



2016 Top Markets Report **Semiconductors and Semiconductor Manufacturing Equipment** Sector Snapshot

Semiconductors

The United States is the semiconductor industry global leader with U.S.-based semiconductor companies making up 50 percent of the total world market.¹ Although the U.S. is the second ranked market for semiconductors sales, it makes up less than 20 percent of the total global sales. Therefore, U.S. semiconductor companies need to focus abroad to ensure commercial success. Over three-quarters of worldwide semiconductor sales take place in the five country case study areas (China, the EU, Japan, Korea and Taiwan) and in the U.S. home market.

Industry Overview

The vast majority of electronics production is concentrated in the Asia-Pacific region. As a result, the Asia-Pacific region continues to grow faster as a U.S. export market than Europe and Latin America, though the EU continues to be a key market for semiconductors. Five of the top six markets for semiconductors (China, the European Union, Japan, South Korea and Taiwan) are featured in the country case studies. Singapore is ranked fifth among the top U.S. export markets for semiconductors; information on that market is limited, however, so it has been omitted from deeper analysis. A regional overview and a brief synopsis on Singapore, other key Southeast Asian markets and other markets of note outside the country case studies is included in the sector snapshot.

Semiconductor is the scientific name given to materials that partially conduct electricity. In this report, semiconductors relate to three distinct categories of microchips: discrete semiconductors, having one diode and transistor; integrated circuits (ICs), having up to several billion transistors on one microchip; and system-level products, typically multiple ICs encased in a single package or IC, and

MEMs (microelectromechanical systems, or micromachines) sensors or passive components encased in a single package. Semiconductors are the “brains” inside electronics and make the global trillion dollar electronics industry possible.

According to IC Insights, in 2015, certain categories of discrete semiconductors – including optoelectronics and sensors and MEMs– reached

Figure 1: Semiconductor Markets Rankings (Top 20)

1. China
2. Japan
3. South Korea
4. Singapore
5. Taiwan
6. Malaysia
7. Germany
8. Mexico
9. Thailand
10. Vietnam
11. India
12. Brazil
13. France
14. Indonesia
15. Netherlands
16. Philippines
17. Thailand
18. Israel
19. Poland
20. Hungary

record sales of \$66.6 billion, and MEMs accounted for 18.8 percent of the total semiconductor industry, up from 15.3 percent in 2005 and 12.7 percent in 1995. New end-use applications, especially IoT, along with overall global economic growth, are expected to result in increased sales of semiconductors. IC Insights projects that optoelectronics (such as LEDs, image sensors and infrared) are growing at a CAGR of 8.3 percent, that sensors and actuators (such as pressure sensors) are rising by a 5.6 percent CAGR, and other discrete semiconductors (such as non-photon diodes) are rising by a 3.5 percent CAGR in the 2015 to 2020 period.² For integrated circuits, Gartner Group expects NAND Flash to grow at a CAGR of 8.7 percent through 2019.³ Although sensors sales are the highest percentage of value for IoT, analog, processors, connectivity (network communications) and memory ICs are also used for IoT.⁴

There are three main types of semiconductor companies:

- *Integrated Device Manufacturers* (IDMs) design, manufacture and sell their own semiconductors. Examples are Intel or Samsung.
- *Dedicated Foundries* are essentially “factories for hire” with the sole purpose of manufacturing semiconductors per customers’ specifications.
- *Fabless* companies design semiconductors and contract out the manufacture of their proprietary designs to either foundries or IDMs with spare manufacturing capacity.

IDMs are increasingly offering foundry services as well as manufacturing their own semiconductors (both first ranked Intel and second ranked Samsung are doing so).⁵ Because a single state-of-the-art fab requires a capital investment of \$5 to \$10 billion dollars,⁶ it needs to be producing at a certain capacity to justify the initial and ongoing expense, so the foundry industry has developed to serve as manufacturers for fabless companies. Intellectual property protection, licensing, R&D spending and trade secret protection are important issues for all types of semiconductor firms, but they are vital issues for fabless companies, as their designs are their product.

The U.S. is home to global leaders in the three categories of semiconductor companies. Examples

include Intel (IDM), Globalfoundries (U.S./Dubai)(foundry), and Qualcomm (fabless). U.S. companies lead in both the IDM and fabless shares of the world IC market, with 50 percent and 63 percent, respectively. In contrast, Korea and Japan both have less than a 1 percent share of the fabless IC market; Taiwan has only 2 percent of the IDM market; Europe has 8 percent of the IDM market and 2 percent of the fabless market, and China and others have less than 1 percent of the IDM market.⁷ Taiwanese companies lead in foundry, with 74 percent share of that world market; the U.S. is in second place with a 12 percent share.⁸

A related industry is *outsourced semiconductor assembly and test* (OSAT), which is the back-end manufacturing focused on packaging and testing semiconductors, a critical but more automated part of the semiconductor supply chain. Many IDMs have their own captive semiconductor packaging business, which often takes place in dedicated subsidiaries in China, Taiwan and Southeast Asian countries.

Semiconductor applications or end markets can be divided into six categories:

1. *Communications* is the largest end-market – growth in this area is driven currently by demand for smartphones and wireless networks and, in the not too distant future, by the Internet of Things (IoT) – connected devices in the home or workplace.
2. *Computers* – growth in this area is being driven by demand for tablets.
3. *Consumer Electronics* – leading growth in this category are digital TVs including game consoles, audio for home theater systems, blue tooth enabled speakers, the sudden proliferation of fitness wearables that track just about every part of your day and, in the not too distant future, the IoT.
4. *Automotive Electronics* – advanced electronics now control just about every aspect of the automobile, and the installation of “infotainment” systems is growing especially fast.
5. *Industrial/Medical* – smart grids, smart cities, factory automation and robotics, industrial IoT and health IT are major forces at work in the category.
6. *Government and Military* procured products.

U.S. Semiconductor Export Base

Semiconductors drive innovation and are key components of computers, telecommunications equipment, consumer electronics, automobiles, aviation, medical equipment, industrial and commercial machinery, and critical infrastructure.

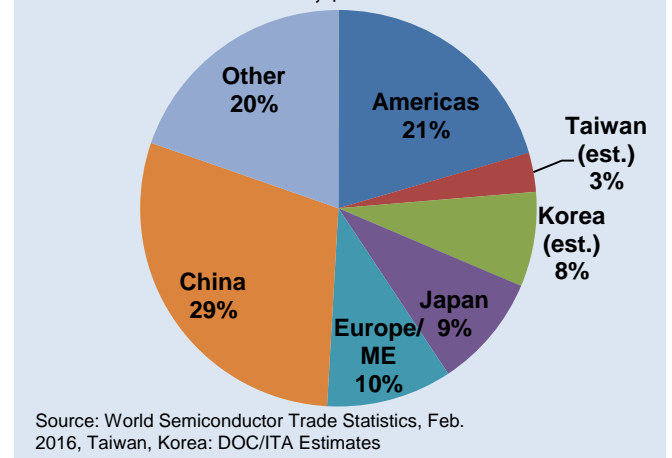
According to industry, in 2015, the semiconductor industry directly employed over 240,000 workers in the United States, and for every direct job, there were 4.89 jobs supported in other parts of the U.S. economy. That equals approximately 1.2 million additional jobs because of a thriving U.S. semiconductor industry; even more impressive is that a job in the semiconductor industry pays on average 2.5 times more than the average salary of all U.S. workers.⁹ The semiconductor industry is consistently among the top U.S. exporting sectors and is a worldwide leader in R&D, design and manufacturing. The industry is a driver of innovation, productivity and high wage jobs.

The U.S. share of world semiconductor exports does not measure the true U.S. share of the global market due to the high volume of re-exports for OSAT and transshipments. The industry's preferred measure of competitiveness is sales: sales by U.S. firms within the United States, direct U.S. exports, sales by U.S.-owned overseas subsidiaries and foreign sales of U.S. chips fabricated under contract overseas, rather than U.S. exports and imports alone, which reflect only the movement of goods.

Overview of Global Export Market Opportunities

Although at the end of 2015 worldwide sales of semiconductors had remained flat in comparison to 2014 (reduction from \$335.8 to \$335.2 billion or 0.2 percent), if exchange rates had remained constant, sales would have risen. According to WSTS, China remained the largest regional market, with 29.4 percent of sales, followed by North America with 20.5 percent, Europe and the Middle East with 10.2 percent, Japan with 9.3 percent and all other

Figure 2: Key Markets for Semiconductors, 2015 Sales, \$Billions



countries, primarily Korea, Taiwan and countries in Southeast Asia, taking up the remaining 30.6 percent.¹⁰

Current growth in electronics production is the main driver of the global semiconductor industry. Growing demand for smartphones, tablets, digital televisions, wireless communications infrastructure, network hardware, computers and electro-medical devices are stimulating global demand of semiconductors, although the overall annual growth is expected to slow to 3.5 percent.¹¹ The Internet of Things (IoT) – aka, internet connected devices – is in its infancy but will contribute significantly to semiconductor demand in the long-term as will the development of smart grids, smart cities and automated manufacturing.

North America

The North American market is mostly the U.S. market. The United States is the second largest market for semiconductors in the world. Mexico is a notable destination for U.S. exports, but the demand is mostly for assembly of electronic equipment on contract, known as EMS (Electronic Manufacturing Services), and the semiconductor buying decision would likely be made elsewhere.

Europe/Middle East (ME)

According to ITA estimates based on production of electronic equipment containing semiconductors,

and regional market share figures, and world import figures, the EU market represents 9 percent of the world market – the majority of the 10 percent share represented by Europe/Middle East. Of the other countries in the region, the only markets of note are Switzerland and Israel.

Southeast Asia

According to estimates, the South East Asian market makes up slightly over half of the “other” category. Southeast Asian markets in the top 10 (when counting the EU as a single market) are Singapore, Malaysia, Thailand and Vietnam. Although Singapore outranks Taiwan as a market, most of the electronic equipment manufacturing in Singapore is done by an EMS company or by non-Singaporean electronic equipment manufacturers with assembly factories in Singapore. In the latter case, the semiconductor buying decision often is made at the headquarters of the electronic equipment company, not at the site of the manufacturing plant. Notable among EMS companies is Singapore-owned Flextronics, the fifth largest EMS company in the world.¹² Singapore also is a major South East Asia shipping hub.¹³ All products entering Singapore, including semiconductors, are completely duty free.

A large percentage of the Malaysian electronics manufacturing is OSAT, and in the case of OSAT, the imports are not purchases. Instead, they are for the assembly of the semiconductors into packages and for testing and then exported to end markets. The same is true on a smaller scale for Thailand, and Singapore also has an OSAT industry. Malaysia and Thailand are participants in the WTO ITA and the recently negotiated WTO ITA expansion (see Appendix 1). Vietnam is a participant in the original WTO ITA so most semiconductors are duty free.

Other

There are many countries in the “other” category, but only India and Brazil are of note. They are ranked 11th and 12th respectively when the EU is counted as a single market. Neither is a very friendly market for U.S. exports – Brazil is not a participant of the WTO ITA, so semiconductors and semiconductor manufacturing equipment do not have duty-free access to that market. While India is party to the WTO ITA, recent information indicates India may still have duties on certain integrated circuits.

Competition

In 2015, 10 of the top 20 semiconductor companies were U.S. firms,¹⁴ and U.S. semiconductor companies generated over \$165.9 billion in sales and had 50 percent of the \$335.2 billion global market.¹⁵ The United States is the birthplace of the semiconductor industry, has always been in the forefront of the industry and has been a global market share leader, only losing the position for a short time to Japan in the late 1980s and early 1990s.

During the 1980s and 1990s, the semiconductor industry experienced over 15 percent compound annual growth rate.¹⁶ In the 1980s, Japan rose in prominence but later waned in the late 1990s, as South Korea’s share rose. Both countries benefitted from the double digit growth rates in the industry, with the most intense competition taking place in the DRAM space. The European Union competes primarily in certain niche products, such as smart cards and automotive semiconductors. Taiwan is the leader in the foundry sub-sector, which is not included in the competition chart in the overview because foundries are sub-contractors for the fabless semiconductor companies, and inclusion would cause double-counting.¹⁷

Currently, Korea is the second ranked semiconductor manufacturing economy in the world (after the U.S.) and the leader in the memory market. Samsung and Hynix, together, hold 70 percent share in the global DRAM market and 50 percent of the global NAND flash market.¹⁸ The U.S. also competes in the memory sub-sector, primarily through Micron.

Challenges

The market for semiconductors is no longer growing in the double digits; the compound annual growth rate for the integrated circuits sub-sector has slowed to around 3.5 percent beginning in the 2000s and is expected to retain that rate well into the 2020s.¹⁹ Looking ahead, in the medium to-long term, China’s ambitious national integrated circuits industry development policies may upend the competition in the world semiconductor industry, as China’s government tries to increase China’s share of a slow-growing global semiconductor market.

According to IC Insights, “China’s ambitious goal to become self-sufficient in semiconductor manufacturing and reduce imports of ICs from foreign suppliers has also launched a number of acquisitions by Chinese companies and investment groups. IC Insights believes that the increasing number of mergers and acquisitions (M&As), leading to fewer major IC manufacturers and suppliers, is one of major changes in the supply base that illustrates the maturing of the industry. In addition to the wave of M&As currently taking place, trends, such as the lack of any new entry points for startup IC manufacturers, the strong movement to the fabless and “fab-lite” business model, and the declining capital expenditure as a percent of sales ratio, all promise to dramatically reshape the semiconductor industry landscape over the next five years.”²⁰ More information on China’s government initiative to achieve this goal is provided under the China country section of this report.

According to the Semiconductor Industry Association (SIA), counterfeit semiconductors cost the U.S. semiconductor industry an estimated \$7.5 billion per year, which translates into nearly 11,000 lost American jobs.²¹ Counterfeit semiconductors pose serious risks to global supply chains, public health and safety, and civilian and military infrastructure. They are a growing problem for the United States and many other countries, despite gradual improvements in IPR enforcement around the world. Often harvested from electronic waste (e-waste), most counterfeit semiconductors are e-waste components re-marked to indicate that they are new or that they perform to a higher standard. These counterfeits are assembled inside supposedly new electronic equipment.

Due to age, mishandling or unsuitability to the task, these counterfeits can prematurely fail or simply not function as expected. This is especially dangerous when they are assembled into navigational, detection, testing or monitoring electronics and similar products, as the buyer may not have any warning that the product is not functioning properly. Many of these counterfeit semiconductors originate from China.

Semiconductor Export Opportunities in the Near Term

Worldwide semiconductor sales, according to WSTS projections, will grow 0.3 percent in 2016 and then 3.1 percent in 2017. WSTS regional projections, however, groups all of Asia except Japan – including top markets China, Korea and Taiwan – into one category, so ITA is unable to develop useful projections for the specific markets. ITA expect the rankings to remain virtually unchanged from 2015 into 2016, but China’s status is less certain and is likely to take some, albeit modest, market share from other major players.

Planning for the Long Term

International Data Corporation expects that semiconductors sales will grow at a CAGR of 3.1 percent from 2014 to 2019 (though values will change from year to year).²² As electronics production shifts to lower cost countries, U.S. companies should consider entering or increasing their sales in Vietnam, the Philippines, Thailand and Indonesia.

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- ¹ "SIA 2016 Factbook", [Semiconductor Industry Association](#), March 2016.
 - ² "Nine O-S-D Product Categories Achieve Record Sales in 2015, says IC Insights" [Digitimes](#) 3/17/2016
 - ³ "Chip Forecasts, Drivers Diverge" [EETimes](#) 1/12/2015.
 - ⁴ "Sensors Hold Key to IoT Competitive Advantage" [EETimesAsia](#), 3/6/2015.
 - ⁵ "Fabless-Foundry Model Hit by Technology Chasm" [MarketRealist](#) 10/10/2015.
 - ⁶ "Beyond Borders – The Global Semiconductor Value Chain" SIA, Nathan Associates, April 2016.
 - ⁷ "U.S. Companies Continue to Capture Bulk of IDM and Fabless IC Sales" [IC Insights Research Bulletin](#), 4/5/ 2016.
 - ⁸ "Beyond Borders – The Global Semiconductor Value Chain" SIA, Nathan Associates, April 2016.
 - ⁹ "SIA 2016 Factbook" [Semiconductor Industry Association](#), March 2016.
 - ¹⁰ World Semiconductor Trade Statistics, Blue Book, December 2015, 2/2016.
 - ¹¹ "Global Semiconductor Market Slumps in 2015, IHS Says", [IHS.com](#) 4/4/2016.
 - ¹² "Major EMS Players Continue to Nose Their Way Into the Traditional OEM Space" [Circuit Assembly](#) 4/29/2016.
 - ¹³ "Industry Forecast – Singapore Q2 2016" Freight Transport and Shipping [Business Monitor Online](#) 4/13/ 2016.
 - ¹⁴ "Global Semiconductor Market Slumps in 2015, IHS Says" [IHS.com](#), 4/4/2016.
 - ¹⁵ "SIA 2016 Factbook" [Semiconductor Industry Association](#), March 2016.
 - ¹⁶ "Global Semiconductor Market Slumps in 2015, IHS Says", [IHS.com](#) 4/4/2016.
 - ¹⁷ "Apple Drove Entire Foundry Sales Increase at TSMC in 2015" [IC Insights Research Bulletin](#) 4/26/2016.
 - ¹⁸ "An Overview of the Semiconductor Industry" [Market Realist](#) 9/10/2015.
 - ¹⁹ "Global Semiconductor Market Slumps in 2015, IHS Says", [IHS.com](#) 4/4/2016.
 - ²⁰ "Tsunami of M&A Deals Underway in the Semiconductor Industry in 2015", [IC Insights Research Bulletin](#) 4/26/2016.
 - ²¹ Oral Testimony of SIA President Brian Toohey during the Senate Armed Services Committee Hearing on Counterfeit Electronic Parts in the Department of Defense's Supply Chain, November 8, 2011.
 - ²² "An Overview of the Semiconductor Industry" [Market Realist](#) 9/10/2015.