

Growing capabilities China's impact on the semiconductor industry 2012 update

Chapter 5:
Manufacturing

November 2012

About this report

In 2004, PwC released its original report, *China's impact on the semiconductor industry*, in response to our clients' interest in the rapid growth of the semiconductor industry in China. Specifically, clients wanted to find out whether China's production volumes would contribute to worldwide overcapacity and a subsequent downturn in the industry. For the past seven years, we have provided updates that included an analysis of both the semiconductor market (consumption) and industry (production). We also covered design, the value chain and possible production growth scenarios along with a number of other topics.

Because the report relies on a number of data sources, we have been unable to deliver it in full until the fourth quarter of the following year. This year, in an effort to get you this vital information in a more timely fashion, we have chosen to release the report in a tiered fashion. This is the fifth chapter in the series. Please note that figure and table numbering continue from the fourth chapter, thus the first figure in this chapter is numbered 22 rather than 1. In the coming weeks, we will release additional chapters, until we have covered as much material as in previous reports. At the end of the release period, you will be able to download a complete pdf file of the full report.

Please visit www.pwc.com/chinasemicon over the next several weeks to read or download each chapter of this year's report.

Chapters released to date include:

- 1. Market and industry overview*
- 2. China's semiconductor industry*
- 3. Design in China*
- 4. Greater China*

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Samsung's Xi'an NAND Flash memory fab, which broke ground in September 2012, will become China's largest and most advanced technology wafer fab upon its completion, currently estimated to be in 2014.

China's relative revenue growth will lag significantly if its foundries continue to compete on price rather than leading-edge technology.

Over the past three years, China's share of wafer fab capacity allocated to the O-S-D (optoelectronics-sensors-discretes) sector has been increasing. It could increase to 30% for China versus 15% worldwide by 2015.

Packaging, assembly and test is probably the largest of China's semiconductor manufacturing sectors when measured in terms of value added, production revenue, employees and manufacturing floor space.

China's SPA&T (semiconductor packaging, assembly and test) facilities continue to rank first in share of worldwide SPA&T manufacturing floor space for the third year, ahead of Taiwan and Japan.

Manufacturing the future

Chapter 5: Manufacturing

Wafer fab capacity

During 2011 China increased wafer fab capacity faster than the worldwide average for the second year in a row and for nine out of the past eleven years. During the past year, China increased the net number of fabs in production by 13, or 9%—and increased its net capacity by 9%—while the worldwide industry only increased the net number of fabs in production by 25, or 2%, for a 4% increase in net capacity.

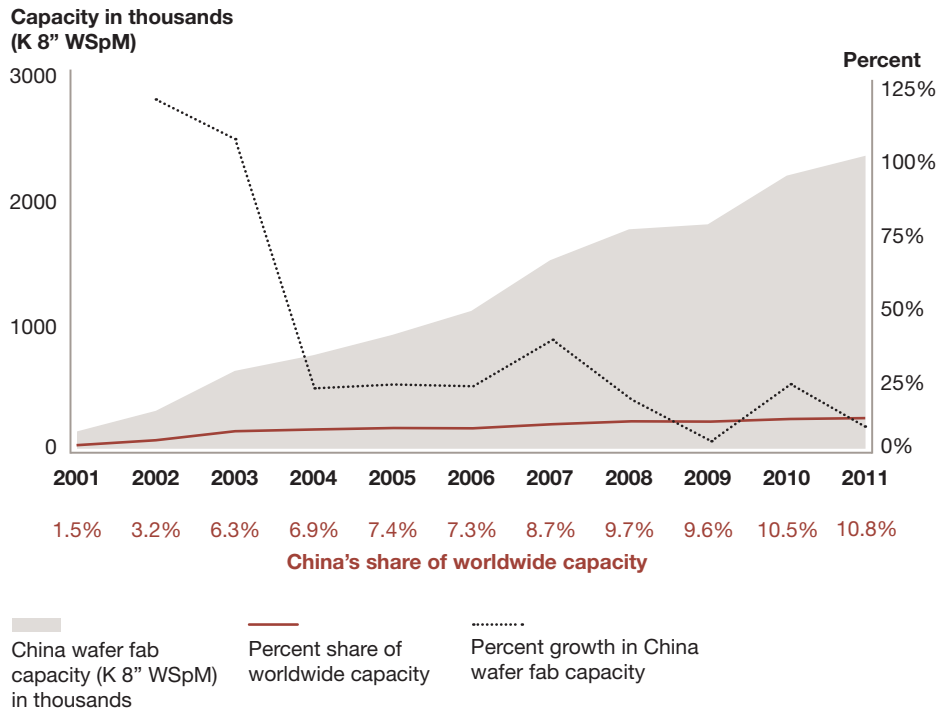
Based upon their current capabilities (rather than intentions, i.e. World Fab Watch, WFW, Probability ≥ 1.0), China will now be able to increase its share of total worldwide semiconductor wafer production from the $\leq 2\%$ realized in 2003 to $\geq 10.8\%$ by 2014 by just fully equipping and ramping to full capacity at mature yields all of their existing

wafer fabrication modules. This would more than quintuple their share of worldwide wafer production compared to 2003 and represents a further increase in China's relative capacity during the past year from 10.5% to 10.8% of worldwide capacity.

As a result of the increased awareness of the significance and impact of China's local O-S-D (optoelectronics–sensors–discrete) sector, a further four existing Chinese wafer fabs were added to the WFW database. All four were discrete wafer fabs. Their inclusion was in addition to the 10 existing wafer fabs added in 2010, 26 added in 2009 and 13 added in 2008. These continuing revisions have provided a more comprehensive understanding of China's local O-S-D sector. Because of the 2011 additions, China's 2010 current wafer fab capacity has been revised to 2,170.4K Wafer

During the past year, China increased the net number of fabs in production by 13, or 9%—and increased its net capacity by 9%—while the worldwide industry only increased the net number of fabs in production by 25, or 2%, for a 4% increase in net capacity.

Figure 22: China's wafer fab capacity and share of worldwide capacity, 2002–2011



Source: World Fab Watch 2002-2012

Starts per Month (a 2% correction) which represented 10.5% of 2010 worldwide capacity.

China currently has 22 additional wafer fabs committed and under construction. This is half the total of the 44 additional committed fabs under construction worldwide, but only represents slightly more than 9% of the total capacity of the 44 fabs. China is getting less capacity per new

wafer fab plant because it is adding a greater proportion of 4-inch (100mm) or smaller O-S-D fabs than other regions and has a lower proportion of 12-inch (300mm) plants. Twenty-four (24) of the 28 fabs that started production during 2011 and 19 of the 22 fabs that are committed and under construction are all LED wafer fabs and most are 2-inch (50mm) wafer fabs. During the past five years, the number of wafer fabrication modules committed and under construction in China has varied widely. It decreased from 20 in 2006 to 8 in 2008 before growing to 12 in 2009 and 22 in both 2010 and 2011. These 22 modules under construction have the potential to further increase China's wafer fabrication capacity by 5.5%, which is less than the 6.6% increase in potential worldwide capacity from the total of 44 modules under construction worldwide. At that point, China will no longer be increasing wafer fab capacity faster than other regions.

Based upon their current plus committed capabilities—plants in production plus plans under construction (i.e., WFA Probability ≥ 0.8)—China could increase and maintain its share of total worldwide semiconductor wafer production from the $\leq 2\%$ realized in 2003 to $\geq 10.7\%$ through 2015. This would require financing, completing the 22 wafer fabrication plants currently under construction and full equipping and ramping to full capacity at mature yields those new plants plus all of China's existing wafer fabrication

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Table 8: Comparison of current wafer fab capacity, 2011

	China		China's % of Worldwide	Worldwide	
	Capacity	%		Capacity	%
Geometry					
≥ 0.7μm	621.4	27%	20%	3,089.2	14%
< 0.7 to ≥ 0.4μm	159.6	7%	14%	1,175.0	5%
< 0.4 to ≥ 0.2μm	202.9	9%	10%	2,073.6	10%
< 0.2 to ≥ 0.12μm	315.0	14%	14%	2,269.2	11%
< 0.12 to ≥ 0.06μm	467.3	20%	16%	2,888.6	13%
< 0.06 to ≥ 0.028μm	562.5	24%	11%	5,333.7	25%
< 0.028 μm	0.0	0%	0%	4,086.8	19%
N/A		0%		611.0	3%
Total	2,328.7	100%*	11%	21,527.1	100%
Wafer size					
≥ 4"	345.7	15%	34%	1,019.8	5%
5"	186.9	8%	26%	724.6	3%
6"	396.3	17%	13%	3,093.9	14%
8"	619.0	27%	11%	5,814.1	27%
12"	780.8	34%	7%	10,874.8	51%
Total	2,328.7	100%*	11%	21,527.2	100%

Capacity = 1000s 8" Equivalent Wafer Starts per month (KWSpM)

Current capacity = World Fab Watch Probability ≥ 1.0

*Total % may differ from 100% due to rounding.

Source: SEMI World Fab Watch, May 2012

modules. If this were to come to pass, it would increase China's share of worldwide wafer production by slightly more than five times and have a moderate impact on the semiconductor industry.

Capacity by process node and wafer size

From a geometry/technology node distribution standpoint, China's current wafer fabrication capabilities continue to lag the worldwide industry in moving to leading-edge capabilities. When fully equipped and ramped, China will only have 24% of its capacity at the advanced <0.06μm

node compared to a worldwide industry distribution of 44%. None of China's advanced capacity will be at the leading edge ≤ 0.028μm node versus 19% of current worldwide industry capacity. By contrast, China will have 20% at the less advanced <0.12 to ≥0.06μm nodes versus 13% worldwide and 23% at the mid-range <0.4 to ≥0.12μm nodes versus 21% worldwide. Probably because of its heavier focus on O-S-D—and especially LED production—China will also have 34% of its capacity at the mature >0.4μm nodes versus worldwide 19%.

Also because of its heavier focus on LED production and mature technologies, China's current capabilities in

Table 9: Comparison of committed future wafer fab capacity, 2011

	China			China's % of Worldwide	Worldwide		
	# Fabs	Capacity	%		# Fabs	Capacity	%
Geometry							
≥ 0.7μm	19	94.7	74%	62.3%	23	152.1	11%
< 0.7 to ≥ 0.4μm	1	4.0	3%	83.3%	2	4.8	0%
< 0.4 to ≥ 0.2μm	1	10.0	8%	80.0%	4	12.5	1%
< 0.2 to ≥ 0.12μm	0	0.0	0%	0.0%	1	45.0	3%
< 0.12 to ≥ 0.06μm	1	20.0	15%	16.7%	2	120.0	8%
< 0.06 to ≥ 0.028μm	0	0.0	0%	0.0%	3	360.0	25%
< 0.028μm	0	0.0	0%	0.0%	9	726.8	51%
N/A	0	0.0	0%	0.0%	0	0.0	0%
Total	22	128.7	100%	9.1%	44	1,421.2	100%*
Wafer size							
≥ 4"	19	94.7	74%	100.0%	19	94.7	7%
5"	0	0.0	0%	0.0%	0	0.0	0%
6"	0	0.0	0%	0.0%	8	60.8	4%
8"	3	34.0	26%	25.4%	4	134.0	9%
12"	0	0.0	0%	0.0%	12	1,127.8	79%
18"	0	0.0	0%	0.0%	1	4.6	0%
Total	22	128.7	100%	9.1%	44	1,421.9	100%*

Capacity = 1000s 8" Equivalent Wafer Starts per month (KWSpM)
 Committed future capacity = Wafer Fab Watch WFW Probability ≥ 0.8 to <1.0
 *Total % may differ from 100% due to rounding.

Source: SEMI World Fab Watch, May 2012

terms of wafer size continue to be more concentrated in the smaller size ranges. To illustrate, China has:

- 15% of its capacity in 4-inch or smaller wafers versus the worldwide mix of 5%;
- 25% of its capacity in 5-inch or 6-inch wafers versus the worldwide mix of 17%;
- 27% of its capacity in 8-inch wafers equal to the worldwide mix of 27% and
- 34% of its capacity in 12-inch wafers compared to the worldwide mix of 51%.

During 2011, the production startup of SMIC's Mega Fab 5 in Beijing and Hua Li's Fab 3 in Shanghai, plus the ramp up of Intel's Fab 68 in Dalian, improved China's 12-inch (300mm) fab capacity somewhat. Of the 103 12-inch (300mm) wafer fabrication plants currently in production worldwide, eight are now in China, constituting 7.2% of worldwide 300mm capacity. However, China did not have any of the 12 additional 12-inch (300mm) wafer plant committed and under construction worldwide during 2011. When they are completed, fully equipped and ramped to full capacity—which could be three years from now—China's share of

worldwide 300mm capacity will be decreased to 6.5%. As a result, for at least the next three years, wafer fab plants in other locations will continue to have the capabilities for retaining low mix/high volume advanced technology (e.g. DRAM NAND Flash) wafer manufacturing cost leadership.

Overall, China continues to have newer wafer fabrication plants with older technology. More of China's current wafer fab capacity has been brought into production within the last five years. Seventy-six (76) of China's current 163 wafer fab plants started production after 2006 and represent 37% of China's current capacity. By contrast, worldwide wafer fab plants starting production after 2006 only represent 27% of total current capacity. At the same time, China lags the worldwide average in technology node and wafer size. Previously this apparent anomaly had been the result of many of China's wafer fab plants being established with transferred used equipment and technology. Currently it also reflects China's recent concentration in the establishment of new LED wafer fabs.

From a business model standpoint, China's wafer fabrication capabilities remain noticeably different from worldwide capabilities. Foundry capacity continues to dominate both China's current and committed capabilities.

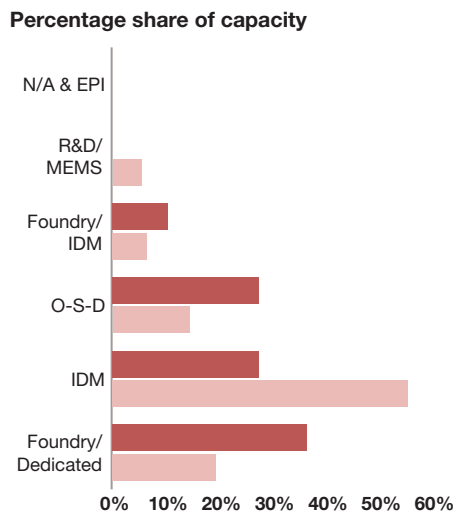
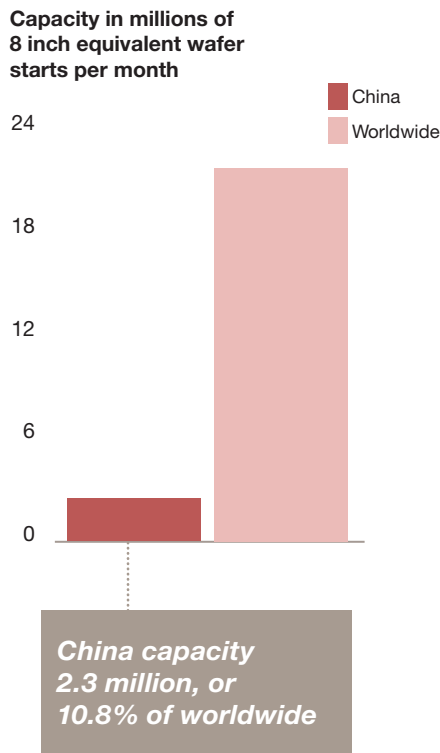
For the future, China does have three 12-inch (300mm) wafer fabs that are announced and planned, including the Samsung Xi'an NAND Flash memory fab which broke ground in September 2012. If and when these three planned fabs are completed, equipped and ramped into production, China's share of worldwide 12-inch capacity will increase to 9.8%. The Samsung Xi'an fab is the most significant of these three planned 12-inch fabs. It represents 70% of their added capacity and, when brought into full production, will become China's largest and most advanced technology wafer fab surpassing the Hynix Wuxi fab.

Offsetting this relative lack of 12-inch (300mm) wafer fab capacity, China continues to maintain a greater than worldwide average concentration of 6-inch and smaller fab capacity. China currently has 138 6-inch or smaller wafer fabs in production, constituting 40% of total capacity compared to a worldwide average of 22%. To a considerable extent, this mix is the result of China's concentration in the O-S-D sector and recent growth of its LED capabilities. One hundred and five (105) of these smaller fabs are O-S-D, including 63 LED wafer fabs, and 41 discrete fabs.

Capacity by business model

From a business model standpoint, China's wafer fabrication capabilities remain noticeably different from worldwide capabilities. Foundry capacity continues to dominate both China's current and committed capabilities. For example, when fully equipped and ramped to volume, foundry production will occupy 46% of China's current capacity compared to just under 26% worldwide. In the future, if all the committed wafer fab plants under construction are fully equipped and ramped to volume worldwide, foundry production will continue to account for 44% of China's capacity versus 26% worldwide. China also has a greater share of its current wafer fab capabilities dedicated to discrete at 20% and optoelectronics/LED at 7% compared to worldwide discrete at 10% and optoelectronics/LED at 4%. China's share of wafer fab capabilities dedicated to optoelectronics/LED will increase further to 11% versus a worldwide

Figure 23: Current wafer fab capacity comparison, China and Worldwide, 2011



Source: World Fab Watch 2012

share of 4% in the future when all the committed wafer fab plants under construction are fully equipped and ramped to volume worldwide.

China's wafer foundry revenues decreased by nearly 3% in 2011, while worldwide foundry revenues increased by 6%. As a result, China's share of worldwide foundry revenues decreased to about 10% in 2011, down from 11% in 2010. The most significant revenue decreases in 2011 were recorded by SMIC, Shougang NEC and He Jian. This drop in share is likely the continuation of the trend that started four years ago, when China's share of worldwide foundry revenues decreased from a peak of 12.5% in 2007 to 11.5% in 2008.

Since 2007, China's wafer foundry revenue growth of 2% CAGR has been significantly less than the worldwide average growth of 8% CAGR. Based upon its current capabilities, China should be able to increase its share of worldwide foundry production to slightly more than 19% by 2013 by fully equipping and ramping to full capacity at mature yields all of their existing wafer fabrication modules. This could have a significant impact on the semiconductor industry. However, its relative revenue growth will lag significantly if its foundries continue to compete on price rather than leading-edge technology.

Based upon SMIC's relative peer performance, China's foundries have only been earning 75.7% of the worldwide average revenue per wafer start over the past five years. Further, even if all of the worldwide committed wafer fabs under construction are completed and ramped to full production, China's potential share of foundry production would be reduced to about 18% by 2015. This would equate to China reaching no more than a 14% potential share of worldwide foundry revenues by 2015, given their continuing below worldwide average revenue per wafer start.

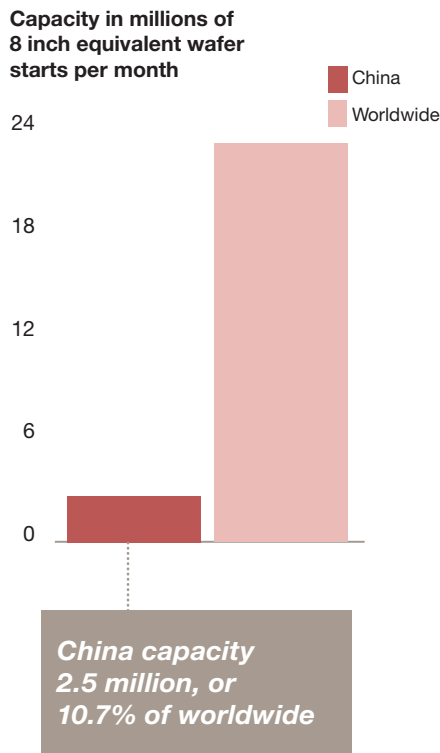
During the past year, China's share of current wafer fab capacity allocated to IC IDMs decreased slightly to 27% and remained notably less than the worldwide average of 56%. This is because there were no IC IDM fabs among the 29 fabs that started production in China last year. Three of China's 29 fabs that started production last year were foundry fabs, accounting for 56%; 25 were discrete LED fabs, accounting for 36%; and 1 was a discrete power fab, accounting for 6% of the added capacity. As a result, China continues to only represent about 5% of worldwide IC IDM capacity.

This low IC IDM participation was probably the result of the timing of the opening of China's semiconductor sector to foreign investments, an election to mimic the Taiwan foundry model and the very weak market position of China's state-owned semiconductor companies. It has been continued by China's focus on developing the IC design (fabless) and O-S-D (LED) sectors. Currently, there are only five foreign IDMs with some form of invested IC wafer fabrication capacity in China: Hynix, Intel, NEC, (Hua Hong & SG JVs), NXP (JaLin JVs) and TI.

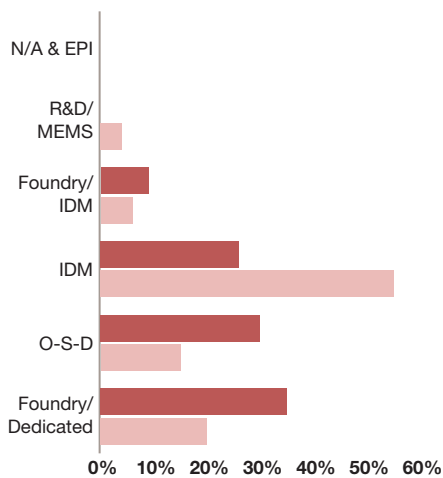
China's IC IDM participation will improve somewhat after 2014 when Samsung's planned Xi'an NAND Flash fab starts production. At that time, China's share of wafer fab capacity allocated to IC IDM's will have been increased to 34% and its share of worldwide IC IDM capacity to 9%.

One hundred and six (106) of China's 163 current wafer fabs are dedicated to the O-S-D sector. Over the last three years, China's share of wafer fab capacity allocated to the O-S-D sector has been increasing. O-S-D capacity now represents 27% of China's current wafer fab capabilities versus 14% of worldwide. It could increase to 30%

Figure 24: Current and committed wafer fab capacity comparison, China and Worldwide, 2011



Percentage share of capacity



Source: World Fab Watch 2012

for China versus 15% worldwide by 2015 if all of the committed wafer fabs under construction are completed and ramped to full production. China currently accounts for 20% of worldwide O-S-D capacity and that could increase to 22% by 2015 if all of the committed wafer fabs under construction are completed and ramped to full production. Currently there are fourteen foreign companies with some form of invested O-S-D wafer fabrication capacity in China. Seven are from Taiwan: Arima Optoelectronics, Epistar, FOREPI, Liteon, SemiLEDs, United LED and Walsin Lihwa. Three are from the US: Cree, InvenLux and Littlefuse. Two are from Korea: AUK and KEC. There is one each from Europe, NXP and Japan, Toppan.

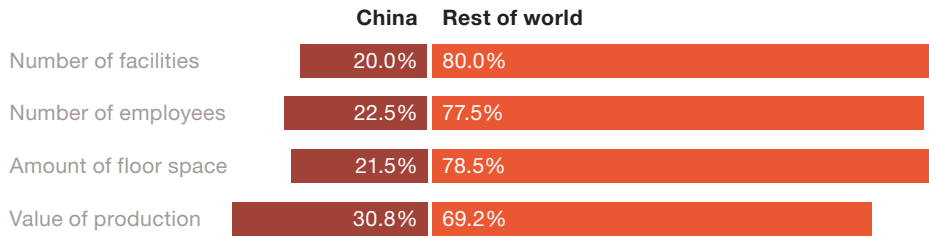
As of the May 2012 WFW, there were nine additional new wafer fabs announced and/or planned (i.e. WFW probability of $\geq 0.45 < 0.80$) for China that had not been committed to start construction. This is five less than a year ago, but it represents 32% of the 28 new fabs announced and/or planned worldwide, and 29% of their equivalent capacity. The number of such announced and/or planned but not committed new fabs worldwide has decreased noticeably from 54 in 2008 and 41 in 2011. If all of these additional new fabs were completed and ramped into full production at mature yields, China's share of total worldwide semiconductor wafer production would increase from the $\leq 2\%$ realized in 2003 to 12.4% by 2017. This is a notable increase in share from the plans of a year ago, and certainly from those of three or four years ago before the economic downturn, and could have moderate impact on the semiconductor industry.

While it remains uncertain whether all of these announced and/or planned wafer fab plants will be realized, they do provide a measure of the evolving prospects for China's semiconductors. Four of the nine are planned to be 12-inch (300mm) fabs which would account for 86% of the potential additional capacity. One of those four is the Samsung Xi'an NAND Flash fab, which accounts for more than 50% of the potential additional capacity. The other three are foundry fabs. There are two planned 8-inch (200mm) analog/mixed signal fabs that account for 12% of the potential additional capacity. The remaining three are two 2-inch (50mm) and one 4-inch (100mm) specialty LED fabs. Chinese companies are responsible for five of these possible additional wafer fabs. Taiwan-based UMC (He Jian Technology) and Tekcore are involved with two, Korea-based Samsung and US-based TI are each related to one of these nine total possible additional wafer fabs.

Packaging, assembly and test production

Packaging assembly and test is probably the largest of China's semiconductor manufacturing activities when measured in terms of value added, production revenue, employees and manufacturing floor space. This relationship is often missed because a significant portion of China's semiconductor packaging assembly and test (SPA&T) production is allocated to the O-S-D industry sector which is reported as a separate sector from the IC packaging and testing industry sector. China has continued to gain share of worldwide SPA&T production value during 2011. The composite weighted average of China's 2011 SPA&T production is estimated to be about 31% of

Figure 25: Comparison of China and all remaining countries' SPA&T resources, 2011



Source: Gartner Dataquest 2012

worldwide, up from 28% in 2010. The value of China's IC SPA&T production increased by 5% to represent more than 19% of the value of worldwide production in 2011, which is about a one percent more share than it represented in 2009 and 2010. At the same time, the value of China's O-S-D SPA&T production increased by 18%, to represent more than 33% of the value of worldwide production value in 2011, an increase from the 32% it had represented in 2008 and 2009. As a result, the composite of China's SPA&T production value increased by a weighted average of almost 11% in 2011 to represent slightly less than

with their ICs accounting for 37% of worldwide unit volume and their OSDs for 70%, compared to 34% of ICs and 66% of OSDs in 2010.

During 2011, China's reported IC packaging, assembly and test (ICPA&T) quarterly revenues fluctuated dramatically, from a record peak in 2Q, to a 50% drop in 3Q, followed by a 40% recovery in 4Q. As a result, China's ICPA&T revenues, measured in local RMB currency, reported a 2.8% drop in 2011. However, because of the continuing strengthening of the RMB exchange rate, China did report a modest 1.8% increase in 2011 ICPA&T revenues (measured in dollars) to US\$9.5 billion. China achieved these slightly higher dollar revenues with about the same share of worldwide SPA&T facilities, but a greater share of manufacturing floor space than a year ago.

2011 saw the first expansion of overall semiconductor packaging, assembly and test (SPA&T) facilities in three years. Although 10 existing worldwide SPA&T facilities were closed in 2011, several new facilities started production, for a net increase of 12 facilities and an overall

China's increased share of worldwide SPA&T value during 2011 was the result of its increased share of worldwide production volume, especially for LED devices, with a corresponding increase in O-S-D ASPs (average selling prices).

31% of the worldwide production value. China's increased share of worldwide SPA&T value during 2011 was the result of its increased share of worldwide production volume, especially for LED devices, with a corresponding increase in O-S-D ASPs (average selling prices). China's SPA&T production continues to be more heavily utilized for higher volume and lower cost packages and products,

manufacturing floor space increase of more than 6%. As part of these changes, China reported the closure of four old facilities, the addition of six existing but previously not reported facilities, the opening of one new facility, and the expansion of several others. As of the end of 2011, China had 109 SPA&T facilities, an increase from 106 in 2010. These 109 facilities represent 20% of the

total number of worldwide SPA&T facilities, more than 21% of worldwide SPA&T manufacturing floor space and 23% of reported worldwide SPA&T employees. During 2011, China's SPA&T manufacturing floor space, a proxy for potential manufacturing capacity, increased to represent almost 21.5% of worldwide SPA&T manufacturing floor space. As a result, China's SPA&T facilities continued to rank first in share of worldwide SPA&T manufacturing floor space for the third year, ahead of Taiwan (at slightly more than 20%) and Japan (at 17%). China's SPA&T facilities also ranked first in number of reported employees, with 23% of worldwide SPA&T employees at the end of 2011, ahead of Taiwan (17%) and Malaysia (16%).

The largest foreign ownership is that of companies from the US which represent more than 18% of China's SPA&T facilities.

Semiconductor assembly and test services (SATS)

Figure 26 shows China's share of its SPA&T capacity that is dedicated to SATS (semiconductor assembly and test services) suppliers compared with all other regions. China's share remains somewhat more concentrated than that of other regions. SATS resources represent 76% of China's SPA&T manufacturing floor space and 65% of China's SPA&T facilities versus 53% and 56% for all other countries.

At the end of 2011, 74 SATS facilities were in production in China. Of these, 40 were owned by Chinese companies and 34 by foreign companies. Each of the seven largest and eight of the ten largest multinational (MNC) SATS companies had one or more facilities in China. The eight included ASE, Amkor Technology, SPIL, STATS ChipPac, Powerchip Technology, UTAC, ChipMOS Technologies and STS Semiconductor. These eight largest MNC SATS companies with facilities in China averaged 22% of their manufacturing capacity in China. By comparison, all 35 of the IDM SPA&T facilities in production in China by the end of 2011 were owned by foreign companies that had an average of 18.5% of their SPA&T capacity in China.

China's SATS facilities represent a mix of three-way competition between wholly foreign-funded enterprises, China-foreign joint ventures and domestic-funded enterprises. Among these, the SATS plants set up by large international enterprises

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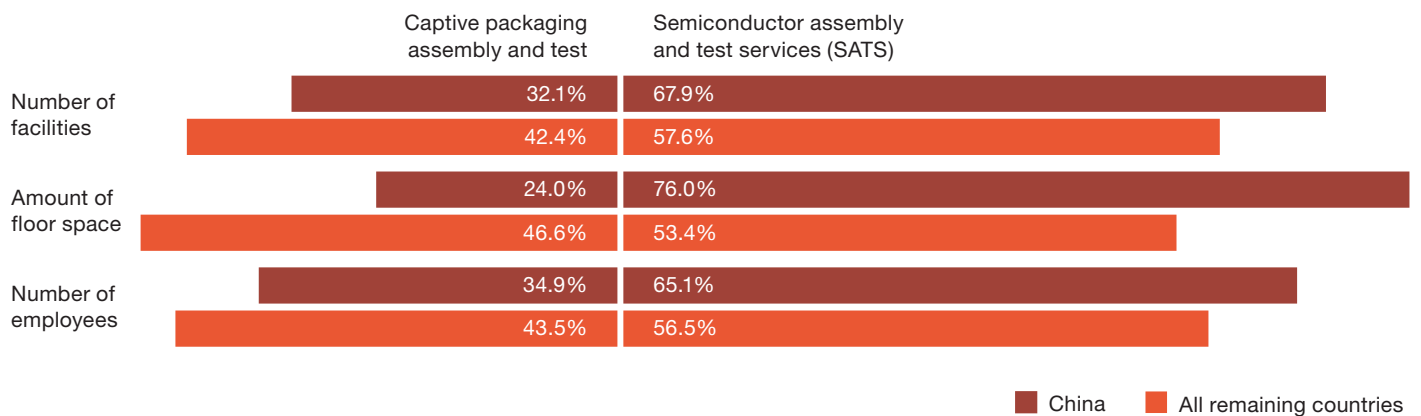
While China has the second largest share of planned future SPA&T facilities, it may have the largest share of planned capacity. Of the 19 SPA&T facilities planned worldwide at the end of 2011, five were located in China compared to eight in Taiwan and one each in six other countries. These five represent 26% of the planned facilities and more than 85% of the announced planned manufacturing space.

In terms of the ownership of China's SPA&T facilities, very little has changed since 2008. Of the total 109 SPA&T existing facilities, about 37% belong to Chinese companies and 14% belong to companies from Taiwan (12%) and Hong Kong (2%).

have been leading in terms of scale and technology. However, a trio of domestic-funded SATS enterprises consisting of Xinchao Group, Nantong Fujitsu Microelectronics Co., Ltd. and Tian Shui Hua Tian Microelectronics (TSHT) are growing rapidly. Two of these Chinese SATS companies are ranked among the 20 largest SATS suppliers on a worldwide basis. They are Xinchao Group (including JCET and JCAP) and Nantong Fujitsu (NFME). During 2011, the Xinchao Group improved its worldwide market share from 2.3% in 2010 to 2.5% and its ranking from ninth in 2010 to eighth in 2011. However, NFME's market share decreased in 2011 from 1.1% in 2010 to 1.0% and, as a result, its ranking dropped from eighteenth in 2010 to nineteenth in 2011. All three companies have grown to reach a sizeable scale in the leadframe segment of the SATS sector, while moving into the substrate and more advanced package sectors, and they have the ability to make an impact on pricing. They also have received support from China's National Major Science and Technology Project 02

(Project 02), which enabled JCET to successfully move into advanced QFN (quad flat no-lead) package technology and BGA (ball grid array) package technology. Similarly, Project 02 support enabled NFME to successfully move into BGA, QFN and copper wire bonding package technologies. TSHT also receives government support through the Chinese government's Western Area Development Plan. All three are expected to develop even more advanced, smaller volume package technologies, including FC (flip chip), SIP (system in package) and TSV (through silicon via), with JCET recently announcing its patented MIS (Molded Interconnected System) packaging technology. TSHT, the former state-owned Yonghong Appliance Factory, is the core of Tian Shui Huatian Technology Company, and is the main IC packaging enterprise in China's western region. All three of these leading Chinese SATS companies expanded their capacity during 2011 and are now working to expand their share of markets outside of China.

Figure 26: Comparison of China and all remaining countries' SATS share of SPA&T capacity, 2011



Source: Gartner Dataquest 2012

The top Chinese semiconductor manufacturers

Table 10 lists the 50 largest semiconductor manufacturers in China—those reporting 2011 revenues of US\$131 million or more. This revenue threshold is up from both the US\$89 million threshold of the top 50 in our 2011 report and the US\$72 million threshold of the top 50

in our 2009 report. It is the highest revenue threshold to date and reflects the growing number and size of Chinese semiconductor manufacturers, especially the new LED manufacturers.

This table includes seven groups that each own one or more companies in the various sectors of China's semiconductor industry. These groups are listed in place of listing their several individual

Seven groups with their most significant companies

	Revenue (US\$M)			
	2008	2009	2010	2011
China Resources Microelectronics (Holdings) Ltd.	654	540	669	631
Wuxi China Resources Microelectronics Co., Ltd. (CR Micro) (former CSMC)—Foundry	154	144	179	169
Wuxi China Resources Huajing Microelectronics Co., Ltd.—Discrete	134	121	168	134
Wuxi China Resources Semico Microelectronics Co., Ltd.—IC Design	90	84	91	124
XINCHAO Group	574	618	944	969
JECT (Jinansu Changjiang Electronics Technology Co., Ltd.)—Pkg & Test	342	347	531	611
Nantong Huada Microelectronics Group Co., Ltd.	383	398	618	620
Nantong Fujitsu Microelectronics—Pkg & Test	173	181	254	251
Shanghai Huahong (Group) Co., Ltd.	431	411	555	671
HHNEC (Shanghai Huahong NEC Electronics Co., Ltd.)—Foundry	279	240	367	389
Shanghai Hongli Semiconductor Co., Ltd.—Foundry				231
Shanghai Huahong IC Co., Ltd.—IC Design	88	95	96	94
China Huada Integrated Circuits Design (Group) Co., Ltd. (CIDC Group)	208	211	215	246
CEC Huada Electronics Design Co., Ltd.—IC Design	84	68	74	127
Beijing Huada Zhaibao Electronic Systems Co., Ltd.—IC Design	32	40	55	75
Nationz Technologies Inc.	31	68	104	88
Shenzhen National Holdings Co., Ltd.			163	173
Shenzhen State Microelectronics—IC Design	27	46	61	73
Shenzhen Sunmoon Microelectronics—IC design				
Shenzhen State Micro Technology—OEM				
Hangzhou Silan Microelectronics Co., Ltd.	134	140	224	206
Hangzhou Silan Microelectronics Co., Ltd.—Design	76	86	96	
Hangzhou Silan Integrated Circuit Co., Ltd.—IDM/Foundry	56	59	96	
Hangzhou Silan Azure Co., Ltd.—LED	26	29	58	53

companies in order to better reflect their increasing significance in the growth and concentration of China's semiconductor industry. This approach also corresponds to the CSIA's (China Semiconductor Industry Association's) current reporting practice, which reports the group totals (by industry sector) in response to requests by the groups.

In addition to these seven groups, Table 10 also lists a single entry for each of several multinational semiconductor companies that have more than one manufacturing facility in China though each facility may be legally organized as a separate company in China. These companies include ASE, Diodes, Freescale, Hynex, Intel, Renesas, RFMD, Samsung Electronics, ST Microelectronics and UTAC. Each listing reflects the combined revenues of all the companies' manufacturing facilities in China.

There are eight companies that are new to the top 50 Chinese semiconductor manufacturers list for 2011. They are all LED companies and reflect the growing awareness and importance of this segment of China's semiconductor industry. Several should have been included in prior years' top 50 lists, but were overlooked due to a lack of information about China's LED segment. These newly included eight LED companies (listed by 2011 ranking) are described below.

Huizhou Cree was established in 2007 by Cree's acquisition of Hong Kong-based Cotco and expanded in 2010 to become Cree Huizhou Solid State Lighting Col, Ltd. by the acquisition and development of a 529,000 square foot factory to become Cree's first overseas chip manufacturing facility. Cree is a US multinational manufacturer of semiconductor materials and devices; and a market-leading innovator of

The combined 2011 revenues reported for these top 50 enterprises is US\$26.2 billion, representing 60% of China's total 2011 semiconductor industry revenue of US\$44 billion.

The combined 2011 revenues reported for these top 50 enterprises is US\$26.2 billion, representing 60% of China's total 2011 semiconductor industry revenue of US\$44 billion. Although this year's top 50 share is up from 55% in 2010, China's industry still remains less concentrated than the worldwide industry in which the top 50 companies represent 82% and the top 16 companies 60% of the total market. The combined reported RMB revenues of the continuing 46 of these top 50 manufacturers increased more than 15% in 2011, while their dollar revenues increased by 21%, which in both cases was significantly (6%) more than the increase reported by China's total semiconductor industry.

lighting-class LEDs, LED lighting and semiconductor solutions for wireless and power applications. Cree's product families include LED fixtures and bulbs, blue and green LED chips, high-brightness LEDs, lighting-class power LEDs, power-switching devices and radio-frequency/wireless devices.

Liteon Technology (China) Co., Ltd. manufactures LED related products. It reports to be one of the best optoelectronics manufacturers globally, mainly producing a series of SMT LEDs, infrared communication modules, digital tube, infrared LEDs, phototransistors, optocouplers, photoelectric switches, etc. Its plant in Tianjin was founded in 1995. The

Table 10: Major Chinese semiconductor manufacturers (including groups) in 2011

Name of company	Rank		Sales revenue (RMB: 100M)			Sector	Sales revenue (US\$M)			
	2010	2011	2010	2011	Change		2010	2011	Change	
Intel Products/Semiconductor (Chengdu/Dalian) Co., Ltd.	1	1	186.13	308.00	65.5%	◆	2,750	4,765	73.3%	
SK Hynix Semiconductor (China) (incl Hytech JV)	2	2	137.86	158.51	15.0%	◆	2,037	2,452	20.4%	
SMIC (Semiconductor Manufacturing International Corp.)	3	3	104.60	85.00	-18.7%	●	1,545	1,315	-14.9%	
Freescale Semiconductor (China) & (Suzhou) Co.,Ltd.	4	4	85.29	72.32	-15.2%	◆	1,260	1,119	-11.2%	
HiSilicon Technologies Co., Ltd.	8	5	44.16	66.68	51.0%	●	652	1,032	58.1%	
XINCHAO Group	6	6	63.89	62.61	-2.0%	◆	944	969	2.6%	
Samsung Electronics (Suzhou Semi & LED) Co.,Ltd.	18	7	21.86	54.19	147.9%	◆	323	838	159.6%	
Spreadtrum Communications Inc.	15	8	25.00	44.20	76.8%	●	369	684	85.1%	
Shanghai Huahong (Group) Company Ltd.	12	9	37.56	43.40	15.5%	●	555	671	21.0%	
ASE Assembly & Test (Shanghai+ Khunshan+WeiHai +Suzhou) Ltd.	14	10	40.00	42.46	6.1%	◆	591	657	11.2%	
China Resources Microelectronics (Holdings) Ltd.	7	11	45.30	40.80	-9.9%	◆	669	631	-5.7%	
Hiuzhou Cree		12		40.80		▼		631		
Nantong Huada Microelectronics Group Co., Ltd.	9	13	41.81	40.08	-4.1%	◆	618	620	0.4%	
Shanghai Panasonic Semiconductor Co., Ltd.	11	14	39.43	38.89	-1.4%	◆	583	602	3.3%	
Renesas Semiconductor (Beijing & Suzhou) Co.,Ltd.	10	15	39.83	41.58	4.4%	◆	588	643	9.3%	
RFMD (RF Micro Devices (Beijing) Co.,Ltd.	5	16	64.37	37.84	-41.2%	◆	951	585	-38.4%	
Diodes Shanghai Co., Ltd.	19	17	20.98	28.53	36.0%	◆	310	441	42.4%	
ST Microelectronics	13	18	32.15	27.20	-15.4%	◆	475	421	-11.4%	
Leshan Radio Co., Ltd. (incl ON Semiconductor JV)	16	19	24.19	26.88	11.1%	▲	357	416	16.4%	
TSMC (Shanghai) Co., Ltd.	21	20	17.80	23.66	32.9%	●	263	366	39.2%	
Liteon Technology		21		23.60		▼		365		
Infineon Technologies (Wuxi) Co.,Ltd.	17	22	22.20	21.93	-1.2%	◆	328	339	3.4%	
STATS ChipPAC	20	23	20.63	20.53	-0.5%	◆	305	318	4.2%	
Everlight Electronics		24		19.90		▲	0	308		
RDA Microelectronics, Inc.	31	25	12.81	18.19	42.0%	●	189	281	48.7%	
Tianshui Huatian Microelectronics Co., Ltd.	29	26	14.60	17.75	21.6%	◆	216	275	27.3%	
Sanan Optoelectronics		27		8.63	17.47	102.4%	▼	128	270	112.0%
No. 50 Research Institute of China Electronics Technology Group Corporation	42	28	8.11	16.24	100.2%	■	120	251	109.7%	
China Huada Integrated Circuits Design (Group) Co., Ltd.	30	29	14.58	15.90	9.1%	●	215	246	14.2%	
Shanghai Grace Semiconductor Manufacturing Co., Ltd	23	30	15.46	14.90	-3.6%	●	228	231	0.9%	
UTAC Dongguan, Shanghai, Chengdu, Ltd.	37	31	13.94	14.54	4.3%	◆	206	225	9.2%	
HeJian Technology (Suzhou) Co., Ltd.	25	32	15.06	13.45	-10.7%	●	223	208	-6.5%	
Amkor Technology China Ltd.	27	33	14.84	13.40	-9.7%	◆	219	207	-5.4%	
SanDisk Semiconductor (Shanghai) Co. Ltd.	28	34	12.12	13.31	9.8%	◆	179	206	15.0%	
Hangzhou Silan Microelectronics Co., Ltd.	24	35	15.16	13.30	-12.3%	●	224	206	-8.1%	
TianJin ZhongHuan Semiconductor Co., Ltd.	26	36	7.66	12.62	64.8%	▲	113	195	72.5%	
Galaxycore Inc.	40	37	8.40	11.68	39.0%	●	124	181	45.6%	
Fairchild Semiconductor (Suzhou) Co., Ltd.	38	38	8.88	11.41	28.5%	◆	131	176	34.5%	

● IC Design ▲ Discrete ▼ Discrete (LED) ● Foundry ■ IDM ◆ Packaging & Testing

Name of company	Rank		Sales revenue (RMB: 100M)				Sector	Sales revenue (US\$M)		
	2010	2011	2010	2011	Change	2010		2011	Change	
Shenzhen National Holdings Co., Ltd.	34	39	11.00	11.20	1.8%	●	163	173	6.6%	
Shenzhen ZTE Microelectronics Technology Co., Ltd.	35	40	10.00	11.00	10.0%	●	148	170	15.2%	
Shougang NEC Electronics	32	41	12.10	10.61	-12.3%	●	179	164	-8.2%	
MLS Co., Ltd.		42	7.82	10.40	33.0%	▼	116	161	39.3%	
Siliconware Technology (Suzhou) Co., Ltd.	39	43	8.70	10.35	19.0%	◆	129	160	24.6%	
Foshan Nationstar Optoelectronics		44	8.15	10.20	25.2%	▼	120	158	31.1%	
Unity Opto Technology		45		9.90		▼		153		
ASMC (Advanced Semiconductor Manufacturing Co., Ltd.)	36	46	9.56	9.50	-0.6%	●	141	147	4.1%	
Leadcore Technology Co., Ltd.	45	47	7.90	9.44	19.5%	●	117	146	25.1%	
Elec-Tech International Co., Ltd.		48	3.70	9.10	145.9%	▼	55	141	157.6%	
BCD Semiconductor Manufacturing Ltd.	43	49	8.04	8.81	9.6%	■	119	136	14.7%	
Jilin Sino Microelectronics Co., Ltd.	33	50	11.00	8.45	-23.2%	▲	163	131	-19.6%	

Source: CCID, CSIA, GDQ, PwC 2009–2012

first phase of construction of its East China Regional Headquarters in Wujin, Changzhou, was completed in July 2009. By September, there were 14 production lines running and that figure was projected to increase to 40 production lines by the end of the year, with a monthly capacity of six million units and 4,500 employees in the plant. In China, the Lite-On Group has established comprehensive sales and production facilities with more than 50,000 employees in 30 locations.

Everlight Electronics Co., Ltd. was founded in 1983 in Taipei, Taiwan. Playing a critical role in the formation of the global LED industry, the company is rapidly ascending to become a leading supplier due to its dedication to certification, R&D, production, quality, marketing and global customer service. It has had manufacturing facilities in China since 1991, with its current facilities located in Suzhou; Guangzhou. It is ISO 9001, ISO 14001 and TS 16949 qualified.

San'an Optoelectronics is China's earliest-established and largest production base for full-color ultra-high brightness LED epitaxial products

and chips with optimum quality. It was established in 2000 and produced its first epitaxial wafers in 2002. San'an is mainly engaged in the R&D, production and marketing of full-color, ultra-high brightness LED epitaxial products, chips, compound solar cells and high-power concentrating solar products with internationally leading performance. It is ISO 9001, ISO 14001 and ISO/TS 16949 qualified.

MLS Co., Ltd. is one of the leading companies of LED encapsulation and LED application products. It was founded in 1997 and, after years of development, has grown to more than 180,000 square meters of manufacturing floor space and 10,000 employees. MLS's main products include LED displays, LED lights, DIP LEDs, SMT LEDs and high-power LEDs. It is ISO 9001 and 14001 certified.

Foshan Nationstar Optoelectronics Co., Ltd. was registered in 1970 and is a high-tech enterprise of the Nation Torch Project that specializes in manufacturing semiconductor optoelectronics devices and LED applied products. It has 64,000

square meters of manufacturing floor space and more than 1500 employees. Its products include LEDs (LAMP LED, CHIP LED, TOP LED, POWER LED), LED traffic signals, LED display modules, LED backlights, LED light modules, LED displays, LED illuminating and decoration serial products, IR. LED, IR. Receiver, numeric displays, clock displays, photodiodes, LED clusters, LED linear light sources and tuners. It is ISO 9001, ISO 14001, ISO/TS 16949, and OHSAS18001 certified.

Unity Opto Technology has designed and manufactured optoelectronics since 1993. Today, Unity is a world leader in high bright visible LEDs, IR devices and various lighting modules. It was founded in Taiwan in 1991 and started mass production in its China factory in 1997. It now has facilities in Suzhou, Jiangsu; Long Gang District, Shenzhen and Yangzhou, China.

and designs, including 14 patents certificated in foreign countries. In 2008, Elec-Tech Group made a large investment in the optoelectronics industry, including 100 sets of MOCVD devices, with the target of becoming a leading company in the field in two to three years, and to be the most competitive optoelectronics manufacturer in the world.

Correspondingly, there were eight 2009 top 50 manufacturers that did not qualify for the 2011 list, although three of the companies reported revenue increases. However, each of the other five reported double-digit declines in dollar revenues, so that these combined eight companies experienced a 20% decline in 2011 dollar revenue. They are described below in 2010 ranking order.

Chipmore Technology Corporation, Ltd. is a China-based LCD driver IC backend service provider, providing gold bumping, tape carrier packaging (TCP), chip on film (COF) and chip on glass (COG) packaging services whose majority shareholder is Chipbond Technology Corporation, Taiwan's leading packaging service provider for LCD driver ICs, providing turkey solution for driver IC design houses. It reported a 117% decline in dollar revenue for 2011, due to the Japan earthquake and Euro Crisis putting the terminal consumer market in recession, and thus failed to meet the qualifying revenue threshold.

Suzhou Good-Ark Electronics Co., Ltd. is a discrete device manufacturer which had returned to the top 50 list in 2010 with a reported 72% two-year increase in dollar revenue, but fell short of the higher 2011 qualifying criteria with a reported 5% increase in dollar revenue for 2011.

Correspondingly, there were eight 2009 top 50 manufacturers that did not qualify for the 2011 list, although three of the companies reported revenue increases.

Elec-Tech International Co., Ltd was established in May 1996 and is mainly engaged in the design, production and sale of optoelectronics, SDA (Small Home Appliances), mini & particular motor and wind power equipment. Its main optoelectronics products include LED epitaxy, LED chips, encapsulation, LED lighting and LED displays. Elec-Tech Group has 12 subsidiary companies located in Zhuhai, Zhongshan, Shenzhen, Yangzhou, Wuhu and Dalian with 20,000 employees, including more than 2000 professional and technical personnel. It is ISO 9001 certified and has 145 patented technologies

EEMS (Suzhou) Co., Ltd. and EEMS Tech are WFE (Wholly Foreign Invested) subsidiaries of the EMS Group, the result of the spin-off of an operating unit of Texas Instruments, that is a worldwide leader in assembling and testing semiconductor modules and DRAM memories. They were the first independent A/T service provider in China to offer state-of-the-art 300mm assembly line packaging with a wide array of packages in single and stacked die configuration. However, they reported a 17% decrease in dollar revenue for 2011 and thus failed to meet the qualifying threshold.

GEM Electronics (Shanghai) Co., Ltd. is a WFE subsidiary of GEM Services, a multinational semiconductor assembly and test contractor that specializes in small-outline surface-mount packages for power management semiconductors. GEM operates two factories in Jiading (Shanghai) and Hefei, China, producing high volume, high quality, industry standard and advanced discrete, IC and MCM packages. Although reporting a 15% increase in 2011 dollar revenues, it just missed the qualifying criteria for the 2011 list.

Nationz Technologies Inc. Founded in 2000 as a part of China's Project 909 (national efforts to encourage domestic IC design and production capabilities), Nationz Technologies is the leading provider of security processors and RF chips in China. However, the company reported a 15% decline in dollar revenues for 2011 and failed to meet the qualifying threshold.

Beijing Vimicro Co., Ltd. was founded in 1999 by several entrepreneurs from Silicon Valley, with initial support from the Ministry of Information Industry (MII). Dedicated to the development of advanced mixed-signal multimedia chips, Vimicro successfully launched a series of products into domestic and international markets, targeting fast-growing application fields such as computer, broadband, mobile communication and consumer electronics and, in 2005, became the first fabless chip company from China listed on NASDAQ. However, it has reported declining revenues for four of the last five years, including in 2011, and failed to meet the qualifying threshold.

Datang Microelectronics Technology Co., Ltd. (DMT), formerly the IC center of China Academy of Telecommunications Technology (CATTIC), is a subsidiary of Datang Telecom Technology Co., Ltd (DTT). As one of the larger IC design companies in China, DMT has led the stable and rapid growth of the mobile communications smart card market in China for the last several years. Although reporting a 7% increase in 2011 dollar revenues, the company missed the higher qualifying criteria for the 2011 list.

China Wafer Level CSP Ltd. (Suzhou) (WLCSP) is a leading global supplier of wafer-level chip size packaging and test services for the growing digital imaging and small form factor such as RFID markets. It reported a 42% decline in dollar revenue for 2011, due to the Japan earthquake and Euro Crisis putting the terminal consumer market in recession, and thus failed to meet the qualifying threshold.

Measured in dollars, China's reported semiconductor industry revenues increased by 14.4% or US\$5.5 billion during 2011.

Measured in dollars, China's reported semiconductor industry revenues increased by 14.4% or US\$5.5 billion during 2011. The 46 continuing companies in China's top 50 manufacturers accounted for a bit more than one-third of that increase. Five of China's top 50 semiconductor manufacturers each reported revenue growth of more than US\$250 million in 2011: Intel, Hynix, HiSilicon Technologies, Samsung Electronics and Spreadtrum. Another five manufacturers reported 2011 revenue increases of between US\$100 and US\$250 million and a further six manufacturers between US\$50 and US\$100 million. Similarly, four of China's top 50 semiconductor manufacturers each reported revenue growth of

more than 100% in 2011: Samsung Electronics, San'an Optoelectronics, No. 50 Research Institute and Leadcore Technology. An additional four manufacturers reported 2011 revenue growth of between 50% and 100% and a further 12 manufacturers between the industry average 14.4% and 50%. In total, 20 of China's top 50 semiconductor manufacturers reported above industry average revenue growth for 2011.

However, 10 of China's top 50 semiconductor manufacturers reported revenue decreases in 2011, an increase from the two reporting revenue decreases in 2010.

The next chapter

Check back at <http://www.pwc.com/chinasemicon> for our next chapter in this series coming in a few weeks. It will feature a number of topics, including changing government regulations, the IPO market and patents, to name a few.

PwC can help

If your company is facing challenges doing business in China, or you just want to have a deeper discussion about what's happening in the market and how we can help, please reach out to one of the technology industry leaders listed below.

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