion

DOD’s Science and Technology Program – The Department of Defense (DOD) is a key federal supporter of research in the physical sciences. The R&D supported by DOD’s Science and Technology Program plays a direct role in protecting and equipping our nation’s armed forces to carry out their present and future missions and is the source of many of the innovations that drive our high technology economy. Recent breakthroughs in optics and photonics at the agency include bringing directed-energy weapons systems closer to deployment; these systems could provide efficient, cost-effective countermeasures in an age of drones and other airborne threats.

President’s FY19 Budget Proposal - $13.7 billion FY18 Omnibus - $14.86 billion

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For more information, visit www.lightourfuture.org or contact Emily Pappas at 231.357.6330 or Krisinda Plenkovich at 360.483.8786.
NATIONAL PHOTONICS INITIATIVE URGES EMPHASIS ON EDUCATION AND WORKFORCE DEVELOPMENT

EXPANDED OPPORTUNITIES REQUIRE EXPANDED WORKFORCE

Our nation’s ability to fully optimize the growth opportunities presented by optics and photonics – the science and application of light – depends upon the preparedness of the American workforce in the physical sciences and engineering. The development of photonics technologies could lead to additional defense and commercial employment opportunities if there is a workforce ready to take advantage of them.

According to a 2012 study by OP-TEC, the National Center for Optics and Photonics Education, only 300 optics and photonics technicians graduate annually in the United States. At the same time, the optics and photonics industry is growing at a pace that demands at least three times as many technicians to sustain that growth.

The National Photonics Initiative (NPI) urges a continued emphasis on private and federal investment to establish and fuel partnerships in optics and photonics education training.

Examples of programs with current federal investment in workforce training in the sciences include:

- Advanced Technological Education (ATE) program, Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM), and Cyber Corps within the National Science Foundation (NSF);
- Community College Internship (CCI) program within the Department of Energy; and
- Manufacturing USA, a public-private partnership that promotes American manufacturing via innovation, collaboration and education.

Programs like these create a pipeline of qualified optics and photonics technical students to help advance the U.S. industry. Former members of the military present an excellent potential pool of technicians that can enter the optics and photonics workforce. The federal government should prioritize the retention and training of these individuals to keep talent and technology here in the United States.

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LABORATORY FOR LASER ENERGETICS DESERVES CONTINUED FEDERAL SUPPORT

ABOUT THE LLE

The Rochester, NY-based Laboratory for Laser Energetics (LLE) is one of three major facilities supported by the inertial-confinement fusion (ICF) program, which falls within the National Nuclear Security Administration at the Department of Energy (DOE). These three labs comprise LLE’s Omega Laser Facility, Sandia National Laboratories’ Z machine and Livermore National Laboratory’s National Ignition Facility. Research at these facilities supports the U.S. nuclear weapons stockpile, both in maintenance and modernization, as well as training scientists capable of assessing the nuclear capabilities of other countries. In addition to furthering nuclear weapon science through the research it performs, LLE is the largest National Nuclear Security Administration (NNSA) training facility for graduate students, providing a critical pipeline of specialized experts. The Omega laser is also critical to maintaining the U.S. position in laser technology by increasing our scientific knowledge key to industrial progress and to non-nuclear defense applications.

The National Photonics Initiative (NPI) is deeply concerned with the President’s FY19 budget proposal to cut 20 percent of the ICF program, and a three-year phase out of funding for the Omega Laser Facility. Such a cut would negatively impact the ICF’s ability to achieve its mission as a whole, depriving our nation of the significant contributions of the LLE facility.

CRITICAL CONTRIBUTIONS

The LLE is a vital contributor to national security, an invaluable source of scientific education and leadership and key to strategic work on an independent energy future. The OMEGA lasers (Omega and Omega EP) are the largest and most capable found at any academic institution, both in the United States and worldwide. A recent report from the National Academies of Sciences, Engineering, and Medicine, titled “Opportunities in Intense Ultrafast Lasers: Reaching for the Brightest Light,” points out that the U.S. is losing ground in a second laser revolution of highly intense, ultrafast lasers that have broad applications in manufacturing, medicine and national security. Currently, between 80 to 90 percent of the high-intensity laser systems are overseas, and all of the highest-power research lasers currently in construction or already built are overseas as well. The report makes recommendations that would improve the nation’s position in the field, including for the U.S. DOE to create a broad network to support science, applications and technology of these lasers. Enacting the drastic cuts proposed in the President’s FY19 budget would further undermine the U.S.’s ability to regain its previous leadership in this important space.

Over 360 skilled scientists, engineers and technicians are currently involved in the program. The DOE has also designated the LLE as the National Laser User’s Facility (NLUF), which allows the LLE to host more than 400 scientists and 100 graduate students from 55 universities, to carry out fundamental research,
training and education. The proposed budget reduction will affect the training of the current and future workforce working in high-energy-density physics who are highly qualified to evaluate the safety and reliability of our nuclear stockpile.

CONTINUED FEDERAL SUPPORT IS NECESSARY

Therefore, we ask that the subcommittees continue to build on the support provided in the FY 2018 omnibus by providing $80 million for the LLE Omega Laser Facility and $555 million for the ICF program in the FY 2019 Energy and Water Appropriations bill.

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IMPLEMENTATION OF NATIONAL QUANTUM INITIATIVE CRITICAL TO LONG-TERM SECURITY, COMPETITIVENESS OF U.S.

NATIONAL QUANTUM INITIATIVE (NQI)

The National Photonics Initiative is calling for a National Quantum Initiative (NQI) to accelerate the development of commercially available quantum-based technologies to facilitate growth in the U.S. economy and keep pace with accelerating international competition. The NQI will also bridge significant workforce gaps in the United States that exist between the world’s leading quantum researchers and industrial engineers, and catalyze a new sector in the science, technology, engineering and math (STEM) workforce. The specific operational goals of the NQI are to:

- Engage and produce a world-leading industrial quantum technology workforce;
- Engineer, industrialize and automate quantum technology, including quantum computers, communications systems and sensors;
- Provide access to the emerging quantum computer systems;
- Develop conventional technology and intellectual property needed to support and enable quantum technology;
- Produce quantum software and new applications of quantum technology; and
- Continue the fundamental research needed to support these NQI goals and those that arise from the capabilities of quantum technologies.

QUANTUM TECHNOLOGIES

Quantum technologies – based on fundamental particles of nature such as individual atoms and photons – hold great promise to become the computers, networks and sensors of tomorrow. Quantum information science is based on exploiting subtle aspects of quantum physics, such as “quantum superposition” and “entanglement,” for valuable, real-world technologies. These technologies can:

- handle computationally complex problems;
- provide communication security; and
- enhance navigation, imaging and other sensing technologies in ways that are impossible using binary-based computer systems.

INTERNATIONAL INVESTMENT

The United States has yet to capitalize on the available opportunities – such as those in the field of cybersecurity – to move promising quantum technology from the laboratory to the marketplace. Meanwhile, other nations are investing heavily in quantum-based technology.

- China is aggressive in its commitment to quantum; the Chinese government recently launched a satellite devoted to quantum communication protocols.
In Europe, entities have recently established large, focused, academic/industrial thrusts, including the UK Quantum Hub Network ($400 million over five years), the Netherlands QuTech Initiative ($150 million/10 years) and the European Union (EU) Flagship Quantum Program ($1.3 billion/10 years).

Major initiatives are also underway in Australia and Canada.

IMPLEMENTATION PLAN

In a white paper released in June 2017, titled A Call for a National Quantum Initiative, and in a subsequent action plan and testimony before the U.S. House Science, Space and Technology Committee in October 2017, the NPI has called for an investment in three to six new facilities called Quantum Innovation Laboratories (QILabs), along with a Quantum Research Network (QRNet) and a Quantum Computing Access Program (QCAP).

- The QILabs will serve as proving grounds and testbeds for quantum technologies, and will follow the proven model of academia, government and industrial scientists and engineers working collaboratively on shared objectives at central facilities across the U.S., each with its own distinct and focused research and development mission.
- The QRNet program will support fundamental research of quantum technology by funding individual efforts to investigate and collaborate with QILab technologies, combine different quantum technology for hybrid quantum systems, and uncover promising quantum systems for future quantum bit realization and quantum technology development.
- The QCAP will support the activities of the QILab and QRNet programs by providing access to the most advanced American quantum computing systems and simulators.

QILabs/QRNet/QCAP will be administered and funded in a coordinated fashion by an appropriate grouping of programs within NSF, NIST and DOE, to be decided jointly by those agencies, and informally advised by quantum technology experts selected by NSF, NIST, DOE, and the DOD and Intelligence agencies, accounting for recommendations by industry. These agencies will coordinate their existing programs in underlying quantum science and technology with the QILabs. The QILab and QRNet performers will be selected by the above agencies based on existing solicitation and evaluation procedures. Each QILab will be led by a scientific and administrative director, who will coordinate the operation of the QILab with the above agencies.

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