GILDER TECHNOLOGY REPORT

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Seattle Sunburst

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Inside:

Bursting through the gray mists of Seattle, where I visited my friends at Discovery Institute this week, the world of technology continues to rise and rotate at an ever accelerating pace. Not only was the Optical Fiber Conference in Anaheim full of exciting advances, but our old friends at **Terabeam** in Seattle, the free space optical pioneers, command several hundred millions of cash, a new compact Elliptica in-window optical transceiver, and serious traction at major carrier customers. Widely deployed in six U.S. and European cities, Terabeam's gigabit Ethernet "lambda laterals" promise to break open the last few hundred meters between fiber optic networks and the in-office domains of urban businesses, without any costly under-street excavations or even in-building "riser" fiber optics between floors.

While the pace of advance in optics remains furious, however, the finances of telecom remain deep in the doldrums. We will have ample time to cover these innovations in months and years to come. More important for investors in the immediate future is a sudden siege of radical innovation in semiconductors, led by the companies inspired by the new analog paradigm of Caltech's Carver Mead. The one chip Foveon camera (*GTR* February 2002) is only the beginning.

Having devoted my book *Microcosm* heavily to the history of **Intel Corporation** (INTC), I do not lightly use the appellation "the next Intel." My favorite current digital chip innovator, **EZchip** (LNOP), seems on the verge of releasing to the world a network processor some two whole generations ahead of the competition, including Intel. EZchip's audacity is equaled only by the ingenuity of its key Intel defector engineers in Israel. But EZchip is relying on **IBM** (IBM) to produce its extraordinary new design. A key to the innovation is IBM's ability to integrate dynamic random access memory cells on an ordinary CMOS logic chip. By contrast, Intel itself not only largely invented the new devices it unleashed back in 1971—the microprocessor, the DRAM, and the Erasable Programmable Read Only Memory (EPROM)—but it also contrived the process by which they were fabricated. **JDS Uniphase** (JDSU) promised to dominate the component scene in optics, and I dubbed the company an "Intel of the Telecosm," but the fact is that JDSU, impressive though it is in its industry-leading range of optical products, is not introducing a revolutionary innovation in any single area.

Last week in Seattle, however, sitting in a conference room in a drab office structure on the north side of Lake Union, I had the distinct feeling that I was experiencing an historic moment in the history of semiconductors, truly comparable to the unique sunburst of Intel's revolution of 1971. The source of the innovation is Washington professor Chris Diorio, the former Carver Mead student most thoroughly exploiting his analog VLSI paradigm, and founder of the next chip giant, **Impinj**. By putting the analog circuitry linking every chip to the real world on a Moore's law path where everything gets cheaper and better as it gets smaller, Impinj will make mixed-signal microchips a routine product of commodity wafer fabs. Every other semiconductor company making systems on a chip in the old way will have to respond. Few will succeed. So along with its luminosity, Impinj casts a deep shadow. We will be writing much about this amazing company in months to come.

Meanwhile, the key to EZchip's apparent accomplishment is to break what might be called the Intel bottleneck. Although the world is preoccupied with the last mile bottleneck, the bandwidth bottleneck that concerned me first—and the one that gave rise to our entire system-on-a-chip (SoC) paradigm—was the bottleneck inside the computer itself. The logic-memory bottleneck.

It was clear even in the mid-1990s that although the density of both memory and logic scaled with Moore's law—doubling every eighteen months—the performance of memory, where bits are stored, lagged that of logic, where bits are processed. As Nick Tredennick and Brion Shimamoto of *Dynamic Silicon* explain in their superb March 2002 report, "In 1981, microprocessors and DRAMs were about the same speed…" At 4.77 MHz, the clock of an IBM PC processor ticked once every 210 nanoseconds, and it could access its 64 Kb DRAM chip once every 225 nanoseconds. Virtually identical. The chips ran in synch. Over the last 20 years, however, even as DRAM capacity has kept pace with Moore's law—witness the gigabit DRAM available from **Samsung** and others next year—the time it takes to search that memory has not. A vast and crippling performance chasm has opened. In 2002, leading edge microprocessors are 60 times faster than DRAMs.

The router on a chip will not be realized without IBM, increasingly the across-the-board leader in process technologies

As Amdahl's law tells us, a system is only as fast as its slowest component. Thus, clock speed advances, now beyond 2 GHz in the Pentium 4, are wasted. Tredennick and Shimamoto detail these rapidly diminishing returns. Depending on how often the Pentium 4 must go "off-chip" to access the DRAM instead of its small on-chip cache, a 100 percent increase in clock speed can result in a systemic performance increase of just a few percent. The upshot is that the clock frequency is no longer a limiting factor in PC performance. Most of us could not tell the difference between a 1 GHz computer and a 2 GHz computer, but we all know it when our RAM is doubled.

This bandwidth bottleneck takes on new meaning as we move out of the world of web surfing and spreadsheets and into the world of packet processing on the high-speed optical Internet.

There the challenge is to parse, sort, alter, and route ten billion bits of disparate, far-flung data in a single second, a task far too speedy and complicated for a Pentium. Today a router or switch is a box, a big, expensive box full of custom ASICs, memory, classifiers, and the wires and interfaces connecting them all together. Tomorrow the router could be a chip.

The company closest to creating a router on a chip is the same one that is most aggressively dissolving the bandwidth bottleneck between logic and memory, the one transcending the off-chip light-speed delay, the one potentially cutting the cost of a 10 gigabit router by 90 percent, enabling a faster, smarter, more profitable Internet. The company melding logic and memory is EZchip.

To route a 10-Gbps Internet stream, you need at least 320 Gbps of memory bandwidth, and you need to store more than one million IP look-up tables. But a Pentium 4 doesn't come close. While the link between the Pentium 4's two on-chip SRAM caches achieves 384 Gbps, it has 10 times less on-chip memory resulting in some 10 times more off-chip searches. Going off-chip to a gigabit DRAM yields just 25 Gbps. EZchip's ingenious design puts 5 MB of DRAM on the same chip as its 64 custom processors, eliminating most of the time-consuming off-chip searches, and squeezing out 500 Gbps.

Fab-u-lous IBM

Without a partner, however, EZchip's ideas would have remained in slideware. The router on a chip will not be realized without the help of embattled Big Blue. Although distracted by SEC investigations and earnings disappointments, IBM is increasingly the across-the-board leader in process technologies.

From silicon germanium to copper interconnects, and from 90 nanometer geometries to embedded DRAM, IBM has mastered silicon manufacturing and become the fab of choice for designers of advanced microchips. In a recent *Electronic News* article, rivals claim IBM is struggling with "yield and material issues" in its 130 nanometer process. If that is so, asks the same article, why did IBM's ASIC business grow in 2001, even as its closest competitors suffered 20 to 40 percent revenue declines?

One fabless chip company CEO summed it up: "IBM is very demanding, and they may not be the fastest, but they are meticulous—and they deliver chips that work."

EZ does it?

EZchip followed this latest trend and went to IBM to solve the embedded DRAM challenge. Logic gates must be fast, so they tolerate "leaky" transistors that never turn off completely. The threshold between a "1" and a "0" is somewhat fuzzy. But DRAM transistors need to hold their "1s" and "0s" on a capacitor for precious microseconds to read and write the stored data. Logic chips and dynamic memory chips are therefore built differently. Most on-chip memory is static random access memory (SRAM), which is highly compatible with logic circuits but is at least six times less dense than DRAM. EZchip, running at 200 MHz, can outpace a speedy 2 GHz Pentium because it chooses the path that's "low and slow." Its parallel processors more closely couple the clock frequency with the memory speed, yielding increased performance at just one-quarter the power dissipation.

Some DRAM suppliers are developing double-data-rate DRAM (DDR DRAM) ahead of the industry-standard schedule—attempting to deliver 400 MHz products this year, while DDR-333 MHZ isn't due until 2003 and DDR-II-533 MHz until 2004. Even with DDR-400 MHz, however, system level bandwidth is just 25 Gbps, an order of mag-

nitude less than the 500 Gbps that EZchip achieves by placing the DRAM and logic on the same chip.

Putting 5 MB of DRAM on a high-performance semiconductor like EZchip's NP-1 would be a real advance and would signal new possibilities across numerous silicon applications. Previous announcements foretold a March 2002 delivery of samples to EZchip, so any day we might learn whether IBM has taken another step ahead of the fabrication pack—and whether EZchip has consummated our system-on-a-chip paradigm with the world's first silicon router.

If EZchip can really reduce the electronics cost of gigabit Ethernet by 80 or 90 percent, you might ask what the optical guys are doing to pull their weight.

Turpin resPONds

Camouflaged amid March's Optical Fiber Conference confusion—850 technical papers, up 47 percent over 2001, and 1,204 peddlers, up 24 percent—were a handful of breakthrough products and innovations poised to lead analog optics to the sea of digital PCs. It was Terry Turpin's law that helped us drown out the noise: when we're on the right path, things get simpler; when we throw away components, we know we're right.

Turpin himself put us on the trail—look for thousands of lambdas all the way down to the access networks, he said. "The PON (passive optical network) guys are excited about Hyperfine because you can take lambdas up to the passive broadcast splitters." Already, gigabit Ethernet vendors are asking Turpin about 3.125 gigahertz Hyperfine lambdas. With **Essex** (ESEX), each gigabit Ethernet data-stream gets its own analog transport. It's simply cheaper and better than combining several GigE streams onto a fatter WDM wavelength.

At issue is cornucopian connectivity. In the wavelength division multiplexed (WDM) network, multiplexers take several "colors" or wavelengths of infrared light, each bearing a separate bitstream, and fuse them together on a single fiber. Demultiplexers separate them again at the other end to be sent to their destinations. In between, amplifiers boost the signal down the line; without them it dwindles and has to be recovered by electronics.

Each wavelength or frequency, also called a channel, bears information in the optical network. The difference between pushing the technology toward more wavelengths and pushing it toward fewer, higher bitrate wavelengths is the difference between multiplying connections and multiplying the capacity of a single connection. How many wavelengths can we fit on a single fiber and thus how many customers can a single fiber or cable serve?

As wavelengths move closer together in spectrum space, Turpin tells us, they line up and behave better and use a fraction of the power. With too much power, the wavelengths will interfere with each other and quickly become unreadable unless they are spread further apart across the spectrum. Lower-powered wavelengths carry fewer bits per second but are plenty spacious for a single customer.

Undulating through a point in space like a sine function, lightwaves exhibit characteristics of length (the distance from one wave peak to the next), frequency (the number of waves passing a fixed point in one second, called hertz), and amplitude (the height of the peaks and troughs). In a given medium each color of light has a unique wavelength. Turpin's Hyperfine mux can combine and separate wavelengths just 25 picometers (trillionths of meters) different in length, equivalent to 3.125 GHz (billions of hertz) in frequency. At a maximum data rate of one bit per hertz, Turpin can easily carry the billion bits per second of GigE over his well-ordered channels. By contrast, the densest spacings in today's operational systems are 100 GHz, with 50 GHz at the cutting-edge, each channel transporting 2.5 or 10 gigabits per second (Gbps).

Smaller lambdas are more abundant lambdas since each takes up less spectral space. In the standard fiber transmission window, we can fit up to 200 carrier channels at 50 GHz spacing. With 3.125 GHz Hyperfine lambdas, we get 3,200 data-bearing channels. That's connectivity.

Pundits often laugh at our talk of "thousands of lambdas on a single fiber, millions across the network." But with **Broadwing** (BRW) selling them by the dozens, it won't be long before our bravado becomes cliché. Thousands of lambdas do, however, present challenges. Along with thousands of lambdas per fiber come an astronomical number of lasers to transmit signals down fiber optic lines. Cost, power dissipation, and reliability are the key concerns. Today, the dominant lasers are fixed. They can only emit a single frequency band. If the user wants to shift to another, he must invoke a different laser permanently tuned to another light path.

Following VCSELs to their logical market, Bandwidth9 reaps rewards which elude competitors

Over the past few years, some dozen companies have emerged to pursue the dream of a laser that can be tuned over an increasingly wide band of colors. With such "tunable lasers," only one or several need be kept in inventory as spares, solving the burdensome stock and maintenance problem. Even more important, tunable lasers add flexibility to optical networks, increasing wavelength options at each node and thereby reducing the number of lasers needed to source thousands of lambdas.

Looney tunes

Tunable laser gurus are using a baffling diversity of technologies. But the potential winners can be separated from the likely losers by the filters of simplicity and of scalability to dense channel-spacings. Most of the complexity being built into tunable lasers devolves to the misguided quest for powerful lambdas that can stretch over great distances and for wide spectral tuning ranges regardless of channel density.

TELECOSM TECHNOLOGIES

ONI Systems (ONIS)

METRO WDM PLATFORMS

MAR '02 MONTH END: 5.85 | 52-WEEK RANGE: 3.50 - 40.95 | MARKET CAP: 828.1M

MORE DIRTY LAUNDRY—ONI and future mate Ciena can't escape the telecom downdraft. Sent reeling by Ciena's revelation of a 28% slide in promised January-quarter revenues, ONI returned the favor, cutting its revenue projections for the March quarter in half, from $41 million to $18-$24 million, and inflating its expected loss per share by up to 9 cents. The acquisition now bounces back in favor of Ciena as ONI revenues fall from 42% to 20% of Ciena's April projections of $100 million. The bruised couple now combines at some $120 million in sales compared to $265 million barely a month ago.

That's a Switch: Ciena announces an all-optical add/drop mux based on Corning liquid crystal technology. CTO Steve Alexander heard muttering, Where're the bits? Perhaps there's hope for ONI CTO Rohit Sharma.

JDS Uniphase (JDSU)

ACTIVE AND PASSIVE OPTICAL COMPONENTS

MAR '02 MONTH END: 5.79 | 52-WEEK RANGE: 4.74 - 29.50 | MARKET CAP: 8.7B

ANY TAKERS?—In a whirl of activity defiant of telecosmic entropy, JDSU set OFC to drooling over new showroom models such as ever smaller erbium amplifiers, digital Raman pump units, a WDM power balancer, tunable lasers, wavelength monitors, dispersion compensators, 25 gigahertz add/drops, transponders, muxers, whatever. All paradigm paraphernalia. Now, if only someone will buy the stuff.

Avanex (AVNX)

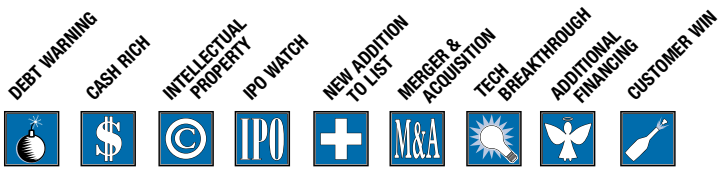
ADAPTIVE PHOTONIC PROCESSORS

MAR '02 MONTH END: 4.06 | 52-WEEK RANGE: 2.70 - 19.20 | MARKET CAP: 281.5M

OPLINK ANNEX—On March 18, Avanex and fellow passive component supplier Oplink announced they would merge companies. "With the Oplink merger, we wanted to settle the debate over who was number two," Simon Cao told us, referring to the competition among smaller companies to move in behind JDS Uniphase as the second largest supplier of passive WDM components and modules. "Oplink gives us a strong foothold in the commodity parts market, and we'll continue to design and sell custom, high-end modules and subsystems." Potential technology pluses for Avanex, which will continue to spearhead R&D: Oplink's fiber Bragg gratings; amplifier components such as tap couplers, isolators, and gain flatteners; EDFA modules; and acousto-optics based on the principle that sound waves in crystals and fibers can filter lambdas. Customer, cost, and technology synergies—and $400 million in cash—may prove crucial to each company's survival. Avanex also announced two new products based on its Lambdaflex liquid crystals: a scalable, tunable wavelength router dubbed PowerRouter, and a power balancer, dubbed…you guessed it…PowerBalancer.

Oplink Verdict: Overall positive for Avanex, pending feng shui approval.

KEY



Essex (ESEX.OB)

OPTICAL PROCESSORS

MAR '02 MONTH END: 5.85 | 52-WEEK RANGE: 2.88 - 8.25 | MARKET CAP: 29.7M

HYPERACTIVITY—The Hyperfine multiplexer moved into hypergear at OFC as WDM innovators gathered around one of the leading minds in all technology—Terry Turpin. Lead by Fiberspace with its hyperstable laser-locker, and followed by the University of Central Florida's hyperdense multi-line laser, Harris Corporation's hyper-ready manufacturing, and hundreds of hyper-accessible lambdas over multimode fiber from the University of Essex in England, companies from across the industry spectrum are taking notice of Turpin's insight and technology.

The hype? We can't find any.

Corvis (CORV)

WDM SYSTEMS, RAMAN AMPLIFICATION, EDGE SWITCHES

MAR '02 MONTH END: 1.25 | 52-WEEK RANGE: 1.08 - 10.77 | MARKET CAP: 456.4M

BANK ON IT—Carriers are croaking, but Corvis-enabled Broadwing remains steady and is now considered *the* source for lightwave lambda services. After witnessing Broadwing's record Teleglobe deployment of 58 OC-192s in 90 days last year, Bank of America (BoA) came calling. The result is another record—14 OC-48 circuits in just three weeks—not to mention BoA's very own 2.5 Gbps national express enterprise backbone for a scant $70 million. Sonet-based "competitors" would have taken 12-18 months and charged five times as much. At Broadwing prices, look for more *Forbes* 500 companies to "build around the Bells," replacing specialized, costly retail telecom services with big, cheap, dumb bandwidth.

Stupidity Paradox: Note to David I.—brainless networks can indeed make money.

StorageNetworks (STOR)

DATA STORAGE MANAGEMENT, SOFTWARE

MAR '02 MONTH END: 3.36 | 52-WEEK RANGE: 3.10 - 23.54 | MARKET CAP: 326.9M

Despite volumes of innovation revealed at Storewidth 2002, the recurring theme from last year's conference was that data storage management remains a staggering task. That's why customers like Worldcom, BellSouth and EDS, with hundreds of petabytes of data outsource enterprise storage management to StorageNetworks. Signing several new engagements with the likes of British Telecom and Freddie Mac, and upping services to existing customers, like State Farm and Salomon Smith Barney, STOR reported narrower than expected 1Q loss. With revenues up 17% over 1Q01 and its first EBIDTA positive quarter, STOR has $273.5 million in cash and expects a reduction of $600 thousand per month in operating expenses from employee headcount reductions. Look for STOR's first stand-alone software product in the second half of this year.

Scale Eight

MASSIVELY PARALLEL GLOBAL STORAGE

PRIVATE

LOOK OUT NETAPP—Previously a provider of global storage *services*, Scale Eight now has a network attached storage (NAS) *product*. At Storewidth 2002, Scale Eight founder and CTO Josh Coates announced distributed software that enables pools of NAS boxes to be aggregated to increase capacity and performance with a single system management interface. Swimming with the storage commoditization current, Scale Eight's solution puts all the intelligence in software and leverages plummeting prices for 2 GHz processors

MEAD'S ANALOG REVOLUTION (see Carver's Companies/page 8)

National Semiconductor (NSM)
Synaptics (SYNA)
Sonic Innovations (SNCI)
Foveon
Impinj
Applied Neurosciences
DigitalPersona

COMPANIES TO WATCH

Analog Devices (ADI)
Bandwidth 9
BlueArc
Blue Sky Research
Fiberspace
Samsung
Xilinx (XLNX)
Xtera

and high-capacity disks. Look for Distributed Storage Software in the third quarter.

Fast chips, cheap disks: At Storewidth Google's Larry Page seconded Scale Eight's commodity hardware strategy, citing the search engine's well-known reliance on "10,000-plus cheap Linux boxes." Most of the industry, however, insists that enterprise customers still want customized, high-end performance.

Mirror Image Internet

GLOBAL CACHING AND STOREWIDTH PLATFORM

PRIVATE

AT YOUR SERVICE—Preparing enterprises for the impending impact of web services, Mirror Image is adding an application delivery network for web services on top of its existing CAP (content access point) infrastructure. While Mirror Image's CDN (content delivery network) business remains viable, its CAPs encapsulate the three basic elements of storewidth; bandwidth, storage, and computes, making them ideal vessels for multiple value-added services for existing customers. Addressing many of the unsolved challenges of web services, the Mirror Image infrastructure will also provide a platform for the billing, reporting, and centralized management of web services.

Equinix (EQIX)

SECURE INTERNET BUSINESS EXCHANGES

MAR '02 MONTH END: 1.19 | 52-WEEK RANGE: 0.33 - 3.53 | MARKET CAP: 95.2M

SAFETY FIRST—Growing amid the carnage, Equinix maintains its neutral position at the center of Internet traffic where it sits miraculously unaffected by all of the disruptions in the co-lo and hosting (data center) industry. Security and continuity upheaval on 9-11 brought IT spending into focus in the last seven months and triggered a migration of mission-critical, enterprise equipment to strategic locations on the network, driving revenue from the single source hosting providers to Equinix peering and exchanging super-centers. Playing multiple, competing backbone and service providers off one another, Equinix continues its quarter on quarter growth-increasing performance while decreasing costs. Serving 5 of the top 7 content providers, including Yahoo!, MSN, and Google, Equinix retired $42 million in Senior Notes over the past six weeks, reducing its total debt obligations by nearly $130 million since October 2001 and this week was ranked third for the "fastest sales growth among the largest 300 companies in Silicon Valley," by the *San Jose Mercury News*. Accelerating its time to profitability, EQIX looks to be cash flow positive by year's end. Watch Wednesday, April 24 for Equinix's 1Q earnings announcement.

Sprint PCS (PCS)

NATIONWIDE CDMA WIRELESS NETWORK

MAR '02 MONTH END: 10.08 | 52-WEEK RANGE: 7.22 - 29.05 | MARKET CAP: 10B

Investor demand turned a proposed $2 billion bond offering into a $5 billion harvest, relieving the Street's liquidity concerns. First quarter results were better than expected for subscriber growth, churn, and EBITDA. Net additions of 725,000 beat the consensus estimate of 690,000 and dwarfed Cingular's 234,000 net additions. Churn of 3.0%, lower than the 3.1-3.2% estimate, should relieve some concern over the credit worthiness of Sprint's customers, many of whom use the ClearPay ASL (pre-pay) program. EBITDA of $640 million was better than the consensus estimate of $590 million and a 153% increase over 1Q01.

Qualcomm (QCOM)

CDMA MICROCHIPS, IP, SOFTWARE

MAR '02 MONTH END: 37.57 | 52-WEEK RANGE: 31.03 - 71.04 | MARKET CAP: 28.8B

QCOM BOOSTS UNICOM—Carriers smart enough to have chosen Qualcomm's CDMA technology migration are seeing results. In the last month, Verizon Wireless expanded its data-friendly 1x coverage to 13 new cities, covering 33% of its subscribers today and 50% by the end of May. Japan's KDDI launched 1x services on April 1 in 33 municipalities and 477 regional communities, compared to NTT DoCoMo's next-generation WCDMA-based network coverage of Tokyo only. KDDI is promising 85% coverage by year end, more than double DoCoMo's commitment, and is also joining its Korean CDMA counterparts by deploying 2.4 Mbps 1x EV-DO services in time for this summer's Soccer World Cup. China Unicom CDMA subscribers now total over 800,000. Recovering from a aberrant February, growth accelerated massively with 280,000 new Chinese subscribers between March 18 and April 7.

CDMA in China: Only one billion to go.

Altera (ALTR)

PROGRAMMABLE LOGIC DEVICES

MAR '02 MONTH END: 22.00 | 52-WEEK RANGE: 14.66 - 33.60 | MARKET CAP: 8.5B

Equipment vendors are restocking communications ICs now that the inventory bulge has subsided. That's good news for Altera and Xilinx, who analysts believe will report calendar first quarter earnings at the high end of guidance. Restocking is not the same as new growth, however, so until the telecom, wireless, and storage sectors restart their engines, Altera can only outpace the industry by invading the microprocessor, DSP, and ASIC markets—the Nick Tredennick strategy. With its brand new Stratix line, Altera is obliging, integrating memory and new DSP functionality on a chip 40% faster than its own Apex II family.

Storewidth Bandwagon: Pirus becomes latest storage vendor to use Altera's PLDs to speed the data path, a la BlueArc.

EZchip (LNOP)

10 GIGABIT NETWORK PROCESSORS

MAR '02 MONTH END: 11.69 | 52-WEEK RANGE: 2.70 - 14.00 | MARKET CAP: 85.2M

DRAM DELIGHT—Are you ready for some *good* news from Israel? Although we wish the president and Secretary Powell well, in the short term we're more likely to receive glad tidings from EZchip than Arafat.

Operation Toaster: Net processor critics ask whether EZchip can succeed without landing Cisco and its implied chip volumes. EZ CEO Eli Fruchter says, "It's not a matter of if Cisco will choose a network processor, but when." [Operation Toaster is the name of Cisco's internal net processor project…]

Broadcom (BRCM)

BROADBAND INTEGRATED CIRCUITS

MAR '02 MONTH END: 35.80 | 52-WEEK RANGE: 18.40 - 53.35 | MARKET CAP: 9.6B

CYNICAL STRONGMAN—Henry Nicholas resumed his acquisition spree of 2000 with the purchase of Mobilink, designer of GSM and GPRS mobile handset chips. Getting into the GSM/GPRS business as CDMA continues its ascent is not a great long-term move, but Broadcom's strategy has usually been to enter a market as it approaches maturity and then dominate it with the cheapest and most integrated designs.

Caveat: If Europe doesn't fix its two big 3G problems—a crushing $110 billion in debt used to purchase new spectrum licenses and WCDMA technology that no one besides Qualcomm has successfully delivered—GSM/GPRS could dominate the continent for several more years.

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Texas Instruments (TXN)

DIGITAL, ANALOG, MIXED-SIGNAL PROCESSORS

MAR '02 MONTH END: 32.93 | 52-WEEK RANGE: 20.10 - 42.91 | MARKET CAP: 57.2B

Texas Instruments reported results for the March quarter slightly above expectations. Revenues of $1.827 billion were up 2% sequentially, better than expected but down 28% versus last year. The strength in TI's business during the first quarter flowed most notably from the analog semiconductor business, which saw revenue up 8% sequentially orders up 30% sequentially on strong demand for notebook power management devices and mixed-signal devices for printers. TI's DSP business saw a slightly better than expected 7% increase in revenue. Strength in wireless came not from unit shipments but rather from improved ASPs associated with a ramp of shipments into the 2.5G (GPRS) marketplace.

National Semiconductor (NSM)

SINGLE-CHIP SYSTEMS, FOVEON IMAGERS

MAR '02 MONTH END: 33.50 | 52-WEEK RANGE: 19.70 - 35.10 | MARKET CAP: 6.0B

Fiscal 2Q revenues grew 1% while bookings grew 22% sequentially and 16% versus 2Q01, representing the first positive year-over-year comparison in six quarters.

Get a Bigger Trophy Case: Foveon's X3 imager, just one month old, awarded CHIP magazine's 2002 CeBIT Innovation Award.

Narad Networks

GIGABIT ETHERNET COAXIAL CABLE NETWORKS

PRIVATE

Even the audio/visual techies at the Storewidth 2002 show were impressed. "Narad is the coolest thing I've seen this week," one told us, after CTO Vikram Saksena described how his company will transform the nation's cable TV companies into full-service Internet, telecom, and storage service providers.

Any Takers?: See Narad Executive Vice President Andy Chapman's $2,000 "bet" that at least one BOC will go Bell-y up in the next five years: http://www.longbets.org/bet/proposed.

Soma Networks

BROADBAND WIRELESS ACCESS, NETWORK SOFTWARE

PRIVATE

JAPAN DOES SOMETHING RIGHT!—NTT Communications of Japan announced the first deployment of Soma's broadband wireless voice and data system, which is based on the Qualcomm CDMA standard. An initial roll-out in one metro area will take place in the next month, with a nation-wide deployment expected to follow. Earlier this year, NTT as well as two US PCS spectrum holders successfully field-tested the Soma system, which delivers IP voice and broadband data to portable—and soon-to-be mobile—antennas, connected not in a circuit-switched telco environment but in a "soft" network based on distributed computing. Japan's DSL roll-out has been rapid, and subscriber take-up brisk, but service providers are still losing money on each customer. Soma CEO Yatish Pathak believes his system—consisting of base-stations built by Solectron and customer units made by Sharp—can be deployed profitably at $25 per subscriber per month but will likely generate $50-$75 per month.

Take Away: Good news for CDMA, good news for Qualcomm, and great news for the last mile and Phase II of the Telecosm.

The Telecosm Technologies list is not a model portfolio. It is a list of technologies in the Gilder Paradigm and of companies that lead in their application. Companies appear on this list only for their technology leadership, without consideration of their current share price or the appropriate timing of an investment decision. The presence of a company on the list is not a recommendation to buy shares at the current price. Mr. Gilder and other GTR staff may hold positions in some or all of the stocks listed.

The quest takes endless turns—optical pumping of a VCSEL (vertical cavity surface emitting laser) which requires a complex dual-laser configuration…lasing a VCSEL at 980 nm (nanometers) where it is naturally higher-powered and converting to a 1550 nm transmission wavelength using exotic materials…stretching VCSEL cavities like Silly Putty and adding mirrors in a rite of epitaxial existentialism…combining a VCSEL and an edge-emitter into a GCSEL (grating coupled surface emitting laser)…or simply throwing our hands up on VCSELs and instead extending edge-emitters into the complexities of four- and five-section DRBs (distributed Bragg reflectors) or GCSRs (grating-assisted co-directional coupler with sampled reflector). Don't ask.

There are undoubtedly more ways to squeeze out power, but instead we rushed over to the OFC booth of VCSEL vendor **Bandwidth9**.

Bandwidth9 comes out on top

VCSELs are easier to manufacture than the established edge-emitters: A thousand or so can be grown on a single wafer, and since they emit light out of their tops rather than their sides, they can be tested early on, while they're still on the wafer and before money has been spent on expensive packaging. VCSELs emit circular light beams, which are easier to couple to fiber than the elliptical output of edge-emitters. They also emit narrow linewidths, are cooler to run for higher reliability, and lase in only one transmission wavelength because of the short cavity length. The longer cavities of edge-emitters lase over a dozen or more channels and "hopping" to unwanted wavelengths can become a problem.

VCSELs are inherently low-power devices. Resonating light vertically between mirrors results in a much shorter path through the gain medium when compared to edge-emitters, which resonate from side to side across the medium. Further decreasing power prospects for VCSELs, their indium phosphide (InP)-based compounds are maladapted to the highly-reflective multilayer mirrors required in vertical cavity architectures.

While VCSEL rivals CoreTek (**Nortel**; NT), **Princeton Optronics**, and **Novalux** are adding complexity to meet the power challenge, Bandwidth9 is following the technology to its logical market: low-powered lambdas in access and metro networks. With laser output of 0.45 mW, Bandwidth9 reaps the VCSEL's cost, reliability, and efficiency rewards, which elude competitors reaching for the 5–20 mW stars.

Blue Sky's edge

Bandwidth9 lets VCSELs do what they do best, and it leaves power to the amplifiers. That's what *they* do best. It turns out that a 0.45 mW source can make it down 50 kilometers of single-mode fiber without help, plenty for metro or access markets. For greater distances, Bandwidth9 incorporates a semiconductor optical amplifier chip to boost power out.

Bandwidth9 currently tunes to 40 different lambdas at a 50 GHz spacing but can potentially tune to any lambda

in its gain spectrum by simply lengthening or shortening the resonator cavity using a MEMS (microelectromechanical system) as its top VCSEL mirror.

But don't throw out the edge-emitters just yet. There's an advantage to all that channel hopping, and **Blue Sky Research** is exploiting that to its own advantage with C- and L-band lasers that tune to 50 GHz spacing (with 25 GHz "to come") non-mechanically. Using a simple and cheap Fabry-Perot diode, Blue Sky makes rainbows while standing perfectly still. The trick is electro-optical tuning. The science of electro-optics tells us that some materials, when subjected to an electrical field, undergo a change in optical properties as molecules reorient themselves or change shape. With electro-optics, prisms deflect lambdas at adaptable angles, etalons resonate at varying frequencies, and liquid crystals block or pass wavelengths at whim.

Using electro-optics, Blue Sky can pick and choose the lambdas it wants to reflect back to the diode for lasing. With a conventional F-P diode and no movement, Blue Sky reduces cost and increases reliability. But that's far from Blue Sky's limit. The gain spectrum of an F-P diode typically ranges over 40 nm in the 1550 nm transmission window. Blue Sky currently reflects one lambda at a time. Why not reflect dozens simultaneously for lasing? With its F-P diode, Blue Sky has power to spare, transmitting a single channel at 20 mW.

Today OEMs and carriers claim power is a top priority, but as WDM slides swiftly down its learning curve, Blue Sky has a unique opportunity to adapt to the multi-lambda paradigm. Lasing dozens or more lambdas simultaneously would drastically reduce the number of lasers required to source thousands of channels as well as take advantage of modulator advances. Modulators are the devices that encode digital signals on laser light. Today there is one modulator for each laser. Terry Turpin tells us that **Sanders Corporation** of Nashua has already developed an array of 250,000 modulators at 500 MHz per element for the National Security Agency. What's a mere few thousand lambdas for telecom? Many cheap modulators could be attached to each expensive laser.

Our second company to watch in tunable-lasers, the brilliant Blue Sky has already outdistanced its edge-emitter adversaries with its elegant simplicity. Rivals such as Altitun, **ADC** (ADCT), **Agility**, **Agere** (AGRa), JDSU, **Iolon**, and sadly, our once favored now imploding pile of venture cash, **New Focus** (NUFO), are all crippled by kludges and complexities. All employ intricate tuning cavities with one or more moving parts, or add thermally- or electronically-tuned grating and gain sections for power and tuning range. New Focus and Iolon both illustrate that all the high voltage venture capital in Silicon Valley cannot save companies that lack a grasp of the lambda paradigm of WDM.

As abundant channels crowd closer together, locking each to its center frequency becomes increasingly critical; a slew of sardine channels must be cemented precisely to their center frequencies lest they slither into a hopeless tangle of lambda pasta and indigestible data. Today, lambdas are commonly locked using an etalon as the wavelength reference. An optical resonator, the etalon reflects light back and forth between two mirrors, separating or combining wavelengths of virtually any number or spacing based only on the separation of the two mirrors. As lightwaves resonate between the two mirrors, they interact in such a way that some colors are aligned additively at their peaks and hence strengthen, while other colors' peaks are aligned with troughs and hence cancel. At just the right cavity length, the resonant frequencies line up with the desired WDM channels and the etalon becomes a wavelength reference. If the laser frequency has drifted off center, a sample of its output traversing the etalon will emerge weaker and prompt a tweak of the laser driver to nudge the laser light back onto the WDM grid.

Turpin hurtles into Fiberspace

Fiberspace has perfected this feedback process and becomes the third company to watch in tunable lasers. Cofounder and CTO Brad Mells, who's 17-year history in laser stabilization research has taken him through Hughes Aircraft's solid-state laser engineering lab and **Western Research Corporation's** high-power laser development for ballistic missile defense, claims an advance in metrology some two orders of magnitude more precise than current methods. Because Mells measures the phase shifts of the light passing through the etalon instead of the power fluctuations, he eliminates dependence on the complex and unpredictable feedback electronics and temperature sensors characteristic of today's lockers, and simply relies on the accuracy of his fine-tuned etalon.

Fiberspace's Gridlocker is likely the only commercial laser that can meet Hyperfine's demands for channel stability

Mells has developed a tunable DFB (distributed feedback) laser built around his optical phase locked loop technology; from the beginning DFBs have offered the simplest structure for telecom. Mells mechanically tunes to as many as 16 wavelengths by changing the temperature of the grating in the laser cavity and uses his locker to fine-tune the driver current. Mells's Gridlocker is likely the only commercial laser that can meet Hyperfine's demands for channel stability, and his efforts have been heartily endorsed by Terry Turpin, who has agreed to co-market his Hyperfine mux with Fiberspace's Gridlocker tunable laser.

Fiberspace, along with Bandwidth9 and Blue Sky, understands Turpin's law of simplicity and the connectivity paradigm.

So does **Xtera**. A systems house, the Allen, Texas, company preaches a Turpintine paradigm which, in a more financially liquid carrier environment, will make them a big winner in metro and regional networks.

Xtera wastes bandwidth. Lots of it. And by doing so, it finds that things get simpler and cheaper. But you can't waste

bandwidth you don't have, so Xtera starts with 100 nm of seamless spectrum, almost three times the 35 nm of the erbium C-band. Riding the Raman technology curve into the S-band, the purists at Xtera banish band-splitters along with expensive L-band and S-band amps…swap out switches in favor of unostentatious OADMs (optical add-drop multiplexers)…cast out complex Raman/EDFA hybrid amps along with EDFA noise…deport the dynamic modules and appended software that burden reconfigurable networks…and offer 240 channels, higher even than today's leading long-haul systems of 160 channels.

A quintessential **Corvis** (CORV) for the metro, Xtera found that beginning at around 180 channels, all-Raman systems become more efficient and more cost effective than bandwidth constrained erbium edifices. Xtera's Nu-Wave is already in trials with carriers. But with carriers conserving cash, Xtera may need a partner, and we hope an acquisitive David Huber is watching.

A rule of thumb at OFC was that every OEM is in trials with carriers. And every component house is in trials with OEMs. The entire Telecosm is on trial.

Bottoms up for investors

For investors, this means that in the short run successes will bubble up from the bottom. Look for companies that can get important wins without a resurgence of the global economy or carrier cap-ex budgets. EZchip, for example, with its breakthrough net processor, will immediately cut the cost of scores of enterprise routing and switching products. Or Foveon chips from **National Semiconductor** (NSM), which are quickly making their way into inexpensive consumer cameras. Touch-pads from **Synaptics** (SYNA) and hearing aids from **Sonic Innovations** (SNCI) can also sell in a down economy. This scenario is beginning to percolate on Wall Street, where the chips have been running the last week.

If the first phase of the Telecosm was top-down—build it and they will come—the second phase is likely to be bottom-up. EZchips and Terabeam's Elliptica unleashing enterprise Ethernet. Soma and Narad following suit in the small business and consumer markets. People needing bandwidth and storage for gigabytes of Foveon photos. You surely read the *Wall Street Journal* story about the military's crucial shortage of satellite bandwidth for its Global Hawk and Predator unmanned planes. Such stories will repeat across industry and society, and such phenomena will undoubtedly one day fuel an optical rebirth as the current Internet is once again swamped with an upside Internet traffic surprise. But until the last-mile bottlenecks are broken or the global economy turns up, bet on semiconductors. Bet on EZchip. Bet on Carver Mead.

George Gilder and Charlie Burger
with Bret Swanson
April 19, 2002

CARVER'S COMPANIES

Sonic Innovations (SNCI)

ADVANCED HEARING AID COMPONENTS

MAR '02 MONTH END: 5.00 52-WEEK RANGE: 3.01 - 7.50 MARKET CAP: 100.6M

Sonic uses Carver Mead's analog concepts to create the uniquely directional hearing aids that make it the world's fastest growing hearing aid company. A relatively new entrant, SI is exploiting its technology advantage to challenge the longstanding top six incumbents (GN/Resound, Phonak, Siemens, Starkey, Widex, and William Demant/Oticon). A new behind-the-ear (BTE) model with proprietary noise reduction technology released in Europe in August should help sales rebound. Commenting on the company's prospects and $47 million in cash, U.S. Bancorp finds the current $116 million valuation "a real bargain." Still gaining share in the $2 billion global industry, the company now holds about 3% of the worldwide hearing aid market and about 5% of the U.S. market. The digital segment now represents about 27% of total U.S. units (up from 20% last year), where Sonic commands an increasing 15+% share. With hearing problems pandemic among aging, hippie baby-boomers, Sonic is still at the beginning of a long march through the industry.

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