WHERE ARE THEY NOW – PAST GSA AWARD WINNERS

THREE GLOBAL MEGATRENDS AND THE IMPLICATIONS FOR THE SEMICONDUCTOR ECOSYSTEM

OVERCOMING CHALLENGES OF CONNECTING THE LAST INCH

Semiconductors: Powering Innovation
UMC’s collaborative foundry approach is based on strengthening our partnerships with customers, providing competitive advanced technology, and committing sufficient capacity to secure mutual long-term growth opportunities. We offer advanced technology down to 28nm, multiple specialized technologies, and a broad IP portfolio including ARM, Faraday, and Synopsys offerings. These foundry solutions establish a comprehensive process platform to streamline our customers’ path to SoC silicon success, for now and the future.
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- 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

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Combine billions of Internet protocol (IP) enabled devices, radio frequency ID (RFID) tags, wireless sensor networks, machine-to-machine (M2M) communications, iPhone apps, white space TV spectrum and cloud computing, and the result is the practical realization of the Internet of Things (IoT).

Despite the hype, IoT technology has become in many cases commercially viable, making life easier, safer and greener for millions of people. We’ll see the first waves of IoT implementation in diverse pockets of innovation—in our homes, offices, factories, warehouses and hospitals and in metro infrastructure, transportation and agriculture.

According to IoT pundits, the number of connected devices will surpass 15 billion nodes by 2015 and reach over 50 billion by 2020. The challenge for the embedded industry is to unlock the value of this growing interconnected web of devices.

According to Metcalfe’s Law, the value of a network is equal to the square of the number of devices connected to it (see Figure 1). At the edge of the IoT are the appliances and equipment that we use every day. These “things” are interconnected across an infrastructure or backbone using combinations of ZigBee, sub-GHz, Wi-Fi or power line communications (PLC) connectivity to provide a robust bi-directional communications link with relatively long range, low latency for fast responsiveness, low power and a sufficient data rate to aggregate information from many connected devices. This infrastructure also serves as the gateway to the Internet and enables remote monitoring and control of devices by other networks, utility companies and end users.

The majority of connected devices in the IoT, however, are nodes located at the “last inch” of the network. These nodes contain microcontrollers (MCUs), wireless devices, sensors and actuators that provide the brains, eyes and fingers of the IoT. The goal isn’t so much to enable users to connect to all of these devices. Frankly, users don’t want to have to monitor 50+ sensors placed throughout their homes to see if they’ve left the air conditioner on with a window open. It’s the information these devices gather that’s important, as well as the ability of machines to communicate among themselves and make decisions so that we don’t have to (see Figure 2).

**Figure 1. The Value of a Network is Equal to the Square of the Number of Devices Connected to It**

**Figure 2. Home Area Networks Often Contain Numerous Connected Devices**

**Envisioning the IoT**

Smart meters represent a prime example of a high-profile IoT application. Rather than simply measuring power consumption, smart meters enable utility companies to communicate in near real time with consumers, or through opt-in programs and to proactively shut down the operation of heavy load appliances, such as air conditioners, during peak-demand times. The result is a lower electricity bill for consumers and a shift of loading so that utility companies don’t have to invest in new power generation sources for the few days a year when supply is challenged by demand.

Smart meters are just one aspect of the emerging smart home. In addition to sharing computing files and multimedia content, connected home networks enable a wide range of security, monitoring and automation applications comprising intelligent lighting, smart appliances and other devices. The availability of even a few sensors — temperature, motion, humidity, light, glass breakage — enables a powerful mesh network that extends the capabilities of all devices connected to it. In fact, the IoT can provide significant benefit to industrial automation, lighting control, home/building automation, security and monitoring, health and fitness, and agricultural applications, to name a few (see Figure 3). The IoT also provides new ways to interact with devices. The term “app-cessory,” for example, has already been coined to refer to applications on a user’s smartphone that can communicate and control sensors and lights in the home and business.

**Overcoming Challenges of Connecting the Last Inch**

**Thomas Barber, Director of Marketing, Silicon Labs**
Higher Efficiency
When connected to the IoT, devices can determine the best time to operate; i.e., a clothes dryer can wait until after peak demand hours to operate using lower-cost electricity.

Proactive Usage
Today, users can set the air conditioner to run for when they plan to get home from work. If they are late, the system will operate with no one home. Smart home systems, such as Iris from Lowes and smart energy systems from AlertMe, enable remote control of climate control systems so end users can alert their homes to make shifts in usage for higher operating efficiency. These systems can also communicate with homeowners when required through text messaging.

Proactive Maintenance
Intelligent devices can monitor their own operating health and notify users or OEMs of potential issues before they result in downtime. For example, a dishwasher may exhibit a recognized wear pattern that leads to failure within, say, three months, enabling an OEM to automatically update the system with new features and algorithms that increase efficiency and drop operating costs. This can also reduce the number of warranty service calls for OEMs.

Single Control Interface
Since users can use their own devices, such as smartphones, to manage the network, it becomes possible for a single application to control devices, rather than requiring users to learn a different user interface (UI) for every new appliance or node added to the network. Note also that, for many applications, implementing a display is not cost-effective. On a washer, for example, a robust and more expensive display would be required to provide sufficient durability to handle the shaking of the machine. Another issue is that displays are typically out-of-date by the time the appliance reaches the store. For these and other reasons including reduced system cost and complexity, OEMs are exploring ways to enable end users to manage their own displays. The Nest Learning Thermostat, for example, enables homeowners to remotely program climate controls from any Internet-connected device, such as a smartphone.

Ease-of-Use
When devices can be managed over a network, users have the ability to control the network from anywhere they want, using the applications they want. Troubleshooting is greatly simplified as well. For example, instead of a dishwasher lighting up several LEDs to signal an error code, the device can clearly describe any operational failures or issues.

The power of Metcalfe’s Law means opportunities for companies in every industry. While a security company could expand its reach to homes, it could also instead partner with established lighting and home automation vendors to create value-added services. This is the power of an ecosystem. The IoT enables electronic component suppliers, software vendors, OEMs and service providers to focus on their core competencies and leverage the strengths of partnerships to create compelling applications for consumers.

Interoperability through Standard Protocols
For the IoT to work, all devices must be able to connect seamlessly. However, there is no one wireless or wireline technology that can efficiently serve across an entire network. To develop cost-effective products, engineers need to be able to select the optimal communications channel and protocol for their application. As a result, the IoT will be based on a variety of standard and proprietary protocols.

For devices to be able to reach out across the Internet, they will need to support IP somewhere along the communications channel. At the edge, however, IP can be a rather full-featured protocol with a great deal of overhead and cost for simple applications. Similarly, while Wi-Fi is ubiquitous, it consumes too much power for devices restrained to battery or energy harvesting power sources.

Connected devices need to be able to use protocols, such as ZigBee and IPv6 over low power wireless personal area networks (6LoWPAN), that are lightweight and have a data rate that reflects their requirements. Devices that connect to the IoT through a centralized controller can even employ proprietary standards given that their data is aggregated and converted to a standard format before being passed out onto the Internet via a gateway device.

The ideal combination of radio technologies and protocols depends upon the specific application. Today, Wi-Fi is the appropriate technology when high data rates are required, such as when transporting video. For low-bandwidth applications that do not require direct user interaction, 2.4 GHz ZigBee and sub-GHz technologies present a lower power wireless link that is much more easily integrated into embedded systems. For simple applications, such as garage door openers or systems requiring long-distance connectivity like irrigation systems, using a sub-GHz radio is likely the optimal approach. If two-way communication, security or a large number of devices need to be connected in a mesh network, ZigBee offers a robust implementation.

Employing a mesh topology is ideal for many IoT applications. Consider a home lighting system where the number of nodes can quickly exceed 30 lights and sensors. Whereas a Wi-Fi router may not be able to provide whole-house coverage, a mesh topology enables robust coverage for every location within the house with the lowest per-node cost. In addition, meshes can automatically configure new devices so that they leverage usage patterns that the system has already learned. Scalability is an important factor as well.

Achieving Ultra-Low Power Efficiency
For many last-inch applications, such as motion and light sensors placed throughout a house, the cost of installing new wiring to power these devices is prohibitive compared to the cost of the device and the function it is to perform. As a consequence, these devices must offer superior power efficiency so they can operate using a battery or harvest energy from their environment. In addition, these devices must be easy to install, even in difficult-to-reach spaces, and they must be able to operate for years without requiring battery replacement or other servicing.

Faster Time-to-Market for IoT Applications
To help customers bring their IoT devices to market faster, semiconductor suppliers must offer a diverse range of advanced design tools, such as application libraries for accelerating the implementation of key functions, production-ready sample applications, firmware development tools, complete communication and radio stacks with built-in security, and simple demonstration applications that show, for example, how to connect a smartphone to a last-inch device over the Internet.

Today, development tools are available that provide a macroscopic
Accelerating Innovation

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What Will You Design Next?
**Path Finding: Who Performs and When?**

**Bill Martin, President/VP Engineering, E-System Design**

Path finding is similar to a person compressing a balloon filled with air. You compress up to a point and when released, the balloon returns to its original form. Compress too much and the balloon bursts. Similar to a balloon, products have mechanical, thermal and electrical properties that degrade until permanent damage. The trick is to determine where these breaking points are, and if or how they can be enlarged: this is path finding’s value.

**The End Goal: Successful Products**

A product is purchased if its functionality and/or performance aid the consumer and it justifies the upfront and recurring operational costs. Before this purchasing decision can be made, product developers must define a product that meets or improves an unmet need. During this process, product designers design and then search for suppliers capable of manufacturing target unit volumes that are within costs targets. If each eco-system participant performs their roles (market analysis, pricing, functionality, performance, costs, etc), a product could soar in popularity. If they collectively miss on any aspect, a product would have a short lifespan. Successes are easy to identify, i.e. Apple’s iPhones. Failures are difficult to list, since they normally do not last long in the market. In 1993, Apple released their first personal digital assistant (PDA), the Newton. The first month’s sales vaulted the Newton as one of the top selling products within Apple. But this quickly faded as consumers found issues in the functionality promised, versus what was delivered. In time, Newton’s handwriting recognition was mocked in a “Doonesbury” comic, as well as on “The Simpsons” TV show. Years later, Apple applied the lessons learned from Newton and released a line of “i” products, all wildly successful with avid and repeat customers for each new “i” product generation.

**How to Begin**

Path finding methods, not necessarily tools, have existed for a long time. Time consuming and costly experimentation allowed engineers to analyze large amounts of data to determine optimum solutions (manufacturing, design, etc). Product designers have used path finding methods for decades. Spice, bread boarding and silicon bread boarding were methods to prove, disprove or improve an idea. Manufacturing companies ran design of experiments (DoE) where a matrix of material was manufactured and tested to determine whether correlations existed between process variables, throughput and yields. It helped manufacturers find the “sweet” spot where they could minimize waste (expenses) and maximize their return on investment (ROI). All of these path finding methods were costly in time, resources and dollars. Over time, with increased computing power, and as models became more accurate, path finding tools were developed; reducing the cost, resources and time required in finding solutions. Experimentation became virtualized. As high technology enters the 2.5/3D packaging world, additional path finding tools are needed for mechanical, thermal and electrical (MTE) analysis that navigate tight costs constraints required by mass-produced products.

**The Basics: Economics and Yields**

To see how economics are defined by yields, a simple example is discussed. At each process step, yield is the critical factor in the end product’s cost.

\[
\text{Yield} = \frac{\text{Devices out of Process}}{\text{Initial Devices into Process}}
\]

Scrapped units can be attributed to mechanical, thermal or electrical failures.

Anyone that has ever worked in a manufacturing environment understands the impact of yield on manufacturing costs. The manufactured cost is a function of the labor exerted and the raw materials used to create a manufactured unit. This can be calculated at each process step:

\[
\text{Yielded} = (\text{Unit's Incoming Cost} + \text{New Material} + \text{Labor Cost}) \times \text{Yield at Process Step}
\]

Let’s say an incoming product cost is $1.00 and a new operation adds $0.25 per unit. A yielded cost chart can quickly show how costs are dramatically affected by yield:

<table>
<thead>
<tr>
<th>Yield</th>
<th>100%</th>
<th>90%</th>
<th>80%</th>
<th>50%</th>
<th>10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yielded</td>
<td>1.25</td>
<td>1.39</td>
<td>1.56</td>
<td>2.5</td>
<td>12.50</td>
</tr>
</tbody>
</table>

Ideally each process step would result in 100 percent yield and the cumulative yield of the entire line would be 100 percent. In reality, this is rarely achieved. In silicon manufacturing, a “cook book” for
Yields: Caveat Emptor
High yields are not always the best metric. A high yielding process step early in the manufacturing process can lead to dramatic yield loss at the end of the manufacturing line. The key arbitrator is the end customer. End customers determine whether a product is good or not. The end customer cares about functionality, performance, battery life, etc. when the finished product is used.

The fact that an intact wafer makes it through this manufacturing gauntlet does not ensure it will perform as expected. Any loss at this point can be attributed to handling/mechanical issues. Electrical tests must be performed to ensure functionality and performance goals are met across a specified temperature range. The good news is that foundries and OSATs are very good at these repetitive operations and yields are high. Otherwise, the economics would probably prevent many consumer products from being developed. In the process defined above, we have not created a through silicon structure to enable 2.5D/3D package structures. Additional processing steps such as grinding the backside of the wafer, capping, depositing/etching a redistribution layer (RDL), adding passivation (glass) to protect the die and then adding bumping, and wafer dicing along with bonding, along with more testing are all required. Are these difficult steps? Maybe at first, but in time these steps are also mastered to optimize yield.

Manufacturers (silicon, interposers, packages, etc) are faced with all three failure mechanisms. The products they produce must be mechanically sound to survive all the handling and process steps required to manufacture their product. Too rigid or too flexible can cause yield issues during processing; so the wafer or package's thickness must be analyzed, in addition to its via density and radius. Too dense and the resulting product becomes too fragile, too loose and the product size might become too large, costly and fragile. Once mechanical path finding has been finalized, a range of viable options will exist: each with various tradeoffs in MTE performances versus yield. These mechanical ranges start to hone the path finding required for thermal and electrical path finding. Why path find on variables that are not in the safe mechanical solution set? Remember: if we cannot manufacture the device, yield is zero percent. So thermal and electrical path finding will have restrictions based upon mechanical path finding. Rather than an infinite number of parameters and values, fewer variations can be considered. Manufacturers should also perform thermal and electrical path finding on their material to find solutions that increase the thermal and electrical capabilities. As manufacturers improve their yields, they will continually modify the design rules provided to their customers. Without continual rule updates, products will produce inconsistent yields driving up costs to all.

Product developers and integrators must evaluate components that they will integrate from manufacturers. Some of their path finding is restricted to available process nodes, packages/lead frames, design rules, etc that will be used to manufacture their products. Mechanical is a lesser concern for product developers since many turn over manufacturing to their suppliers who must focus on maximizing yields. What the manufacturers do not understand is a design’s specific functionality and performance. To manufacturers, this is a “black box”. Product developers need to focus on the size, functionality and performance of their product. Depending on the architecture, operating frequency and process chosen, both electrical and thermal performance will be impacted by various decisions. As shown in the GSA Forum's March issue, electrical performance can be improved by shorter, larger vias that are spaced farther apart for printed circuit boards (PCB), as well as for silicon or glass interposers.

 Winning the Battle but Losing the War?
Virtual prototyping (path finding focused on algorithms and architectures) can have a dramatic impact on performance and power. But without performing path finding on possible interconnects used to implement the architecture, a developer can overlook details preventing optimum performance. Why spend all the time honing the architecture and then use sub optimal interconnects? Figure 2A shows a simple comparison between wire bonding, through glass (TGV) and through silicon vias (TSV) up to 10GHz. A signal’s insertion loss (IL) is critical to performance and functionality. By running a quick path finding experiment, users can demonstrate the significant difference between the various methods. TGV and TSV show very stable operation over frequency, while the third (wire bond) has wider variation based upon wire's length and operating frequency. Figure 2B is zoomed in showing less than 6GHz performance. Depending on the design’s performance goal, any of these interconnects might be sufficient, but designing with wire bonds requires more rigorous analysis. Many might consider a redistribution layer as a solution, but depending on the RDL’s layout and operating frequency, it might pose performance issues. As an example, an RDL line that is 2mm (78.74 mils) long and 5u wide approaches -4dB insertion loss at 10 GHz. Performance is a little better than a 100 mil long bond wire and much worse than either TSV or TGV solution.
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NovaThor™ ARM Cortex™ A9 in 28 nm FD-SOI, built on Soitec FD-2D substrates demonstrated 3 GHz peak performance and 1 GHz at 0.6 V for low-power applications.
Q: The Innovation Center by SKTA Innopartners offers a way to seed new start-up companies and accelerates their development. Describe the services the Innovation Center offers.

A: At a high level, we handle everything not related to product development. Our goal is to ensure entrepreneurs dedicate 100 percent of their time and effort doing what they do best - product development. We do the rest. For example, we arrange independent legal counsel to provide legal services including incorporating the start-up, patent filing, contract drafting and negotiation, and implementation of employee incentive plans, among others. Our finance group will help with financial accounting including payroll and taxes. We have a highly experienced program manager to help establish milestones and procure resources necessary to create and maintain the momentum of product developments. Our HR department will assist with establishing the processes and procedures related to employment and regulatory adherence. They will also assist by providing recruitment and payroll services as needed. In addition, we have a talented and energetic IT department to provide everything from video conferencing to disaster recovery assistance. While this isn’t an exhaustive list of the services we provide, it should be enough to show that we thought hard about what would be required to allow entrepreneurs the freedom to be laser focused on product development.

Q: Are you working towards special agreements with ecosystem partners/suppliers that help enable you to provide these services, such as licensing agreements with electronic design automation (EDA) and intellectual property (IP) suppliers and foundries for shuttle services?

A: We are well on our way to having formal arrangements for EDA tools, foundation IP and shuttle services at the foundries.

EDA tools are a primary hurdle for many start-ups and we are committed to providing them to our incubated companies. Aside from the established tool companies, there are some relatively new tool suppliers that have expressed interest in making their tools available.

The foundation IP issue is, as with all IP matters, complicated. As such, it will be dealt with on a case by case basis. The strategic sponsors we have engaged are willing to provide the IP they own to the start-ups. IPextreme offers some interesting opportunities for IP licensing. Similarly, our engagement with the Open Compute Project will provide an avenue for IP access.

We are also actively working to expand our relationships with foundries both domestically and abroad to provide shuttle services. Our engagements so far have been received favorably. The foundries are as incentivized to produce new tape-outs as we are. In that respect, we are well aligned. For now it’s simply a matter of finding the right structure that works both for them and the start-ups.

Q: As you know, Samsung recently announced a $100 million Catalyst Fund as part of their Innovation and Strategy Center. What distinguishes what SK Telecom is doing from what Samsung is doing and do you see the two centers as competitors?

A: I do not know all of the details for the Samsung Strategy and Innovation Center. However, even if Samsung took our white paper and copied it word-for-word, we would not be in a competitive position. Both companies can bring different resources and perspectives to the semiconductor community. Given the pent up demand for semiconductor innovation, and the limited amount of funds that both Samsung and Innopartners have to deploy, we would welcome Samsung’s participation. Our goal is to reinvigorate semiconductor innovation in Silicon Valley. We can’t do that alone. The more “Innovation Centers” that take hold, the better. Actually, that would epitomize success.

Q: What is the motivation for SK Telecom to implement the Innovation Center?

A: The motivation came from SK Telecom’s acquisition of Hynix. After the deal was completed, it became apparent that innovation in the semiconductor arena was structurally impaired and not enough funding was going to the heart of innovation – to start-ups. The problem is larger than one company alone can rectify. The Innovation Center is, therefore, aimed at reinvigorating investment in semiconductor innovation by fundamentally changing the way startups are funded, incubated and acquired. It’s a concept that we hope will take root and we’ll see more Innovation Centers and renewed interest in funding semiconductor start-ups.

Q: Since SK Telecom is the largest mobile carrier in Korea and they acquired Hynix, does this mean the

— Jodi Shelton, President, GSA
Fabless company IC sales have increased more than three times the rate of the total IC market during the period from 1999 to 2012, according to IC Insights. In my interview with Jack Harding, President and CEO, eSilicon, we discussed this growth, how it compares to the rest of the industry, and how fabless companies can continue to grow and outpace the rest of the industry. We also discussed eSilicon’s successful operation as a VCP; the eSilicon Access® production management system; its 2.5D packaging technology; and much more.

— Jodi Shelton, President, GSA

**JACK HARDING**
President and CEO, eSilicon

Q: eSilicon operates as a Value Chain Producer (VCP), a company that collaborates with foundries, intellectual property (IP) and service providers, electronic design automation (EDA) suppliers, and package, assembly and test operations companies in designing and producing chips for fabless IC, integrated device manufacturer (IDM) and original equipment manufacturer (OEM) companies. eSilicon also offers customizable IP and I/Os. Describe the services that eSilicon offers.

A: eSilicon delivers packaged tested chips to our customers. There’s often a misconception that we’re a “design shop”, but we’re not. We earn our money by shipping silicon, and we’ve done so for the past dozen years. As you pointed out, we also have an IP business, which has two interesting dimensions to it. One, is that we sell the IP separately as a standalone business, because we want our customers to have the option of accessing our capability in that form, but also, and even more importantly, we deploy our IP inside of the application-specific ICs (ASICS) and systems-on-chip (SOCs) we developed as part of that solution. So, we have two directions to go with IP, selling it standalone, or delivering it as part of the total ASICS solution. In any case, we’re a full service company that provides everything from the physical design all the way through to end of life package, development, design for test (DFT), test development and quality, and we’re very proud of the model. It’s getting great traction, and I think it reflects the growing needs in the industry around both complexity and the realities of the business model.

Q: According to your Web site, eSilicon develops an average of 20 new chips per year across a variety of markets and boasts first time right silicon across over 250 tapeouts at 28nm to 250nm. How are you able to effectively serve such a wide customer base?

A: Well, for starters, we work very hard. I think that’s probably clear, but, there are really two dimensions to our ability to service a broad market. The first is that we have a very deep domain expertise. I’m proud of the fact that we’ve assembled fantastic teams in both design and manufacturing, as well as in administration and logistics that allow us to process a wide variety of technologies across many process nodes and into many end markets.

But part two of that is equally important. Having capable people is not enough. The other part is that we’ve developed what I think of as an electronic hub, where we automate virtually everything inside of our company. From the time a customer calls us to investigate our capabilities and we discuss their needs, we’re loading their questions into online systems that generate die size estimates, cost models, even fundamental technology architectures. When a chip goes into production, we manage it for its entire lifetime on our unique eSilicon Access® business-to-business production management system, which is a remarkable system that we developed here over the last decade. It fits comfortably on top of an Oracle database system and an enterprise resource planning (ERP) system, and what it entails is downloading all the information from all of our suppliers 24/7. It goes through a module that cleans the errors out of the data downloads, which is a unique capability that we have patented. In other words, it purges the typical and common errata out of the downloads from as many as 50 different suppliers. We then post that information to an Oracle database, and then we publish it to the Internet, whereby we and our customers are allowed to log on and watch every aspect of the development of their chip. In other words, while we’re processing literally hundreds of chips — different types of chips — through our business, we are doing it with machines and many fewer people than one might expect.

I’ve been in a lot of other semiconductor companies where people are running around with their hair on fire with spreadsheets, hoping that they’ve got the data right, and we simply don’t do that. Our machines are working around the clock, while we’re interfacing to our customers and deploying that value-add expertise, and anything that’s mundane or trivial is being replicated through software in the systems that we’ve developed and deployed.

Q: eSilicon recently announced the mobile version of the eSilicon Access® production management system, which allows customers to track semiconductor supply chain activity from their phones. Can you describe this tool a little bit farther, how it came to be and what it offers to customers?

A: Sure. Well, as I mentioned, the eSilicon Access production management system is a remarkable system that we developed here over the last decade. It fits comfortably on top of an Oracle database system and an enterprise resource planning (ERP) system, and what it entails is downloading all the information from all of our suppliers 24/7. It goes through a module that cleans the errors out of the data downloads, which is a unique capability that we have patented. In other words, it purges the typical and common errata out of the downloads from as many as 50 different suppliers. We then post that information to an Oracle database, and then we publish it to the Internet, whereby we and our customers are allowed to log on and watch every aspect of the development of their chip, and I mean every aspect, right down to our suppliers’ shop floors in many cases.

So that’s been running successfully for 10 to 12 years, but
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Great things don’t happen by accident. They happen when great companies collaborate. GLOBALFOUNDRIES brings innovative ideas to some of the finest companies in the world. Then works with them to build the next greatest thing.
Jeremy Rifkin, a well-known American Economist and bestselling author, has observed that great economic revolutions happen when two disruptive phenomena occur together. The two phenomena that are driving the third industrial revolution are Internet communication and renewable energy\(^1\). The Internet grows in value as more users join this global network. Similarly, renewable energies: solar, water, bio and wind are also likely to scale up with the number of consumers and, unlike fossil fuels, don't get exhausted if more people enter the system. The scalability of these two phenomena is expected to create a powerful, sustained and synergistic driving force for the economic revolution in the current century. While the Internet is expanding ever rapidly into every corner of the world, the transition from traditional fossil-based energy to renewable energy is falling behind miserably. Given that fossil fuel production may not expand in the future, the demand for energy to feed economic growth is likely to outpace the supply of affordable energy, arresting the potential for achieving sustainable global economic growth.

Sooner or later, the transition from fossil-based energy sources to renewables will happen, shaped by economic, technological and various geo-political factors. But during this slow transition, we will experience a few powerful megatrends that will not only transform the semiconductor ecosystem, but also our everyday lives. Indeed, some of these megatrends are not new and have been developing in isolation for some time; but when combined together, these megatrends will propel the semiconductor industry in new directions beyond those seen in the past five decades. These megatrends will also create new winners and losers in the semiconductor industry. We identify three such megatrends simply as: (1) Green Everything, (2) Wireless Everywhere and (3) Smart Everything. These megatrends will require semiconductor technologies along the “More-than-Moore” axis to play a more central role, complementing the conventional digital technologies governed by Moore’s Law.

**Megatrend 1: Green Everything**

In the past two decades, emerging economies such as China, India, Brazil and others in South East Asia and more recently, countries in sub-Saharan Africa have seen remarkable rates of economic growth. As these countries have continued to modernize and industrialize, their demand for energy has increased exponentially. In parallel, the developed economies are consuming energy at their peak levels to keep their economies from shrinking. As a result, the voracious global demand for energy is expected to eclipse the traditional global fossilized energy supply. To prepare for this energy crunch, nations are turning to scientists and technologists to solve this problem in two ways: (1) by accelerating the transition to renewable energy sources, and (2) by decelerating rate of consumption of existing fossilized energy sources. This transition will be slow, inefficient and complex. Therefore, nations and public-private partnerships are rallying behind solving the second problem by improving efficiencies of energy consuming sectors - or, in other words, “Greening” of sectors and everything around us.

According to the Energy Information Administration (EIA), more than half of the world’s energy is consumed by the industrial sector\(^2\). Therefore, greening of this sector is likely to give us the biggest bang for the buck. Power electronics can help improve energy efficiency throughout the complete power generation, transmission and delivery value chain: from primary energy transport to electrical conversion efficiency to transmission and finally to production and equipment operation. For example, increased adoption of insulated gate bipolar transistor (IGBT) switches in variable frequency drives (VFDs) would allow for a more energy efficient operation of motor drives that are used widely in applications ranging from industrial conveyor belts / extruders / and various compressors to household HVAC systems. In general, a much broader adoption of highly efficient power metal-oxide semiconductor field effect transistors
(MOSFETs), IGBTs and bipolar junction transistors (BJTs) will help improve production and equipment efficiencies, at the point of energy usage where the inefficiency is the highest.

Unlike the industrial sector, the consumer electronics sector is experiencing rapid greening due to more frequent technology refresh cycles. Through various circuit and device optimization techniques, engineers continue to reduce power dissipation per function for servers, PCs, portables and other similar gadgets. However, power savings come not only from reducing the current consumption when the gadget is “ON”, but also when the gadget is in the “sleep” mode. For example, the total power consumption of Zigbee sensor devices is dominated by the sleep current because the devices are in sleep mode most of the time. Engineers are innovating to aggressively reduce biasing and quiescent currents for circuit blocks that need to stay on during the “sleep” mode. In general, power management ICs, such as linear regulators, buck/boost DC-to-DC converters, various gate drivers and low-resistance switches are getting integrated to both improve efficiency and reduce ON/OFF-state power. The need for power reduction is nowhere greater than in battery operated electronics, and is essential for enabling the next megatrend.

**Megatrend 2: Wireless Everywhere**

For the past three decades, personal computers (PCs) have been the dominant machines for individuals and corporations to interact with the Internet. But that changed in 2011, when more smartphones were sold worldwide than total client PCs, making smartphones the primary Internet access pathway. Advent of high-speed WiFi 802.11a/b/g/n/ac and 3G and 4G cellular technologies have made wireless Internet a reality. Expanding this concept even further, the Internet of Things (IoT) is becoming a definite, albeit still distant, possibility where every object has virtual representation in an Internet-like architecture and can be tracked or catalogued wirelessly into a single large interconnected knowledge-base in the “Cloud.” In IoT, every device will be connected to the Internet and, in many cases to each other, wirelessly. The intelligence would reside in the “Cloud” and each device would merely become a wireless “gateway” device accessing that Cloud. Storage and computing servers powering the Clouds would need to become bigger, and even more powerful, and the wireline and wireless networks that provide connectivity to clouds would become even faster with minimum latency. We will be connected to the Internet wirelessly from everywhere at all times.

The “Holy Grail” of wireless communication may be a unified standard; but it is more advantageous and cost effective to keep these standards optimized for specific and local use, and to integrate them in various gateway devices to provide seamless connectivity to the Internet. For example, the latest Samsung Galaxy IV supports GSM/ GPRS/EDGE, HSPA, LTE, 802.11 a/b/g/n/ac, GPS, NFC, BT4.0 and infra-red. To enable seamless connectivity even further, recently, AT&T and General Motors announced partnership to bring 4G communications technologies in cars - making a car essentially a smartphone on wheels.

Since mobility is fundamental to using wireless everywhere, the gadgets need to deliver high performance without requiring large, heavy battery packs. That means faster high definition (HD) quality data rates, higher signal fidelity in noisy environments and more functionality in ever shrinking form factor need to be offered without increasing the power budget. Indeed, wireless charging technology may one day become good enough to enable charging of devices anywhere on-demand, should the battery run out. But the bottom line is this: the dollar content for radio frequency (RF), analog and power management ICs in portable electronics will increase substantially year after year. Ecosystem players offering differentiated enabling technologies – analog, RF and power management - complementing the core, digital CMOS, will find themselves better situated to win from the wireless megatrend.

**Megatrend 3: Smart Everything**

As we become ever more dependent on electronics not only for entertainment, comfort or convenience, but also for critical functions (or data), where a system failure/inefficiency can cause catastrophic damage to life, environment and/or other critical assets, the need for imparting smartness to electronics becomes an absolute necessity. Smart systems sense multiple stimuli, make decisions based on predetermined (or ad-hoc) criteria, and then respond to stimuli in the most efficient and effective way, doing it in a fail-safe way without squandering valuable resources or energy. We will soon find all the things around us incorporating a varying degree of smartness – from wall outlets to smartphones to smart cars to smart robots! This is the third megatrend – “Smart Everything”.

Smart electronics is not new; but the integration of smartness into systems is definitely accelerating as we are entering the third industrial revolution. Take an example of a family car. In the 1970s, car electronics used to be less than five percent of the total vehicle cost. Today, electronics can make up to 50 percent of the total vehicle cost, depending on the model and options. Electronics is used in powertrain transmission systems, in passenger/vehicle safety systems, for navigation and in-dash infotainment and in passenger comfort/climate systems. Stringent vehicle emission and mileage standards are driving car manufacturers to innovate newer energy efficient propulsion systems (e.g., gasoline, diesel, methanol, fuel-cell, hybrid, electric or even solar) that incorporate even more electronics, to help conserve every gallon (or kW) of fuel and eliminate every ton of greenhouse gas. In the future, self-driven cars will use an army of image, vibration and mm-wave sensors to feed real-time information to central computer(s) to make instantaneous decisions about speed, safety and fuel efficiency with minimal traffic congestion or accidents.

Our homes are getting smarter too, with smart climate control, smarter electronics (smart TVs, refrigerators, etc.), smart lighting (with auto motion sensors, mood lighting) and smart metering and monitoring to optimize energy/water efficiency and security. Our utility systems are now called “Smart Grids” as they optimize power delivery to balance out the peak loads to prevent system overload or blackouts. These smart grids will also have capabilities to self-repair in the case of a natural disaster or a terrorist attack. In fact, due to the strategic value of these “smart” technologies, several public-private partnerships are actively participating and sponsoring leading-edge research and development of smart embedded systems that can be developed for use in critical applications (e.g. European Technology Platform on Smart Systems Integration – or EPoSS).

Imparting system smartness requires integrating a multitude of technologies – digital, analog/mixed-signal, RF, power management, microelectromechanical systems (MEMS) and image sensors (CMOS, CCD, thermal). Integrating these diverse technologies requires a deeper understanding of heterogeneous elements of a complete system, and optimization at both point-of-use and at point-of-delivery. And the heterogeneous nature of elements means increasing alliances and partnerships across the entire value chain to develop and deploy right technologies for enabling smart-products.
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- Packaging/test

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Aquantia is the industry leader in 10 Gigabit Ethernet connectivity over copper (10GBASE-T). 10GBASE-T in data centers, is projected to grow from one million ports in 2012 to 30 million in 2015, making it the most ubiquitous and fastest growing connectivity solution in data centers. Beyond data centers, Aquantia is targeting the one billion ports of Gigabit Ethernet shipping every year, from enterprise and consumer to the cellular infrastructure, and its upcoming need for connectivity upgrade. Based on a highly disruptive mixed-mode signal processing architecture, with 50+ issued patents, Aquantia’s 10GBASE-T solution has consistently delivered the best performance and lowest power in the industry. Aquantia’s engineering team is a combination of the best talent in the industry in analog, digital signal processing (DSP), communication theory and system-on-chip (SOC) integration. Aquantia’s best-in-class engineers are complemented by an experienced executive team that has turned technology innovation into business success. As reported by industry analysts and evidenced by the company’s broad product adoption, Aquantia has established itself as the market leader in 10GBASE-T semiconductors. Aquantia is located in Milpitas, CA, and has over 100 employees. The company has raised $140 million to date from tier-1 VCs and strategic investors.

"As the industry transitions to 10 Gigabit Ethernet, Aquantia has quickly established itself as the technology and business leader in 10GBASE-T semiconductors with more than one-million ports shipped. With the move to large-scale deployments of 10BASE-T, we feel it is important to participate in the GSA’s initiatives to further the support for the global semiconductor industry. We look forward to collaborating with the GSA community.”

– Faraj Aalaei – President and CEO

Faraj Aalaei – President and CEO
Ramin Farjad – Chief Architect
Linda Reddick - CFO
Kamal Dalmia – VP, Sales and Marketing
Phil Delansay – VP, Business Development
Darren Engelkemier – VP,
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Vango Technologies, Inc. (Vango), was founded in 2006 as a fabless mixed-signal chip company for smart grid applications. It is headquartered in Hangzhou, Zhejiang Province, China. Vango holds 13 Chinese and US key patents and has filed 18 more patents covering low-power high-resolution analog design, system-on-chip (SOC) technologies, energy metering algorithms and design for reliability. It currently offers a wide range of chips for smart meters including metering analog front ends (AFEs), metering SOCs and RS-485 chips. It has shipped more than 12 millions chips. In the tendering of China rural grid meters of March 2013, Vango grabbed 50 percent of the market share. Vango has won many awards and is recognized by both the government and its peers as the one of the most innovative chip companies in China.

“I have always been involved in FSA (now GSA). As a fabless start-up, once a company reaches its knee curve and sees shipments increase, challenges are bountiful. There is no better organization than GSA to provide a platform to address common challenges. The GSA also brings together CEOs of big corporations and of small start-ups to share their views of the semiconductor industry. We find participation very beneficial for a growing company.”

– Dr. Nick Tan - Chairman & CEO

Dr. Nick Tan - Chairman & CEO
Yue Zhang - Executive Board
Robbin He - VP of Marketing/Sales
Shupeng Zhong – Vango Fellow
& Deputy Chief Engineer

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ASE Group: The world's largest provider of independent semiconductor manufacturing services in assembly, test, materials and design manufacturing.
The annual GSA Awards Dinner Celebration, held in Santa Clara, California, is the industry’s premier event. GSA recognizes companies that have demonstrated excellence through their vision, strategy, execution and future opportunity. The celebration honors the achievements of semiconductor companies in several categories ranging from outstanding leadership to financial accomplishments, as well as overall respect within the industry.

Award Categories Include

▪ Dr. Morris Chang Exemplary Leadership Award
▪ Start-Up to Watch Award
▪ Most Respected Private Semiconductor Company Award
▪ Best Financially Managed Semiconductor Company Award
▪ Most Respected Public Semiconductor Company Award (Achieving >$1 Billion in Annual Sales)
▪ Most Respected Public Semiconductor Company Award (Achieving $251 Million to $1 Billion in Annual Sales)
▪ Most Respected Emerging Public Semiconductor Company Award (Achieving $100 Million to $250 Million in Annual Sales)
▪ Analyst Favorite Semiconductor Company Award
▪ Regional Awards

Dr. Morris Chang Exemplary Leadership Award
The Dr. Morris Chang Exemplary Leadership Award recognizes individuals, such as its namesake, Dr. Morris Chang, for their exceptional contributions to drive the development, innovation, growth and long-term opportunities for the semiconductor industry. Previous winners include Dr. Morris Chang, Dr. Irwin Mark Jacobs and Sir Robin Saxby. Nominations for this award have closed.

Start-Up to Watch Award
GSA’s Start Up to Watch Award was designed to recognize those companies that demonstrate the potential to positively change their market or the semiconductor industry, in general, through the innovative use of semiconductor technology or through a new application for semiconductor technology.

GSA’s Private Awards Committee, comprised of members of the Emerging Company CEO Council, venture capitalists and select serial entrepreneurs in the industry, selects up to two winners of the Start-Up to Watch Award by identifying the semiconductor company (or companies) that demonstrates the potential to positively change its market or the semiconductor industry, in general, through the innovative use of semiconductor technology or a new application for semiconductor technology. GSA has recognized 25 companies with this award since it was first given in 2001. Nominations are due June 28, 2013.

Criteria
▪ Company must be a semiconductor company (Fabless or IDM).
▪ Company must be privately held.
▪ Company must NOT have achieved greater than or equal to $20 million of cumulative product revenue (i.e., cumulative product revenue since market introduction).

Most Respected Private Semiconductor Company Award
The industry’s Most Respected Private Semiconductor Company Award is designed to identify the private company garnering the most respect from the industry in terms of its products, vision and future opportunity.

GSA’s Private Awards Committee reviews all private semiconductor companies, conducts analysis of each company’s performance and likelihood of long-term success, and provides
a list of respectable private companies to be voted on by GSA membership. On-line voting takes place to allow GSA members, including semiconductor companies and partners, to cast a ballot for the private semiconductor company that they most respect. Nominations are due June 28, 2013.

Criteria
- Company must be a semiconductor company (Fabless or IDM).
- Company must be privately held.
- Company must have achieved a minimum of $20 million of cumulative product revenue (i.e., cumulative product revenue since market introduction).

Best Financially Managed Semiconductor Company Award
The Best Financially Managed Semiconductor Company Award is derived based on a broad evaluation of the financial health and performance of public fabless and IDM semiconductor companies. Numerous financial metrics as well as their respective rates of change or year-over-year improvement are analyzed. These financial metrics transverse various categories including but not limited to growth rates, margins, cash flow, profitability ratios, efficiency ratios and return on capital. All companies are ranked on each metric as well as its rate of change, and then the overall performance is compared to the peer universe to determine the winner. All public company awards are determined by GSA using public financial data; therefore, nomination forms are unnecessary. Previous winners include NVIDIA, Xilinx, Qualcomm, MediaTek, Altera and Avago.

Most Respected Public Semiconductor Company Award (Achieving $100 Million to $250 Million in Annual Sales)
The industry’s Most Respected Public Semiconductor Company Award is designed to identify the public company garnering the most respect from the industry in terms of its products, vision and future opportunities. The criteria for this award include achieving annual sales between $251 million and $1 billion. In addition, profitability and market capitalization, among other financial and product successes, are considered to be listed on the ballot. On-line voting takes place to allow GSA membership, including semiconductor companies and partners, to cast a ballot for the public semiconductor company they most respect. Previous winners include Broadcom, Cavium, NVIDIA and Xilinx.

Most Respected Emerging Public Semiconductor Company Award (Achieving $100 Million to $250 Million in Annual Sales)
The industry’s Most Respected Emerging Public Semiconductor Company Award is designed to identify the company garnering the most respect from the industry in terms of its products, vision and future opportunities. The criteria for this award include achieving a minimum of $100 million and a maximum of $250 million in annual sales. In addition, profitability and market capitalization, among other financial and product successes, are considered to be listed on the ballot. On-line voting takes place to allow GSA membership, including semiconductor companies and partners, to cast a ballot for the public semiconductor company they most respect. Previous winners include Intel and Qualcomm.

Analyst Favorite Semiconductor Company Award
Semiconductor financial analysts from top-tier firms select their favorite semiconductor company for this award. The analysts base their decision on historical, as well as projected data, such as stock price, earnings per share, revenue forecasts and product performance.

Regional Awards
As a global alliance, GSA introduced an award specifically for the Europe/Middle East/Africa (EMEA) and Asia-Pacific (APAC) regions. The awards will recognize a semiconductor company headquartered in each respective region that clearly demonstrates the most strength when measuring products, vision, leadership and success in the marketplace. GSA’s APAC and EMEA Leadership Councils will determine the nominees and the winners of their respective regions. Awards include:
- Outstanding Asia-Pacific Semiconductor Company Award
- Outstanding EMEA Semiconductor Company Award - Nomination Deadline date: July 12, 2013.

The 19th annual Award's Dinner Celebration will be held on Thursday, December 12, 2013, at the Santa Clara Convention Center in Santa Clara, CA, and will feature Newark, New Jersey mayor Cory Booker as the keynote speaker. The dinner is made possible by title sponsor TSMC, as well as general sponsors Advantest, Amkor, Broadcom, Cadence Design Systems, CSR, GLOBALFOUNDRIES, KPMG, Magnachip, UMC and SuVolta.
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Today, mainstream semiconductor innovation that follows the traditional Moore’s Law path is reasonably predictable. All major foundries can show you process roadmaps several years into the future. A common thread is the daunting capital investment requirement, measured in the billions of dollars.

In contrast, microelectromechanical systems (MEMS) and specialty process innovation seems far less predictable. Success is less clear and investment is usually measured in the millions, not billions, of dollars, putting it square in the sights of venture capital investment. Applications are wide ranging, from highly specialized markets to consumer mass-market. To demonstrate the breadth of activity, listed below are just a few companies working on MEMS and specialty process innovation.

**908 Devices** has raised $8.1 million in Series A funding to develop ultra-compact mass spectrometry tools. A common theme in MEMS sensing innovation is shrinking conventional laboratory size instruments into portable, handheld devices by using MEMS devices. The lab-based mass spectrometer market is roughly $2.5 billion per year. 908 Devices believes that the market opportunity for portable mass spectrometer outside the lab could be about the same size.

**Aledia** has raised approximately $13 million to develop LEDs based on a 3D architecture using gallium-nitride (GaN)-on-silicon microwires. Conventional LEDs are typically fabricated on expensive two- to six-inch wafers made of sapphire, silicon carbide or gallium nitride. In contrast, Aledia’s 3D GaN-on-Silicon microwire technology uses economical silicon wafers with diameters of eight inches (200mm) or larger, enabling production of LED chips at 25 percent of the cost of traditional LEDs. The high-brightness, packaged LED lighting market is forecasted to reach $15 billion by 2016, a huge market opportunity.

**Alphabet Energy** was founded in 2009 to commercialize an inexpensive silicon-based thermoelectric technology for generating electricity from wasted heat. The company’s silicon thermoelectric waste-heat recovery technology can be 100 times cheaper than existing approaches, which are typically based on bismuth telluride. The company’s technology is well suited to existing semiconductor infrastructure and trailing edge foundries. The initial product targets exhaust flows from engines in industrial applications, which represents an $8.5 billion opportunity within the $90 billion potential market for the conversion of medium- and high-grade waste heat into electricity.

**Telecardia** has raised $3.5 million to develop MEMS-based pH measurement sensors. The company currently fabricates the devices at the University of Pittsburgh, and is in discussions with potential MEMS foundry partners. The commercial pH measurement industry represents a $1.7 billion market opportunity and medical applications for pH measurement/monitoring represent another $1 billion plus market opportunity, not exactly a small market opportunity.

The common threads amongst these companies are relatively modest capital investments, innovative MEMS and specialty process expertise, and target market opportunities that consistently exceed a billion dollars. This makes them ideally suited to venture capital investment and I expect that we will see many more such companies formed in the coming years.

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.
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GSA’s Start-Up to Watch Award

Over the last several years, the semiconductor industry has seen a decrease both in new venture capital investment and in the founding of new semiconductor companies. Long gone is the boom of new start-ups we saw in the early 2000s. And unfortunately, as we all well know, the amount VCs have invested in semiconductor start-ups has also steadily decreased. Companies are having a harder time getting off the ground, which is resulting in fewer start-up companies; both of which are signs of maturity and consolidation for our industry.

However, every year continues to represent promising new companies, technologies and applications, and GSA’s Start Up to Watch award was designed to recognize those companies. The Award recognizes companies that demonstrate the potential to positively change its market or the semiconductor industry, in general, through the innovative use of semiconductor technology or through a new application for semiconductor technology.

GSA has recognized 25 companies with this award since it was first given in 2001. Many of those companies are still thriving and in business today. One of the companies, Ambarella, is a publicly traded company; and several past winners are on the verge of becoming public and considering IPOs. Ten of the companies have had successful exits through mergers or acquisitions and several others continue to operate today. Five of the greatest success stories are featured below.

GSA 2002 Start-Up to Watch Award Winner

eSilicon

In operation since 2000, eSilicon, pioneered the value chain producer (VCP) business model and today operates as the largest independent semiconductor VCP. The company specializes in designing, productizing and manufacturing application-specific ICs (ASICs) for its customers, which include system original equipment manufacturers (OEMs) and fabless semiconductor companies (FSCs). GSA recognized eSilicon’s innovative business model by awarding it with the 2002 Start Up to Watch award.

eSilicon has raised over $54 million in funding since it’s founding and has served as a long-time member of the GSA Board of Directors.

In 2009, GSA recognized the VCP market segment by creating a VCP Board seat on its Board of Directors. In 2010, Jack Harding, eSilicon’s President and CEO, was elected as the first VCP Director to the GSA Board of Directors.

In describing the last 10 years, Harding said: “It was a tough decade. The industry had a lot of downturns and a lot of challenges, and I saw a lot of great companies fail that would not have in regular times. But we worked hard and we had some good fortune. We hit some milestones, including shipping our millionth chip. The moon and stars aligned for us a couple of times when we needed them to. I think we’ve turned the corner to be a sustainable and-long term member of the community, and we’re very appreciative.”

GSA 2005 Start-Up to Watch Award Winner

SiTime

SiTime is revolutionizing the $6 billion timing industry with silicon microelectromechanical (MEMS)-based oscillators and clock generators. The company’s timing solutions are rapidly replacing legacy quartz crystal products by offering higher performance and reliability at a lower cost.

SiTime products are used in all major market segments by more than 800 customers in over 100 applications. The company has raised nearly $30 million in funding and its highest volume designs are in the networking, consumer, computing and storage segments. In 2011, SiTime also began offering products for telecom, wireless and industrial applications.

“GSA recognized SiTime’s potential to revolutionize the timing market with our groundbreaking silicon MEMS and analog technology. SiTime has come a long way since winning the Start-up to Watch Award in 2005. We have shipped over 150 million units with zero MEMS failures. Customers are now receiving benefits that cannot be achieved by quartz solutions – 20 times better reliability, unprecedented flexibility and two to four week lead times; SiTime is now the fastest growing semiconductor company and has 80 percent market share of the MEMS timing market,” said Piyush Sevalia, executive VP of SiTime. “With our focus, passion and dedication to customers, we are successfully bringing a $4 billion Frequency Control market to the semiconductor industry.”

Where are they Now – Past GSA Award Winners

GSA STaff

See Awards Dinner page 25
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.

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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 improves its process technologies to get your designs produced right the first time.

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Implications for Semiconductor Ecosystem Players

Fabless/IDMs

Digital CMOS has dominated the global electronics engine for over five decades. Governed by Moore’s Law, advancement in silicon technology has offered exceptional cost and scale to drive economics of digital ICs in a predictable fashion over many generations. However, it is becoming increasingly difficult to extend Moore’s Law due to both fundamental physics and economics. Thus, extracting same chip-level cost savings by moving to the next CMOS node is not trivial. Designers are looking for other “knobs” to improve overall system performance and lower system cost. One of those knobs is incorporating more of “More-than-Moore” technologies. Since the world operates in analog, significant performance improvements can be had by improving all interface functions, by integrating analog, RF, power/BCD and various sensor (optical, thermal, mechanical, magnetic) technologies. These specialty technologies will deliver greater value and differentiation to the end-user by complementing, not replacing, core digital technologies that will become primarily focused on computing and storage.

As a result, analog intensive market segments are expected to grow faster than the core digital market segments. Companies in those analog intensive market segments will therefore, experience rapid increase of total available market (TAM). In the GSA’s top 30 list of companies, we already see several digital segment leaders diversifying into higher growth analog intensive market segments. This trend is expected to accelerate in the future as the three megatrends continue to strengthen and converge. Indeed, companies solely focused on specialty technologies / products will also need to integrate larger digital content to meet newer standards that allow heterogeneous system integration (e.g., media industry processor interface, or MIPI). Such diversification will create new opportunities for organic growth as well as inorganic growth through increased mergers and acquisitions activity. In the case of IDMs, strong partnerships with foundries would be highly beneficial to not only gain access to (and customize) state of the art technologies, but also to reduce overall product cost through scale to compete better with fabless companies and each other.

Table: Key Semiconductor Market Segments and Their Growth Potential

<table>
<thead>
<tr>
<th>Segment</th>
<th>2009 ($ Mil)</th>
<th>2015 ($Mil)</th>
<th>2009 to 2015 Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Semiconductor</td>
<td>230,194</td>
<td>400,806</td>
<td>74%</td>
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<tr>
<td>Sensors/Actuators</td>
<td>3,970</td>
<td>9,832</td>
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<tr>
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<td>35,988</td>
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<td>36,073</td>
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<td>48,463</td>
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<td>Logic</td>
<td>64,582</td>
<td>98,309</td>
<td>52%</td>
</tr>
</tbody>
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Sources: Nikkei, 2011
industry. It must either specialize in a single technology segment (e.g., power, RF, MEMS, etc.) – as many do today - or diversify across a broader portfolio of technologies to enable heterogeneous integration of multiple technologies. Choosing the latter model expands the foundry’s TAM, and allows for a greater synergy across multiple technologies. However, developing strong capabilities across multiple specialty technologies takes many years of strategic focus and investment. Therefore, diversified foundries must strategically combine organic growth for continuous roadmap extension for existing offerings, and inorganic growth for adjacent/disruptive offerings, and be extremely good in integrating these technologies to enable IDM/fabless customers to incorporate them seamlessly into their products.

Finally, convergence of multiple technologies calls for enrichment of design enablement offerings from foundries and EDA vendors. The EDA software must allow ease of migration from digital to analog intensive technologies. Similarly, foundry PDKs must offer a strong foundation and standard building-blocks for the base digital-CMOS technology and advanced modular features for designing/modeling and simulating RF, high voltage, sensors and/or novel packaging features. Modularity of the PDK will allow maximum flexibility to designers to add/subtract features quickly to meet specific application needs. IDMs/Fabless companies, foundries, EDA vendors and IP providers must collaborate even more closely to create synergy and cadence for technology development roadmap.

Summary

We are living in an unprecedented era of the third industrial revolution, guided by three megatrends affecting our everyday lives: (1) Green Everything, (2) Wireless Everywhere and (3) Smart Everything. Companies that anticipate and lead these trends are likely to grow more rapidly than those that are slow to adapt. Many of the skills and technologies required for exploiting these trends are not new; but greater innovation and closer collaboration will be required along the “More-than-Moore” axis to enable heterogeneous integration of analog interface technologies into a single chip, a package or a system to deliver optimal application specific product performance.

References

2 http://www.eia.gov/tools/faqs

About the Authors

Russell C Ellwanger is the chief executive officer of TowerJazz, an analog semiconductor foundry based in Migdal Haemek, Israel. Previously, from 1998 to 2005, he served in various executive positions for Applied Materials Corporation, including group vice president, general manager of the Applied Global Services (AGS) division from 2004 to 2005, and group vice president, general manager of the CMP and Electroplating Business Group from 2002 to 2004. Mr. Ellwanger also served as corporate vice president, general manager of the Metrology and Inspection Business Group from 2000 to 2002, during which he was based in Israel. From 1998 to 2000, he served as vice president of Applied Materials’ 300-mm Program Office, USA. Mr. Ellwanger also served as general manager of Applied Materials’ Metal CVD Division from 1997 to 1998 and from 1996 to 1997, he served as managing director of CVD business development, during which he was based in Singapore. In addition, Mr. Ellwanger held various managerial positions at Novellus Systems, Inc. from 1992 to 1996 and at Philips Semiconductors from 1980 to 1992.

Amol M Kalburge is senior director of sales and strategic marketing for TowerJazz. Previously, he has held several positions of increasing responsibility at Jazz Semiconductor, including director of R&D engineering and manager of device technology. He also served as vice president of process engineering at RF Nano Corp – a nanotech start-up based in California, and was a senior manager at PRTM Consultants (now PwC), where he consulted for leading semiconductor companies, before joining TowerJazz in his current position. He holds an MS and a Ph.D. from the University of Southern California, and a B.Tech. from the Indian Institute of Technology, Bombay. He holds 27 patents and has numerous published journal articles.

Overcoming Challenges continued from page 3

view of the entire network from a single console and create a back-channel link to facilitate troubleshooting and tracing of packets across the network. Specialized wireless development tools are also available to enable developers with little to no RF design experience to easily create efficient, robust and cost-effective ZigBee and sub-GHz wireless applications. With the availability of a wide variety of development boards for evaluating the connectivity and performance of various protocols, engineers can simultaneously design and debug application code and firmware, begin RF design and optimization and finalize network and protocol stack development while hardware prototypes are still under development.

Summary

The value of connecting devices to the Internet and having them seamlessly communicate with each other independent of human intervention is no longer under debate. The IoT will continue to open new markets and drive new applications and opportunities for OEMs and application developers across all industries. There is no question about whether the IoT is going to happen given the rapid expansion of applications, such as smart meters and smart home appliances. The IoT has become a tangible reality with commercially successful deployments in several markets, including connected home and green energy applications.

What many OEMs and their suppliers want to know is when the IoT is going to grow out of its infancy and achieve the critical mass necessary to become a 10 million plus unit market. With the availability of the fundamental technologies, products, software and tools necessary to create efficient, ultra-low power devices for the last inch, it is clear that the answer is now.

About the Author

Thomas Barber is the director of marketing for ZigBee products in Silicon Labs’ Embedded Systems group. Previously, Mr. Barber held marketing director positions at ST-Ericsson and NXP Semiconductors, focusing on RF and baseband products for mobile communications. He has also served in marketing manager roles for cellular platforms at Analog Devices. Mr. Barber holds an MBA from Northeastern University, an SM (Master’s Degree) in electrical engineering from MIT and a BS in electrical engineering from Michigan Technological University. Mr. Barber can be reached at Thomas.barber@silabs.com.
Thermal is last to analyze since it can be improved internally and externally to a product. Once all internal thermal solutions have been analyzed, external thermal solutions are explored. External solutions can involve embedded heat slugs on packages, attached slugs and/or fins on packages and may even add fans to force air across the package. With 2.5/3D packaging, vias can be used not only as methods to efficiently route signals and power distribution networks (PDN), but also to improve heat dissipation throughout the structure. Path finding can help identify potential solutions and cost tradeoffs.

Who Owns Path Finding and When to Apply It?
Where and how path finding can be used spans the GSA’s ecosystem: From foundries (silicon and interposers) and OSATs (interposers and packages) to system integrators and product developers. Which path finding tools are used by each participant will depend on how much integration they perform in the overall process. Since the goal for each participant is to be profitable, each will want to maximize their yields. As shown earlier, yield loss can be attributed to mechanical, thermal and electrical causes. Path finding can help optimize solutions in MET and minimize yield loss.

Whether designing a product or a process, developers should understand how path finding tools can aid their decision making in a complex world and thus implement path finding tools into their development flows as early as possible. The worst and most costly situation is finding an issue when ramping up volume manufacturing.

About the Author
Bill Martin has over 30 years of experience in consulting, product design and project management with semiconductor and electronic design automation (EDA) companies. Prior to joining E-System Design, Bill worked at Mentor Graphics as the GM of their silicon intellectual property (IP) division and earlier as VP of their Mentor Consulting Division. Prior to Mentor, Bill worked at Synopsys as director of corporate application engineering, releasing new products to the market. Earlier in his career, Bill worked in the semiconductor industry at VLSI Technology and Mostek. While at VLSI, Bill’s last position was director of corporate planning, where he coordinated all technical disciplines required by their application-specific IC (ASIC) customers. Earlier in his VLSI tenure, Bill held various field technical and management positions. Bill started his career at Mostek where he held various positions including product engineer and product engineering manager. Bill earned an MBA from the University of Texas at Dallas, and a BS in Computer Engineering from the University of Illinois, Urbana. He has been granted five patents and has others pending. Bill can be reached at: bill.martin@e-systemdesign.com or (469) 766-5127.

GSA 2008 Start-Up to Watch Award Winner
Tilera Corporation
Tilera Corporation is the developer of the highest performance, low-power, general purpose manycore processors for network intelligence, video and cloud computing. The company’s products power the infrastructure delivering secure data, video and voice for enterprise and web datacenters. Tilera has raised nearly $120 million since its founding in 2004.

“Our product innovation and execution has enabled us to remain an industry leader even in the most challenging of economic times,” said Devesh Garg, president and CEO, Tilera Corporation. “In 2013 alone, we released the world’s highest performance 64-bit processor - the TILE-Gx72 - which rounds out our robust TILE-Gx processor portfolio that also includes 9-16-36-core processors. This is just the beginning since customers are demanding scalable performance which ensures the coming year will be an important and exciting period of growth for our company.”

GSA 2009 Start-Up to Watch Award Winner
Ambarella
Ambarella, Inc. (NASDAQ: AMBA), is a leading developer of low-power, high-definition (HD) video compression and image processing solutions. The company’s products are used in a variety of HD cameras including security IP-cameras, wearable sports cameras, digital still cameras and automotive video camera recorders. Ambarella technology is also used in television broadcasting with TV programs being transmitted worldwide using Ambarella compression chips. Prior to becoming publicly traded in October, 2012, Ambarella also received the GSA 2010, 2011 and 2012 awards for “Most Respected Private Semiconductor Company.”

“Ambarella’s continued success is based upon delivering innovative, high quality and low power video solutions for high definition sports, IP-security and automotive cameras,” said Fermi Wang, CEO of Ambarella. “These markets have grown significantly even during hard economic times for traditional consumer camera makers.”

GSA is eagerly anticipating recognizing the 2013 Start-Up to Watch award winners at its 19th annual Award's Dinner Celebration to be held on Thursday, December 12, 2013, at the Santa Clara Convention Center in Santa Clara, CA. Who will be the next company to shape the future of the semiconductor industry?

GSA’s Private Awards Committee, comprised of members of the Emerging Company CEO Council, venture capitalists and select serial entrepreneurs in the industry, selects up to two winners of the Start-Up to Watch award by identifying the semiconductor company (or companies) that demonstrates the potential to positively change its market or the semiconductor industry, in general, through the innovative use of semiconductor technology or a new application for semiconductor technology. Nominate your company today!

Start-Up to Watch Criteria

- Company must be a semiconductor company (Fabless or IDM).
- Company must be privately held.
- Company must NOT have achieved greater than or equal to $20 million of cumulative product revenue (i.e., cumulative product revenue since market introduction).
we decided we had to take it one more step and let any customer look at anything real-time on their phone. So we simply deployed a slightly restructured version to any smart phone, whether it be an iPhone or Android-based system, and I can tell you, I use mine every day.

When I'm in front of a customer and they ask, "What's the schedule for this certain product line?" I just pop it open, I look at their account, and I can tell them within minutes exactly what they're going to get and when. Our customers love it — it gives them global access to their business that they can't get anywhere else.

Q: Your website touches on three basic business units at eSilicon. Can you describe those unique business units and what each unit provides to customers?

A: Sure. One of the units is our ASIC business unit, which is the classic ASIC company engagement model. People give us a net list, we do physical design, we make the chip and we deliver it to them over the life of the product. It's no different than what you might see at LSI Logic or IBM or any other ASIC provider.

Our next business unit is somewhat of a corollary to that. It's the Semiconductor Manufacturing Services (SMS) business unit, and the SMS BU is an outsourcing model where companies come in and outsource the entire back end operations to us, where we manage the entire flow. We've aggregated the skill sets and the systems — once again, electronic systems to give them in fact better information than they had themselves, more timely updates, and we're able to reduce their operating expenses substantially as we do that work for them.

And then the last business unit is the one we've discussed — the IP BU, which serves a dual purpose of supplying our ASIC BU with IP to optimize SOCs in ASIC development and also sells IP to a broad range of customers, from the largest companies in our industry down to the smallest. It has an extraordinary customer list and provides high performance SRAM technology and assorted IOs.

We believe they all integrate together and provide significant synergy. Without the IP business unit, our effectiveness in ASICs would not be as strong. Our ability to have outsourcing for our customers for whom we make ASICs is attractive, and the converse is also true, where when we outsource the operations for a company, they end up making their ASICs with us. We believe that each part of the business feeds upon the other, and it's contributed to our success.

Q: Fabless company IC sales have increased more than three times the rate of the total IC market from the period from 1999 to 2012, according to IC Insights. Are you surprised by this growth and how it compares to the rest of the industry, and how do you believe that fabless companies can continue to grow and outpace the rest of the industry?

A: No, I'm not surprised, as you might guess. I've been a strong proponent of the fabless model even prior to my co-founding of eSilicon. Even back in my Cadence days, it was clear that the aggregation of both engineering skill and cost centers made a lot more sense than trying to duplicate assets that were otherwise available on the open market. Back in the early 1970s, we saw the beginning of that, with a downturn in the IC business, and a lot of people outsourced their then-shrinking production to package and test shops in Southeast Asia, Indonesia and Malaysia, and when the market turned back around in 1974, a lot of the manufacturing VP's went to their CEOs and said, "Hey, boss, should we bring all of that back in house now?" and they said, "Hell, no. These guys are half the price with higher quality. Why would we ever do that again?" And that was the beginning of the package and test industry.

Well, that repeated itself in the early 1980s with EDA, again in the late 1980s and early 1990s with TSMC and UMC, and in the last decade we've seen the outsourcing of IP development and design capability. So simply said, this is a 40-year trend that's been predictable and it's been economical and it's taken the number of relevant semiconductor companies in the early 1970s from a handful to thousands today. And so the model has borne fruit for a long time. There's nothing new or unpredictable about it.

In fact, the very essence of the eSilicon model is that we believe that the last thing that's still done inside of most companies' operations should be outsourced in and of itself, and that's why we have the SMS business unit. There's no reason for every company to have five to 50 operations people replicating the same functions over and over again, particularly as the number of design starts are shrinking and the complexity is growing. It's once again the time to aggregate another sub-function of the entire semiconductor business and jettison that into what is now the VCP model. VCPs like eSilicon are now collectively running about a billion dollars a year and growing about 20 percent a year, and it's because people have adopted that fundamental model.

So the answer is, no, I'm not surprised that the semiconductor fabless market has grown significantly. It will continue to grow, because when you can focus on innovation and invention and not on operations and redundancy, you're just going to outperform your more stagnant, more vertically integrated competitors.

Q: IC Insights also forecasted that in 2017, fabless companies would command at least a third of the total IC market, especially if more large companies such as IDT, LSI, Agere and AMD continue to make the move to fables over the next five years. Over the long term, IC Insights also said that fables IC suppliers and the foundries that serve them will just continue to become an even stronger force in the total industry. Do you think that this growth will be primarily driven by established companies, or will we see an increase in newly founded companies?

A: Well, if we're talking about the customer side of the equation, unfortunately, I don't think we're going to see a lot of new companies. The economics of starting a chip company today just simply don't work, and you've seen a dearth of venture capital investment in the last several years, and I don't think it's about to come back any time soon. I think it's a shame that, as in a lot of other maturing industries, we'll see new folks entering the market, but it will be dominated by larger companies who continue to consolidate.

Now, if we're talking about suppliers, I've got a more optimistic view. I believe that there is a relentless growth and complexity going into the making of each subsequent generation of semiconductors, so that there will have to be more suppliers, because the larger companies simply will not be able to innovate in a focused way to solve every problem coming into our space.

I really do look forward to a broader supply chain, and I hope new companies arrive, because we need the specialty and best of breed innovation that they will bring to the market.

Q: eSilicon has been a very active member of GSA's 3D IC working group. Are you guys working on anything interesting in packaging?

A: We are. As companies move from 28nm, stopping briefly at 20nm, and then going on to 16nm or 14nm processes, the cost of those activities become so high that many people will start to reconsider how they deploy their technology. At 16nm and 14nm, NRE could run $15 million to $18 million, and companies are going to think twice before starting that chip and getting into production.

Conversely, the 2.5D technology that we're diligently working on
allows people to recombine existing die from their own portfolio, die from their partners, competitors and even central repositories, and add to that their next-generation innovation or secret sauce and go to market with very low NRE in a timely way.

Yes, those packaged devices will cost more, but they will also consume more of the area on the printed circuit board to which they will be deployed. So, on a system basis, we might see the economics are pretty good as compared to a chip when it comes to unit costs, but the 2.5D package technology won’t even scratch the surface of the cost of a 20nm or 14nm IC. We feel strongly that this is a great direction for not only our industry, but for eSilicon. We have a very strong packaging team and capability here, and we’re very bullish that this will be a market that we can serve for a long time.

This market’s not going to materialize tomorrow, but on the other hand, there’s much to figure out and much to understand before this gets deployed on a broad-scale merchant and commercial basis. So it’s a key focus for my company.

Q: eSilicon has also been a long time member of GSA. What has been one of the greatest benefits of being a GSA member?

A: Well, for me, the answer is twofold. One, is that of course we’ve enjoyed the membership of GSA. There’s a fantastic opportunity to work closely with your peer group, with your customers, your suppliers and even your competitors in meaningful and well-organized events, whether they are driven by technology interests or commercial interests, or even just to get together once a year to recognize each other with the awards ceremony.

Secondly, for me, I’ve been a member of the board of directors for five or six years now, and I have to say that some of my best relationships in this industry have come out of those meetings. We have a remarkably high performing and collaborative board. The attendance record of each member is outstanding. We get real work done, and there’s sort of an unwritten code that a lot of the competition and a lot of the potential conflict is left at the front door. When we’re discussing important issues for the industry, we’re really doing so with the best interests of the entire industry and not that of the individual members.

So with that and Jodi Shelton’s leadership, it’s been a fantastic experience for me, and I’m delighted to have been able to contribute in a small way to the success of the GSA.

SKTA Innopartners LLC continued from page 8

Innovation Center is only interested in memory or wireless technology or is it broader than that?

A: Innopartners is interested in semiconductor innovations. It would be disingenuous if we didn’t acknowledge that the motivation is unrelated to SK Telecom’s mobile carrier and memory businesses. However, the root of the problem is the ecosystem around the semiconductor industry. To fix the ecosystem for a productive future, the scope has to be broadened to the industry as a whole. Fundamentally, we can’t focus on SK Telecom and its businesses alone. To accomplish our goal, we must foster innovation throughout the entire semiconductor industry.

Q: Interested strategic partners are key to the success of your model; why are they choosing to partner with SK Telecom’s Innovation Center versus funding their own R&D?

A: The simple answer is that strategic partners are able to fill a gap in their portfolio faster using the Innovation Center process than if they do it themselves. It’s not that strategic partners are not, or even should not, be funding their own R&D. Clearly, each company has a vested interest in building upon their existing product lines and IP. What the Innovation Center offers strategic partners is the ability to tailor a start-up that perfectly fills a gap in the strategic partner’s portfolio in two to three years. By having the start-ups completely dedicated to product development, we ensure that the time-to-market is faster through the Innovation Center, than if it were developed within the confines and overhead of a strategic partner. While the cost of using the Innovation Center to the strategic partner will be a bit higher than an internal development, the Innovation Center concept will be considerably less costly than acquiring a late stage company.

Q: The semiconductor industry is a global industry with a variety of regions contributing to the overall health of the industry, with particular hot spots in China and Israel. Is this initiative restricted to companies from the Bay Area or will you consider companies from other regions?

A: The Innovation Center is a type of matchmaker between strategic partners and start-ups. We are currently seeding companies here in the Silicon Valley because that is where we have our facilities and our network of VCs, EDA providers and entrepreneurs. For strategic partners, we are reaching out globally. Even our own SK affiliates are all located overseas. We have some of the most sophisticated video conferencing systems available to enable the level of collaboration required between the start-ups and the strategic sponsors.

Q: Is there a defined number of companies SKTA wants to engage with at any one time and when/how do you replenish these companies?

A: We have space and funding to host five to six companies at a time while providing a high level of service. To keep the incubator full, we plan to keep an active pipeline of entrepreneurs who can take over a space vacated by the successful exit of a previous start-up.

Q: What has been your biggest challenge to date?

A: So far, getting the word out has proved to be the most difficult. We are doing something different, which requires some careful messaging, since anything new is always met with some level of skepticism. We’ve done a good job of building solid alliances with VCs and strategic partners. Now the challenge is finding the entrepreneurs to fund.

Q: I’m an entrepreneur in need of seed funding and incubation; what do I need to ensure I have in place before I come and talk to you?

A: You need a good idea to solve a problem in the semiconductor industry. We do the rest.