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BOOM OR BUST: WHY THE CYCLES?

A business cycle that offers a wilder ride than the most gut-wrenching roller coaster has long been the bane of the semiconductor industry. Just when there was starting to be a growing consensus that the violent swings could fade, the industry has now run headlong into another major downturn.

Why?

Are these cycles a self-fulfilling prophecy?

see FEATURE STORY, see page 4

INSIDE:

2 JUMP ON THE BANDWAGON
3 EXECUTIVE PERSPECTIVE
4 FEATURE: BOOM OR BUST?
7 NEWS AND VIEWS
9 INTERNATIONAL NEWS
13 CUSTOMER PARTNERSHIP
14 PRODUCTS
20 GLOBAL CALENDAR

Agilent Technologies

Jump on the bandwagon

By Kenzo Ishiguro, Hachioji Semiconductor Test Division



Kenzo Ishiguro is business manager of Agilent's Hachioji Semiconductor Test Division in Japan.

As the business manager for the parametric test businesses of Agilent Technologies, I had several opportunities to exchange thoughts recently with industry leaders from all over the world on the future trend of the semiconductor industry. From these discussions, the following trends emerge:

- Integrated Device Manufacturers (IDMs) consider more and more outsourcing.
- Continual strong growth of flash memory.
- Adoption of 300mm wafer technology.

Many customers agree that 300mm is an effective choice for cost reduction. This is simply because 2.25 times more devices can be produced from a 300mm wafer, compared to a 200mm wafer. Recently, more and more customers decided to jump on this 300mm bandwagon. In a survey conducted in 1998, there were only five pilot lines expected to run in 2001. What we see now, however, is more than 10 pilot lines have been announced, and more are expected next year. Parametric testers play a crucial role for ramping up fabs and keeping yields high so that the bandwagon proceeds at a high speed with a low cost.

What do you need to consider in selecting the right parametric testers for your 300mm?

Adopting 300mm usually means not only a size expansion but also engagement of new technologies. For example, a 300mm wafer with 0.13 µm technology would provide more than four times the number of devices compared to a 200mm wafer with a 0.28 µm design rule. In addition, technologies such as copper and low-K are employed for even faster and lower power consumption products. These new technologies are driving the need for advanced process control, where Agilent's 4073A Ultra Advanced Parametric Tester plays the central role. Its ultra low current measurement capability down to 10fA range in conjunction with a more than 30 times faster measurement speed have made the 4073A an industry standard for 300mm fabs.

How many of you have actually held a 300mm wafer? It weighs about 800 grams or 1.8 lbs. Factory automation is a must for this technology, because no one wants to risk dropping a cassette of wafers, which can cost millions of dollars. Thus, every customer is very keen on realizing factory automation throughout the fab (material handlers, robots, testers, etc.).

SECS/GEM is the industry standard protocol for factory automation for fabs. SECS/GEM is a relatively new concept to everyone and is continuously upgraded. This is one of the reasons why Agilent started working with standard committees and industry consortia years ago.

From a financial viewpoint, adoption of 300mm wafers involves a big capital investment. How fast one can reach the breakeven point is the key. That's why Agilent focuses on lower cost of ownership. With an astonishing 16,000 hours of MTBF (Mean Time Between Failure), Agilent's record shows a leading-edge system uptime ratio of more than 95 percent.

Finally, I am very excited that every 300mm fab of eight leading companies as well as three industry consortia have chosen our 4070 series (as of writing of this article). ◆

DID YOU ? KNOW

Why do carbonated drinks cause a tingly sensation?

The pleasant tingle when you drink a glass of sparkling water has nothing to do with the bubbles, according to recent research. It is the result of carbonic anhydrase reacting with carbon dioxide that is still dissolved in the drink.

Two experiments revealed the enzyme's role. In one, a drug called acetazolamide (used to help prevent altitude sickness) blocked the enzyme's action, making even the bubbliest drinks taste dull. In the other experiment, volunteers drank fizzy liquids in a high-pressure chamber where bubbles never formed. In spite of the lack of fizz, the carbonated drinks still tingled.

The tingle itself is actually a low-intensity pain stimulus. It affects the tongue's branch of the trigeminal nerve, the same nerve responsible for toothaches, sinus pain, and some kinds of headaches.



A talk with CEO Igor Khandros of FormFactor

Q: What is your view of the economic downturn in the semiconductor industry?
A: We are witnessing a downturn in pricing in the DRAM industry. How deep it is, is a different question. I look upon a downturn as an opportunity. In the up cycles, the industry leaders only think about capacity and getting things out the door on time. Everyone is scurrying to place orders for equipment. There is no available bandwidth to think about new things.

In a down cycle there's an opportunity to commit to new technologies, to position a company in a different way. For FormFactor, it is an opportunity to get on corporate radar screens in a grander scale.

Q: What do you think is the cause of this economic downturn?
A: Two factors are at work, I think. The first is economic cycles in "killer applications." The internet, communications, personal computers are all killer applications. A lot depends on how these areas are faring. If corporations in these applications cut back or their sales decrease, it affects the semiconductor industry.

The second factor is the overall ability of the semiconductor industry to plan ahead. It is like mixing wine. Some industry leaders plan well; some are "me-too's" and do not plan as well. The overall mix is usually bad.

The real leaders of the industry plan well. They usually are the first to market and the first to benefit. They start ordering equipment from suppliers first. When enough of the "follower" companies come in with their orders, you get significant price erosion, longer delivery times and ultimately create an oversupply of product. The industry suffers as a result.

In most industries you see a steady increase in prices year after year. But the semiconductor industry is different: Prices continue to drop while the performance levels get higher and higher. This puts additional price pressure on poor planning.

Q: Who is FormFactor? What do you do?
A: We are an eight-year-old private company with 300 employees that has introduced an integrated wafer-level back-end process—testing, burn-in and packaging—for the semiconductor manufacturing market. Our enabling technology is the Microspring™ contact—the tiny interconnect element that brings signals from the entire wafer to the tester itself. We do probe, burn-in test and final test at the wafer level. Testing is scalable this way. As a result, we can produce higher yields and reduce costs due to increased accuracies, allowing feedback between front and back-end processes, and basic scaling efficiencies. We estimate our customers can see a 25 to 30 percent cost savings in the back-end through this integrated wafer-level process.

Q: What trends do you see developing in the semiconductor market?
A: The really long-term trend will be the convergence of chips and the human body. As new kinds of semiconductor products are developed, they will become the vehicle for prolonging life for humans and perhaps improving health. For example, MEMs use semiconductor

Continued on page 6



Igor Khandros, president and CEO of FormFactor in Livermore, California.

DID YOU ? KNOW

Totally useless but interesting information

Peanut shells are one of the ingredients of dynamite.

There are 293 ways to make change for a U. S. dollar.

The average person's left hand does 56 percent of the typing.

A shark is the only fish that can blink with both eyes at the same time.

Two-thirds of the world's eggplant is grown in New Jersey.

On a Canadian $2 bill, the flag flying over the parliament building is an American flag.

All of the clocks in the movie "Pulp Fiction" are stuck on 4:20.

Winston Churchill was born in a ladies' room during a dance.

A cat has 32 muscles in each ear.

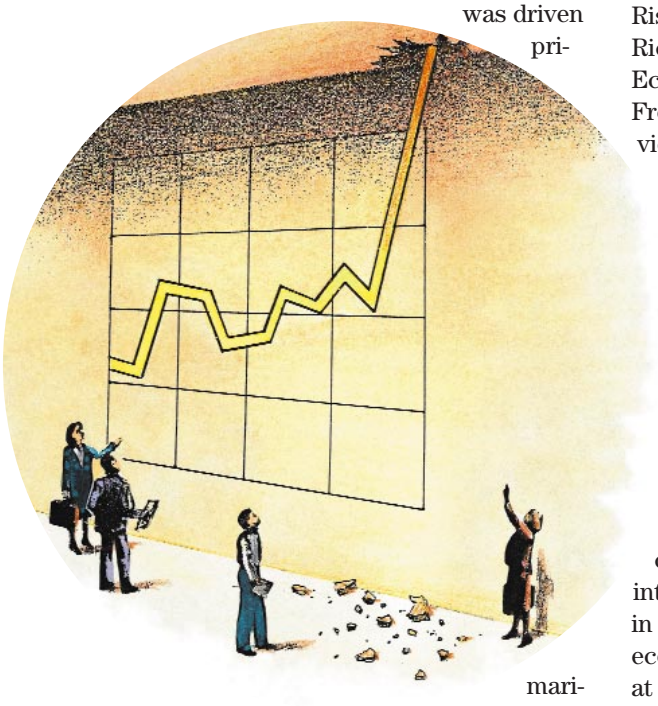
An ostrich's eye is bigger than its brain.

A goldfish has a memory span of three seconds.

Boom and bust: Why does the cycle continue?

A business cycle that offers a wilder ride than the most gut-wrenching roller coaster has long been the bane of the semiconductor industry. Just when there was starting to be a growing consensus that the violent swings could fade, the industry has now run headlong into another major downturn.

The main reason for growing optimism about the cycle is that chip usage is far more diversified now than in earlier cycles, when demand was driven primarily by personal computers. These days, semiconductors are used in everything from cell phones to Internet infrastructure to DVD players; even Old Economy industries like automobiles need chips. So today it's theoretically possible for a slowdown in PC sales to be offset by strong demand for other semiconductor-dependent equipment such as mobile phones or DVD players. Yet the ever-wider use of semiconductors does not seem to be taking much of the sting out of a notoriously volatile industry.



Are the swings a foregone conclusion? A self-fulfilling prophecy? . . . First and foremost, the semiconductor industry is dependent on the overall economy, which also is undergoing a major slow-down, if not a full-blown recession.

A self-fulfilling prophecy?

Are the swings a foregone conclusion? A self-fulfilling prophecy? We asked several industry analysts (Laurie Balch of Gartner Dataquest; Risto Puhakka of VLSI Research; Richard Carlson, CEO of Spectrum Economics, and Bal Ganjoo of Frost & Sullivan) to share their views on why the boom and bust cycle continues.

First and foremost, the semiconductor industry is dependent on the overall U.S. economy, which also is undergoing a major slow-down, if not a full-blown recession. No one knows how soon a recovery will occur. One thing is certain: The health of the overall economy and that of the semiconductor industry are closely intertwined. "Even minor changes in the bottom of the food chain (the economy) can create violent effects at the top of the food chain (the electronics and semiconductor industries)," says Puhakka.

Are massive fabs the culprit?

In addition to broader economic trends, Balch cites an imbalance between supply and demand as the major driving force behind the volatility. In order to increase manufacturing capacity and meet growing demand for ICs, she says, it is necessary to build huge fabs, which means very large investments over a relatively long period of time. During the period in which the fab is being built, there is a shortage of manufacturing capacity in the industry and prices inflate because the supply is too low to meet the demand. "These are boom times for the semiconductor industry," explains Balch.

Semiconductor manufacturers see this imbalance between supply and demand and have the incentive to invest in new fabs to meet the rising demand. "When the new fabs come online with additional manufacturing capacity, suddenly the demand is met with adequate (or more probably, an overabundance) of supply capacity and chip prices drop," Balch adds. "The industry plunges into a downward cycle until demand rises once more to balance with the larger supply capacity. Until, that is, the demand once again grows to exceed the supply and the manufacturers decide to invest in more fabs. And so the story goes."

Puhakka concurs, explaining that capacity in the semiconductor industry can only be added in large chunks. "Everyone adds capacity at the same time in an upturn. They overbuild, and that leads to oversupply," he says. "Last July, we were all celebrating how great this business is and in September we already had our thoughts on the coming down cycle."

All commodities fluctuate

Carlson describes the semiconductor industry as a commodity industry and there are ups and downs

"because it is a commodity and all commodities have fluctuated." The semiconductor industry is more pronounced in its cycles because it has a long lead time between building a new plant and coming on line.

"Commodity-type semiconductors, such as DRAMs," Carlson says, "will always be a cyclical industry, with mild swings in price and profitability. However, the recent economic troubles in Japan and Korea should moderate those cycles as banks are less likely to fund new billion-dollar speculative semiconductor ventures."

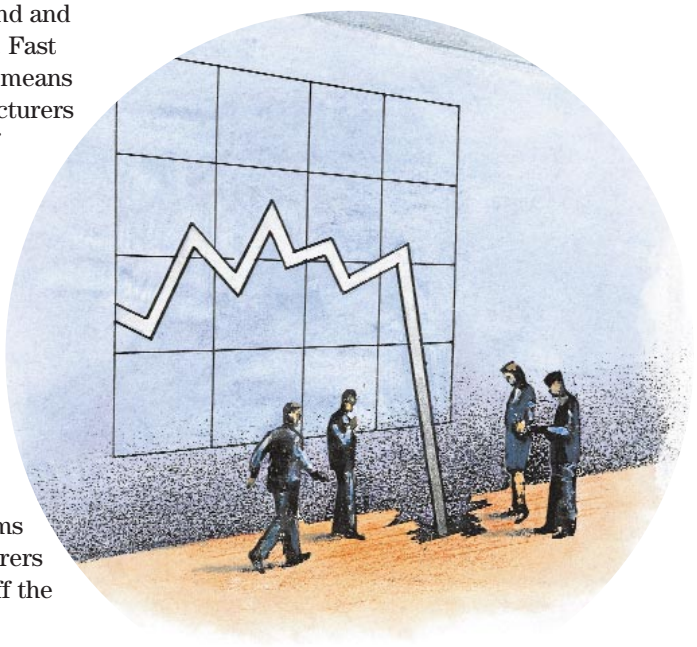
Too much optimism

Another problem, according to Puhakka, is that manufacturers continue to build chips to forecasts that are not always accurate. When the economy is good, manufacturers all forecast optimistically. "Collectively, this leads to overly optimistic demand forecasts which leads to capacity build up—and again we overbuild and oversupply," says Puhakka.

Balch suggests that there is one way to close the gap between supply and demand: cooperation between semiconductor vendors. "If vendors decided up-front how many new fabs were needed throughout the market and only built that many then they could probably alleviate the volatility in the industry," she said. But the problem, of course, is who decides which semiconductor companies will build fabs and therefore reap the profits of new capacity? "Each company will build whatever it wants, without regard to its competitors, because each company wants to get a piece of the expanding market," Balch adds. "There has been quite a bit of investment in new manufacturing capacity over the last couple of years and we're now beginning to see the results of that activity."

The next killer app

Given the fact that the semiconductor industry now feeds a wide variety of OEM industries, it would seem that demand overall would begin to stabilize. However, technology cycles are another powerful factor contributing to the industry's ups and downs. Today, new technologies mature within a matter of months, causing both demand and prices to drop precipitously. Fast and ferocious price erosion means that semiconductor manufacturers have only a brief window of opportunity to reap profits while margins are still high for the latest application. "When there is high demand for a new application, everyone in the industry rushes to make ICs for this particular application while it is profitable," says Ganjoo. "Manufacturers increase production. Then, the application quickly booms and matures and manufacturers can't get their inventories off the shelves fast enough."



According to Ganjoo, the problem now is intensified because the cycles are getting shorter. Twenty years ago, technologies matured over a period of four to five years. Now, maturation is happening much faster. "According to Moore's Law, a chip's speed increases every

Continued on page 6

If vendors decided up-front how many new fabs were needed throughout the market and only built that many then they could probably alleviate the volatility in the industry. . . But who decides what?

Boom or bust

Continued from page 5

18 months, but its cost also decreases so quickly that manufacturers have to go for the next big thing very quickly," says Ganjoo. "Two years ago, cell phones cost hundreds of dollars. They are practically free now, even though they are a very sophisticated piece of technology. Prices fall so fast that we are almost perpetually doomed to endure a boom and bust cycle."

Some manufacturers are going out of their way to try to predict what the next killer app will be. They are setting up research organizations to foresee the future. "Companies that succeed at predicting what's next will be the winners," says Ganjoo. "The problem is that existing products become so commoditized, so quickly, that the industry is on an endless treadmill."

Two types of tech cycles

According to Puhakka, there are two types of technology cycles: those driven by killer applications like DVD or cell phones and those driven by new generations of technology in existing products. For example, when older generation processors are replaced with the next generation, the impact ripples throughout the semiconductor industry. "When we're on the verge of a faster chip like we are today with Intel's Pentium 4, many people wait to upgrade their systems," says Puhakka. "Why get the PC with older generation MPU when by waiting six months you can get the new generation at a reasonable cost?"

No matter what its underlying causes, Ganjoo takes an optimistic stance toward the industry's violent swings. "Last year, manufacturers didn't even have time to think, because all they could do was to ship out products. Now we have time to take stock and look to the future, to get products ready for the next wave, whether it's telecom, wireless or fiber optic networking. The demand for faster, better, higher-level chips will be here before we know it." ◆

Khandros interview

Continued from page 3

processes for producing ultra-tiny machines that can pinpoint and fix problems from within the body.

Another big trend will be virtual reality — all kinds of things in the entertainment field are experiencing virtual reality — the gaming industry already offers virtual reality experiences. Lots of processing power will be needed.

The short-term trend is wireless broadband. There are lots of challenges in going wireless, and broadband technologies will enable even more wireless opportunities. ◆

DID YOU ? KNOW

More Silicon Valley jargon watch

Here's some of the latest jargon coming out of Silicon Valley:

Impoverished Display

A low-quality screen on a handheld device that's too dinky to be useful.
Type of copy-protection scheme Hollywood

Obliteration Application

wants built into future digital TVs and recording devices that would control how often content could be copied to another machine (once, never, etc.)

Postcrash Realism

The bracing sobriety that has swept the dot-com world, leading many to be more cautious about their choice of projects and their techno-utopian prognostications.

Thumb Culture

Mobile gadget users who have become unusually adept at using tiny phone and two-way pager keypads, as well as other miniature input technologies.

Source: Wired magazine

A perspective on the future of SOCs

Single-chip systems (SOCs) are transforming the semiconductor industry these days, but equally important are System Level Integrators (SLIs) which are more encompassing and include multiple chips in a single package, known as System-on-a-Package (SOPs).

This according to James Hines, a semiconductor analyst for Gartner Group/Dataquest, who spoke before an FSA (Fabless Semiconductor Association) meeting in late winter.

SOCs are, by definition, an IC on a rectangle of silicon which contains a computing engine (MPU, DSP, MPEG/graphics); memory; and programmable logic. Both SOC and SLIs are self-contained units.

The main SOC characteristics are:
- A concept rather than a product
- Mostly a subsystem in a chip
- Appropriate to combine when processes are compatible

SLIs are:
- Manufacturing strategies rather than product concepts
- More flexible than SOCs
- Can be used across the board and in more applications

Drive for more units per design

A cost-impact issue for the SOCs is that they tend to be low-volume designs because they are targeted to a specific niche, Hines said. With SLIs, however, the drive for the higher number of units per design will be a major factor, particularly because there are options for designs.

The 2001 market will affect the balance between SOCs and SOPs, Hines predicted.

The key trends, he said, in the semiconductor industry are:
- Manufacturing economics (how much it costs to produce something) is overshadowing Moore's law. Transistor scalability is becoming less important. The move now is to manufacturing economics.
- Design concepts evolve in chip systems.
- Chip scale packaging enables multichip package design to grow faster than SOC design. By 2005, there will be further models of system integration and more systems will be combined—there will be small packages of multiple chips.
- The chip package board design will be gone.
- The lines between the foundry, chip contractors and manufacturers will blur.

New manufacturing disciplines

New manufacturing disciplines, Hines said, are appearing in the semiconductor industry:
- More factory automation to develop more sophisticated methodologies for measuring flow through the fab process
- Sophisticated software systems to track the path through the fab.
- A multiplicity of priorities, and thus constant change.
- In the foundry model, more manufacturing flexibility .
- A lot of methodologies implemented in software solutions. ◆

DID YOU ? KNOW



Plumbing those fiber optic lines

Could the answer to the broadband bottleneck be hidden in America's sewers? Robert Berger, CEO of CityNet Telecommunications, based in Silver Spring, Maryland, has embarked on a novel scheme to lay fiber-optic cable in city sewage pipes.

Berger said the big problem in connecting buildings is the asphalt and concrete. "You need a clear pathway to buildings without ripping up the streets. Sewer pipes are deep and protected and they run into every basement."

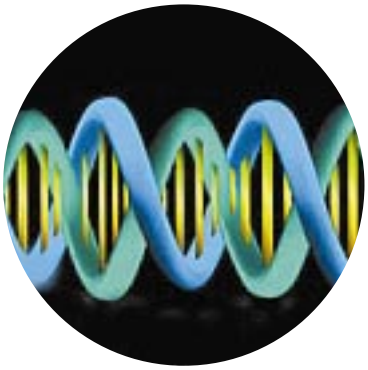
Today, fewer than 5 percent of the 750,000 multi-tenant commercial buildings in the U.S. have fiber connections to the high-speed data networks that loop through most metropolitan areas.

The company, which is building networks in Albuquerque, Omaha and Indianapolis, expects to be in about a dozen cities by year's end. After connecting downtown buildings, CityNet will lease the fiber lines to telecommunication carriers.

Running fiber-optic cable to a building in the traditional dig-up-the-street method costs $100,000 to $300,000 and can take up to six months. Berger figures that his method can cut 60 percent of the time at far less expense. City Net's fiber cable is laid by robots that look like cylindrical vacuum cleaners on wheels. A single robot can lay 400 to 500 feet in a day.

Source: Wired magazine

DID YOU ? KNOW



How are artificial chromosomes made?

Adding a new gene to an animal is usually done in a very haphazard way. The DNA molecule, a copy of which is carried in each cell, is typically composed of dozens of chromosomes, which are in turn composed of tens of thousands of genes, which together give a blueprint for the body of the animal. To add a new gene artificially (to prevent a disease, for example), new DNA is injected into the cells, with the hope that it will be incorporated into one of the existing chromosomes. But artificial chromosomes may offer much greater control.

To make an artificial chromosome, a natural one is stripped of its functional genes, and new genes are added in precisely the sequence desired. Then the new chromosome is injected into a cell. If the artificial chromosome is injected into a fertilized egg, then all the cells of the baby animal will contain copies of it. When the new animal grows up and has young of its own, it can even pass on the new chromosome to them.

Toshiba and Sandisk select Agilent's flash memory test system

World's largest suppliers of high-density NAND memory choose V4400 NVM test system

Agilent has been selected by FlashVision LLC, a joint venture between Toshiba Corporation and SanDisk Corporation, to test flash memory devices with the Agilent V4400 Non-Volatile Memory Test System at Dominion Semiconductor in Virginia, Toshiba's Japan facility, SanDisk's California facility and numerous contract manufacturers worldwide.

"This is a great endorsement by Toshiba Corporation, the world's largest manufacturer of NAND Flash semiconductors, and SanDisk Corporation, the world's largest supplier of flash data and audio storage products," said Gayn Erickson, marketing manager for Agilent's Memory Test Division. "Their joint selection of the Agilent V4400 to test NAND and NOR Flash devices affirms Agilent's leadership in Flash memory test."

Leading the industry in meeting the needs of Flash manufacturers, Agilent currently has the largest market share in the NOR Flash sector with more than 1,000 systems installed worldwide. More than 21 patented hardware and software features on the Agilent V4400 lower the cost of ownership for NAND, NOR and embedded Flash test systems while providing the highest performance to meet future needs.

The recently introduced Versatest Series Model V4400 provides a solution to test up to 36 NOR or up to 144 NAND devices at speeds of true 100 MHz (200 MHz in MUX mode). All the pin electronics are in a compact test head using Agilent's leading-edge technology, resulting in the industry's smallest—under 28 sq. ft. The V4400 proven tester-per-site architecture provides a turnkey solution to test up to 300mm wafer, not only for Flash, but also for other memory and microcontroller devices.

"We selected the Agilent V4400 based on its performance, lowest cost of test, and the platform's flexibility to address our NOR/NAND devices today and into the future, including wafer sort and final test," said Sanjay Mehrotra, senior vice president of engineering, SanDisk Corporation.

According to Shigeo Koguchi, vice president of Memory Division, Toshiba Flash Business, Agilent's experience in Flash testing and its understanding of Flash technology was key in selecting the V4400. ◆

Silterra honors Agilent for helping achieve a first wafer in 89 days

Silterra Malaysia Sdn. Bhd., a Kulim, Malaysia-based company, recently honored Agilent's contributions in helping Silterra achieve production of its first wafer—89 days from their equipment move in.

The event was attended by Silterra vendors from Japan, Southeast Asia, and the U.S.

The local Agilent team helped to ramp up Silterra's technical capabilities, and provided training to the engineers to realize the full advantage of Agilent's 4072A Semiconductor Parametric Test System.

"Agilent Technologies effectively demonstrated its strengths as a global test and measurement solutions provider with both U.S. and local teams working closely in helping Silterra to meet its milestones for production ramp. The team has successfully completed and ensured a smooth transition during the conversion from another platform to Agilent's technology platform, said K.C. Ang, vice president, operations, at Silterra.

C. S. Yeoh, senior manager, test operations, said at the February ceremony, "Agilent's 4072A semiconductor parametric solution allows faster test time and higher throughput. The SPECS framework also provides a user-friendly environment. The reliable test data obtained from the test system allows process integration and yield engineers to confidently analyze the parametric data and correlate to the inline process parameters."

"We are confident that Agilent Technologies will continue to be an excellent provider for us as we grow and expand our facilities. Their commitment and ability to come through with a solution in our initial startup leads me to believe they will be a very reliable partner for many years to come," Ang added. ◆

1st Silicon's clients include U.S. companies

1st SILICON Sdn. Bhd., Malaysia's first 200mm wafer foundry, has succeeded in wooing several U.S.-based hi-tech companies to buy its wafers. CEO Claudio G. Loddo named Jamar, a design house, and ESS, a world leader in manufacturing DVD and VCD chips, as some of its customers.

Besides the American buyers, 1st Silicon's first customer and technology partner is Sharp Corporation of Japan.

1st Silicon started production recently and Loddo said it would gradually ramp up its production to 30,000 wafers per month.The company was founded in January 1998 with its head office in Kuching and a U.S. office in San Jose, California.

Asked about the "softening" of the technology sector at present, Loddo admitted that the "correction" had affected everybody, including 1st Silicon.

"But we (1st Silicon) are still in the ramp-up phase, so we are not punished as severely as, say, those who are producing at 100 per cent capacity," he added. ◆

Source: New Straits Times, Malaysia



Kulkarni named Asia-Pacific marketing manager

Bharat Kulkarni has been named the new Asia-Pacific Marketing Manager based in Hong Kong for Agilent's Automated Test Group. In this newly created position, Kulkarni will be responsible for business development, marketing services and marcom related activities. His mission is to align with Agilent's customers, collaborating to achieve production test leadership.

Kulkarni joined Hewlett-Packard in 1996 and was previously the Worldwide Program Manager for QUALCOMM based in San Diego. Prior to joining Hewlett-Packard, Kulkarni ran his own company that manufactured and delivered memory modules.

Japan giants set up $1.8B Singapore plant

DID YOU KNOW



How did people remove facial and body hair in ancient times?

There is evidence that 20,000 years ago sharpened rocks and shells were used for shaving by hunter-gatherer tribes. Since then almost every culture in history has practiced the removal of facial and body hair.

Native Americans used matching pairs of clamshells to pull out hairs one by one. Sumerians used tweezers, and the Egyptians had razors made of bronze. In the Arabian practice of "threading," a cotton string was used to encircle hairs one at a time and pull them out.Another approach involved rubbing with sandpaper-like abrasives that had the side effect of also removing the outer layers of skin.

Depilatories (creams and lotions) included liquids that hardened in place such as hot wax and sugar syrup, as well as substances that actually dissolved the hairs. Some early depilatories included highly poisonous chemicals like arsenic and caustic lye.

LCD venture between Toshiba and Matsushita will be one of the largest and most technologically advanced

In a boost for Singapore's electronics sector, two giant Japanese electronics corporations are setting up a $1.84 billion plant in Tampines to make liquid-crystal-display (LCD) panels. It will be one of the largest and most technologically advanced plants in the world.

The facility, a joint venture between Toshiba and Matsushita Electric Industrial, will be the first wholly owned Japanese LCD project outside Japan. While Singapore plants already assemble electronic devices, they have to import the LCD component.

Ko Kheng Hwa, the Economic Development Board (EDB) managing director, said, "This. . .is very significant as it marks the birth of a new industry cluster for Singapore's electronics industry."

The companies said they chose Singapore because of its excellent infrastructure, skilled manpower and strong supporting industries.

The joint venture has an initial capital of $750 million, with 67 percent owned by Toshiba and 33 percent owned by Matsushita.

Singapore's electronics industry is a key sector of the economy and its output rose 19.7 percent last year to $82.3 billion. It is grouped into four clusters—semiconductor, key modules, info-communications products and storage devices.

EDB director of electronics Barry Sim said earlier this year that new fields, such as advanced display technology, would be developed into a fifth cluster. ◆

Source: The Straits Times, Singapore

Second largest foundry invests $3.6 billion in 300mm fab in Singapore

United Microelectronics Corp.'s (UMC), the world second largest foundry has announced its plans to build a $3.6 billion 300mm fab in Singapore.

Munich, Germany-based Infineon Technologies AG and the Economic Development Board of Singapore have signed a deal to take a minority stake in the company.

The fab will be built in two phases with a total planned capacity of 40,000 wafers per month. UMC plans to break ground in the first quarter of 2001, with equipment move-in for the first phase scheduled for the third quarter of 2002. The facility will be constructed in Singapore's Pasir Ris Wafer Fab Park. ◆

Source: Electronic News

Agilent promotes semi industry in Greater China

Millions of companies, large or small from all over the world, are keeping an eye on China as it enters the World Trade Organization (WTO). Following the example set by other IT makers, IC makers now are seriously considering building foundries in China.

Agilent Technologies recently announced that it will promote its Semiconductor Test Equipment (STE) Taiwan Customer Business & Service Team from the local Taiwan region to the Greater China Region, which covers Taiwan, Mainland China and Hong Kong. David Huang, former general manager of STE Taiwan, has been appointed vice president and general manager of the STE Greater China Region.

Although it is a U.S.-based company, "Agilent is very successful in its localizations," Huang said. "On the one hand, we can help and support local companies; on the other hand, we can cooperate with other global companies as well.

"I think the development of the China IC industry is very similar to that of Taiwan. First, they now have many skilled engineers in China, as Taiwan previously experienced. As long as the Chinese government comes out with attractive programs, the engineers will go back to China. And through its cooperation with Taiwan and foreign companies, China also has a kind of policy similar to our science-based industry park here in Taiwan—relying on existing know-how. I am sure China will build its own IC industry with its abundant talents and with help from Taiwan companies," said Huang.

Huang gave three reasons for creating this new region. "First," he said, "the Chinese government has set a clear policy to support the semiconductor industry. It was previously difficult to do business without the government's support in China. Second we need to make an economic breakthrough, and China is a place to invest. Third, China is an attractive market — most PC makers have their production base there. There is no reason for the IC industry, which supports PC a lot, to keep away from China. With 10 years' accumulation of resources in China, Agilent will take this opportunity now to provide more support to our mainland customers, similar to what we now do in Taiwan."

As a leader of this new region, Huang said he has set three goals. The first is to grab the largest market share. Second is to become a "best partner" while our customers invest abroad. Third is to provide a more efficient top-down production process than competitors provide.

STE Taiwan has maintained a growth rate in the semiconductor business of 70 percent for several years. For 2000, they have U.S. $247 million. sales revenue with 107 percent growth compared to 1999. "Our existence is based on the real value that we can contribute to our customers," said Huang. ◆

DID YOU ? KNOW



How long was an hour in the ancient world?

The ancient Greeks, Romans, and Egyptians divided the day into 24 hours, but their hours were not all the same length.

The day was divided into 10 hours of light, two hours of twilight, and 12 hours of darkness. The timing of the hours in a given day depended on the position of the sun, so the hours' lengths changed with the seasons. It was not until the invention of mechanical clocks in the late Middle Ages that the hours were set to identical lengths.

Most of the earliest clocks used a moving shadow to indicate the passage of time. As early as 3500 BC, there were tall, thin stone obelisks whose shadows crossed the surface of a flat plaza over the course of the day. Those, and later sundials, were marked with varying scales of hours for the different seasons. A related device called the Merkhet was developed in Egypt around 600 BC to tell time at night by measuring the movement of stars.

Agilent hosts Seoul hospitality night



Lee Yih-Neng, Agilent's general manager of Asia, speaks before customers at a hospitality dinner in Seoul in late January.

A hospitality dinner for Agilent's Korean customers attended by nearly 100 customers was held in late January at the Interncontinental Hotel in Seoul.

The evening honoring customers included introduction of Agilent's new products: the V4400 and 93000 C200e/C400e as well as a discussion of cost-of-test. In the introductory presentation by Lee Yih-Neng, general manager of Asia, Agilent presented a new test approach known as its Intelligent Test solution.

"Today, the 'right cost' concept is important to customers to reduce test cost. Agilent shows how the cost of test has been realized and how concurrent test helps customers, since we have 61 years of experience," Lee said. This was the third annual Agilent Korea "Semicon Night." ◆

Samsung to roll out faster graphic memory chips

Samsung Electronics announced in late February that it began volume production of a higher capacity memory chip to be used in graphic applications, one of the fastest growing segments in the computer components market.

The company said Microsoft has already selected it as the graphics chips supplier for its X-Box game machines. It has already received orders for the first half of the year.

Samsung's new 128M synchronous dynamic random access memory (SDRAM) chip uses a technology called double data rate (DDR), which improves speed by activating output on both the rising and falling edge of the system clock, while existing SDRAMs work on just the rising edge. ◆

Source: Korea Herald

Samsung, Intel team up to expand Rambus DRAM production

Samsung Electronics of Seoul, Korea, and Intel Corp. announced in late February that they are partnering in an effort to expand the market for Rambus Inc.'s Rambus DRAM.

Both Intel and Samsung believe the market for RDRAM is increasing and by working together, the two companies said they can produce enough Rambus memory for Pentium 4-based workstations and desktop personal computers.

Under terms of the agreement, Santa Clara, California-based Intel will support capital investments that will be used to attain more component test and qualifying capacity to boost RDRAM production. Samsung will turn out at least 10 million RDRAM chips per month, the companies said.

Last month Samsung completed the development of a more affordable RDRAM, which would be used in PCs. Now that this deal has been secured, Samsung said it will expand its monthly output of 128M RDRAM to at least 10 million chips. Production will then be doubled to 20 million per month in the second half of this year. According to Samsung, this production rate will give the company at least 50 percent of the market for next-generation RDRAM. ◆

Source: Electronic News (Korea)

Sony relies on Agilent support for professional equipment

Sony's professional high-definition CCD video cameras are widely used throughout the world to address a variety of applications, from machine vision and industrial inspection to broadcasting and home video. To meet the needs of these demanding markets, Sony's cameras must capture exceptionally clear, full resolution images—usually of moving objects. Since 1990, Sony has been using semiconductor parametric test systems from Agilent to ensure highest quality for the devices that drive its world-leading electronics products.

The company

Sony Electronics offers a wide array of products and systems for image capture, production and display. Sony also provides specialized equipment and systems for data recording, duplication, electronic photography/publishing, videoconferencing, high definition video, interactive and security applications.

The challenge

Sony needed to achieve both temperature evaluation characteristics and ultra low current measurements for a silicon wafer—something that many believed to be impossible. Through a cooperative effort with Agilent Technologies in Japan and the U. S. and a third party, Sony achieved its goal using Agilent semiconductor parametric test systems.

The right test

Sony is using Agilent Parametric Test Systems not only for research and development, but also for production in its fabs. By using these test systems for characterization and production, Sony can ramp up semiconductor processes faster, creating highly reliable semiconductor devices in a short time.

The right cost

In addition to testing CCD devices, Sony also uses Agilent Semiconductor Parametric Testers for the 0.25um DRAM SOC process for the Graphics Synthesizer, the device at the heart of PS2. The unparalleled Graphics Synthesizer offers exceedingly advanced image-processing capabilities, on par with those of a supercomputer. Sony recognized it would have to ramp up to volume production very quickly to deliver this high-value product, while at the same time meeting the low cost and fast time-to-market requirements of the consumer marketplace. The keys for success were improved development efficiency and fast ramp-up of fab processes. Agilent's semiconductor parametric test systems played a crucial role in achieving both.

The power of information

For Sony, success rides on having parametric test systems that offer high performance, high reliability, and long uptime. "We're very satisfied with the parametric test systems and support team from Agilent Technologies," said Toyohiro Tsunakawa, assistant manger, LSI Business and Technology Group for Sony. "We can resolve issues through direct contact with each member in the Agilent professional team consisting of a field engineer, system engineers, and customer engineers. The Agilent Parametric Test Systems also can be easily, automatically diagnosed to ensure peak test system operation. And, nearly 100 percent test system utilization enables us to concentrate on process development and improvement."



'Since 1990, Sony has been using semiconductor parametric test systems from Agilent Technologies to ensure highest quality for the devices that drive its world-leading electronics products.'

Toshiro Tsunakawa
Assistant Manager, Process Development
LSI Business & Technology Development Group
SONY Corporation
Core Technology & Network Company

The transition to a 300mm fab environment

DID YOU? KNOW



Fun facts

Cost of raising a medium size dog to the age of 11: $6,400.

Coca Cola was originally green.

The Hawaiian alphabet has 12 letters.

Men can read smaller print than women; women can hear better than men.

City with the most Rolls Royces per capita: Hong Kong.

Percentage of Africa that is wilderness: 28 percent.

Percentage of North America that is wilderness: 38 percent.

What do bulletproof vests, fire escapes, windshield wipers and laser printers all have in common? All were invented by women.

The cruise liner, Queen Elizabeth II, moves only six inches for each gallon of diesel that it burns.

On average, 100 people choke to death on ballpoint pens every year.

If you were to spell out numbers, how far would you have to go until you would find the letter "A"? One Thousand.

The transition to 300mm wafers and full factory automation is a key topic today among most semiconductor industry managers and executives. Unlike the transition to 150mm in 1984 and 200mm in 1992, however, the 300mm transition is unique in three ways:

- Two major consortiums, I300I and J300, are leading an industry-wide initiative to set goals, plan, share R&D costs, and coordinate requirements across suppliers.
- Equipment standards are playing a pivotal role.
- Full factory automation is critical to meeting production cost targets, such as a 30 percent reduction in die costs compared with 200mm.

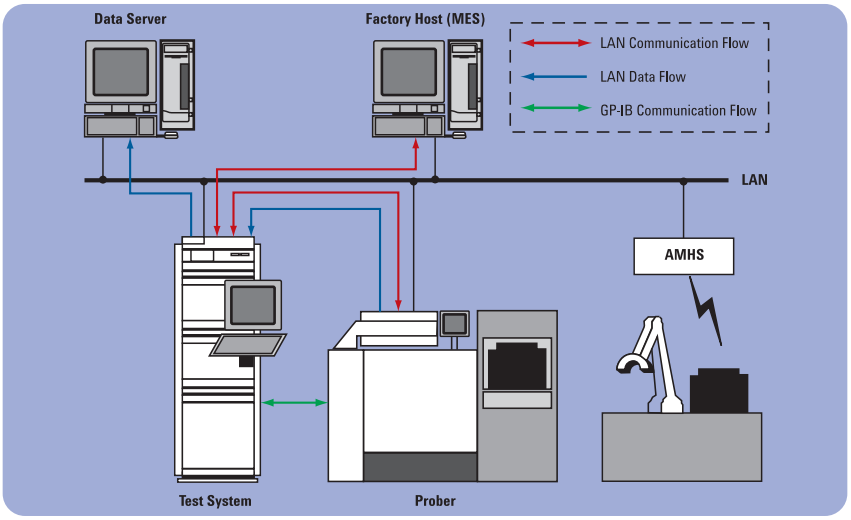
The consortia jointly released comprehensive guidelines, titled "Global Joint Guidance on 300mm Semiconductor Factories," at SEMICON/West 1997. By defining common performance objectives for tool performance from the outset, greater tool vendor and supplier participation is ensured, as is stricter adherence to equipment standards. The final realization of the initiative's goals came to fruition in January 2000 with the completion of Semiconductor 300, a joint pilot-line partnership between Infineon and Motorola in Dresden, Germany. Plans for the construction of 13 new 300mm fabs by 2003 have been published and at least six more pilot-lines have been announced.

The role of test in a 300mm environment

In-line parametrics and wafer sort testing is a critical element in semiconductor wafer processing and cannot be ignored. The SEMI standards that apply to 300mm test are E4, E5, E10, E23, E30, E30.3, E37, E39, E40, E42, E58, E84, E87, E90, E94, and E99.

Standards, however, seldom describe the specific end user application and implementation, and these particular standards describe only how a test cell should appear to the host computer. Effective implementation is left to the tool vendor, and the test vendor must understand that a test work-cell differs from any other wafer processing work-cell in two important ways:

- The test system and prober are provided by different companies



4070 Series now supports the C3600

The 4070 series of parametric test systems now supports Hewlett-Packard's "visualize" c3600 UNIX workstation. The c3600 replaces the older HP 745/132L workstation, which Agilent will stop selling as a controller option for 4070 test systems as of April 1, 2001. The c3600 runs at an impressive 552 MHz clock speed, nearly four times as fast as the 745/132L. The c3600 can be mounted into the 4070 rack (similarly to the existing 745/132L controller), as can an optional external tape drive. The C3600 has been thoroughly tested with the 4070 platform, so current 4070 customers using the 745/132L workstation can migrate to the c3600 workstation with no impact to their test plans. Contact your local Agilent Technologies sales engineer today for more information about how the c3600 can work to reduce your cost of test.



DID YOU? KNOW



What are the most common elements in the Earth's crust?

The Earth's crust is a complex mixture of many chemical elements, but only a few of them are very abundant. In the solid outer crust of our planet, almost all the mass is accounted for by only eight elements.

The most abundant element is oxygen, which also makes up 20 percent of the molecules in the air. By weight, 47 percent of Earth's crust is composed of oxygen atoms. Next is silicon, which combines with oxygen and other atoms to form hundreds of different silicate compounds. Silicon makes up 28 percent of the crust. Third is aluminum, a silvery metal that never occurs in pure form yet makes up 8 percent of the Earth's crust.

Of the remaining mass about 5 percent is iron, which gives many landscapes their reddish-brown color. Almost 4 percent of the crust is calcium, one of the main components of limestone. Sodium and potassium each weigh in at less than 3 percent, and magnesium comes in just under 2 percent. The remaining 1.4 percent of Earth's crust is composed of the other 84 naturally occurring elements.

Correction

The article on the Agilent 4155C/4156C ("New Semiconductor parametric analyzers help solve 300mm wafer process challenges," Winter 2001) showed the voltage resolution and accuracy of the unit as 0.2mV and 10mV (respectively). However, the actual resolution and accuracy are 0.2µV and 10µV (3 orders of magnitude lower than the article stated).

Choosing the right parameter analyzer

DID YOU ? KNOW



What planet has the most tilted axis of rotation?

In our solar system, the planet whose axis is most tilted to its orbit is Uranus, a distant, blue-green gas giant. Its extreme tilt of 97.86 degrees means that each pole of the planet faces the Sun directly for about one quarter of its 84-year orbit.

No one knows how Uranus got tipped so far out of alignment with the rest of the solar system. One theory is that an encounter with another large planet twisted its spin billions of years ago. That other planet was, perhaps, flung out of the system in the encounter.

Because of its extreme tilt, Uranus also has the most extreme seasons. It is now early spring in the northern hemisphere, and gigantic storms have just been seen for the first time in the planet's thick atmosphere. As big as continents on Earth, these huge storms are the first of a number of weather changes that will occur as Uranus enters its next long, slow season.

This is the first part of a series of articles designed to help you choose the semiconductor parameter analyzer that best fits your parametric measurement needs. When deciding on an instrument parametric measurement solution, you should consider many factors. Prominent among these are instrument quality and reliability, ease of use, flexibility, automation test speed, and instrument longevity. Obviously, you need to consider each factor carefully to ensure that a given instrument solution meets your needs. However, the most important thing is to make a balanced decision. Placing too much emphasis on any one feature may ultimately lead to you being unhappy with your choice, and may even require you to replace an instrument sooner than you would like. So how do you select among all these features?

Agilent Technologies offers a variety of options to fulfill your parametric measurement needs. The 4155C and 4156C Semiconductor Parameter Analyzers instruments feature intuitive front-panel control, which includes integrated control of the E5250A switching matrix. The 4155C and 4156C also have built-in quasi-static capacitance versus voltage measurement capability. Moreover, you can use the 4155C and 4156C as the system controller in automated applications. The 4155C and 4156C come standard with 4 Source Monitor Units (SMUs), 2 Voltage Source Units (VSUs), and 2 Voltage Monitor Units (VMUs). You can add additional resources (high-power SMU and pulse generator units) to them via the 41501B Expander Box. You should use the 4156C in situations where you need accurate low-current measurements (<1pA), or you need to make Kelvin (4-wire) measurements. Other than these situations, the 4155C and 4156C are identical in form and function.



The 4156C Precision Semiconductor Parametric Analyzer performing quasi-static CV.

Thus, by choosing either the 4155C or 4156C, and by selecting the appropriate options, you can configure a solution to meet virtually any parametric measurement challenge.

One often overlooked factor when choosing a parameter analyzer is simply the quality and reliability of the instrument hardware. All hardware is not created equal. In particular, when evaluating a parameter analyzer you should consider the following:

- Do the SMUs measure continuously across range changes?
- Do the SMUs exhibit any (voltage/current) spikes during range changes?
- Do the SMU specifications exceed the noise floor of the instrument?

Most problems with SMUs occur during range changes—the SMU has to switch circuitry in and out in order to perform the range change. A well-designed SMU will give you the same measurement answer regardless of whether you are approaching the range change from a lower range to a higher range, or from a higher range to a lower range. This consistency of measure-

ment performance has always been an Agilent strength and a weakness with our competitor's products. It should also be apparent that this type of performance is very hard to achieve using schemes involving external preamplifier circuits, which is why Agilent has never used them. Another problem that can occur at range changes in poorly designed SMUs is voltage/current spikes. Unless the SMU is clever enough to control the non-forced variable during a range change, a voltage/current spike frequently occurs. This problem shows up most frequently on heavily capacitive loads, and can often be large enough to damage the device under test. If nothing else, SMU spikes require you to increase the wait time during a measurement to ensure that the SMU has time to stabilize. Finally, specifying the measurement resolution of a resource beyond the noise floor of the instrument does not make any sense. For example, the high-resolution SMUs (HRSMUs) of the Agilent 4156C have a specified resolution of 1fA, and a readable resolution of 0.01fA. Agilent does not guarantee the validity of the two additional digits because noise (usually) makes them unreliable. Our competitor's has specified an SMU resolution of 0.1fA. However, this specification greatly exceeds the noise floor of their instrument, giving them an effective current resolution much worse than that of the 4156C. The bottom line is that you should never accept performance claims at face value, and you should verify the performance of any instrument before signing on the dotted line.

Benchtop parameter analyzers designed for interactive use need to be versatile, allowing you to control the instrument in more than one way. At a minimum, a well-designed instrument should allow control through both push buttons on the instruments and a keyboard. Only supporting instrument control via a mouse and keyboard can be very limiting, particularly if the instrument is ever mounted into a rack. The 4155C and 4156C exceed these requirements by allowing you to control the instrument in three different modes: push button, keyboard, and knob sweep. The 4155C/4156C front-panel interface enables you to set up a variety of spot, sweep, sampling and quasi-static CV measurements quickly and easily through a few simple menus. Moreover, the 4155C/4156C front-panel user interface can be accessed using either push button on the front of the instrument, or via the optional keyboard. The additional knob sweep mode is essentially a curve tracer emulation mode, for those users who are more comfortable with this type of interface. The 4155C and 4156C also now have control of the E5250A switching matrix integrated into the front panel menus, allowing you to create a benchtop CV-IV measurement station without the need for an external PC. However, if you want a Windows 98 or NT interface with GUI control, Agilent offers Interactive Characterization Software (ICS). ICS can be used to control the 4155C, 4156C, 4284A, and E5250A using an external PC. Separating the PC from the instrument offers many advantages, including ease of upgrading the PC hardware, the ability to rack mount the instruments, and immunity from software incompatibilities "crashing" your instrument. Therefore, the important point is not whether an instrument uses a standard or proprietary operating system, but how well the interface(s) are designed within the operating system that it uses. ◆

DID YOU ? KNOW



More useless but interesting information

There are more plastic flamingos in the U.S. than real ones.

The average person falls asleep in seven minutes.

In Chinese, the KFC slogan "finger lickin' good" comes out as "eat your fingers off."

More than 50 percent of the world have never made or received a phone call.

We shed 40 pounds of skin in a life time.

Girls see better than boys in the dark.

Brains are more active sleeping than watching TV.

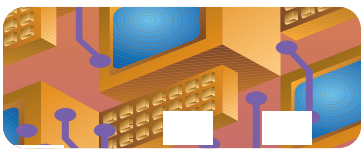
Blue is the favorite color of 80 percent of Americans.

There are more chickens than people in the world.

The thumbnail grows the slowest, and the middle nail grows the fastest.

Everyday, 0.5 percent of the world visits a McDonald's.

Children grow faster in the spring.



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http://www.agilent.com/go/semiconductor

Economical testing of gigabit chips

DID YOU ? KNOW



Well, that explains it

According to the Alaska Department of Fish and Game, while both male and female reindeer grow antlers in the summer each year (the only members of the deer family, Cervidae, that have females do so), male reindeer drop their antlers at the beginning of winter, usually late November to mid December.

Female reindeer retain their antlers until after they give birth in the spring.

Therefore, according to every historical rendition depicting Santa's reindeer, every single one of them, from Rudolph to Blitzen . . . had to be a girl!

We should have known. Only women would be able to drag a fat man in a red velvet suit all around the world in one night, and not get lost.

The characterization and production testing of communication System-on-a-Chip (SOC) devices with embedded gigabit link interfaces is a major challenge for semiconductor manufactures. New test methodologies and new test equipment are required to cope with the specific test problems inherent to these devices.

The high bandwidth of telecom chips through advances in semiconductor technology is boosting the speed of data rates over fibre and copper to several Gbit/s. However, such chips are a major challenge for semiconductor manufacturers, and to produce the high volumes economically requires an improvement in the test methodology.

The challenges of testing gigabit serial links

Jitter. Jitter is the key performance measure. Clock sources have to be chosen with respect to their jitter performance. These sources also need a capability for phase modulation to inject precisely controlled jitter to the DUT.

Bit error rate measurement (BER). The main challenge here is that a traditional BER scan takes minutes for BER beyond 10^{e-12}, even at gigabit data rates. An approximation measures a sample size for a BER of 10e-6 and extrapolates to the target BER. Such a scan requires dedicated high-speed equipment, synchronized with the ATE.

Eye diagrams. While the focus of the BER measurement is the correctness of the data, the eye diagram examines the signal waveform characteristics. Accurately digitizing the signal requires equipment with a bandwidth over four to five times the frequency of the bit clock.

Agilent's solution

Agilent's Parametric Communications Test Option (PCT3600) is an integrated solution. It contains extensive characterization capabilities and provides a scalable low-risk transition from characterization into low-cost production. Figure 1 shows the modular structure of Agilent"s 93000 SOC Series Parametric Communication Test Option.

The Data Communication Analyzer (DCA) is used to acquire, display and test signals used in high-speed

Architecture of the 93000 Gbit serial link test solution

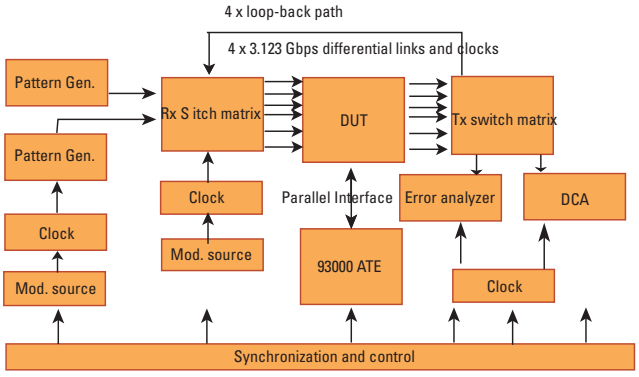


Figure 1

serial standards. The DCA is used to measure jitter, rise/fall times and signal levels on the high-speed line interface of the device under test. It is used for eye diagram mask tests.

A low-jitter clock source is used to provide low jitter reference clocks for the device under test, the Bit Error Rate Tester (BERT) and the DCA. It also provides a phase modulated reference clock or a high-speed bit clock for jitter injection.

The switch matrix matches the bandwidth requirements of data signals up to 3.125 Gbps, for up to four physical layer line interfaces. The matrix also handles access to any available high-speed bit clocks at the device under test.

Characterization

The jitter measurement is mainly determined by testing with respect to a mask for tolerance and generation. The user specifies the mask as an array of jitter frequency and amplitude coordinates. For margin measurements, a sweep of the jitter amplitude is executed at a given frequency. Jitter measurement is performed by the DCA. The DCA records the eye diagram of the high-speed serial data signal with respect to the low-jitter reference bit clock.

Jitter generation and transfer

During the jitter transfer test for the transmitter, jitter is injected into the reference clock and the DCA measures the jitter at the output of the serial link interface of the transmitter. During the jitter transfer test for the receiver, jitter is injected into the pattern supplied by the BERT to the receiver serial line interface. The resulting jitter is measured by the DCA at either the recovered bit clock or the word clock. Jitter frequencies are swept for both the transmitter and receiver tests.

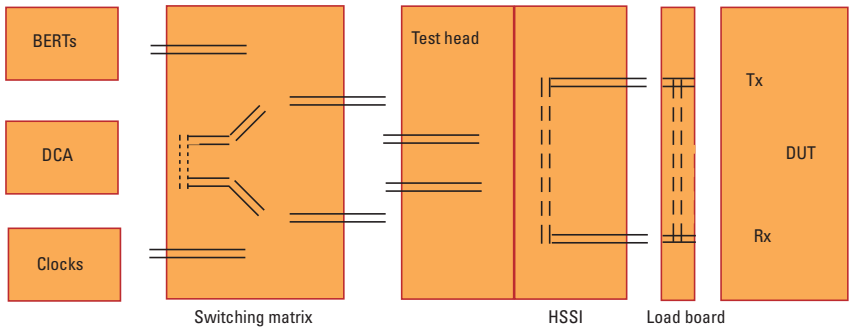
Production solution

The final target for production is a loop-back test configuration to achieve lowest cost. This is possible as soon as extensive characterization ensures parametric performance by design. The production test solution is based on external loop-back at the link interface; this will include the parasitics of the high speed I/Os. The loop-back path may be created in the switching matrix or at the HSSI (High Speed Serial Interface). *(See Figure 2.)* The modular nature of this test solution allows a gradual transition from the characterization setup used in development to this loop-back configuration. The advantage of this approach is a short development time for a production test that correlates to characterization measurements.

Summary

To achieve an economical solution, the Parametric Communication Test Option (PCT3600) on the Agilent 93000 SOC Series provides investment protection with a single scalable platform from full parametric characterization to the lowest cost volume production. ◆

Possible external loop-back path on the serial side



DID YOU ? KNOW



How do sea cucumbers defend themselves?

A sea cucumber may seem harmless. It is a soft, slow-moving creature with a rubbery hide, but it has an effective defense. If it is attacked violently, it quickly ejects part of its own intestines onto the attacker.

Although it may seem like an overreaction, this defense is highly effective. The attacker is suddenly snarled in a mass of slimy, sticky, stringy goo, preventing it from further attack. Meanwhile, the sea cucumber escapes and spends the next six weeks of its slow life regenerating its internal organs.

Sea cucumbers do not often have to resort to such an extreme defense. Many kinds are poisonous, and some are brightly colored to advertise their toxic nature. Most predators focus on more tasty creatures, but in a strange twist of evolution a few have developed the ability to eat the cucumber's ejected intestines.

global calendar

APRIL
SEMICON/Europa
April 24—26
Munich, Germany

Winning in the Wireless World
Agilent's Wireless IC Test Trends
April 27
Munich, Germany

MAY
Winning in the Wireless World
Agilent's Wireless IC Test Trends
May 7— Seoul, Korea
May 11—Singapore
May 14—Taiwan

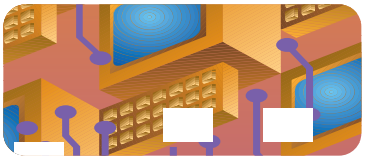
SEMICON/Singapore
May 8—10
Singapore

Wireless Expo
May 21
Seoul, Korea

JUNE
NEPCON
June 27—28
Malaysia

JULY
International Manufacturing Equipment Show
July 3
Taipei, Taiwan

SEMICON/West
July 18—20
San Jose, California



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