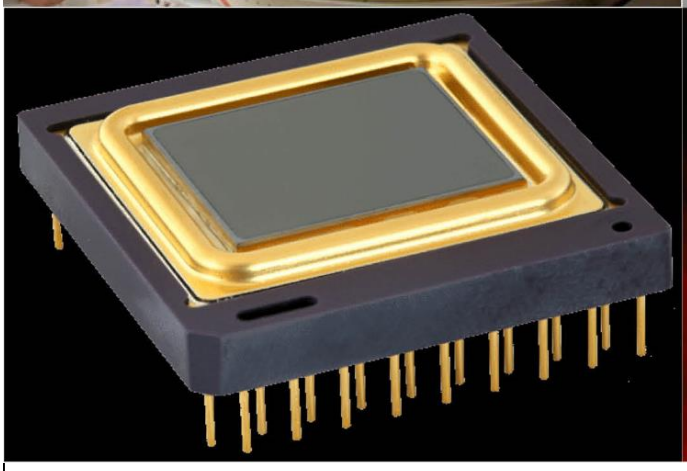

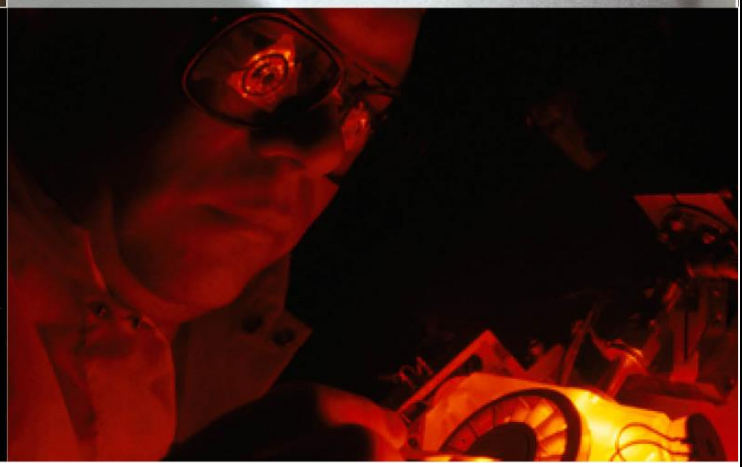

PHOTONICS IN NEW MEXICO

DIVERSE INDUSTRY POISED FOR GROWTH

Prepared by:

nmOptics

LOGICAL MARKETING

Sponsored by:

City of Albuquerque 1706 New Mexico

new mexico MEP manufacturing extension partnership

SPIE.

PHOTONICS IN NEW MEXICO

DIVERSE INDUSTRY POISED FOR GROWTH

The world-wide Photonics-enabled industry (systems using photonics) is estimated to be $780 Billion. The core Photonics Industry is estimated to be a $156 Billion world-wide industry. (SPIE, 2014)

The Photonics industry comprises semiconductor chip processing, solar cell processing, biomedical devices, light-emitting diode (LED) products, automotive parts and assembly manufacturers, telecommunication systems, defense equipment, test and measurement systems for a myriad of industries from food production and safety to materials processing, and therapeutic instruments.

In fact, there is not a single Gross Domestic Product (GDP) category which is not positively impacted by Photonics, with Photonics growing at a 7% Compound Annual Growth Rate (CAGR). (Germany Federal Ministry of Education and Research, VDMA, Spectaris, and ZVEI, 2014)

EXECUTIVE SUMMARY

New Mexico employs more than 6,234 people engaged in the Photonics Industry. These entrepreneurs, manufacturers, technicians, finance, sales, and marketing people create components, build systems, and engage Photonics to generate new devices and services. They account for 8% of the state's manufacturing revenues.

New Mexico's 96 photonics firms produce products and services in several of these international categories. Some firms focus on Research and Development, while some purely on the manufacturing processes. All participate in the Photonics Industry.

These ninety-six (96) firms produce $28B in revenue (shipment value) comprising eight 8% of the state's manufacturing revenues. Thirty-three percent (33%) of the patents (532 of 1596 (US Patent Office, 2009-2014)) granted to entities in the state since 2009 are Photonics-related.

NEW MEXICO PHOTONICS EMPLOYS THOUSANDS

6234 entrepreneurs, manufacturers, technicians, finance, marketing and salespeople across the state work in Photonics.

96 companies produce $28B in revenue (shipment value)

33% or 532 of 1596 patents granted to entities in the state since 2009 are Photonics related.

New Mexico's firms are well-positioned to make significant advances in solar cell manufacturing and optimization, test and measurement systems, semiconductor processing, and biomedical devices.

WHAT IS PHOTONICS AND WHY NOW?

Photonics includes the generation, emission, transmission, modulation, signal processing, switching, amplification, and detection/sensing of **light**. It covers all technical applications of light over the whole spectrum from ultraviolet through the visible to the near-, mid- and far-infrared. The term "photonics" developed as an outgrowth of the first practical semiconductor light emitters invented in the early 1960s and optical fibers developed in the 1970s. (Wikipedia, 2014)

Examples of Photonics in everyday life include:

Photonics function	Device
Generation & Emission	LEDs, laser in computer mouse & DVD players, plasma & LCD displays
Transmission	Fiber optics, infrared remote controls, TV images, cell phones
Modulation	Optical communication, laser marking, LCD
Signal processing	Encryption, optical communication, cameras, image processing, DVD players
Switching	Optical communication
Amplification	Repeaters, laser cutting, LASIK, laser welding
Detection	Chemical analysis, night vision, cameras, barcode scanners, solar panels
Sensing	Pulse oximeters, motion detectors, guidance systems, collision avoidance

The field of Photonics began with the invention of the laser in 1960. Semiconductor lithographic processing which is totally enabled by Photonics created an economical manufacturing method in the 1970s. Other developments followed: the laser diode in the 1970s, optical fibers for transmitting information in the 1980s, and the erbium-doped fiber amplifier in the 1990s. These inventions formed the basis for the telecommunications revolution of the late 20th century and provided the infrastructure for the Internet and the "Cloud" as we know it today. All transformed economies, business, safety and security, and home-life as we experience them in our daily lives today.

In 1998, the National Academies of Science (NAS) National Research Council (NRC) undertook a study entitled "Harnessing Light" (National Research Council, 1998). The NRC analyzed the existing Photonics Industry, the economic impact of Photonics on everyday life, and what the United States could do to further leverage Photonics as the world headed from the Age of Electronics into the Age of Photonics.

European leaders leveraged the Harnessing Light report, and realizing that they could lead the world into the 21st Century if they reallocated research spending and investments focused on creating expertise (education, technologies, and business practices) in the area of Photonics. (Photonics21, 2014) They created an EU-sponsored consortium called "Photonics 21" in which business leaders from the largest companies and the largest Photonics companies contributed to creating a Continental Strategic Plan focused around light-based technologies. The German economy, as an example, is now enjoying a 7% CAGR in the Photonics-enabled industries. (Germany Federal Ministry of Education and Research, VDMA, Spectaris, and ZVEI, 2014)

The 21st Century is being transformed by the Photon.

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INTRODUCTION & MOTIVATION

There is no doubt about the economic importance of Photonics in the 21st Century Worldwide Economy. Between the recently released National Academies of Science report *Optics & Photonics: Essential Technologies for Our Nation*, (also known as 'Harnessing Light 2'), the Institutes for Manufacturing Innovation (IMI) announced by the Department of Defense in October 2014, and the United Nations declaration of 2015 as the *Year of Light* – many, around the world, are beating the Photonics drum.

The question for New Mexico is how to be best positioned for these technological and economic opportunities in Photonics leading to decisions regarding allocations of limited resources, where to put investments, and in which areas of photonics should students be trained. We cannot do it all. We can, however, market and enhance our existing areas of strengths.

The best way to make a Fact-based Decision, is to start with the Facts.

FACT: New Mexico is home to several leading federal government photonics research institutions:

- Sandia National Laboratories
- Los Alamos National Laboratory
- Air Force Research Laboratory

FACT: The University of New Mexico has over 37 faculty engaged in Photonics-based research.

QUESTIONS:

- How many companies are engaged in Photonics?
- How many employees are engaged in Photonics?
- Are we converting NM research into economic opportunities?
- Where are our strengths (which technologies)?
- Where are our opportunities as a state?
- How can we grow what we have faster?

The New Mexico Optics Industry Association, **nmOptics**, has been fielding these questions and more for the City of Albuquerque, for the State of New Mexico, for the Manufacturing Extension Partnership (MEP), and for SPIE (the International Society for Optics and Photonics). The City wants to understand the economic development implications of the Photonics industry. The State is interested in the impact of Photonics as it updates the State's Strategic Technology Plan. Our NM-based MEP wants data with regards to how to improve the US supply-chain for the New Mexico Photonics industry. And, SPIE is interested in data that sheds light on the detailed impact of US policy information required as part of the National Photonics Initiative.

As the factors converged, it became obvious to **nmOptics** that an exhaustive study of the Photonics resources in the state needed to be undertaken. Supposition about what New Mexico resources were needed to be replaced with factual data. And, the only organization in the state capable of marrying the technical aspects of the field with the economic impact of the field was **nmOptics**.

nmOptics in collaboration with the City of Albuquerque, MEP, and SPIE combined their funding to support this project to gather, compile and report upon the State of Photonics in New Mexico through the efforts of Logical Marketing, LLC.

STUDY METHODOLOGY

The study methodology included several phases: Primary and Secondary Data Collection, Primary Data Verification, and Data Analysis. The Data Collection process was modeled on the process utilized by the Colorado Photonics Industry Association.

Purpose

The primary purpose of the study is to quantify the economic impact of the photonics activity in the state of NM. This included:

- Companies – who, where, and areas of expertise
- Revenues – which companies were revenue drivers
- Jobs – which companies were major employers
- Major product and market areas of expertise -- was there a grouping of expertise
- Patents granted and technology transferred by the universities
- Students graduated and where they were employed by the schools of higher education

The quantification of “what we have” along with “what we do not have” would provide information to help formulate useful insights that Policy Makers, Economic Development Strategists, and Industry Association Programs can use to strengthen the business climate within the State of New Mexico and generate long-term economic growth drivers and job creation.

Methodology

Companies engaged in photonics often do not identify themselves as a photonics-based company. For example, companies engaged in making medical devices, metal-working devices, unmanned aerospace vehicles, or semiconductor lithography equipment will register themselves under the North American Industry Classification System code (NAICS) corresponding to their market application, but not “Photonics”.

A biotech company building a medical device that will require FDA clearance will need to be registered as a medical device company. A company bidding on UAV programs will need to be listed under the appropriate NAICS code to qualify as a legitimate bidder for those programs. Because of the nature of Photonics, *as an enabling component of a larger system*, the majority of the participants cannot or do not use an NAICS code that would readily identify the sector’s data from US Census or NM State Economic Data.

Therefore, **nmOptics** had to create a new database of technology companies that manufacture photonics, incorporated photonics in their products, or utilize photonics in the production of their own products. Further complicating the effort, some companies with a multiple-state footprint may engage in photonics, but not in their NM facility – thus, the in-state efforts needed to be confirmed by the local entity.

An extensive secondary research effort comprising an initial dataset of 9000 “tech companies” were investigated yielding 600 “suspect photonics companies.” These 600 were then further filtered into three categories of Photonics Companies:

1) Photonic Component Suppliers
2) Photonic System Integrators
3) Photonics’ Enabled Companies

This company characterization effort culminated in 120 firms which provided great perspective on the companies in New Mexico which have a percentage of Photonics in their product offering.

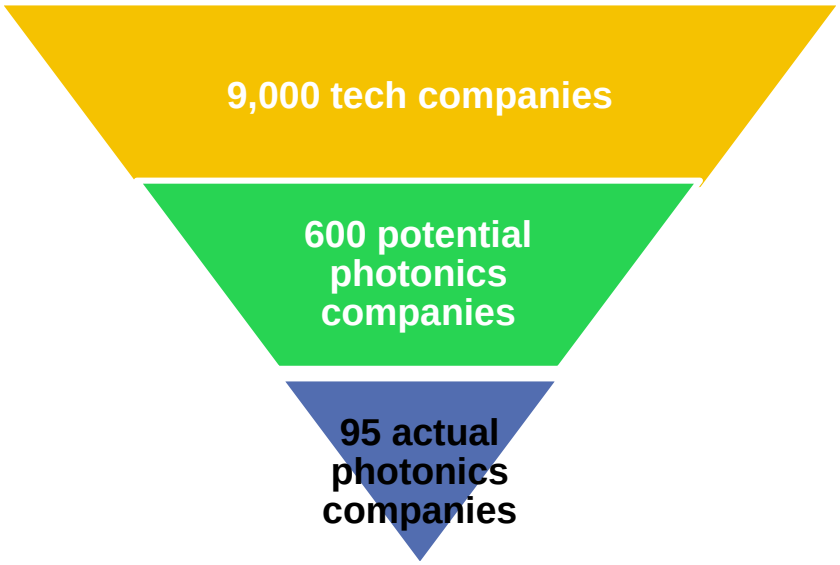


FIGURE 1. COMPANY METHODOLOGY FUNNEL.

The next step in the research methodology was a rigorous primary research effort confirming the public data and querying very specific issues with regards to the following:

1) employee recruitment and retention
2) policy regulations which hampered growth
3) supply chain issues within and external to the state
4) taxation
5) R&D partnerships
6) foreign exports

Study Reliability and Reporting Limitations

Primary and secondary research was conducted over a five month period to determine company revenue, employee counts, and specific answers to the issue questions. Extensive effort was made to provide reliable information. The original secondary information was gathered from company websites, annual reports, Hoovers, and A-to-Z database. Every effort was made to confirm the public data by personal interviews with each company’s executive team.

Data interpretation

All of the revenue figures in this report are reported in US$ Million (unless specified). All employee counts are assumed to be Full Time Equivalents (FTE). NAICS codes are those reported in the Hoover’s Database (a Dun & Bradstreet product).

Definitions

To establish a solid basis for the terms used throughout the Report, the definitions of a number of the technical terms are given here.

Photon

A particle of energy which has a wavelength (sometimes referred to as a color), a speed, and a direction. It has no mass.

Photonics

The study and manipulation of the Photon. Photonics historically has been focused on wavelength ranges from 10 nano-meters (nm) (Extreme Ultra-Violet) to 10,000 nm (Far Infrared). Recently, the soft-X-ray range has been included as semiconductor processing is trying to get to 1 nm line width for making smaller line spacing for chip manufacturing. Also, terahertz radiation above 10,000 nm is being explored for sensors, test and measurement, and as directed-energy weapons.

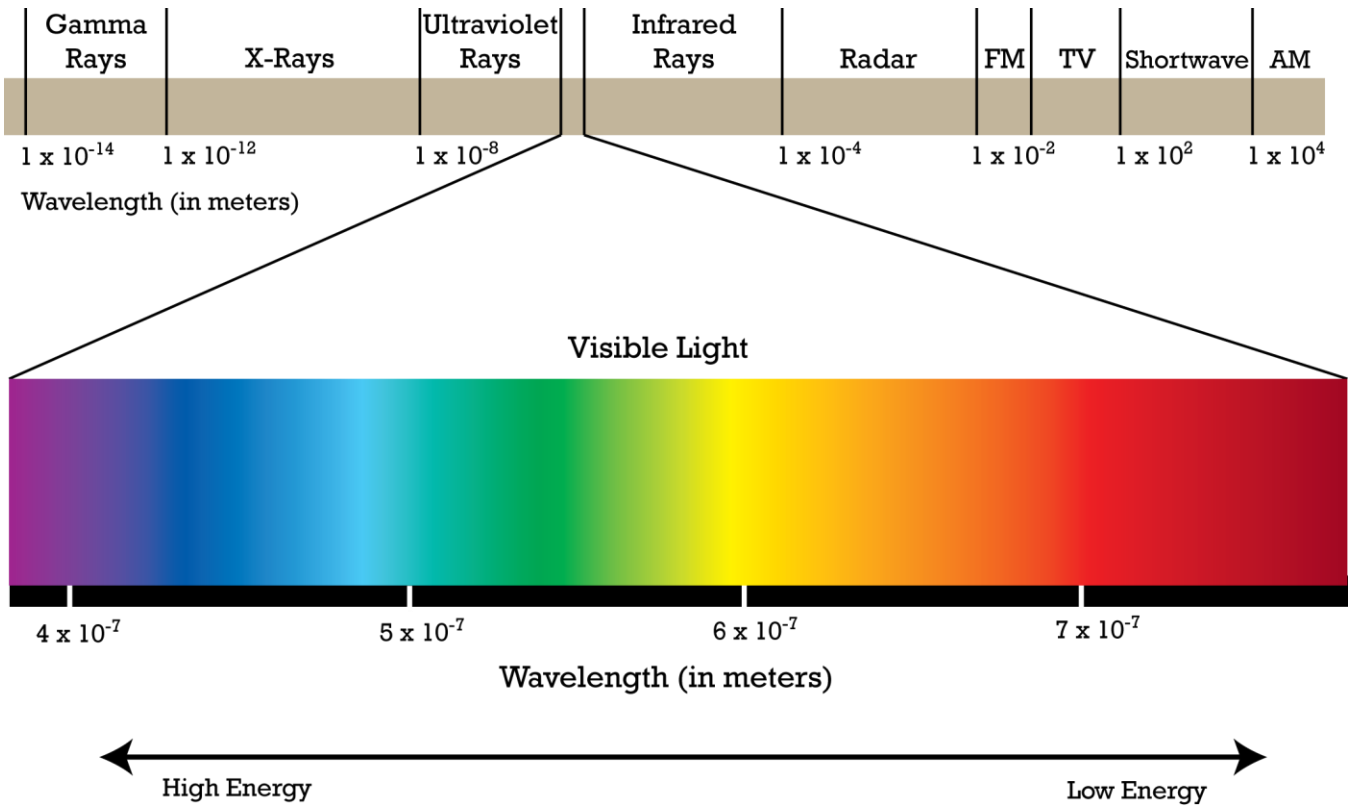


FIGURE 2. ELECTROMAGNETIC SPECTRUM WITH THE VISIBLE LIGHT PORTION HIGHLIGHTED. PHOTONICS INCLUDES EVERYTHING FROM X-RAYS TO INFRARED RAYS ON THIS CHART. (INFRALINE, 2014)

Component

A component is defined as a photonics item which cannot function alone, such as an optic, a detector, a laser, or light source.

Sub-System

A collection of components which cannot function alone, but for which the assembly and the alignment

of the “sub-system” are difficult. These could almost be considered “super components” as they cannot function alone.

System

A complete system that the end-user can operate such as an instrument, a laser marker, 3D printing system or biometric installation.

Integrator

A company which integrates several components into a system specifically for a customer – these are generally “built-to-order” and may have little Intellectual Property involved in the integration. Company advantage is generally around supply chain optimization and distribution knowledge.

Photonics-Enabled Company

A company which requires the use of photonics in order to ship its own products. These companies require a great deal of internal photonics knowledge in order to safely and accurately specify and utilize these pieces of equipment.

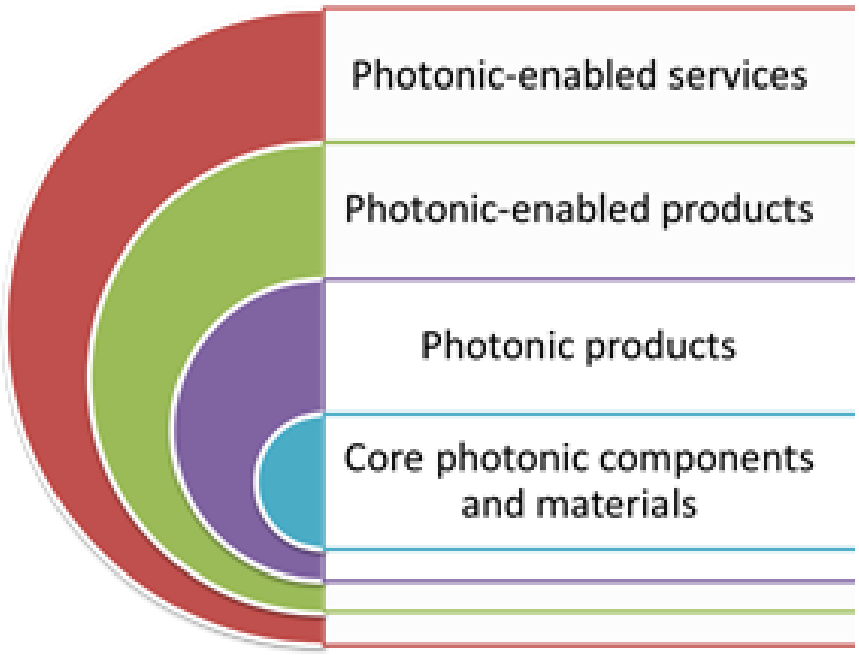


FIGURE 3. PHOTONICS CATEGORIES FROM SPIE AUGUST 2014 INDUSTRY UPDATE.

OVERVIEW OF NEW MEXICO ECONOMY

The New Mexico economy has struggled in the past 4 years. This is easily seen when comparing New Mexico Manufacturing jobs to the National averages. A beacon of hope is that New Mexico is creating manufacturing companies, whereas the rest of the United States appears to be losing manufacturing companies.

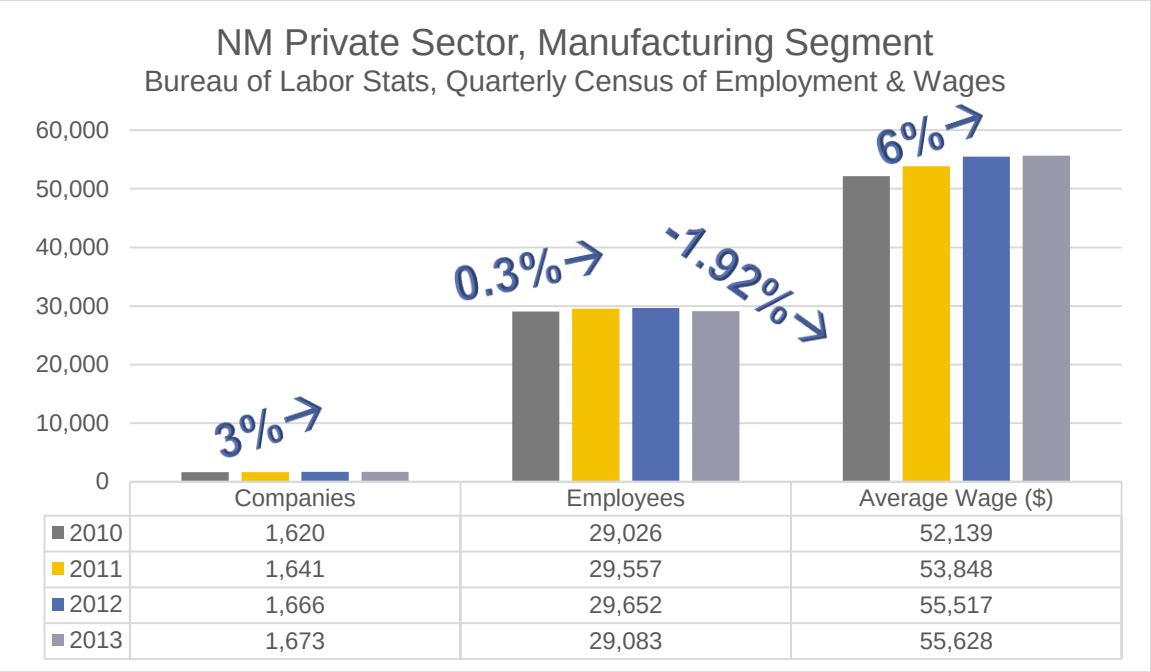


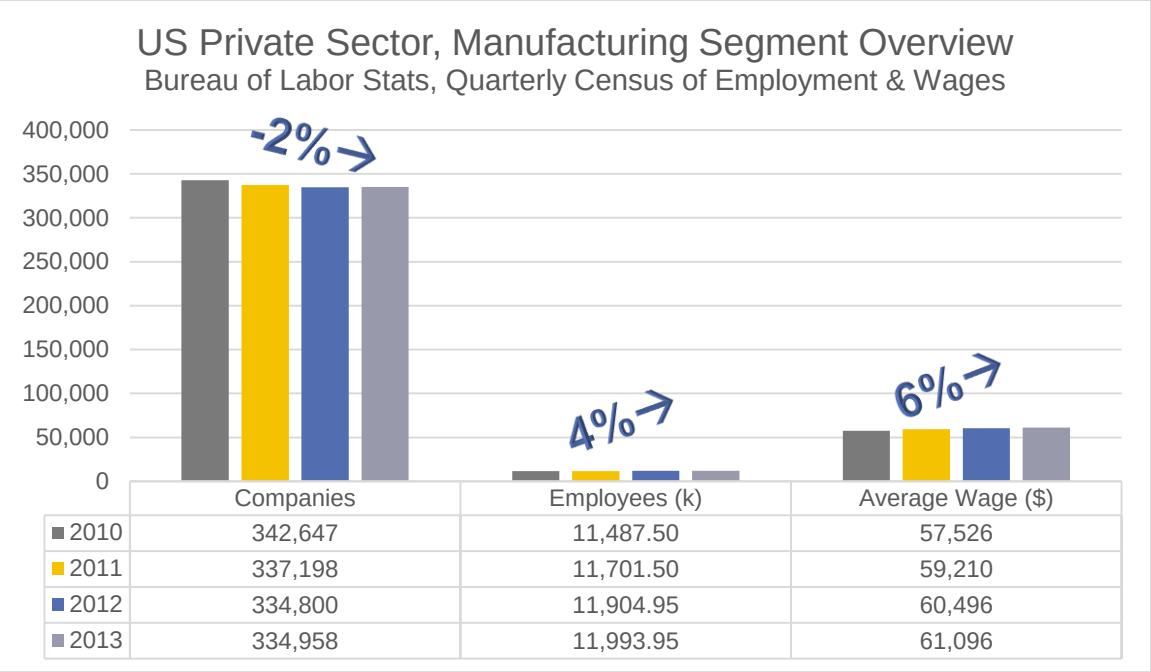
FIGURE 4. COMPANIES AND JOBS HAVE GROWN IN THE PAST 4 YEARS ACCORDING TO US CENSUS DATA. (U.S. CENSUS BUREAU, MANUFACTURING & CONSTRUCTION, 2013)

The figure above shows that New Mexico over the past 3 years has added nearly 20 manufacturing companies a year, resulting in a growth of the number of companies of 3%. Unfortunately, the new companies are not employing as many people as the original companies were – and the manufacturing sector has overall lost 600+ jobs between 2012 and 2013 – returning to the recession low of 29,000 manufacturing jobs. (U.S. Census Bureau, Manufacturing & Construction, 2013)

The average manufacturing wage has increased 6% since 2010 – in line with the National wage increases. (U.S. Census Bureau, Manufacturing & Construction, 2013)

NATIONAL & REPRESENTATIVE STATES COMPARISON

The National Economy indicates that, although the total number of manufacturing firms has been shrinking, the actual number of those employed has been increasing with wages increasing at an even faster pace.



	Companies	Employees (k)	Average Wage ($)
2010	342,647	11,487.50	57,526
2011	337,198	11,701.50	59,210
2012	334,800	11,904.95	60,496
2013	334,958	11,993.95	61,096

FIGURE 5. QUARTERLY CENSUS OF EMPLOYMENT AND WAGES (QCEW) DATA FROM 2010 TO 2013 TOTAL FOR ALL STATES IN MANUFACTURING SEGMENT. (US DEPARTMENT OF LABOR, BUREAU OF LABOR STATISTICS, 2010, 2011, 2012, 2013)

Perhaps more telling than the National Story is a comparison between New Mexico and its representative peer states.

The comparison states – Colorado, Arizona, Texas, and New York – have vibrant Photonics Industries:

Colorado • 76 companies from the Photonics Spectra Buyer's Guide (Photonics Media, 2014) • 280 companies listed in the CPIA 2008 Directory (Colorado Photonics Industry Association, 2008) • National Institutes of Standards and Technology (NIST) • Joint Institute for Laboratory Astrophysics (JILA) • The National Science Foundation Engineering Research Center for Extreme Ultraviolet Science and Technology (NSF EUV ERC)	**Arizona** • 72 companies from the Photonics Spectra Buyer's Guide (Photonics Media, 2014) • 250 companies listed in the Arizona Optics Industry Association Directory (Arizona Optics Industry Association, 2014) • University of Arizona, College of Optical Sciences
Texas • 76 companies from the Photonics Spectra Buyer's Guide (Photonics Media, 2014) • National Center for Optics and Photonics Education, OP-TEC (OP-TEC, 2014) • Nanophotonics Center @ Texas Tech University (Texas Tech, 2014)	**New York** • 250 companies from the Photonics Spectra Buyer's Guide (Photonics Media, 2014) • 117 companies listed in the New York Photonics Industry Association Guide (New York Photonics, 2014) • 5 Regional Clusters • University of Rochester, Institute of Optics

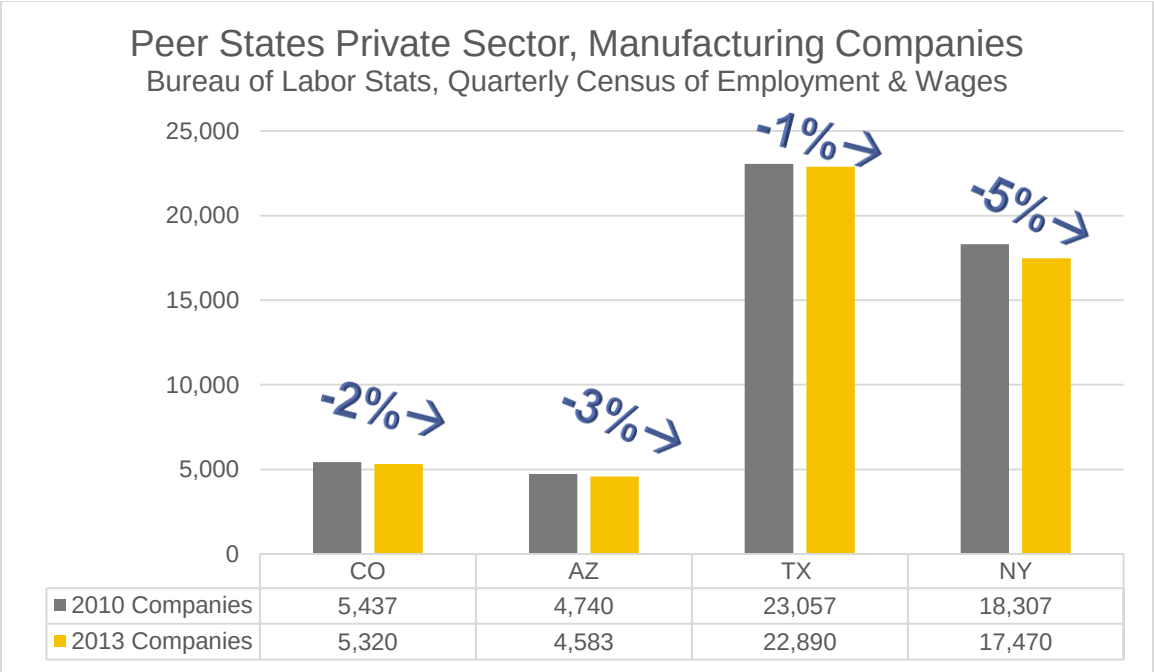


FIGURE 6 QUARTERLY CENSUS OF EMPLOYMENT AND WAGES (QCEW) DATA FROM 2010 TO 2013 TOTAL FOR SELECTED STATES IN MANUFACTURING SEGMENT. (US DEPARTMENT OF LABOR, BUREAU OF LABOR STATISTICS, 2010, 2011, 2012, 2013)

The neighboring and peer states show a decrease in total number of manufacturing firms, including firms that have gone out of business or have been consolidated through merger and acquisition activity.

Counter to the decrease in number of firms in the neighboring/peer states, is a huge growth in manufacturing employees. This may be indicating that consolidation is leading to stronger firms that can actually increase employment.

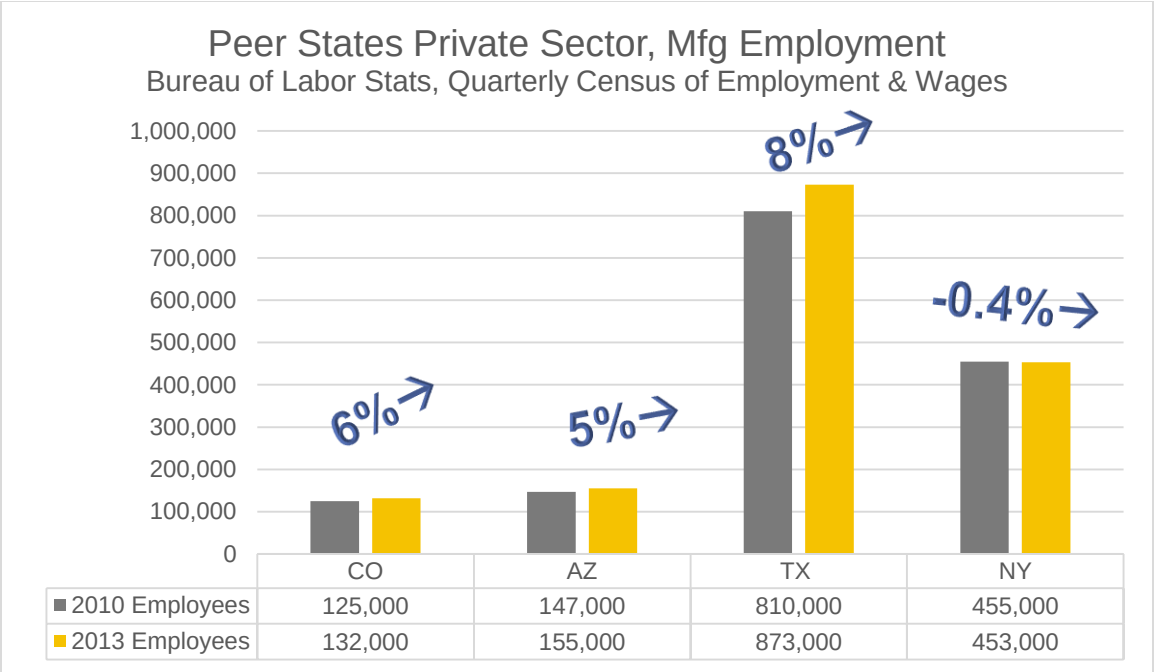


FIGURE 7 QUARTERLY CENSUS OF EMPLOYMENT AND WAGES (QCEW) DATA FROM 2010 TO 2013 TOTAL FOR SELECTED STATES IN MANUFACTURING SEGMENT. (US DEPARTMENT OF LABOR, BUREAU OF LABOR STATISTICS, 2010, 2011, 2012, 2013)

In the growing states, (Colorado, Arizona, and Texas), the number of employees per manufacturing company has increased 10% over the period. New Mexico's companies on average got smaller and New York's stayed nearly the same size.

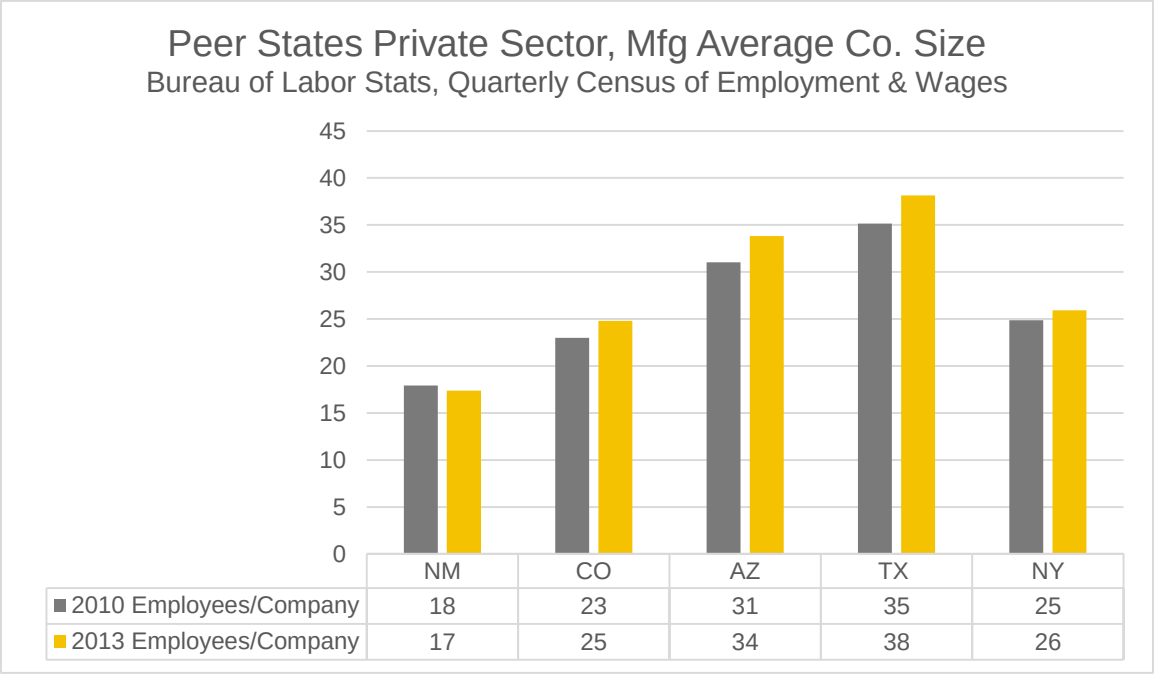
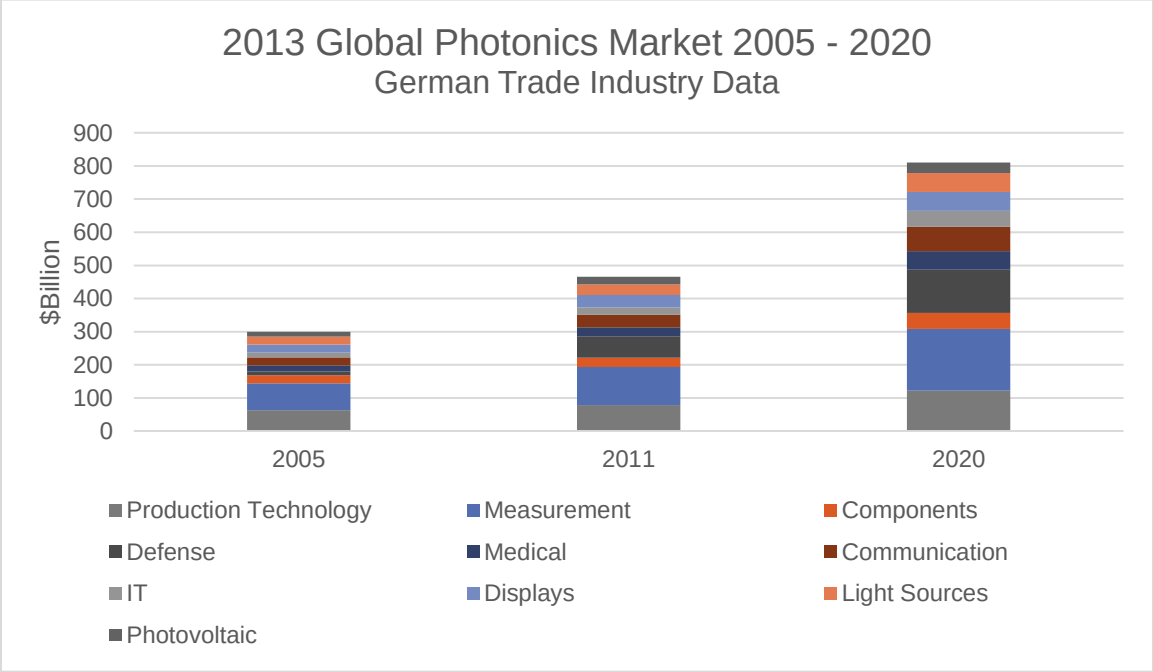


FIGURE 8 QUARTERLY CENSUS OF EMPLOYMENT AND WAGES (QCEW) DATA FROM 2010 TO 2013 TOTAL FOR ALL STATES IN MANUFACTURING SEGMENT. AVERAGE WAS CALCULATED FROM TOTAL EMPLOYEES DIVIDED BY TOTAL NUMBER OF COMPANIES. (US DEPARTMENT OF LABOR, BUREAU OF LABOR STATISTICS, 2010, 2011, 2012, 2013)

WORLDWIDE PHOTONICS INDUSTRY

Photonics is a core technology that crosses over many industries. Many photonic technologies originated in the United States and have benefited greatly from federally funded programs such as: National Science Foundation (NSF), National Institutes of Health (NIH), Small Business Innovation Research (SBIR), and Small Business Technology Transfer (STTR).

In 2013, a consortium of German Industry Associations presented “Photonics Industry Report 2013” (Germany Federal Ministry of Education and Research, VDMA, Spectaris, and ZVEI, 2014) which predicts the global photonics market will grow from $461 billion in 2011 to $811 billion by 2020. The prediction for photonics assumes a compound annual growth rate (CAGR) of 6.5 percent per year, as reflected in the industry since 2005, a growth rate twice that of worldwide gross domestic product.



The German photonics sector experienced above-average real growth of 7 percent, slightly better than the global average, thanks to strong exports in production systems, image processing and measurement technology, and optical components and systems. Germany alone added 30,000 new photonics-related jobs between 2005 and 2011, to create a total workforce of 134,000 employees. (Germany Federal Ministry of Education and Research, VDMA, Spectaris, and ZVEI, 2014)

NEW MEXICO PHOTONICS INDUSTRY

Overview

New Mexico has a growing photonics industrial community comprising well-known Fortune 500 companies (Boeing, Raytheon, and Intel) and smaller, local companies (Mesa Photonics, InSync, ATA) focused on producing components with photonics, companies producing systems or sub-systems comprising photonic components, and the components themselves.

There are ninety-six (96) companies, located in seven (7) counties, with the largest percentage of the companies located in Bernalillo County (81%). The other companies are located in Dona Ana (7%), Sandoval (5%), Santa Fe (3%), Socorro (2%), and Quay and Miguel each have 1 company each (1%).

The New Mexico manufacturing sector, according to the US Bureau of Labor's Quarterly Census of Employment and Wages, comprises 1,673 manufacturing companies and 29,083 workers. The ninety-six (96) photonics companies therefore comprise 5.9% of the companies and 21% of the manufacturing workforce.

The majority of the companies and half of the Photonics workers are located within Bernalillo County. Bernalillo hosts 676 manufacturing companies and 12,447 workers (US Department of Labor, Bureau of Labor Statistics).

The 79 photonics companies located in Bernalillo Country therefore comprise 11% of the manufacturing companies and 25% of the New Mexico manufacturing workforce.

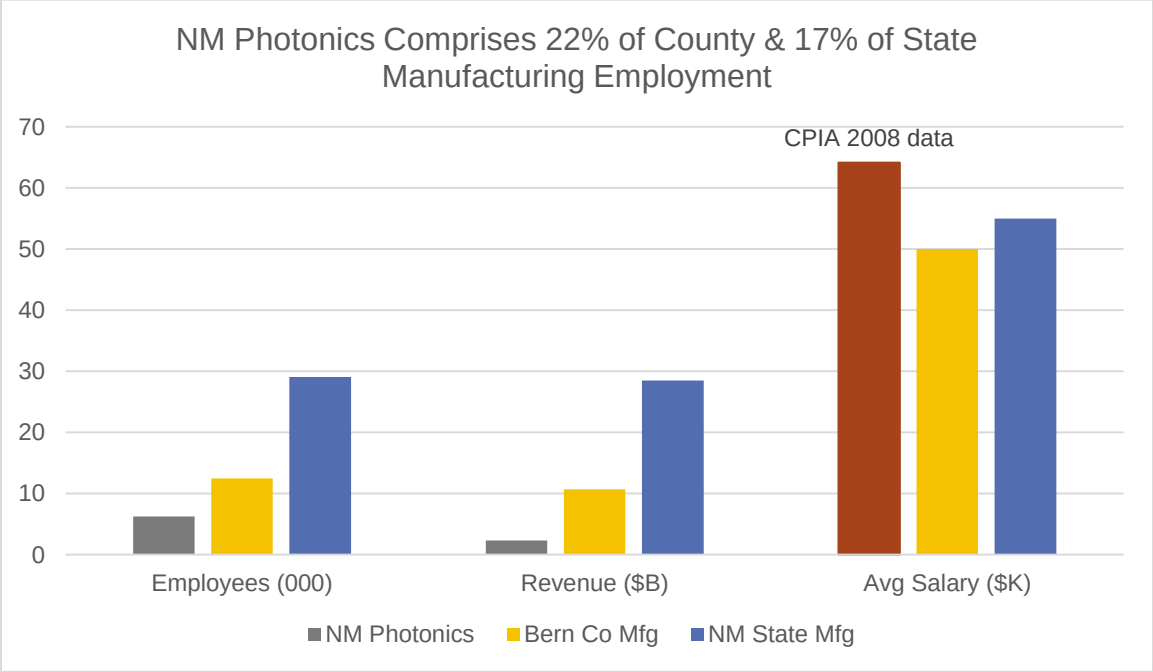


FIGURE 9 DATA AVERAGE SALARY FOR BERNALILLO COUNTY AND NM STATE AS REPORTED BY US CENSUS. REVENUE IS REPORTED AS SHIPMENT VALUE. (U.S. CENSUS BUREAU, MANUFACTURING & CONSTRUCTION, 2013)

According to the US Census Bureau, state manufacturing (NAICS 31-33) accounts for $28B of revenue and Bernalillo County contributes $10B to that revenue number.

Photonic components and enabled-components comprise 8% of the state's manufacturing revenues, and 22% of Bernalillo County's manufacturing revenues.

US Census Shipment Value was used as Revenue in this Report not Gross Receipts as reported by NM Tax and Revenue. The large public companies reported their public $/employee (which is what they sold the product for to customers) and their public employee counts. Therefore, it was determined that the US Census Bureau number was more comparable to the data we collected.

Gross Receipts does not include product shipped from a NM facility to another state's facility before being sold to a customer. It also includes transfer pricing (the price an item is "sold" to an overseas location) – which is lower than the price the item is sold to the actual customer.

As this was the first year capturing NM data, some of the participating companies were hesitant to share their data until they could see how the data were used. Therefore, this study focused on Corporate Revenues (not average wages). We do not have average salary wages for NM Photonics companies.

Responding companies were also invited to share their challenges as a business operating in New Mexico. These challenge categories included:

1) Supply chain
2) Regulations
3) Retention and recruitment of employees
4) Taxation

Photonics Industry Salary Averages

The average salary reported in 2008 by Colorado Photonics Industry Association (CPIA) was $64,650.

SPIE reports a US Median Salary of $110,000 in their latest Salary Report (SPIE. Career Center, 2014).

Many companies reported difficulty recruiting employees to the state. Issues included:

1) Crime
2) Low wages
3) Poor public schools
4) Lack of jobs for a spouse or significant other

Many companies found it difficult to recruit from out-of-state. Some companies focus on in-house training and development programs. A few companies work hard to create a pipeline of future employees by working with key university faculty members.

Retention was noted as not an issue. Once they recruited the employee to the area, the employees tended to stay, enjoying the low personal income taxes, property taxes, easy commutes, and enjoyable environment.

Federal regulations issues cited were very specific to application area: FDA approval was cited by the Biotechnology companies; ITAR and export regulations cited by defense component manufacturers; and a few reported issues regarding conflict mineral documentation.

The most often-cited issue regarding supply chain was around the expertise and capacity of local machine shops. **It is important to note that optics and electronics are sourced globally – but there is often a need to source the opto-mechanics locally.**

Company websites provided secondary information regarding products and application areas. The primary applications are (ranked in order of number of companies):

1) Electronics
2) Aerospace / aviation
3) Defense and homeland security
4) Biotechnology
5) Renewable energy

Several companies expressed concern that their businesses are tied entirely to government funding cycles and that their growth is limited entirely to what happens with large Federally-funded projects. These companies appear to have little interest (or possibly ability) to create products that can be marketed and sold into commercial applications.

Revenues

The ninety-six (96) companies engaged in the New Mexico Photonics Industry generate approximately $28B in shipment revenue (as calculated by the external sales price of the products). These companies comprise 8% of the state's manufacturing revenues (which includes technical and non-technical manufacturing outputs such as food (12%), dairy (7%), and construction machinery (1%)).

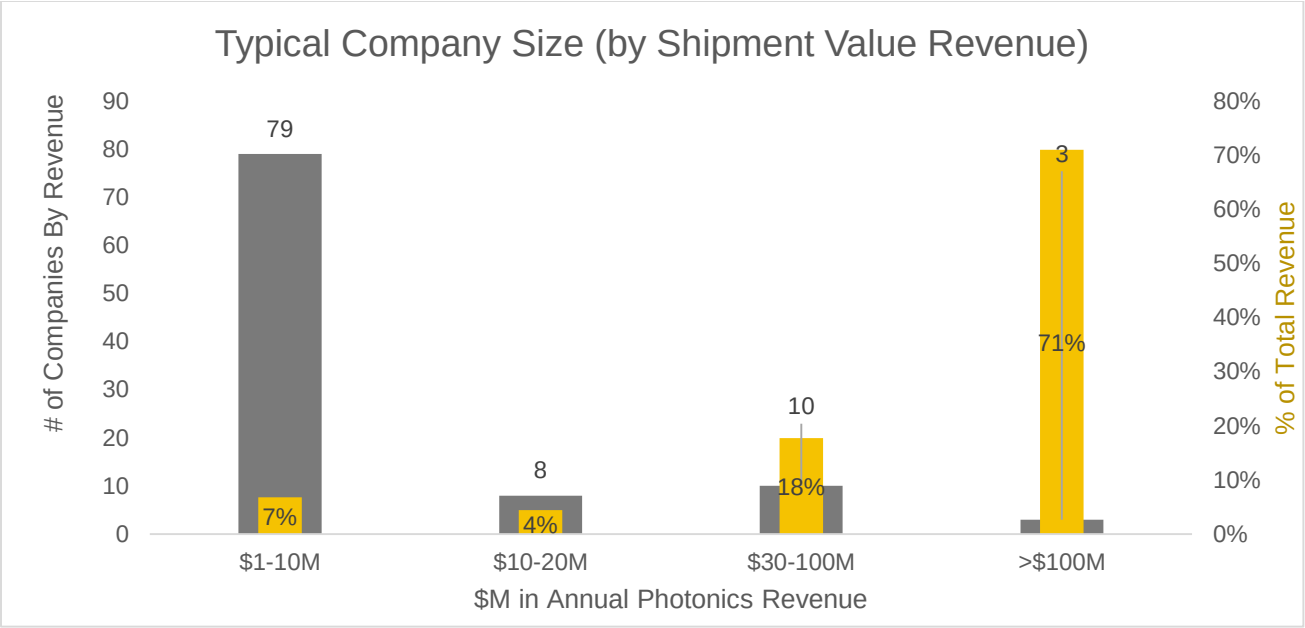


FIGURE 10 NUMBER OF COMPANIES BY REVENUE SIZE AS COMPARED WITH THEIR PERCENTAGE OF THE TOTAL NM PHOTONICS REVENUE.

There are only three entities in the state which exceed $100M in Annual Photonics Revenue. The majority of the companies are very small, $10M or less.

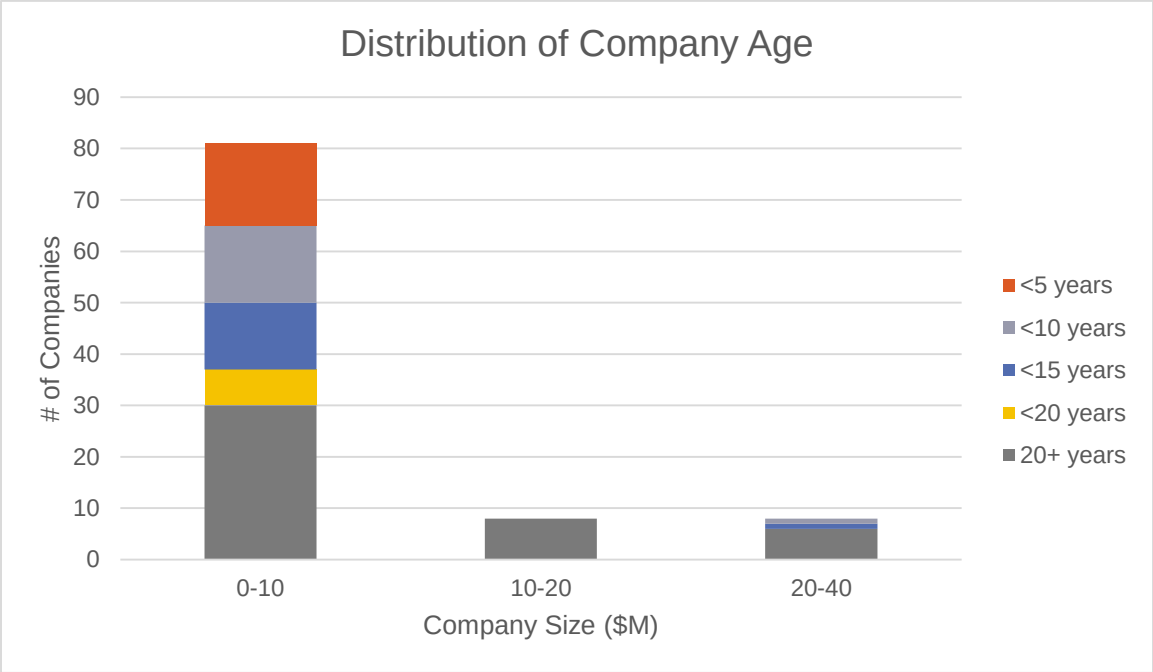


FIGURE 11. DISTRIBUTION OF COMPANY AGE OF SMALLER COMPANIES. THERE IS A MIX OF OLD COMPANIES, YOUNG COMPANIES WHICH WERE PURCHASED BY “OLD” FORTUNE 500 COMPANIES, AND YOUNG START-UPS.

These small companies are comprised of small businesses (sometimes called “Lifestyle Companies” – as they have no intention of growing larger or taking themselves public), start-up companies (which do intend to grow large or to be acquired by a large public company), and small subsidiaries (the parent location is generally in another state).

The distribution of the age of these companies appears to be what most investors would call “healthy”. There is a good mix of young, established, and mature companies.

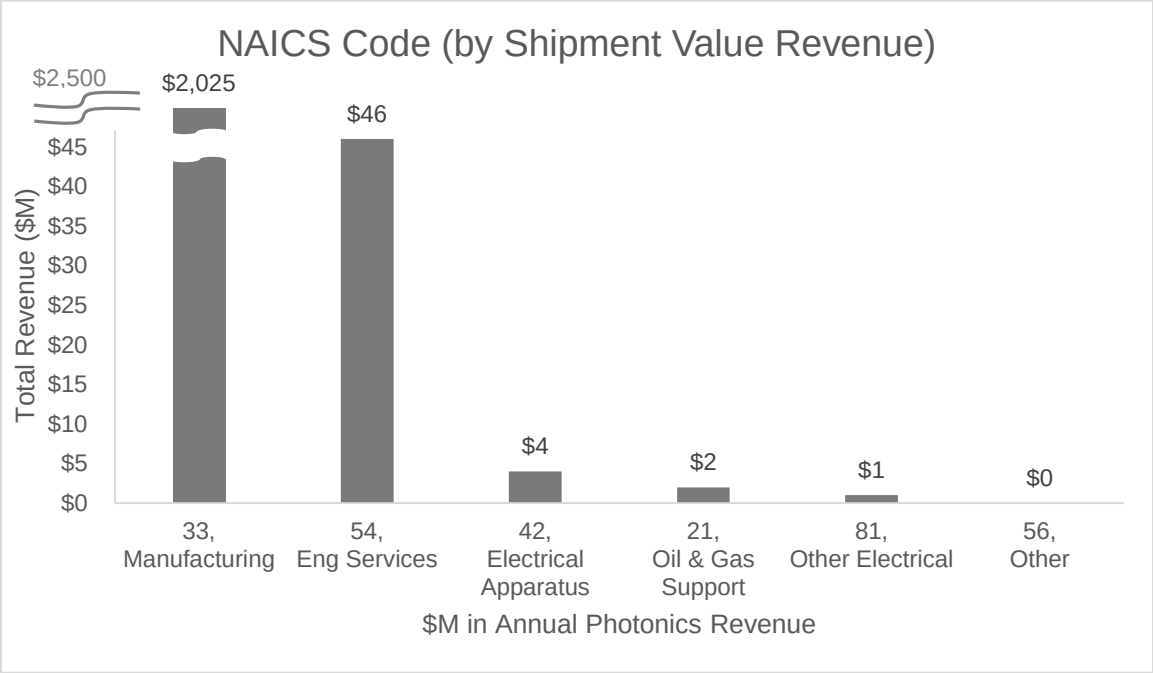


FIGURE 12 HISTOGRAM OF REVENUE BY NAICS 2-DIGIT CODE FOR THE NM PHOTONICS COMPANIES.

The majority of the New Mexico Photonics companies are involved in manufacturing. Seven (7) % of the revenue, 28 companies, have Engineering Services or Contract Research and Development as their primary NAICS code. However, examination of these companies’ products indicates that more of them are involved in Manufacturing than their primary NAICS code would indicate.

Jobs

6,230 people are employed by these Photonics companies throughout the state.

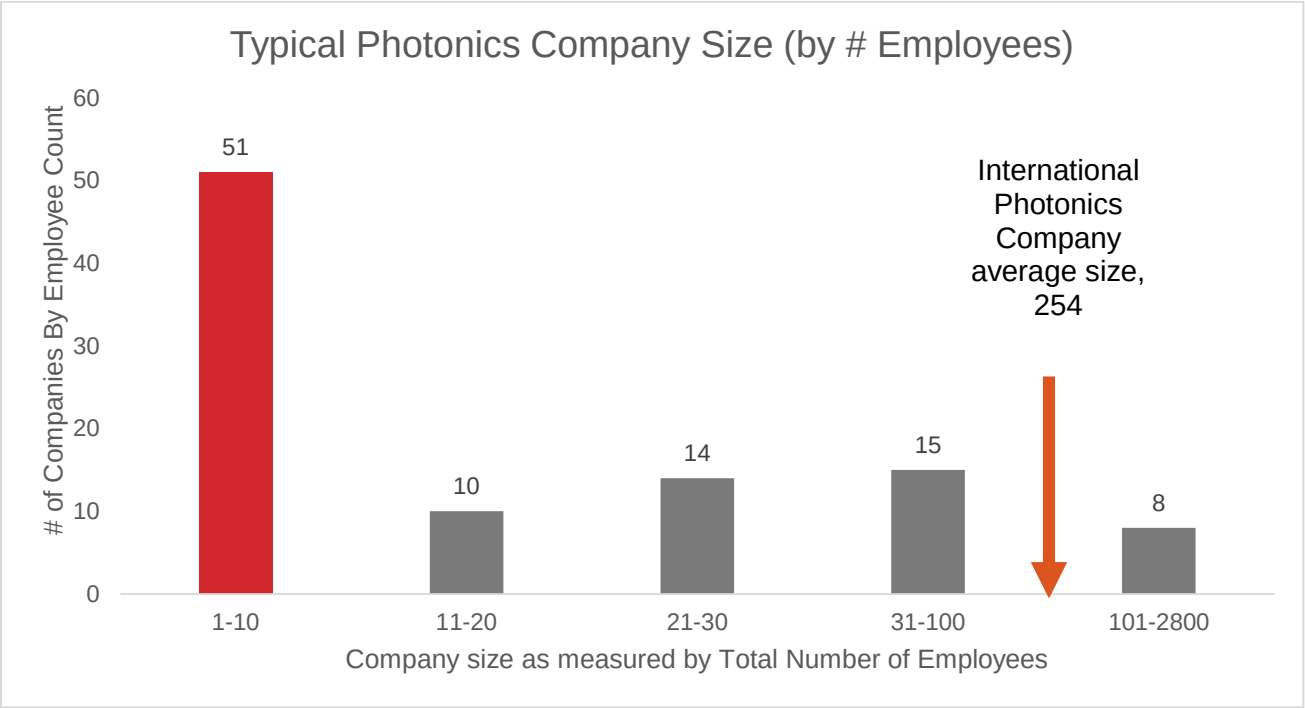


FIGURE 13. BREAKDOWN OF COMPANY SIZE BY EMPLOYEE COUNTS. FOR REFERENCE THE SPIE REPORTED INTERNATIONAL COMPANY AVERAGE IS INCLUDED (SPIE, 2014).

The majority of the companies are 10 people or less. This super-small company size creates unique challenges as they try to import raw materials and export finished goods.

Regulations and paperwork become tremendously difficult burdens in a company so small that every employee is holding down more than one job function. Federal ITAR, EAR, and Conflict Materials Documentation were noted as huge regulations issues for the 1-10 employee companies.

In comparison, these companies are half the size (by employee count) as the typical New Mexico manufacturing company and one-third the size of the neighboring/peer state manufacturing company.

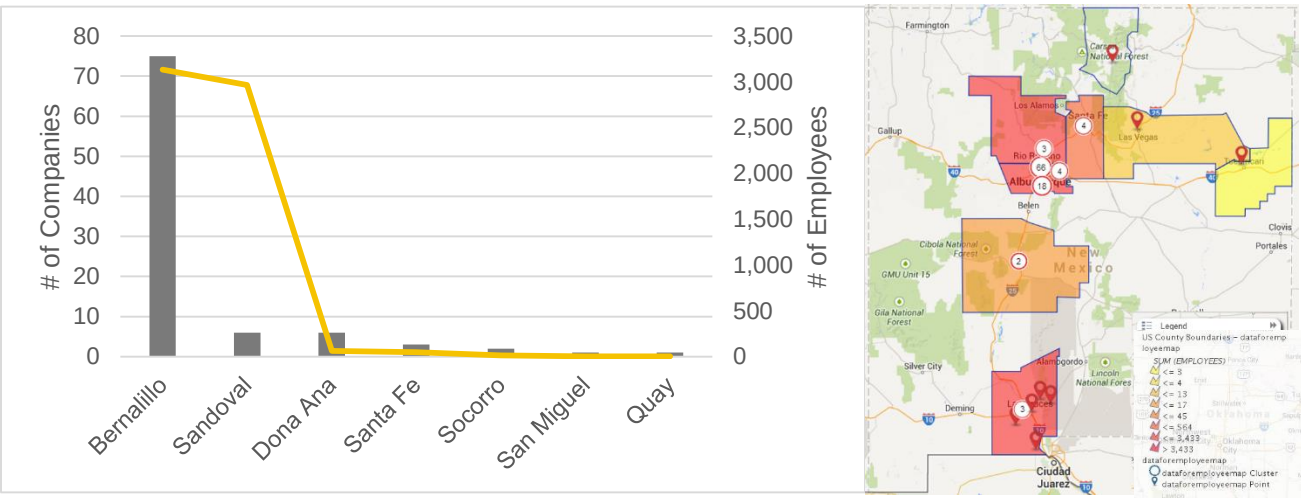


FIGURE 14. HISTOGRAM OF PHOTONICS COMPANIES AND EMPLOYEES BY NM COUNTY. GEOGRAPHIC LOCATION ON THE MAP DEMONSTRATES SPREAD WITHIN COUNTIES.

The companies are generally clustered around the 3 universities with Graduate Programs: University of New Mexico, New Mexico Institute of Mining and Technology (also known as New Mexico Tech), and New Mexico State University.

Bernalillo County has a good diversity of photonics companies and has the highest employee count of all of the counties. The diversity enables the county to withstand a downsizing and absorb the employees into other companies. The high concentration of jobs with one employer in Sandoval County makes it very difficult to absorb jobs in the event of a single-company downsizing effort.

Intellectual Property

In the past 5 years, 1596 patents have been assigned to entities in the state. These include private sector companies, Universities and Colleges, and the various Federal Laboratories (SNL, LANL, AFRL, and Naval Research Laboratory).

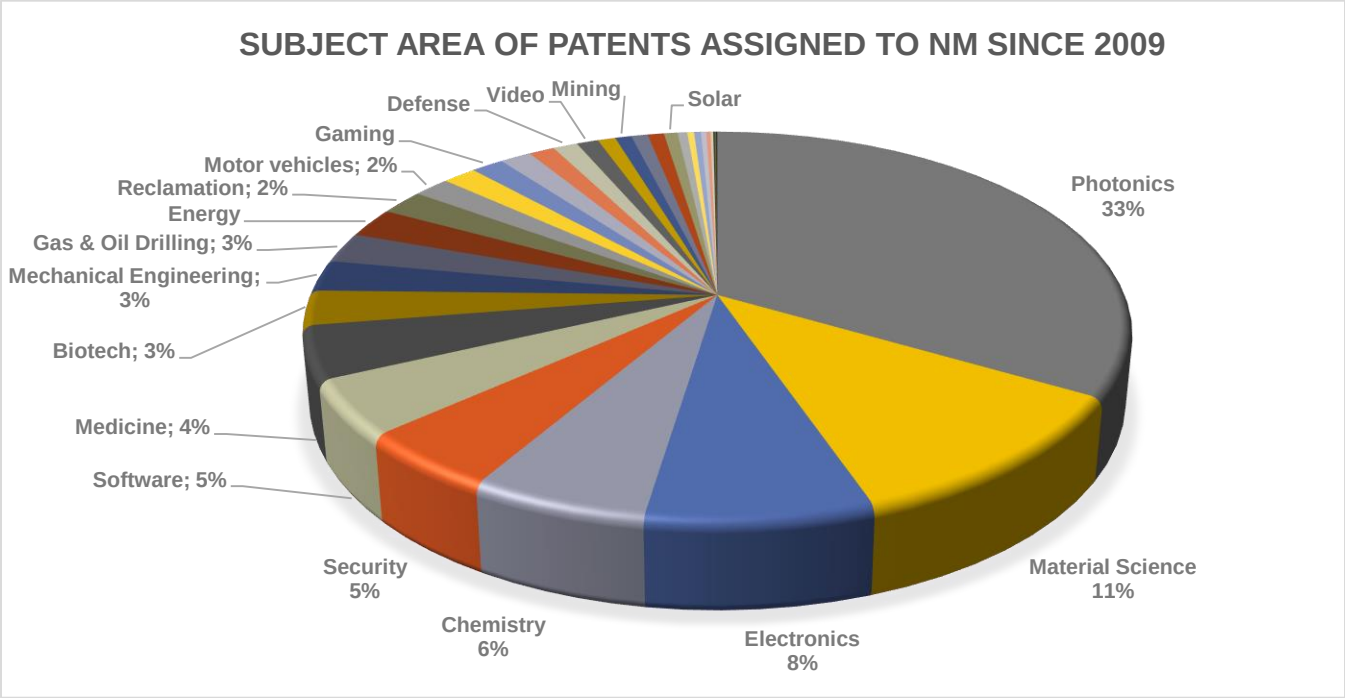


FIGURE 15. BREAKDOWN OF PATENTS ASSIGNED TO FIRMS WITHIN THE STATE BY SUBJECT AREA. PHOTONICS ITSELF COULD BE BROKEN DOWN INTO THE OTHER APPLICATION AREAS.

532 of these patents are related to Photonics in some way:

1. describe the **manufacture** of a photonic-device (solar cell, LED, optical component);
2. describe the usage of a device that **comprises photonic-components** (spectroscopy, LIDAR, photo-chemistry).

That Photonics-related patents comprise 33% of the state's Patent Portfolio should come as no surprise – but as validation that Photonics is so pervasive, it has become a key technology in many other applications from energy generation, to production technology, to defense and security.

What may be a surprise is the apparent lack of correlation between the patent portfolio ratio (33%) and the manufacturing revenue portfolio (8%). This would suggest that much of the technology is "trapped" in research laboratories or not being fully utilized in the commercial sector within the state (this data does not indicate whether any of the patent portfolio has been licensed to entities outside of the state).

Further, this data only includes the intellectual property which has been patented. Some companies choose to utilize trade-secret as their intellectual property protection strategy.

The data does not judge the quality of the patents which may be subject to a bias in "patent-production" as government laboratories, research entities, and start-ups may emphasize patents as an indication of productivity (not just intellectual property protection).

Product Areas

The majority of the Photonics companies in New Mexico build sub-systems or complete systems. Few of the companies manufacture core-photonics components.

Also, many of the component manufacturing technologies can be very capital-intensive – access to capital is one of the often-stated issues entrepreneurs list when asked "what constrains growth."

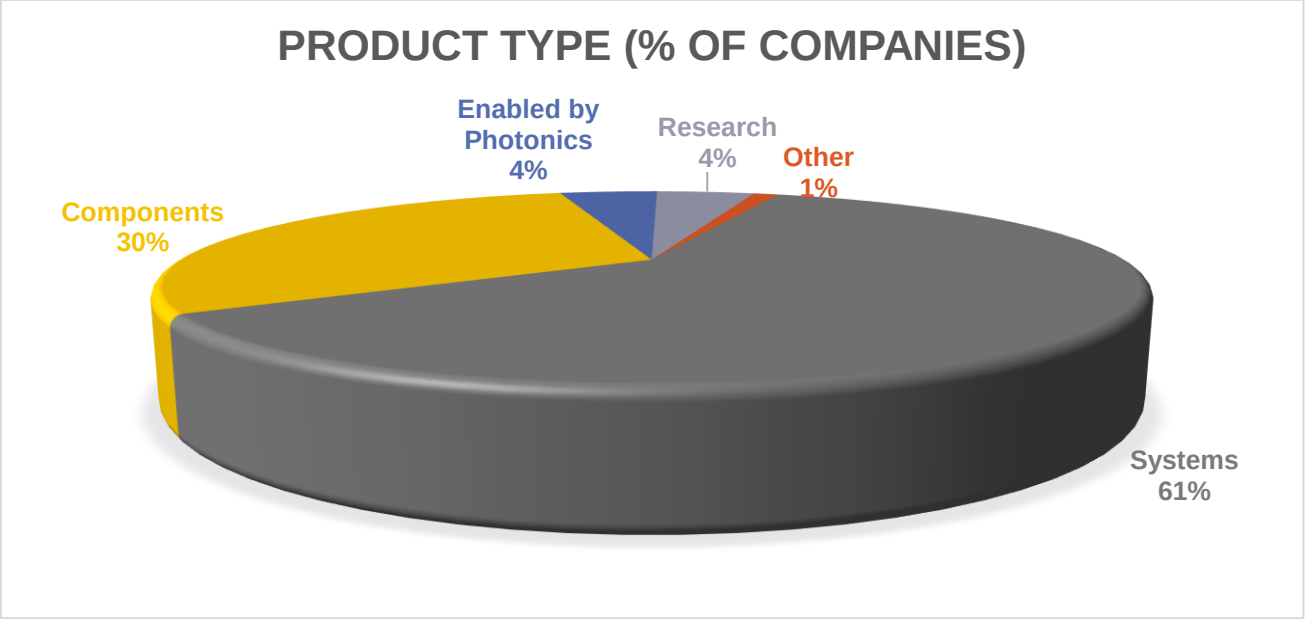


FIGURE 16. THE NUMBER OF COMPANIES IN THE STATE PRODUCE SYSTEMS OR SUB-SYSTEMS COMPRISING PHOTONICS. THE SYSTEM COMPANIES OVERWHELMINGLY REPORTED SOURCING ALMOST EXCLUSIVELY OUT-OF-STATE: A COMPLETE SUPPLY-CHAIN DOES NOT EXIST WITHIN THE STATE.

Several of the small component companies listed University or Government Laboratory-shared space as one of the benefits they do utilize.

Growth Hurdles

SUPPLY CHAIN CONSTRAINTS

Companies were asked whether they would purchase more goods in-state if the supply chain existed for these types of components or products.

The most often requested capabilities were:

- NM-based capability for silicon photonics and microprocessors
- Wafer dicing capability
- Qualified, precision machine-shops for production and for R&D prototypes
- Large optics capabilities (>4" diameters)

REGULATION CONSTRAINTS

Companies were asked what regulations constrained their growth. The answers (as expected) were grouped based on the markets or applications the companies' served:

- Federal Food and Drug Administration (FDA) approvals were time-consuming and costly
- Federal regulations regarding export control (defense and national security related items)
- Federal Conflict Materials documentation
- Federal Acquisition Regulation (FARS) and Defense Federal Acquisition Regulation (DFARs)

RECRUITMENT

People are a company's greatest asset. The companies that expressed issues regarding recruitment were in agreement with the issues:

- Difficult to recruit highly specialized people to the state due to reputation for high crime and poor schools
- Difficult to recruit employees "in a relationship" – as the partner often found it difficult to find suitable employment
- Higher paying jobs in other states

Retention of employees was noted as not an issue.

TAXATION

Most people recognize that taxation is required to provide various services. Write-in responses varied from acknowledgements of an improved system to continued frustration.

NM Gross Receipts Tax (NMGRT)

Gross receipts comments were grouped around the following themes:

- NMGRT creates a disadvantage to the local companies and favors out-of-state competition
- NMGRT collection is unnecessarily complex

Corporate Taxes

In addition to NMGRT, there were comments regarding:

- High corporate taxes – *unless the company was large enough to "work a deal"*
- Capital improvement taxes dis-incentivized investment

OTHER CONCERNS

Other issues that were identified as consuming management's time revolved around China and the need to safeguard intellectual property, and medical insurance compliance.

NEW MEXICO EDUCATIONAL RESEARCH AND TRAINING PROGRAMS

New Mexico is home to three state-sponsored universities, all of which conduct photonics-based research: University of New Mexico, New Mexico Tech, and New Mexico State University. New Mexico's community colleges, which train many of the non-exempt staff for the participating companies, have developed or are developing photonics-based curricula.

University of New Mexico

Research Program

University of New Mexico's Photonics Research Programs are leaders in:

- Design and nanofabrication of semiconductor devices (lasers & detectors)
- Semiconductor materials
- Nonlinear optics
- Ultrafast optics
- Biophotonics
- Nanolithography
- Microscopy
- Quantum optics
- Imaging science and technology
- Optical fibers

Education Program

The University of New Mexico grants Photonics-related Masters and Ph.D. degrees in three programs:

1) Optical Science and Engineering
2) Physics and Astronomy (PANDA)
3) Electrical and Computer Engineering

In an average year, between the three programs, the school graduates 24-26 photonics-related degrees.

Physics undergraduates may also concentrate in Optics by taking a few targeted courses.

Graduating students go on to find positions (in rank order)

1) Universities in post-doctorate programs and/or faculty positions
2) Industry in New Mexico and in other states and countries
3) Federal Labs (Air Force Research Laboratory, Sandia National Laboratories, Navy Research Laboratory and others)
4) Start-up their own company

Twenty (20) % of the graduates remain in New Mexico.

Patents, Licensing, and Industry Partnerships

Sixty-one (61) patents have been issued since 2009 and 39% (24) have been licensed by companies intending to bring products to market.

The programs that offer Photonic degrees at the University of New Mexico have Research and Development Partnerships with DoD and the Department of Energy Federal Government laboratories,

such as Sandia National Laboratories and Los Alamos National Laboratory, Air Force Research Laboratory, and the Center for Integrated Nanotechnologies (CINT).

Companies also work with Center for High Technology Materials (CHTM); these include BAE Systems, Raytheon, as well as local companies Trilumina, Dynamic Photonics, SKINfrared, Actoprobe, Emcore, FirstPhotonics, and Skorpios to name a few.

Faculty

Researcher	Department	Specialty
Sang Han	Chemical and Nuclear Engineering	Selective heteroepitaxy of Ge and III-V compound semiconductors on Si for multijunction solar cells and RF applications, Scanning tunneling microscopy of quantum structure and film growth, and organic-inorganic hybrid systems, Hybrid micro/nanofluidic systems for advanced bio separation and analysis, including high-resolution protein separations in nanofluidic FET devices, Nanocrystal synthesis, functionalization, and integration for nonlinear optical and biological applications
Yixiang Xie	Chemical & Nuclear Engineering	Energy materials, Electro caloric polymers and electro hydrodynamics, Photonic crystals, Nano materials and characterization, Atomic layer infiltration, Langmuir monolayer device fabrication
Terefe Habteyes	Chemistry	Energy transfer in coupled quantum dot and plasmonic nanostructures, DNA mediated optical coupling, Semiconductor-metal hybrid nanomaterials, Fabrication and optical characterization of plasmonic sensors and probes
Elena Plis	CHTM	Growth, fabrication and characterization of type-II InAs/(InGa)Sb Strained Layer Super lattice (SLS) IR detectors for MWIR and LWIR spectral regions; Chemistry of GaSb-based materials; Biomedical applications of IR detectors, such as early detection of skin cancer.
Arash Mafi	EECS	Quantum and nonlinear behavior of optical waveguides. Anderson localization: Wave propagation in random media.
Ashwani Sharma	EECS	Micro-Nano-Electronics Nanoscale lithography and nanofabrication with applications to nano-opto-electronics, and radiation effects on devices.
Daniel Feezell	EECS	Epitaxial growth, fabrication, and characterization of group III-nitride materials and devices, including nonpolar/semipolar orientations. Solid-state lighting and high-efficiency LEDs. Visible edge-emitting and vertical-cavity surface-emitting lasers. Applications of group III-nitrides to energy efficiency and renewable energy.
Francesca Cavallo	EECS	2D materials: structural, mechanical and electronic properties Flexible electronics, optoelectronics and photonics, Rolled-up Nanotec, Bio-devices integration, THz radiation

Frederic Grillot	EECS	Optoelectronics, quantum dots, advanced laser diodes for low-cost applications.
Ganesh Balakrishnan	EECS	Semiconductor device development including epitaxy and characterization, high power vertical external cavity surface emitting lasers and novel semiconductor material development for Mid-Infrared lasers.
Ladan Arissian	EECS	Mode locked Ti:Sapphire Lasers, Mode locked Ring lasers
Majeed Hayat	EECS	Avalanche photodiodes, optical communications, image/signal processing, algorithms for infrared and spectral sensing and imaging, distributed networks and computing.
Mani Hossein-Zadeh	EECS	Electro-optics, microwave-photonic devices and systems, ultra-high-Q optical micro resonators, optomechanical interaction in UH-Q optical resonators, optical communication, photonic sensors, optofluidics and plasmonics.
Marek Osinski	EECS	Nanotechnology, biomedical applications of colloidal nanocrystals, nanoscintillators for nuclear radiation detection, optoelectronic integrated circuits, semiconductor lasers, light-emitting diodes, group-III nitrides, degradation mechanisms and reliability, computer simulation.
Payman Zarkesh-Ha	EECS	Statistical modeling of VLSI systems, design for manufacturability and reliability, low-power and high-performance VLSI design.
Peter Eliseev	EECS	Physics and technology of semiconductor lasers and related photonics devices: semiconductor optical amplifiers, laser gyros, light-emitting diodes
Ravi Jain	EECS	Quantum electronics, optoelectronics, electro-optics, experimental solid-state physics.
Sanjay Krishna	EECS	Mid-infrared detection using self-organized quantum dots (QDs) and novel antimonide based materials grown by Molecular Beam Epitaxy.
Steve Hersee	EECS	GaN-based nanowire devices and nanostructures; advanced semiconductor materials and devices.
Steven R. J. Brueck	EECS	Nanoscale lithography and nanofabrication with applications to nanophotonics, nanofluidics, and nanoscale epitaxial growth and sources/detectors; tunable infrared lasers; ultra-high resolution optical microscopy.
Tom Gavrielides	EECS	Laser physics, optical resonators and quantum electronics and in particular in problems in interactions of radiation with atoms and radiation propagation phenomena.
Tom Rotter	EECS	Epitaxy, processing and characterization of semiconductor devices for optical applications, crystal growth of arsenides, antimonides and phosphides including highly mismatched materials, high power surface emitting lasers, self-organized quantum dots and dashes, quantum well saturable absorbers

Young Shin Park	EECS	Experimental optical physics of semiconductor quantum dots, single-particle spectroscopy, QD-LEDs, QD lasers, Quantum optics with QDs
Zhaobing Tian	EECS & CHTM	physics and development of infrared optoelectronic devices, including semiconductor detectors, lasers, and photovoltaic devices
Jean-Claude Diels	EECS & PANDA	Development of Femtosecond sources, Intracavity Phase Interferometry, Self-filamentation, Laser Induced Discharges, Femtosecond Communication
Kevin Malloy	EECS & PANDA	Semiconductor physics, device physics.
James Thomas	PANDA	optical and fluorescence studies of phospholipid layers and cell membranes
Keith A. Lidke	PANDA	Fluorescence super-resolution techniques, single particle tracking, and hyperspectral microscopy.
Mansoor Sheik-Bahae	PANDA	Laser Cooling in Solids, Ultrafast Phenomena, High Intensity Interactions, Nonlinear Optics
Paul Schwoebel	PANDA	Surface Physics, Medical Imaging, Nuclear Sensors. Crystal growth and nucleation phenomena; vacuum, gaseous and solid electrical breakdown; high electric field processes; ion sources, neutron generators, x-ray sources, radiation damage, plasma physics.
Sudhakar Prasad	PANDA	Mathematical theories and fundamental limits on imaging, Information theoretic and Bayesian interpretations of digital imagery, Compressive spectral imaging for space applications, Theories of coherent radiation and scattering by resonant atomic excitations
Wolfgang Rudolph	PANDA	Ultrafast lasers and spectroscopy, microscopy with femtosecond light, pulses in material science and biomedicine, lasers in the mid infrared for remote sensing and imaging through the atmosphere

New Mexico Institute of Mining and Technology

Research Program

Two departments at New Mexico Tech have research programs related to Photonics research: Physics and Electrical Engineering.

A key and unique asset to both departments is the Magdalena Ridge Observatory which is home to a 2.4 meter telescope and the Magdalena Ridge Observatory Interferometer (a ten-element imaging interferometer to operate at wavelengths between 0.6 and 2.4 microns with baselines from 7.8 to 340 meters).

New Mexico Tech is also home to the Energetic Materials Research and Testing Center.

Education Program

New Mexico Tech offers a Bachelor of Science and/or a Master of Science in Electrical Engineering. Students may choose to minor in Optical Science and Engineering.

Approximately 30 students a year graduate from these programs. They find jobs at Air Force Research Laboratory, Navy Research Laboratory, Sandia National Laboratories, Los Alamos National Laboratory, AOS, ATA, Schafer, and Boeing or continue on to graduate study at other schools.

Patent and Licensing History

Thirteen patents have been assigned to New Mexico Tech or its affiliate New Mexico Technical Research Foundation in the past 10 years. Only one of those patents is Photonics in nature. However, many of the faculty have patents with their sponsoring/funding organizations. The inventors are from New Mexico; the patents are assigned to entities outside of the state.

Faculty

Researcher	Department	Specialty
Anders M. Jorgensen	EE	Astronomical Optical Interferometry methods and instrumentation, Space plasma physics and space weather Distributed Autonomous sensor networks
Hector Erives	EE	Hyperspectral sensor calibration, Multi- Hyper- and Ultra spectral data analysis, 3-D Hyperspectral imaging, Active optics-based image registration
Scott W. Teare	EE	Experimental Adaptive Optics. This includes wave front control and manipulation in optical imaging systems and high-energy laser beam propagation.
Nickolai Kalugin	Materials Engineering	Optical and Electron Transport Properties of Semiconductor Nanostructures, quantum dot structures, THz Lasers & Detectors, THz via Quantum Coherence, Quantum Optics, Femtosecond CARS for bio applications
Paul Fuerier	Materials Engineering	Nanocrystalline Ceramics for Dye Sensitized Solar Cells

Michael Hargather	Mechanical Engineering	Development and application of optical techniques to the study of high-speed compressible flows and explosions, explosive characterization, computational simulation of energetic materials, schlieren image velocimetry, and general fluid dynamics.
Michelle Creech-Eakman	Physics	Mid-infrared imaging/spectroscopy and optical/infrared interferometry, pulsation & dust production in Miras

New Mexico State University – Las Cruces Campus

Education Program

At New Mexico State University, undergraduates receive either Electrical Engineering or Physics degrees. They can minor in Optics.

Patent and Licensing History

40 patents have been assigned to New Mexico State University and its affiliate the Arrowhead Center in the past ten years. 5 of which were Photonic in nature.

Faculty

Researcher	Department	Specialty
Hongmei Luo	Chem E	Functional oxide, nitride, and nanocomposite thin film heterostructures for microelectronics, optoelectronics, magnetism, superconductors, catalysts, sensors, and energy applications; Nanostructured materials (nanoparticles, nanowires, nanotubes, and mesoporous materials) for magnetism, catalysts, sensors, water splitting, battery, and solar cell applications; Electrochemical deposition, sol-gel, polymer-assisted deposition, self-assembly, hydrothermal.
Julio Martinez	Chem E	Nanotechnologies; BioSensing Applications; Organic Photovoltaics
Charles Creusere	EE	Digital Signal Processing for audio, image, and video; Compressive Sensing/Sparse Reconstruction for LIDAR and continuously streaming signals; Communications related to space missions
David Voelz	EE	Spectral & Polarimetric Sensing; Optical Propagation through Atmospheric Turbulence; Free Space Optical Communications
Deva Borah	EE	Wireless Communications, optical communications, signal processing, detection and estimation techniques
Kwong Ng	EE	Computational Electromagnetics; Bioelectromagnetics; Source and Structure Imaging; Antenna and Microwave System
Laura Boucheron	EE	Image Processing, including feature extraction & selection, object-level analysis, and incorporation of temporal information; Pattern Recognition and Machine Learning; Interdisciplinary Applications of Image and Signal Processing; Signal Processing, including speech enhancement and coding
Robert Paz	EE	Robotics & Automation, Reduced Gravity Simulation, Embedded Systems, Robust Control Systems, Source and Structure Imaging; Antenna and Microwave System
Sang Yeon Cho	EE	Nanoscale devices for photonic applications; Optical Bio/Chemical Sensors; Advanced high-resolution microscopy system; Optoelectronic Devices including photodiodes and lasers.
Steven Stochaj	EE	Solar Energetic Particles; Cosmic Ray Physics; Neutron Detectors; Small Satellite Design
Stefan Zollner	Physics	Ellipsometry

New Mexico State University – Alamogordo Campus

Education Program

New Mexico State University – Alamogordo Campus has recently launched a new Associates Degree program for renewable energies (solar and wind).

The program will be focusing on solar panel installation and certification.

Central New Mexico CC (CNM)

Education Program

The Microsystems and Laser Optics Concentration provides its students classes in lasers, optics, and microsystems applications. Emphasis is on fabrication and hands-on experiments to prepare graduates for a successful career in contributing to high tech industry and laboratories.

The program of study uses facilities containing modern equipment for testing, troubleshooting, calibrating, analyzing, designing and fabricating electronic and microsystems for processing wafers in both Microelectromechanical systems (MEMS) and Semiconductor Manufacturing Technology (SMT) applications.

Students study the laser, both as an instrument and as an integral part of a system designed for industrial application and scientific research. The laser optics classes cover topics such as laser alignment, safety and the use of lasers in electronics production, testing and maintenance - students acquire a hands-on skills and knowledge of light, geometrical and physical optics, optical components and systems.

CNM also offers an Advanced Systems Technology course in Automation and Communications which requires a 3 unit photonics course. Students receive an Associate of Applied Science (AAS) degree.

Approximately four (4) students a year graduate from the CNM programs. It is reported by CNM that graduates have been successful finding employment at TruTouch Technologies, VeraLight, ATA, Northrup Grumman (in Illinois) and Trumpf (in Michigan). CNM also reports that entry-level jobs have been very hard to find or pay at minimum wage within the State of New Mexico.

Faculty

Researcher	Department	Specialty
Michael White	Photonics	

Navajo Technical University

Navajo Technical University provides college readiness programs, certificates, associate, baccalaureate, and graduate degrees.

The University is committed to a high quality, student-oriented, hands-on-learning environment based on the Diné cultural principles.

The vision of Navajo Technical University is to educate Navajo individuals; to utilize state-of-the art technology; and to enhance the desirable character traits of integrity, self-discipline, loyalty and respect, which give the Navajo people hope, courage, and the resiliency essential to their survival as a people, using the strengths inherent in the Navajo cultural values and traditions.

Education Program

NTU offers several programs that develop photonics skills:

- Associates Degree (AAS) in Building Information Modeling (BIM)
- Bachelor of Science Degree in Industrial Engineering
- Bachelor of Science Degree in Digital Manufacturing
- Bachelor of Science Degree in Computer Science

Bachelor of Science students will learn laser scanning metrology and manufacturing methods as they relate to Industrial Engineering, Advanced Manufacturing, or Computer Science programming. AAS students learn laser scanning techniques as they apply to architecture and/or building technologies.

Faculty

Faculty	Department	Specialty
Gregory Dodge		Laser Scanning Techniques

OPPORTUNITIES

Few industries are growing faster than the typical country's GDP. Photonics is one of the few sustaining industries that is doing so. This is because Photonics is an enabling technology that positively affects virtually every GDP category.

In 1998, the "Harnessing Light" Report (National Research Council, 1998) presented a comprehensive overview of the potential impact of optics and photonics on major sectors of the US economy. In 2005, European leaders founded Photonics21, a European Technology Platform which united 2300 companies, research organizations and political leaders. (Photonics21, 2014) In 2009, Photonics was named by the Commissioner for Enterprise and Industry of the EU as a Key Enabling Technology (European Commission, 2014) In continuing and increasingly significant response, several nations around the world moved to advance their already strong optics and photonics industries: in 2011, Germany committed nearly €1 billion ($1.3 billion in USD) to photonics 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 (National Research Council, 2012).

Historically, the United States has done well at investing in basic research but recently has fallen behind in investing in manufacturing science and technology. As a result, and for associated reasons, research is occurring domestically while manufacturing and those jobs supported by this industry have migrated overseas. Greater investment in manufacturing science and technology will ensure that US investment in R&D remains in the United States (National Photonics Initiative, 2013).

National Photonics Initiative

In 2012, the National Academies of Science NRC released an update to the 1998 "Harnessing Light" Report entitled, *Optics & Photonics: Essential Technologies for our Nation*. The Optics & Photonics Report reviewed the substantial progress made in the optics and photonics fields, and **called for a National Photonics Initiative (NPI)** to identify and further advance areas of photonics critical to regaining US competitiveness and maintaining national security. (National Photonics Initiative, 2013)

INTERNATIONAL YEAR OF LIGHT

An International Year of Light is a tremendous opportunity to ensure that international policymakers and stakeholders are made aware of the problem-solving potential of light technology.

We now have a unique opportunity to raise global awareness of this.

John Dudley, Chairman of the IYL 2015 Steering Committee

The NPI is working on the following five areas:

- **Drive funding and investment** in areas of photonics critical to maintaining US competitiveness and national security — advanced manufacturing, defense, energy, health and medicine, information technology, and communications;
- **Develop federal programs that encourage greater collaboration between US industry, academia, and government labs** to better support the research and development of next-generation photonics technologies;
- **Increase investment in education and job training programs** to reduce the shortage of technically skilled workers needed to fill the growing number of photonics-based positions;
- **Expand federal investments supporting university and industry collaborative research** to develop new manufacturing methods that incorporate photonics such as additive manufacturing and ultrashort-pulse laser material processing; and
- **Collaborate with US industry to review international trade practices** impeding free and fair trade and the current US criteria restricting the sale of certain photonic technologies overseas.

Integrated Photonics Manufacturing Institute

On October 3, 2014, the Department of Defense announced that the next Institutes For Manufacturing Innovation (IMI) will be focused on Integrated Photonics. The Institute will focus on developing an end-to-end photonics 'ecosystem' in the U.S., including domestic foundry access, integrated design tools, automated packaging, assembly and test, and workforce development. The Department of Defense will issue a Broad Area Announcement (BAA-RQKM-2015-0007) in mid-November inviting proposals demonstrating an end-to-end 'ecosystem' in the US for Integrated Photonics.

The IMI will need to demonstrate responsive domestic integrated photonics chip fabrication foundry access, integrated design tools, automated packaging, assembly and test, and workforce development. The IMI will be structured to allow government, industry, and academia to come together with the goal of organizing the fragmented US capabilities in integrated photonics technology. (Air Force Research Laboratory, 2014)

2015 International Year of Light

The United Nations has declared 2015 as the International Year of Light and Light-based technologies.

In proclaiming an International Year focusing on the topic of light science and its applications, **the United Nations has recognized the importance of raising global awareness about how light-based technologies promote sustainable development and provide solutions to global challenges in energy, education, agriculture and health.** Light plays a vital role in our daily lives and is an imperative cross-cutting discipline of science in the 21st century. It has revolutionized medicine, opened up international communication via the Internet, and continues to be central to linking cultural, economic and political aspects of the global society. (United Nations, 2014)

Events regarding light-based technologies are getting international exposure when posted on the IYL website. This is an excellent opportunity to get positive international exposure for our state.

Start-Up Momentum

There are many start-up programs gaining momentum in New Mexico. This may be the best environment for the local entrepreneurs in-waiting to start companies.

STARTUPABQ

Once a month, all levels of entrepreneurs meet for a breakfast event sponsored by one of our community partners. 4-5 entrepreneurs have the opportunity to present a 5 minute presentation on their company/product to the group, and then open the floor to discuss what they need to take their company and/or product to the next level.

ABQID

ABQid is a Startup Accelerator model that focuses on rapid business formation, quick/low cost customer validation, and scaling up. The accelerator provides space, mentors, and small amount of start-up cash in exchange for equity.

ONE MILLION CUPS

Each week, the 1MC program offers two local entrepreneurs an opportunity to present their startups to a diverse audience of mentors, advisors, and entrepreneurs. Presenters prepare a 6 minute educational presentation and engage in 20 minutes of feedback and questioning after they present. Entrepreneurs gain insight into possible ways they can improve their businesses, gather real time feedback, connect with a community that truly cares about their progress, and walk away feeling like they have advanced their business.

INCUBATORS & ACCELERATORS

Incubators:

- WESST Enterprise Center
- Santa Fe Business Incubator
- Enterprise Center at San Juan College
- Fat Pipe
- Levitated
- Clovis Business Incubator
- South Valley Economic Development Center/Rio Grande Community Development Corporation
- Arrowhead Technology Center
- The BioScience Center
- Joseph L. Cecchi VentureLab (CVL) at STC.UNM

Accelerators:

- Santa Fe – The Velocity Project
- ABQid
- High Desert Discovery District

STARTUP NM

Startup New Mexico is an effort to establish New Mexico as a region within the Startup America Partnership in order to bring together high growth entrepreneurs throughout our state, identify their most pressing needs and begin to address them.

NMOPTICS

The New Mexico Optics Industry Association (**nmOptics** – Promote, Connect, Advocate) is an industry-based 15-year old non-profit industry association. **nmOptics** directly represents 54 photonics manufacturers whose mission is to promote the growth and development of the optics industry in New Mexico and the Southwest region. Its efforts are directed toward firmly establishing New Mexico as a world-class center for optics manufacturing, research, development and sales.

nmOptics has a top strategic objective of supporting investments in photonics for innovations and job creation in New Mexico and the Southwest Region.

nmOptics originally formed in 1999 to promote growth and development of the optics industry in New Mexico, advocates for improved Science, Technology, Engineering and Math (STEM) education programs, industrial policies supportive of photonics jobs and sales, and advance workforce development for technology and photonics manufacturing.

CONCLUSION

New Mexico may not have a high number of large Photonics companies, however, it is quite clear from the data that we have a Photonics Industry that creates ideas, generates tremendous amounts of Intellectual Property, and forms companies to take those ideas to the marketplace.

New Mexico Photonics comprises:

- 95 companies
- 6230 employees
- $28B in shipment revenue
- 532 patents
- Conversion of some NM research into economic opportunity within the state
- Predominately systems-based product companies (by count)
- Predominately component-based product companies by revenue
- Mix of super-small, research-for-hire, start-up, and manufacturing-intense companies

Big factors to growth that we cannot control are:

- Internal planning independent of local initiatives at large companies (e.g., Intel, Honeywell, Boeing, Lockheed, Raytheon, Northrop Grumman, and FLIR)
- “SBIR” companies – optimized for landing government contract innovative research jobs but not necessarily strong at product development and marketing

Growth factors we can control are summarized in the following SWOT analysis.

Strengths

New Mexico has some clear strengths it can leverage to accelerate the native Photonics economy.

PHOTONICS WORKFORCE

- 6000+ entrepreneurs, engineers, scientists, and technicians trained in Photonics
- Expertise in developing Intellectual Property (IP)
- Expertise in manufacturing components, sub-assemblies & sub-systems
- Expertise in designing and testing components and systems

TECHNOLOGY EXPERTISE

- Photovoltaics: from wafer fabrication to system design and deployment
- Biotechnology: system design expertise leveraging photonics as an enabling tool
- Optical fabrication: from MEMs device design, to conventional free-space optics fabrication, to complex elements for steering synchrotron radiation
- High energy lasers and beam stabilization expertise for Directed Energy and laser communications applications

PHOTONICS-BASED FACILITIES

- Center for High Technology Materials
- Sandia National Laboratories Microsystems Center
- UNM Center for Micro-Engineered Materials

Weaknesses

New Mexico's weaknesses can be overcome with public-private dialogue and improved communications between government and business.

TAXATION

- Photonics and other knowledge-based industries in the state are uncompetitive suppliers to in-state customers due to New Mexico Gross Receipts Tax.
- Communication of changes to business taxes can be improved
- Communication of business benefits from programs financed by taxes (JTIP, SBA, etc.)

RECRUITMENT

- Uneven national perception of New Mexico as a place to live and build a company
- Education rankings which discourage professionals to move to New Mexico to raise a family

Opportunities

Interviews with the company leaders suggested a lack of a sense of community. If we create a stronger community, then we should be able to band together to create change.

PROFESSIONAL PEER-TO-PEER SUPPORT

- Improvement of professional networking to facilitate more efficient operations
    - Students and faculty knowing more companies will improve recruitment for the companies and of the students
    - Peer-to-peer networking to help company leaders find local and/or better ways to go to market, find new business opportunities, leverage their IP

- Government to business relations to help improve the flow of communication in both ways: regarding taxation, business benefits, and regulations

INTELLECTUAL PROPERTY DEPLOYMENT

- Leveraging of the tremendous IP portfolios in the state to create products made in New Mexico
- Sharing of knowledge of how to grow companies quickly and develop jobs
- Sharing of knowledge of how to manufacture & how to design

DIVERSITY

- Wide diversity of everyday products and conveniences are enabled by Photonics that are developed and produced by companies in NM

Threats

If we make no changes, then we will continue to remain stagnated in recruiting companies, seeding start-ups, and creating jobs – the status quo. Outside the state and internationally, communities are coming together to create Photonics-based economies with economic development incentives from local and regional governments, the educational institutions, and industry groups. Those that have are seeing stellar growth.

OUTSIDE NEW MEXICO

- Investments by local, regional and state governments outside NM and internationally that cultivate an environment fostering growth of manufacturing jobs (Photonics21)
- Regions with cultures of 'sharing' (Silicon Valley's start-up communities) will move faster

INSIDE NEW MEXICO

- Our own impressions of a state that does not work well
- Our own fears about exporting, working in Asia, or doing something new
- "Nothing changes" attitude
- Continued policies and taxation that are disincentives to NM-based technology activities and manufacturing of photonics

FOLLOW ON WORK

After completing the research and analysis for this Report, it appeared that the economic development interests of the City of Albuquerque and the State of New Mexico would be served by taking some additional next steps to support and develop assets regarding:

- Data base of the most active patenting firms in the state and city
- List of the most active patent subject (technology) areas in the state and city
- Developing a Photonics 'asset list' and a 'personnel asset list' to aid recruitment and to support pursuit of economic development funding
- Advocacy support to the National Photonics Initiative (NPI)

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DIRECTORY OF NM PHOTONICS COMPANIES

Company Name	NAICS Code	City	Telephone Number	Web Site
3D Glass	334516	Albuquerque	866-559-8982	www.3dglasssolutions.com
Active Optical Systems	446130	Albuquerque	505-245-9970	www.activeopticalsystems.com
Advanced Optical Technologies	335999	Tijeras	505-250-9586	www.advanced-optical.com
Aerospace Corp	334511	Albuquerque	505-872-6200	www.aerospace.org
Aerospace Corp	334511	Kirtland AFB	505-256-0042	www.aerospace.org
Akamai Physics Inc.	541611	Las Cruces	575-532-8600	www.akamaiphysicsinc.com
Alpha Omega Power Technologies	541711	Albuquerque	505-341-4828	www.alphaomegapt.com
AMO WaveFront Sciences, LLC	333314	Albuquerque	505-275-4747	www.wavefrontsciences.com
amp	811219	Cedar Crest	505-286-8338	www.amphdr.com
Applied Research Associates	541330	Albuquerque	505-881-8074	www.ara.com
Array Technologies	333414	Albuquerque	505-881-7567	arraytechinc.com
AS-Photonics LLC	541690	Albuquerque	505-998-0048	www.as-photonics.com
ASRC Aerospace Corp	334511	Albuquerque	505-348-1513	www.asrcaerospace.com
A-Tech Inc	334419	Albuquerque	505-823-1320	www.atacorp.com
ATK Advanced Weapons	336414	Socorro	575-835-5803	-
ATK Aerospace Systems	334511	Albuquerque	505-503-7367	www.atk.com
Atlantic International Imaging		Sandia Park	505-286-0497	www.atlantic-international.org
ATOC	811219	Albuquerque	505-343-1250	www.opticalsputtering.com
Avisa Pharma	423450	Albuquerque	505-820-1400	www.avisapharma.com
Ball Aerospace & Technologies	334511	Albuquerque	505-242-2227	www.ballaerospace.com
Boeing Co	334511	Albuquerque	505-449-4600	www.boeing.com
Cabot	541712	Albuquerque	505-342-1492	www.cabot.us/
CFV Solar Test Laboratory	423720	Albuquerque	505-998-0100	cfvsolar.com
CIC Photonics Inc	423490	Albuquerque	505-343-9500	www.cicp.com
Comet Solutions	541511	Albuquerque		www.cometsolutions.com
Contrast Optical Design & Engineering	811219	Cedar Crest	505-286-8338	www.contrastoptical.com
CVI Laser Optics	333314	Albuquerque	505-296-9541	marketplace.idexop.comstore/cvi-laser-optics
Cycad Products	333314	Las Vegas	505-425-9505	www.cycadproducts.com
Daystar, Inc	541330	Las Cruces	575-522-4943	www.daystarpv.com
Direct Power and Water Corporation	334413	Albuquerque	505-889-3585	www.power-fab.com

Company Name	NAICS Code	City	Telephone Number	Web Site
Dynamic Photonics		Albuquerque		www.dynamic-photonics.com
EMCORE Corporation	334413	Albuquerque	505-332-5000	www.emcore.com
Energy Related Devices	334413	Tucumcari	575-4619814	www.energyrelateddevices.com
FASORtronics	335999	Albuquerque	650-796-3469	www.fasortronics.com
Fiore Industries Inc	541330	Albuquerque	505-255-9797	www.fiore-ind.com
FLIR Systems	334513	Santa Teresa	575-589-1536	
General Dynamics Corp	334511	Las Cruces	575-541-7700	www.generaldynamics.com
Genevolve Vision Diagnostics	923120	Albuquerque	505-504-9607	www.genevolve.com
Google/Titan Aerospace		Moriarty		titanaerospace.com
Gratings, Inc.	541712	Albuquerque	505-345-9564	www.gratingsinc.com
Great River Technology	541512	Albuquerque	505-881-6262	www.greatrivertech.com
Harris Corp	334511	Albuquerque	505-792-4280	www.harris.com
Honeywell Aerospace	334511	Albuquerque	505-828-5000	www.honeywell.com
Ht Microanalytical Inc	335314	Albuquerque	505-341-0466	www.htmicro.com
Information Systems Laboratory		Albuquerque	505-217-9781	www.islinc.com
Innovasic Semiconductor	334413	Albuquerque	505-883-5263	www.innovasic.com
Insight Lighting	335121	Rio Rancho	505-345-0888	www.insightlighting.com
InSync	333314	Albuquerque	505-345-2660	www.insyncoptics.com
Intel Corp	334413	Rio Rancho	505-893-7000	www.intel.com
Intor	333314	Socorro	575-835-2004	www.intor.com
JSA Photonics	541618	Rio Rancho	505-896-1509	www.jsaphotonics.com
Kentek Inc	423610	Albuquerque	505-858-0202	www.kenteklaserstore.com
Kestrel Corporation	541330	Albuquerque	505-345-2327	www.kestrelcorp.com
Kiara Networks	423840	Albuquerque	505-268-3600	www.kiaranetworks.com
L-3 Detector Networks	423690	Albuquerque	505-797-0446	www.sds.l-3com.com
LASEN	423610	Las Cruces	575-522-5110	www.lasen.com
Leidos (formerly SAIC)	541712	Albuquerque		https://www.leidos.com
Libration Systems Management	334511	Albuquerque	505-243-6767	www.librationsystems.com
Lidar Guys	541618	Albuquerque	505-792-6870	www.lidarguys.com
Lockheed Martin Corp	334511	Albuquerque	505-765-2660	www.lockheedmartin.com
Lumidigm	334118	Albuquerque	505-272-7084	www.lumidigm.com
Medici		Albuquerque	5052643122	www.medicitechnologies.com
Mesa Photonics, LLC	541712	Santa Fe	505-216-5015	www.mesaphotonics.com
Mk Photonics Inc	423490	Albuquerque	505-294-5654	www.mkphotonics.com
MOOG CSA	541330	Albuquerque	505-323-4900	www.csaengineering.com

Company Name	NAICS Code	City	Telephone Number	Web Site
MZA Associates	541511	Albuquerque	505-245-9970	www.mza.com
Nanogenesis	541330	Albuquerque	505-881-1003	nanogenesisgroup.com
NASA	334511	Las Cruces	575-524-5293	
NASA	927110	Las Cruces	575-524-5215	www.nasa.gov
Nikon Precision Inc	334413	Rio Rancho	505-899-0714	www.nikonprecision.com
Northrop Grumman	334511	Albuquerque	505-998-8100	www.northgrum.com
Optisource LLC	423610	Albuquerque	505-792-0277	www.optisourcellc.com
Optomec Inc	541330	Albuquerque	505-761-8250	www.optomec.com
Paradise Power Co	335312	Taos	575-737-5896	www.paradisepower.net
Praxis Optics	541330	Albuquerque	505-239-9095	www.praxis-optics.com
Protected Logic	423610	Albuquerque	505-792-0892	www.protectedlogic.com
QinetiQ North America	541511	Albuquerque	505-884-2300	www.qinetiq-na.com
Raydec, Inc	541712	Albuquerque	505-292-5002	www.raydec.com
Raytheon Co	334511	Las Cruces	575-678-9181	www.raytheon.com
Raytheon Co	334511	Albuquerque	505-400-0921	www.raytheon.com
Richmond Products	333314	Albuquerque	505-275-2406	www.richmondproducts.com
RIEtech Global	334511	Albuquerque	505-299-6623	rietechmotioncontrol.com
Sandia Electro Optics	333314	Albuquerque	505-816-0211	www.se-oc.com
Schafer Corp	334519	Albuquerque	505-242-9992	www.schafercorp.com
Senspex	423490	Albuquerque	505-891-0034	www.senspex.com
Silent Falcon UAS Technologies	336411	Albuquerque	505-938-6230	www.silentfalconuas.com
SKINfrared	541712	Albuquerque	505-504-6846	skinfrared.com
Skorpios	541712	Albuquerque	505-369-1542	www.skorpiosinc.com
SOL POWER SOLUTIONS LLC	541712	Albuquerque	505-507-1955	
Southwest Infrared	334516	Albuquerque	505-271-1620	www.swinfrared.com
Southwest Sciences Inc	541710	Santa Fe	505-984-1322	www.swsciences.com
Spectral Products	334516			www.spectralproducts.com
Star Cryo	334419	Santa Fe	505-424-6454	www.starcryo.com
Sumitomo Electric Device Innovations USA Inc	561990	Albuquerque	505-323-3400	www.sstp.orgcompanies/sumitomo-electric-device-innovations-usa-inc-2
Suncore Photovoltaic Incorporated	238220	Albuquerque		suncoreus.com
Symphony Sensors, Inc.	335999	Rio Rancho	505-892-1195	www.symphonysensors.com
Tau Technologies	541330	Albuquerque	505-244-1222	www.tautechnologies.com
Thermo Eberline	334519	Santa Fe	505-471-3232	thermofisher.com
Thermo Fisher Scientific Inc	334519	Santa Fe	505-471-3232	www.thermofisher.com

Company Name	NAICS Code	City	Telephone Number	Web Site
Tokyo Electron America	334413	Rio Rancho	505-994-6720	www.tel.com
Tred Displays	541850	Albuquerque	505-856-2488	www.treddisplays.com
Trilumina	334413	Albuquerque	505-633-8800	www.trilumina.com
TruTouch Technologies	334519	Albuquerque	866-721-6221	tttinc.com
Ultra Communications Inc	334413	Albuquerque	505-823-1293	www.ultracomm-inc.com
UTC Aerospace Systems	334511	Albuquerque	505-345-9031	www.goodrich.com
VeraLight	334510	Albuquerque	505-272-7023	www.veralight.com
Vision Quest Biomedical	541710	Albuquerque	505-508-1994	www.visionquest-bio.com
Wellkeeper	**213112**	Albuquerque	505-232-6908	www.wellkeeper.com
Xilinx, Inc.-Albuquerque	334413	Albuquerque	505-828-2032	www.xilinx.com
Zomeworks	332322	Albuquerque	505-242-5354	www.zomeworks.com

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