SCIENCE & TECHNOLOGY IN ARIZONA

A Sector Profile

Prepared by The Council For Community And Economic Research

ARIZONA COMMERCE AUTHORITY

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Science and Technology in Arizona

Contents

Science and Technology in Arizona:

A Sector Profile

Introduction

Leading-edge science, technology and innovation have long provided the engine for Arizona's continued economic growth. As we enter the 21st century, Arizona companies face new kinds of competition from China, India, and other countries that are shifting their emphasis from providing low cost products and services to developing high-technologies and innovation. Fostering science, technology and innovation is the key for Arizona to retain its competitive edge.

Arizona has been at the forefront of U.S. leadership in semiconductor manufacturing, biomedical and surgical instrument manufacturing, aviation, and aerospace manufacturing. With continuous investment in research and development, Arizona can lead the U.S. and the rest of the world in the research and innovation required for economic growth in critical global niches related to a wide variety of technologies including semiconductor materials and design, computer systems design, optics and photonics, unmanned flight, as well as solar energy production to name but a few. Moving forward, Arizona's science and technology industries are going to continuously grow with steady investment in technology and innovation at both academic and industrial level.

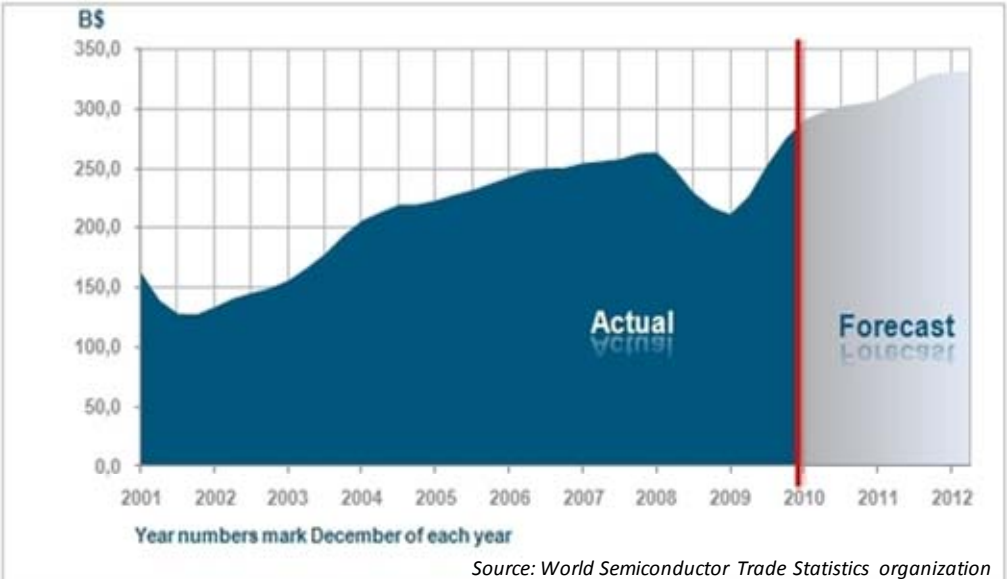
Trends in Key Science and Technology Sectors

This report focuses on four key science and technology segments that could potentially have the biggest impact on almost every aspect of our daily life: semiconductor, optics, nanotechnology, and biosciences. These technologies are widely applied across many technology-intensive industries such as biomedical, information and communication technology, aerospace, renewable energy, and advanced manufacturing. Many agree that the development of these four segments is critical for the nation to stay globally competitive.

Semiconductor

According to data from the Semiconductor Industry Association, the U.S. has the largest share of the world market in semiconductor production and leads the world in advanced technology research. However, the continued pressure for microelectronic producers to provide "more for less" creates a unique manufacturing dynamic in the U.S. semiconductor industry, leading to incredibly fierce global competition, especially from Asia. Furthermore, as Asian markets continue to expand and Asian producers become increasingly sophisticated in the technologies they can develop, the electronic equipment and semiconductor industries is expected to continue evolving into a truly global market.

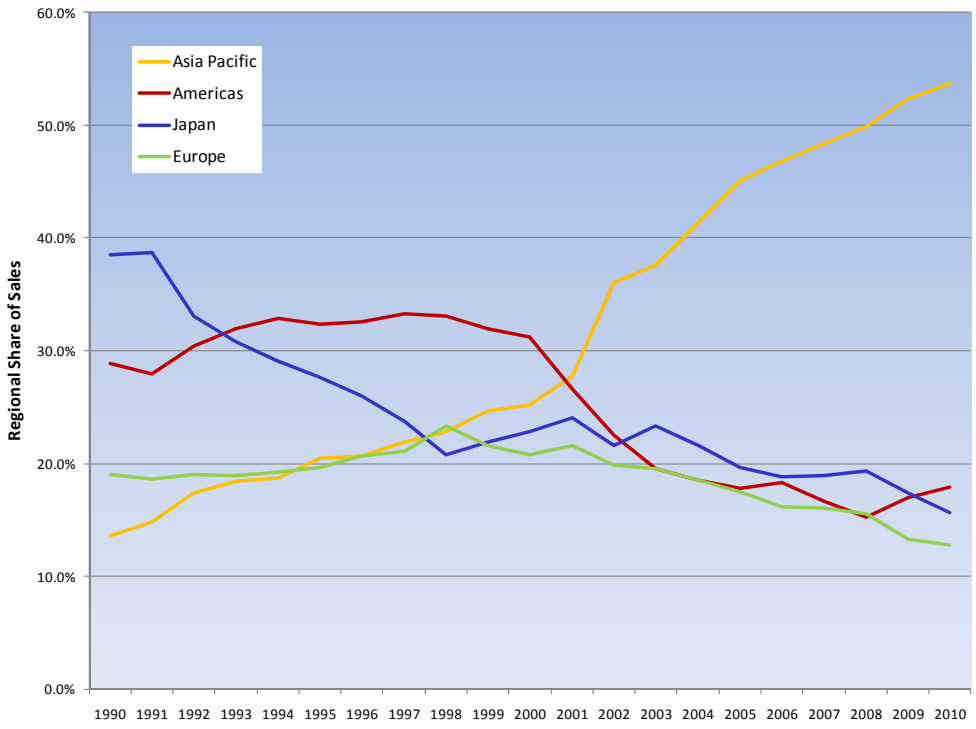
Figure 1: Global Semiconductor Market Trends, 2001-2012



Source: World Semiconductor Trade Statistics organization

- In 2010, total global semiconductor sales were expected to exceed $300 billion according to the World Semiconductor Trade Statistics (WSTS) organization after falling to $195 billion in 2009 (see Figure 1).
- Global semiconductor sales in 2011 are expected to grow about 2.3 percent.
- The Asia-Pacific region is the biggest consumer market for semiconductor industry. In 2010, nearly 54 percent of total worldwide semiconductor production was shipped to the Asia-Pacific region (see Figure 2).

Figure 2: Semiconductor World Market Shares



Source: Semiconductor Industry Association

- Today USA companies are still the biggest semiconductor producers in the world. In 2009, nearly half of worldwide sales ($115 billion) were produced by USA semiconductor companies.
- U.S. semiconductor companies employ a domestic workforce of about 207,500.
- Intel remains the global leader in semiconductor sales and nine US companies rate among the global Top 20 (See Figure 3).

Figure 3: 20 Global Semiconductor Sales Leaders, 2010

Rank 2010	Rank 2009	Company	Country of origin	Revenue (million $ USD)	2010/2009 changes	Market share
1	1	Intel Corporation	USA	40 020	24.3%	13.2%
2	2	Samsung Electronics	South Korea	28 137	60.8%	9.3%
3	3	Toshiba Semiconductors	Japan	13 081	26.8%	4.3%
4	4	Texas Instruments	USA	12 966	34.1%	4.3%
5	9	Renesas Electronics (1)	Japan	11 840	129.8%	3.9%
6	7	Hynix	South Korea	10 577	69.3%	3.5%
7	5	STMicroelectronics	Franceltaly	10 290	20.9%	3.4%
8	13	Micron Technology (2)	USA	8 853	106.2%	2.9%
9	6	Qualcomm	USA	7 200	12.3%	2.4%
10	15	Elpida Memory	Japan	6 678	74.2%	2.3%
11	14	Broadcom	USA	6 506	52.1%	2.1%
12	8	AMD	USA	6 355	22.0%	2.1%
13	11	Infineon Technologies	Germany	5 226	39.7%	2.0%
14	10	Sony	Japan	5 336	19.4%	1.8%
15	18	Panasonic Corporation	Japan	5 128	58.1%	1.7%
16	17	Freescale Semiconductor	USA	4 329	27.2%	1.4%
17	19	NXP	Netherlands	4 021	24.1%	1.3%
18	23	Marvell Technology Group	USA	3 680	43.1%	1.2%
19	16	MediaTek	Taiwan	3 595	1.2%	1.2%
20	20	NVIDIA	USA	3 189	12.8%	1.0%
Top 20				198 207	40.1%	65.2%
All Other companies				105 799	20.2%	34.8%
TOTAL				304 006	32.5%	100.0%

Notes:

(1) Renesas Electronics formed by merger of Renesas Technology and NEC Semiconductors.

(2) Micron Technology includes acquisition of Numonyx.

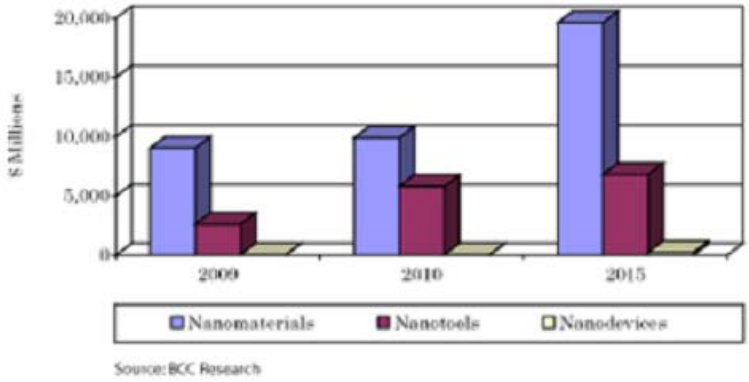
Source : preliminary 2010 rankings from iSuppli Corporation / (foundries excluded)

- In 2008, U.S. companies conducted $28.8 billion in semiconductor-related R&D, representing 15 percent of sales, according to the National Science Foundation; $21.2 billion of U.S.-supported R&D was performed at domestic U.S. research centers
- Arizona State University, the University of Arizona, and Intel are among the members of the Semiconductor Research Corporation, the world's leading non-profit technology research consortium based in North Carolina. SRC program initiatives include the Global Research Collaboration (GRC) (focused on near-term materials, interconnect, devices, design, and tools); the Focus Center Research Programs (FCRP) (for future-generation IC requirements); the Nanoelectronics Research Initiative (NRI) (for determining the post-CMOS information element by 2020); and the Energy Research Initiative (ERI) (supporting research in photovoltaics, smart grid, electrical energy storage and power management).
- The University of Arizona is the lead institution for SRC/SEMATECH's Engineering Research Center for Environmentally Benign Semiconductor Manufacturing.

Nanotechnology

Global estimates for nanotechnology products totaled nearly $9.4 billion in 2005 and over $10.5 billion in 2006. Total worldwide sales revenues for nanotechnology were $11.7 billion in 2009, and are expected to increase to more than $26 billion by 2015, a compound annual growth rate (CAGR) of 11.1 percent.[1] Figure 4 illustrates that nanomaterials are expected to continue driving growth, but nanotools have emerged as important market opportunities in recent years.

Figure 4: Global Market Potential for Nanotechnologies, 2009-2015



Key technological and engineering issues exist in adopting nanotechnology in manufactured products. Those issues relate to product scalability, quality and reliability. To address these challenges will require close collaboration among government, academic and industry players to improve technologies and bring down the high costs associated with nano-materials, special equipment and tooling.

The U.S. is the world's leader in nanotechnology basic research and nanotech applications in many key areas, such as biomedical, solar energy, and electronics. The National Nanotechnology Initiative (NNI), a federal program that facilitates cooperation around the nanotechnology research activities of 25 federal agencies, serves as the primary resource for nanotechnology development (http://www.nano.gov/).

[1] BCC Research, "Nanotechnology: A Realistic Market Assessment." July 2010.

Figure 5: NNI Budget History by Agency (dollars in millions)

Agency	2001 Actual	2002 Actual	2003 Actual	2004 Actual	2005 Actual	2006 Actual	2007 Actual	2008 Actual	2009 Actual
Department of Defense	$125	$224	$220	$291	$352	$424	$450	$460	$459
National Science Foundation	$150	$204	$221	$256	$335	$360	$389	$409	$409
Department of Energy	$88	$89	$134	$202	$208	$231	$236	$245	$333
National Institutes of Health	$40	$59	$78	$106	$165	$192	$215	$305	$343
National Institute of Standards and Technology	$33	$77	$64	$77	$79	$78	$88	$86	$93
National Aeronautics and Space Administration	$22	$35	$36	$47	$45	$50	$20	$17	$14
Environmental Protection Agency	$5	$6	$5	$5	$7	$5	$8	$12	$12
U.S. Department of Agriculture (NIFA)			$1	$2	$3	$4	$4	$7	$10
Department of Health and Human Services					$3	$4	$7	$5	$7
U.S. Department of Agriculture (FS)						$2	$3	$6	$5
Department of Justice	$1	$1	$1	$2	$2	$0	$2	$0	$1
Department of Homeland Security		$2	$1	$1	$1	$2	$2	$3	$9
Federal Highway Administration						$1	$1	$1	$1
TOTAL	***$464***	***$697***	***$761***	***$989***	***$1,200***	***$1,353***	***$1,425***	***$1,556***	***$1,695***

Source: National Nanotechnology Initiative

- The NNI has developed an extensive infrastructure of over 60 research and education centers and user facilities across the country for researchers from academia and the private sector (See Figure 6).
- Within this infrastructure network, Arizona State University's NanoFab serves as the primary user facility in the Southwest region. This facility has provided equipment and services for a full range of operations, including bio-systems and chemistry, inorganic materials, and hybrid structures.
- There has been steady growth in the NNI investment in the past decade (see Figure 5). The cumulative investment in NNI now totals about $14 billion since 2001, including the 2011 request. The Department of Defense and National Science Foundation, and Department of Energy are the top 3 agencies that have invested most in nanotechnology research and development.

Figure 6: Major University-based Nanotechnology Research Facilities

Source: National Nanotechnology Initiative

Optics/Photonics

Worldwide, the role of optics/photonics and optoelectronics has changed dramatically, from pure science to application-oriented technologies that are used in many key industries during the past ten years. According to MarketsandMarkets (M&M), demand for devices capable of high-speed data transfer is driving greater need for the adoption of optical fibers and other optoelectronic components. The cost of these technologies are driving the search for less expensive silicon photonic materials that provide 90 percent

of the efficiency and one-third of the power use for one-tenth of the cost of other traditional optoelectronic components.

M&M estimates that the 2008 market size of global silicon photonics market was about $23 million.[2] Intense competition and relatively high R&D investments required for silicon photonics has restrained past growth in this market, but future deployment is expected to more than double *each year* during the period between 2009 and 2014, reaching $1 billion as new product and application commercialization continues.

In general, companies taking the first mover advantage by quick commercialization with extensive R&D have gained an edge over their competitors. Agreements and collaborations as well as new product launches are some of the most popular strategies adopted by market players to stay ahead of the competition and to expand into new geographies. The U.S. is the dominant market for silicon photonics products with early commercialization and high absorption rates among electronic products.

In 2009, the U.S. represented 56% of the global silicon photonics product market. Europe represents the second largest market with 26% share of the market. The key players in the silicon photonics market include Intel, IBM Corp., Luxtera, Lightwire, Kotura, and Sun Microsystems. In addition, U.S. companies hold 66% of all patents. Out of 89 registered patents, 59 were registered in U.S. with Luxtera and Kotura leading the way in patenting activity. In 2009, wavelength division multiplex filters gained an early advantage in commercialization into new products and dominated the market with a 31% share followed by photo detectors with a 20% market share.

There are growing numbers of optics and photonics clusters established across the country. Eight major optics and photonics clusters are centered primarily in the Southwest and East coast regions with Tucson representing one of the most important.

- Tucson Optics Cluster -- includes over 300 optics-related companies and organizations in Biotechnology and Life Sciences, Defense, Astronomy, Aerospace, Consumer Electronics, Display Technology, Data Storage, Healthcare, Security, and Telecommunications

Bioscience

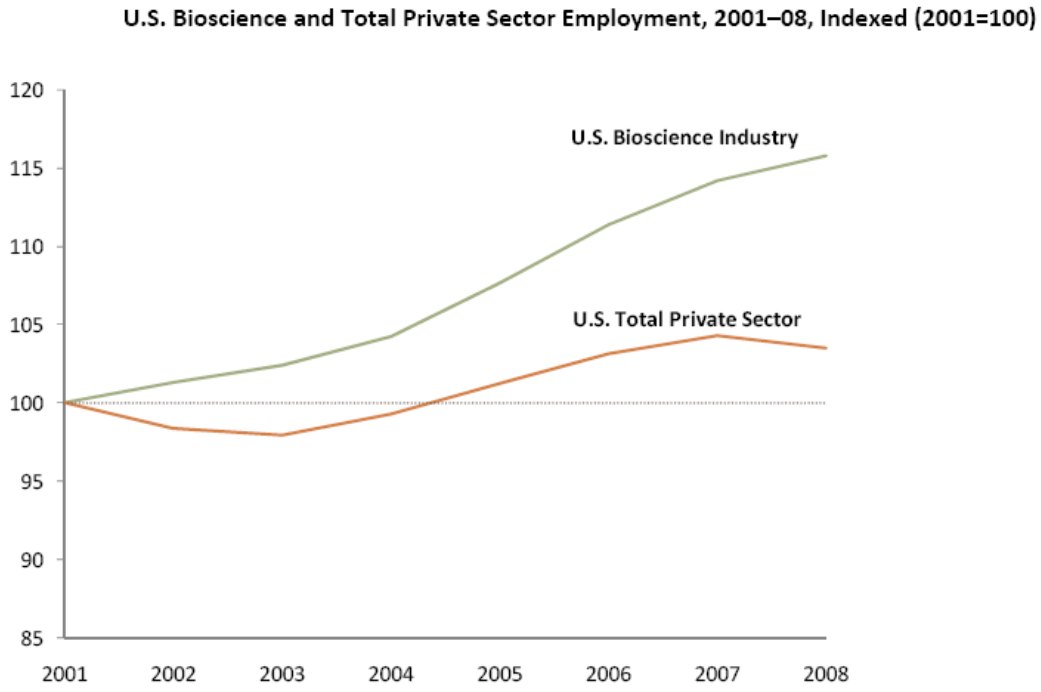
Driven by increasing demands from biomedical applications, agricultural, renewable energy, and industrial biotechnology, the bioscience sector grew dramatically during the past decade. According to Battelle Memorial Institute, a science and technology research organization based in Ohio, and Bioscience Industry Organization, U.S. employment in bioscience sector reached 1.42 million in 2008, adding nearly 194,000 jobs since 2001. [3] This employment growth represented a rapid growth rate of 15.8 percent, about 4.5 times faster than the overall growth rate for the national private sector during the 7-year period. Due to its highly R&D-oriented nature, bioscience sector's rapid growth was mainly

[2] Marketandmarket.com, "Global Silicon Photonics Market by Products," 2009.
[3] Battelle/Bioscience Industry Organization, "State Bioscience Initiatives 2010", 2010.

resulted from growth in research, testing, and medical laboratories, representing 9 out 10 new bioscience jobs created between 2001 and 2008.

The steady and intense R&D investment makes the U.S. the world's leader in bioscience technology innovation. According to Battelle, the U.S bioscience academic R&D expenditures totaled nearly $32 billion in 2008, accounting for more than 60 percent of all U.S academic R&D. With the aggressive investment in bioscience, U.S. bioscience-related patents reached 13,150 in 2009. However, federal bioscience funding and available venture capital for bioscience declined during the 2008-2009 recession.

Figure 7: Bioscience Employment in U.S.



Source: Battelle Memorial Institute, Bioscience Industry Organization

For instance, a key source for funding, the National Institutes of Health (NIH), was reduced $1.7 billion from 2008 to 2009 before economic stimulus funding was made available. Private venture capital to U.S. bioscience companies reportedly fell from $12.3 billion in 2008 to $7.8 billion in 2009, the biggest decline since 2004.

Related venture investing is highly concentrated in a few key states such as California, Massachusetts, New Jersey, Pennsylvania, and Texas where bioscience activity has also concentrated. However, many states are seeking to grow their bioscience industry by adopting strategies such as investing in funds that agree to make in-state investment, helping companies access Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) and directly investing in companies. Many state investments have focused on increasing investment in early-stage bioscience companies.

Even though the state is not yet identified as a national leader, Arizona's bioscience sector experienced significant growth in the past ten years. According to Battelle, Arizona's bioscience grew at a rate roughly twice the national bioscience growth rate between 2001 and 2008:

- The bioscience industry added 14,717 workers in Arizona in 2008. Research, testing and medical laboratories, and medical devices & equipment are the two biggest bioscience subsectors in Arizona, representing 53 percent and 36 percent of the state's bioscience sector activity.
- Academic research expenditure in biosciences totaled $388 million in 2008, while the total bioscience venture capital invested between 2004 and 2009 reached nearly $290 million.
- The majority of Arizona's 899 bioscience patents issued between 2004 and 2009 were related to surgical and medical instrument and drugs and pharmaceuticals.
- Flagstaff, Phoenix, and Tucson metro areas are the bioscience hot spots in the state. Flagstaff is home to major medical devices and equipment companies, and hospitals. Phoenix hosts over 200 research, testing and medical laboratories firms and organizations. Tucson has a bioscience niche in research, testing and medical laboratories and hospitals.
- The big bioscience companies in Arizona include Medtronic Microelectronics Center, Allied Waste Services, Avnet Inc., Dial Corp, and Ventana Medical System Inc.

Research and Development Investment in Arizona

During the past decade, Arizona's research and development investment in Science and Technology experienced steady growth at both the academic and industry level. When compared to other key science and technology states, Arizona's performance remained stable during the same period.

Academic Research and Development Activity

From 2003 to 2008, academic R&D spending in Arizona increased from $618 million to $831 million. However, the respective per capita R&D spending averages, which was $111 in 2003 and increased to $128 in 2008, somewhat below the U.S. average which moved from $138 to $171 per capita during the same period.

Summary of Arizona's University Research Budgets

- The Federal government plays a critical role in supporting the state's academic R&D activities. In 2008, 50 percent of Arizona's major state university research budget came from the federal government (see Figure 8).
- The University of Arizona had the biggest research budget among the three major state universities, spending nearly $546 million in FY2008.
- Arizona State University experienced fastest growing in its research spending at an annual growth rate of 12 percent between 2001 and 2008.

Figure 8: 2008 University R&D Expenditures, by Source of Funds (Dollars in thousands)

	Arizona State U.	Northern Arizona U.	U. of Arizona
Federal government	125,558	13,298	277,897
State and local government	22,856	3,819	31,370
Industry	16,126	3,480	11,325
Institution funds	84,065	5,223	186,912
All other sources	10,898	0	38,365
All R&D expenditures	259,503	25,820	545,869

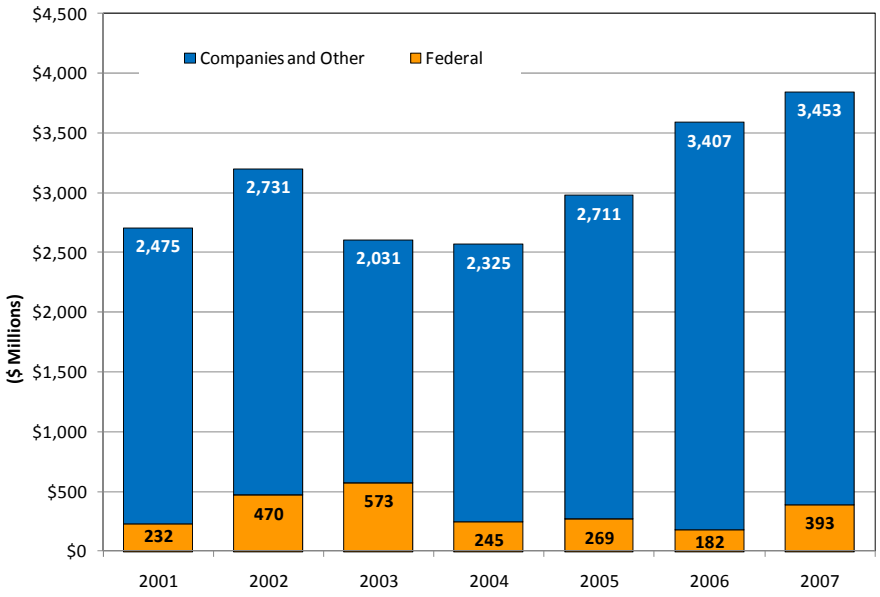
Source: National Science Foundation, Survey of Research and Development Expenditures at Universities and Colleges, FY 2008.

Industry Research and Development Activity

From 2001 to 2007, expenditures on industrial R&D in Arizona increased from $2.71 billion to $3.85 billion, according to the National Science Foundation. The respective per capita amounts grew from $510 to $605 during that time, below the national figures of $709 and $893 between 2001 and 2007.

- While companies and other non-federal sources made the majority of industry R&D expenditures from 2001 to 2007, their combined proportion of the total varied considerably, from 78 to 95 percent (See Figure 9).

Figure 9: Total Arizona Industry R&D Spending (2001-2007)



Source: National Science Foundation/Division of Science Resources Statistics, Survey of Industrial Research and Development.

Highlights of Major Corporate Research and Development Efforts in Arizona

- Intel spends $450 million annually[4] on R&D conducted at its Chandler plant, where 45nm microprocessors are developed and manufactured. The company recently announced the decision to locate another fabrication plant in Chandler, which is expected to be the most advanced in the world when it opens in 2013.
- IBM operates an R&D hub in Tucson for their computer storage hardware and software efforts. This facility is housed at the University of Arizona's Science and Technology Park and has an estimated 1,500 employees and annual revenues of $1.75 billion.

[4] http://www.rdmag.com/News/FeedsAP/2011/02/manufacturing-intel-to-build-new-5-billion-factory-in-chandler/

- Ventana Medical Systems, a University of Arizona biotech spin-out and subsidiary of the Roche Group, develops new products to test for cancer. Its facility in Oro Valley's Innovation Park has 800 employees and annual revenues of roughly $240 million.
- Sanofi-Aventis' facility at the Oro Valley Innovation Park serves as the pharmaceutical company's hub for combinatorial-chemistry research efforts.
- In 2008, Henkel relocated their consumer product R&D center to Scottsdale. Between the headquarters of their subsidiary Dial Corporation and the R&D center, their Scottsdale operation employs 750 people and generates annual revenues of more than $800 million.

Small Business Innovation Research Grants

Small Business Innovation Research Grants (SBIR) are important funding sources for science and technology innovation in Arizona, especially for companies seeking to access federal research and development dollars. The cumulative investment from SBIR totals $157 million from 2005 to 2009.

- In recent years, the three largest sources of SBIR grants to Arizona have been the Department of Defense, Department of Health and Human Services, and National Air and Space Administration. As seen in Figure 10, the Department of Defense has traditionally been the largest funder.
- The Department of Energy's investment in SBIR grants has increased dramatically due to the rapidly rising R&D investment in solar and other renewable energies. The Department of Energy's SBIR grants budget has increased by 150 percent between 2005 and 2009.

Figure 10: Arizona SBIR Grants by Agency ($Awarded)

Agency	2005	2006	2007	2008	2009
Department of Defense	19,459,246	21,884,784	16,340,996	17,006,589	15,839,392
Department of Health and Human Services	7,758,090	7,988,717	3,900,223	1,863,374	13,471,043
NASA	2,937,111	2,280,389	2,297,797	1,898,870	3,299,046
Department of Energy	1,049,200	1,744,543	1,149,769	2,299,369	2,646,093
Department of Education	499,981	0	0	0	849,960
National Science Foundation	1,841,654	669,946	299,700	99,748	649,429
Environmental Protection Agency	225,000	0	69,997	70,000	345,000
National Institute of Standards and Technology	0	0	0	0	89,977
U.S. Department of Agriculture	67,025	239,810	426,000	80,000	80,000
Department of Homeland Security	1,699,270	850,000	249,998	0	0
Department of Transportation	0	0	499,948	0	0
Total	**35,536,577**	**35,658,189**	**25,234,428**	**23,317,950**	**37,269,940**

Source: Small Business Administration, Tech-Net 2011

Key Science and Technology Assets in Arizona and Nationwide

University Research Centers

The three state universities operate many of Arizona's key research assets, many of which focus on bioscience, nanotechnology, optics, environmental science, and commercialization of technology. Figure 11 lists some of the most prominent S&T centers at each university and describes their mission. Some of these are the product of $1.44 billion of state approved funding for science and technology research facilities and programs at the state universities.[5]

Figure 11: Key University Research Centers in Arizona

Research Asset	Self-Description	Website
Arizona State University		
Biodesign Institute	This multidisiplinary institute houses ten centers, which focus their research on issues of: -Predicting, preventing and detecting the onset of disease -Developing renewable energy and reducing environmental damage -Developing innovations that safeguard our nation and the world.	http://www.biodesign.asu.edu/
The Flexible Display Center	The center's mission is to advance full-color, video rate, flexible display technology and catalyze development of a vibrant flexible display and flexible electronics industry to produce integrated electronic systems with advanced functionality.	http://flexdisplay.asu.edu/
Center for Applied Nanoionics	Scientists are looking at new types of memory that can store more information in less and less physical space. At ASU, engineers are improving the memory capacity of electronic chips using a stacking technique.	http://researchstories.asu.edu/taxonomy/term/266
Skysong	SkySong is a unique technology accelerator in Scottsdale that provides support for entrepreneurs and start-up companies – all of whom have access to the vast resources of Arizona State University -- while also providing larger multinational companies with commercial build-to-suit space.	http://www.skysongcenter.com/
University of Arizona		
Bio5	At this institute, scientists from five disciplines (basic science, engineering, agriculture, medicine, and pharmacy) are capitalizing on breakthroughs in the molecular life sciences to improve the quality of life in the 21st century and beyond.	http://www.bio5.org/
Center for Astronomical Adaptive Optics	The center's mission is to support the advancement of astronomical science by providing the means by which to exploit observations at very high resolutions. The Center demonstrates this focus through its current activities and plans for state-of-the-art adaptive optics systems and related technologies for the many large telescope projects of Steward Observatory, in cooperation with partners from elsewhere on campus, across the country, and around the world.	http://caao.as.arizona.edu/CAAO/index.html
Engineering Research Center for Environmentally Benign Semiconductor Manufacturing	This is a multi-university research center that works to create environmentally friendly semiconductor manufacturing processes.	http://erc.arizona.edu/
Campus Research Corporation (CRC)	The University of Arizona's CRC includes a Technology Park and Bioscience Park, which facilitate the transfer of laboratory research into marketable technology. The Technology Park also includes the Arizona Center for Innovation, an incubator that helps grow technology companies; particularly in the areas of aerospace, advanced composites and materials, information technology, environmental technology, life sciences and optics/photonics.	http://www.azinnovation.com/
Northern Arizona University		
Environmental Genetics and Genomics Laboratory (EnGGen)	The Environmental Genetics and Genomics Facility at NAU is a multi-user research laboratory designed for diverse biological applications. This high-throughput laboratory is a regional resource center that supports molecular genetic analyses and training across a wide user base including regional academic, government and private institutions. Users of this facility are studying plant evolution, ecological community genetics, conservation genetics, microbial diversity, molecular epidemiology and molecular forensics.	http://www4.nau.edu/enggen/
National Institute for Climate Change Research	The National Institute for Climatic Change Research (NICCR, pronounced "nicer"). The goal of NICCR is to mobilize university researchers, from all regions of the country, in support of the climatic change research objectives of DOE/BER. The NICCR is managed and coordinated through five Regional Centers, hosted by Pennsylvania State University, Duke University, Michigan Technological University, Northern Arizona University, and Tulane University.	http://niccr.nau.edu/

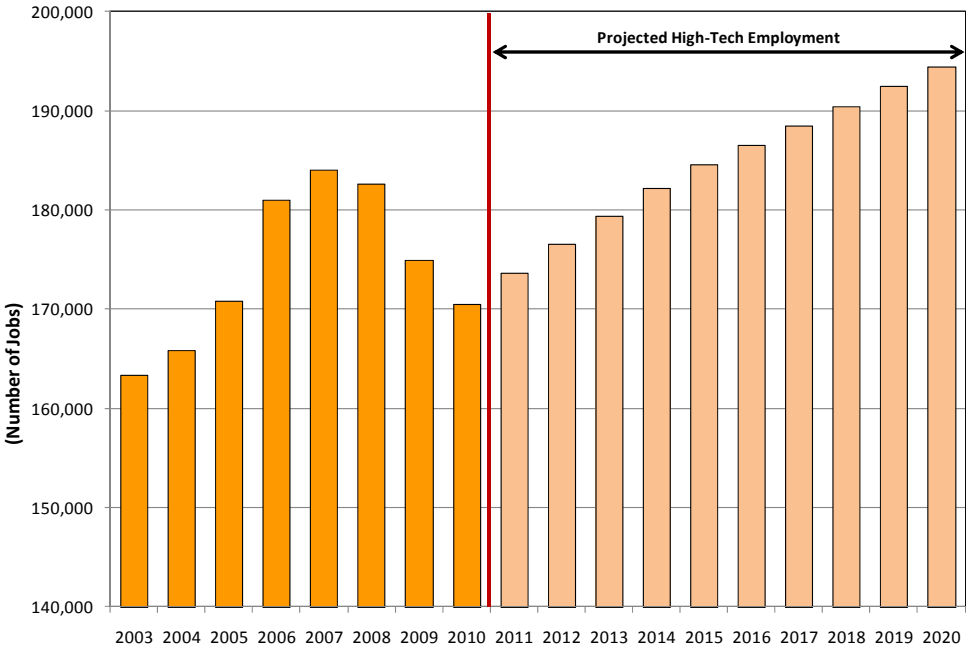
Source: Council for Community and Economic Research

[5] Arizona voters passed Proposition 301 in 2000 designated $1 billion over 20 years for university research. Legislation in 2003 designated $440 million in funding for university research facilities. http://www.flinn.org/file/2010_prog_report.pdf

Science and Technology Industry Growth Trends

This section uses the concept of high-tech industry as defined by US Bureau of Labor Statistics to identify the science and technology industries and analyze their growth trends.[6] In 2010, Arizona had 170,513 jobs in industries considered to be high-technology industries. Between 2003 and 2007, the high-technology industries in Arizona experienced an annual growth rate of about 3 percent (see Figure 12). However, employment in many high-technology industries started to decline after the peak in 2007, experiencing an annual employment decline of 1.4 percent between 2007 and 2011. Moving forward, these high-technology jobs are projected to grow slowly at an annual rate of 1.3 percent between 2010 and 2020, reaching approximately 194,500 jobs by 2020.

Figure 12: High-Technology Employment in Arizona

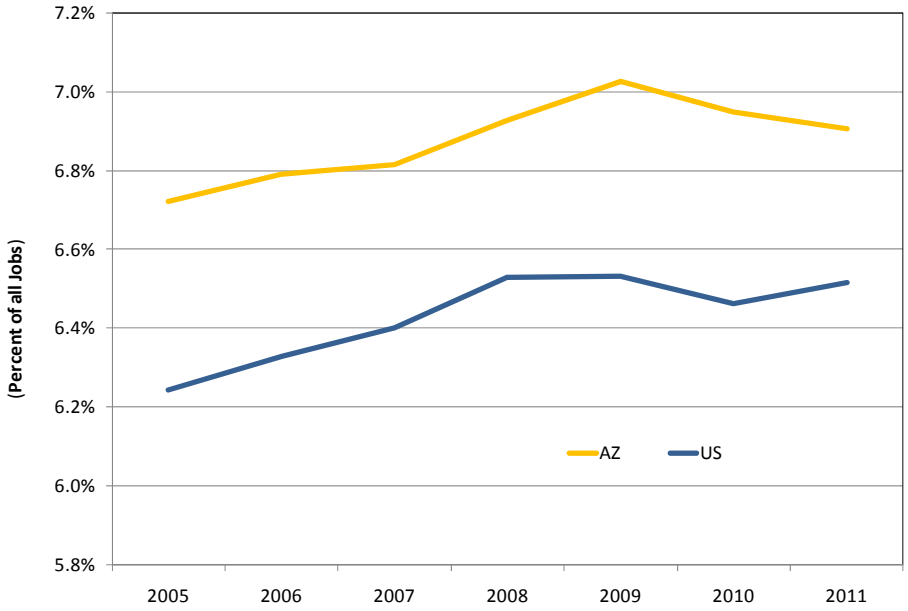


Source: EMSI 2011

[6] http://www.bls.gov/opub/mlr/2005/07/art6full.pdf The definition here focuses primarily on the high- and medium-content technology industries.

As illustrated in Figure 13, these high-tech jobs represented 7 percent of Arizona's overall employment in 2010, slightly higher than the high-tech jobs' proportion of total employment in the whole country (6.5 percent). After the peak in 2009, the representation of high-tech jobs in Arizona started to decline slowly.

Figure 13: Percent of Jobs in High-Tech Industries



Source: EMSI 2011

Biggest Science and Technology Industries in Arizona

- The engineering services industry was the high technology industry with the greatest employment in Arizona. In 2010, engineering services accounted for 17,650 jobs, which represent 10.4 percent of the state's total high-technology employment.
- Arizona's big science and technology industries include semiconductor and related device manufacturing (17,298 jobs) and guided missile and space vehicle manufacturing (12,783 jobs).

Figure 14: Largest Science and Technology Industries in Arizona

NAICS	Industry Name	2005	2010	2015	2020
541330	Engineering Services	17,005	17,650	23,380	27,525
334413	Semiconductor and Related Device Manufacturing	22,066	17,298	10,632	7,410
336414	Guided Missile and Space Vehicle Manufacturing	11,478	12,783	13,346	13,181
541512	Computer Systems Design Services	7,426	10,754	13,621	15,372
541511	Custom Computer Programming Services	6,746	9,452	12,072	13,747
334511	Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instrument Manufacturing	9,359	8,684	10,208	10,987
336412	Aircraft Engine and Engine Parts Manufacturing	6,337	7,429	7,490	7,631
221112	Fossil Fuel Electric Power Generation	5,680	5,312	5,002	4,543
423430	Computer and Computer Peripheral Equipment and Software Merchant Wholesalers	5,438	5,043	4,558	4,050

Source: EMSI 2011

Fastest Growing Science and Technology Industries in Arizona

- Engineering Services is also projected to be Arizona's fastest growing science and technology industry between 2010 and 2020, adding nearly 10,000 jobs (see Figure 15).

Figure 15: Fastest Growing Arizona Science and Technology Industries in projected new employment (2010-2020)

NAICS	Industry	2010-2020
541330	Engineering Services	9,875
541512	Computer Systems Design Services	4,618
541511	Custom Computer Programming Services	4,295
334511	Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instrument Manufacturing	2,303
518210	Data Processing, Hosting, and Related Services	1,812
541712	Research and Development in the Physical, Engineering, and Life Sciences (except Biotechnology)	1,055
541310	Architectural Services	930
541519	Other Computer Related Services	601
333314	Optical Instrument and Lens Manufacturing	449

Source: EMSI 2011

- The other fast growing technology industries that are adding at least 400 jobs during the 2010s are related to information technology and advanced manufacturing.

Key Science and Technology Companies Located in Arizona

Below are snapshots of the largest science and technology companies in Arizona (see Figure 16). The key science and technology industries chosen below are the ones that already have the largest employment in the state.

Among these key industries, Guided Missile and Space Vehicle Manufacturing has the most science and technology workers in Arizona. Raytheon Missile System alone employed 12,400 workers in 2010.

Most of the large or medium-sized employers (50 or more employees) in these key industries are clustered around Phoenix and Tucson, with a couple of important companies located in Sierra Vista.

Figure 16: Large Companies in Key S&T Industries

Name	Location	Employees on Site
Semiconductor and Related Device Manufacturing		
Intel	Chandler	8,000
ON Semiconductor	Phoenix	1,500
Microchip Technology, Inc.	Chandler	600
Microsemi Corp	Phoenix and Scottsdale	675
Computer Systems Design Services		
Cyberheat Inc.	Tucson	100
Succeed Corp	Mesa	210
Custom Computer Programming Services		
Insight	Tempe	600
JDA Software Group	Scottsdale	600
Pegasus Solutions	Scottsdale	600
Thomson NETg	Scottsdale	300
Guided Missile and Space Vehicle Manufacturing		
Raytheon Missile System	Tucson	12,400
Medical, Dental, and Hospital Equipment and Supplies Merchant Wholesalers		
Ascension	Tucson	125
Dial Corp	Scottsdale	750
Ventana Medical Systems	Oro Valley	800
Medtronic Microelectronics	Tempe	1,500
Optical Instrument and Lens Manufacturing		
MRI Medical	Tucson	101
Bruker Nano Inc.	Tucson	70
Gold Tech Industries	Tempe	55
Lincoln Laser Corp	Phoenix	75

Source: Reference USA, 2011

Recent Announcements in Arizona related to Key Technology Areas

Recent announcements of new and expanded facilities described in Figure 17 provide insight into the future direction of the science and technology industry. This is a list of 2010 announcements for facilities in Arizona.[7]

Figure 17: Science and Technology Industry Plant Announcements in Arizona, 2010

Company	City	Product	Category	Type	Employees
eBay / PayPal	Chandler	Data Center	NEW	Office	2,000
Intel*	Chandler	Semiconductors	EXPANSION	MFG	1,000
Safelite AutoGlass	Chandler	Data Center	NEW	Office	1,000
Roche	Oro Valley	Pharmaceuticals	EXPANSION	MFG	500
First American Financial	Phoenix	Data Center	NEW	Office	400
Amonix	Phoenix	Semiconductors	NEW	MFG	167
Tyco International Safety Systems	Phoenix	Safety Products	NEW	Dist/Warehouse	30
Closed Loop Refining & Recover Inc.	Phoenix	Recycling CRT's	NEW	MFG	--
Cognizant	Phoenix	Comp Programming Svcs	NEW	Office	--

Source: Conway Data New Plant Report

[7] The Conway Data New Plant Report provides announcements of new or expanded facilities through the end of 2010. Investments must be $1 million, have a floor area of 20,000 square feet or more, and include companies with 50 or more employees. Leases must reflect investments of $1 million or more in lease costs, renovations, or improvements and must either add 50 or more new jobs to the lessee's payroll or consist of 20,000or more square feet.

- Despite projections of significant employment losses in Arizona's semiconductor and related device manufacturing, recently announced plants (Intel and Amonix) are expected to result in nearly 1,200 new permanent jobs in this sector.
- All announcements, except Tyco International, were in high-content technology industries.
- State, county, and city incentives totaling as much as $11.2 million were provided to entice Roche's expansion of its Ventana Medical Systems operation in Oro Valley. The resulting 500 new jobs are expected to earn an average wage of $70,000[8].
- Though not listed in Figure 17 there were also six announcements in the related renewable energy industry during this time, which are expected to create 535 new jobs in the state.

Key Science and Technology Initiatives in Arizona

Science Foundation Arizona

Science Foundation Arizona (SFAz) plays a leading role in fostering the strategically critical science and technology sectors in Arizona. SFAz provides financial support and networking resources for a full range of science and technology development activities, from innovative science research and STEM education to technology commercialization. SFAz has been and will continue to be the most critical initiative to grow and prosper Arizona's knowledge-based economy. Below are some important facts about SFAz:

- Established in 2006, SFAz was created through a collaboration with three Arizona CEO business organizations – Greater Phoenix Leadership, Southern Arizona Leadership, and the Flagstaff 40. Incorporated in the State of Arizona.
- Existing focus research areas of SFAz include Biomedical, Sustainable System and Renewable Energy, Information and Communication Technology, and Solar Technology.
- The Foundation had significant impact on job creation, technology development and STEM educaton in Arizona since its establishment:
    - 16 new companies created
    - 84 patents applied for and/or issued
    - 11 technology licenses granted
    - Generated $330.9 million in Economic Activity in the first 3 years
    - Created 2,641 jobs in all industries
    - Helped 159,688 K-12 students study STEM subjects

The Translational Genomics Research Institute (TGen)

The Translational Genomics Research Institute (TGen) is the top research organization focused on innovative translational genomics clinical research, one of the leading-edge scientific areas in the world. According to a study by the research firm Tripp Umbach,[9] "TGen provides Arizona $77 million in annual economic impact with $321 million in impacts predicted by 2025."

[8] http://www.flinn.org/news/986

[9] Details of this study can be found at http://www.tgen.org/news/index.cfm?pageid=57&newsid=1705

- Located in downtown Phoenix
- Established in 2002, TGen represents a collaborative effort of state, business and scientific leaders
- Key research areas include the development of diagnostic, prognostics and therapies for cancer, neurological disorders, diabetes and other complex diseases.
- Highlights of 2008 impacts of TGen operations and TGen-led research and commercialization from a Tripp Umbach study:
    - Returned $14.07 on every $1 invested by the state
    - Created 703 jobs in Arizona
    - Generated $5.7 million in tax revenues for Arizona
    - Resulted in an annual economic impact of $77.4 million for Arizona

Astronomy, Space, and Planetary Science Sector

Arizona is a leader in the field of astronomy due in large part to a collection of observatories located in the Tucson region including the Kitt Peak National Observatory and the Steward Observatory at the University of Arizona. According to a new economic impact study prepared by the Arizona Arts, Sciences and Technology Academy (AASTA), [10] Astronomy, Space, and Planetary Sciences research had the following impact on the Arizona economy:

- $250 million annual based on the institutions alone (resulting from spending by the institutions, their suppliers and visitors and excluding any commercial activity), including:
    - $138.6 million in average earnings
    - $114.2 million in other value added
- 1,830 jobs created by the observatories and space science sector
- An additional 1,500 jobs resulting from the impacts of indirect activity resulting from area suppliers and expenditures in the local economy by the direct employees of the institutions

Science and Technology Related Business Incentives

Arizona provides tax credit for companies investing in research and development. At the federal level, the major incentives aiming at science and technology development are grant programs. However, many technology-related incentive programs were terminated at both the state and federal level due the budget cuts during the past few years.

The Arizona Research & Development Income Tax Credit provides an income tax credit for increased research and development activities conducted in this state, including research conducted at a state university and funded by the company. More information may be found at: http://www.azdor.gov/.

At the federal level, expenditures on research and development ("R&D") are typically treated as capital expenses, but businesses may also amortize those expenditures over a period of up to 60 months, allowing companies that have negative income in the year of the investment to take a credit in future

[10] AASTA's report, "Astronomy, Planetary Sciences and Space Sciences Research Opportunities to Advance Arizona's Economic Growth".

years in which they may earn a profit. The Congressional Budget Office estimated that the U.S. provided about $5.6 billion in subsidies to firms in 2004 through the research and experimentation tax credit.[11] This supplemented the estimated $137 billion in direct Federal investments in research and development activities.

In addition, the Small Business Technology Transfer Program represents one of the most important S&T incentives. The three-phase program provides up to $600,000 for small businesses investing in scientific and technological innovation. More information may be found at: http://www.sba.gov/.

Arizona Science and Technology Outlook

With steady investment in research and development and business innovation, Arizona experienced robust growth in science and technology during the past ten years. Arizona has developed its own niches in semiconductor, nanotechnology, optics/photonics, and bioscience. The development of these key science and technology segments has generated significant growth in various areas that are critical to Arizona's long-term prosperity. These critical areas include aerospace, renewable energy, bioscience technology, and information technology etc.

Overall

- Even though not the most aggressive investor in research and development, Arizona experienced continuous growth in the R&D investment in the past decade, ranking around 20th out of the 50 states at both academic and industrial level.
- Arizona's universities host many of nation's key research centers in areas such as bioscience, nanotechnology, optics, and commercialization of technology.
- Many big brand science and technology companies have plants in Arizona. These companies include Intel, IBM, Henkel, Dial Operation etc.
- With effective support from government, universities, and industry, Arizona has developed competitive niches in semiconductor, bioscience, renewable energy, aerospace, astronomy, and optics.
- Science Foundation Arizona plays a critical role in Arizona's sustainable development of science and technology in the future.

Semiconductor

- Research and Development Assets
    - Home of Engineering Research Center for Environmentally Benign Semiconductor Manufacturing, University of Arizona is the most important academic semiconductor research resource in the state.
    - Intel is the most active industry investor in semiconductor research, spending $450 million annually on R&D conducted at its Chandler plant.

[11] U.S. Congressional Budget Office, Federal Support for Research and Development, June 2007.

    - IBM operates an R&D hub with annual revenues of $1.75 billion in Tucson for their computer storage hardware and software efforts.
- Industry Highlights
    - The semiconductor and semiconductor-related manufacturing is the biggest science and technology sector in Arizona in terms of employment.
    - The largest semiconductor employers in the state are Intel, ON Semiconductor, Microchip Technology, Inc., Microsemi Corp.
    - Due to the "more for less" manufacturing dynamic, semiconductor manufacturing is expected to experience continued global competitive pressures.
    - Technology innovation such as nanotechnology application in semiconductor is key to sustain Arizona's strength in semiconductor sector.

Nanotechnology

- Research and Development Assets
    - Arizona State University is the most important nanotechnology research resource in the state.
    - Arizona State University's NanoFab serves as the primary user facility in the Southwest region.
    - Arizona State University's Center for Applied Nanoionics plays a critical role in nanotechnology application in other areas such as memory storage.
- Industries Impacted by Nanotechnology
    - In Arizona, the industries impacted most by nanotechnology include guided missile and space vehicle manufacturing, biomedical equipment, renewable energy, and optical instrument and lens manufacturing etc.
    - Employing nearly 12,500 workers in the state, Raytheon Missile System is the biggest company impacted by nanotechnology in the state.

Optics/Photonics

- Research and Development
    - Arizona has well established research resources and facilities in optics/photonics area. The key optics/photonics research centers are Arizona State University's the Flexible Display Center, Center for Astronomical Adaptive Optics.
- Industry Highlights
    - Tucson is home of one of the biggest optics clusters in the nation that includes over 300 optics-related companies and organizations in biotech and life sciences, aerospace, display technology, health care etc.
    - The most important optics-related companies in the state are MRI Medical, Bruker Nano Inc., Gold Tech Industries, Lincoln Laser Corp. They are mostly located in Tucson, Phoenix and Tempe.

Bioscience

- Research and Development

    - Academic research expenditure in biosciences totaled $388 million in 2008, while the accumulative bioscience venture capital reached nearly $290 million between 2004 and 2009.
    - ASU's Biodesign Institute, UA's Bio5, and NAU's EnG Gen play a leading role in bioscience academic research and development in the state.
- Industry Highlights
    - Flinn Foundation is Arizona's critical asset for bioscience research and technology commercialization.
    - Flagstaff, Phoenix, and Tucson metro areas are the bioscience hot spots in the state. Flagstaff is home of major medical devices and equipment companies, and hospitals. Phoenix hosts over 200 research, testing and medical laboratories firms and organizations. Tucson has a bioscience niche in research, testing and medical laboratories and hospitals.
    - The big bioscience companies in Arizona include Medtronic Microelectronics Center, Allied Waste Services, Avnet Inc, Dial Corp, and Ventana Medical System Inc.