

Made in the USA or China

Memory lane and a look down the road: China progressing in NAND but hurdles remain

China's Memory Efforts

We believe that China's efforts to enter the global DRAM and NAND markets merit a deeper dive into how the memory industries have evolved over time, what impact China's entry into other commodity tech industries (such as LEDs and solar) has had on fundamentals, where we believe the leading China-based memory companies stand at present with their efforts to enter the market (and the challenges that still exist for entering the market — with GlobalFoundries as an example that leading-edge semi production is difficult even for well-funded efforts), and what we believe all this means for the stocks of the established memory, drive, and semi equipment companies.

With over \$150 bn of semiconductors shipped to China in 2018, per the Semiconductor Industry Association (SIA), and China domestic semi firms having just 3% market share at the chip level in 2018 (per Gartner), developing a domestic semi industry is one of the focus areas of the Made in China 2025 plan. Central to those efforts are memory semis, which make up about one-third of the global semi market, and a market in which the current suppliers are concentrated in the United States, Korea, and Japan. The leading memory companies in China are Yangtze Memory Technologies Corp (YMTC) for NAND, and CXMT (Innotron) for DRAM. Tsinghua Unigroup also announced on July 1 that it plans to enter the DRAM market.

The bottom line is that we believe that China is further along with NAND flash development than DRAM per our discussions with the supply chain, and YMTC already makes trailing edge 32L NAND in small quantities, **although we believe that economic and technical hurdles remain that could limit the extent of domestic NAND manufacturing in the near to intermediate term.** While we believe that NAND company YMTC is considering ramping 60K WSPM of 64L NAND by 2H20 if production trials planned for 2H19 go well, **we also believe that the very low prices of NAND flash globally today coupled with YMTC's likely higher cost**

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structure as well as a learning curve on yields could limit how much volume YMTC would ramp in the next 12 months.

However, a credible future entry by YMTC (and the need for established vendors to stay ahead on technology/scale) could keep global NAND prices relatively low, even if the 2018/2019 capex cuts and potential for elasticity of demand may otherwise allow for a more meaningful 2020/2021 price recovery all else equal. The potential entrance of YMTC could also impact valuations of the memory stocks. **YMTC's plan to eventually add 300K WSPM by 2023 would represent about a 20% increase compared to current industry capacity levels on a WSPM basis.**

To be clear, we believe there are still significant challenges for China-based memory efforts to confront, including IP/R&D and manufacturing. For example, Applied Materials (the largest global semi equipment company) suggested on 2/14/19, when asked about a domestic China memory effort, that 3D NAND is tough to do and that China companies may incrementally spend but could require years to attain competitiveness on cost per bit. Moreover, we believe that YMTC plans to skip 9xL and move from 64L to 128L, and skipping nodes has historically been difficult for memory companies. Regardless, we believe from our discussions with the supply chain that some progress has been made from the China based efforts in particular for NAND. **Importantly, our discussions with YMTC suggest that it is willing to lose money for several years and imply that the company does not need to catch up to the industry leaders on technology in order to ramp** (but also that it wants to be cognizant of the rate of cash burn).

We believe that DRAM will be harder for China to ramp at the leading edge than NAND given the added process steps for DRAM (some SKUs can be nearly twice as long in terms of processing time than NAND) and more advanced linewidths than NAND (with DRAM incumbents exploring either EUV or quadruple patterning). However, in the longer term we see risk of China entering the DRAM market too, and DRAM can also be manufactured for trailing edge applications.

We believe intellectual property will also be important to monitor, and this is another obstacle in particular for DRAM. As we wrote about in our note on 11/5/18, recall that the US Department of Commerce placed DRAM company Fujian Jinhua IC on the export control list due to alleged IP infringement. As we wrote in that note, because of the strong position of US-based companies in semi cap equipment, being placed on the list makes it extremely difficult to obtain the necessary tools to make memory chips.

Stock implications: Positive: Semi Equipment (new entrants typically spend more in capex), Micron, Samsung Electronics, and SK Hynix (as these companies are more exposed to DRAM than NAND, and we think China's entry into DRAM is still in the early innings and will be harder to do); **Mixed to Negative:** WDC and STX (we believe the threat of China NAND is not as bad as feared by some investors, but still an incremental negative for NAND ASPs and in turn HDDs over the longer term).

Key analysis in this report: (1) Case studies on China-based companies entering tech markets/semi manufacturing; (2) Analysis on what lower prices of memory could mean

for China consumers; (3) What our industry and supply chain discussions suggest on the status of China domestic memory efforts; (4) What the entrance of China memory efforts, if successful, may mean for industry supply/demand and HHI.

Exhibit 1: A memory refresher

MEMORY 101

DRAM



What is it?

DRAM (Dynamic Random Access Memory) is a high performance memory used for **temporary storage**. DRAM typically stores code/other data that programs need to quickly access while operating. DRAM enables faster access to data than storage (SSDs/HDDs), but data is not stored once the device is turned off. It's mostly used in PCs, smartphones and servers.

How big is the market?

~\$100BN in 2018



Who are the Key players?



~40-45%
market share



~30%
market share



~20%
market share

NAND



What is it?

NAND is a non-volatile storage medium and does not require power to retain data, so it's used to store data for longer time periods (such as photos, videos, and music). NAND is less expensive on a per GB basis than DRAM (but is lower performance), and it's typically more expensive than HDDs (but is higher performance). The market is in the midst of a shift from 2D to 3D NAND, a format that allows memory cells to be stacked vertically. This enables denser configurations (in other words, more memory with the same chip size).

How big is the market?

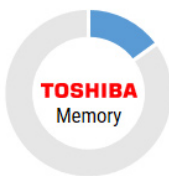
\$54BN in 2018



Who are the Key players?



~35-40%
market share



~15%
market share



~15%
market share



~10%
market share



~10%
market share



~5%
market share

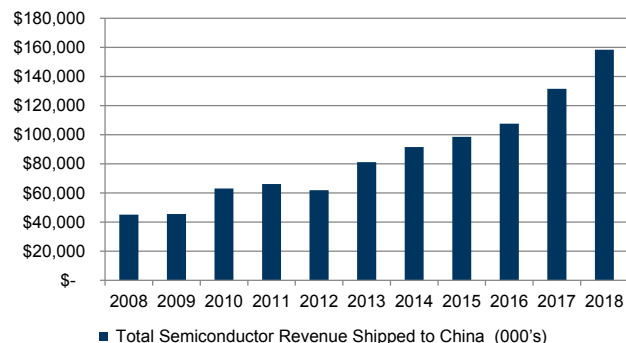
Source: SIA, Data compiled by Goldman Sachs Global Investment Research

China is a large consumer of semis and memory, and semis are a key focus for the Made in China 2025 plan

Over \$150 bn of semiconductors were shipped to China in 2018 per the Semiconductor Industry Association (SIA) and the percent of industry revenue shipped to China has risen from less than 20% in 2008 to nearly 35% as of 2018 (Exhibits 2-3).

Exhibit 2: Total semi revenue shipped to China has increased materially over the last 10 years

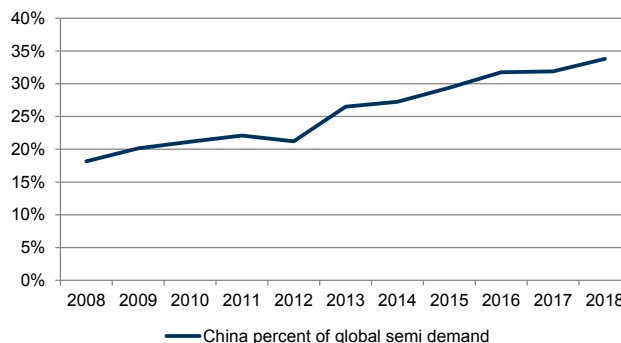
Total semiconductor revenue shipped to China



Source: SIA

Exhibit 3: China's share of global semiconductor shipments has increased

Semiconductor revenue shipments to China as a percent of total

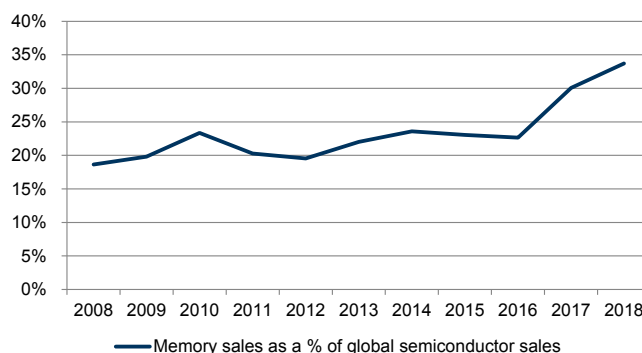


Source: SIA

Memory semi revenue increased from 19% to 34% of total semiconductor industry revenue from 2008 to 2018 (Exhibit 4).

Exhibit 4: Memory sales as a % of global semiconductor sales is now about a third

Memory sales as a percent of global semiconductor sales



Source: SIA

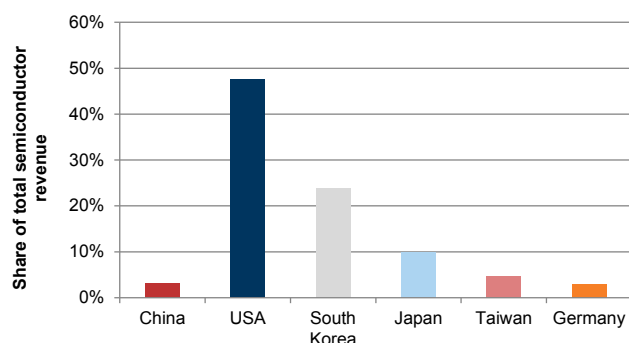
However, China domestic semi firms had just 3% share of total semiconductor revenue at the chip level in 2018 (per Gartner) despite the high level of chip shipments to China (Exhibit 5). The memory semi industry is dominated by suppliers located in the United States, Korea, and Japan (Exhibit 6).

This is lower than the share of end demand in China. As we showed in our initial Made in the USA or China report in March 2017 (Exhibit 18 in [Made in the USA ... or China?](#) 25

Years of Supply Chain Investment at a Crossroads), about 20-30% of end consumption of key tech applications such as smartphones and cars is in China.

Exhibit 5: China domestic firms have limited market share

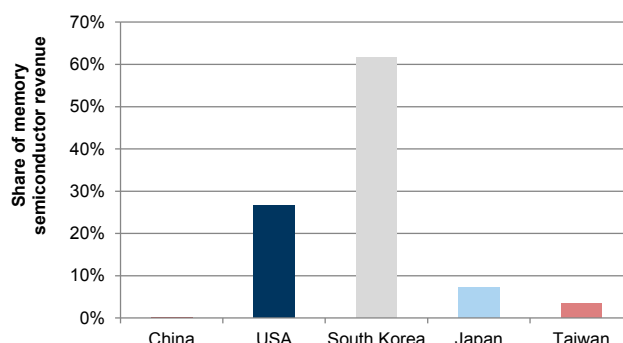
Share of total semiconductor revenue



Source: Gartner

Exhibit 6: The memory industry is dominated by companies from the United States, South Korea, and Japan

Share of memory semiconductor revenue



Source: Gartner

Partly as a result of the relatively limited share in semiconductors, increased self-reliance for semiconductors is a focus area for the Made in China 2025 plan.

There are also potential benefits to China consumers if the price of memory were lower. For example, over 400 mn smartphones were shipped to China in 2018, per IDC. We assume that the global average of embedded NAND content per phone was about 60 GB of NAND in our supply/demand model, but we believe average content in China is lower given generally lower ASPs for phones in that region. For this scenario we assume there was 48 GB of NAND on average per phone in China (which is in-between a 32- and 64-GB model). Using an ASP of about \$0.20 per GB (a discount to the average ASP of \$0.24 in 2018, per the SIA, to account for lower-performance NAND often used in consumer applications plus the purchasing power of handset OEMs) implies that about \$4 bn was spent on NAND by smartphone consumers in China. Given that smartphones make up about 40-45% of global NAND demand, this implies that total China NAND end consumption was about \$9 bn in 2018. **Therefore, for illustrative purposes, if the entry of a China-based NAND company were to cause a 10-15% decrease in global NAND ASPs - all else equal in the long term (which we believe is reasonable based on our case studies and our discussions of the gross margins YMTC could target that we discuss in this report), then we estimate it could lead to savings of nearly \$1 bn annually for China consumers.**

China memory efforts center on YMTC and CXMT (Innotron); we believe YMTC is closest to volume production

China lacks a large-scale domestic memory effort at present, although there are several fabs in China today from established memory companies including in Xian (Samsung), Wuxi (Hynix) and Dalian (Intel). Micron has back-end operations in China.

The leading local effort for NAND is Yangtze Memory Technologies Corporation (YMTC), and the leading effort in DRAM is CXMT (Innotron). A different domestic DRAM company, Fujian Jinhua IC (or Jinhua) was (as mentioned above) the subject of export controls imposed by the US Department of Commerce due to alleged IP theft, which we wrote about in our note of 11/5/18, "[Implications from export controls on Jinhua for Memory & Semi Cap](#)". Tsinghua Unigroup, which has an ownership stake in YMTC, also announced on July 1 that it plans to enter the DRAM market.

We discuss the status of the key China efforts in this section.

A) YMTC planning risk production of NAND in 2H19

YMTC (Yangtze Memory Technologies Corporation), the parent company of XMC and a subsidiary of Tsinghua Unigroup, is the leading effort for China in NAND, with headquarters in Wuhan, China and initial funding of about \$24 bn. We believe that YMTC currently has over 1,000 engineers, and the company developed its initial 32L product in partnership with Spansion (now part of Cypress). We met with YMTC CEO Mr. Simon Yang in Wuhan on our Asia trip in December 2016, as we discussed in our note [Asia Trip: Top 10 takeaways for the technology supply chain](#). More recently, Allen Chang met with YMTC on 6/13/19, as discussed in his note [YMTC visit: key takeaways on Chinese memory progress and implications on local equipment vendors](#).

YMTC makes NOR flash in Wuhan, has a shell ready for NAND, and manufactures 32L NAND in small volumes (we believe about 10K WSPM). YMTC also has plans for a fab in Nanjing and one in Chengdu. In total, **we believe that YMTC plans to ramp 300K WSPM of capacity in total across these factories by 2023, which would equate to a more than 20% increase in global NAND WSPM if this were ramped in full.**

Mr. Yang gave a keynote address at the [Flash Memory Summit in August 2018](#) that we attended, and he detailed plans for YMTC to add to the industry technology capabilities with an approach called Xtacking (with the NAND array and logic on separate wafers) that could lead to higher performance (3.0 Gbps of I/O) and increased bit density than current NAND chips, albeit we believe at a higher cost given the stacking of wafers instead of using a single wafer.

YMTC makes 32L NAND today, but we believe that the company has just a small amount of capacity in production for cost reasons (10K WSPM compared to a full NAND fab that is typically 100K or more). Given that the established NAND makers with more mature yields are mostly manufacturing on the more advanced 64L/92L/96L NAND at present and struggling with profitability in the weak current market, we believe that YMTC loses money for every wafer it manufactures today at 32L. For example,

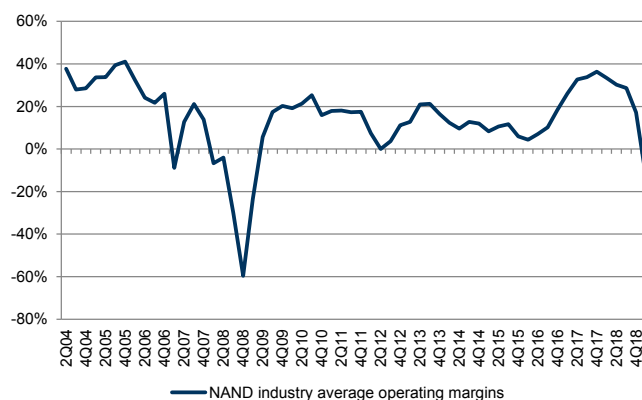
assuming 350-500 net chips per wafer at a trailing edge capacity of 128 Gb would imply \$500-\$1,000 of revenue per wafer (compared to fully loaded COGS per NAND wafer that we estimate are often \$1,000+ for an established NAND maker and higher for a new entrant that does not have scale).

We believe from our discussions with the supply chain that YMTC plans to ramp around 60K of 64L NAND by the end of 2020, assuming risk production goes well in 2H19.

How much cash burn YMTC is willing to tolerate is a key question, as YMTC has said it is prepared to lose money for several years to enter the industry but also wants to be cognizant of the rate of losses. Per **our 2016 meeting with YMTC, we believe that YMTC would only ramp in scale if it had a positive gross margin**, and also because many of the mature NAND companies are nearing or below cash costs in 2Q19 (Exhibit 7) and likely have a better cost structure, we believe that current market pricing could limit the scale at which YMTC ramps even if risk production goes well. **We believe that this implies NAND would need to be selling at \$0.10 per GB or more to allow for YMTC to reach its prior positive gross margin goal.** We believe that NAND pricing is currently at about \$0.07 per GB. That said, **in our team's most recent meeting YMTC only emphasized that it realizes it will lose money to enter the business and against the backdrop of a trade dispute the economics may now be different for YMTC. YMTC's current stated main goal is technology development.**

Exhibit 7: NAND industry margins have been cyclical

NAND industry average operating margins



Source: Company data, Goldman Sachs Global Investment Research

However, we believe the 64L equipment could be reusable for 128L, and that YMTC has said it plans to quickly transition from one node to the next in order to close the cost gap. We therefore expect YMTC to continue to strive to close the technology gap. Moreover, with several local memory module/hardware companies in China, we believe that YMTC could have a local advantage with its go to market (note that YMTC currently sells its NAND products through Tsinghua Unigroup).

We believe that there are still significant hurdles to ramping 3D NAND in volume and YMTC may end up struggling to achieve this. However, with a large amount of funding, and potential local customers, we believe that YMTC could be successful in time even if only in targeted applications like consumer NAND.

B) CXMT/Innotron — working on low power DDR4 DRAM

CXMT (previously named Innotron and also Hefei Changxin) is the leading DRAM effort in China.

We believe that the company taped out an 8 Gb DDR4 chip in July 2018, and plans to tape out a low-power version in 2H19.

Per our discussions with the supply chain, we believe that Innotron is targeting 20K WSPM by the end of 2019 at 19 nm. The company hopes to add two additional fabs and move to 17 nm in the longer term.

We believe that CXMT has more work to do than YMTC to ramp. First, **we believe that DRAM will be harder for China to ramp at the leading edge than NAND** given the added process steps for DRAM (as already noted, some SKUs can be twice as long in terms of processing time than NAND) and more advanced linewidths than NAND (with DRAM incumbents exploring either EUV or quadruple patterning).

The IP development situation is less clear to us for CXMT than for YMTC. Our supply chain discussions suggest that CXMT has hired many former employees of the developed memory companies. We believe that CXMT has purchased some IP from Qimonda (which went bankrupt in 2009) per our supply chain discussions and a 6/12/19 [Nikkei article](#).

Case studies — Entry of China-based suppliers into commodity tech industries has led to significant margin pressure for established providers, but entering the semi industry for leading edge manufacturing has been tough even for well-funded efforts

We show in the case studies in this section (using LED and solar, but other industries such as display also come to mind) that the entry of China-based firms into commodity tech industries has historically led to significant margin pressure for incumbents. However, it is important to note that entering the leading-edge semiconductor manufacturing industry has historically been tough to do (and we discuss examples of SMIC and GlobalFoundries as evidence of this).

We believe these case studies in aggregate show that if China-based memory companies are successful at entering the industry, then this move would likely lead to margin pressure for the incumbents. However, they also show that the ability to enter the memory industry (which can require \$10 bn in capital for a fab and significant technology to compete at the leading edge) is difficult, in particular if companies are trying to move at an accelerated pace.

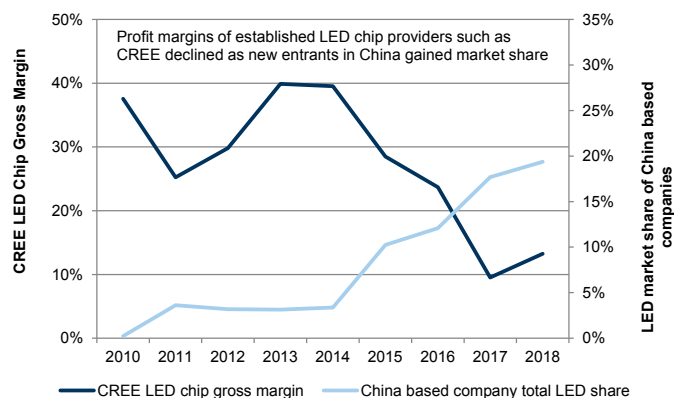
LED Case Study — China entry caused a decline in Cree's LED gross margins

One example is in LEDs, where the Chinese government offered subsidies to purchase MOCVD manufacturing equipment that is used in LED production (as discussed in the 10-K of MOCVD supplier Veeco). This surge in China consumption contributed to Veeco's revenue from China rising to 66% of its total revenue in 2011 compared to 29% of its total revenue in 2010 and 10% in 2009.

As China-based LED companies began to convert the equipment purchases into revenue, it led to an increase in market share per Gartner from near 0% in 2010 to about 20% from China headquartered companies in total as of 2018. Coinciding with this, the profits of established LED suppliers declined. For example, the LED chip gross margin of Cree (covered by Brian Lee) declined to sub-20% in recent years from the 30-40% range prior to the increase in China based LED company revenue (Exhibit 8). As discussed by Brian Lee in his [past Cree research](#), increased competition and supply from China competitors were main causes of this shift.

Exhibit 8: China-based vendor entry into the LED market impacted CREE's gross margins

CREE LED gross margins vs. China-based company LED market share

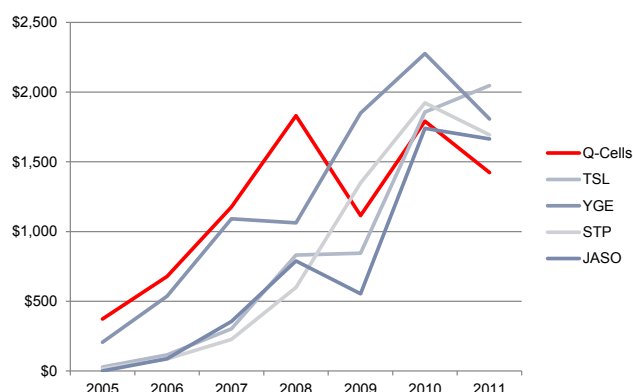


Source: Gartner, Company data, Goldman Sachs Global Investment Research

Solar Case Study — low-cost Asian competition significantly altered market share and margins

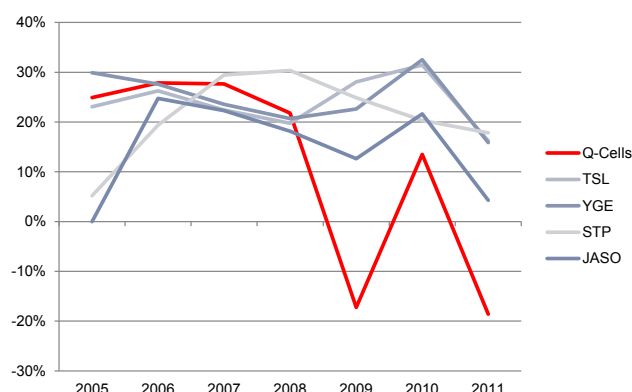
As GS Clean Tech analyst Brian Lee discussed in a 2015 report, the solar industry in the mid-to-late 2000s is another example where the entry of China-based solar cell makers pressured margins of incumbents. Europe-based Q-Cells (which has since been purchased by Hanwha) was historically the largest solar cell manufacturer before the increase in competition from China. Initially the Chinese manufacturers had lower cell efficiency and long-term quality concerns that limited their impact, but they were cheaper and over time drove Q-Cells' industry-leading margins (which were 25%+ in 2007) to low teens and eventually to below zero in 2009 and 2011.

Exhibit 9: Early on, Q-Cells was a leading market share holder in the global solar industry before the onset of Chinese competition
Revenue (\$ mn) across solar peers, 2005-2011



Source: FactSet

Exhibit 10: Similarly, margins for Q-Cells - which were once industry leading - fell precipitously given increasing commoditization and corresponding ASP pressures evidenced by module prices over this time period
Gross margin across solar peers, 2005-2011



Source: FactSet

Foundry examples suggest that leading-edge semi manufacturing can be very hard to do

While the solar and LED case studies we discuss above are illustrations of what can happen to commodity tech industries from China-based competition, **we believe it is important to point out that leading-edge semi manufacturing can be very difficult to do, and this is applicable given that mainstream memory is manufactured internally and at the leading edge.** Foundries (or outsourced semi manufacturing) is a good example of this phenomenon.

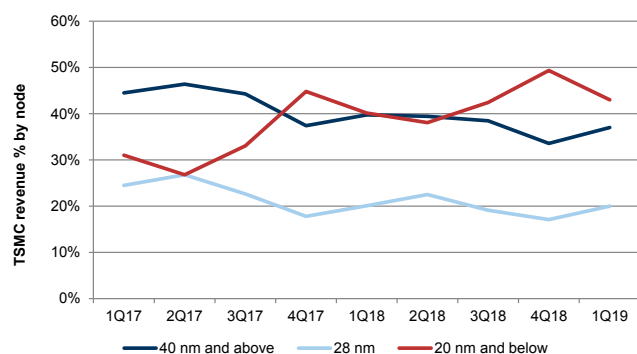
For example, GLOBALFOUNDRIES (GF; with about \$5 bn of annual revenue and the second-largest foundry by revenue, according to Gartner) announced in August 2018 that it was indefinitely pausing leading-edge 7 nm development, doing some workforce reductions, and refocusing its R&D team. This follows significant capital investment in GF since the company was first formed in 2009 when AMD spun out its manufacturing assets. Recall that the Advanced Technology Investment Company of Abu Dhabi (which acquired a majority stake in the former AMD factories) initially planned to invest at least \$5.7 bn into GF, and GF subsequently acquired Chartered Semiconductor for total consideration of \$3.9 bn in early 2010. Moreover, GF invested significant levels of capex annually, and GF spent about \$5 bn per year in capex in the 2013/2014 timeframe (per company comments and press reports such as in the WSJ).

Another example of how hard it is to operate at the leading edge is Semiconductor Manufacturing International Corporation (SMIC), which is headquartered in Shanghai and had grown quickly from its founding in 2000 through its initial offering in 2004, per company filings. The company expected to grow along with the China demand for semiconductors in part from its local presence and also leading edge semiconductor process technology. The company did significantly expand revenue, from US\$365 mn in 2003 to over US\$3 bn by 2018, per company data, making it the fifth-largest foundry by market share, per Gartner.

However, only a small percent of SMIC's revenue is on 28 nm and below process technology, compared to over 60% from TSMC (Exhibits 11-12).

Exhibit 11: TSMC has successfully transitioned to leading edge nodes

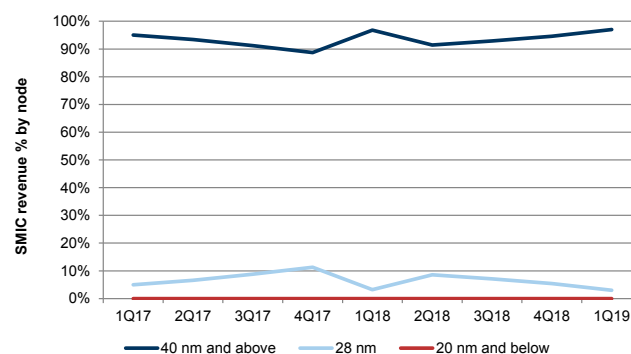
TSMC revenue mix by node



Source: Company data, Goldman Sachs Global Investment Research

Exhibit 12: SMIC's mix of revenue by node has been relatively stable

SMIC revenue by node



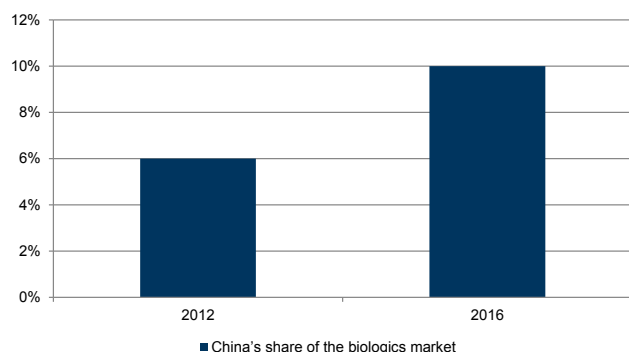
Source: Company data, Goldman Sachs Global Investment Research

China's entry into biologics: WuXi Biologics case study

The biologics market is a subset of the global pharmaceutical industry, and market share in biologics has historically been concentrated with North American and European companies. However, emerging markets like China have increasingly been outgrowing the overall market and gaining market share. For example, Chinese companies grew their revenue market share in biologics to about 10% in 2016 from 6% in 2012 (and in biologics outsourcing share grew from 2% to about 4% over this time period) although North American and European companies combined for about two-thirds market share in 2016 (Exhibits 13-14).

Exhibit 13: Chinese companies have grown their share of the biologics market

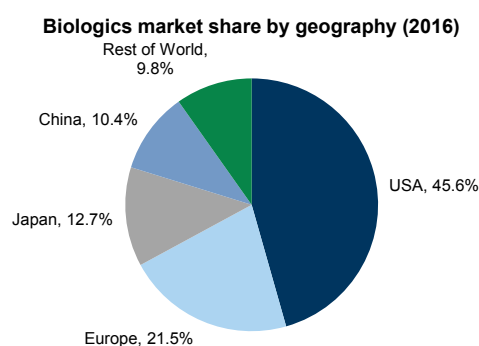
Chinese company market share in biologics



Source: Company data

Exhibit 14: North American and European companies remain the dominant market share leaders in biologics

Market share by geography for biologics (2016)



Source: Company data

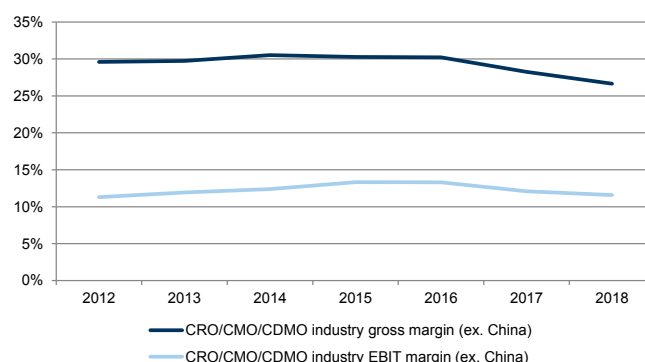
An example of a company that has in part driven share gain for China in the biologics market is WuXi Biologics (a leading biologics CRO/CMO/CDMO service provider in China with 75.6% biologics outsourcing revenue market share in China in 2018, according to WuXi Biologics' estimates). The company has grown its global biologics outsourcing

revenue market share from 1% in 2015 to 3.2% in 2018, driven by organic investments (e.g., in manufacturing facilities/capacity, and hiring US and domestically educated scientists).

Interestingly, as China's share of the biologics market has grown, margins for the largest CRO/CMO/CDMO companies in aggregate have remained relatively flat (Exhibit 15). However, we note that China's market share on a global basis remains relatively smaller than the US and Europe.

Exhibit 15: Gross and EBIT margins have remained relatively stable for non-Chinese CRO/CMO/CDMO companies

Gross and EBIT margin for LH, IQV, SYNH, MEDP, PRXL, CRL, PRAH, ICLR, LONN, CTLT



Source: FactSet, Goldman Sachs Global Investment Research

We note that, similar to the semiconductor industry, the Chinese government has identified biotechnology as a strategic emerging industry and plans such as Made in China 2025 prioritize its development.

Implications for supply demand and industry consolidation

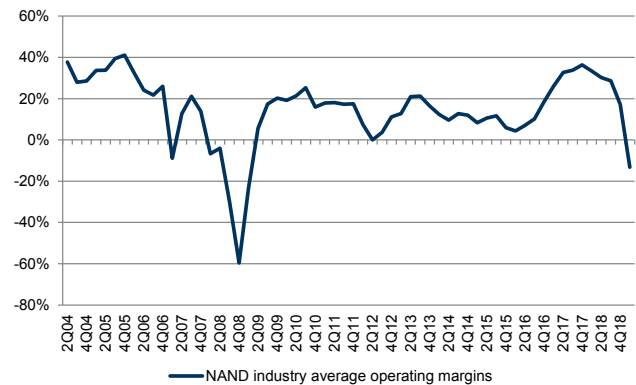
The DRAM market has had slowing supply growth cycle to cycle as a result of both consolidation as well as the increasing challenges arising from Moore's law. The DRAM HHI index (a measure of consolidation) has increased over time, and there are three main DRAM suppliers at present (Samsung Electronics, SK Hynix, and Micron) with Nanya a smaller provider. While the NAND industry has not consolidated in terms of number of suppliers, the shift to 3D from 2D and challenges with Moore's law have led (at least to a degree) to constraints on bit supply growth. Cost per bit reductions have also slowed in conjunction with slowing bit growth per wafer. The result of these factors led to record high profit margins for both DRAM and NAND makers during the last upturn, and the DRAM industry has also exhibited higher trough-to-trough margins as well (although the current downturn is still ongoing and there is the chance that DRAM margins will be negative by the time the current downturn ends).

We believe YMTC's goal to ramp 300K WSPM of capacity could add 20% to NAND industry wafer supply, if the company is successful with its efforts. NAND is already a somewhat competitive industry based on an HHI analysis, with six mainstream

suppliers at the chip level and more at the drive level. NAND company margins have been under pressure (Exhibit 16), and YMTC entering the industry in size would likely enhance the degree of competition using WSPM as a proxy for market share (Exhibit 17).

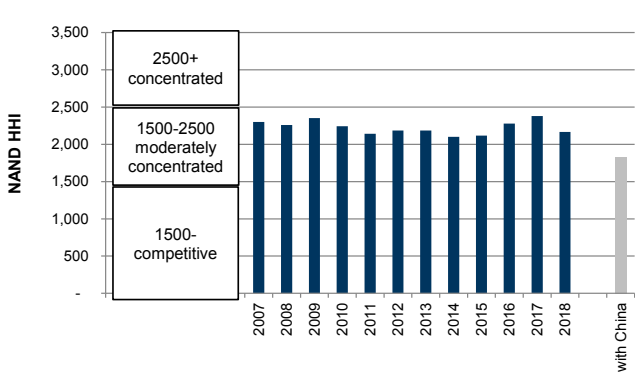
The DRAM industry is currently consolidated based on an HHI market share analysis (Exhibit 19), but **if a China-based company were to develop competitive IP and manufacturing technology for DRAM, then we would expect plans for large-scale production to shortly follow. That said, we believe from our industry discussions with the supply chain that China-based DRAM companies still have a ways to go in their technical development.**

Exhibit 16: NAND industry margins have been cyclical
NAND industry average operating margins



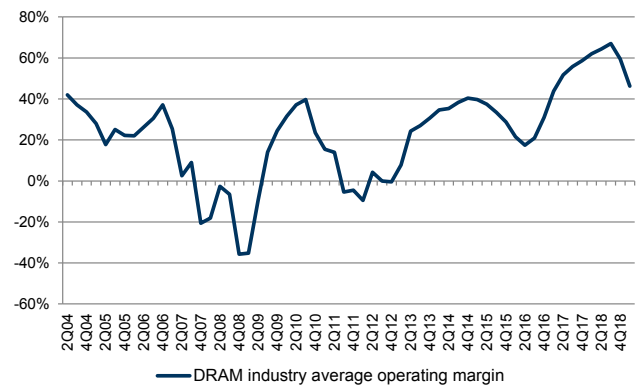
Source: Company data, Goldman Sachs Global Investment Research

Exhibit 17: The NAND industry has not consolidated
NAND industry HHI



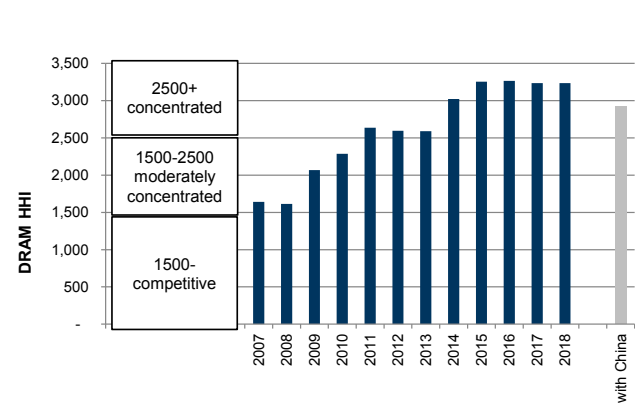
Source: Gartner, Goldman Sachs Global Investment Research

Exhibit 18: DRAM operating margins have improved over time despite cyclicity
DRAM industry average operating margins



Source: Company data, Goldman Sachs Global Investment Research

Exhibit 19: The DRAM industry has consolidated over time
DRAM industry HHI



Source: Gartner, Goldman Sachs Global Investment Research

Stock views

We believe our views in this report are positive for semi cap equipment (as new entrants typically spend more on capex in part to help compensate for lower yields, and China could be a longer-term source of capex), and for the memory stocks that are more exposed to DRAM such as Micron, SK Hynix, and Samsung Electronics (given our findings that DRAM will be harder for China to ramp in volume production than NAND, and even in NAND there are still hurdles).

We believe the findings in this report are mixed to negative for primarily NAND and HDD-exposed stocks such as WDC and STX. We believe that China's domestic efforts to enter the NAND flash market in volume, where YMTC is the leader, still face hurdles and the situation is not as bad for incumbents as some headlines suggest. However, we believe the actual or potential entrance of YMTC in NAND in volume could add a moderate amount of incremental supply over the intermediate term and/or cause the incumbent NAND companies to try to stay ahead on cost structure and (all else equal) keep NAND prices lower than they would otherwise be (and also in turn contribute to SSD share gain from HDDs). In addition, we see any such entry as a headline negative that could weigh on multiples.

MU: We have upgraded Micron stock to Buy from Neutral in a [separate report out today](#), and we view the longer-term competitive landscape in DRAM that we discuss in this report as part of our thesis. Our 12-month price target of \$56 is based on 9X our normalized EPS estimate of \$6.25 including SBC. Key risks to our view relate to Micron's Huawei exposure (13% of revenue over the last 9 months per Micron's latest 10-Q), DRAM and NAND supply/demand (i.e., lower-than- expected demand or higher-than-expected supply), server/PC/handset unit growth, tariffs, the United Microelectronics (UMC) lawsuit in China, market share (i.e., Micron's ability to execute on its technology transition roadmap and its strategy to sell bits into higher value markets), margins (i.e., Micron's execution on cost reductions), and the potential entry of China into the memory industry in scale.

Samsung Electronics: We raise our Samsung price target in a [separate note out today](#), and we continue to have a positive view on the name as our core thesis of memory industry becoming less cyclical, its well diversified earnings structure, and shareholder friendly stance is intact. We believe improving memory fundamentals heading into 2020 will likely lead the company to see resumption of earnings growth. Our new SOTP-based 12-month target price is W57,000 (from W51,000 previously) as we roll over our valuation period to 2020E from 2019/2020E average and raise our 2020/2021E EPS estimates by 4-5%. Key risks to our view include major deterioration in memory supply/demand and sharp contraction in smartphone margins.

SK Hynix: We have upgraded SK Hynix stock to Buy from Neutral in a [separate report out today](#), as we are more constructive on 2020 memory supply/demand and memory pricing outlook. Plus, from a long-term perspective, we continue to be constructive on memory due to the less cyclical nature of the industry, technological migration difficulties, increased supply discipline, and secular demand drivers such as AI, servers,

IoT, 5G, etc. Our new 12-month price target of W90,000 (from W69,000 previously) is based on 1.2x 2020E P/B target multiple, as we change our target multiple from 1.0x to 1.2x and raise 2020/2021E EPS estimates by 18-19%, since we believe we are at least passing through the middle of the downturn. Key risks to our view include major deterioration in memory supply/demand and delay in technology migration.

AMAT: We have upgraded Applied Materials stock to Buy from Neutral and add to the Conviction List in a separate report out today, and we view the potential entrance of China-based memory companies as a longer-term upside opportunity for semi equipment. Our 12-month price target of \$56 is based on 14x normalized EPS of \$4.00. Key risks include 1) changes in memory supply/demand and therefore the memory capex outlook, 2) insertion of EUV, 3) changes in the competitive landscape, particularly in Etch and Deposition, and 4) changes to the outlook for Display spending.

LRCX: We have upgraded Lam Research stock to Buy from Neutral in a separate report out today, and we view the potential capex from China based memory companies as a longer-term upside opportunity for semi equipment. Our 12-month price target of \$231 is based on 14x normalized EPS of \$16.50. Key risks include 1) changes in memory supply/demand and therefore the memory capex outlook, 2) insertion of EUV, and 3) changes in the competitive landscape, particularly in Etch and Deposition.

KLAC: We have upgraded KLA stock to Neutral in a separate report out today, and we view the capex from China-based memory companies as a longer-term upside opportunity for semi equipment. Our 12-month price target of \$130 is based on 13x normalized EPS of \$10.00. Key risks to the upside and the downside include 1) stronger/worse than expected recovery in WFE, 2) upside/downside to Orbotech's business, 3) upside/downside to synergies.

SCREEN Holdings: We believe semi equipment companies such as SCREEN could be beneficiaries in the long-term as China based companies seek to enter the memory industry. We are Buy-rated on SCREEN shares. Our 12-month target price of ¥5,900 is based on FY3/21E EV/DACF of 8.8X and implies FY3/21E P/E of 14X. Risks include sharp declines in memory investment, continued inventory adjustments at foundries, and more intense price competition.

Ulvac: We believe semi equipment companies such as Ulvac could be beneficiaries in the long-term as China based companies seek to enter the memory industry. We are Buy-rated on Ulvac shares. Our 12-month target price of ¥6,000 is a weighted average based (1) 85% on fundamental value of ¥5,400, derived from SOTP-based FY6/21E EV/DACF multiples (SPE 8.8X, FPD 5.3X); and (2) 15% on M&A value of ¥9,600, derived from the average EV/EBITDA of 11X in past global SPE deals and our FY6/21 EBITDA estimate. The target price implies FY6/21E P/E of 15X. Risks include a slowdown in FPD investment, intensification of US-China trade tensions, and declining memory investment.

Tokyo Electron: We believe semi equipment companies such as Tokyo Electron could be beneficiaries in the long-term as China based companies seek to enter the memory industry. We are Neutral-rated on Tokyo Electron shares. Our 12-month target price of

¥16,000 is based on FY3/21E EV/DACF of 8.8X and implies FY3/21E P/E of 13X. Risks include swings in memory investment, changes in shareholder return policy, and trends in macroeconomic conditions.

ASML: We believe semi equipment companies such as ASML could be beneficiaries in the long term as China-based companies seek to enter the memory industry. We are Buy rated on ASML stock with a 12-month price target of €208, based on an unchanged 21X 2020E P/E multiple. Key risks to our view and price target include EUV delays, capex cyclicalities and market share shifts.

WDC: We are Neutral-rated on WDC shares. Our 12-month price target of \$54 is based on 9X normalized EPS of \$6.00 including SBC. Key risks to our view relate to NAND supply/demand, HDD demand, margins (which are tied to ASPs, mix, and the success of cost reductions), the success of new product introductions, leverage, and the entry of China into the NAND industry.

STX: We are Sell-rated on STX shares, and our estimates and price target are unchanged. Our 12-month price target is \$37 based on 8X our normalized EPS forecast of \$4.60. Key risks to our Sell thesis relate to better-than-expected HDD fundamentals (potentially from tighter NAND supply/demand than we expect, or from better overall HDD pricing or volume from faster data creation), better than expected trends in gross margins, a longer near-line demand growth cycle relative to history, M&A, and the dividend.

Disclosure Appendix

Reg AC

We, Mark Delaney, CFA, Allen Chang, Daiki Takayama, Toshiya Hari, Satoru Ogawa, Alexander Duval and Giuni Lee, hereby certify that all of the views expressed in this report accurately reflect our personal views about the subject company or companies and its or their securities. We also certify that no part of our compensation was, is or will be, directly or indirectly, related to the specific recommendations or views expressed in this report.

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