



THE MICROELECTRONICS CLUSTER IN **GREATER PHOENIX**

THE FUTURE OF THE REGION'S CORE TECHNOLOGY DRIVER



MARKET INTELLIGENCE PROGRAM

This report is a product of the Greater Phoenix Economic Council (GPEC) Market Intelligence Program. Launched in 2012, the program is a collaborative effort with GPEC's 23 cities and towns, Maricopa County, and regional private-sector stakeholders. It is designed to support the region's efforts to retain and grow local businesses by working with GPEC communities and other regional stakeholders.

The detailed analyses of industry trends are of significant value to communities and enable economic development professionals to engage industry executives in in-depth discussions regarding the opportunities and threats facing the industry.

Previous reports include The State of Greater Phoenix's Aerospace and Defense Industry (February 2013) and An In-Depth Analysis of the Software Industry in Greater Phoenix (January 2015).

This examination of the microelectronics cluster in Greater Phoenix has been a collaboration with the Southwest/Arizona Chapter of SEMI, the industry association for the microelectronics manufacturing supply chain.

FOREWORD

This collaboration between SEMI and Greater Phoenix Economic Council was formed out of a common goal to bring together public and private leaders in support of the further development of the microelectronics and semiconductor manufacturing supply chain in Greater Phoenix. By combining GPEC's expertise in economic development and SEMI's insider knowledge of the industry, this report captures the vital role that this microelectronics cluster plays in the regional economic growth.

The study has several important objectives: collecting data on the health of the local industry, documenting the economic benefits that it provides, and identifying workforce development opportunities. It highlights ways to collectively further growth and documents the benefits of a highly skilled local workforce.

Growing this cluster within Greater Phoenix will provide economic stability for years to come, and we believe that the region is poised to contribute greatly to new advanced technology and innovation. As SEMI Arizona continues to advocate for policies, investments, and improved workforce development programs, GPEC will lead efforts to strengthen this cluster through business attraction, marketing and sector analysis. As this report shows, greater regional cooperation is needed to continue to advance the cluster, and we hope this collaboration will strengthen a regional partnership around microelectronics and lead to more intentional strategic action.



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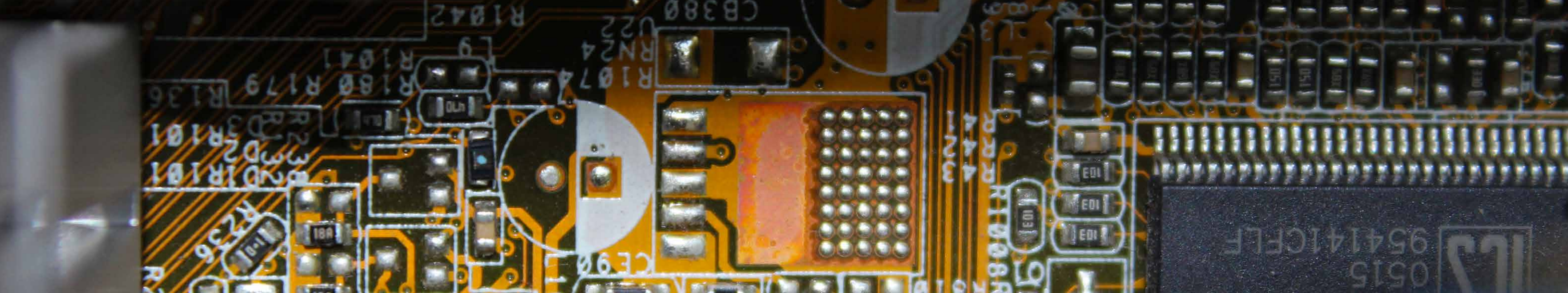


Photo Credit Laura Sposato

INTRODUCTION

Over the last few decades, integrated circuits have revolutionized innovation and technology, improving productivity and helping to create new inventive products that impact our everyday lives. Continuing to develop and support our local microelectronics cluster allows the region to connect to a global supply chain, driving economic growth and placing Greater Phoenix as a key leader in the next wave of technology development.

The microelectronics cluster has been shaping the Greater Phoenix economy since 1949 when Motorola first opened a facility in the region. Motorola and other companies were lured by the proximity to California, the favorable weather, low land cost, and as part of a national defense strategy. More electronics (and electronics-related aerospace) manufacturers moved to Greater Phoenix in subsequent years, including what would eventually become Lockheed Martin and Honeywell through mergers and acquisitions.

These companies not only helped to shape the region’s economy but had a key role in advocating for improvements to Arizona’s educational system. They championed advancements to the state’s only engineering program at the time at the University of Arizona in Tucson, and supported, both publicly and

financially, the creation of Arizona State University (from Arizona State College in Tempe) and its professional engineering school.¹

As Motorola invested in a variety of electronics manufacturing capabilities, Phoenix became a prime location for these activities. Over the past few decades, several of the company’s divisions have spun off from Motorola: ON Semiconductor in 1999 and Freescale (now NXP) in 2004.² Additionally, some of its product offerings were sold to other local companies, such as General Dynamics and Garmin.

Although Motorola no longer has a presence in the region, it has left behind the effects of its industry advocacy. With Intel, ON Semiconductor, NXP, Microchip, and Honeywell, and the many small firms that support these major companies, the local microelectronics cluster is still thriving and poised to grow.

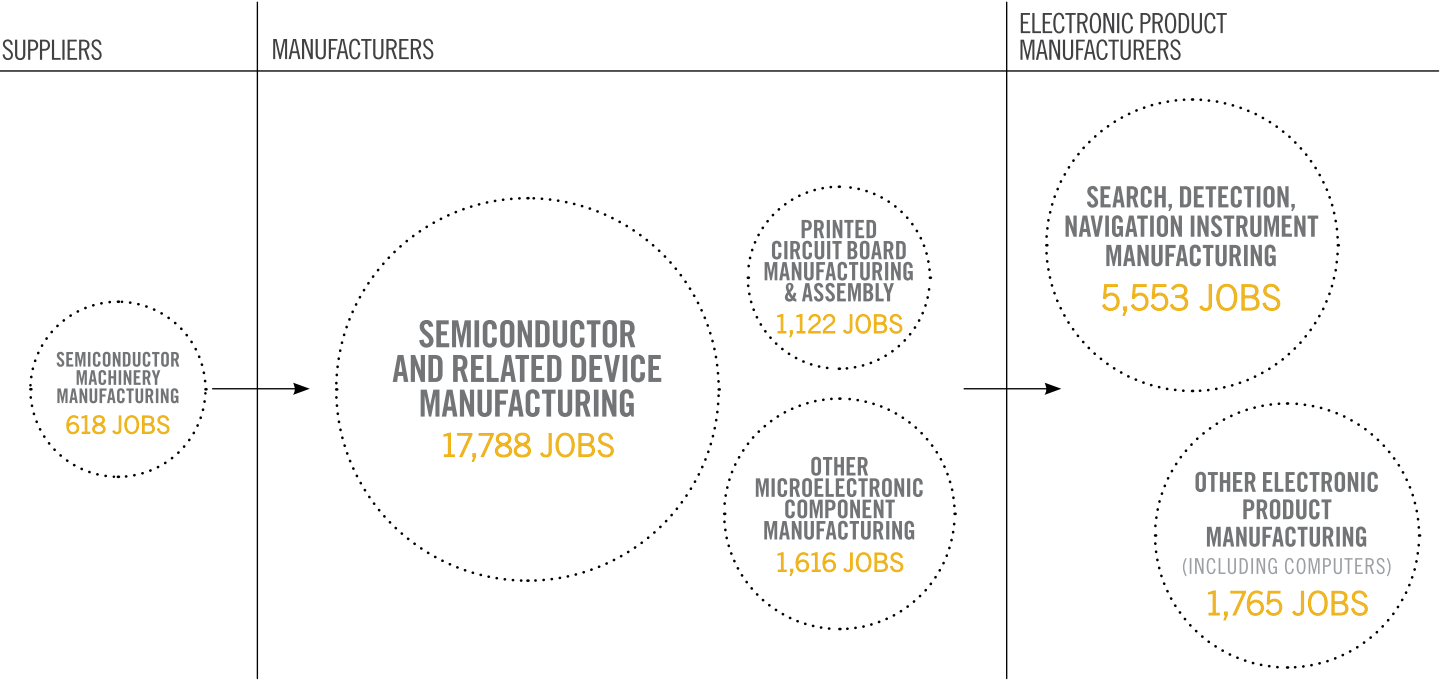
The agglomeration of like companies along the microelectronics supply chain has allowed companies to realize the economic benefits of an industry cluster. Improvements to local education efforts have improved the available workforce, and clustering has encouraged

knowledge pooling, providing opportunities for small companies to share in the labor force market and benefit from lower transportation costs along the supply chain.

Today, new technological trends, including the Internet of Things (IoT), flexible electronics, and smart cities, represent growing markets for semiconductor products.

As the demand for internet-connected devices grows to an estimated 28.1 billion units by 2020, IoT is predicted to be a \$7.1 trillion market.³ This growth will create a number of opportunities for companies in the microelectronics cluster to produce new and innovative products that will support and enhance this emerging market.

MICROELECTRONICS CLUSTER SUPPLY CHAIN IN GREATER PHOENIX



THE GLOBAL IMPACT OF MICROELECTRONICS

As technology has developed, new players including China, South Korea, and Taiwan have been investing in their electronics manufacturing capabilities. However, the United States still controls the largest share of the market. In 2014, U.S. companies accounted for 51% of the semiconductor manufacturing market and 44% of the semiconductor manufacturing equipment market. Semiconductors have been the country’s third largest manufactured export since 2010 with a high volume of sales going to the Asia-Pacific region, where packaging, assembly, and other electronics production has grown over the past few years.⁴ Recently, the Chinese government has expanded efforts to encourage increased semiconductor manufacturing in the country with plans to invest \$19 billion over five years in the growing industry.⁵

As this global market becomes more competitive, the U.S. continues to be at the forefront of innovating and developing the new technologies that enhance production and create new products. Greater Phoenix, as a major U.S. hub for these activities, must also continue to explore and invest in this cluster in order to support these companies that provide sizable benefits to our regional economy.

THE CURRENT STATE OF THE MICROELECTRONICS CLUSTER IN GREATER PHOENIX

Greater Phoenix is the seventh largest metro area for electronics employment, and despite seeing a decline in employment over the past five years, the cluster in the region is following an overall national trend that has seen shrinking employment as automation has improved productivity.

THE MICROELECTRONICS CLUSTER IN KEY REGIONS

METRO	2005 JOBS	2015 JOBS	CHANGE	% CHANGE	2015 AVERAGE EARNINGS	2015 PAYROLLED BUSINESS LOCATIONS
Phoenix	37,465	28,631	-8,834	-24%	\$137,889	210
Austin	26,554	24,721	-1,833	-7%	\$146,005	128
Boston	41,115	29,024	-12,091	-29%	\$151,948	368
Los Angeles	84,985	59,107	-25,878	-30%	\$127,343	830
Portland	32,974	35,239	2,265	7%	\$154,256	194
San Jose	96,465	101,581	5,116	5%	\$237,756	645
United States	959,513	782,529	-176,984	-18%	\$134,578	11,408

Source: Economic Modeling Specialists International, 2015.4 Class of Worker.

The microelectronics cluster makes up 4% of our gross regional product. As output continues to grow despite the employment losses, technological advancements, many of which are developed in the cluster, allow these companies to produce more goods with fewer employees. The automation of manufacturing processes has become more common, which has encouraged competition in the form of innovation, becoming the driving force behind the output growth of the cluster.

Despite seeing a growth in productivity since 1990, Greater Phoenix has gone from having the highest to the lowest rate of the major metros in the cluster, mostly due to slower output growth. In contrast, Portland has seen massive output and productivity growth, likely a result of their investment in research and development, allowing them to increase production without large employment growth.

MICROELECTRONICS OUTPUT AND PRODUCTIVITY IN KEY REGIONS

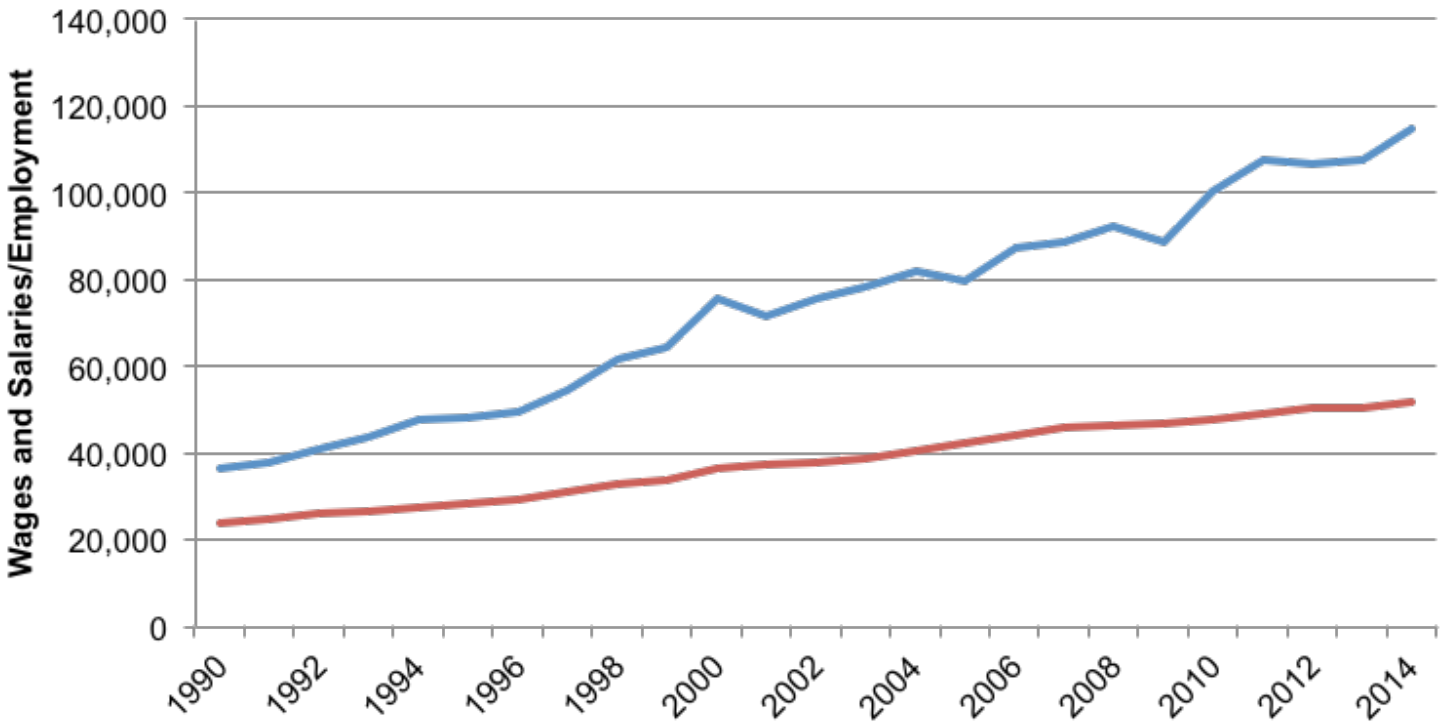
METRO	OUTPUT 2014 (BILLION)	PERCENT GROWTH IN OUTPUT 2005-2014	PRODUCTIVITY 2014 (OUTPUT/ EMPLOYMENT)	PERCENT GROWTH IN PRODUCTIVITY
Phoenix	\$7.4	45%	\$239,049	83%
Austin	\$7.9	56%	\$288,097	85%
Boston	\$13.6	73%	\$286,933	113%
Los Angeles	\$19.2	46%	\$287,043	105%
Portland	\$37.4	293%	\$1,065,795	299%
San Jose	\$28.8	109%	\$295,170	108%
United States	\$248.1	86%	\$264,101	124%

Source: Output: U.S. Bureau of Economic Analysis; Moody’s Analytics Estimates
Employment: U.S. Bureau of Labor Statistics (BLS): Current Employment Statistics (CES), Quarterly Census of Employment and Wages (QCEW); Moody’s Analytics Estimates

Microelectronics companies produce not only a large number of jobs, but also well-paying ones, with higher average wages than those seen across the broader economy. In 2014 the average wage for the microelectronics clusters was \$114,445 compared to \$51,685 for all industries. These jobs require middle- to high-skill levels ranging from entry-level technical to complex engineering, supporting a variety of workers and contributing to an economy that provides opportunities for a diverse group of individuals.

While the region’s microelectronics cluster has a rich and unique history, there is much to be gained by a deep exploration of the existing landscape and opportunities for growth. As Greater Phoenix looks towards innovation to compete in this post-recession economy, the microelectronics cluster is an opportunity to leverage existing assets in the pursuit of future growth.

AVERAGE ANNUAL WAGE IN GREATER PHOENIX



Source: Wages and Salaries: U.S. Bureau of Economic Analysis (BEA); U.S. Bureau of Labor Statistics (BLS); Moody’s Analytics Estimates
Employment: U.S. Bureau of Labor Statistics (BLS): Current Employment Statistics (CES), Quarterly Census of Employment and Wages (QCEW); Moody’s Analytics Estimates

Microelectronics All Industries



Photo Courtesy of Microsoft

THE INDUSTRY OUTREACH PROCESS

Based on 48 interviews and/or questionnaires with local companies, representing approximately 18,000 jobs, 63% of total microelectronics jobs in the region, the following findings and recommendations are aggregated insights from industry professionals. When possible, interviews were conducted with C-level executives, with topics ranging from workforce, supply chain, research and development activities, and general attitudes about the cluster in Greater Phoenix.

Interview appointments were facilitated and attended by economic development professionals at GPEC’s member communities that corresponded to companies’ jurisdictions. These meetings took place between June and November of 2015.

The companies interviewed were semiconductor suppliers, semiconductor manufacturers and designers, electronics assemblers, and other electronic products manufacturers. This provided a variety of perspectives from companies along the entire vertical cluster in the Greater Phoenix region and from both large and small firms.

NUMBER OF COMPANIES INTERVIEWED BY SECTOR	
Semiconductor Machinery Manufacturing/ Refurbishment	16
Other Products/Services for Semiconductor Manufacturers	7
Semiconductor Design/Manufacturing	9
Printed Circuit Board Assembly or Related Components Manufacturing	5
Electronic Products (Communications, Surveillance, Audio, etc.)	11
TOTAL	48

COMPANIES INTERVIEWED BY SIZE (NUMBER OF EMPLOYEES IN GREATER PHOENIX)	
Less than 20 employees	20
20-49 employees	8
50-200 employees	13
Over 200 employees	7
TOTAL	48

FINDINGS

Mergers, acquisitions, and large company consolidations are making headlines, but small firms are driving growth and innovation in the cluster.

As the microelectronics cluster has matured, much has been discussed about the ongoing trend of consolidation. Locally, ON Semiconductor and NXP recently acquired Fairchild Semiconductor and Freescale, respectively. Additionally, six other smaller firms that were interviewed had recently been acquired or merged with another company.

While news about larger company mergers has often dominated industry trends, small firms now have a large impact on employment growth and are fueling innovation and attracting large firm investment in the region.

In 1990, twelve establishments in the microelectronics cluster in Greater Phoenix had over a thousand employees. By 2013, there were only eight. These large companies now make up only 53% of employment compared to 69% in 1990. Employment at companies with fewer than 50 employees has grown by 45%, while employment at large firms has shrunk by 34%.⁶

SMALL VS LARGE FIRM GROWTH IN MICROELECTRONICS

	Small Firms (Less than 50 employees)		Large Firms (More than 1000 employees)	
	ESTABLISHMENTS	EMPLOYMENT	ESTABLISHMENTS	EMPLOYMENT
1990	235	2,659	12	32,450
2013	459	3,856	8	21,400
Percent Change	95%	45%	-33%	-34%

Source: National Establishment Time Series, 2013

Many small business owners are former employees of the major manufacturers in the region. As larger firms have consolidated, employment cuts have fueled new startups from exiting employees. Additionally, small chip designers have benefitted from the growth in fabless production (where companies outsource the manufacturing of the semiconductors), which allows them to produce without a high capital investment in manufacturing equipment.

These small companies have found success by carving out markets not served by larger firms that have higher overhead costs and a need to drive profits. This also allows them to innovate quickly and produce new products. The process by which consolidation creates more entrepreneurs and startups is a cyclical one, wherein these new innovative companies drive increased consolidation as they are often acquired by larger firms that are in search of new intellectual property.

Supporting creative entrepreneurs to grow new businesses with innovative technology actually encourages investment in the region from larger firms through this acquisition process. These small firms also fuel more employment growth and provide a strong supplier network for the large companies in the region.



Photo Courtesy of Microsoft

Some sectors within the cluster are thriving due to innovative processes and products, while other firms try to find new markets for their products.

While the overall microelectronics cluster has seen some reduction in employment over the last few years, some sub industries have seen rapid growth, and others have experienced larger employment losses.

The semiconductor machinery manufacturing industry has seen large employment growth in recent years, much of which has been fueled by a few fast-growing companies that are focusing on new ways of adapting old technology and equipment. These smaller businesses focus on refurbishing old equipment, making replacement parts, and rehabbing machinery for new uses. This has allowed them to compete with major manufacturers of this equipment.

Alternatively, printed circuit board (PCB) manufacturers have seen employment losses and some establishment closures over the last two years. The processes involved in PCB and electronics assembly are more standardized and have become easily replicable overseas. Much of this production and other packaging and testing activities now take place outside of the U.S., and existing companies in the region are competing against a few global manufacturers that own a large share of the market.

Some of the local PCB manufacturers are experiencing less competition within the region as major players, such as Jabil Circuit, closed their Greater Phoenix operations due to slowing sales. Other companies are experiencing a lull in domestic business, leading to softening sales activity that is creating larger obstacles to continued growth.

In Greater Phoenix, most of the downstream electronic products manufacturers are closely tied to the aerospace industry. As discussed in the previous Market Intelligence report, The State of Greater Phoenix’s Aerospace and Defense Industry, defense spending has a large impact on this sector. Recent military budget cuts have strained many companies’ profits. While some of these firms have closed or seen major employment cuts, others are looking to new commercial markets to expand their business and combat these new challenges.

The region’s robust microelectronics supply chain supports a growing number of small companies and the establishment of a true industry cluster.

The microelectronics cluster in Greater Phoenix is characterized by a diverse and strong, supportive supply chain. Companies throughout the vertical cluster indicate a strong preference for purchasing from other local companies. Overall, 70% of companies interviewed bought mostly from other companies in the United States, and 63% of those companies mostly purchased products from other Arizona companies.

In addition to having a concentration of employment in the cluster, the Greater Phoenix region is also a net exporter of products in the microelectronics cluster. Seventy percent of companies said that most of their products were sold in the United States, but 61% of those companies sold mostly outside of Arizona. An estimated 45% of the regional demand for products from the microelectronics cluster is satisfied within the Greater Phoenix region, yet 89% of the sales from these sectors are to places outside of the region. The most significant supply chain strengths are in the semiconductor and related device manufacturing sector, where 90% of regional demand is met from within the region and the semiconductor machinery manufacturing sector, where 78% of demand is met by local companies.

Small companies in Greater Phoenix work directly with or supply major manufacturers in the region and in California. These establishments are a combination of sales and service offices of companies headquartered outside of the region and smaller local companies that were founded in Greater Phoenix. The major distinction

between these two types of establishments is that sales offices are mostly serving the region and possibly other areas of the West, while locally headquartered companies might export from the region and profits can be maintained here.

The region’s reputation as a microelectronics hub has made it a prime location for these regional sales offices, which form an essential piece in the microelectronics supply chain, bringing more large companies to the region and supporting the local cluster.

Attracting millennial workers to the cluster is becoming more important as companies face an increasing number of retirements.

Microelectronics companies are facing new challenges in hiring millennials both as technical workers and more skilled engineers. The supply of technical workers is tightening due to an increase in graduates attending higher education institutions instead of technical schools, while the overall sector struggles with competition from the software sector of the technology field.

Today’s society places a large emphasis on the importance of earning a bachelor’s degree. However, the economy needs a large, diverse supply of workers with varying skills. The technical aspect of the microelectronics cluster is an important one, especially in semiconductor machinery manufacturing and electronics assembly sectors.

Six of the companies interviewed reported that the largest source of their turnover was retirement, and many were concerned with the availability of experienced technical workers and whether local community colleges will continue to produce

enough workers to make up for an increasing number of retirements.

Additionally, hardware manufacturing companies often compete with the software industry for young workers who want to move into high-technology fields. Increased competition amongst software companies for talented millennials has led to the offering of lifestyle incentives, such as flexible hours, work from home options, and in-office food and entertainment.

While software companies can often compete with each other on these incentives, many of these are options that hardware manufacturers cannot offer their employees because of the nature of the manufacturing environment. Some fabless semiconductor producers, however, are starting to leverage their ability to compete for workers with these types of benefits. Additionally, small companies promote quality of life and diversity of work over the large manufacturers in the region.

Data suggests that the Greater Phoenix region is producing graduates in engineering and manufacturing-related fields at a rate comparable to other major metropolitan areas. This suggests more industry-led efforts should be made to customize programs for company needs. Many firms in the region have started to work with local community colleges and high schools to improve programs and market their organization to the potential workforce.



Photo Courtesy of Arizona Republic

ENGINEERING AND MANUFACTURING GRADUATES FOR THE 2013-14 ACADEMIC YEAR				
4-YEAR INSTITUTIONS	GREATER PHOENIX	SAN JOSE METRO	PORTLAND METRO	AUSTIN METRO
Bachelor	1,044	1,074	384	1,308
Master	820	1,892	183	467
Doctor	101	264	15	249
Associate	113	0	48	45
TOTAL	2,078	3,230	630	2,069

Source: National Center for Education Statistics 2015.



Technology advancements require a more talented, well-rounded workforce, creating new challenges for engineering education programs.

As the foundation for much of today’s new technology, the microelectronics cluster requires a talented and intelligent workforce that can constantly innovate and come up with original ideas that help build new products and make existing products more efficient.

Engineering programs, as the primary source of this workforce, must adapt and find unique ways to teach these complicated subjects. Most of the compliments or critiques of these programs revolve around whether these programs should focus on teaching theory or more practical applications. There was not a consensus among our interviewees on this topic.

Some respondents thought that a deep knowledge of theory allowed engineers to quickly pick up new and specific processes at their particular companies. Others believed that theory was not useful if engineers did not know how to apply that in practice.

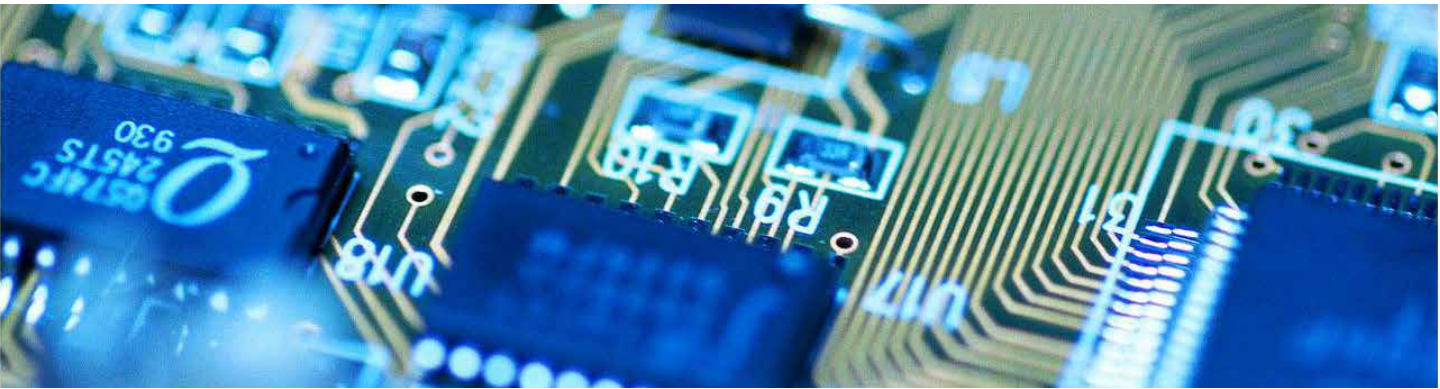
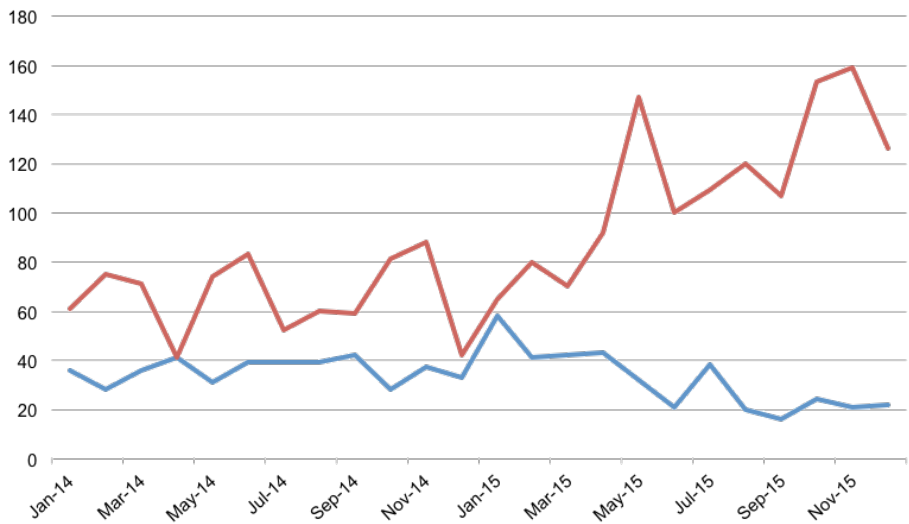
Fourteen of the companies indicated that Arizona State University was the largest source of their new engineering hires, and most of these companies were satisfied with the engineers that ASU produced. Some also noted that ASU’s engineering program has made large improvements over the last few years.

Over the last year, there has been an increased demand for electronics engineers, while the number of active job seekers has decreased. As the labor market tightens in the strengthening economy, ensuring that our region continues to produce a talented, quality engineering workforce is important to retaining and growing the cluster.

ELECTRONICS ENGINEERS
SUPPLY AND DEMAND IN
GREATER PHOENIX

Number of Active Candidates
Number of Job Postings

Source: Careerbuilder.com



RECOMMENDATIONS
Strengthen the economic benefits
of agglomeration by supporting
the growth of a complete
microelectronics cluster.

The economic benefits of clustering come in the form of reduced transportation and distribution costs, increased labor force concentration, and the collection of common knowledge that can expand companies’ efficiency and increase innovation and research opportunities.

The Greater Phoenix region is unique in the composition of its microelectronics cluster in that our supplier network is complex and growing. Attracting more companies in the cluster, especially missing links in the supply chain, will ensure the continued strength of the cluster by providing new resources and opportunities for existing local companies.

Supporting more intraregional sales strengthens the connections that companies have with the region and will provide economic justification for local expansions and the continued presence of this cluster in Greater Phoenix.

Additionally, statewide efforts aimed at encouraging new enterprises with resource support for startups can allow for greater stability and scalability of these businesses, making sure they stay in the region as they grow.

More local companies will also help the expansion of a diverse labor force supply and reinforce the demand for enhanced research and product development opportunities that can broaden the region’s innovation capabilities.

Create a workforce development
strategy that targets the specific
needs of companies and encourages
more industry participation in
designing programs.

As workforce development becomes increasingly important, academic institutions should work more closely with the industry to build programs that will produce graduates suitable for careers in microelectronics.

By working directly with local community colleges and education institutions either through internship programs or by articulating workforce needs to help refine academic programs, the industry is investing more in the local workforce and is able to realize the benefits through less on-the-job training.

Not only will this allow companies to increase the supply of workers suitable to their needs, but it encourages a stronger connection between academic institutions in the region and the local companies. It also enhances the workforce, not only for the microelectronics cluster, but for other industries as well as skills may transfer to other companies and sectors.

Strengthening and improving technical workforce programs can expand opportunities for the entire population and allow people with diverse skill sets to participate more successfully in the local economy.

Facilitate increased research collaboration between companies, universities, and other organizations, especially amongst smaller firms.

As technology advancements and innovation become the cornerstone of a successful microelectronics cluster, ensuring that local companies have access to resources and tools to expand their research and product development capabilities is important to maintaining growth in the cluster. Collaboration between companies and universities allows for greater participation in and connection to the local economy and creates opportunities for smaller companies to innovate.

Leveraging resources at Arizona State University and other academic institutions in support of the microelectronics cluster can drive new research and products and create a reputation for innovation in Greater Phoenix. Furthermore, supporting the research being done by entrepreneurs and small startups can encourage increased investment in the cluster from larger firms through the acquisition of small firms for their innovative intellectual property.

Forming an industry consortium that brings together small and large firms can allow for collaboration on functional applied research. The SEMATECH model provides an example of how a university-industry partnership can benefit both players through the development of marketable technologies.

Concerns over the ownership of intellectual property and costs can sometimes prevent smaller companies from using universities as a resource. Creating programs that alleviate these issues can bring more companies into the research network formed through the collaboration of many different players in the microelectronics cluster.

Improve regional marketing of the local cluster that can facilitate growth and support companies’ workforce recruitment efforts.

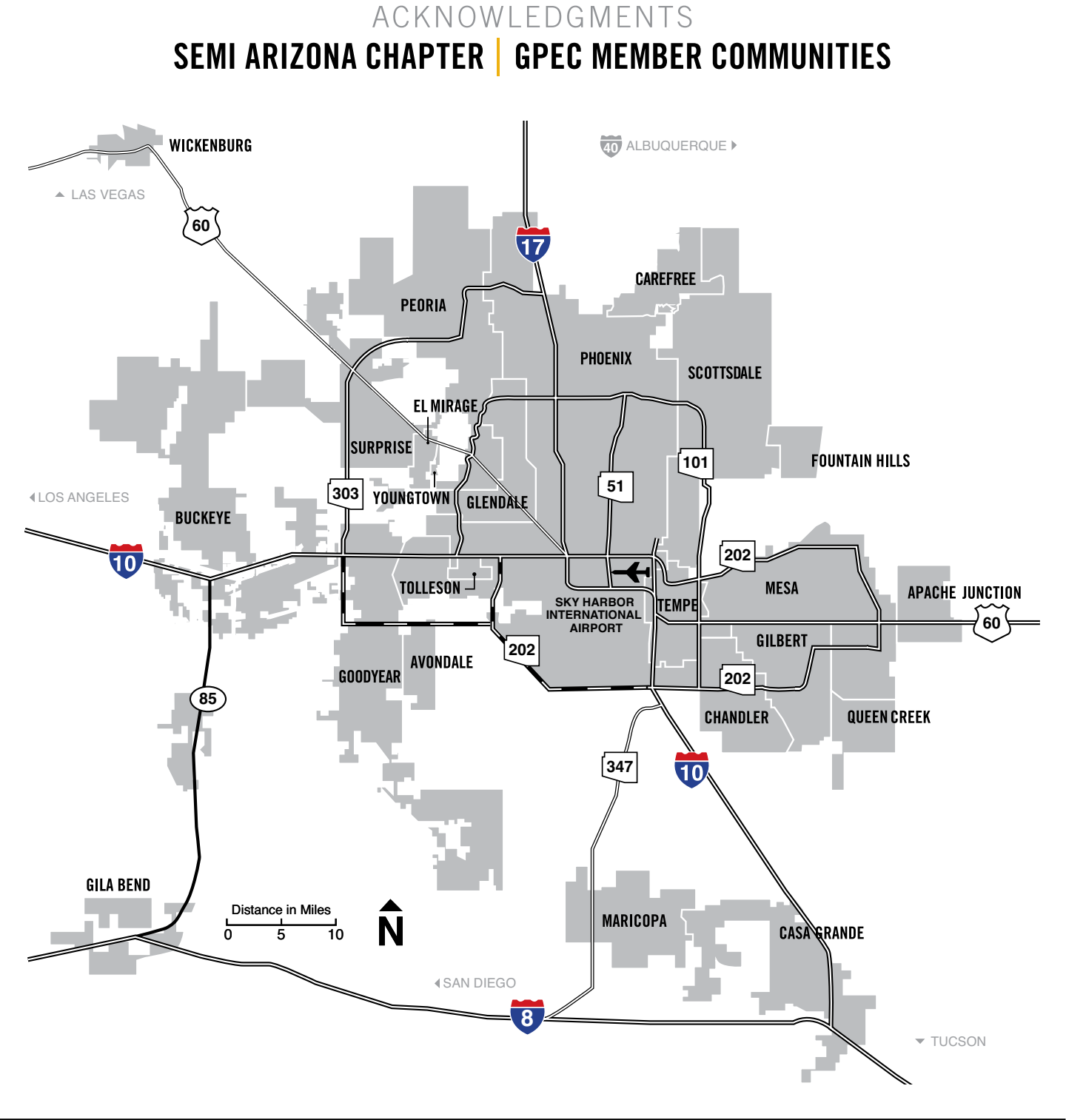
Most of the companies interviewed expressed the microelectronics cluster in Greater Phoenix is still strong and growing, but many were concerned about its brand in the region. With major manufacturers and a strong history, Greater Phoenix should work to create a reputation as a hub for microelectronics.

With changes in the industry causing increased mergers and acquisitions and new rising tech regions including Austin and upstate New York getting more attention, now is the time to invest in order to maintain an advantage. Local companies are competing nationally and globally, and marketing the region can allow these companies to expand their business.

A greater regional brand can also drive business attraction efforts, bringing new businesses that create jobs and complement existing companies in the cluster. This can drive more local business to the support sectors in the region and grow the network of local suppliers.

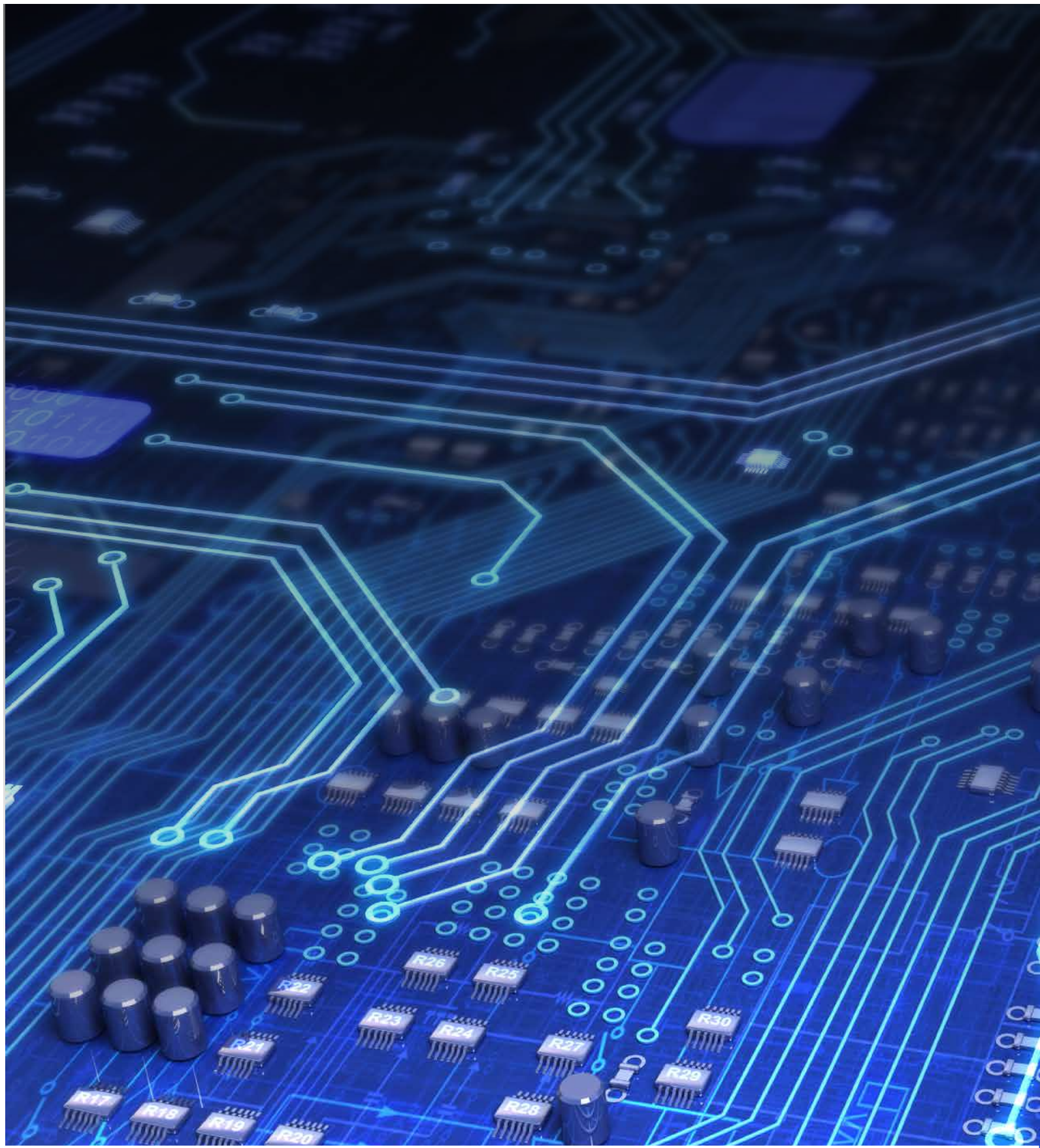
Lastly, marketing the microelectronics cluster in Greater Phoenix to a national audience can help with workforce recruitment. Companies in the region mentioned the difficulties in attracting talented workers from outside of Greater Phoenix. Without a national reputation for microelectronics, industry professionals who are being recruited by local companies may feel that there are not enough other opportunities in the region if the original job opportunity does not work out.

Additionally, launching an industry-led talent attraction initiative to recruit from outside the region will provide for a cohesive message and one that supports individual companies and the cluster as a whole. This overall branding effort will ensure we continue to advance our standing as a major player in the microelectronics industry.




END NOTES

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