THE DUALITY OF TECHNOLOGY

Technology Vision 2019
Semiconductor
New technologies impact industries across the board. But in the semiconductor industry, the very technologies disrupting the way companies operate are the same technologies they will use to create new products and businesses.

Now is the time for semiconductor companies to take a strong position and proactively define the next generation of technology—in a dual role, as customer and producer.
Five trends shape the near future:

**TREND 1: DARQ POWER**

*Understanding the DNA of DARQ*

Nine out of 10 semiconductor companies are experimenting with DARQ technologies already. DARQ technologies will not only change the semiconductor industry as they are applied by semiconductor companies, they will also drive business growth. Blockchain/Distributed ledger technology is centered on driving improvements to business operations, via data provenance and faster traceability as well as enablement of compute and artificial intelligence (AI) capabilities. AI and extended reality will require custom chips. And quantum computing will introduce an entirely new universe of compute engineering.

**TREND 2: GET TO KNOW ME**

*Unlock unique consumers and opportunities*

As silicon technology becomes commoditized, semiconductor companies are looking for ways to differentiate. Offering silicon-as-a-service, participating in platforms, is one way to do that. As chips become more specific in nature for targeted applications, semiconductor companies want to own a connected asset capability, versus just a piece of hardware.

To do that successfully, they’ll have to know their customers inside and out—predicting and anticipating needs before they even occur.

**TREND 3: HUMAN+ WORKER**

*Change the workplace or hinder the workforce*

Even as the workforce evolves at a rapid pace, most semiconductor companies are optimized for the workforce of the past. Moving to a digital workplace requires a workforce with digital skills.

**TREND 4: SECURE US TO SECURE ME**

*Enterprises aren’t victims, they’re vectors*

Large semiconductor companies are working to embed security into their chips and their ecosystems, knowing they are a critical link to national security as well as that of private citizens.

**TREND 5: MY MARKETS**

*Meet consumers’ and organizations’ needs at the speed of now*

Custom chips, chiplets and 5G are essential in a world of intensely customized and on-demand customer experiences. As nontraditional competitors change the semiconductor playing field, incumbents are in a race to remain relevant to their customer base.
TREND 1
DARQ POWER
Understanding the DNA of DARQ

DARQ DEFINED
New technologies are catalysts for change, offering extraordinary new business capabilities. Distributed ledger technology, artificial intelligence (AI), extended reality (XR) and quantum computing will be the next set of new technologies to spark a step change, letting businesses reimagine entire industries.

DARQ technologies will not only change the semiconductor industry as they are applied, they will also drive business growth. Blockchain/Distributed ledger technology is centered on driving improvements to business operations, via data provenance and faster traceability as well as enablement of compute and AI capabilities. AI and extended reality will require custom chips. And quantum computing will introduce an entirely new universe of compute engineering.

TRANSFORMATION FOR LEADERS BY 2022
Nine out of 10 (87 percent) of semiconductor executives are experimenting with one or more DARQ technologies already—no surprise, given the semiconductor industry is high-tech.
Perhaps more surprising is that 60 percent of semiconductor companies anticipate the combination of DARQ technologies will have transformational or extensive impact on their organization in a relatively short timeframe—over the next three years. That impact will come in varied forms, as each technology moves the needle in its own way.

**DARQ technologies and some of the capabilities they enable**
The duality of technology

**Trend 1: DARQ power**

60% of semiconductor companies anticipate DARQ technologies will transform their company over the next three years.

**AI in the Lead for Market Take-Up**

A majority of companies are at least piloting each DARQ technology, but 63 percent say that AI will have the greatest impact on them over the next three years.

**Semiconductor organization’s stage of adoption for each of the following emerging technologies today**

- **55%**
  - 55% of the semiconductor executives said that they were at least piloting distributed ledgers/blockchain today compared to 65% executives globally

- **77%**
  - 77% of semiconductor executives said that they were at least piloting AI today compared to 67% executives globally

- **73%**
  - 73% of semiconductor executives said that they were at least piloting extended reality today compared to 62% executives globally

Global chip market growth projections are astronomical, with a 45.4 percent compound annual growth rate (CAGR). AI will drive growth not only for traditional semiconductor companies, but also non-traditional competitors (like Alibaba and Amazon) moving into the sector.

**Operating Model: The Art of the Possible Using AI**

Micron launched a first-of-its-kind effort to use AI technology to boost its fabrication operations.

**Result:** AI was 25 percent faster to get to the yield target desired. It was 35 percent faster to get to the defect per million (DPM) levels desired than it was before.
AI FOR SPEED

Nvidia and OmniSci are collaborating to empower data scientists with GPUs, AI and analytics. Traditional CPU-based computers don’t have the capacity to handle the massive data sets organizations now want to digest for insights. Nvidia and OmniSci worked with a cable operator, for instance, whose network generates a terabyte a day. The operator’s dataset was akin to a spreadsheet with 500 million rows, a dataset that would take eight days just to ingest for analysis with traditional CPUs. Then, each data query would take several hours to run.

The partners installed a GPU-based system. Its parallel-processing reduced loading time to just four minutes, allowing for queries in real-time. Instead of data scientists having to wait over a week just for data to load, they now have an interactive system in less time than it takes to eat a meal—and can use AI to full, speedy advantage.

ECOSYSTEMS FOR DARQ COMPETITIVE ADVANTAGE

Established semiconductor companies can inject innovation quickly through a well-designed ecosystem. Partnering with startups can help them leap ahead on the innovation curve, saving time and money versus trying to build capabilities in-house.

For example, Nanotronics is building automated microscopes that use AI and machine learning to analyze and find chip defects automatically. Manufacturers can analyze 100,000 chips within minutes.4

Semiconductor companies that can partner to connect their data sets across manufacturing and other functions—working with innovative partners to do so—will leapfrog ahead. Not only because of increased speed, but more holistic insights they can use to better run their business.
Technology-driven interactions are creating an expanding technology identity—digital demographics—for every consumer.

This living foundation of knowledge will be key to not only understanding the next generation of consumers, but also to delivering rich, individualized, experience-based relationships in the post-digital age.

Digital demographics are important in every industry, but particularly so in the semiconductor industry. Customers now have a “real-world” demographic, but also a digital demographic—who they are in the digital world based on what they do there.

In the past, semiconductor companies might design one type of chip that worked for millions of users, but now market needs are fragmenting. A chip designed for a specific Internet of Things (IoT) use, like a self-driving car, is completely different than a chip designed for a user who wants to mine Bitcoin.

As silicon technology becomes commoditized—treated as hardware—semiconductor companies are looking for ways to differentiate. Offering silicon-as-a-service, participating in platforms, is one way to do that. As chips become more specific in nature for targeted applications, semiconductor companies want to own a connected asset capability, versus just a piece of hardware.
To do that successfully, they’ll have to know their customers inside and out—predicting and anticipating needs before they even occur.

94% of semiconductor IT and business executives believe that digital demographics give their organization a new way to identify market opportunities for unmet customer needs vs 83% of global executives.

81% of semiconductor executives report that customer digital demographics is expanding the number of ways they deliver products and services either significantly or extensively vs 75% of global executives.

71% of semiconductor executives expect the amount of data their organization manages about customers’ digital demographics to increase exponentially or significantly over the next two years vs 78% of global executives.
TREND 3
HUMAN+ WORKER

Change the workplace or hinder the workforce

Workforces are becoming human+: each individual worker is empowered by their skillsets and knowledge plus a new, constantly growing set of capabilities made possible through technology. Now, companies must adapt the technology strategies that successfully created this next-generation workforce to support a new way of working in the post-digital age.

HARDWARE VERSUS DIGITAL MENTALITY

While semiconductor companies produce an incredibly innovative product, most do not offer a cutting-edge, innovative employee experience. Many will admit they act more like product companies than modern technology companies.

Samsung makes AI talent a priority

Samsung aims to have 1,000 AI developers working in five countries by 2020. To drive efforts, the company appointed ex-Google AI developer David Eun as its first chief innovation officer. The new CIO’s role is to cultivate new businesses of the future on themes like AI and the fourth industrial revolution, digital. The company is searching for talent outside of the corporate realm also, as it has hired two prominent American AI researchers, Sebastian Seung of Princeton University and the University of Pennsylvania’s Daniel Lee.
Even as the workforce evolves at a rapid pace, most semiconductor companies are optimized for the workforce of the past. An amazing 71 percent of industry executives agree that their employees are more digitally mature than their organization, resulting in a workforce that is waiting for its organization to catch up.

**NEW WORLD REQUIRES NEW TALENT**

The semiconductor manufacturing industry is fighting to attract, educate, and retain the necessary talent for its continued growth. A significant workforce gap of up to 10,000 global positions stretches the industry’s ability to meet the world’s already demanding technology needs. Enrollment in STEM education has fallen, while demand for high-skilled tech workers has increased partly because of the extraordinary growth of popular consumer-facing companies like Facebook, Amazon, Google and Netflix—all of whom compete for the same talent semiconductor companies do.

Developments like 5G, AI and autonomous driving require new chip architectures and improved reliability—which require talent with different skill sets. Without the right workforce in place, the industry will not be able to capture the growth. Hiring and reskilling talent with the right knowledge and capabilities is essential to competitiveness.

Not only does digital require new talent sets, it attracts them. Most Millennials expect to be in a Human+ workforce, working side-by-side with intelligent machines. Given semiconductor companies are in a high tech, fast-paced industry, workers expect cutting-edge work environments.

**Intel acquires talent for 5G and IoT**

Intel has built up its programmable chips team by acquiring eASIC, a 19-year-old fabless semiconductor company. The acquisition of eASIC’s chip sets and talent base will help drive business in 5G and IoT.
TREND 4

SECURE US TO SECURE ME

Enterprises aren’t victims, they’re vectors

While ecosystem-driven business depends on interconnectedness, those connections increase companies’ exposure to risks. Leading businesses are recognizing that just as they already collaborate with entire ecosystems to deliver best-in-class products, services, and experiences, it’s time security joins that effort as well.

AS SECURE AS THE WEAKEST LINK

Less than one in four semiconductor companies say they know their ecosystem partners are working to be compliant and resilient. Semiconductors are a national security concern in an industry rife with an increasing number of intellectual property violation allegations. Couple that with recent security incidents where threats are originating not from breaches within the company, but through a supplier or a partner, and security becomes a top ecosystem concern. Semiconductor companies are as vulnerable as the weakest link in their ecosystem.

Only 23% of semiconductor companies report they know their ecosystem partners are working diligently to be compliant and resilient with regard to security vs 29% globally
THE INTERNET OF THINGS: SECURITY FROM THE INSIDE OUT

Adding security to the functionality of a chip is an important way for a chip manufacturer to increase the value of their products. Especially in the IoT market, where device makers want to keep their costs low, a chip becomes more valuable if it can take care of security for the IoT device without adding additional components.¹⁰

Security in IoT has evolved and is now being applied directly at the hardware level¹¹

PREVIOUSLY
IoT security was associated with the software platforms installed. These platforms have divided the IoT ecosystem into multiple silos i.e., a separate platform for each application

NOW
Security features are being applied directly at the hardware-level of the device—down to their silicon implementations

IN FUTURE
SoC processors will be handling the security functions by employing various APIs. Chipmakers will be expected to adopt this silicon-level security in advanced IoT edge applications

Large semiconductor companies are partnering with companies that can help them embed security into their chips. We expect this trend to continue and grow substantially, as the IoT expands.
TREND 5
MY MARKETS

Meet consumers’ and organizations’ needs at the speed of now

Technology is creating a world of intensely customized and on-demand experiences, and companies must reinvent their organizations to find and capture those opportunities as they come. That means viewing each opportunity as if it’s an individual market—a momentary market.

CUSTOMIZATION AND REAL-TIME DELIVERY ARE THE NEXT BIG THING

Companies are using custom chips to optimize and differentiate. While there will still be a market for off-the-shelf semiconductors, customized semiconductors will see higher growth.

90% of semiconductor executives agree that the integration of customization and real-time delivery is the next big wave of competitive advantage compared to 85% of global executives.

54% of semiconductor executives say they have about equal priority between customization approach or an on-demand approach to delivering their products and services today compared to 47% of executives globally.

The rise of customization is driving a stream of nontraditional competitors into the industry, from Tesla for automotive uses to Google for servers. They are seeking not only cost and performance advantage, but in some cases, roadmap control—from how and when the product is developed to specification demands and ecosystem partners. Using an OEM-foundry direct business model to build their own chips gives them the edge they are looking for, in many cases.
WHAT’S DRIVING THE CUSTOM CHIP TREND?

Emerging applications like augmented reality, virtual reality and AI offer an opportunity for companies to differentiate and gain advantage by building their own application-specific integrated circuit (ASIC) chips. And, as neural network processing matures, it is also a logical driver of the build-your-own-chip trend.

The current wave of customization is driven by three major areas:

**Cloud service providers** like Amazon, Microsoft and Google. By developing chips designed for specific functions like data mining, web services, or AI, companies can reduce their operating expenses while improving efficiency. These chips consume less power while allowing higher data throughput, with denser system and datacenter configurations. These developments have a significant impact on the return on investment for a semiconductor company’s capital expenditures.\(^\text{12}\)

**Consumer electronics companies** like Apple, Huawei and Samsung. The three largest smartphone vendors all design their own chips, and some smaller vendors have begun considering it as well.\(^\text{13}\)

**AI.** Alibaba, Alphabet, Apple and Facebook are among the companies working on custom designs for processors that can run AI.\(^\text{14}\) Their hope is that their own chips can help improve their AI applications while also lowering costs. Getting this right could reduce their dependency on companies that manufacture the graphics processors modern AI applications require.

THE CHIPLET RACE BEGINS

The basic idea of a chiplet is that you have a menu of modular chips—called chiplets—in a library. Then, you assemble those chiplets in a package, connecting them using a die-to-die interconnect scheme. In theory, the chiplet approach is a faster, less expensive way to assemble various types of third-party chips, such as I/Os, memory and processor cores, in a package.\(^\text{15}\)

The market for multi-die packages like chiplets and others is heating up, because chiplets are viable alternatives to traditional chip scaling. In scaling, features of a device at each node are shrunk, enabling a smaller die with more functions. But, IC scaling is becoming more expensive and benefits are shrinking at each node. Chiplets are a key component of the advanced packages developed to work around the IC scaling roadblock. They reduce the design cycle time and cost semiconductor companies currently face for packaging chips, but provide relatively equivalent performance.


**5G DAWNS**

The rise of 5G brings huge opportunity to semiconductor companies. The market will grow by almost 50 percent over a six-year period.\(^\text{16}\)

**5G chipset market**

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<thead>
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<th>Year</th>
<th>Value</th>
<th>CAGR</th>
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<td>+49.2%</td>
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<tr>
<td>2026</td>
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Only semiconductor companies who are ready to embrace the opportunities 5G provides, though, will be able to capitalize on that market growth. Intelligent cars, smart cities and 5G enabled smart phones are just a few of the drivers bringing opportunity to the industry. But along with those drivers come challenges. Investing in 5G networks will be expensive, bringing technology and infrastructure hurdles. Semiconductor companies will also need to prioritize privacy and security as the IoT applications, connected vehicles and extended reality become more commonplace.

As customization, real-time delivery and 5G become more commonplace, semiconductor companies will need to become more comfortable with momentary—and ever-changing—markets.
**Don’t duel with duality**

As technology takes away some opportunities, it bestows others for semiconductor companies. As a customer and producer of technology, leading industry players are already meeting this duality head on. Those molding it to their advantage are using every tool at their disposal, from DARQ technologies and new talent sets to cybersecurity measures.

Instead of seeing duality as something to combat, forward-thinking semiconductor companies are befriending it. Those who use it to their best advantage put themselves in a good post position for the next wave of change.
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