



INTERNATIONAL
TRADE
ADMINISTRATION

2016 Top Markets Report **Semiconductors and Related Equipment**

A Market Assessment Tool for U.S. Exporters

July 2016



Industry & Analysis' (I&A) staff of industry, trade and economic analysts devise and implement international trade, investment, and export promotion strategies that strengthen the global competitiveness of U.S. industries. These initiatives unlock export, and investment opportunities for U.S. businesses by combining in-depth quantitative and qualitative analysis with ITA's industry relationships.

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Executive Summary

The U.S. semiconductor industry is the leading provider of semiconductors to the world with a majority of global market share. U.S. companies also lead in the semiconductor manufacturing equipment sector, accounting for 47 percent share of the world market. Over 80 percent of U. S. semiconductor sales take place outside of the U.S., and 84 percent of semiconductor manufacturing equipment sales take place outside of the United States. In order to compete in this industry, most semiconductor and semiconductor manufacturing equipment companies must export. Top markets for semiconductors and semiconductor manufacturing equipment are China, the European Union, Japan, Korea (South), Singapore and Taiwan.

Semiconductors: Current growth in electronics production is the main driver of the global semiconductor industry. Growing demand for smartphones, tablets, digital televisions, wireless communication infrastructure, network hardware, computers and electro-medical devices is stimulating global demand for semiconductors, but the overall annual growth for 2015 is expected to slow to 3.5 percent.¹ 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 growth of smart grids, smart cities and automated smart manufacturing.

Semiconductor Manufacturing Equipment: Projections of sales of fab (semiconductor fabrication/manufacturing facility) equipment show 13.2 percent growth in the world market from 2016 to 2017 (to an estimated \$42.8 billion), to be driven by equipment for foundries, and for memory and power semiconductor manufacturing.² China is expected to start or complete eight new fabs in 2015 to 2016, outstripping planned facilities in Taiwan and Southeast Asia, with five new fabs each; the Americas (United States) with four; and Korea, Europe and the Middle East, with one each. All of these facilities, should construction proceed, will need equipping in the late 2016 to 2018 time-period.³

Figure 1: Top Export Markets for 2016

Semiconductors		Semiconductor Manufacturing Equipment	
Rank	Country	Rank	Country
1	China	1	Taiwan
2	European Union	2	Korea
3	Japan	3	China
4	Korea	4	European Union
5	Singapore	5	Japan
6	Taiwan	6	Singapore
7	Malaysia	7	Malaysia
8	Mexico	8	Israel
9	Thailand	9	Mexico
10	Vietnam	10	Philippines

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Overview and Key Findings

Introduction

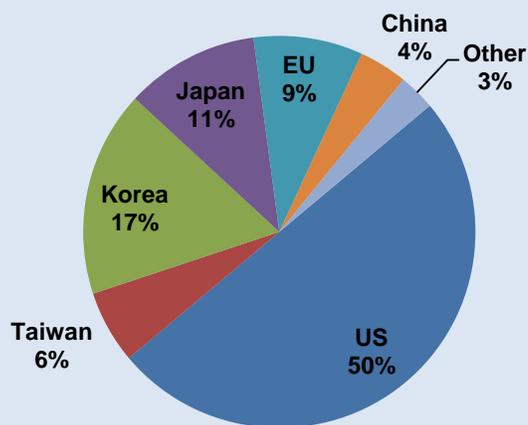
The U.S. semiconductor industry is the leading provider of semiconductors to the world with a majority of global market share. U.S. companies also lead in the semiconductor manufacturing equipment sector, accounting for 47 percent share of the world market. Over 80 percent of U.S. semiconductor sales do not take place in the U.S., and 84 percent of U.S. semiconductor manufacturing equipment sales take place outside of the United States. In order to compete in this industry most semiconductor and semiconductor manufacturing equipment companies must export.

Industry Overview and Competitiveness

After increasing 9.9 percent in 2014 to a record \$335.8 billion, global semiconductor sales fell slightly in 2015 to \$335.2 billion.⁴ Much of the dip in the value of sales was due to exchange rate factors. According to IC Insights, sales by the top 20 semiconductor companies for 2015 would have risen 4 percent instead of remaining flat if exchange rates had remained constant.⁵ World Semiconductor Trade Statistics (WSTS) predicts growth for 2016 at 1.4 percent and 2017 at 3.1 percent.⁶ Five of the top ten and eight of the top 20 semiconductor companies (including foundries) are U.S. firms.⁷

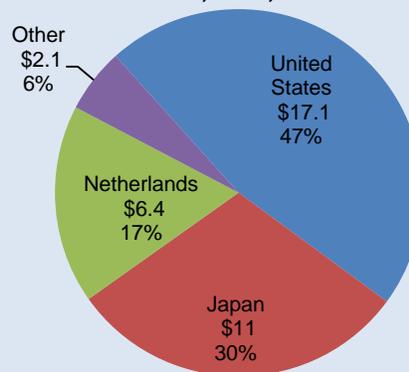
The U.S. is the leader in the semiconductor manufacturing equipment industry, with 47 percent of the world market. Along with Japan and the Netherlands, these top three countries control over 90 percent of the \$37 billion global market. Although there was a slight downturn in the industry in 2015 when the market is calculated in dollars, if exchange rates had remained constant, sales would have risen, and sales did rise on a unit basis. In 2016, the market is expected to enter a cyclical upturn that will continue into 2017. The U.S. market is only approximately 15 percent of semiconductor manufacturing equipment sales; thus U.S. companies need to export. Over 90 percent of global semiconductor manufacturing equipment sales outside the United States take place in five markets: China, Taiwan, Japan, Korea (South) and the EU, creating a very concentrated market.

Figure 2: Global Market Share of Semiconductor Production, 2015



Source: SIA/World Semiconductor Trade Statistics (WSTS)/IHS/PwC/IC Insights
Share based on headquarters of seller: Foundry output not included, fabless included.

Figure 3: Global Market Share of Semiconductor Manufacturing Equipment Production, 2015, Billions



Source: SEMI, SEAJ, Netherlands: ASML, ASMI Press Releases

Key Findings: Top Markets and Methodology

The Department of Commerce's International Trade Administration (ITA) has identified five markets as top markets for both semiconductor and semiconductor manufacturing equipment. These markets are subjects of in-depth country case studies: China, the European Union (EU), Japan, Korea and Taiwan. These markets, plus the U.S. domestic market, represent nearly 70 percent of the world semiconductor market⁸ and over 90 percent of the world semiconductor manufacturing

Figure 4: Top Exports Markets for 2016

Semiconductors		Semiconductor Manufacturing Equipment	
Rank	Country	Rank	Country
1	China	1	Taiwan
2	European Union	2	Korea
3	Japan	3	China
4	Korea	4	European Union
5	Singapore	5	Japan
6	Taiwan	6	Singapore
7	Malaysia	7	Malaysia
8	Mexico	8	Israel
9	Thailand	9	Mexico
10	Vietnam	10	Philippines

equipment market.⁹ In 2016, ITA’s analysis expands beyond Germany and identifies the entire European Union (EU) as a top market as there are opportunities in other European countries.

Moving beyond these top five markets, information on key Southeast Asian countries and other markets of note are included in the sector snapshots on the semiconductor and semiconductor manufacturing equipment subsectors, respectively. Country rankings by industry subsector are located in Appendix 2.

Semiconductors

Top markets for U.S. semiconductor sales include China, the EU, Japan and Korea. All of these markets exhibit vast amounts of electronics production. China has been called the “factory of the world” in terms of electronics, and its population has an increasing appetite for smartphones and consumer electronics. Japan has plenty of consumer electronics production as well as a very large automobile manufacturing sector. The EU is strong in automotive, instrumentation and communications equipment production. Korea is a powerhouse in consumer electronics manufacturing and has a vibrant automobile manufacturing industry. According to WSTS statistics, China was the only region that experienced sales growth in semiconductors (as measured in U.S. dollars) for 2015 (partially due to exchange rate issues).¹⁰

Semiconductor Manufacturing Equipment

According to Semiconductor Equipment and Materials International (SEMI), five regional markets

account for 84 percent of worldwide sales of semiconductor manufacturing equipment: Taiwan, Korea, China, Japan and the United States. This creates a very concentrated market. Europe and the Middle East represent another 9 percent, and other markets (primarily in Southeast Asia) account for the remaining 7 percent of the world market.¹¹

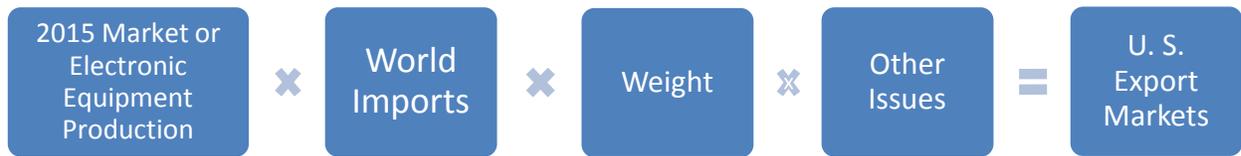
Methodology

The purpose of this methodology is to calculate the ranking of export markets for U.S. semiconductors and semiconductor manufacturing equipment for 2016 and to project exports in the future. This is relatively straightforward for semiconductor manufacturing equipment. It was difficult in the case of semiconductors, however, due to overseas packaging and final assembly of semiconductors and transshipments skewing the import and export data.

Last year, the most quoted source of regional market data for semiconductors, World Semiconductor Trade Statistics (WSTS), published data for the Chinese market, in addition to its country data for Japan. This has improved the methodology for semiconductors, as the WSTS data is used in this year’s calculation. To project the size of each country’s potential export market for U.S. companies, ITA used the formulas described in Figures 5.

Figure 5: Methodology for Ranking Markets

Semiconductors



Semiconductor Manufacturing Equipment



Global Competitive Landscape

China

China, over the last 10 years, has been one of the largest and fastest growing country markets for U.S. semiconductors and semiconductor manufacturing equipment and will continue in the near-term. Headwinds brought on by slowing global demand for ICT products, slowing transitions to smaller integrated circuit production nodes and a strong dollar will be complicated further by China’s opaque policies and unprecedented, massive, state-led investment to develop an indigenous semiconductor industry. China’s policies cause medium and long-term uncertainties for U.S. industry prospects in the Chinese market.

European Union

The case study for Germany is replaced this year with an EU case study, as it makes sense to look at the entire market when selling into the EU. The EU is the second largest market for semiconductors, and the EU is expected to be the fastest growing market for semiconductor manufacturing equipment in 2016. As a participant in the World Trade Organization Information Technology Agreement (WTO ITA), most types of semiconductors and semiconductors manufacturing equipment enter EU Member States duty-free, and wider product coverage came with the WTO ITA expansion that was agreed upon in December 2015.

Japan

Japan is both an important market and competitor for U.S. semiconductor and semiconductor manufacturing equipment companies. Japan is a participant in the WTO ITA, and will eliminate tariffs on all products under the WTO ITA expansion on the implementation date – July 1, 2016. Japan hosts the very successful trade show for semiconductor manufacturing equipment and materials – and increasingly semiconductor-related electronics – SEMICON Japan, which will be a U.S. Department of Commerce certified trade show for the third year in a row.

Korea

Korea is the fourth largest export market for semiconductors and the second largest export market for semiconductor manufacturing equipment. Korea is a participant in the WTO ITA; thus, most types of semiconductors and semiconductor manufacturing equipment enter the country duty-free, and any remaining types are covered under the U.S.-Korea Free Trade Agreement and the WTO ITA expansion.

Taiwan

Taiwan is the top market for semiconductor manufacturing equipment, and the sixth largest U.S. export market for semiconductors. Taiwanese companies are major manufacturers of electronic equipment. While final product assembly often takes place across the straits in Mainland China and U.S. semiconductor export sales are mainly attributed to

that market, both design and buying decisions for the semiconductors in electronic equipment often take place in Taiwan. As a participant in the WTO ITA and the WTO ITA expansion, Taiwan has no significant tariff or non-tariff barriers to U.S. exports. Taiwan's leading position in the semiconductor foundry sector necessitates purchase of state-of-the-art semiconductor manufacturing equipment.

Challenges and Barriers

Although the U.S. leads in these sectors, there are competitors, primarily from China, the EU, Japan, Korea and Taiwan, for semiconductors, and Japan and the Netherlands for semiconductor manufacturing equipment.

China's IC Industry Development Policies

The U.S. semiconductor industry and global semiconductor value-chain faces a challenge from the Chinese government's highly orchestrated and well-funded program to develop an independent domestic semiconductor industry supply chain. China's government is investing upwards of \$150 billion into the industry over the next decade through what is dubbed the "National IC Fund".¹² These policies, as mentioned earlier, cause medium and long-term uncertainties for the U.S. industry prospects in the Chinese market. See the China Case Study for details.

Counterfeits

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.¹³ 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. Protection and enforcement of IPR and trade secrets are priority issues for both the semiconductor and semiconductor manufacturing equipment industries.

Opportunities

WTO Information Technology Agreement Expansion

In December 2015, the United States and over 50 developed and developing country partners at the World Trade Organization announced a landmark expansion of the Information Technology Agreement, which will phase out hundreds of tariffs on U.S. information technology exports all over the world. The expanded agreement will eliminate tariffs on technologies developed since the initial Agreement was signed in the late 1990s as well as broader applications of information and communication technologies (ICT).

The expansion of the Agreement covers a list of 201 product categories, which the WTO estimates to be worth \$1.3 trillion in global exports per year (about 10 percent of total global trade). The United States exports \$180 billion in these products each year. The agreement includes semiconductors, semiconductor manufacturing equipment, and semiconductor related products. See Appendix 1 and country case studies for details.

Semiconductors

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 is stimulating global demand of semiconductors, but the overall annual growth is expected to slow to 3.5 percent.¹⁴ The Internet of Things (IoT) – aka, internet connected devices – is in its infancy but will contribute significantly to semiconductor demand over the long term, as will the development of smart grids and Smart Cities and automated smart manufacturing.

Semiconductor Manufacturing Equipment

Projections of sales of fab equipment show 13.2 percent growth in the world market from 2016 to 2017 (to an estimated \$42.8 billion), to be driven by equipment for foundries, and for memory (NAND and DRAM) and power semiconductor manufacturing.¹⁵ China is expected to start or

complete ten new semiconductor manufacturing facilities (fabs) in 2016 to 2017, outstripping planned facilities in the U.S., Taiwan and Southeast Asia, with two new fabs each; and Japan, Korea, and Europe and the Middle East, with one each. All of these facilities, should construction proceed, will need equipping in the late 2016 to 2018 time-period.¹⁶

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Sector Snapshots

This section contains a sector snapshot that summarizes opportunities for the semiconductors and semiconductor manufacturing equipment industries. The snapshots provide country rankings, export outlook and challenges for each sector.

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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.¹⁷ 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 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.¹⁸ For integrated circuits, Gartner Group expects NAND Flash to grow at a CAGR of 8.7 percent through 2019.¹⁹ Although sensors sales are the highest percentage of value for IoT, analog,

Figure 6: 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

processors, connectivity (network communications) and memory ICs are also used for IoT.²⁰

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).²¹ Because a single state-of-the-art fab requires a capital investment of \$5 to \$10 billion dollars,²² 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.²³ 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.²⁴

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.²⁵ 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

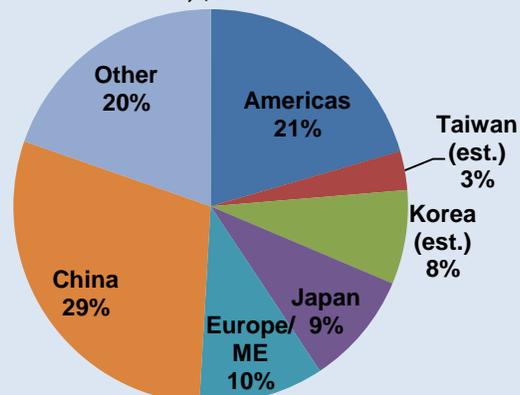
Although at the end of 2015 worldwide sales of semiconductors had remained flat in comparison to 2014 (reduction from \$335.8 to \$335.2 billion or 0.2 percent), if exchange rates had remained constant, sales would have risen. According to WSTS, China remained the largest regional market, with 29.4 percent 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 countries, primarily Korea, Taiwan and countries in Southeast Asia, taking up the remaining 30.6 percent.²⁶

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.²⁷ 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

Figure 7: Key Markets for Semiconductors, 2015 Sales, \$Billions



Source: World Semiconductor Trade Statistics, Feb. 2016, Taiwan, Korea: DOC/ITA Estimates

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.²⁸ Singapore also is a major South East Asia shipping hub.²⁹ 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,³⁰ and U.S. semiconductor companies generated over \$165.9 billion in sales and had 50 percent of the \$335.2 billion global market.³¹ 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.³² 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.³³

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.³⁴ 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.³⁵ 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.”³⁶ 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.³⁷ 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).³⁸ 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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Semiconductor Manufacturing Equipment

The U.S. is the leader in the semiconductor manufacturing equipment industry with 47 percent of the world market. Along with Japan and the Netherlands, the top three countries control over 90 percent of the \$37 billion market. Although there was a slight downturn in the industry in 2015 when calculated in dollars, if exchange rates had remained constant and on a unit basis, this is not the case. In 2016, the market is expected to enter another cyclical upturn to continue into 2017. The majority (over 90 percent) of semiconductor manufacturing equipment sales take place in the five country case study areas (China, the EU, Japan, Korea (South) and Taiwan) plus the United States.

Industry Overview

There are two main sub-sectors for semiconductor manufacturing equipment: front end equipment (includes crystal pulling and bare wafer manufacturing, reticle and mask manufacturing, and auxiliary fab equipment and accessories as well as wafer processing equipment), and semiconductor final assembly/packaging and test equipment, sometimes known as back end equipment. Fab building is now mostly for new technology fabs in established product areas by established companies, but there may be some new fabs at the 200 mm wafer level for IoT devices. China is an exception. Its IC Industry Development plan funds and the growing market itself are leading to planned fab building and equipment upgrades by both Chinese and foreign companies.

Most sales will be upgrades, after-sale parts and service, or sales of accessories and parts to other semiconductor manufacturing equipment companies to assemble into their equipment (especially in sales to the Netherlands) or directly to semiconductor fabs (semiconductor manufacturing/fabrication facilities) that are established customers. Therefore, it is important for U.S. semiconductor manufacturing equipment suppliers to establish long-term relationships with their customers. Trade shows for the industry, which provide an important opportunity to showcase U.S. semiconductor manufacturing equipment to potential buyers,

include the SEMICON shows, notably SEMICON Japan, a 2016 Department of Commerce certified trade show.

U.S. Semiconductor Manufacturing Equipment Export Base

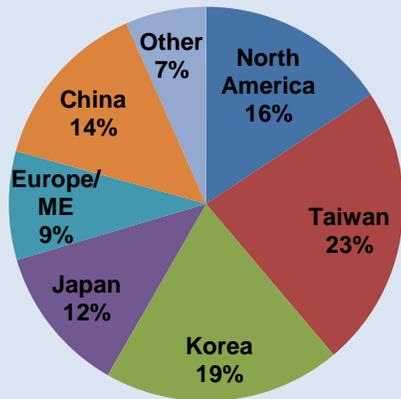
Overview of Global Export Opportunities

In 2016, 84 percent of worldwide sales of semiconductor manufacturing equipment are expected to be in five markets (Taiwan, Korea, China, Japan and the U.S./North America) creating a very concentrated market. Europe and the Middle East (primarily the EU and Israel) represent another

Figure 8: Semiconductor Manufacturing Equipment Market Rankings (Top 20)

1. Taiwan
2. South Korea
3. China
4. Japan
5. Singapore
6. Germany
7. Netherlands
8. Ireland
9. Malaysia
10. Israel
11. France
12. Austria
13. Belgium
14. Italy
15. United Kingdom
16. Mexico
17. Philippines
18. Russia
19. Thailand
20. Vietnam

Figure 9: Key Markets for Semiconductor Manufacturing Equipment, 2015 Sales, \$Millions



Source: SEMI, including estimates for growth 2015-2016

9 percent, and other markets (primarily Southeast Asia) account for the final 7 percent of the world market.³⁹ Worldwide sales in general track with U.S. exports, except in the case of Japan, a major competitor in semiconductor manufacturing equipment, and North America, which consists primarily of the United States market (which would be ranked fourth, after Taiwan, Korea and China). Mexico rounds out the top 10 when the EU is considered a single market, but to ITA's knowledge, the Mexico market is primarily for solar panel assembly equipment. There also is a subsidiary of Texas Instruments in Mexico dedicated to semiconductor final assembly/packaging and test.

The top U.S. export markets for semiconductor manufacturing equipment (China, the European Union, Japan, Korea and Taiwan) are highlighted in the country case studies. Other key markets and an overview of the markets are covered below:

Europe and Middle East

Many countries in Europe, especially EU Member States, have at least one semiconductor fab, and the EU countries make up the bulk of sales of semiconductor manufacturing equipment in the Europe and Middle East region. The only major market for semiconductor manufacturing equipment in the Middle East is Israel. U.S. exports of semiconductor manufacturing equipment to Israel were \$93 million in 2015, but the value oscillates annually, depending on Intel's investment. Intel is the largest fab operator in Israel by far, but there are also other fabs in Israel - notably those of Israel's

foundry TowerJazz. The U.S. and Japan trade places, depending on the year, as the top source of import by Israel, but on the average over the last eight years the exports from the U.S. are higher in value.

Southeast Asia

The majority of the "other" market is Southeast Asian countries. It is difficult to find information on the Southeast Asian markets for semiconductor manufacturing equipment; therefore, only a short synopsis is possible. Singapore is slightly different than the other SE Asian markets, with some fabs belonging to major U.S. semiconductor companies (Globalfoundries, Micron, Avago/Broadcom) and other foreign companies (ST Micro, NXP/TSMC, UMC). In addition, Singapore companies are leaders in OSAT (Outsourced Semiconductor Assembly and Test). U.S. exports to Singapore of semiconductor manufacturing equipment were \$925 million in 2015.

Malaysia's top electronics industry is semiconductor production; however, it is primarily OSAT.⁴⁰ There are also around a dozen fabs located in Malaysia, most foreign-owned.⁴¹ Imports of all ICT products into Singapore are already duty-free. Malaysia is a participant in the WTO Information Technology Agreement (ITA) and WTO ITA expansion.⁴² For more information on the WTO ITA expansion, see the endnote and Appendix 1. The Philippines is also a WTO ITA expansion participant, and its imports of semiconductor manufacturing equipment are mostly semiconductor assembly and test equipment. U.S. exports of semiconductor manufacturing equipment to Malaysia and the Philippines were \$167 and \$120 million, respectively, in 2015.⁴³

- 2017 Trade Show for Southeast Asia: SEMICON SEAsia April 25-27 2017, Penang Malaysia

Competition

U.S. companies have 47 percent share of the world market,⁴⁴ followed by Japan with a 30 percent share.⁴⁵ Sales by ASML and ASMI, the two largest semiconductor manufacturing equipment companies in the Netherlands, give that country at least 17 percent share. According to estimates based on sales of integrated circuit manufacturing equipment, other players, including South Korea and Germany, have less than 3 percent share each, and China, Taiwan, Singapore and a few other, mostly

European, countries have 0.5 percent share or less each.⁴⁶

U.S. companies are also leaders in most semiconductor manufacturing equipment subsectors, except lithography – where Dutch and Japanese manufacturers are the leading global suppliers – and cleaning and drying equipment. There are U.S. suppliers in these subsectors as well (such as U.S. lithography equipment company Ultratech).⁴⁷ U.S. companies are also known suppliers of parts and accessories to ASML (the Netherlands), the top supplier of lithography equipment. Eighty-two percent of U.S. semiconductor manufacturing equipment exports to the Netherlands are accessories and parts – far exceeding the 22 percent share for accessories and parts for U.S. exports to the world. This contributes to the Netherlands' place among the top 10 export markets (and ranking as the second largest European market). The Netherlands also has some semiconductor fabs, most owned by NXP (formerly Philips Semiconductor).⁴⁸

Despite last year's proposed Applied Materials and Tokyo Electron merger, the two companies abandoned their plans when the companies were unable to resolve competitive concerns raised by the U.S. Department of Justice.⁴⁹ Instead, the merger of the year was Lam Research and KLA Tencor, two U.S. companies, one on the fab equipment side (Lam) and the other on the OSAT (inspection equipment) side (KLA), with both sides having virtually no overlap in product coverage. According to Gartner Group, this will create the second-largest semiconductor manufacturing equipment company, after Applied Materials, giving the U.S. the top two slots based on sales (using 2015 and 2016 projections).⁵⁰ To ITA's knowledge, as of April 1, 2016, this deal is still undergoing regulatory review. ASML (the Netherlands), Tokyo Electron (Japan) and Screen Semiconductor (Japan, formerly Dai-Nippon Screen) are the third, fourth and fifth ranked semiconductor manufacturing equipment companies.⁵¹

The Semiconductor Equipment Export Opportunity in the Near Term

SEMICON Japan, for the third year in a row, will be a Department of Commerce certified trade show. Some SEMICON shows, including SEMICON Japan include an IoT (Internet of Things) pavilion featuring

some semiconductor producers. See Japan case study for more information on this market.

The successful conclusion of the WTO ITA expansion negotiations represents increased opportunities for this industry, as the scope includes some semiconductor equipment and accessories that were not clearly included in the scope of the original WTO ITA.⁵² See endnote and Appendix 1 for more information.

Taiwan, Korea, the European Union, Japan and China will continue to be the principal export markets through 2016. Planned fab upgrades and new fab equipping will drive this growth. China has substantial plans for equipping fabs for 2016 through 2018. Europe and the Middle East are expected to have the fastest growth in 2016; see section on the EU for details. Intel is also expected to upgrade its fabs in Israel. Also, China is expected to pass Japan and become the third largest U.S. export market for semiconductor manufacturing equipment.

In the other market category, Singapore will continue to be the largest market, with sales continuing elsewhere in Southeast Asia as well. The Malaysian market is primarily semiconductor assembly and test equipment, as is Thailand's. Brazil's Six Semiconductores fab upgrade reported last year appears to have been equipped through the purchase of the former LFoundry Rousset fab (France), so that does not represent new sales opportunities.⁵³

Up and coming Vietnam, currently representing only \$6 million in U.S. exports of semiconductor manufacturing equipment, is a participant in the original WTO ITA, so U.S. exports are duty free for most semiconductors and for most semiconductor manufacturing equipment. In Vietnam, preparation of the government-owned CNS/Saigon semiconductor fab proceeds, with groundbreaking expected in 2016. Equipment buys would occur in the next few years if preparations continue. There also is some OSAT business in Vietnam.⁵⁴ Equipping the CNS fab would contribute to the expected jump in "other market" sales for 2016. This fab, however, will manufacture older technology semiconductors.

As a result, most of the purchases will be used equipment.⁵⁵ Therefore, the best markets will continue to be the established ones – though there

will be opportunities for some U.S. companies in Brazil and Vietnam.

Planning for the Long Term

Although two consortia-led fabs in India were mentioned in the previous year's report, press reports in late April 2016 indicated that Indian partner Jaiprakash has dropped out of the Jaiprakash/IBM/Tower Semiconductors fab consortia,⁵⁶ so the feasibility of that project is now uncertain. If the other consortia-owned fab (HSMC/STMicroelectronics/SilTerra) starts breaking ground, there may be sales of semiconductor manufacturing equipment in India in the future, but to ITA's knowledge, site selection has not taken place, so the process is not proceeding in a timely fashion. This fab would start out with older technology, so there would not be new semiconductor manufacturing equipment sales at first. There are plans to upgrade in the future. A third fab project was announced by U.S. startup Cricket Semiconductor to manufacture analog semiconductors in India, which appears likely to move forward.⁵⁷ This project, however, probably will only require used, not new, semiconductor manufacturing equipment.

The top export markets rankings from 2015 and through 2018 in general are not expected to change, with the exception of China passing Japan again. Projections of sales of fab equipment show 13.2

percent growth in the world market from 2016 to 2017 (to an estimated \$42.8 billion), to be driven by equipment for foundries, and for memory (NAND flash and DRAM) and power semiconductor manufacturing.⁵⁸ China is expected to start or complete ten new fabs in 2016 to 2017, outstripping planned facilities in the U.S., Taiwan and Southeast Asia, with two new fabs each; and Japan, Korea, and Europe and the Middle East, with one each. All of these facilities, should construction proceed, will need equipping in the late 2016 to 2018 time-period.⁵⁹

In the longer-term, Technavio predicts a CAGR of 4 percent for the industry until 2020⁶⁰ (though the value will change from year to year). With the rise of IoT as an end application for semiconductors, there will be increased demand for legacy 200mm wafer equipment (300mm equipment will also remain in demand). It remains to be seen if the used equipment market can absorb this increased demand or if, contrary to previous years, new equipment for smaller wafers will need to be produced – and if it is needed, how it can be profitable. Innovative semiconductor packaging techniques for multilayer and small footprint ICs will also lead to sales of semiconductor final assembly/packaging and test equipment.

Country Case Studies

The following pages include country case studies that summarize U.S. semiconductor and semiconductor manufacturing equipment opportunities in selected markets. The overviews outline ITA's analysis of the U.S. export potential in each market and offer recommendations to exporters that can improve their competitiveness. The markets represent a range of countries to illustrate a variety of points – and not the top markets overall.

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China

Over the past decade, China consistently ranks as one of the largest and fastest growing country markets for U.S. semiconductors and semiconductor manufacturing equipment and will continue to do so in the near-term. Global headwinds brought on by slowing global demand for ICT products, slowing transitions to smaller IC manufacturing nodes and a strong dollar, however, will be exacerbated by China's opaque policies and unprecedented, state-led investment to develop an indigenous semiconductor industry. China's policies create medium and long-term uncertainties for U.S. industry prospects in the Chinese market.

Semiconductors

1

Semiconductor Manufacturing Equipment

3

China remained the top market for semiconductors in 2015, representing the destination for \$98 billion or nearly one-third of total global shipments of semiconductors.⁶¹ According to Semiconductor Equipment and Materials International (SEMI), in 2015, China's semiconductor manufacturing equipment market traded places with Japan, causing China to drop one place to fourth in ITA's country rankings for semiconductor manufacturing equipment, but it is expected to regain third place in 2016.⁶²

Near-term prospects for China's overall market seem favorable and stable for many sectors, including high-end ICT goods and services. Slowing economic growth, rising costs for U.S. companies operating in China, increasing Chinese domestic competition and market access barriers for foreign companies, however, have led to decreased U.S. company optimism about China's market in the long-term.⁶³ In 2015, turmoil in China's stock market, deceleration of GDP growth and increasing capital flight were witnessed in what is likely the beginning of a broader paradigm shift for China and its economy that will differ markedly from the last two decades of unprecedented expansion.

In response to its macro-economic challenges and in a broader effort to support national security, China has accelerated implementation of its strategy to develop a completely domestic information and communications technologies (ICT) supply chain (including semiconductors and related equipment).

This ICT supply chain strategy also aligns with China's aim to move from labor-intensive, low value-added production for export to higher margin, cleaner industries that produce goods made by China for China.⁶⁴ This includes products used to manufacture ICT products in China that could eventually be exported, including semiconductors and semiconductor manufacturing equipment. China's leadership strongly believes that this industrial development model (which it terms "indigenous innovation") will lead to more sustainable and stable economic growth.

China is also utilizing various administrative and regulatory levers to support indigenous innovation by employing market access restrictions on foreign competition. This will increasingly affect what has consistently been the biggest and fastest growing ICT market for the last decade and a critical component in many multinationals' global supply chains. Despite these long-term hurdles, ITA expects there will be a continuation of strong, albeit slowing, growth in demand for semiconductors in China and a marked increase in demand in the semiconductor manufacturing equipment market in the near-term.

Overview of the Markets

Semiconductors

China ranks first in our study based on semiconductor demand for its electronics manufacturing industry. Demand is also increasing

markedly from China's growing domestic market. China is the largest and fastest growing semiconductor market in the world, representing 29 percent (\$100 billion) of the \$335 billion global market in 2015⁶⁵. In fact, China was the only growth region in sales for 2015, partially due to exchange rate fluctuations, with 7.7 percent growth from \$91.5 billion to \$98.6 billion.⁶⁶

While growth in semiconductor exports to China has traditionally been propelled by consumer electronics assembled for export, China's domestic consumption represents an increasing share of China's semiconductor market. Domestic consumption is mainly being driven by data processing and communications applications sectors, with consumer electronics also being a significant contributor.⁶⁷ Semiconductor demand growth is forecast to remain in the double digits for years to come. U.S. semiconductor companies have been successful in selling into the Chinese market, and 2015 was no exception. China's appetite for semiconductors is so great that domestic production only counts for 9 percent of consumption – leaving 91 percent of China's demand to be satisfied by imports,⁶⁸ including 56.2 percent from the United States. Globally in 2015, U.S. companies represented 50 percent of total semiconductor sales, while Chinese companies only had 4 percent market share.⁶⁹

Semiconductor Manufacturing Equipment

As mentioned above, China dropped from the third to fourth ranked market for U.S. semiconductor manufacturing equipment in 2015. ITA expects increased Chinese spending on semiconductor manufacturing equipment to equip and upgrade fabrication (fab) facilities. Total global sales of semiconductor manufacturing equipment in China reached \$4.9 billion in 2015 (13.4 percent of the \$36.5 billion world market), up 12 percent over 2014,⁷⁰ and sales are forecast to grow another 8.5 percent in 2016.⁷¹ Taiwan Semiconductor Manufacturing Corporation (TSMC), the largest foundry in the world, received approval from the Taiwanese government to build a fab in China.⁷² Chinese chip-maker XMC is poised to start groundbreaking for a new NAND fab in Wuhan, and press reports indicate that Beijing NMC or Tsinghua Unigroup will build a memory fab in the Beijing area.

All of this fab building and other upgrades/equipment purchases will result in a

significant uptick in Chinese purchases of semiconductor manufacturing equipment from 2016 to 2018. Fab construction spending in China is expected to slow down in 2017,⁷³ which may result in a pause in the increase of semiconductor equipment spending in 2018 to 2019, but the general trend will still be upward. China also buys a significant amount of machinery for outsourced semiconductor assembly and test (OSAT). China represents 27 percent of the world's floor space for OSAT.⁷⁴

Challenges and Barriers to U.S. Semiconductor and Related Equipment Exports

Semiconductors –China's IC Industry Development Plan

China's leadership views China's reliance on foreign semiconductors as a major national security concern. Because semiconductors are foundational to information and communications technologies, China's leadership views the industry as a cornerstone of China's goal of securing its ICT ecosystem and technologies of the future through indigenization of the ICT supply chain while concurrently transforming and upgrading China's economy. The Chinese government has begun implementing ambitious policies aimed at supporting domestic semiconductor design and manufacturing in order to develop a globally competitive semiconductor industry by 2030. Potentially discriminatory policies implemented to support its industry to become self-sufficient pose a real long-term threat to not only U.S. firms but the entire global semiconductor ecosystem.⁷⁵

China's government is committed to investing upwards of \$150 billion into the industry over the next decade through what is dubbed the "National IC Fund," with additional funding encouraged at the sub-central level by provincial and municipal governments, to develop a globally competitive domestic industry.⁷⁶ The initiative also has strong support from China's senior government leadership.

Since announcement of its semiconductor industry development policies in June 2014, China's objective has come into focus. China's government aims to replicate, to the furthest extent possible, the semiconductor value chain within China to reduce its reliance on foreign chips while simultaneously strengthening its economy and moving up the value-

chain. To accomplish this, China is aggressively targeting memory ICs and IC design as the first step toward its IC industry ambitions. China is deploying its strategy along three main paths: mergers and acquisition (M&A), market power and regulation.

The flurry of M&A and foreign talent recruitment by Chinese companies is expected to continue in 2016 and beyond. It is important to note here the disparity between the unprecedented M&A activity that is taking place in the global industry and the M&A strategy being undertaken by China's government. In the latter case, the proposed deals are not between two commercial businesses looking to save costs and leverage synergies, rather the Chinese government appears to be driven by a desire to acquire know-how in all segments of the semiconductor supply chain.

China is also keenly aware that foreign chip companies need continuous access to the biggest market for semiconductors. U.S. industry contends that as China develops its industry, it tilts the playing-field further in favor of domestic firms by actions such as dictating indigenous standards and imposing local-content requirements. Industry has also raised concerns about potentially discriminatory enforcement of China's Anti-Monopoly Law.⁷⁷

Semiconductors – Counterfeit ICs

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.⁷⁸ 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.

Semiconductor companies and their authorized distributors, resellers and aftermarket distributors/manufacturers have extensive, proven controls to ensure products are properly manufactured, tested, handled and stored to prevent failures. Counterfeiters have few, if any, such controls. In addition, crude methods are often

used to extract used semiconductors from discarded boards. These used counterfeit semiconductors are assembled into supposedly new equipment. The result is that, unlike legitimate semiconductors from authorized sources, counterfeits and other semiconductors available from unauthorized sources often have low quality and poor reliability. Often the equipment containing the counterfeit semiconductors will function for a while but prematurely fail before the end of the equipment's expected life cycle or perform below specifications. This is especially dangerous in detection, testing or monitoring electronics and similar products, as the buyer may have no warning that the product is not functioning properly.

In one illustrative case, used and re-marked semiconductors were sold by a Chinese firm as new, and they were installed into the de-icing modules for new reconnaissance aircraft. The problem was detected during a test flight. Luckily, most of the 300 counterfeit semiconductors had not been installed into the planes yet. Counterfeit semiconductors have also caused fires in residential vacuum cleaners, have caused an overvoltage condition for Automated External Defibrillators (AEDS), and have caused a failure of a power supply used for airport landing lights. According to an estimate by SMT Corp., used and remarked semiconductors sold as new accounted for 80 to 90 percent of counterfeit parts in circulation.⁷⁹

Many of these counterfeit semiconductors originate from China. There are also reports that unscrupulous actors within China are upgrading counterfeit capabilities by setting up fabs to produce new counterfeit semiconductors, representing a worrying escalation of counterfeiting capabilities.

There are some notable developments in anti-counterfeiting. In 2015, the U.S. Trade Facilitation and Trade Enforcement Act of 2015, Pub. L. No. 114-125, was enacted and includes a key provision to combat counterfeit merchandise by authorizing the U.S. Customs and Border Protection to share information and suspect counterfeits with rights holders. This will facilitate expeditious identification of counterfeit semiconductors. In March 2016, the JEDEC published a new standard identifying the best commercial practices for mitigating and/or avoiding counterfeit products by all manufacturers of electronic parts. The new standard applies to monolithic circuits, hybrid circuits and discrete

semiconductor products.⁸⁰ In another development, in June 2014, a U.S. citizen pleaded guilty to trafficking counterfeit semiconductors from China, including selling them to contractors that were supplying them to the U.S. military for use in nuclear submarines.⁸¹ In April 2016, three Chinese nationals pleaded guilty to conspiring to buy top-end, military-spec chips from a U.S. Navy base and replace them with counterfeit chips.⁸²

Semiconductor Manufacturing Equipment-IC Development Fund

China produces a nominal amount of semiconductor manufacturing equipment, less than a 0.5 percent share of the world market.⁸³ Although no less than 60 percent of IC development program funds are earmarked for IC manufacturing, the remaining funds are earmarked to develop indigenous Chinese semiconductor manufacturing equipment, semiconductor materials, OSAT and other semiconductor related industries.

China's IC industry development program goals call for Chinese semiconductor manufacturing equipment to achieve production application for 65 to 45 nanometer critical equipment by 2015 (this goal was not reached); for Chinese critical equipment and materials to be included in the international procurement system by 2020; and for China to be acknowledged and accepted as a global leader in all segments of the equipment supply chain by 2030.⁸⁴

Imports of semiconductor manufacturing equipment, however, are expected to see continued near-term growth, as foreign firms continue to build capacity in China and also as funds from China's National IC Fund are used to build and upgrade Chinese company fabs in China. Increased purchases of semiconductor manufacturing equipment supported by loans and subsidies could cause over-capacity, as the expected volume of follow-up equipment sales may not occur, since building a fab does not guarantee increased IC sales, and also could lead to a glut of used semiconductor manufacturing equipment on the market.

Semiconductor Manufacturing Equipment – IP Issues

The U.S. semiconductor manufacturing equipment industry reports some concern over protection of IPR in China. There also are reports of pressure on

U.S. manufacturers to transfer proprietary information about semiconductor manufacturing equipment designs, especially for parts.⁸⁵ U.S. exhibitors at semiconductor manufacturing equipment trade shows in China and selling in China should follow best practices in protecting their IPR.

Opportunities for U.S. Companies

WTO Information Technology Agreement (ITA)

China is a participant in the WTO Information Technology Agreement (WTO ITA) and the expansion that goes into effect on July 1, 2016. China has the least ambitious tariff reduction schedule among all of the participants in the WTO ITA expansion. All tariffs on items covered under the WTO ITA expansion will be reduced to zero within seven years and most within five. See Appendix 1 for details.

Semiconductors

China accounts for over 50 percent of the world's electronics production and represents nearly one-third of the global market for semiconductors. Not all of the buying decisions for semiconductors are made in China, however. The foreign companies that contract out electronic goods production to China often make such decisions. The supply chain is global and semiconductors in different stages of completion are transshipped and re-exported from numerous markets.

Domestic demand from China will also be a growing source of revenue for U.S. semiconductor manufacturers over the next few years, despite China's policies. ITA thus encourages U.S. companies to continue targeting Chinese consumer electronics, data processing and communications companies manufacturing in China. Lenovo and Huawei, for example, are among the top 10 buyers of semiconductors globally, and other Chinese companies, including ZTE, Datang Telecomm, Xiaomi and Haier, are also major purchasers.

Semiconductor Manufacturing Equipment

As stated earlier, overall sales of equipment in China grew by 12.2 percent in 2015 to \$4.9 billion, and China is expected to surpass Japan in 2016 with sales reaching \$5.4 billion.⁸⁶ If even some of the fab building and upgrade projects reach fruition, China will probably surpass Japan again in 2017 and 2018.

The National IC Industry Development plan creates opportunities but the projects funded may spur artificial demand for semiconductor manufacturing equipment. In addition, there are some IPR issues. Overall, the U.S. semiconductor manufacturing equipment industry enjoys good access to the Chinese market, but this could change if the approach becomes similar to that for semiconductors. In the case of semiconductor manufacturing equipment, however, there is only a small specialized market; and there are few

companies left that are easy to acquire that are not niche product or trailing technology, so an aggressive acquisition strategy is unlikely to lead to China's goals. Overall, the market is open, but IPR and oversupply issues should be carefully monitored when selling in the market.

2017 Trade Shows/Events in China

March 2017: SEMICON China 2017, Shanghai, China

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European Union (EU)

The case study for Germany in the 2015 report is replaced this year with an EU case study, as it makes sense to look at multiple countries when selling into Europe. The EU is the second largest market for U.S. semiconductor exports, and the EU is expected to be the fastest growing market for semiconductor manufacturing equipment in 2016. Due to the EU's participation in the WTO Information Technology Agreement (WTO ITA), most types of semiconductors and Semiconductors Manufacturing Equipment enter EU member states duty-free, and further coverage came with the WTO ITA Agreement expansion that was agreed upon in December 2015.

Semiconductors

2

Semiconductor Manufacturing Equipment

4

Overview of the Markets

Semiconductors

According to World Semiconductor Trade Statistics (WSTS), the Europe/Middle East (ME) market for semiconductors was \$34.3 billion in 2015, comprising 10.2 percent of the total worldwide market. ITA estimates based on semiconductor imports, production of electronic equipment containing semiconductors, and regional semiconductor market data placed the EU market at just under \$30 billion, around 8.5 percent of the world market. Switzerland, Ukraine, Russia and Turkey are the only notable markets outside of the EU in this regional category, and no non-EU Member State market in the regional category is among ITA's top 20 U.S. export markets for semiconductors.

EU Member State markets among the top 20 markets for U.S. exports are Germany, France, the Netherlands, the Czech Republic and Hungary. As stated above, Europe/ME is expected to be the fastest growing market for semiconductors in 2016. See Appendix 2 for the full country market rankings for the semiconductor and semiconductor manufacturing equipment sectors.

The EU imported \$28.2 billion worth of semiconductors from the world in 2015. By country (including internal EU trade), Germany is the largest importer (\$18.1 billion), followed by the Netherlands (\$7.8 billion), France (\$6.2 billion), the United

Kingdom (\$4.6 billion), Hungary (\$2.6 billion) and the Czech Republic (\$2.5 billion).⁸⁷ The rankings for imports differ from our top market rankings because imports may be re-exports to shipping hubs (such as the Netherlands) or imports from semiconductor final assembly/packaging and test facilities. Imports are, however, included in this analysis, as it is one of the few ways to measure individual country market size.

Germany

Germany is a manufacturing powerhouse when it comes to automobile electronics, industrial electronics and medical electronics -- all important end markets for semiconductors. As Europe's largest electronics producing nation, Germany is a significant but mature market for U.S. semiconductors. Automotive electronics production (valued at \$19.5 billion in 2013)⁸⁸ is the largest sector of the German electronics industry with a 39.6 percent share; industrial electronics is the second largest sector, with 25.1 percent share of German production and also representing 50 percent of Europe's total industrial electronics market.⁸⁹ Germany's electronics production is expected to grow from \$34.9 billion in 2014 to \$36.9 billion in 2016,⁹⁰ an annual average growth rate of 3 percent.

France

France has the second largest electronics industry in Europe after Germany. The French electronics industry is dominated by the production of fixed and wireless communications (24 percent of total output in 2012), but France is also a leading producer of radar, navigation and defense electronics. It has eight of the top 50 leading indigenous electronics companies in Europe and nine of the top 50 European EMS (contract assembly of electronic equipment) providers.⁹¹

The Netherlands

The Netherlands also has a high ranking among the EU countries as an import market for semiconductors. As stated above, some of this is due to the Netherlands' importance as an import hub for Europe. The Netherlands also has significant medical electronics and navigation instrument industries.⁹²

Other EU Markets

The Czech Republic and Hungary are also among the top 20 export markets for U.S. semiconductors. This is largely because a number of European electronic equipment manufacturers have moved production or assembly to lower cost locations in Eastern Europe during the last 5 to 10 years.⁹³ Therefore, although these countries are growing as importers of semiconductors, the semiconductor purchasing decisions are often made at the contracting companies in Western Europe or at the main office of the EMS company. We estimate that their share of the world market is only around 1 percent combined – most of the export markets for U.S. semiconductors are in Asia.

Semiconductor Manufacturing Equipment

According to the SEMI industry association, the Europe/Middle East (ME) market for semiconductor capital equipment fell to \$1.94 billion in 2015 from \$2.38 billion in 2014, a 19 percent decrease. Due to the large volume of expected fab upgrades, however, the market is predicted to jump to \$3.37 billion in 2016, an over 70 percent increase.⁹⁴ ITA estimates that the EU market will reach \$2.8 billion in sales in 2016 (84 percent of Europe/ME – the rest is primarily Switzerland and Israel), representing approximately 7.7 percent of the world market. The

United States is the top source of semiconductor manufacturing equipment imports into the EU.⁹⁵

The EU imported \$3.6 billion worth of semiconductor manufacturing equipment in 2015 (due to re-exports, the inclusion of parts and other issues, this exceeds market size), including nearly \$1.8 billion worth from the United States. By country (including internal EU trade), the Netherlands is the largest importer, importing nearly \$2 billion. This, however, is primarily parts and accessories for ASML, and our ranking considers announced purchase plans for fab equipment and projections of the size of markets for fully assembled semiconductor manufacturing equipment as factors; and the Netherlands ranks considerably lower by those measures.

Germany is next in imports at \$1.1 billion, but due to the Netherlands primarily being parts, in our calculation Germany has a higher ranking as a country. Ireland also out-ranked Germany in imports for 2015 at nearly \$1.4 billion, but due to the large swings in imports from one year to another (due to purchases of equipment by a single company – Intel), Germany out-ranks Ireland on the average.

Germany

There are over 40 semiconductor fabs in Germany, run by a diverse set of companies, including Infineon, the Fraunhofer Institute research organization, NXP (Netherlands), and Osram/Siemens. Infineon finished its acquisition of U.S. company International Rectifier in 2015, and its ranking among worldwide semiconductor companies changed from 13th in 2014 to 12th in 2015.⁹⁶ U.S. companies, such as Globalfoundries and Texas Instruments, also have fabs in Germany.⁹⁷ Depending on the year, usually either the Netherlands or Germany is the top EU importer of semiconductor manufacturing equipment.

Average annual U.S. exports (from 2009 to 2013) were \$587 million, and the United States is the top supplier of semiconductor manufacturing equipment into Germany with over 30 percent market share. Globalfoundries plans to make further investments in its Dresden fabs for its FD-SOI technology⁹⁸, which would probably include state-of-the-art semiconductor manufacturing equipment purchases. Infineon is also expected to purchase semiconductor manufacturing equipment in 2016.⁹⁹

The Netherlands

Imports of semiconductor manufacturing equipment into the Netherlands are primarily for parts and auxiliary accessories for major Dutch semiconductor manufacturing equipment producer ASML. Over 90 percent of the \$1,979 million imports of semiconductor manufacturing equipment into the Netherlands were parts and auxiliary equipment (\$1,808 million). There also are some semiconductor fabs in the Netherlands, most owned by NXP (formerly Philips Semiconductor). NXP bought out U.S. semiconductor company Freescale (formerly part of Motorola) in 2015, and according to IHS, NXP jumped from the 15th largest semiconductor company to seventh.¹⁰⁰

The top exporters of semiconductor manufacturing equipment into the Netherlands were Germany (\$890 million) and the United States (\$680 million). Eighty-eight percent of Netherlands imports from the United States were parts, however, and for imports from Germany, nearly 98 percent were parts.¹⁰¹ Depending on the year, the Netherlands sometimes surpasses Germany as a U.S. export market; however, on the average Germany is a larger market than the Netherlands.¹⁰² Although some of the imports of parts are parts for repair or replacement, ASML equipment contains parts manufactured around the world.

Ireland

Ireland's semiconductor manufacturing equipment market ranking is primarily due to Intel's fabs in that country. For instance, Ireland surpassed Germany as a U.S. semiconductor manufacturing equipment export market in 2014, but this was due to Intel's upgrade of its semiconductor fabs (semiconductor fabrication/manufacturing facilities) in Ireland.¹⁰³ Intel announced major investments in its Irish fabs in 2014 of 3.5 billion Euros,¹⁰⁴ and equipment purchases are now showing up in the statistics. This is expected to continue in 2016. Irish imports of semiconductor manufacturing equipment reached \$1.3 billion in 2015. Japan is the top supplier with \$728 million, and the United States is in second with \$350 million.

France

French/Italian company STMicroelectronics, SOITEC, LETI (research institute) and others have fabs in

France.¹⁰⁵ STMicroelectronics is the top EU semiconductor company, with fabs in France, Italy and Singapore.¹⁰⁶ French imports of semiconductor manufacturing equipment from the world were worth \$124 million in 2015, of which \$66 million came from the United States (ranked first) and \$57 million from Germany. STMicroelectronics is expected to purchase additional equipment in 2016.¹⁰⁷

Belgium

Although representing less than 1 percent of world imports and U.S. exports in 2015, Belgium will be notable as a market for U. S. semiconductor manufacturing equipment for 2016 because of a major fab equipping by Belgium research consortium IMEC.¹⁰⁸

Challenges and Barriers to U.S. Semiconductor and Related Equipment Exports

Although the European Union continues to be an important manufacturer of semiconductors and semiconductor equipment, its global market share has not seen substantial growth due to competition from Asian and U.S. firms.

Overall, U.S. companies enjoy access to the EU semiconductor and semiconductor manufacturing equipment markets, which present no significant tariff or non-tariff barriers to U.S. exports. Semiconductor companies new to the market, however, need to be aware of EU regulations that indirectly affect them. Semiconductor manufacturing equipment is subject to some regulations. Most U.S. exports of semiconductors and semiconductor manufacturing equipment enter the country duty-free because EU member states participate in both the WTO Information Technology Agreement (WTO ITA) and the newly-signed WTO ITA expansion.

Semiconductors

Semiconductor production in the EU comes both from large indigenous companies in a handful of member states and, to a lesser extent, from European facilities owned by non-European (primarily U.S.) firms. EU firms held 9 percent of the global market share for semiconductor supply in 2015. During the same period, U.S.firms held 56.6 percent of the Europe/ME market, slightly over the 50 percent U.S. companies have of the world

market.¹⁰⁹ European semiconductor companies primarily compete in automotive ICs and sensors.

Semiconductor Manufacturing Equipment

Netherlands company ASML is the leader in lithography equipment – the only major segment of semiconductor manufacturing equipment where the United States does not have a top producer. ASML, another Dutch company, is also a major player in semiconductor manufacturing equipment. Although some German companies produce semiconductor manufacturing and test equipment, German companies represent less than 5 percent share of worldwide integrated circuit manufacturing equipment sales.¹¹⁰ U.S. companies face competition in the EU, primarily from Dutch, German and Japanese firms, which also have good sales networks in Europe.¹¹¹

Opportunities for U.S. Companies

WTO Information Technology Agreement Expansion

Implementation of the expansion will begin in July 2016. The EU will offer immediate duty-free access for almost all of the 34 semiconductor and semiconductor manufacturing related products in the WTO ITA expansion. Semiconductor-related products that are not granted immediate zero are

photoblanks, objective lenses, optical filters and other optical elements. These products will be duty free on January 1, 2019, after three tariff cuts on July 1, 2016; January 2017 and January 2018.¹¹² See Appendix 1 for a list of the semiconductor-related products in the WTO ITA expansion, information on the WTO ITA expansion and links to key documents.

Semiconductors

WSTS predicts a slight drop in sales in Europe/ME market in 2016 of -1.6 percent to \$33.7 billion and a slight recovery of 2.5 percent in 2017 to \$34.5 billion.¹¹³ As the EU makes up most of the Europe/ME market, we expect the EU to follow the Europe/ME trend.

Semiconductor Manufacturing Equipment

After the cyclical downturn last year, SEMI predicts that Europe/ME will be the fastest growing market from 2015 to 2016, increasing 63 percent year to year to \$3.17 billion, making it the largest growth region for 2016.

2016 Trade Shows/Events in the EU

Oct. 25-27: SEMICON Europa 2016, Grenoble, France

Japan

Japan is an important market and competitor for U.S. semiconductor and semiconductor manufacturing equipment companies. Japan has the third largest electronics manufacturing industry in the world and is home to two of the top 10 semiconductor buying companies, Sony and Toshiba, which also are also top semiconductor producers and customers for semiconductor manufacturing equipment. In 2015, Japan switched places with China to regain its position as the third largest country export market for semiconductor manufacturing equipment but is expected to return to fourth in 2016. Japan is a participant in the WTO Information Technology Agreement (WTO ITA), and will eliminate tariffs on all products under the WTO ITA expansion on the implementation date – July 1, 2016.

Semiconductors

3

Semiconductor Manufacturing Equipment

5

Overview of the Markets

According to Japanese industry, production by the Japanese electronics/ICT industry increased in 2014 and 2015 and is expected to increase in 2016, especially for displays, server/storage equipment, electro-medical equipment and electronic measuring equipment, increasing the market for semiconductors. Sensors and other ICs for the Internet of Things (IoT) will also experience strong demand. Japanese industry also expects their production of semiconductors and fab upgrades to increase in 2016, stirring demand for semiconductor manufacturing equipment.¹¹⁴

Semiconductors

Japan's electronic products industry, which is the third largest in the world, is the largest demand factor driving sales of semiconductors to Japan. WSTS predicts Japanese consumption of semiconductors will grow from \$24.3 billion in 2015 to \$31.3 billion in 2016 and to \$32.1 billion in 2017. Although in dollar terms the growth is moderate, exchange rates have an effect. Japanese consumption of semiconductors showed a reduction on a dollar basis from 2014 to 2015 but grew on a yen basis.¹¹⁵ The exchange rate change is to the advantage of Japanese electronic equipment

producers. According to the Japan Electronics and Information Technology Industries Association (JEITA), the Japanese electronics industry was expected to increase domestic production for the second year in a row in 2015 – recovering from the fall in production since the 2011 Great East Japan Earthquake.¹¹⁶ Japan's once-formidable semiconductor industry is greatly diminished today, with some firms going bankrupt, plants closing, assets being divested and companies being sold, but it still remains as a competitor.

Semiconductor Manufacturing Equipment

Japan is the fifth largest U.S. export market for semiconductor manufacturing equipment when the EU is considered a market. Semiconductor manufacturing equipment sales in Japan reached \$4.2 billion in 2014¹¹⁷ and \$5.49 billion in 2015 (a 31 percent increase)¹¹⁸ but are projected to decrease to 4.53 billion in 2016, following the usual two years up and one or two years down cycle characteristic of the sub-sector.^{119,120} Japan ranks first for installed semiconductor fab capacity (when discrete semiconductors, especially LEDs are included - Taiwan ranks first in integrated circuit fab capacity).¹²¹ Top 10 semiconductor company Toshiba is divesting many divisions of its company after an accounting scandal brought to light false reporting of

revenues spanning a number of years. It is concentrating on key profitable divisions, including its semiconductor division. Toshiba is breaking ground on a new semiconductor fab this year, and if the construction proceeds, it should be buying semiconductor manufacturing equipment during the 2017 to 2018 time frame. The big Japan story from last year's Japan country case study, the merger of top ranked Applied Materials with fourth ranked TEL, which would have been the largest value merger in the semiconductor manufacturing equipment industry, was abandoned when the two companies were unable to successfully resolve competitive concerns raised by the U.S. Department of Justice.^{122,123}

Challenges and Barriers to U.S. Semiconductor and related equipment exports

Semiconductors

Unlike other markets, where U.S. semiconductor firms have more than 50 share of the market, U.S. firms have only 35.8 percent share of the Japanese Market. Historically, foreign headquartered firms have held a relatively lower share of the Japanese market than in other markets.¹²⁴ Korean and Chinese chipmakers provide competition to U.S. companies selling in Japan in some types of semiconductors. Japan retains three companies in the top 20, Toshiba, Sony, and Renesas, with Toshiba the only remaining Japanese company in the top ten.¹²⁵ As mentioned earlier, Toshiba is shedding parts of its business. Its semiconductor division, especially for NAND Flash, was one of the few profit-making divisions,¹²⁶ though its sales fell from 2014 to 2015. Renesas's sales also fell. Sony is proving a better performer with 5.7 percent growth from 2014 to 2015.¹²⁷

Semiconductor Manufacturing Equipment

Japan can be a challenging market for U.S. companies due to the in-market competitors.¹²⁸ Japan's share of the global semiconductor manufacturing equipment market – 30 percent – is ranked second after the United States' 44 percent share.¹²⁹ Except for the challenge of domestic competitors, the Japanese market is open to U.S. semiconductor manufacturing equipment.

Opportunities for U.S. Companies

Japan hosts the successful semiconductor manufacturing equipment and materials – and increasingly semiconductor and related electronics – show, SEMICON Japan, which will be a U.S. Department of Commerce certified trade show for the third year in a row in 2016. SEMICON Japan 2015 (December 2015) was a successful certified trade show, and along with semiconductor manufacturing equipment and materials companies, U.S. semiconductor companies, and other innovators, such as Tesla, were exhibitors at the show.¹³⁰ There were 42 U.S. companies exhibiting or represented by a Japanese distributor at the show, the USA Showcase, and U.S. companies were promoted at the press conference and the President's reception, and there were over 200 attendees at the USA Showcase Seminar.¹³¹

WTO Information Technology Agreement Expansion

Implementation of the WTO Information Technology Agreement expansion will begin July 2016. Japan will offer immediate duty-free access for all 201 products covered by the expansion agreement, including the semiconductor and semiconductor manufacturing related products.¹³² See Appendix 1 for a list of the semiconductor-related products in the WTO ITA expansion, information on the WTO ITA expansion and links to key documents.

Semiconductors

The Japan Electronics and Information Technology Industries Association (JEITA) forecasts a third straight year of growth in domestic Japanese electronics manufacturing in 2016, rising 3 percent to reach 4.48 trillion yen (\$37 billion) in sales. This means growth opportunities for U.S. semiconductor companies, especially those that supply chips for display devices in smartphones, which are getting larger and have increasing screen resolution; computer server/data storage equipment (to equip new data centers); electronic measuring instruments and electro-medical equipment; the Internet of Things (IoT); and automotive electronics.¹³³

Semiconductor Manufacturing Equipment

Semiconductor manufacturing equipment sales in Japan reached \$4.2 billion in 2014¹³⁴ and \$5.49

billion in 2015 (a 31 percent increase)¹³⁵ but are projected to decrease to 4.53 billion in 2016, following the usual two years up and one or two years down cycle of the industry. Unit sales most likely will be better – the 2015 global equipment market in dollar terms lost \$2 billion or 7 percent of its value solely due to Yen and Euro currency disruptions.¹³⁶

2016 Trade Shows/Events in Japan

*Department of Commerce Certified Trade Show
December 14-16 2016: SEMICON Japan. Tokyo, Japan*

SEMICON Japan is the largest show in Japan, covering semiconductor manufacturing equipment, materials, services and related industries. Last year's USA Showcase at SEMICON Japan 2015 for U.S. exhibitors was a huge success with over 40 U.S. companies participating. SEMICON Japan is a certified trade show again this year.

- U.S. exhibitors at USA Showcase with booths. Also, USA Showcase brochure.
- USA Showcase and U.S. companies promoted at SEMICON Japan's President's reception.
- Keynote at USA Showcase: Co-sponsored by SEMICON Japan and the U.S. Embassy – IT Forum on IoT. Last year, over 700 people showed up for the event (capacity).
- U.S. semiconductor companies gave presentations last year on "Trends in the U.S. Semiconductor Industry".
- For more information on the USA Showcase for SEMICON Japan 2016, please contact Erick Kish, Commercial Attaché at the U.S. Embassy in Japan (erick.kish@trade.gov).

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Korea

Korea is the fourth largest export market for semiconductors and the second largest export market for semiconductor manufacturing equipment. Korea is a participant in the WTO Information Technology Agreement, so most types of semiconductors and semiconductor manufacturing equipment enter the country duty-free, and any remaining types are covered under the U.S.-Korea Free Trade Agreement and the WTO Information Technology Agreement expansion.

Semiconductors

4

Semiconductor Manufacturing Equipment

2

Overview of the Markets

Korea is a large market for U.S. exports of both semiconductors and semiconductor manufacturing equipment. Due to Korea's position as a leading semiconductor producer, it is the second largest market for semiconductor manufacturing equipment as a U.S. export market and as a world market. The Korean market is receptive to both U.S. semiconductors and semiconductor manufacturing equipment, though it is the top contender in the memory IC industry. Korea ranks lower as a market for semiconductors because the country is less important as a location for ICT/electronics equipment assembly. Semiconductor buying decisions by Samsung, LG and other major electronics equipment manufacturers may be made in Korea, however, even though the actual product manufacturing and assembly will more likely take place in China.

Semiconductors

Korea is the fourth largest export market for U.S. semiconductors and is the world's second largest producer of semiconductors behind the United States. Korea's electronic products industry, which is the largest demand factor for semiconductors, is expected to grow from \$24.7 billion to \$26.2 billion from 2014 to 2016, an average annual growth rate of 3 percent. Growth will be driven by production of consumer electronics, mobile communications, displays, next generation LCD TVs, Internet-enabled

sensors, the Internet of Things and automotive electronics.¹³⁷

Korean imports of semiconductors grew 3.52 percent from 2014 to 2015, from \$35.3 to \$36.7 billion. Imports are not the best measure of the size of market, however, due to imports of semiconductors manufactured on contract (Foundry) and OSAT (Outsourced Semiconductor Assembly and Test - semiconductor final assembly, packaging and test). This is reflected in Korea's import statistics, with Taiwan (leader in foundry/OSAT) and China (leader in OSAT) as the top importers into Korea, even though the U.S. is the top producer of semiconductors.¹³⁸ According to ITA's best-guess estimates, based on Korean production of electronic products containing semiconductors and size of the total Asia other than Japan and China and other semiconductor market,¹³⁹ the Korean market represents around 7 to 9 percent of worldwide sales of semiconductors.

Semiconductor Manufacturing Equipment

As the world's second largest market, Korea is vital for the U.S. semiconductor manufacturing equipment industry, and U.S. companies are well established in the Korean market.¹⁴⁰ Due to continued semiconductor fabrication/manufacturing facility (fab) construction and fab equipment upgrading by Korean semiconductor manufacturers, Korea grew from the third largest market for semiconductor manufacturing equipment to second

in 2010 and has remained there ever since. Korea represented 19 percent of the world market for semiconductor manufacturing equipment in 2015, growing 18 percent to \$8.08 billion from 2014's \$6.84 billion.¹⁴¹

Challenges and Barriers to U.S. Semiconductor and Related Equipment Exports

Overall, U.S. companies enjoy access to the Korea semiconductor, and semiconductor manufacturing equipment markets present no significant tariff or non-tariff barriers to U.S. exports. Korea's semiconductor industry is innovative and is currently the United States' largest competitor, with a global market share of 17 percent in 2015.¹⁴² There is no regulation applied to semiconductor chips, per se, but when chips are assembled into electronic devices, the products are subject to KC Mark conformity assessments.¹⁴³ Also, protection of intellectual property rights is a concern for the semiconductor manufacturing equipment industry.

Semiconductors

Korea is the second largest producer of semiconductors, behind the United States, with 17 percent share of world sales.¹⁴⁴ Korean companies Samsung and SK Hynix are the second and third largest semiconductor companies in the world. Korea has no other companies among the top 10.¹⁴⁵ Korea's strength is in memory (DRAM and NAND) with 63.1 percent and 47.7 percent of the production of those products (2013 – latest available).¹⁴⁶ U.S. company Micron is also a major producer of memory semiconductors. Micron, the fifth ranked producer of semiconductors, is Samsung's and SK's largest competitor in memory (Japan's Toshiba, ranked seventh, also competes in memory, making this a crowded space).¹⁴⁷

The Korean semiconductor industry is perhaps the most cost-competitive in the world, posing challenges to U.S. semiconductor companies. The product mix of the U.S. industry is wider than that of Korea, creating opportunities for U.S. products such as microprocessors, ASICs, analog and sensors.

Semiconductor Manufacturing Equipment

Unlike semiconductors, there are no major Korean producers of semiconductor manufacturing

equipment, and Korean companies have less than 3 percent of the world market.¹⁴⁸ U.S. companies may confront IPR issues in Korea, some of which appear to be influenced by Korean policies to promote local production of semiconductor manufacturing equipment. In a past industry survey, Korea was identified by the semiconductor manufacturing equipment and materials industries as the country of most concern with respect to IPR.¹⁴⁹

Opportunities for U.S. Companies

WTO Information Technology Agreement Expansion

Implementation of the expansion will begin in July 2016. Korea will offer duty-free access immediately after three tariff cuts in 2019 for almost all of the semiconductor and semiconductor manufacturing related products covered by the WTO ITA expansion (with a near 50/50 split). The exception is for microprocessors with a staging period of seven years (tariff free in 2023).¹⁵⁰ See Appendix 1 for a list of the semiconductor-related products in the WTO ITA expansion, information on the WTO ITA expansion and links to key documents.

Semiconductors

In 2015, Korea imported \$36.7 billion of semiconductors.¹⁵¹ Couple that with Korean electronics production of \$24.7 billion in 2014 and you come up with a very attractive market. Korea is a world leader in developing innovative consumer electronic products, including mobile communications, displays (including next-generation Ultra High Definition monitors and televisions), automotive electronics, appliances that digitally talk to one another in a household network (Internet of Things), and "smarter" cars, buildings and entire smart cities—all of which require advanced semiconductors as inputs.

According to the U.S. Commercial Service, semiconductors is a best prospect industry. Best subsectors for U.S. semiconductor companies include analog semiconductors, automotive-related semiconductors (microcontrollers, tire pressure mounting systems and other sensor systems) and system semiconductors (HDMI and power semiconductors, both discrete and integrated circuit).¹⁵²

Semiconductor Manufacturing Equipment

After growing 31 percent from 2013 to 2014 and another 18 percent from 2014 to 2015, the Korean market is forecast to contract in 2016, decreasing 9 percent from \$8.08 to \$7.36 billion.¹⁵³ Korea is expected to retain its ranking as the second largest market and will experience an upturn in future years as fabs are upgraded and built. More than 80 percent of semiconductor manufacturing equipment

sold in Korea is imported, and the U.S. is the top producer, so Korea should continue to be an excellent market for semiconductor manufacturing equipment.

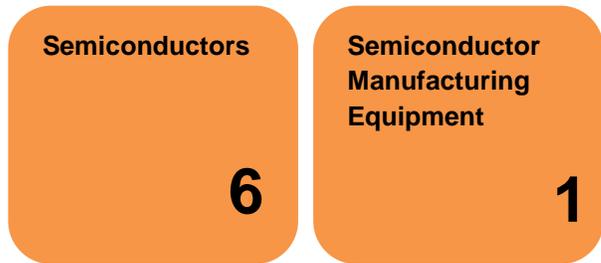
2017 Trade Shows/Events in Korea

February 8-10 2017: SEMICON Korea. Seoul, Korea

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Taiwan

Taiwan is the top market for semiconductor manufacturing equipment and the sixth largest U.S. export market for semiconductors. Taiwanese companies are major manufacturers of electronics equipment. Final product assembly often takes place in China, and semiconductor export sales are mainly attributed to that market. Both design and buying decisions for the semiconductors in the electronic equipment, however, often take place in Taiwan. Taiwan, a participant in the WTO Information Technology Agreement (ITA) and the WTO ITA expansion (with implementation beginning July 1, 2016), presents no significant tariff or non-tariff barriers to U.S. exports. Taiwan's leadership in semiconductor foundry necessitates purchase of state-of-the-art semiconductor manufacturing equipment.



Overview of the Markets

Taiwan is home to electronic equipment manufacturers like Acer, ASUSTek (computers and computer parts) and HTC (smart phones). Taiwan is also home to the largest EMS (electronic manufacturing services – contract manufacturing of ICT equipment) company in the world, Foxconn/Hon Hai. Although much of the manufacturing takes place outside of Taiwan (especially in China), electronic equipment manufacturers and EMS companies often share the semiconductor and other component buying decisions.

Taiwan's semiconductor production industry had sales of approximately \$71 billion in 2015, of which \$31.6 billion were from Taiwan's leading semiconductor foundry subsector. Major Taiwanese semiconductor companies are Taiwan Semiconductor Manufacturing Company (TSMC) and United Microelectronics Company (UMC), both of which serve as foundries (contract semiconductor manufacturing companies) for fabless IC design companies in the United States and elsewhere. DRAM production was \$6.9 billion; fabless production was \$18.6 billion, and the balance (\$13.9 billion) was in OSAT (Outsourced Semiconductor Assembly and Test).¹⁵⁴ With the cost of building a

new semiconductor fab (manufacturing facility) in the billions of dollars, many semiconductor companies worldwide contract their manufacturing to Taiwan – the largest semiconductor foundry manufacturing economy in the world. TSMC and UMC are major customers for U.S. semiconductor manufacturing equipment.

Most Taiwan semiconductor production takes place in science parks, which offer favorable conditions for many types of high-tech manufacturing. Leading science parks include Taiwan Hsinchu Science Park (HSP) (which also includes electronic equipment manufacturing), Southern Taiwan Science Park (STSP) and Central Taiwan Science Park (CTSP) (which also includes computer manufacturing), with total sales of \$44 billion in semiconductor related business for 2015.¹⁵⁵

Semiconductors

The size of the Taiwan market for semiconductors is not available, and import and export statistics for Taiwan are skewed by the large OSAT industry in country. The closest estimate we can come up with based on Taiwan's production of electronic products containing semiconductors and the size of Asia other than Japan, China and other semiconductor market

is 3 percent of the world market.¹⁵⁶ This estimate does not include production outside of Taiwan by subsidiaries of Taiwanese electronic equipment and EMS (electronic equipment manufacturing on contract) companies, so it underestimates the importance of this market.

Computer and telecommunications equipment companies are the largest buyer sectors of semiconductors in Taiwan,¹⁵⁷ including major producers Acer, ASUSTek and HTC.¹⁵⁸ As mentioned above, while assembly of Taiwanese brand electronic products often takes place in China, the semiconductor buying decisions are made in Taiwan. For instance, for servers, electronic equipment manufacturers often make the buying decision for microprocessors and power ICs, and EMS companies often make the buying decision for sensors and other support role semiconductors.¹⁵⁹ Foxconn/Hon Hai has manufacturing facilities around the world, most notably in China, where it employs over 1 million workers.

Semiconductor Manufacturing Equipment

Taiwan has consistently been the top global market for semiconductor manufacturing equipment in recent years, representing over a quarter of the total worldwide market. The Taiwanese market was valued at \$9.6 billion in 2015.¹⁶⁰ The U.S. is the top importer of semiconductor manufacturing equipment into Taiwan, representing \$3.9 billion, or 32 percent of Taiwanese imports. United States imports into Taiwan rose 16 percent from 2014 to 2015 while Taiwan's imports from the world fell 6 percent over the same period.¹⁶¹ Taiwanese foundries TSMC and its rival UMC are both global leaders in semiconductor manufacturing and buy state-of-the-art semiconductor manufacturing equipment. TSMC is ranked second globally in estimated capital spending, with \$9.5 billion forecast for 2016.¹⁶² UMC is ranked eighth, with forecasted capital expenditure of \$2.2 billion for 2016.^{163 164} There are also a number of smaller semiconductor manufacturers in Taiwan, primarily in the memory segment, that also purchase semiconductor manufacturing equipment.

Suppliers of U.S. semiconductor assembly and test equipment (as distinct from wafer fab equipment) will also find Taiwan an excellent market. Although China has more total factory floor space dedicated to

contract semiconductor packaging/final assembly and test, Taiwan also hosts a considerable amount of OSAT capacity (nearly 20 percent of worldwide OSAT factory floor space). Also, Taiwanese companies own much of the OSAT capacity in China and are the leaders in this segment. Taiwanese OSAT companies, in many cases, make the buying decisions for semiconductor assembly and test equipment used by subsidiaries of their companies in China.¹⁶⁵

Challenges and Barriers to U.S. Semiconductor and Related Equipment Exports

There are no significant barriers to U.S. semiconductor or semiconductor manufacturing equipment exports to Taiwan. As a participant in the WTO Information Technology Agreement and the recent WTO ITA expansion, Taiwan allows imports of most semiconductors and related manufacturing equipment to enter duty-free. Taiwan's semiconductor industry is world-class, but it is dominated by foundry manufacturing, which generally partners, rather than competes, with U.S. semiconductor manufacturers (except in the case of other foundries, such as Globalfoundries). Taiwan is the only other market besides the U.S. with a substantial fabless industry (18 percent share of the market). Many U.S. fabless semiconductor companies directly benefit from contracting production of their integrated circuit designs to Taiwan. Taiwan also is a competitor in the fabless space. Taiwan does have a small DRAM manufacturing industry, but it has never reached a notable share of that market. Taiwan's production of semiconductor manufacturing equipment is very limited and poses little competitive challenge to U.S. suppliers.

Opportunities for U.S. Companies

Taiwan is open to trade in both semiconductors and semiconductor manufacturing equipment and presents a good market for U.S. companies.

WTO Information Technology Agreement Expansion

Implementation of the expansion will begin in July 2016. Taiwan will offer immediate duty-free access for almost all of the semiconductor and semiconductor manufacturing related products covered by the WTO ITA expansion. Semiconductor-related products that are not granted immediate

zero are photoresist; fans for microprocessors; CMP (chemical-mechanical planarization) pads; FOSB (front opening shipping boxes) and similar special containers for conveying and shipping semiconductor wafers, masks and reticles; specialty pumps, heat exchange units, and liquid and gas filtering equipment for semiconductor fabs; and electron microscopes. These will all be duty-free when exported to Taiwan in 2019 after three tariff cuts.¹⁶⁶ See Appendix 1 for a list of the semiconductor-related products in the WTO ITA expansion, information on the WTO ITA expansion and links to key documents.

Semiconductors

WSTS (World Semiconductor Trade Statistics) forecasts that the Asia-Pacific/Other market for semiconductors, which includes Taiwan, will grow 0.2 percent in 2016 and another 3.1 percent in 2017.¹⁶⁷

There are a variety of export opportunities for U.S. companies, which include semiconductors used in display products, like computer touch-screen panels, smartphone screens and LCD monitors, and semiconductors used in data center equipment (computer servers and data storage and switching equipment) to facilitate the growth in cloud computing. Semiconductors (especially sensors and communications ICs) used in the Internet of Things (IoT) will be a major demand driver over the next 10 years, though it is starting from a low base value.

Semiconductor Manufacturing Equipment

Although fab equipment spending was essentially flat last year, SEMI forecasted in March 2016 that the market would grow 3.7 percent in 2016, followed by 13 percent growth in 2017.¹⁶⁸ Taiwan is expected to be a large contributor to the growth in 2017, with five semiconductor fabs starting construction in 2015 to 2016, which will lead to equipping in 2017 and later,¹⁶⁹ and is forecast to remain the top market for semiconductor manufacturing equipment.¹⁷⁰ Taiwan overtook South Korea in 2015 to become the world leader in IC fab capacity,¹⁷¹ so there will be increased sales (replacement and upgrades) in the future. U.S. semiconductor manufacturing equipment suppliers already enjoy considerable success in Taiwan, and this trend should continue in the near-term. Just in the first quarter of 2016, TSMC announced it had purchased equipment from U.S. semiconductor manufacturing equipment companies Applied Materials and Lam Research for a total of about \$8.6 billion,¹⁷² and ASE (Taiwan), the top-ranked OSAT company in the world, announced three purchases of semiconductor assembly and test equipment for a total of about \$52.6 million from Kulicke and Soffa (U.S.), Besi (Netherlands) and Disco (Japan).¹⁷³

2016 Trade Shows/Events in Taiwan

September 7-9: SEMICON Taiwan. Taipei, Taiwan.

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Addendum: Resources for U.S. Exporters

The U.S. Government has numerous resources available to help U.S. exporters: from additional market research, to guides to export financing, to overseas trade missions, to staff around the country and the world. A few key resources are highlighted below. For additional information about services from the International Trade Administration (ITA), please visit www.export.gov.

Country Commercial Guides

<http://export.gov/ccg/>

Written by U.S. Embassy trade experts worldwide, the *Country Commercial Guides* provide an excellent starting point for what you need to know about exporting and doing business in a foreign market. The reports include sections addressing: market overview, challenges, opportunities, and entry strategies; political environment; selling U.S. products and services; trade regulations, customs, and standards; and much more.

Basic Guide to Exporting

<http://export.gov/basicguide/>

A Basic Guide to Exporting addresses virtually every issue a company looking to export might face. Numerous sections, charts, lists and definitions throughout the book's 19 chapters provide in-depth information and solid advice about the key activities and issues relevant to any prospective exporter.

Trade Finance Guide: A Quick Reference for U.S. Exporters

<http://www.export.gov/tradefinanceguide/index.asp>

Trade Finance Guide: A Quick Reference for U.S. Exporters is designed to help U.S. companies, especially small and medium-sized enterprises, learn the basics of trade finance so that they can turn their export opportunities into actual sales and achieve the ultimate goal of getting paid on time for those sales. Concise, two-page chapters offer the basics of numerous financing techniques, from open accounts to forfaiting and government assisted foreign-buyer financing.

Certified Trade Fairs

http://www.export.gov/eac/show_short_trade_events.asp?CountryName=null&StateName=null&IndustryName=null&TypeName=International%20Trade%20Fair&StartDate=null&EndDate=null

The Department of Commerce's trade fair certification program endorses overseas trade shows that are reliable venues and good markets for U.S. firms to sell their products and services abroad.

These shows serve as vital access vehicles for U.S. firms to enter and expand into foreign markets. The certified show/U.S. pavilion ensures a high-quality, multi-faceted opportunity for American companies to successfully market overseas. Among other benefits, certified trade fairs provide U.S. exhibitors with help facilitating contacts, market information, counseling and other services to enhance their marketing efforts.

- Semicon Japan: December 14-16, 2016 – USA Showcase

The Advocacy Center

<http://www.export.gov/advocacy/>

The Advocacy Center coordinates U.S. government interagency advocacy efforts on behalf of U.S. exporters that are bidding on public-sector contracts with overseas governments and government agencies. The Advocacy Center helps to ensure that sales of U.S. products and services have the best possible chance competing abroad. Advocacy assistance is wide and varied but often involves companies that want the U.S. Government to communicate a message to foreign governments or government-owned corporations on behalf of their commercial interest, typically in a competitive bid contest.

International Buyer Program

<http://export.gov/ibp/>

The International Buyer Program (IBP) brings thousands of international buyers to the United States for business-to-business matchmaking with U.S. firms exhibiting at major industry trade shows. Every year, the International Buyer Program results in millions of dollars in new business for U.S. companies by bringing pre-screened international buyers, representatives and distributors to selected shows. U.S. country and industry experts are on site at IBP shows to provide hands-on export counseling, market analysis and matchmaking services. Each IBP show also has an International Business Center where U.S. companies can meet privately with

prospective international buyers, prospective sales representatives and business partners and obtain assistance from experienced ITA staff.

U.S. Commercial Service

<http://www.export.gov/usoffices/index.asp>

With offices throughout the United States and in U.S. Embassies and consulates in nearly 80 countries, the U.S. Commercial Service utilizes its global network of trade professionals to connect U.S. companies with international buyers worldwide. Whether looking to make their first export sale or expand to additional international markets, companies will find the expertise they need to tap into lucrative opportunities and increase their bottom line. This includes trade counseling, actionable market intelligence, business matchmaking, and commercial diplomacy.

Report a Trade Barrier

http://tcc.export.gov/Report_a_Barrier/index.asp

Trade barriers inhibit fair competition in export markets. Examples include high tariffs, investment restrictions such as local content requirements, weak enforcement of intellectual property rights, non-transparent regulations and licensing regimes,

burdensome certification requirements not required of domestic manufacturers, non-uniform application of customs procedures, lack of competitive bidding for foreign government tenders, and provision of direct or indirect subsidies by a foreign government in favor of its domestic suppliers. The Office of Trade Agreements Negotiation and Compliance (TANC) works with U.S. companies to remedy the trade barriers they encounter in export markets. Companies can confidentially report a trade barrier and request assistance.

Stopfakes

<http://www.stopfakes.gov/>

STOPfakes.gov was launched to serve as a one-stop shop for U.S. government tools and resources on intellectual property rights (IPR). The federal agencies behind STOPfakes.gov have developed a number of resources to educate and assist businesses, particularly small and medium-sized enterprises (SMEs), as well as consumers, government officials, and the general public.

Appendix 1: WTO Information Technology Agreement (ITA) Expansion Semiconductors, Semiconductor Manufacturing Equipment and Related Products

Semiconductor Related Products in the WTO ITA Expansion:

Partially covered subheadings are identified by the symbol "ex". "Item number" is from the full WTO ITA expansion list.

Attachment A

Item	HS 2007	Ex*	Description	Semiconductor-Related Product
002	370130		Other plates and film, with any side exceeding 255 mm	Photoblanks
003	370199		Other	Photoblanks
004	370590		Other	Photomasks and Reticles
005	370790		Other	Photoresist
007	841459	ex	Fans of a kind used solely or principally for cooling microprocessors, telecommunication apparatus, automatic data processing machines or units of automatic data processing machines	Fans of a kind used solely or principally for cooling microprocessors
008	841950	ex	Heat exchange units made of fluoropolymers and with inlet and outlet tube bores with inside diameters measuring 3 cm or less	Heat exchange units for semiconductor manufacturing
010	842129	ex	Liquid filtering or purifying machinery and apparatus made of fluoropolymers and with filter or purifier membrane thickness not exceeding 140 microns	Liquid filtering or purifying machinery for semiconductor manufacturing
011	842139	ex	Filtering or purifying machinery and apparatus for gases, with stainless steel housing, and with inlet and outlet tube bores with inside diameters not exceeding 1.3 cm	Filtering or purifying machinery and apparatus for gases, for semiconductor manufacturing
012	842199	ex	Parts of filtering or purifying machinery and apparatus for liquids, made of fluoropolymers and with filter or purifier membrane thickness not exceeding 140 microns; parts of filtering or purifying machinery and apparatus for gases, with stainless steel housing, and with inlet and outlet tube bores with inside diameters not exceeding 1.3 cm	Parts of filtering or purifying machinery and apparatus for liquids, for semiconductor manufacturing
041	848610		Machines and apparatus for the manufacture of boules or wafers	As per description
042	848620		Machines and apparatus for the manufacture of semiconductor devices or of electronic integrated circuits	As per description
044	848640		Machines and apparatus specified in Note 9(C) to this Chapter	Machines for the manufacture and repair of masks and reticles, for assembling semiconductors, for lifting, handling, loading and unloading of semiconductor

				boules, wafers, or semiconductors
045	848690		Parts and accessories	Parts and accessories for products under HS 8486
074	852351		Solid-state non-volatile storage devices	Flash drives, solid state drives, etc., non-volatile
075	852352		"Smart cards"	As per description
076	852359		Other	Other solid-state storage
103	854231		Processors and controllers, whether or not combined with memories, converters, logic circuits, amplifiers, clock and timing circuits, or other circuits	As per description, includes MCPs
104	854232		Memories	As per description, includes MCPs
105	854233		Amplifiers	As per description, includes MCPs
106	854239		Other	Other integrated circuits, not elsewhere classified, includes MCPs
107	854290		Parts	Parts of integrated circuits, including parts of MCPs
121	900120		Sheets and plates of polarising material	Sheets and plates of polarizing material – possible parts of semiconductor manufacturing equipment
122	900190		Other	Lenses, prisms, mirrors, other optical elements, unmounted, optically worked – possible parts for semiconductor manufacturing equipment
123	900219		Other	Objective lenses, mounted, optically worked – possible parts for semiconductor manufacturing equipment
124	900220		Filters	Optical filters – possible parts for semiconductor manufacturing equipment
125	900290		Other	Mirrors, other optical elements, mounted, optically worked – possible parts for semiconductor manufacturing equipment
132	901210		Microscopes other than optical microscopes; diffraction apparatus	Re: electron microscopes for semiconductor inspection
133	901290		Parts and accessories	Re: parts of electron microscopes for semiconductor inspection

MCP – Multi-Chip Package

ATTACHMENT B

<p>192</p>	<p>Multi-component integrated circuits (MCOs):a combination of one or more monolithic, hybrid, or multi-chip integrated circuits with at least one of the following components: silicon-based sensors, actuators, oscillators, resonators or combinations thereof, or components performing the functions of articles classifiable under heading 8532, 8533, 8541, or inductors classifiable under heading 8504, formed to all intents and purposes indivisibly into a single body like an integrated circuit, as a component of a kind used for assembly onto a printed circuit board (PCB) or other carrier, through the connecting of pins, leads, balls, lands, bumps, or pads. For the purpose of this definition the following expressions mean: 1. "Components" may be discrete, manufactured independently then assembled onto the rest of the MCO, or integrated into other components. 2. "Silicon based" means built on a silicon substrate, or made of silicon materials, or manufactured onto integrated circuit die. (a). "Silicon based sensors" consist of microelectronic or mechanical structures that are created in the mass or on the surface of a semiconductor and that have the function of detecting physical or chemical quantities and transducing these into electric signals, caused by resulting variations in electric properties or displacement of a mechanical structure. "Physical or chemical quantities" relates to real world phenomena, such as pressure, acoustic waves, acceleration, vibration, movement, orientation, strain, magnetic field strength, electric field strength, light, radioactivity, humidity, flow, chemicals concentration, etc. 3(b). "Silicon based actuators" consist of microelectronic and mechanical structures that are created in the mass or on the surface of a semiconductor and that have the function of converting electrical signals into physical movement. 3(c). "Silicon based resonators" are components that consist of microelectronic or mechanical structures that are created in the mass or on the surface of a semiconductor and have the function of generating a mechanical or electrical oscillation of a predefined frequency that depends on the physical geometry of these structures in response to an external input. 3(d). "Silicon based oscillators" are active components that consist of microelectronic or mechanical structures that are created in the mass or on the surface of a semiconductor and that have the function of generating a mechanical or electrical oscillation of a predefined frequency that depends on the physical geometry of these structures.</p>	<p>As per description. Will be included in HS 8542 in 2017</p>
<p>193</p>	<p>Light-Emitting Diode (LED) Backlights modules, which are lighting sources that consist of one or more LEDs, and one or more connectors and are mounted on a printed circuit or other similar substrate, and other passive components, whether or not combined with optical components or protective diodes, and used as backlights illumination for liquid crystal displays (LCDs)</p>	<p>As per description.</p>
<p>197</p>	<p>Self-adhesive circular polishing pads of a kind used for the manufacture of semiconductor wafers</p>	<p>CMP pads</p>
<p>198</p>	<p>Boxes, cases, crates and similar articles, of plastic, specially shaped or fitted for the conveyance or packing of semiconductor wafers, masks, or reticles, of subheading 392310 or 848690</p>	<p>Re: FOSB, FOUPS, Reticle or wafer shipping box</p>
<p>199</p>	<p>Vacuum pumps of a kind used solely or principally for the manufacture of semiconductors or flat panel displays</p>	<p>As per description.</p>
<p>200</p>	<p>Plasma cleaner machines that remove organic contaminants from electron microscopy specimens and specimen holders</p>	<p>As per description.</p>

Current Participants in the ITA Expansion Agreement (as of March, 2016)

- Australia
- Albania
- Canada
- China
- Colombia
- Costa Rica
- European Union (and its 28 Member States)
- Guatemala
- Hong Kong
- Iceland
- Israel
- Japan
- Korea
- Malaysia
- Mauritius
- Montenegro
- New Zealand
- Norway
- Philippines
- Singapore
- Switzerland/Liechtenstein
- Chinese Taipei
- Thailand
- United States

For More Information

A press release from the WTO with links to the Ministerial Declaration, which includes in its attachments the list of 201 product categories covered, and a link to the parties' tariff reduction schedules can be found here:

- https://www.wto.org/english/news_e/news15_e/ita_16dec15_e.htm

The Ministerial Declaration attachments can help you determine whether your product is covered by the agreement, and the parties' schedules show how the tariff commitments will be implemented over time in each country.

Background: Expansion of the World Trade Organization's Information Technology Agreement

In December 2015, the United States and over 50 developed and developing country partners at the World Trade Organization (WTO) announced a landmark expansion of the Information Technology Agreement, which will phase out hundreds of tariffs on U.S. information technology exports all over the world. The expanded agreement will eliminate tariffs on technologies developed since the initial agreement as well as broader applications of ICT.

The agreement covers a list of 201 product categories, which the WTO estimates to be worth \$1.3 trillion in global exports per year (about 10 percent of total global trade). The United States exports \$180 billion in these technologies each year.

Examples of Covered Products under ITA Expansion:

- *Audio-Video Products*
 - Gaming Consoles and Remotes
 - Television Cameras
 - Loudspeakers and Headphones
 - Educational Electronic Toys
- *Electrical Components*
 - Static Converters and Inductors
- *Instruments*
 - Electrical Test and Measuring
 - Navigational Instruments (GPS)
 - Scales (Digital)
- *Manufacturing Equipment*
 - Semiconductor and Flat Panel Display Manufacturing Equipment
- *Medical Equipment*
 - MRIs, CT scanners, Ultrasounds
 - X-Ray Equipment
 - Pacemakers
 - Other Electro-Medical Equipment
- *Printers*
- *Semiconductors*
 - MCOs (Multi-Component Semiconductors)
- *Software and Media*
 - Flash drives
 - Point of Sale Cards & Licenses
- *Telecommunication Equipment*
- *Satellites (Communication)*

Tariff Elimination

Tariffs will be eliminated by the participating countries on a most favored nation (MFN) basis, so all WTO members will be able to take advantage of the tariff cuts when exporting covered products to parties to the agreement.

The first round of tariff cuts will happen on July 1, 2016. Each participating country negotiated with the other participants how its individual tariffs would be cut. The WTO estimates that 65 percent of the tariff lines, representing 88 percent of the participants' imports of the covered products will be duty-free on day one of the agreement, rising to 95 percent by 2019. 100 percent of the imports by all participating countries will be duty free by 2024.

Membership

The original ITA currently includes 83 WTO members. 53 WTO members (counting the EU and its member states) are now participating in the ITA expansion, representing approximately 90 percent of world trade in the products covered by the expanded agreement. Other WTO members will be able to join the ITA expansion in the future (the original ITA started with 29 WTO members before growing to 83).

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Appendix 2: Country Rankings 2016

Top Semiconductor Export Markets

**EU Member Country*

- | | |
|---------------------|---------------------|
| 1. China | 21. United Kingdom* |
| 2. Japan | 22. Poland* |
| 3. South Korea | 23. Italy* |
| 4. Singapore | 24. Switzerland |
| 5. Taiwan | 25. Ukraine |
| 6. Malaysia | 26. Israel |
| 7. Germany* | 27. Sweden* |
| 8. Mexico | 28. Slovakia* |
| 9. Thailand | 29. Russia |
| 10. Vietnam | 30. Turkey |
| 11. India | 31. Austria* |
| 12. Brazil | 32. Belgium* |
| 13. France* | 33. Ireland* |
| 14. Indonesia | 34. South Africa |
| 15. Netherlands* | 35. Spain* |
| 16. Philippines | 36. Romania* |
| 17. Canada | 37. Finland* |
| 18. Czech Republic* | 38. Portugal* |
| 19. Australia | 39. Estonia* |
| 20. Hungary* | 40. Denmark* |

Top Semiconductor Manufacturing Equipment Export Markets

**EU Member Country*

1. Taiwan
2. Korea
3. China
4. Japan
5. Singapore
6. Germany*
7. Netherlands*
8. Ireland*
9. Malaysia
10. Israel
11. France*
12. Austria*
13. Belgium*
14. Italy*
15. United Kingdom*
16. Mexico
17. Philippines
18. Russia
19. Thailand
20. Vietnam
21. Switzerland
22. Canada
23. Denmark*
24. India
25. Czech Republic*
26. Brazil
27. Indonesia
28. Sweden*
29. Finland*
30. Lithuania*

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