GLOBALFOUNDRIES has shipped >250,000 32/28nm HKMG wafers to date. The milestone represents a significant lead over other foundries in HKMG manufacturing.

On a unit basis, cumulative 32/28nm shipments for the first five quarters of wafer production are more than double that achieved during the same period of the 45/40nm technology node ramp, demonstrating that the overall HKMG ramp has significantly outpaced the 45/40nm ramp.

The tradition of rapidly ramping leading-edge technologies to volume production continues.
ACCELERATE THE GROWTH AND INCREASE THE RETURN ON INVESTED CAPITAL OF THE GLOBAL SEMICONDUCTOR INDUSTRY BY FOSTERING A MORE EFFECTIVE ECOSYSTEM THROUGH COLLABORATION, INTEGRATION AND INNOVATION.

- Address the challenges and enable industry-wide solutions within the supply chain, including intellectual property (IP), electronic design automation (EDA)/design, wafer manufacturing, test and packaging
- Provide a platform for meaningful global collaboration
- Identify and articulate market opportunities
- Encourage and support entrepreneurship
- Provide members with comprehensive and unique market intelligence

MISSION AND VISION STATEMENT

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From its inception, the semiconductor industry has, on average, grown much faster than the global gross domestic product (GDP). Since 1987, when semiconductor growth and global GDP growth started to correlate strongly, the industry has delivered innovation, convenience and capability far exceeding any other innovation, and in doing so grown the business to nearly $300 billion per year. But in the past decade, despite the most prosperous growth in human history, measured simply by global GDP increase; semiconductor industry revenue has not been able to keep up with the society it serves. The interesting and critical issue isn’t which region will take up the larger share of this $300 billion, but how we can break down the regional barriers and mindset to grow the semiconductor industry to $400 billion per year.

Globalization as a Necessity

First, let’s try to illustrate the need for globalization, besides the fact that oscillating around $300 billion isn’t a viable business. Around the globe, all bemoan the problems of flat lining growth, competitive pressure and issues of scale. But each region has its own unique, specific issues. The United States sees a hollowing of capital and human resources to mobile/online media; Japan sees a need for a structural change in its industry; Taiwan sees lack of roadmap clarity for its execution machines; China still struggles to convert “home-field” advantage into growth; and Israel sees promising start-ups mostly turn into subsidiaries of multi-nationals. The fact that each region has its distinctive view of challenges suggests that each region possesses its own strengths, focuses on different areas of the market/value-chain and is vulnerable to its own region-specific issues.

To go a bit deeper into one region, and imagine the problem of this “region-centric” thinking, let’s take Japan as an example. Much has been written about the challenges in the Japanese semiconductor industry. Short term, global competitors in system-on-chip (SOC), microcontroller (MCU) and other traditional Japanese strongholds typically see opportunities to take market share from Fujitsu, Renesas and others. However, what this short-term mindset misses is that Japanese companies are among the most committed to basic technology research, the engine propelling future growth. This mindset is largely missing in, for example, Taiwanese and possibly Chinese semiconductor companies. Long term, a semiconductor industry without a strong Japanese presence is not healthy. This particular mindset is not unique to Japan, or Taiwan or Israel; it’s universal and difficult to change because, after all, we are products of thousands of years of history. Without Japan, we might lose the commitment to fundamental research that does not have near-term applicability. But Japan is also in need of some significant restructuring; much of it requires a new culture. Instead of consolidation within Japan, perhaps a more viable restructure is to integrate globally.

Another example of the need to break down a barrier is in the area of “company-nations,” that of Intel, Samsung, etc. These big companies amass enormous assets (roughly one third of revenue, and more than half of the profit of the total semiconductor industry), but can only invest in markets large enough to fill their manufacturing capacity. While they operate globally, the centralized decision-making and disciplined culture necessary to operate, force them to be just as homogeneous as the headquarters. With the larger companies concentrating their R&D in low-risk, proven markets, it’s no wonder we keep getting faster, smaller, cheaper versions of the same things. Not bad, but the contribution to society is not significant enough to break $300 billion, especially with bright Asian engineers able to cost reduce anything put in front of them. There is no way, or reason, to break up a perfectly profitable and thriving company like Intel, but there is a need, so that the industry can thrive, for the larger companies to expand vision and scope, and take on more risk to benefit both themselves and the industry at large. Globalization may be just the path.

Progressing Towards Globalization

Some might argue that the semiconductor industry has globalized, with companies large and small setting up logistics centers in Asia, software centers in India and executives constantly jet-lagged commuting between them. True enough, but the command center at headquarters for semiconductor companies are largely homogenous, even in the United States strategic decisions on technology investment, target market and engineering executions are all based on historical traditions of the “HQ domicile culture,” as opposed to best practices worldwide. For example, a leading MP3 SOC maker in the United States in 2003 announced its exit from the market because the pricing and gross margin no longer fit the company’s strategic targets.
More recently and importantly, as the industry searches for the next viable memory bit cell technology, U.S. venture investors discovered that their brightest start-ups couldn’t get access to test wafers, because semiconductor manufacturing has largely left the United States. No wonder most venture investors have abandoned the semiconductor business, and even fewer have any interest in a fab. Worse yet, the very best in manufacturing today in Asia are so focused on high-volume manufacturing, that experimental test wafers are seen as a risk instead of an opportunity. Thus, the outsourcing of “experimental production” is nonexistent. The U.S. and Asia regions have not been able to work together fast enough nor efficiently enough to deliver the next breakthrough. As a result, we are relying on the heroic but nonetheless incremental efforts of the memory giants to eke out sufficient progress for consumers.

The easiest and most likely creation of successful globalization is to take two critical-massed companies in different regions and combine them to form a uniquely different company. Such experiments are hard to find today. Most times, there’s an acquirer and a seller, and the acquirer distills the asset to exactly what it needs. For example, Samsung has reached out to acquire CSR’s mobile business. The technology from CSR will be critical building blocks to Samsung’s mobile strategy, but it would be a challenge to think CSR will have a long-term effect on how Samsung makes strategic decisions in Seoul. Intel’s acquisition of the Infineon mobile business is definitely cross-border, but isn’t really cross-cultured enough, and in the end, hasn’t created a significantly different headquarters. All it has done is intensify the confusion on the strategy outside of the traditional x86 business. A potentially more exciting example, GlobalFoundries today is a combination of Chartered Semiconductor from Singapore and AMD in America and Germany. The cultural integration has been challenging, but it would be a boom for the industry if GlobalFoundries can successfully combine the innovation-focused AMD and customer-focused Chartered. The industry needs more cross-border integration of different cultures.

In the GlobalFoundries case, the Advanced Technology Investment Company (ATIC) of Abu Dhabi took a huge risk to enable the globalization experiment. More private equity participation is needed to enable the next waves of innovation through globalization. Through the buy-out effort of semiconductor assets from Motorola, Philips, Agilent and Infineon, the private equity community has learned a lot about the semiconductor business, and some success stories, admittedly difficult, are rewarding. The next waves of innovation will be less about management focus and portfolio management, and more about buying various pieces of different building blocks and combining them to create something compelling.

Globalization as a Reality

There are three ways to think about where possible globalization might emerge. The first way is to see if a value chain aggregation can deliver compelling returns to investors. One example cited earlier is the search for a new memory bit cell. Second, is to reverse the design-by-developed-countries and build-by-developing-countries mentality in the semiconductor business. This so called “frugal innovation,” was best illustrated by GE Medical with the creation of low-cost medical devices based on the requirements of developing countries, with the success then propagated back to the G8 market. Third, is to integrate cultures that are historically compatible, but have not been combined before, and apply the combination to producing a breakthrough to targeted problems all consumers face.

Aggregating or reversing value chain is both easy to identify and quantify, so let’s discuss the cultural aggregation possibility in more detail. The attempt is to create a new headquarters, which is cross-cultured and truly borderless. The first fertile ground is likely to combine the execution excellence of a Taiwanese company with an architectural powerhouse in the United States, United Kingdom or Israel. As the TV/set-top box (STB), PC and GigE markets stagnate, talented Taiwanese design houses struggle to find the “next topic” to chase. On the other hand, many promising start-ups give up the dreams of an independently viable existence and sell out because they don’t see the ability to compete on cost and scale. The interesting question is: Would the semiconductor industry at large be more vibrant and enable higher growth if these companies, say in Israel, are now equal partners with Taiwanese public companies, instead of part of Broadcom? Of course, the issue is risk. Taiwanese culture accepts and almost cherishes execution risk, but shies away from market and technology risks. This mentality creates the need for globalization, but is also the reason why cross-border deals are rare and rarely successful.

Another example is to tackle the equally promising chip industry in Japan, with its enormous technology assets, talented engineers and many companies needing restructuring. Whether it’s a roadmap strategy, international sales force or simply speeding up the decision process, just about any cross-border project will enable a new culture for Japan to move forward. The challenge is finding enough cultural compatibility that creates significant synergy. Despite more than fifty years of internationalization, Japan is still perhaps the most tradition-bound country. What is needed is international management expertise that can integrate the cultures of Asia and the west to create an entity that is far greater than the sum of parts. A recent example is Hitachi CEO Hiroaki Nakanishi, who was picked because of his long experience successfully managing Hitachi’s U.S. operation.

Conclusion

Having argued that globalization is an imperative, it’s also easy to see why globalization is inevitable. After all, the semiconductor industry has some of the most visionary people who have succeeded by breaking conventional wisdom. It is likely that a U.S.-based company will invite private equity expertise to help enable a cross-border acquisition, but will be surprised to find that to grow and succeed, it needs to share the decision-making process and power equally with an Asian-domiciled company, thus beginning the globalization struggle. With perseverance and a little luck, the combined culture will be the first to blend bleeding-edge innovation and market strategy with the relentless pursuit of cost excellence, and enter the top of semiconductor industry before 2020 as the pioneer that grows the industry to $400 billion in annual revenue.

About the Author

Charlie Cheng joined Kilopass as CEO in 2008 and is responsible for leading the company and its business growth worldwide. His career spans more than 10 years in the semiconductor IP industry and an additional 15 years in the global technology marketplace. Prior to Kilopass, he served as vice president of marketing and international business at Faraday Technology. Previously, he was co-founder and CEO of Lexen Inc., an embedded reduced instruction set computer (RISC) CPU IP company.
How we got here...where we are going

Paul McLellan

In the last few decades, electronics have become more and more central to our everyday lives. Two things responsible for this world as we know it include: the inventions of the transistor and of the IC. Due to these two inventions, cell phones today have more power than the supercomputers of yesteryear, cars contain dozens of microprocessors and video game consoles are more powerful than the flight simulators of twenty years ago. A modern IC, or microchip, has changed our everyday lives, may have over a billion transistors on it and yet sell for just a few dollars.

How is it possible that electronics sell for so cheap?

Like the comedian who rehearses intensely until it all looks ad libbed, it turns out that it is really expensive to make inexpensive electronics. Chips are built in factories known as fabs that cost more to build than nuclear power plants. They are filled with specialized machines costing tens of millions of dollars each. Chips are designed by teams of hundreds of design engineers, and are surrounded by an ecosystem of specialized software; software that without which, it wouldn’t be possible, and that sells for tens, if not hundreds of thousands of dollars per copy.

But it all starts with the transistor.

The Early Years

The transistor was invented at Bell Labs in New Jersey in 1947 by John Bardeen, Walter Brattain and William Shockley. The transistor is at the heart of almost all electronics and so is one of the most important inventions of the 20th century. Shockley fell out with Bell Labs and returned to Palo Alto, CA where he had been brought up. He opened the Shockley Semiconductor Laboratory of Beckman Instruments and tried to lure ex-colleagues from Bell Labs to join him. When he was unsuccessful, he searched universities for the brightest young graduates to build a new company, creating the genesis of Silicon Valley and the culture that still exists there today.

When Shockley decided to discontinue research into silicon-based transistors, eight people, known as the traitorous eight, resigned and with seed money from Fairchild Camera and Instrument created Fairchild Semiconductor Company. Almost all semiconductor companies, particularly Intel, AMD and National Semiconductor (now part of Texas Instruments) have their roots in Fairchild in one way or another. It was where silicon-based ICs began, which have turned out to be the winning technology.

The second big step, the invention of the IC, took place simultaneously at both Fairchild and at Texas Instruments in 1957-59. Jean Hoerni at Fairchild developed the planar transistor. Then Jack Kilby at Texas Instruments and Robert Noyce at Fairchild developed the IC.

This turned out to be the big breakthrough. Until that point, transistors were built one at a time and wired together manually. The planar manufacturing process allowed multiple transistors to be created and connected together simultaneously. By 1962 Fairchild was producing ICs with about a dozen transistors. Much has changed in the intervening years, but this same basic principle is how we build modern billion transistor chips today.

In 1965, Gordon Moore was head of R&D at Fairchild, and noticed that the number of transistors on the ICs that Fairchild was building seemed to double every two years. As he pointed out, “ICs will lead to such wonders as home computers, automatic controls for automobiles and personal portable communications equipment.” Remember that this was 1965, when an IC contained 64 transistors, and was an extraordinary prediction. But we certainly do have home computers, automatic controls for automobiles (not quite fully automatic yet) and personal portable communications equipment (cell phones). Surprisingly, nearly 50 years later, semiconductors continue increasing in complexity at this rate. Gordon Moore’s original remark is now known as “Moore’s Law”.

You can also look at Moore’s Law the other way round: the cost of any given functionality implemented in electronics halves every two years or so. Over a period of twenty years, this is a thousand-fold reduction. A video-game console, which is so cheap that children can buy them with their allowances, has far more computing power and much better graphics than the highest-end flight simulators of the 1970s, which at that time cost millions of dollars. Ink-jet printers used in homes today, have far more computing power than NASA had when man first walked on the moon. It is this exponential driving down of electronic costs that has transformed so many aspects of our lives in the last twenty years as ICs have become cheap enough to go into consumer electronic products.

Rise of the Foundry

A modern fabrication line, or fab, can cost as much as $10 billion dollars. Since it has a lifetime of perhaps five years, owning a fab costs around $50 per second, before buying any silicon or chemicals, or designing any chips. Anyone owning a fab had better be planning on making and selling a lot of chips if they’re going to make any money. A modern fab manufactures over 50,000 dinner-plate sized wafers every month.

In the past, fabs were cheaper. And as a result, most semiconductor companies owned their own fabs. In fact, around 1980 there were no semiconductor companies that didn’t own their own fabs since there would be no way for them to manufacture their designs. But, the economics of fabs have completely changed the semiconductor ecosystem.

Some companies found that they had excess capacity in their own fabs, because an economically large fab might turn out to be larger than their needs for their own product lines. Correspondingly, other companies may have the opposite problem: they didn’t build a big enough fab or they were late constructing it, and they could sell more product than they could manufacture.

So, semiconductor companies would buy and sell wafers from
each other to even out their capacity needs. This was the beginning of the foundry business, analogous to a steel foundry. If you want to make a steel casting, you can design it, take it to a foundry and have the parts manufactured. Nobody, not even automobile manufacturers, are large enough that it makes sense for them to own their own foundries. In a similar way, semiconductor companies with shortages would take their designs to other semiconductor companies with surplus capacity (often even competitors) and have them manufactured.

In the early 1980s, another change made ICs more widely available. Specialized companies were created that would help you realize your system dreams as an IC. Perhaps a company knew about a market, but didn’t have specialized semiconductor knowledge. The specialized companies would supply the missing knowledge, manufacture the chips (or have them manufactured) and ship them back to you. These chips were known as application specific ICs or ASICs. Now a system company building components for personal computers (the main driver of electronics at the time) could use ICs without all the infrastructure of a fab. And the ASIC companies would amortize the cost of their fab across hundreds of designs being manufactured simultaneously.

The next step in the evolution of the ecosystem was that in the mid-1980s, some companies realized that they didn’t need to own a fab to have chips manufactured. In principle, they could use the ASIC companies, but in practice there wasn’t enough profit selling components to support two semiconductor companies in the supply chain. In practice, almost all ASIC business was a result of system companies designing high value components for their own consumption in the electronic systems they manufactured and sold.

Instead, these companies would purchase foundry wafers just like any other semiconductor company. These companies came to be called, for obvious reasons, fabless semiconductor companies. Two of the earliest were Chips and Technologies, who made graphics chips for the PCs of the day and Xilinx who made what are known as field-programmable gate arrays (FPGAs); chips that can be configured by the user to do whatever they want. They purchased wafers from other semiconductor companies and sold them just as if they’d manufactured them themselves.

Semiconductor companies with fabs became known as integrated device manufacturers, or IDMs, to distinguish them from the fabless companies. In 1987 the first of another new breed of semiconductor companies was created with the founding of Taiwan Semiconductor Manufacturing Company (TSMC). TSMC was the first foundry, created only to do foundry business for other companies who needed to purchase wafers either because they were fabless, or because they were capacity limited. It was also known, when the distinction was important, as a pure-play foundry to distinguish it from IDMs selling excess capacity, who would often be competing at the component level with their foundry customers.

Until TSMC and its competitors came into existence, getting a semiconductor company off the ground was difficult and expensive. To build an IDM required an expensive fab. To build a fabless semiconductor company required a complicated negotiation for excess foundry capacity at a friendly IDM, which might go away if the IDM switched from surplus to shortage as its business changed. Once TSMC existed, buying wafers was no longer a strategic partnership; you just gave TSMC an order.

This lowered the cost and the risk of creating a semiconductor company and during the 1990s, many fabless semiconductor companies were funded by Silicon Valley venture capitalists to address markets from graphics to FPGAs, from networking chips to wireless chips. Historically, a semiconductor company had to be large to have enough business to fill its fab. Now a semiconductor company could have just a single product, buy wafers or finished parts from TSMC and sell them.

Over time, another change occurred. Many system companies also switched from using ASIC companies to doing their designs independently and then buying wafers from foundries. The specialized knowledge about how to design ICs that was lacking in the system companies in the 1980s was gradually acquired, and by the 1990s many system companies had very large IC design teams. The ASIC companies gradually started selling more and more of their own products until they became, in effect, IDMs.

As fabs got more expensive, another change occurred. IDMs such as Texas Instruments (remember, the IC was invented there) and AMD that had always had their own fabs found they could no longer afford them. Some of these companies changed their business models, and became completely fabless. For example, AMD sold most of its fabs to an investment consortium that turned it into a foundry called GlobalFoundries. Alternatively they kept their own fabs for some of their capacity and purchased additional capacity, typically in the most advanced processes, externally. This was known as fab-lite.

This is the landscape today. There are a few IDMs such as Intel who build almost all of their own chips in their own fabs. There are foundries such as TSMC and GlobalFoundries who build none of their own chips; they just build wafers for other companies. Then there are fabless semiconductor companies such as Xilinx and Qualcomm, who along with their fab-lite brethren such as Texas Instruments, do their own design, and sell their own products, but use foundries for all or part of their manufacturing.

The Future

Looking to the future, Moore’s law is under pressure. Not from a technical point of view; it is clear that it is possible to go on for many process nodes, but from an economic point of view: it is not clear that the cost to manufacture a million transistors is going to come down.

One major challenge is that for the foreseeable future, multiple masks are needed to manufacture some of the chip, pushing up costs. Extreme ultra-violet lithography (EUV) is a possible savior, but there are so many issues that it will not be ready until the end of the decade at the earliest. Bigger 450mm (18-inch) wafers are another possible driver to bring down costs, but are also years away.

So it is possible that the exponential cost reduction that has driven electronics for decades is coming to an end. Electronics will still have more capability, but may not get cheaper and cheaper in the way that we have become accustomed.

About the Author

Paul McLellan has a 25-year background in semiconductor and EDA with both deep technical knowledge and extensive business experience. He works as a consultant in EDA, embedded systems and semiconductor. Paul was educated in Britain and spent the early part of his career as a software engineer at VLSI Technology both in California and France, eventually becoming CEO of Compass Design Automation. He has been VP of engineering at Ambit, corporate VP at Cadence, VP of marketing at VaST Systems Technology and at Virtutech, and interim CEO at Envis Corporation. He blogs at dac.com and at semiwiki.com and has published a book EDAgnafitti on the EDA and semiconductor industries.
The complexities of managing semiconductor supply chains with a global network of wafer fabs, backend sites, inventory warehouses, VMI location and customer ship-to locations are well known to most people familiar with this industry. In a global environment, the need for visibility to events in the supply and demand chain is well established. While financial visibility to the events in the demand chain receives a lot of attention and effort, financial visibility in the supply chain is one area that does not seem to get much attention.

Supply chain visibility is often thought of as being synonymous with inventory and quality visibility, and the need is often couched in product engineering or demand fulfillment terms. When it comes to financial visibility, many fabless semiconductor companies have either created home-grown solutions for this area, or have a complex patchwork of tools and manual processes. The remainder of this article will explore the importance of financial visibility, what it means, what challenges it poses and solution options.

Financial Visibility and Complexity

First and foremost is the question, why is this important and what exactly do we mean by financial visibility? For most fabless companies, financial visibility on the supply side often translates to visibility to events and data that affect invoices and reserve calculations. The bulk of the complexity related to invoices is related to the ability to predict various charges on an assembly or test invoice and then reconcile those charges once the invoice is received. For most fabless semiconductor companies, the Cost of Product Revenue (COPR) is roughly 45 percent to 55 percent of revenue and the service charges for assembly and test can be as much as half of that.

Invoice errors are mostly a function of the complexity of the environment. An IBM white paper (How to Justify the Cost of a TMS by Automating Freight Audit and Payment, http://public.dhe.ibm.com/common/ssi/ecm/en/zzw03092usen/ZZW03092USEN.PDF) on the Freight Audit & Pay process (the logistics analog of the topic under discussion) says it well – “Companies overpay for shipping not because carriers are dishonest but because high-volume, global shipping operations generate too much data for manual processes to absorb. The number of carrier invoices, the level of detail on each invoice, and the variance in charges, rates, services and billing practices create an impossible task to manage without automation. The larger the shipping volume, the higher the potential is for billing errors. So even with very competent staff, money continues to go out the door.”

With a few substitutions, all of the sentiments expressed apply to service invoice projections and reconciliation, as well.

The complexity is best understood through a simple illustrative quote for assembly services. Figures 1-3 represent three charges that may appear on an invoice. Figures 1 and 2 show the charges per unit and how they vary by different device/package attributes. The note under Figure 2 explains how the gold factor column in Figures 1 and 2 is used to calculate a precious metal surcharge on a per lot basis. Figure 3 shows the surcharges. The stylized example of Figures 1-3 is sufficient to hint at the complexities of gaining financial visibility.
The precious metals market). In September 2011, for example, the
double adder, often link the timing of a manufacturing event (completion
of a particular lot. Other charges, such as the surcharge for expedited processing can't be verified without
knowledge of the actual start and end times, as well as the in and
out quantities for a particular lot. Other charges, such as the gold
adder, often link the timing of a manufacturing event (completion
of manufacturing) with a market event (closing price of gold on
the precious metals markets). In September 2011, for example, the
price of gold dropped steeply from a little over $1,850 per troy
ounce to $1,600 per troy ounce in one week and then climbed
just as steeply to $1,670 per troy ounce in a couple of days. The
use of the wrong price in an invoice during this period could make
a significant difference in the total invoice amount. The challenge
that many companies face in this area is that many have supply
chain visibility based on the narrow view of supply chain visibility
that existed at the turn of the last century. That view was driven
primarily by direct material procurement practices. In the waning
years of the last century, the potential of the Internet for business-to-business transactions was realized by enabling visibility based
on PO updates or advance ship notices (ASNs). The standards
and thinking were driven primarily by the needs of manufacturers
who bought material from suppliers, or by those whose needs for
visibility were driven by the Collaborative Planning Forecasting
and Replenishment (CPFR) model. While ASNs and inventory
snapshot visibility work well for buying materials based on a
contracted price, they are not adequate for financial visibility of the
kind being discussed in this article.

A third fact, not reflected in the example but clearly a fact of life,
is that the environment is not static. New sites, revisions, products
and subcontractors are introduced regularly and pricing terms are
revised frequently. Therefore, the challenge is not just to introduce
processes and/or tools for financial visibility, but to introduce them
in a manner that scales and adapts with change.

**Conclusion**

The benefits of a financial visibility solution as described here go
beyond the direct impact on accounts payable. The information
gathered for financial visibility is often a great source of data for
different kinds of analytics that lead to greater benefits. For example,
analysis of invoice details can shed light on opportunities for process
improvement. In many cases, this data is also useful to design engineers
and in projecting costs for alternative designs. Some companies at
the leading edge of process innovation have also leveraged financial
visibility tools to move towards an invoice-less process since they can
reliably project costs. In an intensely competitive environment where
companies have to carefully husband resources to achieve top line
growth while managing bottom line expenses, gaining and leveraging
financial visibility is both valuable and necessary.

**About the Author**

Anand Iyer is senior vice president at Serus Corporation. Prior to joining Serus,
Anand led the Global Process Consulting practice at i2 Technologies. He was
also responsible for incubating i2’s Managed Services business and managing
the company’s global patent portfolio. Anand's experience in supply chain
management comes from working with clients in a wide variety of industries
like semiconductors, high-tech, metals, pharmaceuticals, specialty chemicals and
downstream oil. In addition to having U.S. patents to his credit, he has been
published in peer-reviewed journals and practitioner-oriented magazines. Anand
earned an M.S. in Industrial Engineering and a PhD in Systems & Industrial
Engineering from the University of Arizona.

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**Figure 1: Illustrative Quote for Assembly Services**

<table>
<thead>
<tr>
<th>Package</th>
<th>Body Size</th>
<th>Lead Count</th>
<th>Leadframe</th>
<th>Unit Price</th>
<th>Gold Factor</th>
<th>Factory</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>B1</td>
<td>L1</td>
<td>Stamped</td>
<td>U1</td>
<td>Au1</td>
<td>001</td>
</tr>
<tr>
<td>P2</td>
<td>B2</td>
<td>L2</td>
<td>Etched</td>
<td>U2</td>
<td>Au2</td>
<td>002</td>
</tr>
</tbody>
</table>

*Prices are quotes at the base price of $900 per Troy ounce for gold. Adders are calculated by applying the Gold factor to the difference between the London Gold Fixing 24 hours prior to shipment from the factory and base price.

**Figure 2: Illustrative Quote for Assembly Services**

<table>
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<th>Package</th>
<th>Body Size</th>
<th>Ball Count</th>
<th>Die</th>
<th>Unit Price</th>
<th>Gold Factor</th>
<th>Factory</th>
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<td>C1</td>
<td>1</td>
<td>U3</td>
<td>Au1</td>
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</tr>
<tr>
<td>P2</td>
<td>B1</td>
<td>C2</td>
<td>2</td>
<td>U4</td>
<td>Au1</td>
<td>002</td>
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**Figure 3: Fast Turn Lot Example**

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<th>Cycle Time</th>
<th>Premium</th>
<th>Lot Type</th>
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<tbody>
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<td>P1, P2</td>
<td>2 days</td>
<td>300%</td>
<td>Production</td>
</tr>
<tr>
<td>P1, P2</td>
<td>3 days</td>
<td>200%</td>
<td>Production</td>
</tr>
<tr>
<td>P1, P2</td>
<td>2 days</td>
<td>100%</td>
<td>Engineering</td>
</tr>
<tr>
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<td>3 days</td>
<td>100%</td>
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**Key ASIC** is a leading supplier of high-performance, low-power application-specific IC (ASIC) design and manufacturing services for consumer, wireless and personal electronic applications. Key ASIC’s design expertise, unique intellectual property (IP), superior design flow, optimization technology, flexible engagement model and close relationship with multiple fabs, solve the critical challenges of area, integration and cost for mixed-signal and low-power technologies. Design locations in Taiwan (Hsin-Chu Science Park) and Kuala Lumpur, Malaysia combined with extensive manufacturing, logistics resources and a flexible engagement model, provide a comprehensive support system for modular ASIC innovation from IP development through prototype to production.

Key ASIC also supplies private labeled Customer Specific Standard Products (CSSP) that deliver customized products to customers who do not want to make the sizable investment in an ASIC design team. Using Key ASIC’s System-On-Chip (SOC) Platform, customers can benefit from a highly integrated SOC, efficient board design and associated application software for networking, Wi-Fi, multimedia, various interfaces and other Key ASIC patented features.

Key ASIC’s SOC Platform is enjoying success in applications such as:
- SD cards with Wi-Fi and Flash storage for digital cameras or digital photo frames.
- Machine to Machine (M2M) applications and industrial automation with Wi-Fi, universal serial bus (USB) or SD interface
- Mobile to Machine applications or mobile to other device applications with Wi-Fi
- Home entertainment applications with Wi-Fi, USB or SD interface
- Home appliances with Wi-Fi, USB or SD interface
- Digital signage with Wi-Fi, USB or SD interface

Arteris provides FlexNoC Network-on-Chip (NoC) interconnect intellectual property (IP) to improve performance, power consumption and die size of system-on-chip (SOC) devices for consumer electronics, mobile, automotive and other applications.

Arteris invented SOC NoC technology, offering the world’s first commercial solution in 2006. Arteris connects the IP blocks in semiconductors from Qualcomm, Samsung, TI and others, representing over 50 SOC devices.

Traditional bus and crossbar interconnect approaches create serious problems for architects, digital and physical designers and integrators including; massive numbers of wires, increased heat and power consumption, failed timing closure, spaghetti-like routing congestion leading to increased die area and difficulty making changes for derivatives. Arteris can solve these problems for its customers.

Whether using AXI, OCP, AHB or a proprietary protocol, Arteris FlexNoC NoC IP reduces the number of wires by nearly one half, resulting in fewer gates and a more compact chip floor plan. Having the option to configure each connection’s width, and each transaction’s dynamic priority, assures meeting latency and bandwidth requirements. And, with the Arteris IP configuration tool suite, design and verification can be done easily, in a matter of days or even hours.

Founded by networking experts and offering the first commercially available NoC IP products, Arteris operates globally with headquarters in Sunnyvale, California and an engineering center in Paris, France. Arteris is a private company backed by a group of international investors including ARM Holdings, Crescendo Ventures, DoCoMo Capital, Qualcomm Incorporated, Synopsys, TVM Capital and Vantech.

“Key ASIC rejoined GSA to participate as a member of the semiconductor community. But, we found that GSA does much more for us than just that. We use GSA’s funding and industry updates in our business planning. We also participate in events arranged by GSA, which offer the opportunity to network with industry leaders. GSA also provides reports and forums where we can learn the latest results and trends in our industry.”

– Modesto Casas - VP, Business Development – Key ASIC

J.P. Peng – CEO
Modesto Casas – VP, Business Development
Audrey Ng – VP, Administration

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Over the past several years, the Chinese central government has created a favorable business environment to enable the growth of the semiconductor industry in China. That support was on full display this past October during the 10th China International Semiconductor Exhibition and Forum (IC China 2012), a forum for industry exchange and international cooperation on the development of China’s semiconductor industry. More than 200 exhibitors spanning the entire industrial chain participated in this vibrant, three-day event hosted by the China Semiconductor Industry Association (CSIA).

This has been an important year for the Chinese Semiconductor Industry. The implementation of the National Economic and Social Development 12th Five-Year Plan and the State Council’s decision to accelerate the development of new strategic industries has helped make China the largest semiconductor market in the world, and its consumption of semiconductors the highest worldwide.

China’s semiconductor industry is an important contributor to the global semiconductor industry and IC China underscored a bright future driven by the worldwide demand for semiconductors for all sorts of applications. In fact, speakers and exhibitors each pointed to business and technological innovation driving applications for smart phones, tablet PCs, smart grids, smart transportation, smart city and the mobile Internet era.

The semiconductor industry can find a wealth of companies in China that offer IC design services and product development, as well as IC design tools. China has companies doing chip manufacturing and encapsulation testing. Some produce equipment and parts, semiconductor materials, environmental control and cleaning technology. Others are actual chip designers, offering discrete semiconductor and photoelectric devices, power components, sensors, LED technology and related products. Visitors to China will see manufacturers of flat panel displays, automobile electronics, audio and video products and energy-saving devices.

**Trends Affecting China’s Semiconductor and IC Design Industries**

The 12th Five-Year Plan began in 2011 and set out to accelerate the development of new strategic industries, including next-generation information technology. It has enabled new driving forces, such as high-speed fiber-optic communications, wireless communications, cloud computing, the Internet of things, mobile Internet, new generation display, smart phones and more. Yearly revenue of this market segment is expected to grow approximately 20 percent. China’s goal is to direct this growth and revenue into improving advanced technologies and furthering R&D. The new strategy and policy will also promote commercialized financial market operations. Instead of direct investment from the government, the private sector will help incubate companies with technological innovations for global reach.

Considered a key component of the IT infrastructure, China semiconductor industry revenue will continue to expand steadily and is expected to double in size to reach RMB 330 billion — the equivalent of $52.8 billion — by 2015.

China-based companies are now playing more prominent roles in the global market. For example, Shanghai-based SMIC is now the world’s fourth largest foundry, offering advanced process technologies that range from 0.35 micron to 40nm and is expected to have 32nm/28nm ready in late 2013. SMIC currently operates four 12-inch plants and five eight-inch plants, and recently announced investment in Beijing by adding two new 12-inch wafer plants to expand its capacity.

SMIC has had a rocky few years after a series of changes in its executive team. Changes included the resignation of its founder in 2009, the death of its former board chairman in 2011, followed by the resignations of its former CEO and COO in 2011. SMIC then appointed industry veteran Dr. Tzu-Yin Chiu as its CEO in 2011. A new management team led by Dr. Chiu turned the company around with confidence in the Chinese market. SMIC’s recent quarterly sales reached a historic high, bringing confidence to investors, customers and the semiconductor industry.

China’s IC design community has also exploded with more than 500 companies. Although half have less than 100 people, there are companies that are starting to capture the global market’s attention. Examples include HiSilicon, a fully-owned subsidiary of Huawei, and mobile IC supplier Spreadtrum, both of which are already ranked.
as top 20 fabless semiconductor companies, measured by 2011 revenues, and producing leading-edge products with technologies at 28nm. Both have international operations and design centers in the United States and are strongly tied to both the local and global markets.

The majority of these companies are still at the low-end of the semiconductor market, with products in the low-end consumer electronics market, including game and toy controllers. Only about 10 percent have the capabilities to do IC design at 90nm and beyond, and more than half of those companies do design above 0.25-micron. They are growing and should not be ruled out.

Driven by strong demand, China's IC design company revenue had annual average growth above 20 percent over the past five years, and continues increasing. However, it will take some time for the community to produce high-value chips and compete in high-end markets, such as the CPU and field programmable gate array (FPGA) markets.

In another part of the IC industry chain, Jiangsu Changjiang Electronics Technology Co. (JCET), the largest packaging service provider in China, ranked in the top 10 of semiconductor assembly and testing companies.

**Market Trends and Opportunities**

Even though China's semiconductor industry has grown rapidly and steadily, most of what the market consumes still needs to be imported, a need that will continue for at least the next five years.

Being a driving force of the global market, China imported $170 billion of ICs in 2011 and has attracted leading companies. Among the top 10 IC suppliers, Intel takes the largest share at 19.1 percent. The following nine companies include Samsung, Hynix, TI, AMD, Toshiba, ST, Freescale, Renesas and Qualcomm, occupying another 50.7 percent of the China IC market in 2011, according to data from CSIA.

Foreign companies that have contributed to the development of the Chinese market have been well rewarded and are motivated to invest more. Samsung, for example, recently invested $7 billion in Shangxi Province's capital Xi'an for a new NAND Flash memory plant, and Intel spent $2.5 billion on a 12-inch plant in Dalian about two years ago. Hynix's investment of its 12-inch plant in Wuxi also hit $7 billion. Almost every leading semiconductor company has direct investment or operations in China, or joint ventures with Chinese companies.

Computer, communication and consumer electronics are the majority of the China IC market. According to CSIA, TVs, cell phones and computers made in China are all ranked No. 1, with the percentage at 48.8 percent, 70.6 percent and 90.6 percent, respectively.

Memory, CPU, application specific standard parts (ASSPs) and analog ICs are the top four products taking about 70 percent of the whole Chinese IC market. In recent years, automotive electronics, smart card and computer applications were also among the fastest expanding areas.

Although China is trying to grow local companies, investment from foreign companies is welcome and encouraged by both central and provincial governments. Special policies, tax benefits and other incentives are given to foreign investments or joint ventures. Intel, Samsung, Hynix, TI, TSMC and UMC have fabrication facilities in China, and more companies have set up their assembly and testing plants in China, including Intel, Freescale, STMicroelectronics, Renesas, Infineon, Samsung, Fairchild, Panasonic, MIPS and Fujitsu. Hundreds of foreign companies have operations in China. Many have regional headquarters and R&D centers because they want to be closer to the world's largest market and the large talent base in the country with the world's largest population.

In recent years, there has also been a trend toward acquisitions, especially in the IC design field. Four China-based fabless design houses were acquired by foreign companies in 2010 and 2011.

**Opportunities and Challenges Ahead**

The China State Council in 2000 understood the importance of promoting the software and IC industry in China and developed a strategic plan to promote these industries. The China semiconductor industry has been a beneficiary of this plan, growing quickly in size and technology, boosting both the economics in China and the global industry.

Moving forward, the Chinese government has set special policies and strategies and a favorable business environment for semiconductor companies and is investing in research and development. It's obvious that local companies will grow with the support of the government and market demands.

The market is still growing and the gap between what Chinese companies can supply and what the country needs is still huge. With an emphasis on promoting next-generation IT throughout the country over the next decade, the demand will not abate and the Chinese market will continue to be a powerful motivator to global economics.

While there are opportunities, late-comers have to realize that the Chinese policy and strategy is changing. Local companies are growing and thriving, and the environment will be different.

China is now not simply looking at market size, but pursuing technologies, innovations and competitiveness. The ultimate goal is to transform from “Made-in-China” to “Created-in-China.”

With this goal, companies that want to be involved and contribute to the Chinese market development have the potential to make huge gains. Consuming almost half of the global semiconductor market, China is now an integral part and a key driver of global economics. The best way to win the market is to collaborate with China, through direct investment in China, joint ventures with, or acquiring Chinese companies or working closely with China partners. After all, the world is flat.

The focus by the Chinese government and its support of the semiconductor industry has paid off handsomely. The prospects are bright for China's high-tech information service sector and offer ways for the industry to help local firms grow in size and strength.

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**About the Author**

Dr. Zhibong Liu is executive chairman of ProPlus Design Solutions, Inc. He was most recently corporate vice president for CSV R&D at Cadence Design Systems Inc. Dr. Liu co-founded BTA Technology Inc. in 1993 and invented BSIMPro, the leading SPICE modeling product. He also served as the president and chief executive officer of BTA Technology Inc. and later Celestry Design Technology Inc., acquired by Cadence in 2003. Dr. Liu holds a Ph.D. degree in electrical engineering from the University of Hong Kong and co-developed the industry's first standard model (BSIM3) for IC designs as one of the main contributors at the University of California at Berkeley.
Do you remember the 802.11 Wi-Fi start-up era? How many start-ups were chasing the market? I seem to recall that the number was north of 50 companies. How much capital was invested? This period was more than ten years ago, before the cap-lite era and before semiconductor investing became taboo, so my guess would in the billion-dollar range.

Today, there’s an emerging wireless standard that has a very different investment profile. WiGig (Wireless Gigabit Alliance, IEEE 802.11ad) is a unified specification for 60GHz wireless technologies that will provide multi-gigabit wireless connectivity between PCs, consumer electronics and handheld devices. The 60GHz band has much more bandwidth (7GHz to 9GHz) vs. 20MHz to 160MHz in the 2.4GHz and 5GHz bands, which will allow devices to communicate at data transfer rates up to 7 Gbit/s. Forecasts by ABI Research predict a total market of 3.5 billion WiFi products in 2016, of which 40 percent will be Tri-band, using the 60GHz Wireless Gigabit Alliance (WiGig) band alongside existing 2.4GHz and 5GHz bands.

According to some estimates, there are roughly 20 companies working on 60GHz WiGig ICs. However, in the start-up arena, the number is much lower, perhaps half a dozen or so. And other than Wilocity, most of these start-ups have developed their technology on a shoestring.

**Beam Networks** was founded in 2006 to develop 60GHz wireless technology and secured Series A funding in February 2008. The company has remained capital-efficient by focusing exclusively on developing a 60GHz analog universal transceiver.

**Blu Wireless** was founded in March 2009 and is currently angel and self-funded. The company originally planned on developing and shipping ICs; however, in the start-up arena, the number is much lower, perhaps half a dozen or so. And other than Wilocity, most of these start-ups have developed their technology on a shoestring.

**Peraso Technologies** was founded in September 2008 to develop 60GHz chipsets compliant with WiGig and 802.11ad. Raising more traditional funding amounts, the company secured $10 million (CDN) in Series A funding in October 2009 and a C$8 million follow-on equity financing round in November 2010. Peraso argues that it has developed the industry’s smallest fully integrated 60GHz WiGig transceiver. Characterized by small footprint, low power consumption and competitive price points, the device is targeted at mobile market.

Wilocity was first to market and has raised the most capital. Peraso’s funding is relatively substantial as well. Meanwhile, Beam Networks, Blu Wireless and Nitero have taken the “cap-lite” path, whether by design or necessity, to develop their products. This is the new era of semiconductor start-ups. The question remains whether they can go the distance, building a sizable revenue stream and customer base, or whether they will simply serve as outsourced R&D for large semiconductor companies that have the scale and channels to reach the market.

Stacy Joseph, President & CEO, www.beamnetworks.com

Henry Nurser, CEO, bluwirelesstechnology.com

N. Patrick Kelly, CEO, nitero.com

Ron Glibbery, President and CEO, www.perasotech.com

Cliff Hirsch (cliff@pinestream.com) is the publisher of Semiconductor Times, an industry newsletter focusing on semiconductor start-ups and their latest technology. For information on this publication, visit www.pinestream.com.
Q: ATREG is a global advisory firm specializing in the semiconductor and related advanced technology industries. Describe the services you offer and how these benefit semiconductor companies.

A: ATREG advises semiconductor companies seeking to either augment existing business and enhance their competitive position through strategic investments, or monetize non-core or under-performing business units and related assets. We serve some of the world’s most reputable semiconductor companies and have advised on 35 percent of all semiconductor fab transactions happening worldwide since 2010.

Q: ATREG advises companies in an industry subject to volatility, major capital investments, unpredictable market demand, rapidly evolving technologies, fierce global competition, collaboration and consolidation. What advice does ATREG give to help these companies stay competitive?

A: ATREG’s scope of service reflects 12 years of both behind-the-scenes and front-line experience in carrying out and negotiating numerous transactions. Our services are tailored to address the specific objectives and timelines of each client. Ultimately, ATREG’s objective is to inform the strategic decisions made by semiconductor executive teams, provide a defensible plan of action and complete transactions that can strengthen our clients’ competitive positions. We do this by bringing creative solutions, uncovering innovative opportunities and executing complex transactions based on unique market knowledge.

Q: ATREG was founded in 2000. In the 12 years of the company’s existence, what do you believe have been the major turning points of change and innovation in the constantly changing semiconductor industry?

A: The emergence of the foundry business model has had the most significant impact for our clients. ATREG has helped such companies as Atmel, Freescale, IBM, IDT, LSI, NXP and Renesas, among others, in their transition to either a fab-lite or fabless manufacturing model. The ongoing consolidation of the memory sector is another area where ATREG has been active. We were retained as the advisor in Qimonda’s bankruptcies in the United States and Germany. These were the first 300mm fab assets ever sold in the secondary market. Finally, ATREG has been retained to advise several Japanese clients as part of the restructuring efforts that are currently taking place in Japan.

Q: The semiconductor sector is a global industry with a variety of regions contributing to its overall health. What regions do you think have contributed most to its growth, and which show the most promise for future growth?

A: In recent years, the Asia-Pacific region has experienced the most growth. Taiwan dominates the foundry market with TSMC and UMC; Korea is a memory powerhouse with Samsung and SK Hynix; and China, which has risen as an electronics powerhouse, will continue to make significant strides in the semiconductor industry.

Q: In your opinion, what ongoing issues of our global industry need the most attention today?

A: The semiconductor industry is at an inflection point. What has been a growth industry for 30 years has reached middle-age. Cyclicality can mask this gradual maturing of the industry, as can macro-economic shocks. But the evidence is clear – many firms are experiencing weakening gross margins and slower overall growth rates. Public semiconductor companies are seeing a compression in their trading multiples, as investors no longer believe semiconductor firms can expect to grow at historical rates. This is a game-changer for all industry players. Given this new landscape, we are exploring what possible futures may emerge for the semiconductor industry and how companies might respond to this changing landscape. Of course, different firms in the industry will respond in different ways depending on the market segment in which they operate and the sub-markets they may wish to defend, or perhaps abandon.

Q: ATREG has been a member of GSA since 2010. What has been one of the greatest benefits of being a GSA member?

A: ATREG has greatly benefited from being a GSA member, especially from meeting and networking with senior executives at GSA’s global events. These provide a great platform for meaningful collaboration within the semiconductor industry and comparing notes on where the industry is headed. This past July, I had the honor to be invited to present at GSA’s CEO Roundtable in Taiwan, which gave us the opportunity to share and discuss a variety of perspectives on the future of semiconductor manufacturing and the potential for new hybrid manufacturing models – beyond the
Brazil's internal market and growing economy make the country a highly attractive location for the development of a solid information and communication technologies (ICT) industry.

Brazil is a free democracy growing sustainably by a social inclusion policy, exhibiting a gross domestic product (GDP) growth of 2.7 percent in fiscal year 2011 (FY11). Brazil is currently the sixth largest economy in the world and is expected to move up in the years to come. Despite the ongoing global crisis, there is significant confidence in the future of Brazil’s economy, backed by a strong financial discipline and large cash reserves.

Brazil’s economic growth has relied primarily on exporting commodities. Brazil is currently seeking to diversify its economy by a concerted effort of tax incentives for the ICT industry segment and human resources training by the Scientists Without Borders program.

Brazil has a huge internal market for ICT products, which is a major driver per se. The country occupies the third place in the global market of computers (following the USA and China), the fourth place in the mobile market and the fifth place in the medical equipment market. Even though the country has a quickly increasing electronics industry, this industry imports nearly all semiconductor devices assembled in its products. According to a study from the National Bank for Development (BNDES), Brazil’s imports in semiconductor parts increased from $4.467 billion in 2010 by 10 percent to $4.909 billion in 2011. In addition to an increasing expenditure from a financial perspective, the strategic need to provide for solutions to problems such as national defense, citizen identification, health surveillance and prevention of theft and frauds, has created an important awareness towards the development of a solid semiconductor industry in the country.

**Semiconductor Development Efforts**

Under the auspices of the National Microelectronics Program, Brazil initiated an effort to foster a semiconductor industry around the year 2000 with several measures. This program, besides investing in microelectronics education at graduate level, offered tax reductions and other incentives to semiconductor companies willing to run operations in the country. After passing through a recent reformulation, these incentives have become much more attractive and new companies have made the decision to install in Brazil. Today at least seven companies benefit from these incentives for front-end activities - CEITEC and SIX; for IC design – CEITEC, SiliconReef and Idea; and, for back-end activities – SMART, HTMicron and FlexIC.

In 2005, Brazil’s government created another national program, IC Brazil, whose goal is to develop a microelectronics ecosystem in the country. This program is the result of a partnership between governmental entities, universities, research centers and companies, that offers IC design training in two different centers and supports around 20 affiliated design houses (see Figure 1) with infrastructure (including EDA tools licensing) and grants for the team of designers. These design houses have already designed microcontrollers, power management units, analog intellectual property (IP), chips for instrumentation, multimedia applications, wireless communication and radio frequency identification (RFID) chips. In particular, the adoption of RFID in Brazil has been given a boost by a series of initiatives and laws passed recently, in an effort to move the country’s development forward. This program targets agribusiness, object tracking and transportation as significant segments in which to integrate RFID technology. The enactment of these laws has given IC Brazil design houses a further boost to develop Brazil’s high-tech semiconductor industry.

![Figure 1: IC Brazil Design Houses](image-url)
Performance. To get it right, you need a foundry with an **Open Innovation Platform®** and process technologies that provides the flexibility to expertly choreograph your success. To get it right, you need TSMC.

It is TSMC’s mission to be the **Trusted Technology and Capacity Provider** of the global logic IC industry for years to come. In this regard, TSMC assures your products achieve maximum value and performance whether your designs are built on mainstream or highly advanced processes.

**Product Differentiation.** To drive product value, you need a foundry partner who keeps your products at their innovative best. TSMC’s robust platform allows you to increase functionality, maximize system performance and differentiate your products.

**Faster Time-to-Market.** Early market entry means more product revenue. TSMC’s DFM-driven design initiatives, libraries and IP programs, together with leading EDA suppliers and manufacturing data-driven PDKs, get you to market in a fraction of the time it takes your competition.

**Investment Optimization.** Every design is an investment. Function integration and die size reduction help drive your margins; it's simple, but not easy. TSMC continuously improve its process technologies to get your designs produced right the first time.

Find out how TSMC can drive your most important innovations with a powerful platform to create amazing performance. Visit [www.tsmc.com](http://www.tsmc.com)
The history of the semiconductor industry in India dates back to the mid-1980s, when multinational giants from the United States started outsourcing chip design and software development to India to take advantage of the low labor cost and technical talent pool. Initially, the work was centered around software development for design, tied directly to hardware. It included the development of automation tools, modeling and simulation and embedded software.

Over the years, the scope expanded considerably, with several major global semiconductor companies demanding high-end product development from Indian companies.

Since the beginning, the industry has been growing at a steady pace. By the end of 2012, the Indian semiconductors design services market is estimated to stand at $10.6 billion, which represents close to 3.54 percent of the global semiconductor industry (projected to be $310 billion by the end of 2012). In 2007 the Indian semiconductor design services market was $6 billion1.

The last five years have been fairly significant for the Indian semiconductor industry, witnessing a critical shift towards end-to-end chip design services, as well as electronics system design and manufacturing (ESDM). This has given rise to many indigenous design services companies, some of which chose niche markets in the areas of wireless, analog and intellectual property (IP) building blocks and specialized design services. Today, there are over 120 design houses in India, including almost all of the major U.S., European and Japanese semiconductor and telecom companies including Intel, TI, AMD, Philips/NXP, Broadcom, Qualcomm, Nvidia, Marvell, Cadence, Synopsys, Xilinx, Altera, STMicro, Cisco, Hitachi, Samsung and Toshiba, with well-established captive design centers in India. Nearly 80 percent of these are located in Bangalore with Hyderabad, Delhi, Noida, Pune, Chennai and Kochi being the other upcoming hubs.

The semiconductor industry ecosystem has two constants: the research and development (R&D) continuum and its cyclical nature (the fact that the cyclicity is constant is an interesting oxymoron). In 2011, the industry spent a total of $60 billion on R&D, out of which approximately 20 percent was outsourced to India2. A survey by Zinnov shows that the R&D outsourcing to India reached $13.1 billion in 20113. India is also expected to garner one-fourth of the $310 billion by the end of 2012. In 2007 the Indian semiconductor design services market was $6 billion1.

India’s Electronics and Manufacturing Industry

As of today, India’s IT hardware and electronics manufacturing industry consists of 3,500 electronics manufacturing units and 250,000 small and tiny units directly or indirectly supporting the electronics and electrical manufacturing industry, with production to the tune of $14.5 billion annually. India currently has about 60 large and medium sized printed circuit board (PCB) manufacturing plants, yet there is still a shortage of PCBs in India. In the area of chip assembly, packaging and test, there are a handful of companies with limited volume capacity. There is however, no wafer manufacturing in India. As the global electronics market is projected to grow from the current $40 billion to $400 billion in 2020, there is a major opportunity for India to fabricate and manufacture its own chips. The Government of India’s recently (2012) announced major initiatives to promote the ESDM sector, which includes setting up two semiconductor wafer fabs for the manufacture of chips, will help this sector to move up the value chain and address the complete semiconductor design and manufacturing lifecycle.

Overall, the writing is on the wall; there is a large opportunity for India over the next decade. The question is: Can India capitalize on it? Due to five growth enablers that are key success factors in the industry, the answer is yes.

**Embedded and VLSI Talent Pool**

According to ISA, in 2009, the workforce in the semiconductor design industry in India was around 135,000 and was expected to grow at a compound annual growth rate (CAGR) of 20 percent to reach 230,000 by the end of 2012. This workforce of engineers comprises embedded software and board and VLSI design areas. Of this, the VLSI pool size is over 21,000 engineers. With the focus of the Indian government on improving access to higher education and increasing the number of colleges and universities and increased collaboration between industry and colleges, India adds ~2,500 fresh engineers to the VLSI talent pool each year (captives and non-captives combined). There is a well established training infrastructure in place to train fresh college graduates from circuit branches and to empower them to contribute towards chip design.
Cost Advantage

Despite the fact that salary structures have been on the rise in India as compared to the global average, India still has significant cost advantage compared to the United States, Europe and Japan. All of India’s third-party service companies have dedicated teams (made up of hundreds of engineers) serving global customers, thus enabling considerable cost savings to global semiconductor companies.

Stringent Information Security and IP Protection Measures

The government of India and Indian design companies have strict policies on information security and IP protection. These policies are enforced meticulously across all teams and locations of Indian design companies, which give the confidence and comfort feel to global semiconductor companies to outsource more tasks and thus get access to newer/larger talent pools, at the same time improving their profit margins.

Maturity to Take up Full Ownership

With the ramp up accomplished over the years both in terms of team growth, competency and capability growth, the Indian semiconductor industry has been taking on many complex and challenging design projects. This has enabled many global semiconductor companies to come out with multiple products in parallel, as some of the products are developed by Indian teams from specification to final finished and final tested packages. This in turn has helped global semiconductor companies achieve time-to-market advantage and faster growth rates.

Continue to Take up Derivative and Value Engineering Projects

While the Indian semiconductor industry has been taking up complex and full ownership projects, they continue to service global companies in the area of derivative product development/support, as well as in value engineering activities. This enables major global semiconductor companies to focus on next gen products and leverage a time-to-market advantage.

Further, as depicted in Figure 1, mobility, social media, cloud and big data are four pillars that are going to transform the future (not just of the semiconductor industry, but the world) through convergence of computing, communication and consumer products. And as India is a leading contender in software, firmware and platform integration, the scope for growth is tremendous.

As depicted in the figure above, the first generation platform was the mainframe in the 60s and the minicomputer in the 70s. The enterprise software package cost was $500k and the number of customers was a few thousands. The second generation platform came in the 80s where the cost of the software package dropped and customers increased several orders of magnitude. Moving further into the 21st century, the new computing platforms are smart phones, tablets and ultra PCs with tremendous connectivity such as mobile radio, global positioning system (GPS), Bluetooth and WiFi. The application software cost has dropped even further and the size of the opportunity has increased manifold.

As we move into this new generation of consumer products, the design approach needs to be much more holistic and top down, including HMI, packaging with VLSI & system-on-chip (SOC) and chip set performance (keeping in mind speed, power, battery life, cost, quality and reliability trade-offs). As the design and test challenges move from individual SOC designs to platform design and validation, compatibility with other chips and subsystems including device drivers and operating systems becomes even more important.

The new paradigm in platform design is UX, FW design/development, validation and total solution. Fab also have to rethink how they cater to this new paradigm for the new chip design. They have to provide a total integrated design platform consisting of processes, IP building blocks, CAD tools and 3D chips to connect different technologies, as well as for packaging, assembly and test.

Indian design services companies, with their experience in total system integration are in excellent shape as they are already in the midst of embracing these new paradigms of total platform design, development and validation.

Conclusion

In this extremely upbeat environment and positive outlook, the Indian semiconductor industry has yet to overcome a few challenges in order to be considered at par with the global majors. So far, the contribution of Indian semiconductor companies has been more at an operational, ground implementation level. However, by analyzing the trends of the past five years, it is apparent that the move towards the new technology and R&D paradigms has been silent but strong. Currently, wafer fab and manufacturing facilities are non-existent; there are very few local original design manufacturer (ODM)/original equipment manufacturer (OEM) companies; and there is intense competition from APAC countries such as Philippines, Malaysia, Thailand and Vietnam. However, further growth can be achieved with the rise of indigenous fabless design companies. Clusters around university incubation centers to promote products for the domestic market and increased focus on products for defense, consumer electronics, gadget and toys, smart energy consumption, healthcare and automotive sectors will further aid this growth.

To sum up, the market is ripe, the environment is right, the Government is supportive and India has many advantages it can leverage to leapfrog to significance in the global semiconductor arena. One of the most important is its strong education system, which dates back to 300 B.C., from the days of the world famous Nalanda University. The country continues to produce the largest number of engineers and technical talent, who are well positioned to take up the challenge of these evolving future opportunities and accelerate their contribution to future global growth. The tipping point, of course, is the available twin expertise of the Indian IT and
The Next $100B in Semiconductor Revenues: Where Will They Come From and What Will It Take to Win?

Gaurav Batra, Consultant, McKinsey and Company
Nick Santhanam, Partner, McKinsey and Company

The global semiconductor industry had a banner year in 2010. For the first time, industry revenues exceeded $300 billion. Several important tailwinds powered that growth, including further progress along Moore’s law, enabling performance improvements and making devices like the iPad viable; wave after wave of killer applications, from PCs to networking gear, from portable MP3 players to mobile phones. And an increasing number of chips found their way into automobiles, household appliances and industrial equipment.

Before further growth can be achieved, a number of challenges must be overcome to move beyond the $300 billion level in the near term.

- One challenge includes capturing a “fairer share” of the value created for end users. Despite constant innovation, semiconductor players face constant downward pressure on prices. For instance, between 2000 and 2008, memory prices declined, on average, by five percent a year.

- A second challenge is the industry’s inability to monetize the increasing value of the software bundled into chips. In general, semiconductor companies tend to bet on hardware and focus their innovation efforts on the engineering side of a project, rather than the software dimension. Few major chip makers have more software engineers than hardware engineers, even though the software layer is a key component of chips for mobile phones and other portable devices.

- A third, more serious, challenge faces the industry. At the same moment that costs are jumping at rates of as much as 35 percent for each new node along the path from 130 nanometers to the current 22-nanometer standard, there are outsiders such as Apple breaking into the semiconductor business, designing their own chips and capturing value.

Despite these challenges, there are several reasons for optimism. An analysis of nine global trends shows they should power significant growth for the semiconductor players who align their offerings with the biggest opportunities.

Capturing the Next $100 Billion in Revenue

To understand the market and create a forecast for the semiconductor industry, we studied nine major technology trends likely to evolve and drive growth between now and 2015. Not every trend benefits semiconductor players in a meaningful way. Four trends are likely to power about 90 percent of the growth potential, giving the industry a good chance to turn 2010’s $300 billion in revenues into 2015’s $400 billion (Figure 1).

**Figure 1: Major IT Trends that Will Drive Revenue Growth**

<table>
<thead>
<tr>
<th>Industry Growth</th>
<th>2010 Revenue</th>
<th>5-Year Baseline Growth</th>
<th>Megatrends</th>
<th>Double Counting</th>
<th>Estimated 2015 Revenue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memory (volatile)</td>
<td>-0.2</td>
<td>0.6</td>
<td>0.2</td>
<td>1.7</td>
<td>N/A</td>
</tr>
<tr>
<td>Memory (nonvolatile)</td>
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<td>16.3</td>
<td>1.1</td>
<td>2.5</td>
<td>0.0</td>
</tr>
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<td>Microcomponents</td>
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<td>-2.0</td>
<td>6.4</td>
<td>2.0</td>
<td>1.2</td>
</tr>
<tr>
<td>Logic</td>
<td>0.8</td>
<td>2.9</td>
<td>3.5</td>
<td>5.4</td>
<td>0.0</td>
</tr>
<tr>
<td>Analog</td>
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<td>1.5</td>
<td>1.6</td>
<td>2.2</td>
<td>N/A</td>
</tr>
<tr>
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<td>0.6</td>
<td>0.9</td>
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</tr>
<tr>
<td>Optical</td>
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<td>3.3</td>
<td>1.8</td>
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</tr>
<tr>
<td>Sensors</td>
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<td>0.7</td>
<td>0.1</td>
<td>0.8</td>
<td>N/A</td>
</tr>
<tr>
<td>Total</td>
<td>5.6</td>
<td>21.2</td>
<td>16.0</td>
<td>17.3</td>
<td>1.2</td>
</tr>
</tbody>
</table>

1 Figures may not sum, because of rounding. Source: iSuppli; McKinsey analysis

**Mobile Convergence**

Smartphone and tablet sales are expected to grow at a compound annual rate of 24 percent and 35 percent respectively, between now and 2014, according to IDC and Strategy Analytics. Midrange smartphones, with selling prices in the range of $100 to $190, will see comfortable margins and annual growth rate of eight percent between now and 2014. The entry-level smartphone category will see comfortable margins and annual growth rate of eight percent between now and 2014. The midrange smartphone category is largely over, with Apple, Google and Samsung capturing the lion’s share of the segment.

The growth in smartphones and tablets will benefit Flash-memory (particularly NAND Flash) producers. The use of discrete components should also increase, except at the low end of the spectrum, where integrated components will be preferred. In all, mobile convergence will increase global semiconductor revenues by ~$20 billion over the next three years.
Next-Generation Wireless

Demand of more data-intensive rich media content is exploding. In many markets, the current 3G networks are approaching the limits of their broadband capacity and operators are implementing 4G technologies chips in both application processors and baseband systems. Additional transport ports to support backhaul traffic will be required. Logic chips will support more sophisticated applications on next-wave smartphones and tablets. Finally, power-management technology will also benefit, as these more sophisticated devices will support multitasking. Taken together, the implementation of next-generation wireless networks will add as much as $15 billion to $20 billion to industry revenues by 2015.

The Rise of Immediacy

Given the state of sensor technology, there is a fundamental shift in modes of work coming. Among the industries to be revolutionized are health care, packaging and logistics and consumer electronics.

Rising health care costs are driving demand for low-cost, home-based medical devices (e.g., blood pressure, glucose-level monitoring, etc.) resulting in roughly $4 billion to $5 billion in revenue by 2015. With regard to packaging and logistics, the next wave of so-called smart radio frequency ID (RFID) tags will enable real-time location, authentication and analytics of products, trucks and the like. In consumer electronics, recent advances in low-power radio circuits and core processors will enable a new wave of smarter smart devices, from cable set-top boxes to connected TV sets. These chips will also power over-the-top video and audio services and smart Blu-ray players. While 33 percent of today’s microcontroller unit (MCU) market is higher-end 32-bit ARM MCUs, we project that the chip’s share will increase to 53 percent five years from now. In total, the immediacy trend will also be worth about $15 billion to $20 billion to the industry over the next three years.

The Cloud

By 2015, cloud computing is expected to account for nearly 20 percent of global IT and application spending. Enterprise-server sales are forecast to decline, thanks to server virtualization and greater efficiency resulting from the implementation of multicore processors. Storage servers will decline more modestly because they are still needed to move data between workstations and the cloud. Obviously, there are fewer reasons to buy a PC when a tablet could effectively take its place.

Demand for Flash memory will increase as companies move from PCs to thin-client machines. Sales of networking gear will rise as both wired and wireless infrastructures are upgraded to take full advantage of the cloud. Other categories should benefit, too, such as 32-bit MCUs, optical and other sensors, discrete chips, disk-drive and network-storage controllers, radio-frequency components, Ethernet controllers and attenuators; all are likely to see modest growth over the next three years. Analog and logic components are likely to see decreases in sales volume as virtualized servers shrink data-center stacks.

In all, the cloud opportunity will be worth a net -$5 billion in additional revenue for the semiconductor industry by 2015.

The Recipe to Win—Delivering Alpha Growth

All four trends offer powerful opportunities for revenue growth. However, semiconductor companies will benefit most from careful analysis of the micro segments that stand to grow the most.

A metric known as “alpha growth” measures a company’s ability to grow faster than its market. High levels of alpha growth correlate strongly with the creation of shareholder value and economic profits. In a wide range of industries, the alpha-growth metric accounts for roughly 55 percent of long-term growth (Figure 2). The semiconductor industry, however, is laggard, with only about 27 percent of growth attributable to alpha growth over the last decade.

Figure 2: Alpha Growth Trends across Multiple Industries

A formal analysis of more than 700 large companies from a range of industries suggests there are four definite steps a semiconductor company can take to improve its share of alpha growth, namely:

Creating Wholly New Markets

The first lever involves tapping latent growth opportunities—in essence, going where no one has gone before. Companies with a distinctive ability to create new markets surfaced five notable traits. They:

▪ Adopt an expansive view of which market to play in
▪ Make bold bets when entering a new market and foster a culture of informed risk taking
▪ Avoid “analysis paralysis,” which could prevent the company from entering a new space even if it presents a real growth opportunity
▪ Are ready to move by predefining what success looks like and are willing to abandon projects when necessary
▪ Leverage core capabilities to prioritize which specific markets to play in

A good example of this lever is Cypress Semiconductor’s new focus on programmable products in mid-2000s. Its strategy was built on an existing business line, which produced universal serial bus (USB) microcontrollers, but the company expanded its remit to include programmable-system-on-chip (PSOC) products. As this business gained momentum in 2007, with Cypress’s PSOC powering the click wheel for Apple’s popular iPod music player, the company was able to sell off six noncore businesses. Now that same PSOC product line is scaling into new applications, such as mobile handsets and portable medical devices.
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Copper Pillar μBumps

Cu pillar μbumps
PB-free fc bumps
Si Interposer & TSVs
The Future of Semiconductors in Brazil

by ubiquitous use of RFID tags, signals a long term commitment of a state pervasive presence of semiconductor applications in the country, initiated Brazilian government’s enthusiastic support of IC Brazil and an increasingly becoming an important player in the microelectronics industry. The investments in Brazil.

Investors. For example, two Silicon Valley venture capital firms, has also been a significant amount of recent interest from foreign IC Brazil program began benefiting from these funds to develop efforts started to bear fruit, as the design houses affiliated with the CRIATEC, a funding program run by BNDES. More recently, these tracking.

culminated in a world-class RFID technology platform for livestock future of CEITEC in its business area. To date, CEITEC’s work has owned by the government as well, and set high standards for the future of CEITEC in its business area. To date, CEITEC’s work has culminated in a world-class RFID technology platform for livestock tracking.

Fully aligned with the IC Brazil Program, the government agency FINEP provides seed-stage funding to Brazilian start-ups, as does CRIATEC, a funding program run by BNDES. More recently, these efforts started to bear fruit, as the design houses affiliated with the IC Brazil program began benefiting from these funds to develop microchips for niche applications and regional markets. There has also been a significant amount of recent interest from foreign investors. For example, two Silicon Valley venture capital firms, Repoint Ventures and Accel Partners have recently made multiple investments in Brazil.

With its stabilizing economy, Brazil has the key ingredients for becoming an important player in the microelectronics industry. The Brazilian government’s enthusiastic support of IC Brazil and an increasingly pervasive presence of semiconductor applications in the country, initiated by ubiquitous use of RFID tags, signals a long term commitment of a state policy to diversify its industry into the ICT market.

The Future of Semiconductors in Brazil

In closing, Brazil has both the technical expertise and market size to make it a reference in microelectronics innovation for emerging technologies in the southern hemisphere, as a producer and as technology driver. Brazil is poised to become an important player in the entire ICT chain. ■

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Naresh Batra is the director of the Semiconductor Engineering Practice for TATA Consultancy Services North America. He has over 30 years of high technology experience in semiconductors, communications & networking. Naresh spent 11 years at Texas Instruments in various executive positions, including heading up the TI worldwide linear product development line and strategy. He spent five years as vice president and GM at Brooktree (now Conexant), and two years as vice president & GM of Sierra Semiconductor (now PMC Sierra). Naresh has founded three high tech companies in the Silicon Valley area since 1996. He holds BSEE, MSEE and MBA degrees. He is a member of IEEE and a registered Professional Engineer from the state of Illinois. From 1996-98, he was chairman of the Scientific Advisory Committee of IMSC, USC Los Angles. Naresh has published many papers and articles over his lifetime, and is the inventor of 12 patents. Simon Johnney is the Semiconductor Head for TATA Consultancy Services based in Bangalore. He has over 25 years of experience in semiconductor & embedded systems. Simon spent over six years in the design, development & compliance testing group of Airborne Computing Systems. He spent over 17 years at Wipro Technologies in the Product Engineering Group holding various positions, including GM & head of the Business Practice Group for Embedded & Telecom Services, GM & global head of the Semiconductor IP Group and technical manager of the Semiconductor IP Group. Simon holds a bachelor of engineering degree from IIT Roorkee. Simon has published many papers and articles and has been a guest speaker at many conferences.

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Expanding Beyond the Company’s Comfort Zone to Explore Related Markets

In addition to placing bets on wholly new markets, a second lever for driving alpha growth involves expanding into adjacent markets, located one or two steps from current products or services.

Developing a Strong Focus on Product Innovation and Sales Excellence

There are two functions within each semiconductor company that can add to the overall company’s alpha growth meaningfully if they are focused tightly on best-in-class performance. These are the product development and sales teams.

A study of a broad range of corporations that excel in these two areas revealed five characteristics that top performers share:

- Leverage existing core capabilities in product innovation and brainstorm unique ways to combine their abilities with external sources of intellectual property (IP). Cultivate close collaboration between their R&D and marketing functions to ensure that cross-functional teams make all important product-development decisions.

- Establish a robust, consistent framework for evaluating ideas, examining potential financial impact and assessing the strategic fit of the idea, as well as its feasibility and the positives or negatives of the timing of any potential launch.

- Involve research and qualitative comments from customers early in the product-development cycle.

- Nurture a formal innovation culture, setting a foundation to welcome new thinking and support the development of new ideas, while also underlining the importance of continually improving ideas throughout the development cycle.

Turning to sales—the engine that transforms those new products or services into revenues—there is a five-pronged approach to creating alpha growth (Figure 3).

Figure 3: Sales Approach to Creating Alpha Growth

Delivering Alpha Growth

- Identify and target the most attractive current and future customers and applications
- Align sales resources with the highest-value opportunities
- Focus on value-added support activities
- Coach employees and build the required skills for all roles for solution selling
- Replenish the talent base quickly and efficiently
- Streamline presales and sales support
- Effectively leverage low-cost channels

Efficient coverage

Focused sales strategy

Effective solution-selling skills

Disciplined sales process

Rigorous performance management

- Define and measure the right metrics
- Align financial and nonfinancial incentives with needed performance and behavior

Developing a focused sales strategy is the first element. Players must identify and target the most attractive customers. Many companies identify key accounts based on available market and gear investments toward them, but best-in-class companies develop account level perspectives on where the company can expect to find near-term profits.

The second element is an efficient coverage model. By efficient, we mean that the right sales resources must be devoted to the highest-value opportunities at each point in the account’s life cycle (for example, “hunter” versus “farmer” sales coverage).

Building the solution-selling skills of the sales force is third. The fourth element is a truly efficient sales process. While some are content to streamline quoting or simplify distributor sales models, the best companies define a crisp set of processes with clarity and coordination among the internal teams involved in the sale. They also develop automated tools and resources to minimize the administrative burden on sales teams.

The final building block is a robust performance-management system. Peak performers track metrics such as design wins and share gain in addition to traditional sales data.

Leveraging M&A Selectively to Build Scale or Add Needed Capabilities

The fourth lever involves developing a targeted approach to both M&A and business development activity. A study of top-performing institutions reveals four attributes shared by leaders.

- They develop specific M&A archetypes, such as buying scale versus buying in related markets or in specific geographies. These archetypes align with the company’s overall strategy, and the aim to be build platforms rather than conglomerates.

- They develop a proactive and systematic set of processes to screen for and assess M&A opportunities.

- They develop a rigorous approach to merger management, with a focus on value creation. They rigorously track post-merger activities and operating metrics in addition to traditional financial metrics.

- They tend to over communicate to ensure cultural integration.

Putting the Pieces Together

As mentioned above, key technology trends will spur the next $100 billion of revenue for the semiconductor industry. However semiconductor players will need to be thoughtful about which levers to pull. Should they gain market share by defining new markets or opt to expand into related or adjacent markets? Will they ensure superior execution in sales and product development, and selectively deploy M&A skills to enhance revenue growth through targeted acquisitions? With the elements listed above, semiconductor companies can move from their current idea of growth to one that will prove more sustainable over the longer term.

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