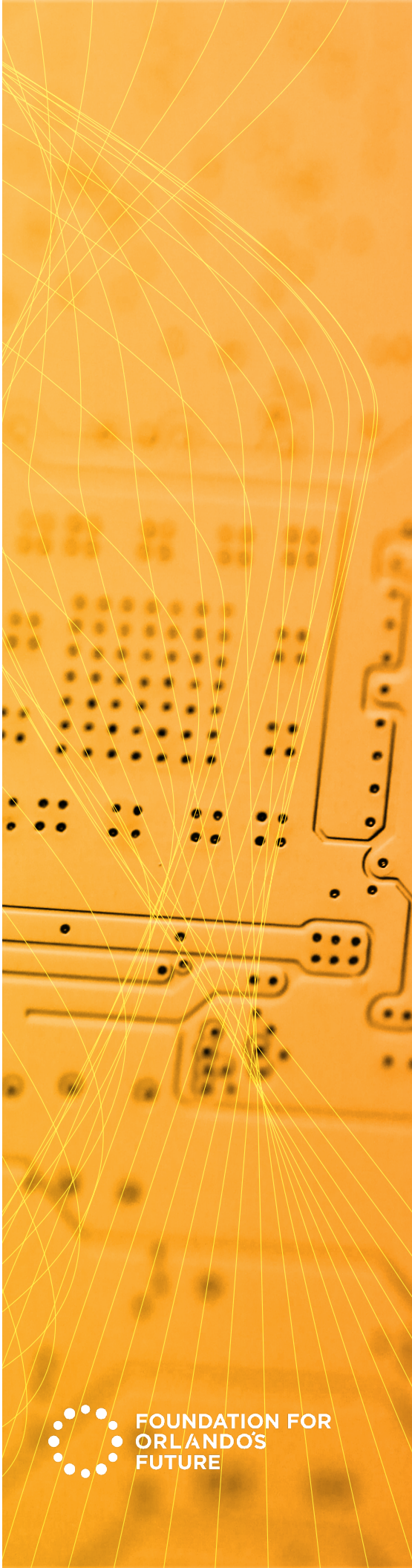
ORLANDO ECONOMIC PARTNERSHIP

Semiconductor Manufacturing in Orlando:

Part I – An Industry and Ecosystem Primer



FOUNDATION FOR ORLANDO'S FUTURE

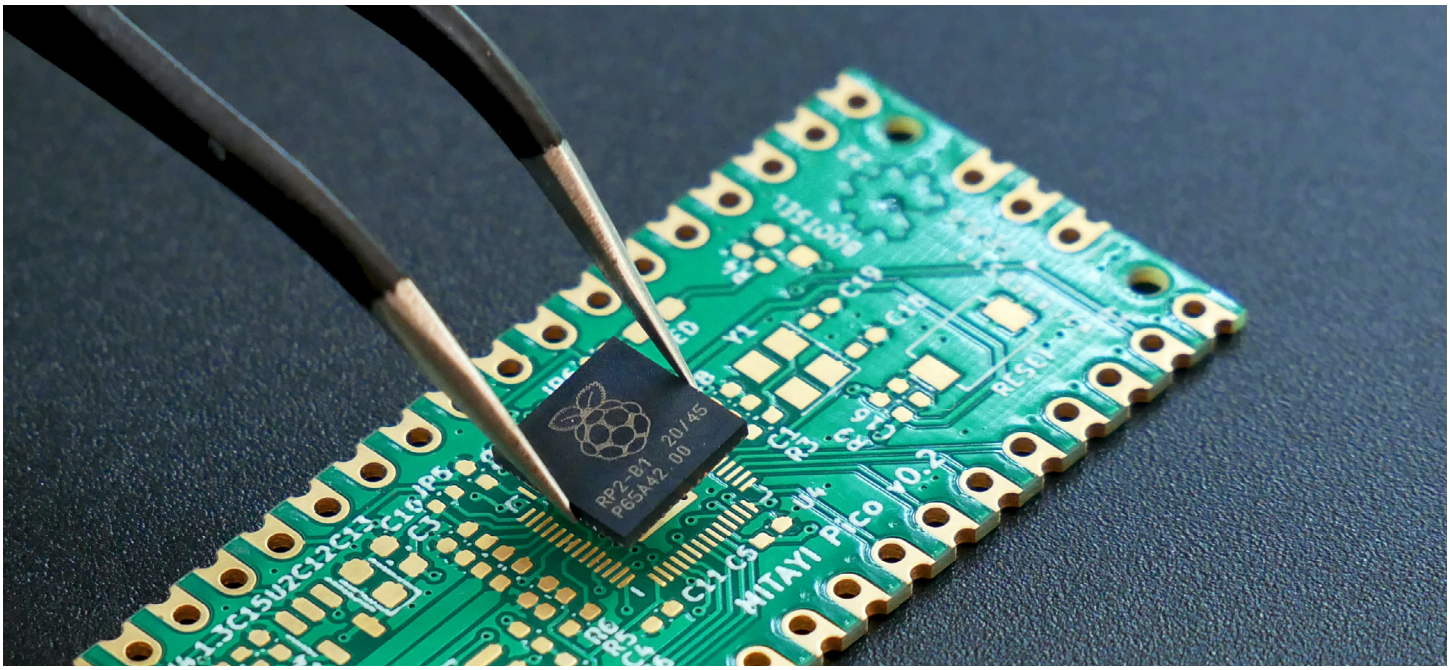
Contents

The Purpose of This Series

This report series is meant to serve a specific audience, targeted to Orlando, including companies in need of semiconductor manufacturing talent or related talent, higher education providers looking to support the development of this industry with programming and training, and workforce development institutions in search of new upward mobility pathways for the individuals they serve.

Part I is meant to be a practical guide to the current semiconductor manufacturing ecosystem in the Orlando region. It is intended as a resource for those who know very little about semiconductor manufacturing but recognize it as an opportunity for workforce development and for those who want to understand the evolving ecosystem supporting this industry in Orlando. Part II is focused on understanding the semiconductor manufacturing workforce and identifying skills-based methods for hiring and upskilling.

This series does not intend to add to the plethora of reports testifying to the general size of the semiconductor industry, outline where new fabs are being built across the country, or even provide an overview of the vision for growth at NeoCity in Osceola County.



The Investment and Opportunity

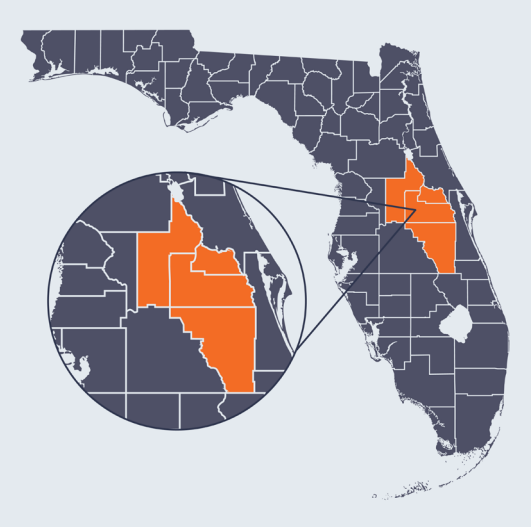
Semiconductors are everywhere. Used in everything from smartphones to spaceships, the simplest definition of a semiconductor is a device that controls or manages the flow of current in electronic equipment and devices. Given its modern connotation, it may be surprising to learn that the term "semiconducting" was first used in 1782 and the first semiconductor device was patented in 1904.[1]

Since then, semiconductors have transformed modern life, and it is difficult to explain beyond platitudes just how important these small devices have become. Sources differ, but there are anywhere from 1,000 to 3,000 semiconductors in a modern car.[2] According to the Semiconductor Industry Association (SIA), "a single semiconductor chip has as many transistors as all of the stones in the Great Pyramid in Giza, and today there are more than 100 billion integrated circuits in daily use around the world—that's equal to the number of stars in our corner of the Milky Way galaxy."[3]

The abundant use of semiconductors is partly why America's semiconductor manufacturing industry has vaulted into national discourse in recent years. While the US holds 90 percent of the global market for semiconductor tool design, 80 percent of the world's semiconductor manufacturing capacity resides in East Asia, mainly in Taiwan and South Korea.[4] Today, the US makes only 12 percent of the world's semiconductors, a drop from 37 percent in the 1990s.[5] Supply chain disruptions caused by the COVID-19 pandemic (as well as other global events) and the resulting chip shortage underscored just how essential consistent semiconductor availability is to everyday life and national security.

In response to the semiconductor shortage, the Federal government passed the CHIPS and Science Act (The CHIPS Act) in August of 2022. The CHIPS Act is a $280 billion-dollar federal investment, over 10 years, in reshoring semiconductor-making capacity.

A NOTE ABOUT GEOGRAPHY: In this report, the term Orlando or Orlando region refers to the Orlando Metropolitan Statistical Area (Orlando MSA), a four-county region encompassing Lake, Orange, Osceola, and Seminole County. MSAs represent regional labor markets and the economic relationships between counties. Occasionally in this report, a wider area that goes beyond the Orlando MSA will be referred to as Central Florida.



(1) https://djena.engineering.cornell.edu/hws/history_of_semiconductors.pdf

(2) https://www.forbes.com/sites/willyshih/2022/11/20/why-are-automotive-chips-still-in-short-supply/?sh=fe0c36d782a2

(3) https://www.semiconductors.org/semiconductors-101/what-is-a-semiconductor/

(4) https://www.ispionline.it/en/publication/microscopic-three-way-competition-30188

(5) https://www.mckinsey.com/industries/public-and-social-sector/our-insights/the-chips-and-science-act-heres-whats-in-it

> *"The majority—$200 billion—is for scientific R&D and commercialization. Some $52.7 billion is for semiconductor manufacturing, R&D, and workforce development, with another $24 billion worth of tax credits for chip production."*[6]

Looking locally, the need to re-shore and reinvent chip-making capacity in America is partly what led to the Orlando region's successful bid for a Build Back Better award from the US Economic Development Administration. The Orlando region was awarded $50.8 million to develop the semiconductor manufacturing industry in Osceola County at NeoCity by accelerating the growth of the specialized semiconductor manufacturing ecosystem and investing in the region's semiconductor workforce development capabilities.

The last comment about workforce development is important. Across America, talent is a major bottleneck for reshoring the semiconductor manufacturing industry (just behind fab capacity). Estimates from a recent eightfold.ai report show that,

> *"to meet the capacity needs for only the critical semiconductor applications, the US needs to add about 5.5 percent of the global production. This would mean about 18 to 20 fabs and about 70-90,000 total fabs jobs.* ***Rising to meet this opportunity would require the US to increase its current workforce by about 50 percent.*** *If the US were to not just handle critical needs but become self-sufficient, almost 20 percent of global production would need to be added. That would mean 74-80 fabs required and 300,000 total fabs jobs."* [7]

As more fab capacity comes online, staffing needs in the semiconductor industry will grow. Orlando is no exception to the workforce development challenges emerging across the county and regional stakeholders are already investing in research and models to understand local workforce needs for the industry. In fact, this report is an outcome of that exact investment.

TERMINOLOGY AND BACKGROUND: A fab, or semiconductor fabrication plant or foundry, is where semiconductors are produced. Fabs require specialized equipment and clean rooms. There are two ways to think about how semiconductor research and development integrates with semiconductor production in fabs. 1) Fabs that produce their own designs, such as Intel, are known as integrated device manufacturers (IDMs). 2) Companies that farm out their designs to be manufactured in fabs they do not own are called fabless semiconductor companies. Those fabs that produce chips they did not design are called pure-play semiconductor foundries.

(6) https://www.mckinsey.com/industries/public-and-social-sector/our-insights/the-chips-and-science-act-heres-whats-in-it

(7) https://eightfold.ai/wp-content/uploads/How_the_US_Can_Reshore_the_Semiconductor_Industry.pdf

The Life Cycle of a Semiconductor – The Basics

Currently, the supply chain for producing semiconductors is spread around the globe. Most design and development take place in the United States while most manufacturing and assembly take place in different parts of Asia. To reiterate, the US holds 90 percent of the global market for semiconductor tool design, while 80 percent of the world's semiconductor manufacturing capacity resides in East Asia, mainly in Taiwan and South Korea.[8]

This story is not unique to the semiconductor manufacturing industry. The globalization of supply chains and industries has allowed each nation to use its competitive advantages to specialize in different ways, resulting in less expensive goods that are available to consumers around the world. However, a cascade of events since 2018 including factory fires in Japan, a winter storm in Texas, power outages in Germany, and a global pandemic created merging ripple effects that resulted in a worldwide shortage of the semiconductor devices modern life has come to rely on.[9]

The map in **FIGURE 1**, adapted from a 2021 Boston Consulting Group and Semiconductor Industry Association (SIA) collaborative report,[10] outlines the current, global nature of the supply chain for semiconductor manufacturing.

As **FIGURE 1** shows, there are many players in the industry ranging from: the firms that design the chips, to the firms that design the tools to make the chips, to the global suppliers of raw materials, to the multiple producers, to the assemblers of final products. As a 2022 report from the American Semiconductor Academy puts it, "the semiconductor industry includes integrated device manufacturers; semiconductor foundries; fabless chip design firms; assembly, testing, and packaging service providers; wafer fabrication equipment and metrology tool vendors; semiconductor wafer and chemical suppliers; electronic design methods and automation software providers. The broader microelectronics ecosystem includes elec-

A NOTE ON TERMINOLOGY: The terms semiconductor, chip, and wafer have come to be used interchangeably, depending on the source. This report recognizes that there is a difference between a semiconducting material, such as silicon, a semiconductor device, such as a transistor, and larger semiconductor systems that fit multiple transistors on a single chip. From this point forward, the term semiconductor is used to broadly describe all manner of semiconductor devices and chips. Occasionally, the term chip will also be used.

"80 percent of the world's semiconductor manufacturing capacity ***resides in East Asia"***

(8) https://www.ispionline.it/en/publication/microscopic-three-way-competition-30188

(9) https://info.fusionww.com/blog/the-global-chip-shortage-a-timeline-of-unfortunate-events

(10) https://www.semiconductors.org/wp-content/uploads/2021/05/BCG-x-SIA-Strengthening-the-Global-Semiconductor-Value-Chain-April-2021_1.pdf

FIGURE 1 – MAP OF THE GLOBAL SEMICONDUCTOR MANUFACTURING SUPPLY CHAIN

Source: Strengthening the Global Semiconductor Supply Chain in an Uncertain Era. Boston Consulting Group & SIA, April 2021.

tronics systems companies, researchers, and educators."[11]

To put it simply, the supply chain is vast. **FIGURE 1** shows how the semiconductor manufacturing industry flows globally. To further simplify this process and understand the lifecycle of a chip, those steps can be reduced down to four main phases of semiconductor development.

1. **Phase One – Research & Development:** The US controls this space, which includes the design and manufacturing of the equipment needed to make semiconductors. For example, "90 percent of the market for EDA tools (the software needed for the conception of all integrated circuits) is controlled by a handful of American companies, with one European exception."[12] EDA stands for electronic design automation meaning these software tools allow for the computer-aided design of semiconductor devices. They simulate how different electronic compo-

(11) https://www.semi.org/sites/semi.org/files/2022-08/SEMI_ASA_Vision_Paper_Version1.pdf

(12) https://www.institutmontaigne.org/en/publications/weak-links-chinas-drive-semiconductors

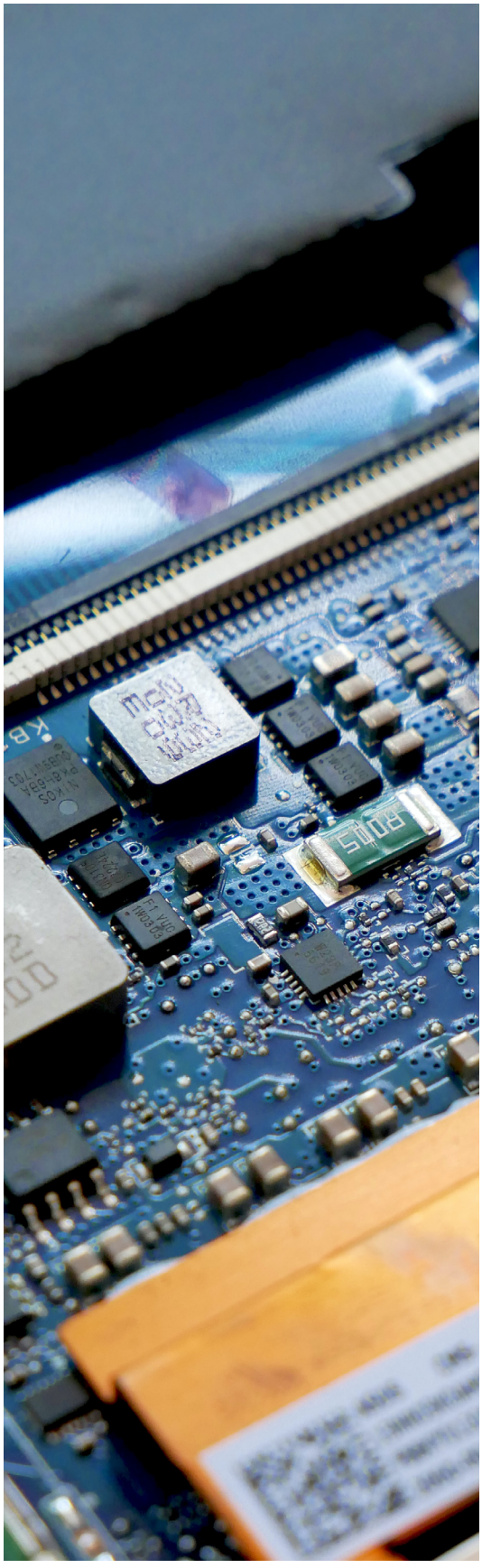
nents will fit together and how well they work before the components are ever assembled in the physical world.

2. **Phase Two – Materials:** Even the raw silicon used to make semiconductor devices has a complicated global supply chain. According to the Boston Consulting Group, "silicon dioxide is mined in the US and refined into metallurgical grade silicon." This product is then "melted and re-crystallized to form a large single crystal called an ingot by a manufacturer in Japan. The ingot is sliced into several wafers in South Korea, which are then polished and shipped to a fabrication plant".[13]

3. **Phase Three – Foundry:** This is the manufacturing stage as it is typically talked about in US media. Imagine clean rooms full of workers in white body suits carefully preparing electronic components. During this phase, a foundry (typically in Taiwan) imprints the polished and prepped wafers with incredibly small patterns. These patterns are important because they determine how many transistors can fit on a chip, which determines how much processing speed and power the chip holds. "Today, the technological frontier (for the distance between transistors) is between 10 and 5 nanometers. Taiwan Semiconductor Manufacturing Company (TSMC) accounts for a 90 percent market share of this technology."[14]

4. **Phase Four – Assembly and Packaging:** The wafters are then sliced into individual components and put together in different configurations, a process called packaging. An outsourced semiconductor assembly and test (OSAT) manufacturer may perform this step in Malaysia, packaging and testing the chips. Packaged chips are then shipped all over the world to be used in the assembly of final products, such as the iPhone factories in China.

Worth noting is the concept of advanced packaging. **Advanced packaging** allows for a high number of connections between devices to increase the efficiency or processing power of chips without having to "resort to smaller transistors".[15] Instead, different technologies and techniques are used to combine arrays of chips into smaller and smaller spaces. Advanced packaging requires the use of processes similar to fabrication, meaning it sits somewhere between foundry and assembly (phases three and four) in the semiconductor device lifecycle.



(13) https://www.semiconductors.org/wp-content/uploads/2021/05/BCG-x-SIA-Strengthening-the-Global-Semiconductor-Value-Chain-April-2021_1.pdf

(14) https://www.ispionline.it/en/publication/microscopic-three-way-competition-30188

(15) https://en.wikipedia.org/wiki/Advanced_packaging_(semiconductors)

Orlando's Role in the Semiconductor Manufacturing Ecosystem

Orlando is poised to carve out a special niche in the semiconductor manufacturing ecosystem. As the CHIPS Act stimulates reinvestment in and the reshoring of semiconductor fabs, Orlando's high concentration of aviation, aerospace, and defense companies makes it the perfect location to focus specifically on advanced packaging of semiconductors for sensitive (from a national security perspective) use cases.

The Orlando region and the neighboring Space Coast (Brevard County) are home to seven of the largest aerospace and defense companies on the Fortune 500 list including Lockheed Martin, Northrop Grumman, L3Harris, and Leidos. Specifically, Orlando is home to Lockheed Martin's Missile and Fire Control division which

> *"develops, manufactures and supports advanced combat, missile, rocket, manned and unmanned systems for military customers that include the U.S. Army, Navy, Air Force, Marine Corps, NASA and dozens of foreign allies."*[16]

When President Biden visited Lockheed Martin's operations facility in Troy, Alabama in early 2022, he noted that Javelin anti-tank missiles (which the US has been producing and providing to Ukraine in their war against Russia) use more than 200 semiconductors each.[17] This has become a go-to example of why it is critical to have a strong, domestic supply of semiconductors in the United States. Looking locally, however, there are similar examples of a need for special semiconductor development in Orlando.

> *"Lockheed Martin has been clear in its support to expand America's semiconductor industry which is critical to the aerospace and defense supply chain and enables our customers' national security missions," says Zach Sherman, Director of Government Relations at Lockheed Martin. "A fighter jet, space mission, or*

... Javelin anti-tank missiles use more than ***200 semiconductors*** each...

(16) https://www.lockheedmartin.com/en-us/who-we-are/business-areas/missiles-and-fire-control.html

(17) https://fedscoop.com/biden-visiting-javelin-missile-factory-urges-congress-to-pass-chips-semiconductor-funding/

helicopter could use thousands of these high-performance semiconductors. A missile or radar may use hundreds. Our operations in Orlando develop and support advanced sensor systems and missiles, and these semiconductors are a critical part of their capability and production."

These defense-related examples offer a clear argument for why there need to be semiconductor producers that not only operate in America but are also fully American-owned and can develop the types of cutting-edge semiconductors needed by the US defense industry. Combined with Orlando's other industries such as healthcare, autonomous vehicles, simulation, gaming, and entertainment, the region offers semiconductor manufacturers a plethora of customers with unique needs.

This is where the concept of advanced packaging comes into play. The types of advanced, highly sensitive, low-to-mid-volume chips needed by the industries noted above cannot be manufactured, for example, in the massive TSMC foundry being built in Phoenix, Arizona, or the large Intel foundry being built in Columbus, Ohio.[18] They require foundries that specialize in advanced packaging, a process that combines phases three and four of the semiconductor manufacturing lifecycle. There are many highly technical tools and approaches used in advanced packaging, meaning that these chips require their own foundries and specialists before they can be assembled into their final products.

Advanced packaging is Orlando's niche in the semiconductor manufacturing space and the presence of specific companies, such as SkyWater Technology (SkyWater), proves it. SkyWater is the only US-investor owned, pure-play semiconductor and technology foundry and specializes in custom technology development. Headquartered in Minnesota, SkyWater established a subsidiary, SkyWater Florida, in 2021 at the Center for NeoVation in Osceola County. The expansion happened, in part, due to the presence of BRIDG, a non-profit that aims to bridge the gap between R&D and commercialization through public-private partnerships. From SkyWater's press release about the expansion,

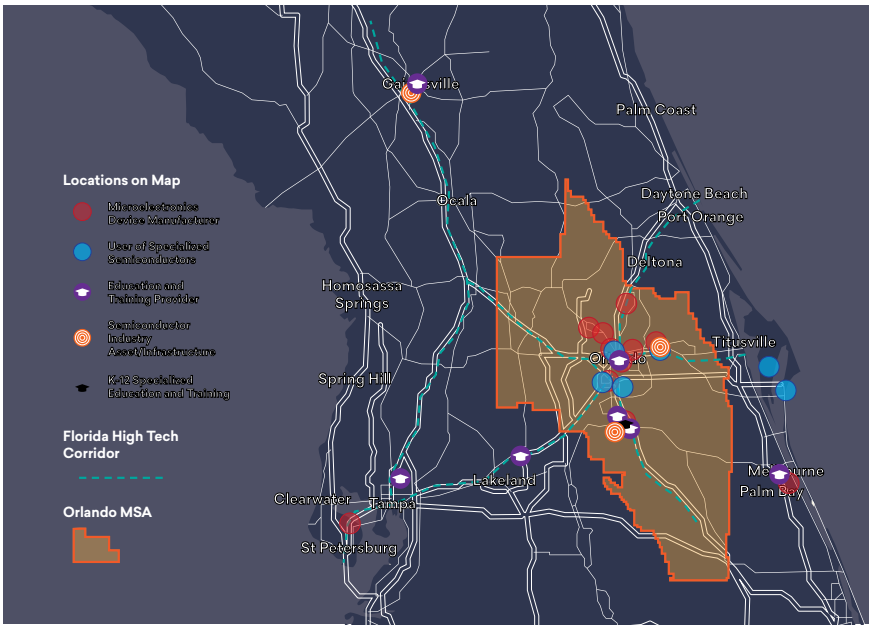
"SkyWater will support BRIDG with multiple Department of Defense contracts, illustrating how US-based public-private partnerships can play a significant role in securing the nation's semiconductor supply chain."[19]

(18) https://www.tomshardware.com/news/new-us-fabs-everything-we-know

(19) https://www.skywatertechnology.com/skywater-expanding-with-florida-facility-to-accelerate-domestic-advanced-packaging-capabilities-for-microelectronics-manufacturing/

FIGURE 2 highlights the infrastructure and regional assets that are part of the semiconductor manufacturing ecosystem in Central Florida. The map can be viewed online with more detail on each of the points of interest by visiting **Orlando.org/upskillsemi-conductor.**

FIGURE 2 – ORLANDO AND BEYOND, SEMICONDUCTOR MANUFACTURING ECOSYSTEM



Microelectronic device manufacturers included on the map are listed in **TABLE 1** below.

TABLE 1: MICROELECTRONIC DEVICE DESIGNERS OR MANUFACTURERS IN ORLANDO AND BEYOND

COMPANY	CENTRAL FL LOCATION
Advanced Micro Devices, Inc.	Orlando
Best Global Source	Apopka
MEI Micro, Inc.	Orlando
MtronPTI	Orlando
Qorvo Us, Inc.	Apopka
Quality Manufacturing Services, Inc.	Lake Mary
Sawstreet LLC	Orlando
SkyWater Florida	Kissimmee
Renesas	Palm Bay
Siemens*	Orlando
Jabil	St. Petersburg

**Siemens works with BRIDG to develop digital twin technologies for the semiconductor industry.*

There are also multiple non-profits, consortiums, and specialized industry assets that bolster the semiconductor manufacturing ecosystem in Central Florida. Those specialized industry assets are listed in **TABLE 2**

TABLE 2: SEMICONDUCTOR MANUFACTURING INDUSTRY ASSETS IN CENTRAL FLORIDA

ORGANIZATION	DESCRIPTION
BRIDG & NeoCity	Established in Florida as a not-for-profit, industry-friendly public-private partnership, BRIDG accelerates technology commercialization by providing solutions to bridge technology and capability gaps across multiple fields. BRIDG is located at NeoCity in Osceola County, a 500-acre, master-planned campus that will serve as a global center of advanced research.
Central Florida Research Park	Central Florida Research Park in Orange County at the University of Central Florida provides a university-like environment where corporations, startups, and university researchers can share facilities and pursue cooperative projects. It is home to the largest cluster of modeling, simulation, and training companies in the world as well as the National Center for Simulation and Training and the Army, Air Force, Navy, and Marines simulation operations.(20)
The Florida High Tech Corridor	The Florida High Tech Corridor covers a 23-county area anchored by three major research institutions: the University of Florida, the University of Central Florida, and the University of South Florida. The Corridor works to align academia, industry, and economic development to promote the development of specific industry clusters in Florida. The Corridor established a formal cluster management organization (CMO) for Central Florida's semiconductor industry. The new semiconductor CMO is focused on leveraging synergies within the cluster community, existing regional strengths, and a well-established global network to address the specific needs of Central Florida businesses. It is the fifth CMO under the Corridor's Cenfluence Cluster Initiative.
SCALES Consortium	SCALES is a non-profit that aims to bring new R&D and prototyping operations to the Southeast. "SCALES brings together leading experts from academia, industry, and national labs in the area of advanced semiconductor design and fabrication; advanced packaging and heterogeneous integration; 2.5D and 3D design; quantum physics; emerging devices and technologies; EDA; test, characterization and assurance."(21)
University of Central Florida	The University of Central Florida (UCF) is one of the largest universities in the country and offers a unique set of assets for the semiconductor industry. For one, "the CREOL Nanofabrication Facility (CNF) consists of 3,000 square feet of Class 100 and Class 1000 cleanrooms with standard optical lithography, deposition and etching tools, as well as a Raith (formerly Leica) 5000+ e-beam lithography instrument capable of 10-nm resolution. CNF is used for the fabrication of integrated photonic devices and circuits. The facility is open to companies and other outside users and is a part of UCF's Nanofabrication Shared Facility, which includes cleanrooms in the College of Engineering and Computer Science and the College of Sciences."(22) Furthermore, UCF recently received Build Back Better funding to develop a digital twin of the Center for NeoVation in Osceola County. The digital twin will "replicate its production line, increasing microchip reliability and productivity, lowering maintenance costs, reducing risk, creating new business, improving supply and delivery chain efficiency, and enabling cross-discipline collaboration to foster innovation."(23)

(20) https://www.ucf.edu/modeling-simulation/

(21) http://scales-consortium.org/about/

(22) https://creol.ucf.edu/research/cleanroom/#:~:text=The%20CREOL%20Nanofabrication%20Facility%20(CNF,capable%20of%2010%2Dnm%20resolution.

(23) https://www.ucf.edu/news/ucf-receives-8-8m-for-digital-twin-initiative-as-part-of-federal-build-back-better-regional-challenge/

After taking in this industry primer, readers are encouraged to continue their journey learning about the semiconductor manufacturing industry in Orlando by reading Part II of this series, **Semiconductor Manufacturing in Orlando: Part II – A Skills-based Approach to Workforce Development.** Part II offers a framework for understanding the talent needs of semiconductor manufacturing companies and highlights occupations that have a strong skill overlap with these in-demand roles.

Part II of this series can be found by visiting **Orlando.org/upskill-semiconductor.**

For more information on how to capitalize on these regional assets or to connect on workforce development efforts, **contact Tammy Humphrey at the Orlando Economic Partnership**.

Tammy Humphrey

Senior Director,
Talent Development

Tammy.humphrey@orlando.org

407.404.2576

About the Orlando Economic Partnership

The Orlando Economic Partnership is a public-private, not-for-profit economic and community development organization. The Partnership represents seven counties in Central Florida, including the City of Orlando, and hundreds of the region's top private businesses.

Through the power of our partnerships, we strengthen our regional assets and businesses, advocate for regional priorities and write the next chapter of Orlando's story. We are injecting fresh resources and perspectives while harnessing the strength of the region's culture of collaboration and innovation to create a new future for our diverse and growing population.

About the Foundation for Orlando's Future

The Foundation for Orlando's Future provides analytical insight, strategic foresight and leadership development to inform and drive the region's pursuit of quality job creation, economic growth and broad-based prosperity by educating and empowering community leaders.

This report was made possible through the generous contributions of

JPMorgan Chase & Co.

Orlando.org/Reports | 200 S. Orange Avenue, Suite 200, Orlando, FL 32801 | 407.422.7159

The Foundation for Orlando's Future is a core Component of the Orlando Economic Partnership