Semiconductor Workforce Landscape U.S., Southeast Region, North Carolina

Final Public Report

Prepared for

Commercial Leap Ahead for Wide Bandgap Semiconductors (CLAWS) Hub
NC State University, North Carolina A&T State University, Central Carolina Community College

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Executive Summary

The Commercial Leap Ahead for Wide Bandgap Semiconductors (CLAWS) Hub, led by North Carolina State University with North Carolina Agricultural and Technical State University and Central Carolina Community College, is a component of the national Microelectronics (ME) Commons program. The ME Commons aims to bring cutting-edge laboratory research in semiconductor technologies to the market to strengthen domestic value chains and impact critical industries such as energy, military and defense, transportation, electronics, and emerging needs in quantum computing, artificial intelligence, and data centers.

As a partner of the CLAWS Hub, RTI International (RTI) conducted a scan of the state of workforce and ecosystem assets for semiconductor manufacturing in the southeastern United States and in North Carolina, looking broadly at the concentration of jobs and industry presence in semiconductors and related industries in the value chain. The data show that while the Southeast does not have the concentrated presence of semiconductor manufacturing seen in other parts of the country, there are important assets for upstream research and development (R&D) and downstream manufacturing industries in the region and opportunities to expand both the workforce pipeline and industry base in the value chain in the region.

The nine states that make up the study area supported 38,680 jobs in semiconductor and electronic components manufacturing in 2023, or 10% of the national total. However, the total ecosystem—including upstream and downstream manufacturing industries—employed a total of nearly 265,000 people, plus an additional 136,000 in R&D. States in the Southeast including North Carolina are home to large and concentrated workforces in R&D services, while others have strong concentrations of downstream manufacturing industries such as electrical equipment manufacturing.

The state's workforce is below national averages per capita for many semiconductor-related occupations including for technicians and engineers. While the state has important anchors in R&D-intensive industries, patent production, and attraction of venture and federal research funding as well as a strong pipeline of engineering talent at the bachelor's and master's level, opportunities exist to strengthen pathways into semiconductor technician manufacturing jobs through certificates and associate's degree programs.

North Carolina's workforce is projected to continue to grow in the future as the number of degrees and certificates continues to increase from the state's institutions of higher education. However, the number of new entrants into the workforce will need to continue to grow at a faster over the next five years to address an increasing rate of retirement of senior engineers and technicians, and to bring the state's workforce closer to the national average for workers per capita.

In addition to the quantitative workforce projections, RTI conducted qualitative interviews with members of the semiconductor ecosystem in North Carolina to inform a roadmap of actions that may strengthen the semiconductor ecosystem and workforce in the state. The interview findings show that the short- and medium-term impacts will require systematic and concerted action from academic institutions, government bodies, industry players, and economic and workforce development organizations within the state. Near-term actions suggested to improve the workforce pipeline for technician and operator roles include bolstering workforce certification training at community colleges, aligning the community college funding model with workforce needs, expanding wraparound services for school transfers and apprentices, and lowering barriers to collaboration between academia and industry. Future actions include investment in career and technical education throughout primary school to elevate awareness of the semiconductor industry as a career path and establishing a research foundry as a service provider to support fabless semiconductor businesses.

This final report covers publicly available data on the semiconductor value chain, industries, occupations, educational institutions, and ecosystem assets including research funding, patents, and venture capital. This report further includes workforce projections and a strategic roadmap to enhance the semiconductor ecosystem and workforce in North Carolina. It serves as a baseline for the CLAWS Hub and its partners to inform the workforce strategy moving forward to strengthen the competitiveness of the semiconductor value chain in North Carolina and the surrounding region.

Introduction and Background

The Commercial Leap Ahead for Wide Bandgap Semiconductors (CLAWS) Hub, led by North Carolina State University (NCSU) with North Carolina Agricultural and Technical State University (NC A&T) and Central Carolina Community College (CCCC), is a component of the national Microelectronics (ME) Commons program. The ME Commons aims to bring cutting-edge laboratory research in semiconductor technologies to the market to strengthen domestic value chains and impact critical industries such as energy, military and defense, transportation, electronics, and emerging needs in quantum computing, artificial intelligence, and data centers. As the lead institution of the CLAWS Hub, NCSU is coordinating and building partnerships across the supply chain in North Carolina and translating research into economic development across the state, in partnership with its workforce development partners, NC A&T and CCCC.

CLAWS seeks to understand the state of the workforce in semiconductors in North Carolina and in the surrounding region to identify assets, strengths, and gaps to improve the competitiveness of the workforce and the region for wide bandgap semiconductors.

Background on Workforce and Ecosystem Report

As a component of CLAWS, the RTI International team mapped the workforce and ecosystem for the semiconductor sector, taking a broad approach to understanding critical industries in the value chain, workforce trends and assets, and ecosystem assets including companies, funders, and innovation assets. This report examines the landscape across the country, across nine states in the Southeast (the principal "Region of Analysis"), and specifically in North Carolina. We take into consideration both core semiconductor manufacturing industries and additional value chain industries including upstream research and development (R&D) activity and downstream electronics manufacturing and packaging, to understand the broader needs in the region. When possible, we delineate workforce or ecosystem assets specific to wide bandgap semiconductors as part of the broader ecosystem. As the report shows, the workforce in the semiconductor industry in the Southeast is small, with wide bandgap semiconductors making up a smaller subsector of the industry. Despite a small workforce footprint in manufacturing sectors, the industry supports high value-add industries that have a multiplier effect on downstream manufacturing sectors and throughout the regional economy.

Region of Analysis

For this report, we define the region of analysis as the nine states in the Southeast—Kentucky, Virginia, Tennessee, North Carolina, Mississippi, Alabama, Georgia, South Carolina, Florida—shown in Figure 1 including the Economic Development Administration (EDA) region served by the Atlanta Office plus Virginia. Across the nine states, the semiconductor manufacturing core industry[1] employed 38,680 people in 2023, or 10% of the national total.

1 Semiconductor manufacturing core defined as NAICS 3344 Semiconductor and Other Electronic Component Manufacturing

Figure 1. Region of Analysis

Note: the term “Southeast” in the report refers to the nine states in the region of analysis

Methodology

To conduct the analysis, we focused on six key data sources to capture the indicators outlined in Table 1. To understand the workforce, these indicators included trends in industry and occupations, as well as educational institutions and the pipeline of graduates from regional institutions. To understand the ecosystem assets in the region, we reviewed funding data from Pitchbook and the Small Business Innovation Research & Small Business Technology Transfer (SBIR/STTR) database, as well as intellectual property from the U.S. Patent and Trademark Office (USPTO).

Table 1. Data Sources and Criteria

Indicator	Data Source	Date Range	Criteria
Industry Trends	BLS QCEW	2003–2023	NAICS Codes Core Semiconductor: 3344 Manufacturing: 3332, 3333, 3339, 3345, 3353, 3359 R&D: 5417
Workforce & Occupations	BLS OEWS	2018–2023	SOC codes listed in appendix
Educational Institutions and Pipeline	NCSES IPEDS	2012–2023	CIP codes related to semiconductors
Ecosystem Assets	Pitchbook	2014–2024	Industry vertical: “semiconductors”
Ecosystem Assets	SBIR/STTR Database	2014–2024	Search terms in abstracts in appendix
Ecosystem Assets	USPTO PatentsView	2014–2024	CPC patent codes in appendix

Note: Full list of codes and analysis methods are in the appendix

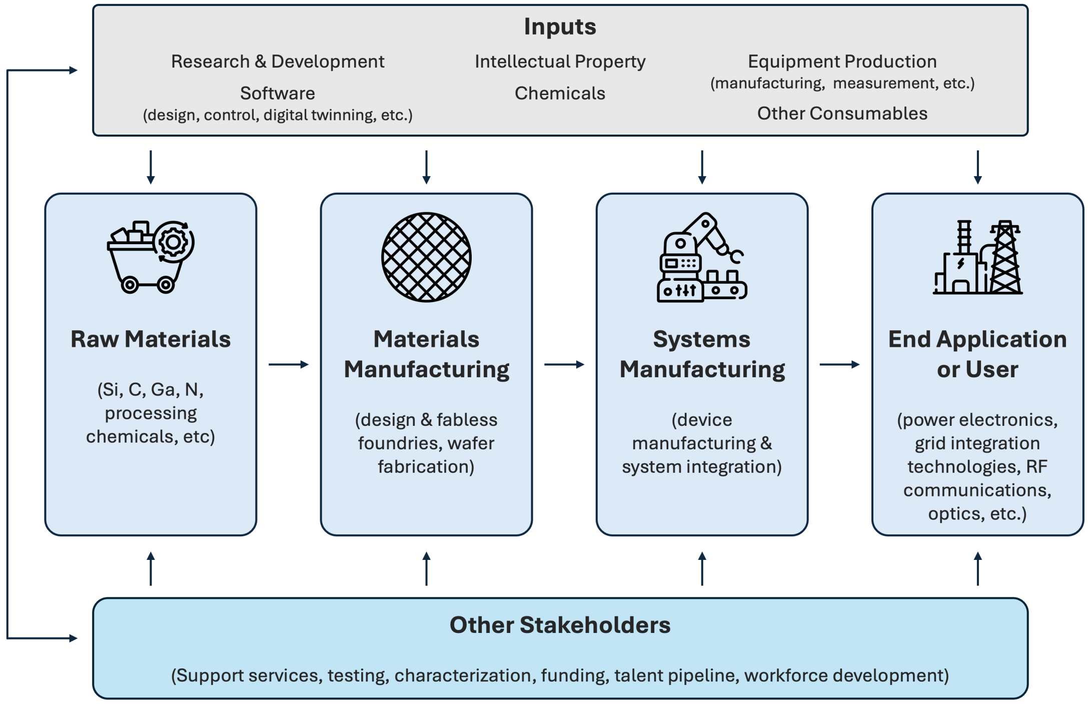
To build the ecosystem roadmap, we interviewed 12 organizations across the semiconductor value chain, including startups, small- to mid-sized businesses, large corporations, and nongovernmental organizations (NGOs). We used these stakeholder interviews to identify workforce gaps and actions to grow the semiconductor workforce and industry in North Carolina. Comments were distilled into a consolidated set of actions and organized according to the timeframe to impact (near, next, and future) and the stakeholder type that should drive the action (academia, government, industry, and NGOs). Interviewed organizations are acknowledged in the appendix.

The ecosystem roadmap was also supported by a workforce needs survey conducted by PowerAmerica, a Manufacturing USA institute, which targeted small (< 50 employees), medium (up to 500 employees), and large (over 5,000 employees) businesses in the semiconductor industry to understand difficulties in hiring for semiconductor-related positions. The 28-question survey received 23 responses from organizations across the semiconductor value chain in North Carolina.

The Semiconductor Value Chain

The semiconductor value chain contains a complex set of contributing components from raw materials production (e.g., silicon, gallium, carbon, and nitrogen for wide bandgap materials) to packaged modules being integrated into final devices implemented in wider systems (e.g., inverters tying solar resources into the electrical grid). As shown in Figure 2, the complex semiconductor value chain can be presented in four core components (Raw Materials, Materials Manufacturing, Systems Manufacturing, and End Application or User) with two peripheral components (Inputs and Other Stakeholders). The two peripheral components feed into and support each of those four core components such that the raw materials can be processed, incorporated into devices, and integrated to larger systems effectively.

Figure 2. Simplified Wide Bandgap Semiconductor Value Chain and Stakeholder Map



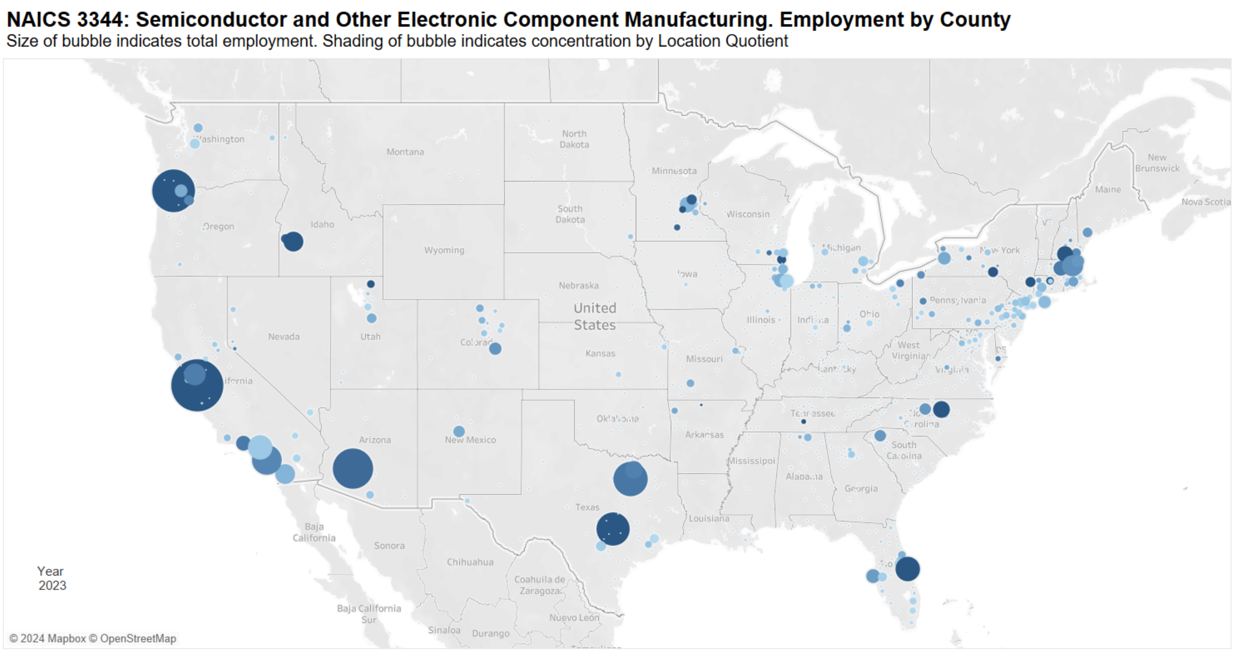
Note(s): Adapted from the Center for Strategic & International Studies' Mapping the Semiconductor Supply Chain.

The scope of the workforce in semiconductor-related industries is not defined by a single NAICS sector or a clear industry delineation. Semiconductors are integrated into several value chains and industries. The Semiconductor Industry Association (SIA), in its 2024 State of the Industry Report, estimated a total of 338,000 jobs in the semiconductor industry manufacturing and design, plus an additional 2 million jobs in industries that make up the semiconductor value chain. This included core semiconductor R&D, manufacturing, and packaging, plus an estimated 300 downstream industry sectors that rely on semiconductors as inputs.

Semiconductor Manufacturing

In 2023, the semiconductor and other electronic component manufacturing sector employed 395,263 people in the United States.[2] Although jobs in the industry grew between 2021 and 2023, the semiconductor manufacturing industry had been in a long-term decline since the start of the 21st century, employing over 460,000 individuals in 2003. As seen in Figure 3, jobs in the industry are highly concentrated in a small number of states and metro areas. In the West, areas including Portland, OR, Bay Area, CA, Phoenix, AZ, Southern CA, and Boise, ID have the highest levels of employment and concentration of jobs. Additional hubs include Dallas and Austin, TX, Central Florida, Durham, NC, and areas in the Northeast including Boston, MA and New York, NY.

Figure 3. Concentrations of Jobs in Semiconductor Manufacturing: 2023



Notes: Annual Averages by County for NAICS 3344: Semiconductor and Other Electronic Component Manufacturing. Redacted data interpreted as no employment. Totals represent average annual employment
Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages (2023).

Sectors Within the Value Chain

In addition to the over 395,000 people employed in semiconductor manufacturing in the United States, we identified an estimated 1.25 million people employed in manufacturing sectors in the value chain, including in electronic instrument, electrical equipment and component manufacturing, and industrial and commercial machinery manufacturing. Additionally, as seen in Figure 4, over 923,000 people in R&D services span a wide range of research activities that are not limited to the semiconductor sector but offer insight into the scale and scope of the R&D

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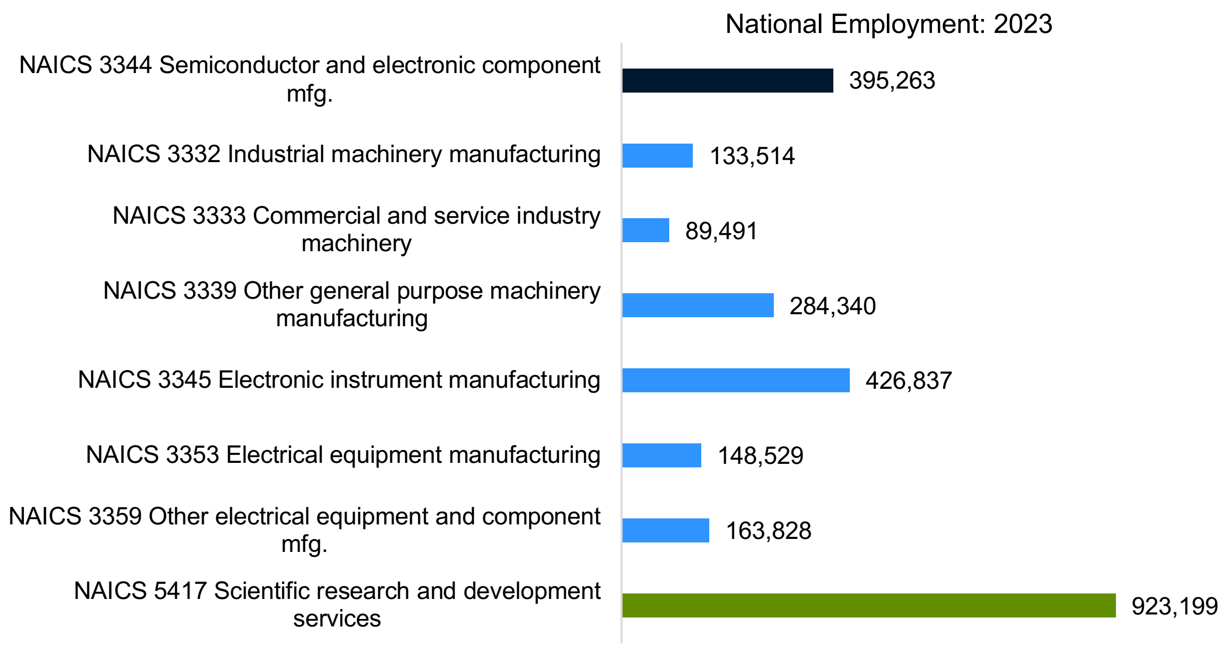
[2] Semiconductor manufacturing core defined as NAICS 3344 *Semiconductor and Other Electronic Component Manufacturing*

sector and its trajectory over time. This represents a total of over 2.5 million jobs in industries within the semiconductor value chain. This broad look is slightly higher than the over 2.3 million estimated by the SIA.

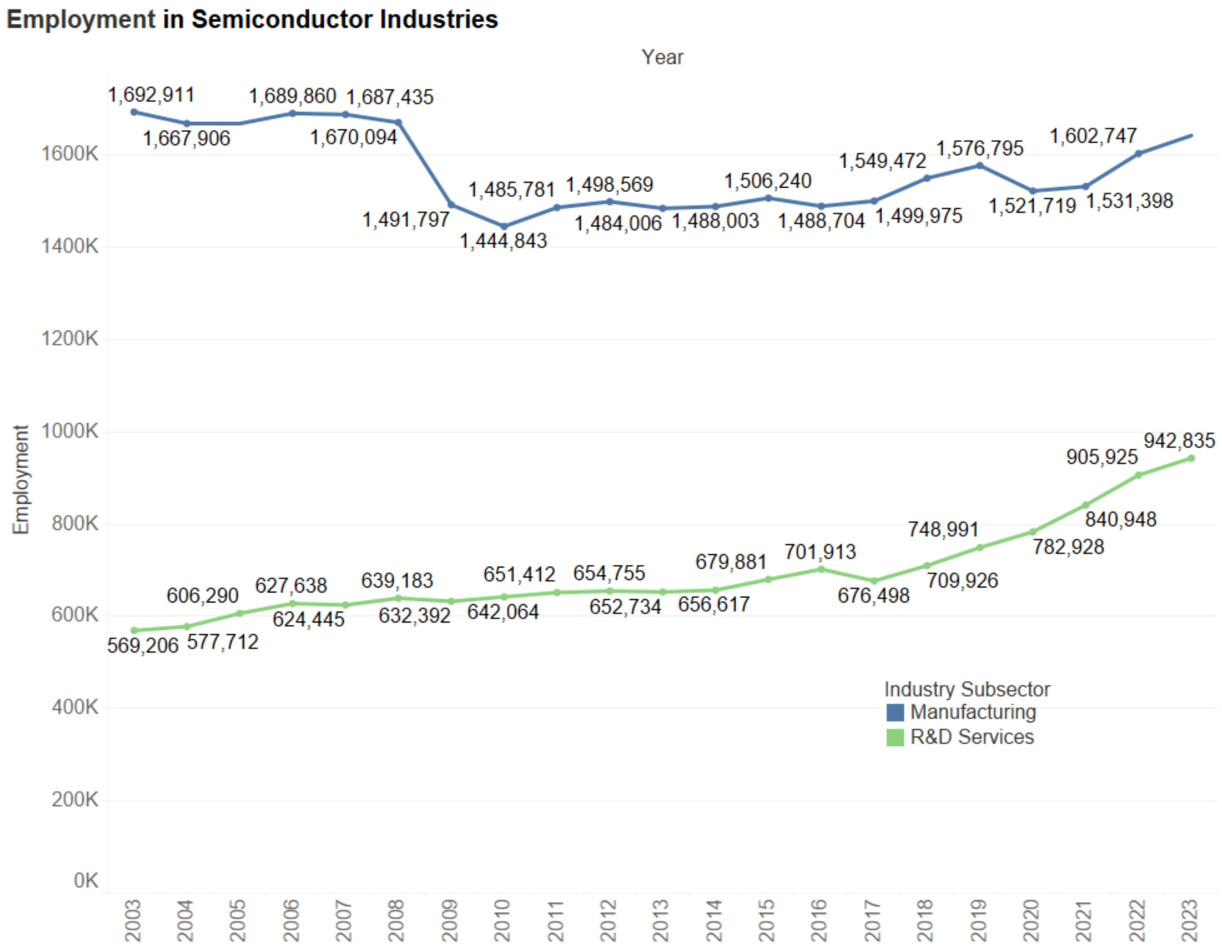
Figure 4. Jobs in Semiconductor and Electronic Component Manufacturing and Value Chain Subsectors: 2023



Note(s): Totals represent average annual employment
Source(s): Bureau of Labor Statistics, Quarterly Census of Employment and Wages (2023).

As seen in Figure 5, national semiconductor and related manufacturing sector employment declined sharply from 2008 to 2010 during the period of the Great Recession, following trends seen in other manufacturing sectors across the United States. By 2023, national employment in semiconductor manufacturing had returned to near prerecession numbers, after over a decade of stagnant job growth. At the same time, employment in research and development grew by over 300,000 jobs, or nearly 50%, indicating the shift away from manufacturing and toward R&D services within the value chain.

Figure 5. Jobs in Semiconductor Manufacturing Sectors and R&D Services in the United States: 2003–2023



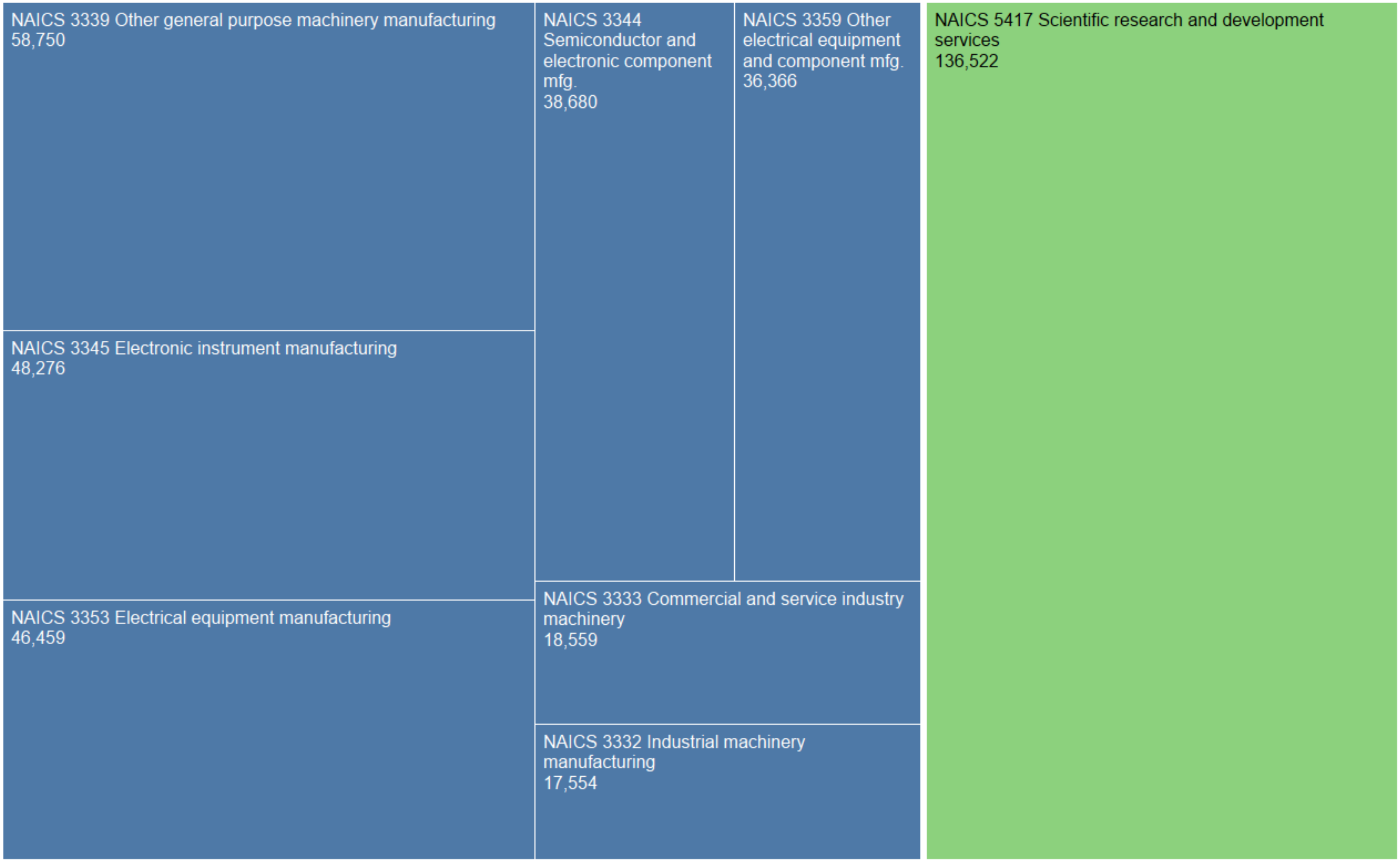
Note(s): R&D Services defined by NAICS 5417. Manufacturing defined as NAICS Codes 3344; 3332; 3333; 3339; 3345; 3353; 3359. Totals represent average annual employment
Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages (2003–23).

Industry Trends in the Southeast

In the nine study area states, semiconductor manufacturing employed 38,680 people in 2023, or 10% of the national total, indicating that the region has a low concentration of jobs in core semiconductor manufacturing. However, as seen in Figure 6, the total ecosystem including upstream and downstream manufacturing industries employed nearly 265,000 people, plus an additional 136,000 in R&D. Machinery manufacturing, electronic instrument manufacturing, and electrical equipment manufacturing represent larger industries employing people in the semiconductor value chain in the Southeast.

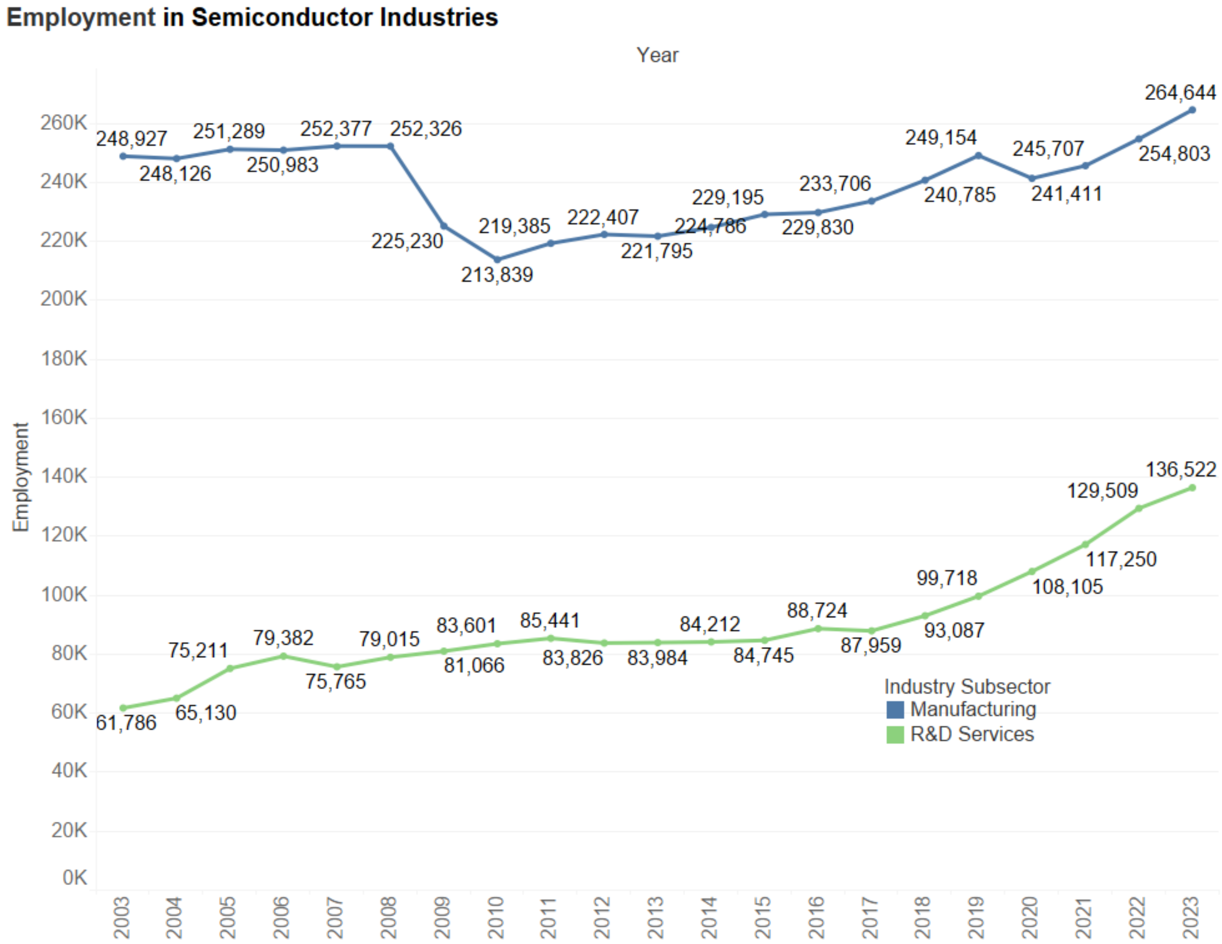
Across the Southeast, employment in semiconductor manufacturing industries declined sharply following the 2008 recession but has experienced steady job growth since 2011, passing 264,000 jobs in 2023. As seen in Figure 7, over the 20-year period from 2003 to 2023, R&D employment doubled in the region. Although only a subset of R&D jobs are semiconductor related, the overall growth in this subsector in the Southeast shows the rapid growth of the R&D services industry in the region as an asset for the semiconductors sector.

Figure 6. Semiconductor Employment in the Southeast: Industry Subsector Breakdown, 2023.



Notes: Southeast region includes Alabama, Florida, Georgia, Kentucky, North Carolina, Mississippi, South Carolina, Tennessee, and Virginia. Totals represent average annual employment
Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages (2023).

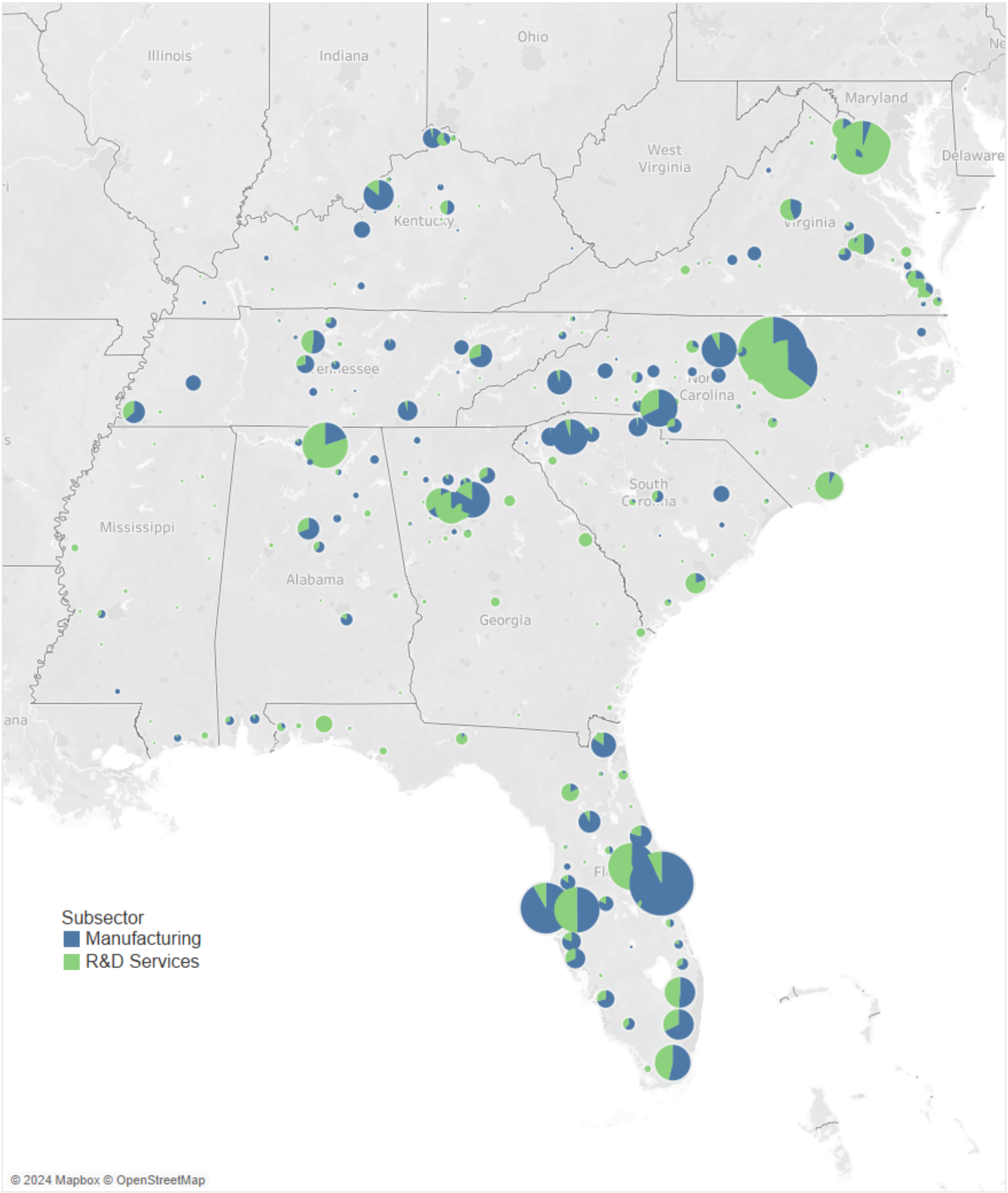
Figure 7. Employment in Semiconductor Industries in the Southeast: Manufacturing and R&D Services: 2003–2023



Notes: Southeast values are sum of state-level annual values for Alabama, Florida, Georgia, Kentucky, North Carolina, Mississippi, South Carolina, Tennessee, and Virginia. R&D Services defined by NAICS 5417. Manufacturing defined as NAICS Codes 3344; 3332; 3333; 3339; 3345; 3353; 3359. Totals represent average annual employment
Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages (2003–23).

As seen in Figure 8, employment in semiconductor manufacturing industries and R&D services is concentrated in a subset of counties and metro areas. Services tend to be concentrated in Northern Virginia, the Research Triangle of North Carolina, Atlanta, Wilmington in North Carolina, and Huntsville in Alabama. Manufacturing is concentrated across the region, including in Central and South Florida, Greenville and Spartanburg in South Carolina, Charlotte and Greensboro in North Carolina, and in smaller concentrations in Tennessee and Kentucky.

Figure 8. Employment in Semiconductor and Related Industries in the Southeast: Manufacturing and R&D Services, by County, 2023



Notes: Includes Alabama, Florida, Georgia, Kentucky, North Carolina, Mississippi, South Carolina, Tennessee, and Virginia. Redacted county-level data interpreted as no employment. Totals represent average annual employment.
Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages (2023).

When compared to national averages, states in the Southeast have a relatively low concentration of jobs in semiconductor manufacturing as seen in Table 2. By location quotient (LQ),[3] semiconductor manufacturing ranges between 0.1 and 0.7 but there are higher LQs in other manufacturing and R&D industries. North Carolina and Virginia have high LQs in R&D, while most of the states (Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia) have relative strengths in accompanying manufacturing sectors including electrical equipment and machinery manufacturing.

Table 2. Location Quotients for Semiconductor Industries in the Southeast: 2023

		State								
Subsector	Industry Title	AL	FL	GA	KY	MS	NC	SC	TN	VA
Core Semiconductor Manufacturing	NAICS 3344 Semiconductor and electronic component mfg.	0.3	0.7	0.1	0.2	0.2	0.6	0.5	0.2	0.4
Manufacturing	NAICS 3332 Industrial machinery manufacturing	0.4	0.3	0.8	1.2	0.4	0.9	0.8	0.7	0.5
	NAICS 3333 Commercial and service industry machinery	0.6	1.5	0.4	0.6	1.9	1.0	0.6	0.8	0.4
	NAICS 3339 Other general purpose machinery manufacturing	0.9	0.6	0.6	2.1	2.2	0.9	1.8	0.9	0.8
	NAICS 3345 Electronic instrument manufacturing	0.5	0.7	0.3	0.1	0.4	0.6	0.5	0.4	0.4
	NAICS 3353 Electrical Equipment Manufacturing	1.0	0.5	1.1	0.9	5.1	1.8	3.0	1.9	1.6
	NAICS 3359 Other electrical equipment and component mfg.	0.8	0.4	1.5	0.8	0.0	2.0	2.4	0.8	0.3
R&D Services	NAICS 5417 Scientific research and development services	0.7	0.5	0.4	0.2	0.2	1.2	0.4	0.6	1.2

Notes: Totals represent average annual employment. Highlighted cells indicate NAICS sectors with a LQ of 1.2 or greater, indicating a relative concentration of jobs when compared to the national average
Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages (2023).

Regional Focus: Research and Development Jobs

Across the United States in 2023, there were 2.3 R&D services jobs for every 1 job in semiconductor manufacturing, an increase from 1.7 a decade earlier. As seen in Table 3, six of the nine study area states in the Southeast have a ratio higher than the national average. North Carolina has the largest number of people employed in the R&D services industry at nearly 36,000, and 4.6 jobs in the R&D services industry for every job in manufacturing. Similarly,

[3] Location Quotient (LQ) is a measure of relative concentration of jobs. A LQ of 1 indicates the number of jobs is equal to the national average, while a LQ below 1 is below the national average of jobs per capita. A LQ above 1 indicates a relatively high concentration of jobs in the industry.

Florida has the largest manufacturing workforce while Tennessee, Virginia, and Georgia have the largest proportion of workers in R&D when compared to manufacturing.

Table 3. Semiconductor Manufacturing and R&D Services Jobs, by State in the Southeast: 2023

State	Jobs in NAICS 3344 Semiconductor and electronic component mfg.	Jobs NAICS 5417 Scientific research and development services	Ratio: R&D Services Jobs/Semiconductor Manufacturing Jobs
Tennessee	1,371	11,927	8.7
Virginia	4,147	29,527	7.1
Georgia	1,567	10,926	7.0
Alabama	1,698	8,971	5.3
North Carolina	7,811	35,859	4.6
Kentucky	831	2,696	3.2
Mississippi	505	1,025	2.0
South Carolina	2,723	5,258	1.9
Florida	18,027	28,751	1.6
U.S. Total	395,263	923,199	2.3

Note: Totals represent average annual employment.
Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages (2023).

The Available Workforce

When viewing the workforce, we look beyond just the workers employed in semiconductor industries and focus on occupations within the broader workforce that could be employed in semiconductor industries. This includes 20 occupations that include engineers, technicians, and researchers that cut across industries and can be in both the private and public sector. In this section, we profile the available workforce including the concentration and growth of key occupations as well as the pipeline for new workers coming from higher education institutions.

Available Workforce in the Southeast

The Southeast has an available workforce of 379,570 workers in semiconductor-related occupations[4] as of 2023, reflecting a compound annual growth rate of 1.4% since 2018. As shown in Table 4, this growth is slower than the national rate of 2.4%. Within the Southeast, Florida has the largest workforce in this sector, with 82,340 workers in 2023—a 3.3% annual increase from 69,770 workers in 2018. North Carolina ranks second, with 59,980 workers. North Carolina also has the second fastest annual growth rate at 2.8% and surpasses the national growth rate. Similarly, South Carolina and Alabama experienced annual increases of 2.4%, with South Carolina's workforce increasing from 31,040 to 34,950 and Alabama's from 32,580 to 34,950 during the same period. Kentucky (0.7%), Mississippi (0.2%), and Georgia (0.1%) had relatively low 5-year annual growth rates.

In contrast, two of the nine states in the region have experienced annual declines in their semiconductor workforce since 2018. Tennessee has seen the fastest decline, but only with a compound annual growth rate of -0.7%, as the workforce shrank from 37,560 in 2018 to 36,220 in 2023—a loss of 1,340 jobs. Virginia's workforce has declined by -0.4% annually, dropping from 51,130 workers in 2018 to 50,090 in 2023. For a full list of occupations, related occupation codes, total employment, location quotients, and annual median wages by occupation for each state, see Table A-2 in the appendix.

The Southeast accounts for 18% of the United States' semiconductor-related workforce, which totaled 2.2 million workers in 2023. This marks a 2.4% increase from 1.97 million workers in 2018. However, as illustrated in Figure 9, national employment in the semiconductor industry peaked at 1.9 million workers in 2019 before declining to 1.8 million in 2020. This trend has been mirrored by some Southeastern states such as Virginia, Tennessee, Alabama, South Carolina, Kentucky, and Mississippi. However, by 2022, most states had surpassed their 2019 peaks.

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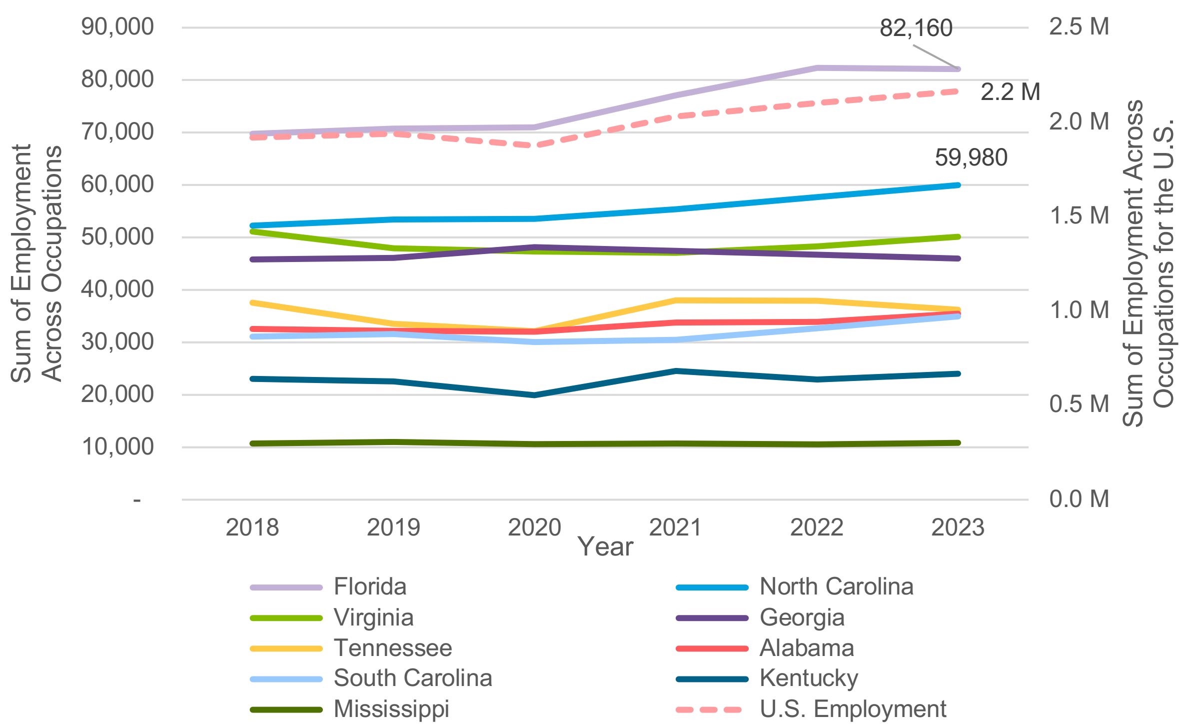
[4] Semiconductor-related occupations were mapped using the Bureau of Labor Statistics' and National Center for Education and Statistics' CIP SOC Crosswalk. The crosswalk matches 6-digit CIP Codes from the 2020 Classification of Instructional Programs (CIP) with 6-digit detailed descriptions from the 2018 Standard Occupational Classification (SOC). It can be accessed here https://nces.ed.gov/ipeds/cipcode/post3.aspx?y=56. To see the full list of occupations used in this report, please see Table 4 or Table A-2 in the Appendix.

Table 4. Employment in Semiconductor-Related Occupations for Southeast States and the United States, 2018–2023

State	2018	2019	2020	2021	2022	2023	2018–2023 CAGR %
Florida	69,770	70,730	70,950	77,070	82,340	82,160	3.3%
North Carolina	52,260	53,380	53,560	55,340	57,720	59,980	2.8%
Virginia	51,130	47,950	47,270	47,070	48,260	50,090	-0.4%
Georgia	45,810	46,080	48,150	47,400	46,740	45,930	0.1%
Tennessee	37,560	33,490	32,130	38,010	37,970	36,220	-0.7%
Alabama	32,580	32,140	32,030	33,820	33,950	35,460	1.7%
South Carolina	31,040	31,540	30,060	30,450	32,630	34,950	2.4%
Kentucky	23,100	22,520	19,920	24,550	22,890	23,960	0.7%
Mississippi	10,730	11,010	10,630	10,680	10,550	10,820	0.2%
Total SE Employment	**353,980**	**348,840**	**344,700**	**364,390**	**373,050**	**379,570**	**1.4%**
U.S. Employment	1,917,920	1,937,790	1,874,660	2,030,880	2,099,780	2,163,390	2.4%

Note: CAGR is compound annual growth rate.
Source: Bureau of Labor Statistics, Occupational Employment and Wage Statistics (2018–23).

Figure 9. Employment in Semiconductor-Related Occupations by Area, 2018–2023



Source: Bureau of Labor Statistics, Occupational Employment and Wage Statistics (2018–23).

Twenty occupations important for supporting the semiconductor industry were identified. Table 5 lists these occupations along with the total employment by state in 2023. Among them, industrial engineers represent the largest workforce in the Southeast, with 65,120 workers. Florida leads in absolute numbers with 13,130 industrial engineers, followed by North Carolina with 10,200. Mississippi has the fewest workers in this field, at 1,990.

Despite Florida's high employment, its LQ for industrial engineers is 0.63, indicating a lower-than-average concentration compared to the national workforce distribution (LQ data can be found Table A-2). In contrast, North Carolina has an LQ of 0.97, close to the national average, while Mississippi, with fewer total workers, has an LQ of 1.37. This suggests an overconcentration of industrial engineers relative to the state's overall workforce size. Alabama is the most specialized in this occupation within the region, with an LQ of 1.65, reflecting a higher-than-average concentration. Other occupations with significant employment in the Southeast include:

- Mechanical Engineers: 44,060 workers
- Industrial Production Managers: 43,250 workers
- Electrical Engineers: 33,760 workers
- Engineers, All Other: 31,270 workers

Conversely, semiconductor processing technicians represent the smallest workforce, with just 620 total workers in the region. This occupation is only found in Virginia (230 jobs), North Carolina (200 jobs), and Florida (190 jobs), but none of these states have a notable specialization. Virginia's LQ for this occupation is 0.33, North Carolina's is 0.24, and Florida's is 0.12—indicating significantly lower-than-average concentrations. Other occupations with relatively low employment include material scientists (990 workers) and physicists (1,960 workers) across the Southeast in 2023.

Available Workforce in North Carolina

North Carolina has an available workforce of 59,980 in semiconductor-related occupations, making the state an important player as it also ranks 10th nationally in terms of total employment within this field. For reference, North Carolina is the 9th largest state nationally by population. As shown in Figure 10, the largest segment of this workforce is in industrial engineering occupations, with 10,200 workers. This occupation has an LQ of 0.97, indicating a workforce concentration nearly on par with the national average. It is also the second-fastest-growing occupation in the semiconductor field, projected to grow 12.2% nationally between 2023 and 2033, according to the Bureau of Labor Statistics.

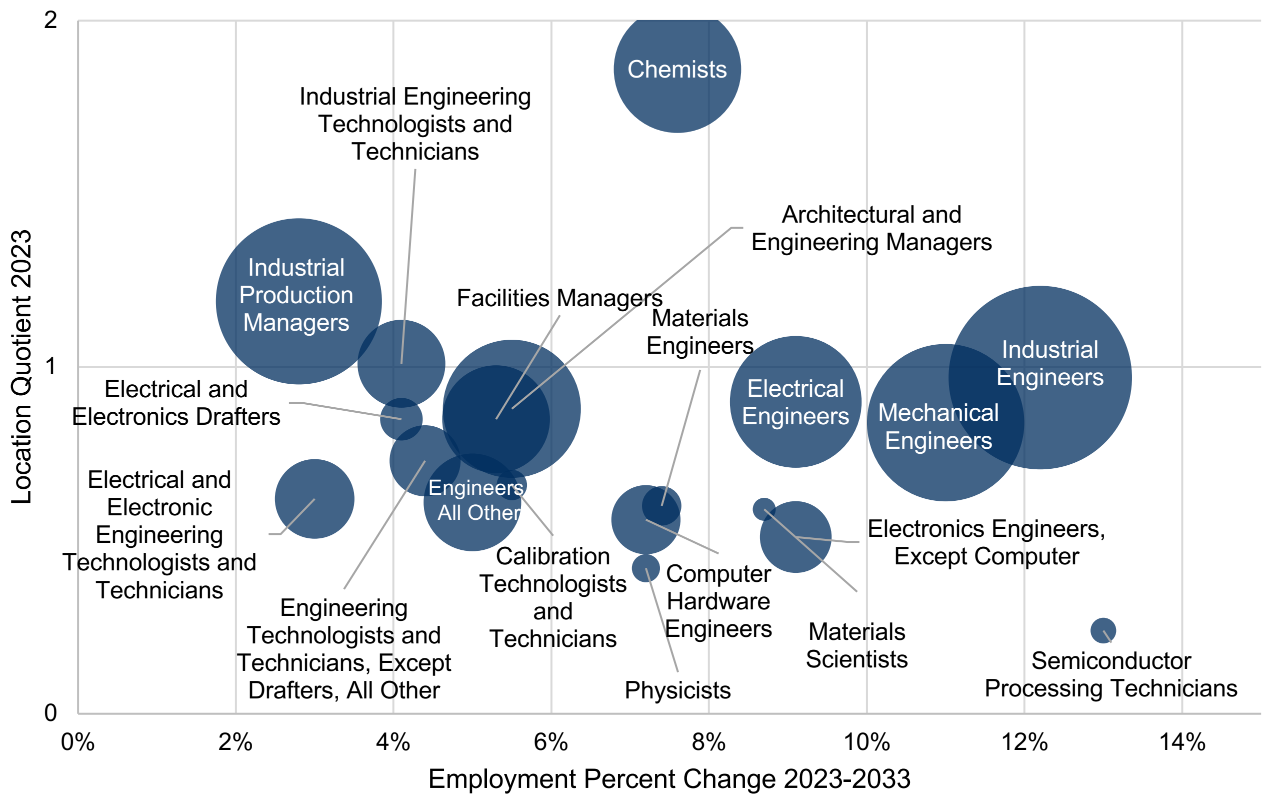
The second-largest occupation in North Carolina's semiconductor industry is industrial production managers, with 8,360 workers, an LQ of 1.19 (indicating a higher-than-average regional concentration), and an expected growth rate of 2.8%. This is followed by mechanical engineers, with 7,500 workers, an LQ of 0.84, and the third-fastest growth rate of 11%.

Table 5. Employment in Semiconductor-Related Occupations for Southeast States, 2023

Occupation Title	FL	NC	VA	GA	TN	AL	SC	KY	MS	Southeast Region
Industrial Engineers	13,130	10,200	5,120	7,440	6,710	7,440	7,070	6,020	1,990	**65,120**
Mechanical Engineers	8,520	7,500	6,150	5,600	2,400	5,280	4,530	2,970	1,110	**44,060**
Industrial Production Managers	7,330	8,360	2,690	4,930	5,310	3,110	5,570	4,410	1,540	**43,250**
Electrical Engineers	6,710	5,260	6,090	4,050	1,980	4,360	2,460	1,870	980	**33,760**
Engineers, All Other	8,080	2,890	5,670	3,750	4,350	3,480	1,640	890	520	**31,270**
Architectural and Engineering Managers	7,160	5,780	4,080	3,270	2,840	2,970	2,670	1,480	920	**31,170**
Facilities Managers	7190	3520	2020	2790	2000	830	1520	1090	750	**21,710**
Electrical and Electronic Engineering Technologists and Technicians	5,690	1,920	3,780	1,890	2,290	1,530	2,200	1,160	1,010	**21,470**
Electronics Engineers, Except Computer	5,640	1,560	3,140	3,220	970	1,760	990	490	330	**18,100**
Industrial Engineering Technologists and Technicians	1,870	2,340	1,150	2,010	2,360	960	2,420	1,210	260	**14,580**
Chemists	1,810	4,920	1,350	1,190	690	620	1,010	640	210	**12,440**
Engineering Technologists and Technicians, Except Drafters, All Other	2,470	1,530	3,300	1,870	820	790	580	410	440	**12,210**
Computer Hardware Engineers	2,130	1,450	2,670	1,260	240	870	550		150	**9,320**
Mechanical Drafters	1,960	850	630	770	1,360	410	670	490	180	**7,320**
Materials Engineers	610	470	410	680	430	610	470	500	140	**4,320**
Electrical and Electronics Drafters	930	550	440	580	400	270	410	200	120	**3,900**
Calibration Technologists and Technicians	470	280	180	360	380		130	130	70	**2,000**
Physicists	170	240	870	110	300	170			100	**1,960**
Materials Scientists	100	160	120	160	390		60			**990**
Semiconductor Processing Technicians	190	200	230							**620**
Total Employment	**82,160**	**59,980**	**50,090**	**45,930**	**36,220**	**35,460**	**34,950**	**23,960**	**10,820**	**379,570**

Source: Bureau of Labor Statistics, Occupational Employment and Wage Statistics (2023).

Figure 10. Projected Employment Growth, 2023–2033, and Location Quotient, 2023, in North Carolina by Semiconductor Occupation



Notes: Center of circles indicate values for Employment Percent Change, 2023–2033, and the 2023 location quotient for North Carolina on the X and Y-axes, respectively. Size of circle represents the relative number of workers in North Carolina in 2023. Not shown is Mechanical Drafters, which had a negative employment percent change of - 4.9% and a location quotient of 0.6

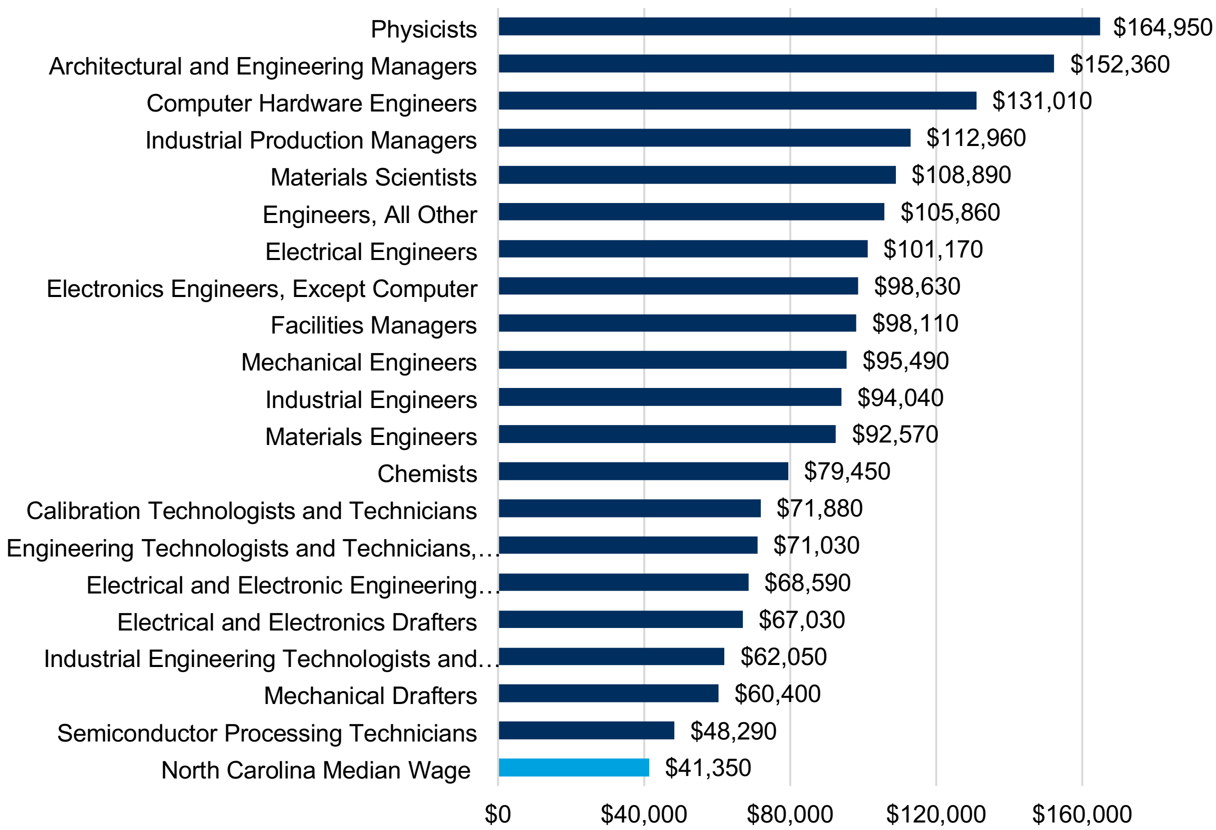
Sources: Bureau of Labor Statistics, Occupation Employment and Wage Statistics (2023); Bureau of Labor Statistics, Employment Projections (2023–33).

Several occupations in North Carolina stand out for their high specialization, as indicated by their LQs. For example, chemists have the highest LQ at 1.86, signaling a strong regional concentration relative to the national average. Industrial production managers and industrial engineering technologists and technicians also have notable LQs, at 1.19 and 1.01.

Semiconductor processing technicians are a core part of the workforce and projected to grow over the next decade—13% nationally by 2033—but are currently underrepresented. In North Carolina, the Bureau of Labor Statistics (BLS) projects that only 200 semiconductor processing technicians will be added to the state's workforce if the status quo continues. This growth rate would result in a low concentration of workers compared to national averages, with an LQ of 0.24. The small workforce and limited presence of the semiconductor manufacturing industry represents a gap when compared to many national peers and leaders, and an opportunity to broaden the educational pipeline and strengthen the manufacturing sector. For a table of projected growth rates, LQs, and total employment figures by occupation, see Table A-2 in the appendix.

Occupations in the semiconductor industry offer higher wages compared to the overall workforce in North Carolina. In 2023, the state's annual median wage was $41,350 (as shown in Figure 11). The 20 occupations that support the semiconductor industry are all above this median figure. The lowest-paying occupation in this sector is semiconductor processing technicians, with an annual median wage of $48,290 in 2023. However, the next lowest occupation, mechanic drafters, has a wage increase of $12,110 over semiconductor processing technicians. Mechanic drafters had an annual median wage of $60,400.

Figure 11. Median Annual Wages for Semiconductor-Related Occupations in North Carolina,2023



Source: Bureau of Labor Statistics, Occupation Employment and Wage Statistics (2023).

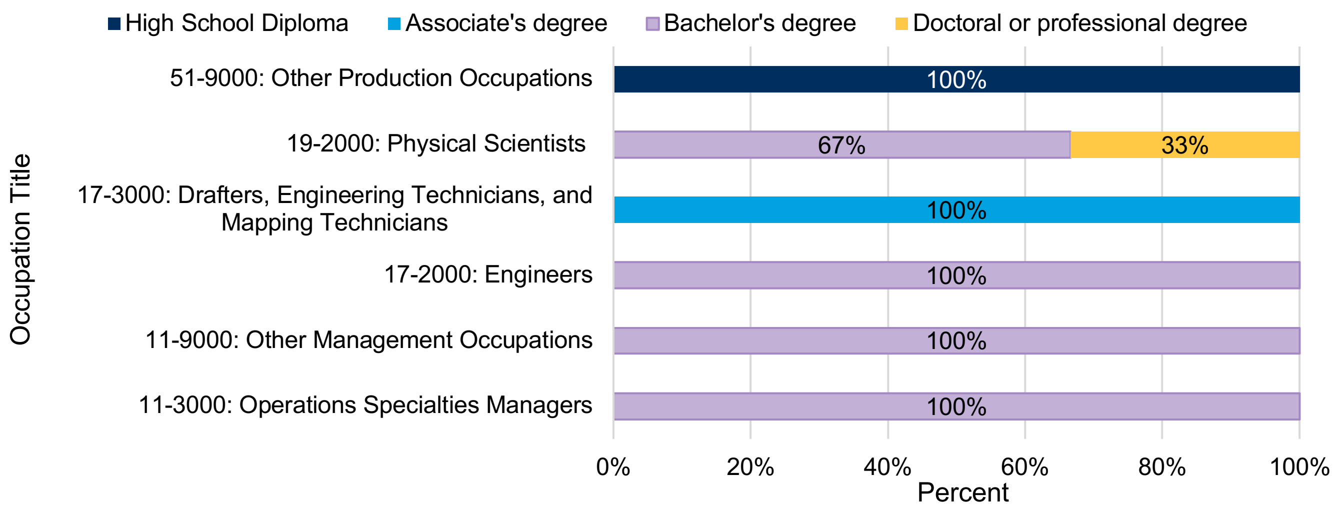
The top earners are physicists, who earn an annual median wage $164,950. This occupation title has an LQ of 0.42 with a total employment of 240 in 2023. These higher-wage occupations provide an avenue of economic mobility for North Carolina's workforce. For example, industrial engineers, one of the state's most prominent semiconductor-related occupations, had a median annual wage of $94,490 in 2023—$52,690 above the state's overall median. With a projected growth rate of 12% nationally between 2023 and 2033, this occupation could play a pivotal role in supporting the state's semiconductor industry while offering lucrative career paths for residents.

The higher annual median wages in semiconductor-related occupations are correlated with the entry-level education requirements as defined by BLS.[5] Semiconductor processing technicians, the lowest annual median wage occupation, only requires a high school diploma. While the highest paying occupation is physicists, within the physical scientist occupation group, it has the highest barrier to entry as entry-level positions within this occupation group require a bachelor's or doctoral degree. As shown in Figure 12, only two of the six occupation groups—other production occupations and drafters engineering technicians, and mapping occupations—have nonadvanced entry-level requirements. Within these two groups, the specific occupations include:

- Electrical and electronics drafters
- Mechanical drafters
- Electrical and electronic engineering technologists and technicians
- Industrial engineering technologists and technicians
- Calibration technologists and technicians
- Engineering technologists and technicians, except drafters, all others
- Semiconductor processing technicians

For a detailed list of occupations and entry-level education requirements, see Table A-4 in the appendix.

Figure 12. Bureau of Labor Statistics Entry-Level Education Requirements for Semiconductor-Related Occupation Groups in North Carolina, 2023



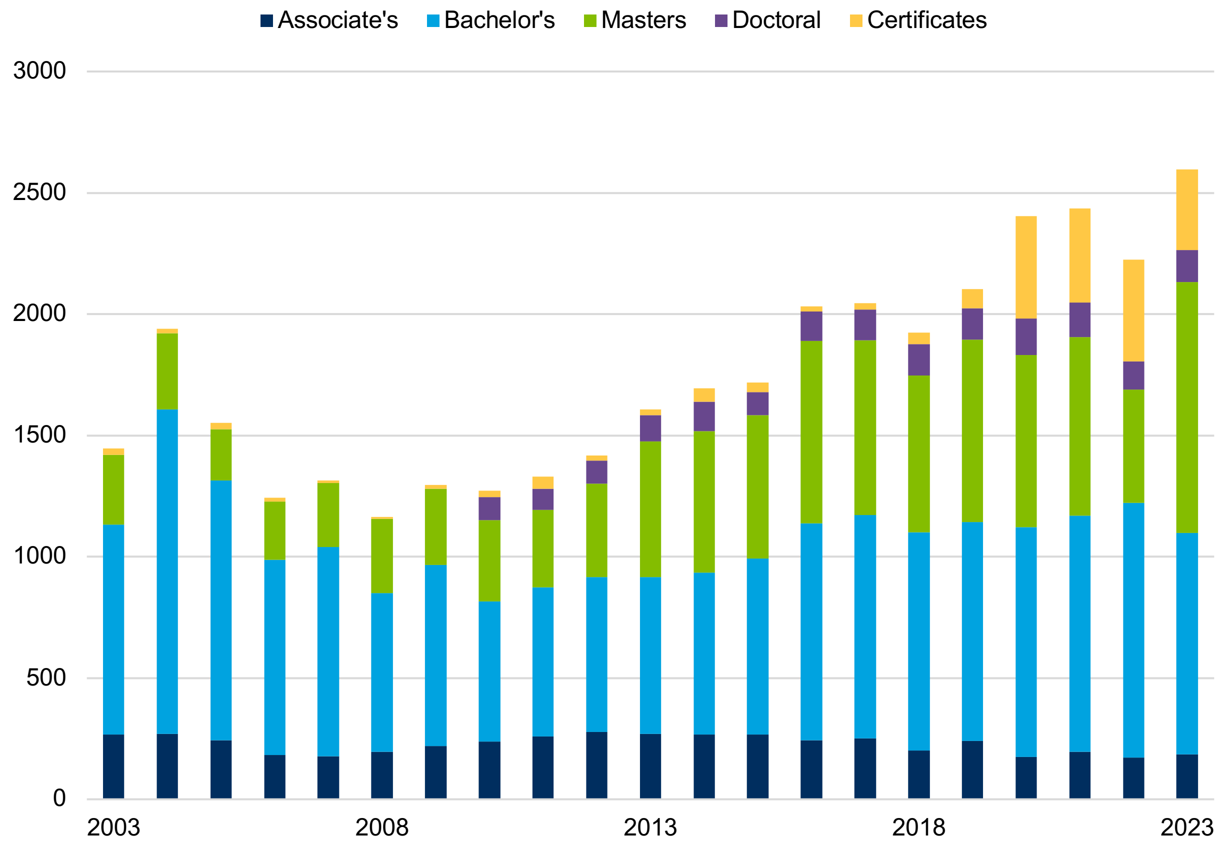
Note: Detailed Standard Occupation Codes (SOCs) are rolled up into high-level occupations groups, defined at the 3-digit SOC level. No occupations list a master's degree as an entry-level education requirement.
Source: Bureau of Labor Statistics, Occupation Employment and Wage Statistics (2023).

[5] BLS uses the Occupational Requirements Survey (ORS) to determine the minimum education required for a job. BLS also provides information on projected job openings by educational requirements. These requirements can be found at https://www.bls.gov/emp/tables/education-and-training-by-occupation.htm.

Education Pipeline in North Carolina

In 2023, 47 educational institutions granted 2,596 degrees in North Carolina at the certificate, associate's, bachelor's, master's, or doctoral level in core programs related to semiconductors.[6] As seen in Figure 13, the number of degrees awarded has grown at an annual growth rate of 5.5% since 2008 but the growth has primarily occurred at the master's, doctoral, and certificate levels. Over the same time period, growth of bachelor's degrees has been slower, and associate's degrees declined, particularly when compared to levels prior to the 2008 recession.

Figure 13. Annual Degrees and Certificates Awarded in Semiconductor Fields in North Carolina, 2003–2023



Notes: Doctoral degrees defined as Research or Scholarship Doctorate, does not include Professional Practice Doctorate degrees. Bachelor's degrees include degrees in which a student's second major is in a related field. Certificates include certificates of at least 12 weeks but less than 1 year, certificates of at least 1 but less than 2 years and Postbaccalaureate certificates. Year represents the academic year (which runs July to June) in which a student completed their degree.

Source: National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS). Degrees and Certificates Awarded (2003–2023)

[6] Core programs include 14 CIP codes that include computer and electrical engineering, materials engineering, industrial engineering electrical and electronics engineering, applied physics, and materials science. The full list of codes is in Table 6.

RTI identified 14 classification of instructional programs (CIP) codes, outlined in Table 6, to map to the educational pipeline for semiconductor workers with the most common awards being in electrical and electronics engineering, computer engineering, and industrial engineering at the bachelor's, master's, and doctoral level. At the associate's and certificate level, the most frequent awards are in electrical, electronic, and communications engineering technology and technicians. Since many of the degrees awarded are in more general fields, it is difficult to determine how many of these graduates go into semiconductor work after graduation.

Table 6. Average Annual Degrees Awarded in Core Semiconductor Fields in North Carolina: 2018 to 2023

CIP Category	Associate's degree	Bachelor's degree	Master's Degree	Doctoral Degree	Certificates
14.0901-Computer Engineering, General		329	156	6	32
14.0903-Computer Software Engineering		1	11		
14.0999-Computer Engineering, Other		1			
14.1001-Electrical and Electronics Engineering		306	258	90	3
14.1099-Electrical, Electronics, and Communications Engineering, Other					1
14.1201-Engineering Physics/Applied Physics		3			
14.1801-Materials Engineering		42	23	15	
14.3501-Industrial Engineering		135	18	63	5
15.0303-Electrical, Electronic, and Communications Engineering Technology/Technician	157	41			310
15.0304-Laser and Optical Technology/Technician	7				
15.0399-Electrical/Electronic Engineering Technologies/Technicians, Other	32	13			48
15.0613-Manufacturing Engineering Technology/Technician	18	59			26
15.1501-Engineering/Industrial Management		29	212		1
40.1001-Materials Science			8	6	

Source: U.S. Department of Education Statistics, Integrated Postsecondary Education Data System (IPEDS), Degrees and Certificates Awarded (2018–2023).

From 2018 to 2023, the most common degree types were bachelor's or master's degrees, with NCSU, UNC Charlotte, Duke, NC A&T, and East Carolina consistently producing the most graduates on an annual basis. Associate's degrees were less common, with the most coming from Southeastern, Johnston, Central Piedmont, CCCC, and Wake Tech Community Colleges. As seen in Table 7, the degree distribution in the educational pipeline is weighted toward bachelor's and advanced degrees, with associate's degrees making up only 8.5% of the degrees awarded between 2018 and 2023 in semiconductor fields.

Table 7. Average Annual Degrees Awarded in Core Semiconductor Fields in North Carolina: 2018 to 2023. Top 5 by Degree Type

Degree Type and Institution	Degrees & Certificates Awarded
Associate's degree	**215**
Southeastern Community College	32
Johnston Community College	14
Central Piedmont Community College	14
Central Carolina Community College	12
Wake Technical Community College	11
Bachelor's degree	**960**
North Carolina State University at Raleigh	445
University of North Carolina at Charlotte	162
North Carolina A&T State University	131
Duke University	113
East Carolina University	59
Master's degree	**730**
North Carolina State University at Raleigh	320
Duke University	296
University of North Carolina at Charlotte	74
East Carolina University	23
North Carolina A&T State University	17
Doctoral degree	**136**
North Carolina State University at Raleigh	71
Duke University	36
University of North Carolina at Charlotte	14
North Carolina A&T State University	12
University of North Carolina at Chapel Hill	3
Certificates	**171**
North Carolina State University at Raleigh	37
Central Carolina Community College	36
Craven Community College	35
Isothermal Community College	33
Catawba Valley Community College	30

Notes: Figures represent average for years 2018 to 2023. Limited to top 5 for each degree type. A full list of North Carolina degree-granting institutions by award level is available in Appendix Table A-5.
Sources: U.S. Department of Education Statistics, Integrated Postsecondary Education Data System (IPEDS), Degrees and Certificates Awarded (2018–2023).

Workforce Projections

To understand the future of the available workforce in North Carolina, RTI developed a labor supply model to estimate the supply of workers in semiconductor related occupations from 2024 to 2030. The model looked at labor inflow and outflow, and the supply of labor that would bring North Carolina's workforce proportional to the national average per capita. The projections show that in a low or medium growth scenario, North Carolina's workforce would remain below the national average and could potentially not keep pace with accelerating retirements in senior engineering positions.

Labor Inflow:

Labor inflow was estimated using graduation data from semiconductor-related programs at four-year universities, two-year colleges, and technical institutions (Figure 13). The average year-over-year change in program completions (4%) was used to define three post-2023 growth scenarios: low (3%), medium (6%), and high (9%). Total annual inflow was calculated as the sum of prior-year employment and current year graduates. New labor entering from out-of-state is captured within total employment, meaning any workforce additions due to migration are reflected in the following year's employment figures.

Labor Outflow:

Labor outflow was estimated based on workforce retirements using staggered data. We utilized the Bureau of Labor Statistics (BLS) Table 11b, Employed Persons by Detailed Occupation and Age (2012–2023), which provides workforce age distribution by occupation. We projected that workers reaching age 65 in specific occupations could estimate retirements in the following year: For example, the number of 65-year-olds in 2012 was used to estimate retirements in 2013. The national retirement rate was calculated as the proportion of workers aged 65+ in total U.S. employment by relevant occupations and applied to North Carolina's workforce in the same occupations. The average year-over-year increase in retirements was 12%, which was used to project labor outflow after 2024.

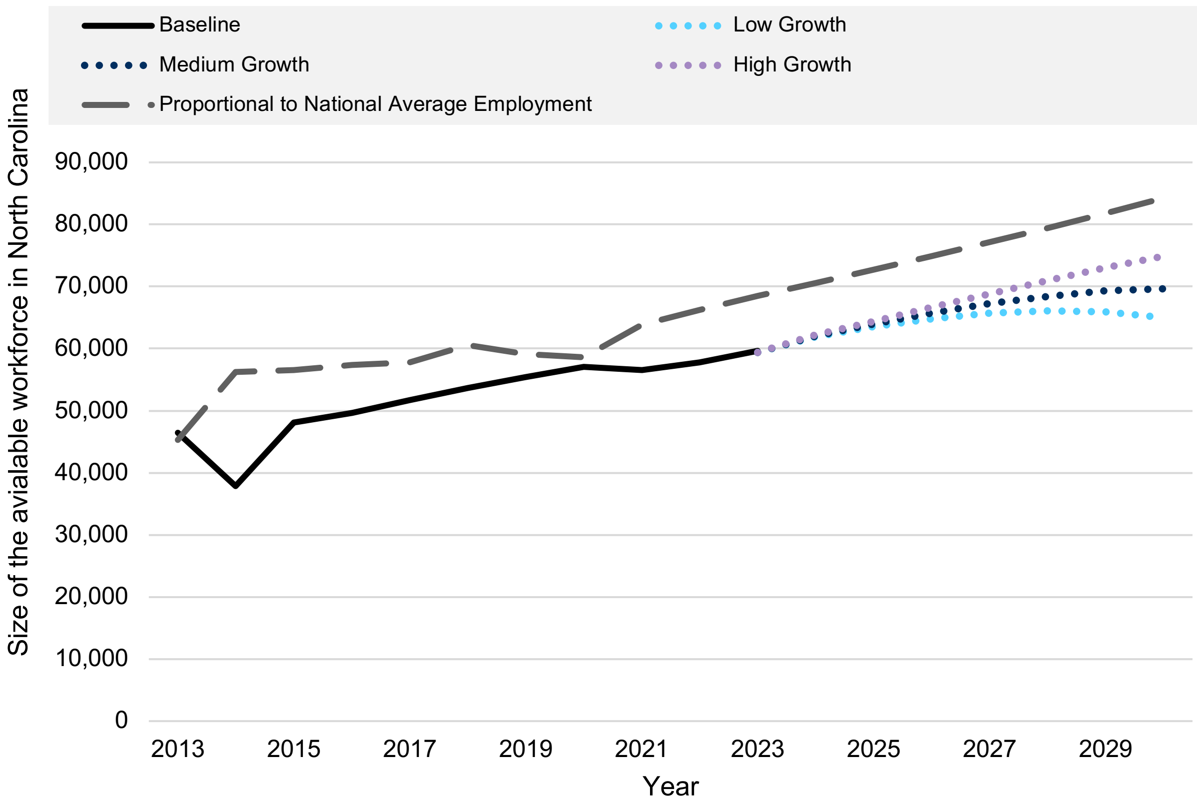
National Average Employment

RTI assessed whether North Carolina's labor supply would be sufficient to meet the national concentration of semiconductor-related occupations. To estimate these employment levels, we applied location quotients, multiplying each occupation's location quotient by the inverse of total North Carolina employment in the same occupation. For 2024–2030, we used the growth rate of 3% to estimate the employment needed to match concentration. This estimate was chosen because the year-over-year change averaged approximately 3%.

Based on an analysis of semiconductor-related occupations in North Carolina, RTI determined that, given estimated growth rates, the supply of new labor entering the workforce will be insufficient to close the state's current semiconductor workforce gap, as shown in Figure 14. By 2030, the state would have between 65,000 and 75,000 workers in semiconductor occupations.

While this would represent growth from the current value just above 60,000, the state would remain below the national average of workers per capita in key fields like engineers, industrial production managers, electrical technicians, and other technical, operations, and management occupations.

Figure 14. Projections of Total Available Workforce in North Carolina: 2025-2030



Source: RTI model, derived from data from BLS Table 11B, OEWS, NCES IPEDS. National average employment based on equivalent to national jobs per capita in selected occupations.

All three growth scenarios result in a total number of workers below the number needed to meet the national average of jobs per capita. In a high growth scenario, North Carolina would continue to have a shortfall of 10,000 workers in semiconductor occupations when compared to the national average per capita. An aging workforce and accelerating retirement of experienced engineers, managers, and technicians represents a challenge for the future growth of the semiconductor workforce in North Carolina.

Ecosystem Assets

SBIR/STTR Funding

The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs aim to stimulate technological innovation, support small businesses in meeting federal R&D needs, and encourage commercialization of innovations. By fostering partnerships and promoting innovation, these programs play a critical role in advancing technology and boosting economic growth for small businesses.

To track small business innovation in the semiconductor industry, a subset of SBIR/STTR awards representing roughly 5% of all awards given were identified as being related to semiconductors based on a keyword analysis of project abstracts associated with SBIR/STTR awards.[7] In 2023, these semiconductor-related SBIR/STTR awards totaled $100.4 million in the United States, a 2% increase from 2018 when these awards totaled $90.3 million (Table 8). However, this 2023 amount is down from 2013, where SBIR and STTR awards totaled $107.9 million.

In 2023, California received the largest share of semiconductor-related SBIR/STTR funding in the nation at $17.8 million followed by Massachusetts with $10.8 million and Texas with $8.0 million. Collectively, the five leading states (CA, MA, TX, CO, and AZ) represent around half of all SBIR funding for the nation in semiconductors, which aligns with their concentrations of employment in semiconductor manufacturing. Oregon, which ranked 3rd in total workforce for semiconductor manufacturing, ranked 20th in the nation by award total in 2023.

In the Southeast, awards totaled $9 million, which represents 9% of national SBIR and STTR awards in semiconductors. The Southeast's annual growth rate (12%) has outpaced the national average (2%). Within the Southeast, this growth has been driven by the past 5 years. Florida's SBIR awards grew significantly, totaling 27% growth, from under $1 million in 2018 to $3.2 million in 2023. North Carolina's awards increased from $1.56 million in 2018 to $2.9 million in 2023, reflecting 13% annual growth. Tennessee, while not receiving any awards in 2013, received $1 million in 2018 and experienced 10% annual growth, reaching $1.6 million in 2023.

Alabama, Kentucky, and South Carolina are classified as EPSCoR (Established Program to Stimulate Competitive Research) states. This designation by the National Science Foundation (NSF) applies to states and territories that receive 0.75% or less of total NSF research funding. Historically, these states have received lower levels of government funding compared to others. However, as EPSCoR states, they are positioned for potential growth in funding through programs designed to bolster R&D capacity in underfunded regions.

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7 Semiconductor-related SBIR awards were identified using a keyword search of award abstracts. For a list of keywords and explanation of methodology please see Table A-6 in the appendix. Data on awards, including abstracts, can be accessed at https://www.sbir.gov/awards.

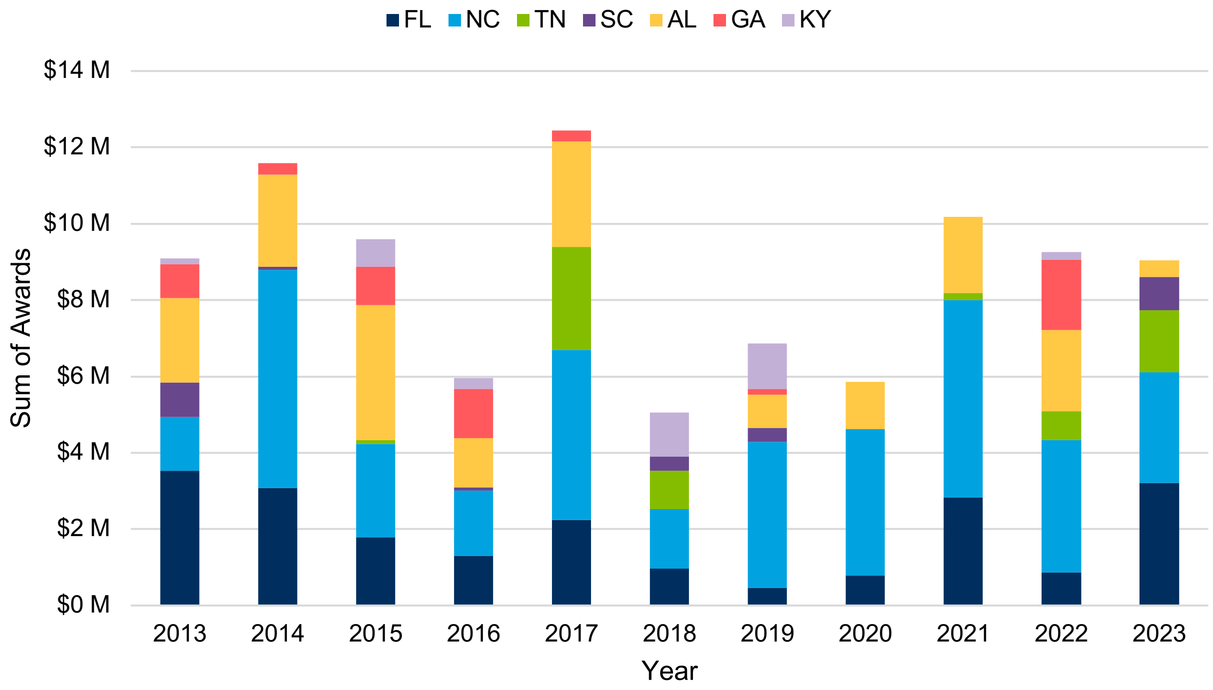
Table 8. SBIR/STTR Awards Classified as Semiconductor Related by State in the Southeast and Among National Leaders, 2013, 2018, and 2023

	Year			CAGR %	
State	2013	2018	2023	2013–2023	2018–2023
National Leaders	**$53,618,440**	**$48,585,473**	**$48,758,384**	**-0.9%**	**0.1%**
CA	$19,708,860	$24,422,862	$17,814,988	-1.0%	-6.1%
MA	$17,472,551	$11,736,831	$10,791,727	-4.7%	-1.7%
TX	$8,923,131	$6,473,584	$7,981,370	-1.1%	4.3%
CO	$5,277,887	$2,929,854	$6,410,886	2.0%	17.0%
AZ	$2,236,011	$3,022,342	$5,759,413	9.9%	13.8%
Southeast	**$9,098,396**	**$5,047,341**	**$9,040,400**	**0%**	**12%**
FL	$3,525,401	$966,939	$3,204,895	-1%	27%
NC	$1,415,183	$1,562,684	$2,904,421	7%	13%
TN		$1,000,000	$1,631,234	NA	10%
SC	$899,959	$367,728	$860,734	0%	19%
AL	$2,208,928		$439,116	-15%	NA
GA	$898,925			NA	NA
KY	$150,000	$1,149,990		NA	NA
National Total	**$107,927,686**	**$90,293,919**	**$100,452,176**	**-1%**	**2%**

Notes: Semiconductor-related is based on author's analysis of award titles and abstracts. Year represents date of award.
Source: Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR). SBIR.gov/data (2013, 2018, 2023). Accessed November 2024.

North Carolina led the Southeast in the amount of semiconductor-related SBIR awards received between the years 2014 and 2022 while in 2013 and 2023, Florida outpaced the state (Figure 15). 2014 marked the highest award amount for North Carolina, totaling $5.7 million. However, in 2023, Florida surpassed North Carolina by $300 thousand. Notably, North Carolina and Florida are the only states within the Southeast to consistently receive funding each year. Tennessee received the third-highest awards in 2023, totaling $1.6 million, but the state has only received funding in four of the past ten years. Additionally, 2017 was the strongest year for SBIR awards in the Southeast, with the region totaling $12.4 million for semiconductor-related research and innovation. This year can be attributed to awards received by North Carolina, Alabama, Tennessee, and Florida. South Carolina has received the fewest semiconductor-related awards since 2013, totaling $2.6 million over 11 years, followed by Kentucky at $3.7 million over the same period.

Figure 15. Semiconductor-Related SBIR/STTR Awards by Southeast States, 2013–2023



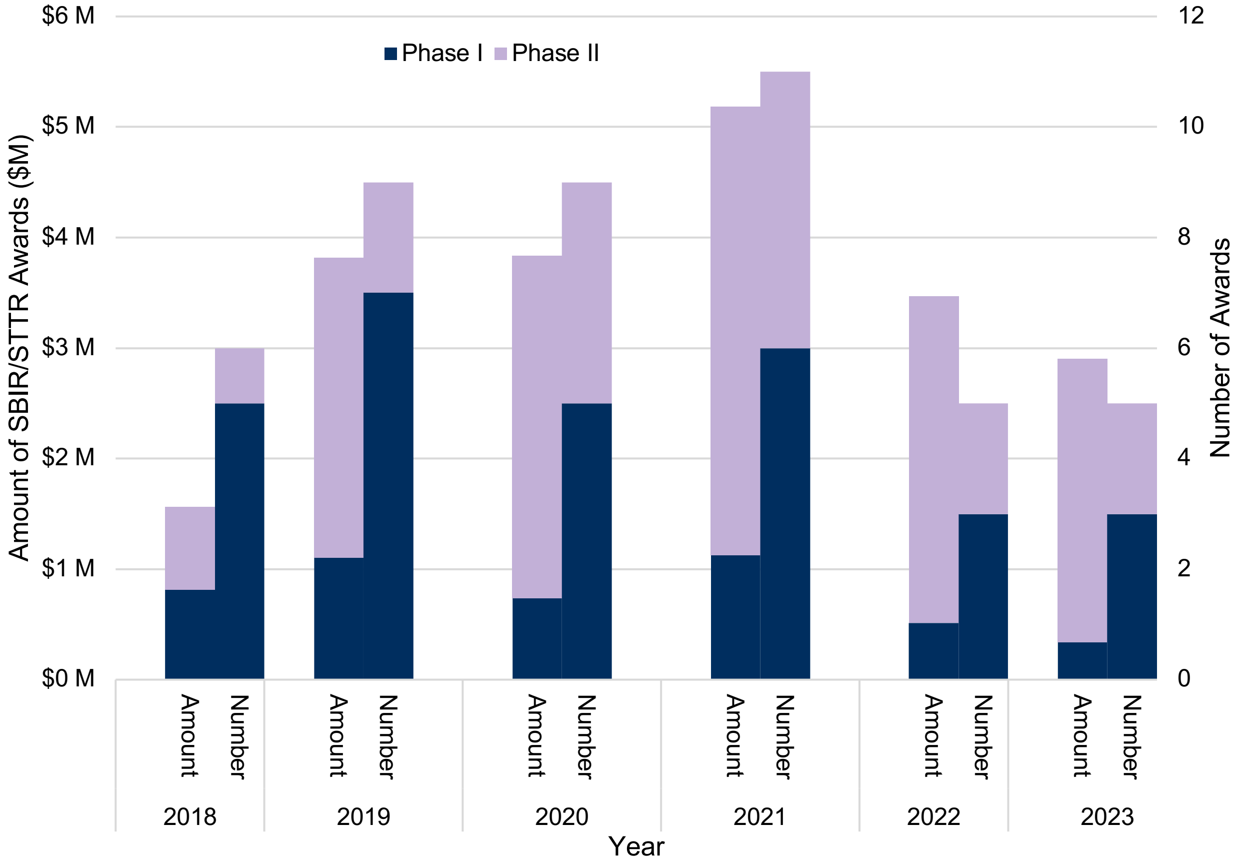
Notes: States are ranked by 2023 sum of awards. Semiconductor-related is based on author's analysis of award titles and abstracts.
Source: Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR). SBIR.gov/data (2013–2023). Accessed November 2024.

North Carolina Focus

SBIR/STTR awards can be broken out by phases. Phase 1 measures the feasibility and proof of concept for a research project. After completing a Phase 1 grant, companies can apply for a larger Phase 2 award to further develop the innovation. Having more Phase 1 awards does not necessarily mean there will be a translation of the research into a product that can be patented.

North Carolina is positioned to advance semiconductor-related research through SBIR awards. In 2023, North Carolina received three Phase 1 awards totaling $339,000 and two Phase 2 awards totaling $2.5 million that are related to semiconductors. Figure 16 shows both the dollar value of awards and the number of semiconductor-related awards that North Carolina has received since 2018. Since 2018, North Carolina has secured 16 Phase 2 awards, totaling $16.1 million, and 29 Phase 1 totaling $4.6 million related to semiconductors.

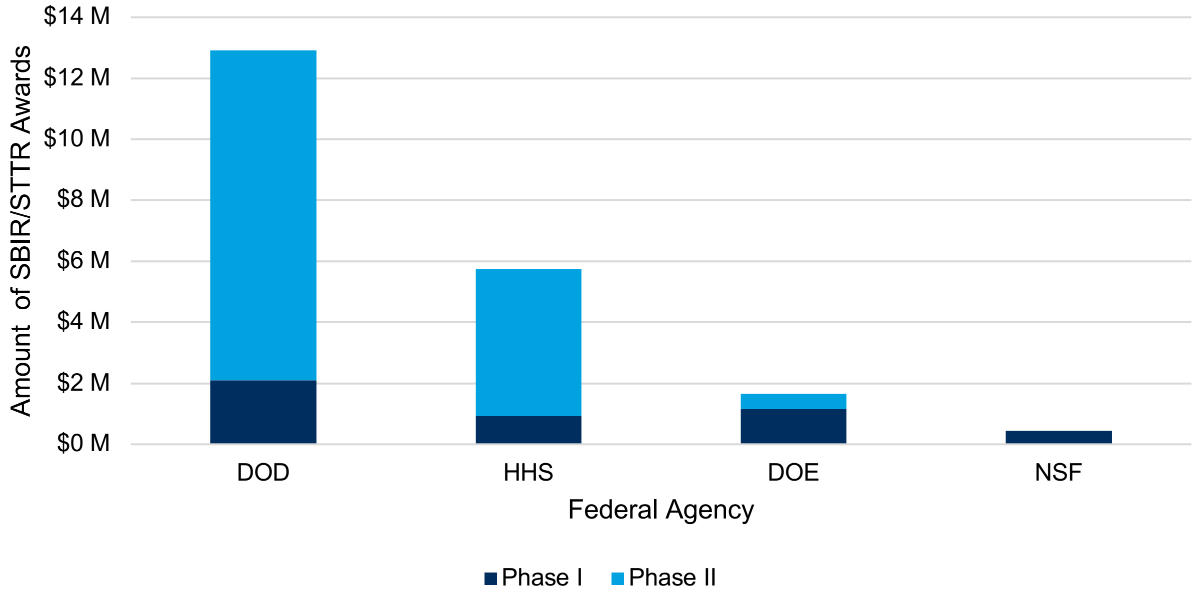
Figure 16. Number and Amount of North Carolina Semiconductor-Related SBIR/STTR Awards by Phases, 2018–2023



Note: Semiconductor-related is based on author's analysis of award titles and abstracts.
Source: Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR). SBIR.gov/data (2018–2023). Accessed November 2024.

From 2018 to 2023, the majority of semiconductor-related SBIR/STTR awards in North Carolina were granted by the Department of Defense (DOD). During this period, the DOD awarded $2.1 million in Phase 1 awards and $10.8 million in Phase 2 awards (Figure 17). The Department of Health and Human Services (HHS) was the second-largest federal agency providing semiconductor-related SBIR awards in the state, with $921 thousand in Phase 1 awards and $4.8 million in Phase 2 awards. The Department of Energy (DOE) and NSF awarded Phase 1 funding at higher rates, totaling $1.1 million and $449 thousand, respectively.

Figure 17. North Carolina Semiconductor-Related SBIR/STTR Awards by Federal Agency, 2018–2023



Note: Semiconductor-related is based on author's analysis of award titles and abstracts.
Source: Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR). SBIR.gov/data (2018–2023). Accessed November 2024.

Since 2018, 19 companies in North Carolina have received SBIR/STTR funding, distributed across different phases. Among them, Adroit Materials Inc. received the greatest amount and number of awards across both phases. Adroit, a nitride technology company specializing in electronic and optoelectronic device applications, secured five Phase 2 awards totaling $3.3 million.

The second-highest recipient is Kyma Technologies, a manufacturer of epiwafers for advanced semiconductor applications. Kyma also received a greater share of Phase 2 funding, with three Phase 2 awards totaling $2.2 million. 10 companies have only received Phase 1 awards as of 2023. Three other companies—Mitorainbiw Therapeutics Inc., Akoustis Inc., and Therabionic—are currently working on Phase 2 awards, having received their initial Phase 1 funding prior to 2018.

Table 9 outlines the companies that received SBIR/STTR funding in North Carolina from 2018 to 2023.

Table 9. Semiconductor-Related SBIR/STTR Awards by North Carolina Companies, 2018–2023

Phase I			Phase II		
Company Name	Sum of Awards	Number of Awards	Company	Sum of Awards	Number of Awards
Adroit Materials, Inc.	$1,107,999	6	**Adroit Materials, Inc.**	$3,365,219	5
Kyma Technologies	$574,992	5	**Kyma Technologies**	$2,249,996	3
Vadum, Inc.	$553,631	4	**Epicypher, Inc.**	$1,965,432	1
Epicypher, Inc.	$300,244	1	**Mitorainbow Therapeutics, Inc.**	$1,805,459	1
RFPi, Inc.	$259,590	1	**Akoustis, Inc.**	$1,747,423	1
Telli Technologies, Inc.	$225,000	1	**Vadum, Inc.**	$1,699,872	2
Kampanics, LLC	$224,999	1	**Oxford Defense North Carolina, LLC**	$1,249,964	1
Oxford Defense North Carolina, LLC	$224,777	1	**Therabionic, Inc.**	$1,059,091	1
Zenalux Biomedical, Inc.	$211,470	1	**0 Base Design, LLC**	$1,000,000	1
SonoVascular, Inc.	$150,000	1			
0 Base Design, LLC	$149,996	1			
Voxel Innovations, Inc.	$149,992	1			
USML, LLC	$149,943	1			
Aura Technologies, LLC	$125,000	1			
HI Fidelity Genetics, Inc.	$112,500	1			
Polaronyx, Inc.	$111,457	1			

Source: Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR). SBIR.gov/data (2013–2023). Accessed November 2024.

Patenting

From 2018–2024, there were over 19,000 U.S. patents related to the semiconductor industry (as determined by CPC Class classifications detailed in Table A-7) granted to assignees in the Southeast. As Table 10 shows, the states with the most prolific patenting activity in semiconductor-related fields are Florida, North Carolina, and Georgia, each with over 3,000 granted patents over the timeframe. Notably, the semiconductor-related patenting activity in Florida makes up over 23% of the total number of granted patents while in both Georgia and North Carolina, the university patents only account for roughly 12% of the total.

The notable university sources of patents in Florida are the University of Florida, the University of South Florida, the University of Central Florida, and Florida State University, all with over 200 granted patents in semiconductor-related fields over the time frame. In North Carolina, the patenting activity is dominated by the three universities that anchor the Research Triangle region (Duke University, the University of North Carolina at Chapel Hill, and NCSU) that each had over 100 related patents granted since 2018. In contrast to Florida and North Carolina, Georgia's university patenting activity is highly concentrated with Georgia Tech, which had over 250 patents granted accounting for nearly 70% of the university patenting activity in the state.

Table 10. Number of Semiconductor-Related Granted U.S. Patents per State in Southeast, 2018–2024.

State	Number of Granted U.S. Patents		
	University Assignees	Industry Assignees	Total
Alabama	215	586	801
Florida	1,197	3,943	5,140
Georgia	377	2,689	3,066
Kentucky	110	465	575
Mississippi	31	79	110
North Carolina	**567**	**4,131**	**4,698**
South Carolina	199	1,118	1,317
Tennessee	236	1,339	1,575
Virginia	281	1,947	2,228
Total (Southeast Region)	3,213	16,297	19,510

Notes: Patents for year 2024 include all granted patents in the USPTO database as of 10/24/2024. Location is based on address of primary assignee organization. Patent relevancy to semiconductors determined by patent classification code (see Appendix Table A-7 for semiconductor-related codes).
Source: U.S. Patent and Trademark Office (2018–October 2024). Accessed November 2024.

Moving beyond the patent classifications to a keyword analysis of the over 19,000 patents of interest reveals that of these patents, over 6,000 have keywords directly related to semiconductors either within the title or abstract of the patent. Using this keyword analysis and weighting scheme (detailed in the Appendix A.4), the patenting activity within each of the states within the Southeast (i.e., the study area) can be rated by the degree to which the patents are directly related to semiconductors and wide bandgap semiconductors specifically as shown in Table 11.

Overall, the patenting activity in North Carolina is rated as the most highly relevant to semiconductors generally and specifically wide bandgap materials being the only state with average ratings above 7 and 6 for the general semiconductor keywords and wide bandgap-specific keywords, respectively, as well as the highest maximum ratings in both categories. Notably, although not within the top three states in overall semiconductor-related patenting activity, the granted patents assigned within Virginia are highly related to semiconductors generally while not being specifically related to wide bandgap semiconductors.

Table 11. Keyword Analysis of Semiconductor-Related Patents Assigned within the Southeast by State, 2018–2024.

	General Semiconductor Keyword Rating		Wide Bandgap-specific Semiconductor Keyword Rating	
State	Average	Maximum	Average	Maximum
Alabama	4.90	19	5.33	4
Florida	5.60	27	5.35	11
Georgia	5.04	18	5.23	7
Kentucky	4.69	18	5.59	7
Mississippi	4.21	11	3.92	4
North Carolina	**7.04**	**42**	**6.63**	**18**
South Carolina	5.77	26	5.81	10
Tennessee	4.76	20	4.84	16
Virginia	6.25	32	5.05	16

Notes: Ratings are generated by the authors to provide a relative metric of centrality for patents to the semiconductor industry and wide bandgap sector based on analysis of patent titles and abstracts. Patents for year 2024 include all granted patents in the USPTO database as of 10/24/2024.
Source: Patent and Trademark Office (2018–October 2024). Accessed November 2024.

Focusing on the patenting activity from organizations within North Carolina, the companies with the highest rate of patenting within the state are the major communications firms CommScope Technologies LLC and Qorvo, Inc. as shown in Table 12. The three major research universities that anchor the Research Triangle region also represented three of the top eight most prolific patenting organizations in semiconductor-related fields since 2018. Cree, which split into Wolfspeed and CreeLED, is represented in its patenting activity in three rows in the table (Cree Inc., Wolfspeed, Inc., and CreeLED, Inc.) and in total accounts for 393 patents

Generally, the top patenting organizations represent four main groups—communications, aerospace, lighting, and energy—several of which are among the key industries in North Carolina as listed by the North Carolina Department of Commerce.[8] Semiconductor (and wide bandgap materials specifically) manufacturing and R&D are key, enabling parts of the value chains for each of these industry areas.

Many of the prolific patenting companies in North Carolina fall on the downstream end of the core semiconductor manufacturing portion of the value chain with the exception being Wolfspeed, which specializes in producing high quality silicon carbide (SiC) and nitride materials and devices that may be incorporated into wide variety of end uses.

8 North Carolina Department of Commerce. Key Industries in North Carolina. https://www.commerce.nc.gov/business/key-industries-north-carolina

Table 12. Semiconductor-Related Patenting Activity with Assignees within North Carolina, 2018–2024.

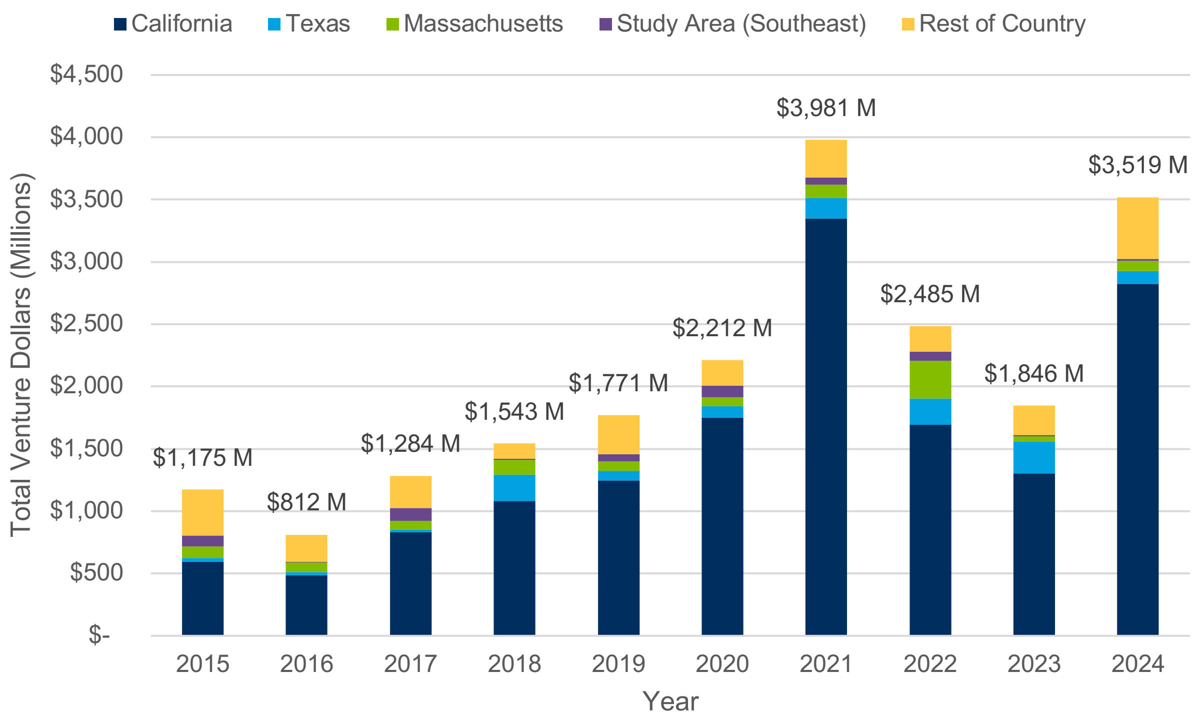
Organization	Type	Year							Total
		2018	2019	2020	2021	2022	2023	2024	
CommScope Technologies, LLC	Communications	30	43	42	30	40	36	21	**242**
Qorvo US, Inc.	Communications	48	47	38	40	18	28	21	**240**
Cree, Inc.**	Lighting	86	65	44	36	1			**232**
Duke University	University	36	38	22	32	25	32	26	**211**
Corning Optical Communications, LLC	Communications	44	53	24	9	7	4	3	**144**
The University of North Carolina at Chapel Hill	University	19	22	16	19	19	12	13	**120**
North Carolina State University	University	8	19	17	17	20	18	16	**115**
US Conec Ltd.	Communications	11	11	12	11	17	22	26	**110**
B/E Aerospace, Inc.	Aerospace	7	11	19	21	19	14	12	**103**
Wolfspeed, Inc.**	Wide bandgap materials					25	48	29	**102**
Akoustis, Inc.	Communications	6	9	9	18	19	27	5	**93**
Celgard, LLC	Energy	6	8	14	10	7	12	7	**64**
GE-Hitachi Nuclear Energy Americas, LLC	Energy	7	13	11	7	12	5	4	**59**
CreeLED, Inc.**	Lighting				9	16	21	13	**59**
Honeywell International, Inc.	Aerospace				4	8	19	21	**52**
LAT Enterprises, Inc.	Energy	1	3	3	9	6	8	20	**50**
Research Triangle Institute (RTI International)	Research Services	10	12	2	8	4	9	2	**47**
Kidde Technologies, Inc.	Aerospace	10	6	7	5	9	4	4	**45**

Notes: Assignees with over 40 semiconductor-related granted patents from 2018 to October 2024. Analysis filters instances where keywords overlapped with non-relevant industries.
**Cree Inc. restructured to form Wolfspeed and CreeLED, Inc. in 2021. Changes in patent assignees reflect the corporate restructure.
Source: Patent and Trademark Office (2018–October 2024). Accessed November 2024.

Venture Funding

Over the decade from 2015 to 2024, total venture funding for semiconductors grew to a peak of nearly $4 billion in 2021 and rebounded to over $3.5 billion by 2024. This follows national trends in venture activity, which experienced a downturn in 2022 and 2023, but the 2024 rebound in venture deals goes against national trends. As seen in Figure 18, California-based companies attracted 74% of the venture funding in semiconductors over the decade, followed by Texas and Massachusetts, which accounted for 6% and 5%, respectively. This reflects the strong geographic concentration of venture activity. By comparison, states in the Southeast attracted 2.5% of the national venture capital deals over the same period, led by North Carolina.

Figure 18. Total Value of Venture Deals for Semiconductors Companies by State or Region, 2015 to 2024



Notes: Completed venture round deals among companies in the "semiconductors" industry. Data for 2024 represents partial year from January to October.
Source: Pitchbook (2015–2024). Accessed November 2024.

Although the Southeast makes up a small percentage of total venture deals in semiconductors, North Carolina ranks 6th nationally in total value of venture deals in semiconductors over the decade from 2015 to 2024, outpacing other national manufacturing leaders such as Oregon and Arizona.

As seen in Table 13 and Table 14, this is led by nearly $300 million raised by Durham, NC-based Phononic, followed by startups across Virginia, North Carolina, South Carolina, and Florida. Much of the activity is concentrated in and around Durham, NC, Northern Virginia, Greenville/Spartanburg, SC, and Central Florida.

Table 13. Total Venture Deals and Funding by State: 2015–2024. Top 10 States

National Rank	State	Count of Venture Deals (2015–2024)	Total Value of Venture Deals (2015–2024)
1	California	756	$15,200 M
2	Texas	107	$1,200 M
3	Massachusetts	138	$1,000 M
4	New York	109	$623 M
5	Colorado	17	$516 M
6	**North Carolina**	**44**	**$384 M**
7	Minnesota	8	$175 M
8	Arizona	50	$172 M
9	Nevada	19	$172 M
10	New Mexico	24	$148 M

Notes: Completed venture round deals among companies in the “semiconductors” industry. Data for 2024 represents partial year from January to October.
Source: Pitchbook (2015–2024). Accessed November 2024.

Table 14. Top Companies in Semiconductors in the Southeast by Venture Capital Raised: 2015–2024

State	Company	Count of Deals	Deal Years	Total Deal Value
NC	Phononic	6	2015–2022	$297 M
VA	GeneSiC Semiconductor	6	2017–2021	$23 M
NC	X Display	1	2020	$22 M
SC	Soteria Battery Innovation	9	2019–2024	$20 M
NC	Nuvotronics	1	2015	$15 M
NC	HexaTech	4	2015–2018	$12 M
FL	AML	6	2017–2023	$12 M
NC	Guerrilla RF	6	2015–2019	$10 M
FL	Morton Photonics	1	2019	$9 M
FL	Semplastics	6	2018–2023	$9 M

Notes: Completed venture round deals among companies in the “semiconductors” industry. Data for 2024 represents partial year from January to October.
Source: Pitchbook (2015–2024). Accessed November 2024.

Ecosystem Roadmap

Roadmap Overview

The CLAWS Hub aspires to improve the competitiveness of the workforce and the region in the wide bandgap semiconductor industry. This ecosystem roadmap identifies critical points of connectivity between ecosystem actors, provides a framework for discussion and alignment, and ultimately inspires collective action toward our common goal. Our region of focus for the roadmap is the state of North Carolina, where the CLAWS Hub has the most direct influence.

Based on interviews with ecosystem actors from across the value chain, our roadmap organizes actions that can be taken according to the time frame when we anticipate they may have impact. Findings and recommendations in the ecosystem roadmap are based on input from industry experts and key informants including private sector, nonprofit, higher education, and scientific research sectors. Lines highlight connectivity between actions, which may be precedent/dependent relationships or simply opportunities for coordination.

Figure 19. Summary of Ecosystem Roadmap Actions

	Near	Next	Future
Academia	Introduce specialized skill education at community colleges Expand semiconductor-relevant community college certifications Increase industry exposure and industry-relevant technical training at the graduate level Lower barriers for faculty to seek private sector partnerships for federal funding proposals	Revamp semiconductor-related curricula with training in creative, independent problem-solving to produce industry-ready graduates Improve methods to attract and incentivize students into semiconductor-related programs	Maintain close ties with industry to understand changing PhD-level workforce needs Explore programs to expand semiconductor awareness, exposure, and industry engagement early within K-12 education
Government	Strengthen state-, county-, and municipality-level support and incentives for small businesses in the semiconductor industry Support state-level funding initiatives for Propel NC and AdvanceNC to optimize alignment between community college curriculum and advanced manufacturing industry needs Explore expanding financial and wrap-around service support for registered apprentices and community college transfers	Consider the role of skilled non-US workers in the semiconductor workforce At the federal level, continue and expand incentives to support end markets requiring wide bandgap semiconductors	Explore supporting a statewide semiconductor- or microelectronics-specific economic development agency Explore a public awareness campaign for semiconductors
Semiconductor Industry	Provide additional, transparent transition pathways into the semiconductor industry Define the workforce credentials needs for your business Collaborate with community colleges to close training and education gaps Enhance the technical service capabilities within the state to support a growing semiconductor industry	Expand the set of students eligible for internships and registered apprenticeship programs Explore various community college collaboration avenues to ensure workforce needs are met Engage local communities to build trust and alignment with new manufacturing sites	Improve the technical capabilities in NC with a wide bandgap-focused research foundry Engage with 5th grade through early high school students to build public awareness and exposure to semiconductors
NGOs	Continue providing general small business and entrepreneur training programs and establish specialized infrastructure Continue organizing multi-stakeholder convening events and opportunities	Increase or establish apprenticeship programs with wraparound services focused on semiconductor manufacturing	Establish a convening or economic development organization focused on semiconductor materials and technology

Note: Actions are organized by the type of organization and by when the actions may have an impact on the semiconductor industry and workforce in North Carolina.

Key Takeaways and Conclusions

Semiconductor manufacturing is a small industry in the Southeast, with no state having a large concentration of industry jobs when compared to national benchmarks and leaders. While some areas like Durham, NC and Central Florida are hubs for semiconductor manufacturing, other industries including electronics and electrical components manufacturing and R&D services employ a larger share of the workforce and have a higher concentration of workers. This combined with a small workforce and educational pipeline for technical roles presents a gap and an opportunity for North Carolina to increase its talent pipeline for technical roles in semiconductors.

- Nationally, semiconductor manufacturing employment peaked before the 2008 recession, and saw a sharp decline alongside other manufacturing industries in the years following. By 2023, employment had returned to prerecession levels in manufacturing, but R&D jobs had grown by over 50%, indicating a shift toward advanced services.
  - The growth in jobs and startup activity in 2023 and 2024 corresponds with increased federal funding and national attention toward semiconductors.
- The Southeast represents 10% of the national workforce in semiconductor manufacturing and no state has a high concentration of semiconductor manufacturing jobs. However, many states are among the national leaders in upstream industries like R&D services and downstream industries like electrical equipment manufacturing.
- North Carolina has a strong workforce and talent pipeline for research and engineering occupations, but gaps exist in the workforce for production roles. The state is one of the smallest for semiconductor processing technicians, which correlates with a low concentration of manufacturing or technician jobs. Certificate programs have grown over the last five years, offering new pathways into the field.
- In North Carolina, science and technology–intensive jobs in semiconductors pay high wages, often over $100,000, but are few in number and frequently require an advanced degree. Opportunities for workers without a four-year college degree are limited due to the low number of technician jobs.
  - The region has the potential to increase the demand for workers without a four-year college degree with more openings for semiconductor manufacturing technicians, and an opportunity to expand certificates and associate’s degree programs for those roles.
- Relative to the size of its semiconductor manufacturing sector, North Carolina outperforms in venture and research activity: although the state ranks 24th in total semiconductor manufacturing employment, it ranks 6th in total venture funding, outpacing national manufacturing leaders like Oregon and Arizona.

Moving into the future, stakeholders across the North Carolina ecosystem will need to take action to make a positive impact on the semiconductor industry and workforce in the short, medium, and long term:

- Short- to medium-term expansion of the semiconductor workforce in North Carolina to meet the industry's growth will require a coordinated effort between academic institutions, government bodies, industry players, and NGOs to ensure (1) there is a sufficient flow of students into semiconductor-relevant college programs; (2) community college, bachelor's, and PhD graduates have the necessary technical training to successfully enter the workforce; (3) alternative pathways to employment like registered apprenticeships and nondegree credentials are properly utilized; and (4) expanded manufacturing facilities are online and hiring is active once graduates are ready.
- Establishing semiconductor- or microelectronics-specific ecosystem support infrastructure will have a medium- to long-term positive impact on the semiconductor industry and workforce in the state. The necessary infrastructure includes technical services (from substrates through to a local foundry) and business support services (e.g., entrepreneur training, startup accelerators, small business incubators) tailored to the specific needs of the semiconductor industry.
- Long-term expansion of the semiconductor industry workforce in North Carolina requires earlier, wider-spread intervention to raise the awareness and pique curiosity about semiconductors. Sparking curiosity about semiconductor career pathways with K-12 students, starting in elementary school around 5^{th} grade, should be the goal. An awareness campaign to educate the general public about the role of semiconductors in modern society is also needed as parents, extended family, neighbors, and other adult figures influence students career choices.
- The approach to roadmapping taken in this project, collecting input via individual interviews, provides a solid starting set of actions that can be taken to improve the workforce. But most of the input referred to near-term actions that can have impact in the next three years. To stretch for more creative solutions, and expand thinking about longer-term actions, a series of multistakeholder, collaborative working sessions could be used to share these initial findings and spur collective action.

Appendix: Data Sources and Details

A.1 NAICS Industry Definitions

Table A-1. 2023 Employment by NAICS Industry Code and State

		State								
Subsector	Industry Title	AL	FL	GA	KY	MS	NC	SC	TN	VA
Core Semiconductor Manufacturing	NAICS 3344 Semiconductor and electronic component mfg.	1,698	18,027	1,567	831	505	7,811	2,723	1,371	4,147
Manufacturing	NAICS 3332 Industrial machinery manufacturing	728	2,288	3,191	2,073	377	3,631	1,522	1,996	1,748
	NAICS 3333 Commercial and service industry machinery	787	8,378	1,185	697	1,275	2,940	843	1,516	938
	NAICS 3339 Other general purpose machinery manufacturing	3,275	9,810	5,011	7,675	4,827	8,567	7,605	5,633	6,347
	NAICS 3345 Electronic instrument manufacturing	2,661	19,650	4,523	785	1,232	8,454	2,898	3,892	4,181
	NAICS 3353 Electrical Equipment Manufacturing	1,952	4,557	5,323	1,631	5,696	8,513	6,576	5,846	6,285
	NAICS 3359 Other electrical equipment and component mfg.	1,799	4,636	7,679	1,744	-	10,587	5,737	2,921	1,253
R&D Services	NAICS 5417 Scientific research and development services	8,971	28,751	10,926	2,696	1,025	35,859	5,258	11,927	29,527

A.2 SOC and CIP Code Definitions

Table A-2. 2023 Employment, Location Quotient, and Annual Median Wage by State and Occupation

State	Standard Occupation Classification Code	Standard Occupational Classification Description	2023 Employment	2023 Location Quotient	2023 Annual Median Wage
Alabama					
	11-3013	Facilities Managers	830	0.47	$109,620
	11-9041	Architectural and Engineering Managers	2,970	1.06	$158,450
	17-3028	Calibration Technologists and Technicians	NA	NA	NA
	19-2031	Chemists	620	0.55	$85,150
	17-2061	Computer Hardware Engineers	870	0.78	$132,930
	17-3023	Electrical and Electronic Engineering Technologists and Technicians	1,530	1.16	$66,210
	17-3013	Electrical and Electronics Drafters	270	0.96	$61,910
	17-2071	Electrical Engineers	4,360	1.74	$105,580
	17-2072	Electronics Engineers, Except Computer	1,760	1.35	$108,840
	17-3029	Engineering Technologists and Technicians, Except Drafters, All Other	790	0.88	$62,840
	17-2199	Engineers, All Other	3,480	1.71	$136,990
	17-3026	Industrial Engineering Technologists and Technicians	960	0.98	$56,690
	17-2112	Industrial Engineers	7,440	1.65	$97,360
	11-3051	Industrial Production Managers	3,110	1.03	$113,480
	17-2131	Materials Engineers	610	1.83	$103,940
	19-2032	Materials Scientists	NA	NA	NA
	17-3013	Mechanical Drafters	410	0.68	$57,960
	17-2141	Mechanical Engineers	5,280	1.39	$97,050
	19-2012	Physicists	170	0.67	$132,930
	51-9141	Semiconductor Processing Technicians	NA	NA	NA

State	Standard Occupation Classification Code	Standard Occupational Classification Description	2023 Employment	2023 Location Quotient	2023 Annual Median Wage
Florida					
	11-3013	Facilities Managers	7,190	0.87	$94,500
	11-9041	Architectural and Engineering Managers	7,160	0.55	$163,050
	17-3028	Calibration Technologists and Technicians	470	0.57	$61,060
	19-2031	Chemists	1,810	0.34	$81,190
	17-2061	Computer Hardware Engineers	2,130	0.41	$113,280
	17-3023	Electrical and Electronic Engineering Technologists and Technicians	5,690	0.93	$63,140
	17-3013	Electrical and Electronics Drafters	930	0.71	$61,090
	17-2071	Electrical Engineers	6,710	0.57	$100,200
	17-2072	Electronics Engineers, Except Computer	5,640	0.93	$114,500
	17-3029	Engineering Technologists and Technicians, Except Drafters, All Other	2,470	0.59	$64,490
	17-2199	Engineers, All Other	8,080	0.85	$100,140
	17-3026	Industrial Engineering Technologists and Technicians	1,870	0.41	$61,600
	17-2112	Industrial Engineers	13,130	0.63	$100,010
	11-3051	Industrial Production Managers	7,330	0.52	$111,000
	17-2131	Materials Engineers	610	0.39	$95,350
	19-2032	Materials Scientists	100	0.17	$132,590
	17-3013	Mechanical Drafters	1,960	0.69	$51,800
	17-2141	Mechanical Engineers	8,520	0.48	$92,810
	19-2012	Physicists	170	0.15	$141,710
	51-9141	Semiconductor Processing Technicians	190	0.12	$36,890
Georgia					
	11-3013	Facilities Managers	2,790	0.68	$109,790
	11-9041	Architectural and Engineering Managers	3,270	0.50	$163,180
	17-3028	Calibration Technologists and Technicians	360	0.86	$65,770

State	Standard Occupation Classification Code	Standard Occupational Classification Description	2023 Employment	2023 Location Quotient	2023 Annual Median Wage
	19-2031	Chemists	1,190	0.46	$91,260
	17-2061	Computer Hardware Engineers	1,260	0.49	$106,460
	17-3023	Electrical and Electronic Engineering Technologists and Technicians	1,890	0.62	$77,830
	17-3013	Electrical and Electronics Drafters	580	0.90	$72,360
	17-2071	Electrical Engineers	4,050	0.70	$103,460
	17-2072	Electronics Engineers, Except Computer	3,220	1.07	$114,900
	17-3029	Engineering Technologists and Technicians, Except Drafters, All Other	1,870	0.90	$62,820
	17-2199	Engineers, All Other	3,750	0.79	$113,230
	17-3026	Industrial Engineering Technologists and Technicians	2,010	0.88	$61,060
	17-2112	Industrial Engineers	7,440	0.71	$95,930
	11-3051	Industrial Production Managers	4,930	0.71	$121,240
	17-2131	Materials Engineers	680	0.88	$82,200
	19-2032	Materials Scientists	160	0.58	$92,660
	17-3013	Mechanical Drafters	770	0.55	$61,680
	17-2141	Mechanical Engineers	5,600	0.64	$84,080
	19-2012	Physicists	110	0.19	$200,310
	51-9141	Semiconductor Processing Technicians	NA	NA	NA
Kentucky					
	11-3013	Facilities Managers	1,090	0.64	$87,150
	11-9041	Architectural and Engineering Managers	1,480	0.55	$129,690
	17-3028	Calibration Technologists and Technicians	130	0.78	$66,130
	19-2031	Chemists	640	0.59	$79,200
	17-2061	Computer Hardware Engineers	NA	NA	NA
	17-3023	Electrical and Electronic Engineering Technologists and Technicians	1,160	0.92	$67,540
	17-3013	Electrical and Electronics Drafters	200	0.74	$59,160

State	Standard Occupation Classification Code	Standard Occupational Classification Description	2023 Employment	2023 Location Quotient	2023 Annual Median Wage
	17-2071	Electrical Engineers	1,870	0.78	$83,190
	17-2072	Electronics Engineers, Except Computer	490	0.39	$94,060
	17-3029	Engineering Technologists and Technicians, Except Drafters, All Other	410	0.48	$57,740
	17-2199	Engineers, All Other	890	0.46	$84,340
	17-3026	Industrial Engineering Technologists and Technicians	1,210	1.28	$61,610
	17-2112	Industrial Engineers	6,020	1.4	$84,980
	11-3051	Industrial Production Managers	4,410	1.53	$103,740
	17-2131	Materials Engineers	500	1.56	$99,830
	19-2032	Materials Scientists	NA	NA	NA
	17-3013	Mechanical Drafters	490	0.85	$62,980
	17-2141	Mechanical Engineers	2,970	0.82	$95,820
	19-2012	Physicists	-	0	$126,160
	51-9141	Semiconductor Processing Technicians	NA	NA	NA
Mississippi					
	11-3013	Facilities Managers	750	0.76	$79,580
	11-9041	Architectural and Engineering Managers	920	0.58	$132,460
	17-3028	Calibration Technologists and Technicians	70	0.69	$59,930
	19-2031	Chemists	210	0.33	$81,760
	17-2061	Computer Hardware Engineers	150	0.25	$81,420
	17-3023	Electrical and Electronic Engineering Technologists and Technicians	1,010	1.37	$61,020
	17-3013	Electrical and Electronics Drafters	120	0.74	$57,200
	17-2071	Electrical Engineers	980	0.70	$98,340
	17-2072	Electronics Engineers, Except Computer	330	0.45	$95,110
	17-3029	Engineering Technologists and Technicians, Except Drafters, All Other	440	0.88	$71,410
	17-2199	Engineers, All Other	520	0.46	$107,810

State	Standard Occupation Classification Code	Standard Occupational Classification Description	2023 Employment	2023 Location Quotient	2023 Annual Median Wage
	17-3026	Industrial Engineering Technologists and Technicians	260	0.47	$66,310
	17-2112	Industrial Engineers	1,990	0.79	$85,540
	11-3051	Industrial Production Managers	1,540	0.91	$107,600
	17-2131	Materials Engineers	140	0.74	$70,300
	19-2032	Materials Scientists	NA	NA	NA
	17-3013	Mechanical Drafters	180	0.53	$55,190
	17-2141	Mechanical Engineers	1,110	0.52	$84,390
	19-2012	Physicists	100	0.71	$116,670
	51-9141	Semiconductor Processing Technicians	NA	NA	NA
North Carolina					
	11-3013	Facilities Managers	3,520	0.85	$98,110
	11-9041	Architectural and Engineering Managers	5,780	0.88	$152,360
	17-3028	Calibration Technologists and Technicians	280	0.66	$71,880
	19-2031	Chemists	4,920	1.86	$79,450
	17-2061	Computer Hardware Engineers	1,450	0.56	$131,010
	17-3023	Electrical and Electronic Engineering Technologists and Technicians	1,920	0.62	$68,590
	17-3013	Electrical and Electronics Drafters	550	0.85	$67,030
	17-2071	Electrical Engineers	5,260	0.90	$101,170
	17-2072	Electronics Engineers, Except Computer	1,560	0.51	$98,630
	17-3029	Engineering Technologists and Technicians, Except Drafters, All Other	1,530	0.73	$71,030
	17-2199	Engineers, All Other	2,890	0.61	$105,860
	17-3026	Industrial Engineering Technologists and Technicians	2,340	1.01	$62,050
	17-2112	Industrial Engineers	10,200	0.97	$94,040
	11-3051	Industrial Production Managers	8,360	1.19	$112,960
	17-2131	Materials Engineers	470	0.60	$92,570

State	Standard Occupation Classification Code	Standard Occupational Classification Description	2023 Employment	2023 Location Quotient	2023 Annual Median Wage
	19-2032	Materials Scientists	160	0.59	$108,890
	17-3013	Mechanical Drafters	850	0.60	$60,400
	17-2141	Mechanical Engineers	7,500	0.84	$95,490
	19-2012	Physicists	240	0.42	$164,950
	51-9141	Semiconductor Processing Technicians	200	0.24	$48,290
South Carolina					
	11-3013	Facilities Managers	1520	0.79	$96,460
	11-9041	Architectural and Engineering Managers	2670	0.88	$141,850
	17-3028	Calibration Technologists and Technicians	130	0.69	$59,250
	19-2031	Chemists	1010	0.82	$76,280
	17-2061	Computer Hardware Engineers	550	0.45	$120,450
	17-3023	Electrical and Electronic Engineering Technologists and Technicians	2200	1.54	$65,090
	17-3013	Electrical and Electronics Drafters	410	1.36	$61,810
	17-2071	Electrical Engineers	2460	0.91	$96,120
	17-2072	Electronics Engineers, Except Computer	990	0.7	$119,310
	17-3029	Engineering Technologists and Technicians, Except Drafters, All Other	580	0.6	$80,950
	17-2199	Engineers, All Other	1640	0.74	$106,540
	17-3026	Industrial Engineering Technologists and Technicians	2420	2.26	$63,720
	17-2112	Industrial Engineers	7070	1.45	$92,470
	11-3051	Industrial Production Managers	5570	1.71	$120,710
	17-2131	Materials Engineers	470	1.3	$96,210
	19-2032	Materials Scientists	60	0.48	$79,750
	17-3013	Mechanical Drafters	670	1.02	$62,950
	17-2141	Mechanical Engineers	4530	1.1	$95,880
	19-2012	Physicists	0	0	$127,780

State	Standard Occupation Classification Code	Standard Occupational Classification Description	2023 Employment	2023 Location Quotient	2023 Annual Median Wage
	51-9141	Semiconductor Processing Technicians	NA	NA	NA
Tennessee					
	11-3013	Facilities Managers	2,000	0.72	$97,100
	11-9041	Architectural and Engineering Managers	2,840	0.65	$141,000
	17-3028	Calibration Technologists and Technicians	380	1.36	$64,030
	19-2031	Chemists	690	0.39	$83,980
	17-2061	Computer Hardware Engineers	240	0.14	$81,460
	17-3023	Electrical and Electronic Engineering Technologists and Technicians	2,290	1.11	$57,140
	17-3013	Electrical and Electronics Drafters	400	0.91	$68,370
	17-2071	Electrical Engineers	1,980	0.50	$103,170
	17-2072	Electronics Engineers, Except Computer	970	0.47	$98,760
	17-3029	Engineering Technologists and Technicians, Except Drafters, All Other	820	0.58	$57,980
	17-2199	Engineers, All Other	4,350	1.36	$86,070
	17-3026	Industrial Engineering Technologists and Technicians	2,360	1.52	$57,920
	17-2112	Industrial Engineers	6,710	0.95	$92,830
	11-3051	Industrial Production Managers	5,310	1.12	$102,300
	17-2131	Materials Engineers	430	0.83	$103,680
	19-2032	Materials Scientists	390	2.07	$0
	17-3013	Mechanical Drafters	1,360	1.43	$60,740
	17-2141	Mechanical Engineers	2,400	0.40	$97,770
	19-2012	Physicists	300	0.77	$121,760
	51-9141	Semiconductor Processing Technicians	NA	NA	NA
Virginia					
	11-3013	Facilities Managers	2,020	0.58	$107,350
	11-9041	Architectural and Engineering Managers	4,080	0.75	$162,040

State	Standard Occupation Classification Code	Standard Occupational Classification Description	2023 Employment	2023 Location Quotient	2023 Annual Median Wage
	17-3028	Calibration Technologists and Technicians	180	0.53	$59,040
	19-2031	Chemists	1,350	0.62	$93,480
	17-2061	Computer Hardware Engineers	2,670	1.23	$145,600
	17-3023	Electrical and Electronic Engineering Technologists and Technicians	3,780	1.48	$83,840
	17-3013	Electrical and Electronics Drafters	440	0.81	$67,310
	17-2071	Electrical Engineers	6,090	1.25	$110,840
	17-2072	Electronics Engineers, Except Computer	3,140	1.24	$124,990
	17-3029	Engineering Technologists and Technicians, Except Drafters, All Other	3,300	1.90	$92,060
	17-2199	Engineers, All Other	5,670	1.43	$136,490
	17-3026	Industrial Engineering Technologists and Technicians	1,150	0.60	$61,830
	17-2112	Industrial Engineers	5,120	0.59	$98,600
	11-3051	Industrial Production Managers	2,690	0.46	$117,000
	17-2131	Materials Engineers	410	0.63	$104,500
	19-2032	Materials Scientists	120	0.52	$118,440
	17-3013	Mechanical Drafters	630	0.53	$63,140
	17-2141	Mechanical Engineers	6,150	0.83	$101,900
	19-2012	Physicists	870	1.82	$128,880
	51-9141	Semiconductor Processing Technicians	230	0.33	$0

Source: U.S. Bureau of Labor Statistics Occupation Employment and Wage Statistics.

Table A-3. North Carolina Semiconductor Occupation Employment Percent Change and Employment Concentration (i.e., Location Quotient, 2023)

Industry Title	Employment Percent Change 2023-33	2023 LQ	2023 Employees
Industrial Engineers	12.2%	0.97	10,200
Industrial Production Managers	2.8%	1.19	8,360
Mechanical Engineers	11.0%	0.84	7,500
Architectural and Engineering Managers	5.5%	0.88	5,780
Electrical Engineers	9.1%	0.90	5,260
Chemists	7.6%	1.86	4,920
Engineers, All Other	5.0%	0.61	2,890
Industrial Engineering Technologists and Technicians	4.1%	1.01	2,340
Electrical and Electronic Engineering Technologists and Technicians	3.0%	0.62	1,920
Electronics Engineers, Except Computer	9.1%	0.51	1,560
Engineering Technologists and Technicians, Except Drafters, All Other	4.4%	0.73	1,530
Computer Hardware Engineers	7.2%	0.56	1,450
Mechanical Drafters	-4.9%	0.60	850
Electrical and Electronics Drafters	4.1%	0.85	550
Materials Engineers	7.4%	0.60	470
Calibration Technologists and Technicians	5.5%	0.66	280
Physicists	7.2%	0.42	240
Semiconductor Processing Technicians	13.0%	0.24	200
Materials Scientists	8.7%	0.59	160

Source: U.S. Bureau of Labor Statistics Occupation Employment and Wage Statistics.

Table A-4. Bureau of Labor Statistics Entry-Level Education Requirements for Semiconductor-Related Occupation Groups in North Carolina, 2023

Occupation Code	Occupation Title	Entry-Level Education Requirements
11-3013	Facilities Managers	Bachelor's degree
11-3051	Industrial Production Managers	Bachelor's degree
11-9041	Architectural and Engineering Managers	Bachelor's degree
17-2061	Computer Hardware Engineers	Bachelor's degree
17-2071	Electrical Engineers	Bachelor's degree
17-2072	Electronics Engineers, Except Computer	Bachelor's degree
17-2112	Industrial Engineers	Bachelor's degree
17-2131	Materials Engineers	Bachelor's degree
17-2141	Mechanical Engineers	Bachelor's degree
17-2199	Engineers, All Other	Bachelor's degree
17-3012	Electrical and Electronics Drafters	Associate's degree
17-3013	Mechanical Drafters	Associate's degree
17-3023	Electrical and Electronic Engineering Technologists and Technicians	Associate's degree
17-3026	Industrial Engineering Technologists and Technicians	Associate's degree
17-3028	Calibration Technologists and Technicians	Associate's degree
17-3029	Engineering Technologists and Technicians, Except Drafters, All Other	Associate's degree
19-2012	Physicists	Doctoral or professional degree
19-2031	Chemists	Bachelor's degree
19-2032	Materials Scientists	Bachelor's degree
51-9141	Semiconductor Processing Technicians	High school diploma or equivalent

Source: U.S. Bureau of Labor Statistics Occupation Employment and Wage Statistics.

Education Institutions and Degrees Awarded

Table A-5. North Carolina Semiconductor-related Degree Completions, by Degree Type and Institution

Degree Type and Institution	Degrees & Certificates Awarded
Associate's degree	**215**
Southeastern Community College	32
Johnston Community College	14
Central Piedmont Community College	14
Central Carolina Community College	12
Wake Technical Community College	11
Isothermal Community College	10
Davidson-Davie Community College	8
Gaston College	7
Coastal Carolina Community College	7
Pitt Community College	7
Stanly Community College	7
Asheville-Buncombe Technical Community College	6
Guilford Technical Community College	6
Mayland Community College	6
Beaufort County Community College	5
Cape Fear Community College	5
Rowan-Cabarrus Community College	5
Surry Community College	5
Vance-Granville Community College	5
Craven Community College	5
Caldwell Community College and Technical Institute	4
Forsyth Technical Community College	4
Fayetteville Technical Community College	4
Western Piedmont Community College	3
Brunswick Community College	3
Durham Technical Community College	3
Nash Community College	3
Cleveland Community College	3
Catawba Valley Community College	2
Richmond Community College	2
Southwestern Community College	2

Degree Type and Institution	Degrees & Certificates Awarded
Tri-County Community College	2
Mitchell Community College	2
Blue Ridge Community College	1
Rockingham Community College	1
Haywood Community College	1
Bachelor's degree	**960**
North Carolina State University at Raleigh	445
University of North Carolina at Charlotte	162
North Carolina A&T State University	131
Duke University	113
East Carolina University	59
Western Carolina University	36
Methodist University	6
Elon University	5
Johnson C Smith University	3
Campbell University	1
High Point University	0
Master's degree	**730**
North Carolina State University at Raleigh	320
Duke University	296
University of North Carolina at Charlotte	74
East Carolina University	23
North Carolina A&T State University	17
University of North Carolina at Chapel Hill	1
Doctoral degree	136
North Carolina State University at Raleigh	71
Duke University	36
University of North Carolina at Charlotte	14
North Carolina A&T State University	12
University of North Carolina at Chapel Hill	3
Certificates	**427**
North Carolina State University at Raleigh	37
Central Carolina Community College	36
Craven Community College	35
Isothermal Community College	33
Catawba Valley Community College	30

Degree Type and Institution	Degrees & Certificates Awarded
Coastal Carolina Community College	29
Davidson-Davie Community College	25
Wake Technical Community College	25
Pitt Community College	24
Beaufort County Community College	16
Central Piedmont Community College	16
Cleveland Community College	13
Forsyth Technical Community College	12
Southeastern Community College	11
Cape Fear Community College	11
Gaston College	10
Vance-Granville Community College	9
Mitchell Community College	6
Nash Community College	6
North Carolina A&T State University	6
Rowan-Cabarrus Community College	5
Blue Ridge Community College	5
Asheville-Buncombe Technical Community College	5
Fayetteville Technical Community College	4
Johnston Community College	4
Brunswick Community College	3
Surry Community College	3
Durham Technical Community College	2
Guilford Technical Community College	2
Haywood Community College	2
Richmond Community College	2
Stanly Community College	1
Caldwell Community College and Technical Institute	1
Rockingham Community College	1

Notes: Figures represent average for years 2018 to 2023. Semiconductor degrees defined in Table 6.
Source: U.S. Department of Education Statistics, Integrated Postsecondary Education Data System (IPEDS), Degrees and Certificates Awarded (2018–2023).

A.3 SBIR Analysis and Methodology

For SBIR/STTR Awards, a keyword analysis was used to define which awards were "Semiconductor Related." Using the full database of awards, each award was given a score based on the frequency in which a set of keywords (see Table A-6) related to semiconductors, power electronics, and wide bandgap materials was used in award titles and abstracts.[9] Keywords found in the title were weighed at three times the weight of a keyword in the abstract. All search terms were weighed equally for simplicity. Awards with composite scores above a threshold, representing roughly 6% of all awards, were designated as semiconductor related. To facilitate exact matches, Award Titles and Abstracts were stripped of punctuation and given proper capitalization.

Table A-6. Industry-Related Keywords Used to Define Industry Relevance

Group	Subgroup	Search term list
WBGs/uWBGs	Overall	"Wide Bandgap" "Wide Band Gap" "Wbg"
	SiC/GaN	"Silicon Carbide" "Sic" "Moissanite" "Carborundum"
	GaN	"Gallium Nitride" "Gan"
	III-Nitrides	"Iii V" "Iii Nitride" "Indium Nitride" "Indium Gallium Nitride" "Ingan" "Gallium Indium Nitride" "Gainn"
	GaAs	"Gallium Arsenide" "Gaas"
	AlN	"Aluminum Nitride" "Aln"
	Other Materials	"Diamond" "Sapphire" "Gallium Oxide" "Boron Nitride"
Power Electronics	Overall	"Semiconductor" "Wafer" "Epitax" "Substrate" "Power Electronics" "Transistor" "Solid State" "Power Semiconductor Device" "Power Device" "Dc Dc Conver*" "Dc to Dc" "Power Conver*" "Power Switch"
	Manufacturing and Component	"Deep Level Transient Spectroscopy" "Insulated Gate Bipolar Transistor" "Joint Electron Device" "Metal Oxide Semiconductor" "Field Effect Transistor" "Complementary Metal Oxide Semiconductor" "Bipolar Junction Transistor" "Basal Plane Dislocation" "Maximum Junction Temperature Rating" "High Electron Mobility Transistor" "Schottky Diode" "Schottky Barrier Diode" "Junction Barrier Schottky" "Hot Carrier Diode" "Total Gate Charge" "Lely Method" "P N Junction" "P Type" "N Type" "Mocvd" "Metal Organic Chemical Vapor Deposition" "Hydride Vapor Phase Epitaxy" "Igbt" "Schottky" "Mosfet" "Spectroscopy" "Thyristor" "Dopant" "Wurtzite" "Hemt"
	Applications	"Light Emitting Diode" "Led ""Radio Frequency" "Rf" "Laser" "Microled" "Micro Led" "Mmic" "Monolithic Microwave Integrated Circuit" "Power Amplifier" "Low Noise Amplifier" "Surface Acoustic Wave" "Bulk Acoustic Wave Filters" "Pulse Power" "Mmwave"

[9] Small Business Administration. Award Data. https://www.sbir.gov/awards. Accessed 11/20/2024.

Group	Subgroup	Search term list
	Devices	"Diode Lasers" "Dfb Laser" "Fabry Perot Laser" "Vertical Cavity Surface Emitting Lasers" "Vcsel" "Waveguides" "Sin Low Loss Waveguide" "Ring Resonator" "Pin Photodiode" "Avalanche Photodiode" "Inverter" "Power Modules Half Bridges" "Gate Drivers" "Jfet" "Junction Field Effect Transistor" "Bjt" "Bipolar Junction Transistors" "Cascode"
Semiconductors	Fabrication	"Fabrication" "Lithography" "Reactive Ion Etching" "Electron Beam Evaporation Sputtering" "Lpcvd" "Dielectric Deposition" "Electroplat" "Electron Beam Evaporation" "Atomic Layer Deposit" "Wafer Map" "Crystal Growth" "Pecvd" "Plasma Enhanced Chemical Vapor Deposition" "Czochralski"
	Integrated Circuits	"Integrated Circuit" "Microprocessors" "Microcontroller" "Static Ram" "Static Random Access Memory"

Note: Terms are modified to be matched to a data stripped of punctuation and with proper capitalization. Some terms are concatenated to accommodate multiple forms of the word (e.g., Search Term "Epitax" can match to either "Epitaxy" or "Epitaxial"). Many materials use both their full name and their chemical notation.

A.4 Patent Analysis and Methodology

Analysis of patents started by defining a list of relevant patents passed on International Patent Classification (IPC) or Cooperative Patent Classification (CPC) Classes (see Table A-7). State was assigned based on the lead assignee, or the state with the most inventors listed if assignee was blank. The full list of inventors and assignees by state was recorded for each patent.

Table A-7. International Patent Classification (IPC) or Cooperative Patent Classification (CPC) Classes Considered for the Patent Analysis

IPC/CPC Class	Title
B01	Physical or chemical processes or apparatus in general
B24	Grinding; polishing
B60	Vehicles in general
B82	Nanotechnology
C01	Inorganic chemistry
C04	Cements; concrete; artificial stone; ceramics; refractories [4]
C08	Organic macromolecular compounds; their preparation or chemical working-up; compositions based thereon
C09	Dyes; paints; polishes; natural resins; adhesives; compositions not otherwise provided for; applications of materials not otherwise provided for
C22	Metallurgy; ferrous or non-ferrous alloys; treatment of alloys or non-ferrous metals
C23	Coating metallic material; coating material with metallic material; chemical surface treatment; diffusion treatment of metallic material; coating by vacuum evaporation, by sputtering, by ion implantation or by chemical vapour deposition, in general; inhibiting corrosion of metallic material or incrustation in general
C30	Crystal growth
F02	Combustion engines; hot-gas or combustion-product engine plants
F16	Engineering elements or units; general measures for producing and maintaining effective functioning of machines or installations; thermal insulation in general
G01	Measuring; testing
G02	Optics
G05	Controlling; regulating
G11	Information storage
H01	Electric elements
H02	Generation, conversion, or distribution of electric power
H03	Electronic circuitry
H05	Electric techniques not otherwise provided for
H10	Semiconductor devices; electric solid-state devices not otherwise provided for

Each patent within the IPC/CPC categories listed above was given a score based on relevance to the semiconductor industry. Using the complete set of search terms in Table A-6, we give a composite score with 3 points for each exact match of a term in the patent's title and 1 point for each exact match of a term in the patent's abstract. To facilitate exact matches, Titles and Abstracts were stripped of punctuation and given proper capitalization. Patents with higher scores are assumed to be on average more closely related to the semiconductor industry.

A.5 Venture Capital Analysis and Methodology

Pitchbook search criteria:

Deal Date: From: 01-Jan-2015;

Deal Status: Completed;

Deal Types: All VC Stages; All Round Numbers; All Series;

Location: United States;

Industries: Information Technology > Semiconductors;