GILDER TECHNOLOGY REPORT

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Optical Opportunities and Black Holes

George Gilder: *Utopia.* Wow! That's what I've been seeking for over 66 years. Forget the freaking financials, Charlie. If you build it, they will come. Put it at the top of the list!

Charlie Burger: That's enough! **UTOPIA** is in Utah and it is a *government sponsored* network. Not investible. Anyway *I* approve the companies. I will brook no more interference with the Burger King Department of Physics, Financials, and Triple Whoppers.

GG: But it's 100 megabits a second, for what?… $40 a month. That's 70 T1 lines for 10 percent of the cost of one. It's like South Korea or Japan. *Life After Television*. Who's writing this letter, anyway?

CB: Who knows? But you're supposed to be doing **Lanoptics/EZchip** (LNOP). Remember them? Network processors as I recall. Hollow out the router. Eviscerate the switch. Two generations ahead. Translated brilliantly from a programmable substrate of PowerPoint slides in 1999 to PowerPoint revenues in 2006. You went all the way to California to bone up on NPUs. Next time I'll send you to Israel. Some 80 design wins,

(CONTINUED ON PAGE 2)

PMC-Sierra's day is dawning, and the resourceful silicon supplier has a long way to grow into its ascendant markets.

Inside:

FEATURED COMPANY: PMC-Sierra (PMCS)

PMC-Sierra has long struck us as a brilliantly managed but ultimately stodgy supplier of chips for tired telcos. This partial misjudgment caused us to miss much of the company's appreciation during the last year. But over the last two months, CEO Bob Bailey has propelled the company back into our minds and onto the Telecosm list by complementing its Bell Labs savvy and marketing agility with transformative new acquisitions in "storewidth" and Internet access.

At present, PMC is a fabless supplier of a potpourri of chips for DSLAMs (digital subscriber line access multiplexers), wireless base stations, edge routers, metro transport equipment, enterprise, storage networks, and even color laser printers (some 10% of PMC's revenue).

Half of the company's sales now come from Asia and half of that from China alone. Supplying chips for **Huawei**'s and **ZTE**'s 3G base station systems, PMC will benefit as 3G ascends in China and other regions. Last quarter, Huawei contributed a rapidly rising 8% of PMC's sales.

With **Agilent**'s (A) former storage business added last month, PMC becomes a storewidth star. The move will increase storage sales to a third of total revenues from 5% and boost enterprise sales to half of revenues from 30%. Announced on Halloween, the $425 million cash purchase is shaping up to be a treat instead of a trick.

The Agilent division of some 240 employees comes to PMC through **KKR** and **Silver Lake Partners**, private investors who bought Agilent's semiconductor business late last year for $2.7 billion and renamed it Avago. The amputation prompted us to take Agilent off the list in the January issue. Now we're glad to get a part of it back, with revenues over $100 million and climbing and with extremely high gross margins of over 70%. Top customers are **Hewlett- Packard** (HPQ) and **EMC** (EMC) and the major competitors are **LSI Logic** (LSI) and **Vitesse** (VTSS).

The Agilent division gives PMC a complete array of storage semis, from low- to high-end systems and lacking only processors for RAID (redundant arrays of independent disks). Lower-end networks are beginning to move from parallel interconnects to serial, such as SAS (serial attached SCSI), and PMC is ready. Higher up, PMC is well positioned for the gathering storm of 4 Gbps-based SANs (storage area networks) with multiple design wins. The company's substantial investment in that area may help it to cut into

Vitesse's share of the market; prior to Agilent, PMC had anticipated storage sales to double to 10% of revenues over the next few years.

In the access market, PMC expects to close its $300 million stock acquisition of **Passave** this month, giving the firm instant dominance of the Japanese market for EPON (Ethernet passive optical network) controllers. Through design wins at **Mitsubishi**, **Sumitomo**, and **UTStarcom** (UTSI), Passave is a rare company making money in passive optical access networks (PONs), having shipped some 2 million units into **NTT DoCoMo**'s (DCM) fiber to the home service in Japan. As the Linley Group pointed out, "Passave's devices include NTT-specific requirements, which make it difficult for competitors to displace them. Passave's products also offer better performance and lower…cost than chips from leading competitor **Teknovus**. As a result, revenue from Passave's chips should continue to increase in 2006."

As a telco oriented supplier, PMC has been a leading innovator in asynchronous transfer mode (ATM) DSLAMs, but it fumbled the move to IP DSLAMs and other Internet devices. With 150 employees and 2005 revenue of $43 million after just five years in operation, Passave is a major player in broadband access and the perfect remedy for the rearview Bellco bias of some of PMC's technology. PMC also can incorporate Passave's PON silicon in gateway offerings for voice-over-Internet Protocol (VoIP) and broadband. From PMC, Passave garners the power of an established telco supplier to help it gain a foothold in GPONs (gigabit PONs), with their ATM intricacies and role in the **Verizon** (VZ) build-out.

By no means a "value" play, PMC at $13.29 is well into growth territory, having more than doubled in just under half a year and now trading at a PE of 83 based on last year's after-tax operating income, excluding restructuring charges and options expensing. But PMC's day is just dawning, and bolstered by a strong balance sheet, this resourceful silicon supplier has a long way to grow into its ascendant markets.

The core business has been expanding at an average rate of about 4.6% per quarter including the forecast for March. Extending that growth through this year and using the current operating margin and tax rate as a guide, we calculate after-tax operating earnings of $42.4 million. Adding in the company's revenue, operating margin, and tax guidance for the Agilent business, we boost earnings another $25.6 million to $68 million. Although adding 10% to PMC's revenues, Passave is expected to be neutral to PMC's earnings this year, and so for the moment we ignore both its contribution and the added shares.

Thus, we estimate an EPS for 2006 of $0.36, yielding a PE of 37 at today's price following growth of 125% over 2005. This conservative estimate discounts any upside surprises in the core business, any growth in either the Agilent or Passave acquisitions, and any synergies in operating expenses from the combined entity. In addition, a PE of 37 next year would imply a sharp slowdown in PMC's growth such that EPS would only reach $0.49 in 2007 for a share price of $18. But continued ascent in PMC's markets and execution, not unlikely, could easily send the stock well beyond that for patient investors.

A solid company with seasoned management and new flair, we add PMC to the list this month.

– Charlie Burger, April 7, 2006

(CONTINUED FROM PAGE 1)

no money, no story. What's up? Where's the beef? And what about **Wintegra**? It's already profitable at the access level and is going public. Leave the optics to me. I'm the physicist around here.

GG: Lay off LNOP. They're going to make us all rich and famous at 10 Gig. Pretty soon you're not going to be able to go to the head or to the movies without a 10-GigE connection. And I like Wintegra. It's needed for the protocol zoo in the local loop. We'll put it on the list if the price is reasonable. What I want to know is where the "physics" is that ascendant company at OFC, the likely 10-bagger for our loyal subscribers, some of whom have hung in there since **Avanex** (AVNX) and NEON and—don't even mention it—Worldcom?

CB: What can I say? Simon Cao moved on. Bernie E. moved up and over. But we already have **Corning** (GLW). Had it two times over. We already have **Essex** (KEYW). I found Terry Turpin for you, don't forget that, you ingrate. We already have **Finisar** (FNSR). What do you want? Nearly all the best companies in optics are still private. The public companies are mostly well-valued or optical illusions.

GG: Well, let's shake them up again and see if anything lases.

Laboring toward utopia

Amid the pitter-patter of acronyms at this year's Optical Fiber Communications (OFC) conference last month in Anaheim, Mr. Sandman brought us a dream… March Madness terahertz… BPON, GPON, EPON, GEPON, APON, ATM, AWG, PLC, TOSA, ROSA, OOPS, OLT, ONI, ODU, ONU, ONT, OXC, SOS, *SOS*?, OAM, OADM, ROADM, *RZDQPSK*? Yes RZDQPSK…OC-192, OC-768, OC-3072… HD over IP over MPLS over GPLS over GMPLS over Ethernet over SONET over RPR, over WDM over lambdas over Hyperfine, over WiMax over **Google** (GOOG) over Metro over VPLS over WAN… It will be an Information Superhighway crowded with alphabet sheep. All with the modulating broadband magic, don't forget, of RZDQPSK, a special sauce that trips on the tongue as "return to zero differential quadruple phase shift key." (Translation: What happened to Duke, Gonzaga, Al Gore, and Avanex.)

Somewhere over the rainbow, over Utah's Wasach Mountains, with reveries of a broadband dotage in Orem or Brigham City, we were slipping fast toward the land of NOD (no optical demand), when Angel Moroni came down from a cloud with a cornucopia of municipal gigabytes…This month, he said we should choose the new ascendant company by a trademarked algorithm termed Oneiric Minddrift (OM): the NCAA in HD over fiber over **Broadwing** (BWNG). It's a slamdunk. If Utopia or **Uniphase** (JDSU) does not cut it for our retirement, then vamp up to the Vs… Maybe **Verizon** (VZ), **Vitesse** (VTSS), or West Valley City (Utah).

No, Charlie says, Vitesse will not cut it. Yes, they're in all the transceivers and will grow with the build-out, designing a wide

assortment of ICs for uses ranging from datacom through long-haul applications, for customers such as **EMC** (EMC), **Lucent** (LU), **IBM** (IBM), and **Cisco** (CSCO). True to its roots as a high-speed specialist (Vitesse means "fast" in French), the company claims to be the leading provider of 10-Gig physical devices while still selling products that support speeds down to 600 Mbps. But with cash and receivables only equal to current liabilities, with continuing negative cash flow, and with prohibitive expenses (e.g., R&D is 42 percent of sales) after a round of restructuring, the current enterprise value of 3.8 times estimated 2006 sales gives us angst.

GG: Angst, huh…

CB: Yeah, angst. We'd prefer to wait for a pull-back and some signs of operational turnaround before jumping in.

GG: So much for Vitesse, at least for now… How, about Verizon then?

CB: It's an idea for widows and orphans with a high level of tolerance for debt and a desire for a new Comcast (CMST).

GG: But they're the king of CDMA and fiber to the home!

CB: We'll keep it in mind.

Our paradigm sensors suddenly issued an interrupt order and we bolted awake. Speaking was one Paul Morris, who billed himself as the executive director of, yes, UTOPIA (Utah Telecommunications Open Infrastructure Agency). Already familiar with Morris's broadband Ethernet network, partly powered by **Amedia Networks**' (AANI.OB) Ethernet switched technology, we had no yen to listen to an update on the fiber-optic network being deployed by a consortium of 14 Utah cities. But Paul was talking our language.

Likening himself to a plumber providing pipes for raw bandwidth, Morris correctly separates content from conduit. He shuns the temptations of the 1980s paradigm of cable TV—with hundreds of channels stuffed and stultified into about a dozen mass-market flavors—that has captivated **AT&T** (T) and most of its sister Bells. By contrast, in the long-tail world of *Life After Television*, it takes only a click or two to exfoliate cornucopian video—diversified into as many niches as books offered on **Amazon** (AMZN) or items for sale on **eBay** (EBAY).

But to get the bandwidth, we may have to move to Utah.

Paul first caught our attention with a table showing the orders of magnitude differences in cost of bandwidth per bit among the different broadband solutions and carriers. Measuring bandwidth per dollar per month, we can sum up the numbers: the various digital subscriber line solutions of **BellSouth** (BLS) and AT&T offer around 25 kilobits per second per dollar per month. The cable people at their best offer maybe four times more: around 100 kilobits per second per dollar per month. Laboring toward utopia on a Pilgrim's Progress trek with a huge burden of new fangled TV and Hollywood programming on its back, Verizon currently provides 200 kilobits per second per dollar per month. But over the next five years it promises to increase that number into the megabits per dollar per second per month with fiber to the home and premises. And Utopia? That's pure conduit fiber, and whether in Japan or Korea or Utah it comes to around 2.5 megabits per second per dollar per month.

Who's ahead in broadband?

By making cents out of bits, Paul Morris hit home with the answer and provided more evidence against those attempting to "fix" the last mile with digital subscriber line (DSL) and cable. Compared to a fiber future, the current wireline plant suffers from capped capacity, limited reliability, and large lifetime costs.

Like frogs happily swimming in a copper kettle as the heat is slowly applied to the copper coil, DSL-dominated systems face a bleak future as customers whet their appetites for more and more bandwidth at lower and lower prices. Raw bandwidth unleashes a spiral of creativity at the edge that brings new apps driving yet more bandwidth. Users will tire of watching video clips the size of postcards on their PCs, calling on UPS to deliver their family videos, and waiting several hours to download the latest movie release onto their **Seagate** (STX) Barracuda Terabyte drives.

They may also begin to wonder why they no longer bump into their neighbors at **Blockbuster** (BBI). Could it have anything to do with the Verizon vans recently seen outside their homes?

Trends in Japan are on Verizon's side. **NTT DoCoMo** (DCM) reports 4.64 million FTTH (fiber to the home) users in Japan, doubling within the year while ADSL only went up 8 percent. In 2007, FTTH is expected to pass ADSL (asynchronous DSL) in Japan, as ADSL customers keep moving up to higher bandwidths—downstream rates of 8 Mbps are accepted by only a small minority now. Preferred are 25 and 40 Mbps and many are now switching to fiber. And this is still pre-Hi Def TV; standard TV streams in at around 4 Mbps, whereas HDTV demands about 20 Mbps using existing MPEG2 compression familiar in cable or satellite systems. With the onset of MPEG4, that may drop to 10 Mbps.

Even more important than average bit-rates are peak bit-rates—as in the evening when homes are humming with interactive gamers, HDTV addicts, video phone calls, and movie downloads sending peak loads past 40 Mbps. According to Telcordia research, networks are now or will soon be seeing 50:1 peak to average traffic ratios.

At a bit over 2 miles all flavors of DSL revert back to basic ADSL and its highly asymmetrical rates of 5 Mbps downstream and less than a tenth that upstream, plummeting to less than 1 Mbps downstream at about 3 miles. By contrast, bits flow through fiber at rates independent of distance, up to the typical transmission window of about 10 miles. As new classes of service evolve, the protocol transparency of fiber will accommodate them more gracefully than will the

TELECOSM TECHNOLOGIES

Advanced Micro Devices	(AMD)
Altera	(ALTR)
Analog Devices	(ADI)
Broadcom	(BRCM)
Broadwing	(BWNG)
Cepheid	(CPHD)
Corning	(GLW)
Energy Conversion Devices	(ENER)
Equinix	(EQIX)
Essex	(KEYW)
EZchip	(LNOP)
Finisar	(FNSR)
Flextronics	(FLEX)
Ikanos	(IKAN)
Intel	(INTC)
Microvision	(MVIS)
National Semiconductor	(NSM)
NetLogic	(NETL)
PMC-Sierra	(PMCS)*
Power-One	(PWER)
Qualcomm	(QCOM)
Semiconductor Manufacturing International	(SMI)
Sigma Designs	(SIGM)
Sprint Nextel	(S)
Synaptics	(SYNA)
Taiwan Semiconductor	(TSM)
Texas Instruments	(TXN)
Xilinx	(XLNX)
Zoran	(ZRAN)

*** Added this month**

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Note: The Telecosm Technologies list featured in the Gilder Technology Report is not a model portfolio. It is a list of technologies that lead in their respective application. Companies appear on this list based on technical leadership, without consideration of current share price or investment timing. The presence of a company on the list is not a recommendation to buy shares at the current price. George Gilder and Gilder Technology Report staff may hold positions in some or all of the stocks listed.

Finisar (FNSR)

PARADIGM PLAY: DATACOM TRANSCEIVERS & COMPONENTS

APRIL 7: 4.77; 52-WEEK RANGE: 0.79 – 5.25; MARKET CAP: 1.43B

Since adding Finisar to our list in December, the stock has more than doubled. Is it still a good value?

The #2 optical components supplier behind **JDSU** (JDSU), Finisar generates 90% of sales from optical transceivers. The company ranks #1 in SANs (storage area networks), #2 in LANs (local area networks), and has a growing MAN (metro area networks) business. **Cisco** (CSCO) is Finisar's largest customer, and Finisar in turn is the largest optical supplier to Cisco. April should bring the eleventh consecutive sequential revenue rise, hoisting sales for fiscal year 2006 to $362m, up 29% from 2005 and double 2004.

Online applications are sending the SAN market into orbit. **Brocade** (BRCD), **EMC** (EMC), and **QLogic** (QLGC) plan to double the size of their installations over the next year and continue to add at a compound annual rate of 70% thereafter. The uptake of 4 Gbps networks accelerated unexpectedly the last few months; Finisar sold out of 4 Gig optics last quarter and expects that by year's end sales of 4 Gig will surpass 2 Gig. At about that time, 8 Gig should launch.

Online apps are also pushing 10 GigE into LANs and MANs. Revenue from 10 Gig more than tripled over the year-ago quarter to $5m, partly due to the newly acquired 10 Gig transceiver line from **Big Bear**. This merely scratches the surface of the long-term opportunity—Ethernet ports in the last mile have been growing 20–30% annually, with 10 Gig still only a small fraction of that.

Two methods are used to transmit at 10 Gig. Serial transceivers use one 10 Gbps laser and one photodector. Parallel transceivers use four 2.5 Gbps lasers and four photodetectors. Most of Finisar's work has gone into serial devices, which they believe will be more efficient, smaller, cheaper. They claim "many" design wins in serial 10 Gig. However, Cisco has few serial designs and remains a big opportunity for Finisar in 10 Gig.

Also benefiting Finisar, telecom is moving from fixed to pluggable optics, apparently in short supply. A Finisar forte, pluggable transceivers give integrators greater flexibility in designing line cards compared to the traditional method of soldering in components supplied by myriad vendors.

Finisar is also the largest supplier of VCSELs (vertical cavity surface emitting lasers) in the industry through the former Honeywell VCSEL division. Using a unique process, Finisar grows the lasers on top of a photodetector, enabling precise readings and low power for optical mice. **Logitech** (LOGI) is selling out of these mice in Europe, limited by Finisar's ability to supply the lasers. A "very difficult semiconductor," yields have been low. The company is investing heavily here, and Logitech has commited to shipping every VCSEL Finisar makes.

In addition to the 90% of revenues from transceivers, the rest of Finisar's sales comes from products that monitor the performance of SANs and LANs. Growth here has stagnated, but the company is working to introduce monitors targeting the new high-speed SANs that will begin deploying later this year. This is a developing market in which Finisar sees much promise.

For fiscal year 2007 beginning in May, management forecasts some $430m of revenue with a pro-forma EPS of $0.15. During the first half of the year operating margin should ascend through the 10–13% range, reaching the long-term goal of 15% thereafter. Helping operations is gross margin, improving from 22% to 34% since last April through economies of scale and better processes.

The company thinks it can grow 20% over the next few years. At that rate, sales would reach $512m in fiscal 2008. Assuming a 15% operating margin and no taxes (Finisar has accumulated $350 million of operating losses), we estimate an EPS of $0.21 or 40% higher than next year's forecast based on the 370m shares management anticipates will account for potential dilution from converts. At a PE of 40, that comes to $8.40 per share. Thus the path to the next double should be tougher and longer. But Finisar has significant upside potential and downside protection.

Finisar is liquid, with cash and receivables more than double current liabilities. Cash flow from operations has risen to $5.4m for the first 9 months of this fiscal year compared to a drain of $28m last year. At this rate, the company soon will be able to fund yearly capex of $24m from ongoing operations and save more cash for its converts: $100m comes due in 2008 and $150m in 2010, with a put payable in stock or cash in October 2007.

Cisco is cutting its optics suppliers to 7 next year, and Finisar is on the short-list. Other system houses are following Cisco's lead, looking for volume pricing and closer ties to suppliers. Fewer rivals in a growing market means Finisar should more than make up in volume what it loses on price. Though its factories are running 24/7, Finisar believes it can support many times today's sales simply by adding and adapting equipment. New construction may not be needed—but "stay tuned" we were told. With manufacturing humming, added equipment brings a quick payback, and every dollar of new business generates 40–50% margins.

The optical mouse business presents another potential upside. Sales in the quarter were under $1m, with Logitech promising to buy $30m annually. For Finisar, a little more yield will go a long way. — *CB*

PMC-Sierra (PMCS)

PARADIGM PLAY: TELECOM & DATACOM SEMICONDUCTORS

APRIL 7: 13.29; 52-WEEK RANGE: 6.20 – 13.77; MARKET CAP: 2.47B

Added to the list this month (see page 1).

Online Bonus Material: For additional analysis on Finisar (FNSR) and PMC-Sierra (PMCS) logon with your *GTR* subscriber ID at www.Gildertech.com.

protocol specific electronics of DSL.

But we're a runaway leader over Verizon in broadband, cries AT&T. Using DSL, we can pass 18 million homes by 2008.

Whoa. Even ignoring the more important capacity constraints, that's not too far ahead of Verizon, which plans to pass 6 million homes with fiber by the end of this year. At its current rate of deployment, Verizon will have passed a total of 12 million by 2008, and the company has hinted that it may soon begin to deploy more quickly. Compared to Verizon, even UTOPIA with its 160 thousand customers is a gated community.

In FTTH, Verizon is rushing down the learning curve ahead of its rivals.

Both BellSouth and AT&T claim that the cost to build all fiber plant far outweighs any saving in maintenance and that you don't gain your opex advantage until you move entire central offices off copper. However, Verizon is already reporting opex savings. Rushing down the learning curve ahead of its rivals, Verizon's cost per home-*passed* plummeted 29 percent last year, from $1,400 to $1,000. That is expected to drop to $890 this year. Falling off a cliff in 2005 was the cost actually to connect a home, plunging from $1,200 to $715. Significantly, Verizon expects earning dilution for broadband fiber builds to fall off after a peak this year. If so, that would be a major hurdle jumped and one still facing its rivals.

Helping Verizon cut capital costs is Corning, which currently bills $90–$210 per home passed for gear enabling FTTH, $40–$55 for FTTC (fiber to the curb), and $25–$40 for FTTN (fiber to the neighborhood). These costs include fiber (already cheaper per-strand than copper), cable, and equipment and are significantly less than a quarter of Verizon's outlays. Corning's new bend tolerant fiber and associated fiber coating can be bowed and twisted from the central office through jammed neighborhood cabinets and into the home with negligible loss of power in the optical transmission.

The most expensive PON optics are the lasers, especially the highly linear 1550-nm lasers required at the central office for analog TV overlay transport in broadband PONs (BPONs). (But, this should be a short-term worry as we move to life after television.) Already, the maintenance and lifetime costs of PONs are less than DSL. The hotter electronics of copper broadband have shorter lifetimes and require backup batteries at intervals along the path. Also adding to the cost of DSL are the complex coding schemes and data compression and decompression unnecessary with fiber because of its huge bandwidth.

The most widely deployed broadband fiber-optic networks are PONs, which are passive optical networks that broadcast downstream to subscribers through a series of splitters, with each line or central office port generally serving 32 or 64 users. Requiring no active components, splitters reduce installation cost and can be buried, resulting in minimal maintenance outlays. To prevent subscribers from seeing each other's data, all packets are encrypted with the destination subscriber's unique key.

Upstream, traffic from the multiple users is combined back onto the single feed fiber using a time-shared or TDMA (time-division multiple access) architecture in which each subscriber's modem sends data during his allotted time slots using burst-mode transceivers. With the laser turned off when not transmitting (to obviate interference with other users), it needs a brief warm-up time before restart, lowering upstream bandwidth.

The most commonly used PON to date is the BPON (broadband passive optical network), supporting 622 Mbps of downstream bandwidth and 155 Mbps upstream. This guarantees a minimum download speed of 19 Mbps to each of 32 customers if all are busy at once and more when fewer users are active. Upstream, each user gets 4.8 Mbps.

In some areas, mostly Asia, BPONs are already being superceded by EPONs (Ethernet PONs, also called GEPONs for gigabit Ethernet PONs) transporting a symmetrical 1 Gbps or a minimum of 31 Mbps up and down to each of 32 users. Also appearing soon will be GPONs with an even speedier 2.48 Gbps download speed and 1.24 Gbps upload rate, translating to a minimum 78 Mbps down and 39 Mbps up per user. As with BPONs, bandwidth under typical conditions can be much greater.

UTOPIA's Amedia Networks active Ethernet service runs at up to 100 Mbps. However, preempting Amedia and other vendors of active broadband over fiber may be ever faster versions of passive architectures. For example, some vendors are already working on 10-Gig EPONs, which would increase minimum downstream data rates to 312 Mbps for networks broadcasting to 32 subscribers and 156 Mbps for 64 subscribers. Ultimately, WDM PONs extending up to 50 miles will deliver one or more virtual fibers to each home for practically unlimited bandwidth measured in gigabits per second.

Deployment of these futuristic networks awaits advances in such technologies as transceivers, tunable lasers, network processors, and error correcting codes which will all combine onto a paradigmatic softening of the network edge as the hardening core moves relentlessly outward.

Imprisoned in ATM cells

Ratified in 1998, the APON (ATM PON) standard uses two wavelengths: 1490 nm to transport bits down to the user and 1310 nm to upload. The standard was enhanced in 2001 to support a triplex overlay of analog video on a third wavelength, 1550 nm, and the name was changed to

BPON. Still dominant around the world, BPON networks busy themselves shuffling data into the voice-oriented short 53-byte ATM (asynchronous transfer mode) packets or cells, into which they are now trying to parcel IP video. Video-on-demand is hard, worried AT&T at OFC; we have to be aware of the traffic flowing through our network in order to manage that coveted service. Other applications will just have to fit around it.

America's Bells are paying a heavy cost for their dream of reproducing obsolescent cable services.

Hence the advent of GPON, which groups multiple ATM cells into larger sizes called GPON encapsulation method (GEM) frames that require elaborate fragmentation and reassembly of packets into the 125 micro second frame boundaries inherited from Sonet. GPON's get their 93 percent efficiency and micromanagement capabilities at the cost of a cumbersome system of cells in capsules in segments in frames on lambdas.

By contrast, Ethernet PONs throw bandwidth at the problem, gaining quality of service through retransmissions. Easier to design and cheaper to build and maintain, EPONs feed on Ethernet's 25-year learning curve of cost reduction, with commodity parts available off the shelf, and with native IP without protocol conversion, of which fragmentation and reassembly is just a part. Currently, some 99 percent of all Internet endpoints are Ethernet based, and its low price is propelling it quickly from access networks and LANs (local area networks) to MANs (metro area networks).

In theory, GPONs benefit from standardization, but initial GPON solutions for the array of opto-electronic interfaces with the metro in the central office optical line terminal (OLT) have been relying on custom field programmable gate arrays (FPGAs) from **Altera** (ALTR) and **Xilinx** (XLNX) to cut down development costs and to meet tight carrier deadlines.

On the customer side, optical network terminals (ONTs) connect users' PCs and LANs to the PON. The ONT is placed on the side of or inside the customer's house, office, or apartment unit and may function as a basic modem or a full-featured gateway. Also terminating PONs are optical network units (ONUs) located in the neighborhood or in multi-tenant buildings for DSL. All this adds up to far more intricate optics and controllers for GPON transceivers, which must use the indium phosphide single-mode DFB lasers typical at data rates greater than 1.25 Gbps.

While GPON is still fitfully being deployed, EPON will leapfrog to 10-Gig EPON. Already proving its viability is Japan's **KDDI** which has reportedly run successful field trials. America's Bells, including Verizon, are paying a heavy cost for their dream of reproducing obsolescent cable services.

Leading in EPON controllers and just purchased by **PMC-Sierra** (PMCS) for $300 million in stock is Passave, an Israeli startup with 150 employees founded in 2001 with headquarters in Silicon Valley (see page 1). Passave's chief rival is the still independent **Teknovus**, founded in 2002 and used by KDDI in central Tokyo to offer the only triple-play service in Japan at 100 Mbps.

The only investment play in EPON silicon is PMC-Sierra. Rival **Centillium** (CTLM) is a scrappy opportunistic player, which prevailed in Japan's DSL market, but has fallen behind **Ikanos** (IKAN), **Infineon** (IFX), and **Broadcom** (BRCM) in VDSL2. We will monitor Teknovus as it either evolves toward public status or is acquired by GPON vendors looking to expand into EPON.

With its high-end systems, the PON market now trails DSL by an order of magnitude. But Infonetics expects PON subscribers to increase to 21 million by 2008, mostly in North America where BPON/GPON will rule. On the revenue side, the Linley Group forecasts annual PON chip revenue to double from $127 million this year to $248 million in 2008 for a run of about $578 million through the period, about half of the $1,103 million expected from VDSL chip sales during the same time. Again, much of that may funnel toward GPON. In North America, that means mostly Verizon, which apparently understands the limitations of its current GPONs and is already talking about 100 Mbps GPON with further upgrades as the technology advances. "It's going to happen," the carrier virtually shouted at OFC. In fact, it already is, according to Verizon, which broke into smiles when asked about systems it has already seen. Test deployments are to begin later this year with installations commencing in earnest early in 2007.

GPONers come on fast

BroadLight is Passave's counterpart in the BPON, the lower grade technology now on the way to becoming a legacy loop. Another Israeli startup founded in 2000 with headquarters in Silicon Valley, the company is still private, with Broadcom an investor and design partner. Unlike Passave, BroadLight sells burst-mode transceivers in addition to controllers. It was also first to announce GPON controllers and software for both the central office and customer ends. Significantly, BroadLight integrates a BPON controller, ensuring backward compatibility with installed BPON ONUs.

At present, investors looking to make money on GPON controllers need to be clairvoyant. There's a lot of information circulating, but very little of use. With Verizon's GPON meeting in January reportedly attracting 14 vendors, there simply are too many would-be GPONers..

Determining the likely winner in burst-mode transceivers is much easier, with **MRV Communication**'s (MRVC) LuminentOIC laying a claim to have the first and only

modules to comply with GPON's strict timing requirements. Luminent intends to transfer its high-volume BPON manufacturing capabilities to its GPON line, which is apparently backlogged from all 14 systems houses. GPON's more complex receivers and distributed feedback lasers are harder to design and build as compared to the simpler pin diodes and Fabry-Perot lasers of BPON. With its own laser foundry and manufacturing plant, Luminent can readily develop and adapt specialized home-grown processes.

But at about $5 a pop, you can't just invest in burst-mode transceivers. Luminent also supplies metro and access transceivers and is part of the optics division of MRVC, home to a metro router. In pluggable transceivers, which are apparently in short supply, MRVC competes with Finisar among others.

Luminent also sells triplexers, the 3-wavelength transceivers that transmit the 1550 nm video overlay wavelength. Verizon, along with the likes of AT&T and **Alcatel** (ALA), has driven Luminent's BPON triplexer business, with over 500,000 shipped to date.

With sales of multiple hundreds of thousands or even a million per year, you might be able to squeeze out gross margins of 20–30 percent in diplexers and triplexers, enough to make a few dollars on the bottom line. But long-term, as Verizon explained at OFC, the carrier will move to an IP-based distribution aggregated onto the 1490-nm wavelength currently used to transport bits downstream. End of triplexers.

Investors on speed

With bandwidth exploding from desktops and servers out onto the network, it's just the beginning for investors. Hundred Mbps home networks are already on the doorstep. Coming a few years later will be GigE, driven relentlessly to the desktop by multimedia and business applications. In multimedia, long-tailed consumers will buck carriers' TV-franchise models, choosing instead each evening from among a century of feature films, half a century of TV programs, myriad niche and amateur videos—downloaded online at the click of a mouse. This will cause angst at cable networks, Blockbuster, and TiVo, but delight vendors supplying optics for disk backup and storage at centralized secure servers. These storage area networks provide "storewidth" for vast amounts of data accessible at high speed. With the advent of true broadband, users will begin backing up entire PCs and servers to secure remote data centers.

Increasing desktop connection speeds, more powerful data-center servers, and more complex security and services are all helping to push 10 GigE everywhere and spurring sales of 4-Gbps and 8-Gbps SANs. Finisar is the market leader in SAN transceivers (see page 4).

Datacom transceivers are one of two basic types of transceivers sold today. The other type powers back-haul networks—wide area networks (WANs) and MANs. As the broadband pipes open, traffic will flood onto the MAN and WAN networks. AT&T is now seeing 4.7 petabytes of traffic on an average business day across its global network of 410,000 route miles, much higher than the carrier had anticipated. (As recently as 1999, 4.7 petabytes crossed the entire Internet in a single month.)

Broadwing is ready for the deluge with its long-haul network connected seamlessly by waves of light. Broadwing can add lambdas as needed by plugging in line cards, and bandwidth services can be turned up in minutes rather than 3 weeks, often provisioned by the customers themselves. Playing catch-up are AT&T, Verizon, and BellSouth.

With its long-haul network connected seamlessly by waves of light, Broadwing is ready.

Now, at the dawning of the Second Great Optical Awakening, AT&T and Verizon have begun to see the light. At OFC, optical switches dubbed ROADMs for reconfigurable optical add-drop multiplexers ranked second only to PONs as the style of the day, and the two Big Bells were in fashion. Both blessed optical switching as integral to their plans to upgrade their long-haul and regional networks to optical oases over the rest of this decade.

In addition, Verizon will extend the reach of its lasers using innovative modulation formats on the transmit side and, eventually, electronic dispersion compensation on the receive end. In Anaheim, researchers were already reporting 600 km transmissions of 10 Gbps signals over standard single-mode fiber, without dispersion compensation or amplification. Corning reported 50 GHz WDM transmission at 10 Gbps up to 1,200 km on non-zero dispersion shifted fiber. Verizon will bypass existing amplifiers and dispersion compensating fiber by splicing through huts, and will increase transmission speeds and distances in metro networks without installing EDFAs (erbium-doped fiber amplifiers). These innovations are bad news for vendors of optical amplifiers, pump lasers, and dispersion compensation devices, such as JDSU, **Bookham** (BKHM), and Avanex.

Today ROADMs make up a minimal part of total equipment sales, but as costs come down they will proliferate across WANs and eventually spread to MANs. Optical-systems house **Ciena** (CIEN) will likely benefit from these trends. But can Ciena prevail against Cisco, **Nortel** (NT), Lucent, **Fujitsu**, **Tellabs** (TLAB), Alcatel, and a troupe of partial players or any merged mixture thereof and become a bonanza investment? The old MCI network uses Ciena's erbium-based system, but Verizon uses Lucent's Raman-based long-haul transport and reportedly has awarded Lucent second-source status for ROADMs, with technology supplied by **Movaz Networks**. Fujitsu is first supplier at Verizon and also at AT&T, where rumor has Tellabs winning the number two spot.

Ciena has been peddling madly back from the core to the edge of the network. With its ONI, WaveSmith, and other purchases it can serve all the legacy links of the metro telcos. But defending the Barnum & Bailey protocols on the edge are even more companies. Better to play optics at the component level where volumes are not crimped by the need to service all the special-needs and regulatory handicaps of the incumbent players, and you can ride the light when it comes. As platforms from Nortel, Lucent, and their ilk evolve, optical components rise as a percent of their makeup. Thus, expect demand for optical components to grow faster than overall demand for optical systems.

The carrier consolidations may aid some components suppliers. Under resulting pressures for lower prices, Cisco, et al. are shrinking their component supplier base dramatically, to the benefit of short-listed suppliers with manufacturing leverage, such as Finisar. Outsourcers such as JDSU will be less flexible and responsive.

Optical Communication Products (OCPI) outsources the manufacturing of its optoelectronic modules, which include transmitters, receivers, transceivers, and transponders for datacom and metro networks. With $145 million in cash, no long-term debt, and a gross margin of 36 percent (2 percentage points higher than Finisar), the company looks to be a promising opportunity at first blush. At around $3, however, the stock (58.4 percent owned by Furukawa) has lopped a quarter off its mid-March high but still trades at a pricey enterprise value (market cap minus net cash) of 2.7 times sales, extrapolated from the first quarter forecast. It should be watched, but is not a buy today.

Benefiting from its own manufacturing plants in China, California-based **Fiberxon** has been profitable for 12 straight quarters upon CEO Li Hsu's word. With revenue of $39 million last year, Fiberxon is the leading supplier of EPON components and modules, having sold more than a million burst-mode transceivers into EPON apps, with an extensive family of transceivers for both OLTs and ONTs. The company also sells transceivers and transponders for GigE, Fibre Channel, Sonet, and CATV, and we await rumored IPO with anticipation.

Also thought to be considering an IPO is **Opnext**, another manufacturer of optoelectronic modules and subsystems with a very broad product portfolio spanning datacom up through long-haul, red and blue lasers, and defense applications—including pluggable transceivers, uncooled DFB lasers, and transceivers dynamically tunable over some 80 wavelengths. Opnext lays claim to many process patents in addition to design innovations. The Eatontown, NJ, company was spun out of **Hitachi** (HIT) almost six years ago and is populated by many former Bell Labs employees. We will keep our eyes on these folks as well.

MRVC has manufacturing capabilities through its Luminent division. But optical components contributed only to 17 percent of company-wide revenues last year, approximately flat with the two previous years. The company is mainly a systems house, competing in switches and routers with the Ciena, Nortel, Alcatel/Lucent crowd. Components include transceivers, discrete lasers and LEDs, and fiber-to-the-premises (FTTP) products. FTTP contributes to more than half of the revenue from this small division. Components are a drag on MRVC, with gross margin of only 11 percent last year, contributing a mere 6 percent of gross profit and with an operating loss of $9.3 million more than offset networking's operating income of $2.3 million. But as a result of restructuring, gross margin in the optical components group increased to 20 percent in the fourth quarter and further improvement is expected.

Last month MRVC added $70 million to its balance sheet through a private placement of 20 million shares at $3.75 per share, a 19 percent dilution. Down some 15 percent from its high of $4.71 on 15 March, the company trades at an enterprise value 1 times sales based on the first quarter projection. The stock has had a nice run, up 150 percent since last May and along with OCPI may continue to benefit from the optical boom with more upsides than downsides in store. Neither company, however, appears as well positioned or as well oiled as Finisar.

Joining the list this month is PMC-Sierra, which is poised to gain from the boom in components (see page 1).

– Charlie Burger, with George Gilder
April 7, 2006

Got Questions?

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