

Optics and Photonics

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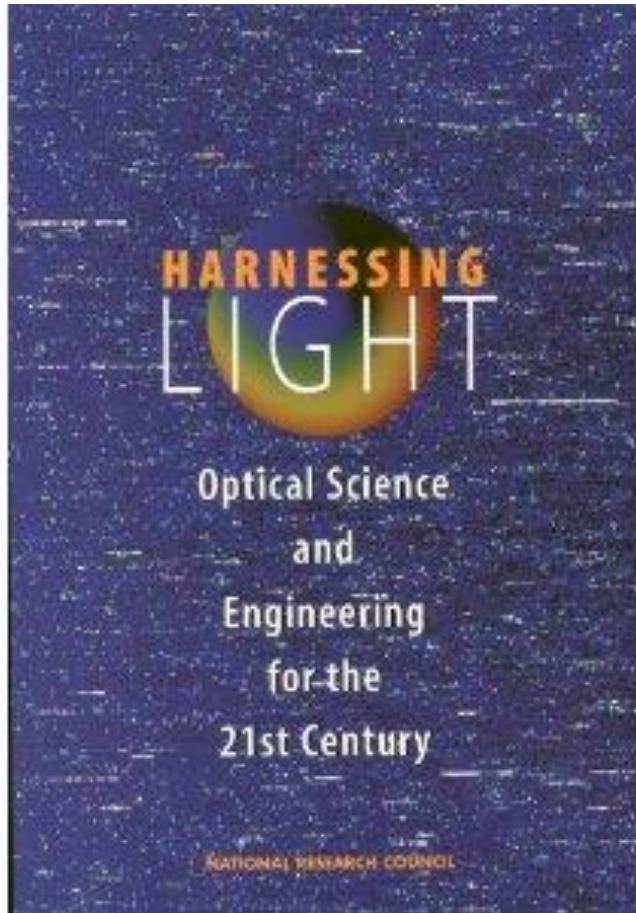
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Nobel Prizes: A few examples

- 1901 Physics: Wilhelm Conrad Röntgen
- 1902 Physics: Hendrik Antoon Lorentz, Pieter Zeeman
- 1907 Physics: Albert Abraham Michelson
- 1921 Physics: Albert Einstein
- 1964 Physics: Charles Townes, ...
- 1986 Chemistry: Dudley Herschbach, Yuan Lee, John Polanyi
- 1997 Physics: Steven Chu, Claude Cohen-Tannoudji, William Phillips
- 1999 Chemistry: Ahmed Zewail
- 2001 Physics: Eric Cornell, Wolfgang Ketterle, Carl Wieman
- 2012 Physics: Serge Haroche and David Wineland

Harnessing Light: **Optical Science and Engineering** **for the 21st Century**



A 1998 report of the
National Research Council
of the National Academies

Optics and Photonics: **Essential Technologies for Our Nation**

A 2012 report of the National Research
Council of the National Academies



Optics and Photonics: Essential Technologies for Our Nation

A 2012 report of the National Research Council of
the National Academies

➤ The NRC study is supported by

- NSF (ENG and MPS)
- DOD (AFOSR, ARO, DARPA), DOE (BES and EERE),
NIST



➤ The NRC study is co-chaired by

- Dr. Alan E. Willner, University of Southern California
- Dr. Paul McManamon, Exciting Technology, LLC



Goals of the Study

- Review progress in field since the 1998 report: *Harnessing Light*.
- Identify technological opportunities that impact society, energy, healthcare, information technology, national security,
- Assess the state of the field in the U.S. and abroad, including market needs, workforce needs, manufacturing infrastructure, and impact on the national economy.
- Prioritize research grand challenges in pursuit of national competitiveness.
- Recommend actions for development and maintenance of global leadership in the photonics driven field.

Chapters of the Report

Chapter #	Chapter Title
Chapter 1	Introduction
Chapter 2	Impact of Photonics on the National Economy
Chapter 3	Communications, Information Processing & Data Storage
Chapter 4	Defense and National Security
Chapter 5	Energy
Chapter 6	Health and Medicine
Chapter 7	Advanced Manufacturing
Chapter 8	Advanced Photonic Measurements & Applications
Chapter 9	Strategic Materials for Optics
Chapter 10	Displays

Study Outcome (to be continued)

- The report discusses the essential role of optics and photonics as an **enabling technology** in modern life that is critical to the Nation's technological leadership.
- The optics and photonics field is **experiencing rapid scientific and technical progress and expanding applications** over a growing range of technologies, markets, and industries, including those of small business.
 - 12 of the 50 best inventions of 2011 listed by *Time* Magazine had optics as a key technological part of the invention
- ...



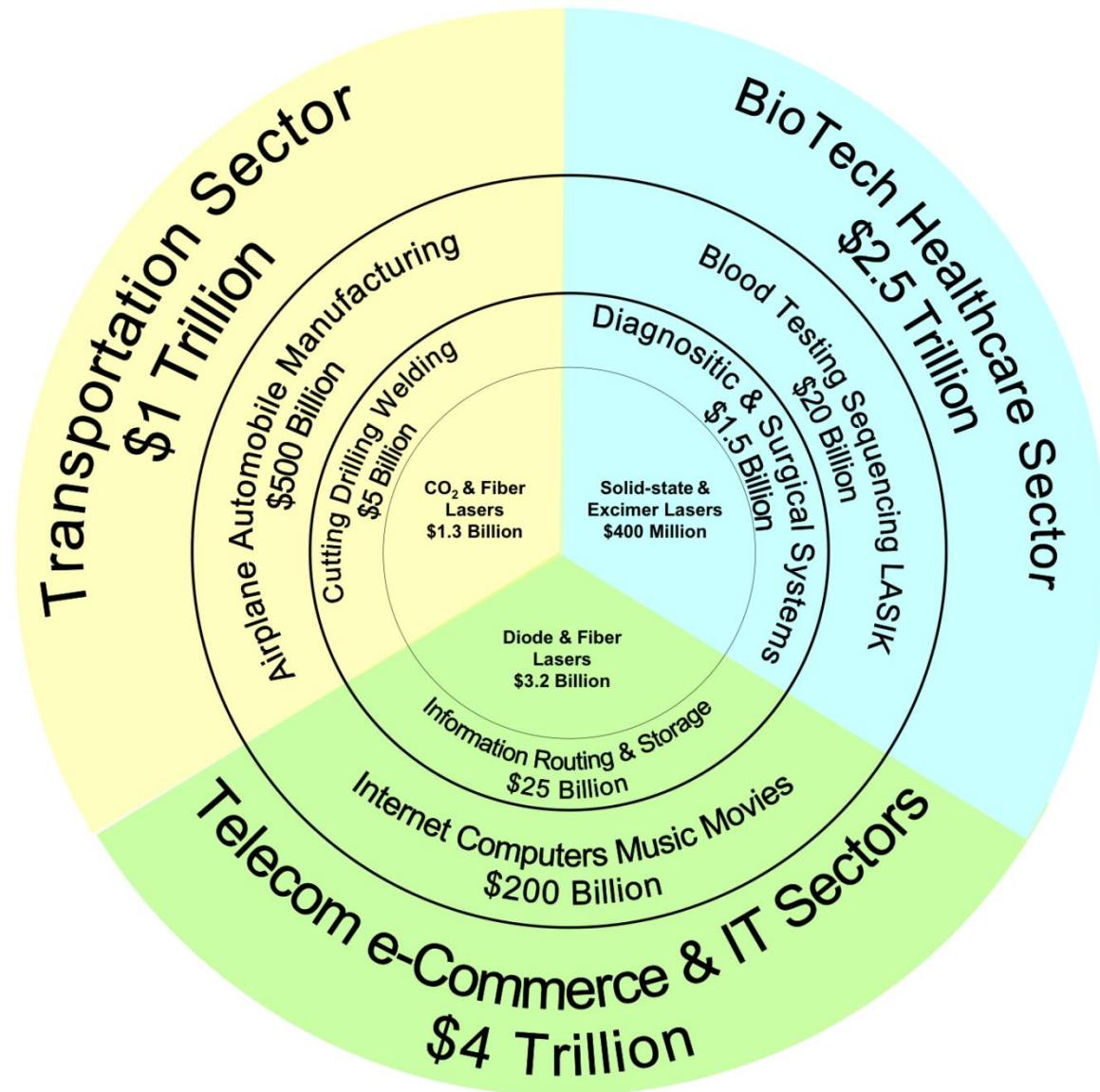
Vignettes of Ubiquitous Impact

- An Internet search on a smart-phone is a prototype example:
 - display, machining, Internet fiber backbone, data centers

- The data center is a strategic U.S. asset.
 - A large data center can have 1,000,000 lasers.
 - Much of the world's data flows through the U.S. due partially to our infrastructure.

Vignettes of Ubiquitous Impact

- Direct sales of photonics equipment leverages a sizable fraction of the U.S. economy (*Baer & Schlachter*):



Examples of Recommendations

- Develop a seamless integration of photonics and electronics
- Invent technologies for the next factor-of-100 cost-effective capacity increases in optical networks
- Develop efficient LED for general-purpose lighting
- Develop new instrumentation to allow simultaneous measurement of all immune-system cell types in blood
- Develop table-top soft x-ray light sources and imaging for lithography and three-dimensional manufacturing
- Develop technology for generating light beams with prearranged photonic structures
- Increase US leadership role in development of materials with designable and tailorable optical properties



Study Outcome (continued)

➤ ...

➤ A strong **educational infrastructure**, including training of a skilled technical workforce, plays a critical role in ensuring a vibrant future in the optics and photonics field

➤ ...

Study Outcome (continued)

- A major recommendation of the report is the call for a **National Photonics Initiative** that would seek to bring together academic, industrial, and government researchers, managers, and policy makers to develop a more integrated approach to managing industrial and government research and development investments in the field.
 - Although many innovations in optics & photonics have occurred in the U.S., our leadership is far from secure.
 - If the U.S. does not act with strategic vision, future scientific advances and economic benefits might be led by others

NSF Action

- The MPS and ENG ADs have asked Dr. Charles Ying (MPS/DMR) and Dr. Lawrence Goldberg (ENG/ECCS) to co-chair a working group of program officers to develop an NSF-wide strategy to respond to the recommendations of the report.
- The working group is charged to:
 - Provide a roadmap of activities that potentially will become a multi-year activity beginning in FY2015.
 - Present a preliminary roadmap to all participating NSF directorates in January 2013, with the final roadmap being delivered by May 2013.
 - Seek to establish interactions and partnerships with other Federal agencies interested in this research area.

Initial Activities of the Optics and Photonics Workgroup

- Expanded the workgroup membership
 - From MPS and ENG to BIO, CISE, EHR, SBE
- Performed a preliminary inventory - Optics and photonics related activities are supported by all NSF directorates, including all five MPS divisions:
 - Discovery and understanding of novel optical phenomena and materials
 - Fabrication/invention of novel optical materials, devices, and systems
 - Utilization of powerful optical tools (lasers, telescopes, microscopes, spectroscopy, ...)
 - Education and workforce development



Major Recommendation

- The major recommendation of the report is the call for a **National Photonics Initiative** that would seek to bring together academic, industrial, and government researchers, managers, and policy makers to develop a more integrated approach to managing industrial and government research and development investments in the field.
 - Although many innovations in optics & photonics have occurred in the U.S., our leadership is far from secure.
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References

- The National Academies' report: *Optics and Photonics: Essential Technologies for Our Nation*

http://www.nap.edu/catalog.php?record_id=13491

- An overview of the report, by SPIE

<http://spie.org/Documents/AboutSPIE/PDF/HLII-OpticsandPhotonics.pdf>

