GILDER TECHNOLOGY REPORT
March 1999 www.gildertech.com Volume IV Number 3
Published Jointly by GILDER TECHNOLOGY GROUP and FORBES MAGAZINE

THE OPTO-INVESTORS' BALL

A merged JDS Uniphase has truly Intel-like salience for the vision of an all-glass network.

On Wall Street in a buying binge and in San Diego on the congested floors of the Optical Fiber Conference (OFC), investors and nerds danced together in a global celebration of the photonic paradigm. Everyone now knows that the old telephone system is dying and a new one is rocketing forth. Once a seminar for a few hundred light starved boffins from institutional labs, the conference this year pullulated with bankers and analysts and venture capitalists.

Literally thousands of companies were rushing toward the lights. Many do a bump and grind, lay some fiber or flash some lumens, and implicitly implore, "Buy me." At this moment of incandescence for the industry, amazingly enough, it is often a good thing for investors to do.

Let us step back to gain perspective. Imagine gazing at the web from far in space. Using a spectroscope, you can see on a screen–translated into visible graphic form–most of the electromagnetic radiation enveloping the globe. At first it may seem a blur of light. Mapping the mazes of electromagnetism in its path, the spectroscope will reveal the World Wide Web. It appears as a global efflorescence, a resonant sphere. It is the physical expression of the Telecosm, the radiant chrysalis from which will spring a new global economy. It is ultimately the source of the worth of all the Amazonian Internet companies.

Then imagine that every hundred days or so the total brightness doubles. Not only does the total number of screens linked to the Net rise by more than one third but also the average traffic on the links rises by 50 percent. **AOL** (AOL) customers leave behind their 28 kilobit links and move to 56 kilobit and ethernet modems. A larger surge ripples across the ball of light. Corporate ethernets leap up from 10 megabits a second to 100 megabits and then to a gigabit, and exfoliate intranets and extranets in ardent loops. Led by **Qualcomm** (QCOM) and **Nokia** (NOKa), digital cellphones begin sending and receiving video images and storing voices. All pump up the lumens of the encircling radiance.

In This Issue:

As the intensity of the light rises–as more and more photons of traffic flash through the webs of glass and air–the overall frequency or average color of the light inches up the spectrum (because at higher frequencies, there is more available bandwidth to carry more information per second). Thus, the global iridescence changes its dominant hues. If it were a rainbow, the center of intensity would move up from red through green toward violet. If it were a meteor, the Doppler blue shift of the Internet would suggest it is hurtling toward you at lightspeed. That is a good analogy to keep in mind.

When appraising the onrush of Internet valuations and volatility, think of this exponentially increasing radiance cascading toward the heavy concrete and steel structures of global commerce. Some of the existing infrastructure will survive in the palpable domain, unfolding in conventional time. The revenues of **Federal Express** (FDX), for example, are rising faster than **Amazon**'s (AMZN). Fedex may well clear more per book (see Chart 8, Page 5). But most of the transactions and interactions will move toward the light.

The companies of the paradigm are mostly engaged in the process of moving the business of the world

Existing WDM systems, dominated by Nortel gear, offer a good news, bad news story.

into the universal radiance of massless photons. There, the potential expands at the amazing pace of traffic doubling every hundred days or so as it has for the last several years. **MCI WorldCom**'s (WCOM) Internet service, UUNet, estimates that its traffic rises tenfold a year, which implies a thousand fold every three years and a millionfold by 2005. Sure, this probably won't happen so fast. But once you comprehend this picture, and contemplate it seriously, there comes a moment of dazzling truth, and then a blind reach for the shares of any company that seems to have a handle on the incandescence.

Ciena Still Shines

At GTR we began with **Ciena** (CIEN) and **Uniphase** (UNPH). Ciena was the innovator of the first Wavelength Division Multiplexing (WDM) systems, and Uniphase's first market. WDM multiplies the capacity of fiber optics by sending messages on many different colors of light–many wavelengths–at the same time down the fiber, allowing a single fiber to bear multiple streams of messages.

Ciena has had its ups and downs; its competitors are such giants as **Lucent** (LU) and **Nortel** (NT). But Ciena is more focused and more entrepreneurial, commands leading-edge factories, and still produces the most advanced WDM gear, combining some 110 wavelengths on one fiber thread. Considered an alluring candidate for a buyout, Ciena is likely to stay in business under some auspices. Since its business is central to the radiance, it will grow fast.

Until early in the 1990s, however, WDM was an elusive grail and many experts at Bell Laboratories and other prestigious institutions regarded it as expensive and unnecessary. After all, SONET (synchronous optical network) systems from the telcos would soon send as many as 10 gigabits per second down a fiber on one wavelength. That's 6600 times the capacity of the T-1 line to your office, typically costing as high as $2k per month. Why complicate the picture with more wavelengths?

More bandwidth is only the most obvious reason. More important, having many wavelengths allows us to divide communications payloads into more easily manageable and manipulable segments. Nortel and other companies promise soon to deliver systems with 40 gigabits (OC-768) on a single wavelength. But it is extremely difficult to imagine many applications that require even 10 gigabits per second let alone 40 for a single destination. (Jim Crowe of **Level 3** [LVLT] fantasizes holographic superbowls on your carpet).

The real need for such bandwith is to serve thousands of destinations. For that purpose, the existing WDM systems, dominated by Nortel gear, offer a good news, bad news story. The good news is that they transmit bits per second at virtually no cost. The bad news is you have to buy a $500 thousand to a million dollar add-drop multiplexer to read them. This is because, flowing on a single wavelength, each of hundreds or thousands of messages have been broken into multiple packets and time slots and coded for reassembly at the other end. Further bad news is that you have to read every header on every packet in the 10 gigabit per second flow in order to find the one set of packets you need.

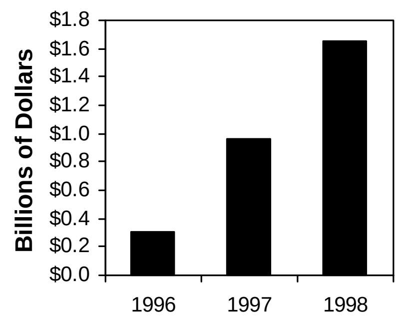
This approach, developed for the POTS (Plain Old Telephone System) copper cage performs acceptably for the far smaller bandwidths available with copper. But, with the enormous capacity offered by fiber, performing this processing can require the equivalent of a supercomputer, as well as slow and costly transformations from photonics to electronics and back. If this system prevails, it will ultimately countermand the mostly passive optics of the

Who Leads the WDM Market?

On December 1 Nortel claimed leadership in WDM sales, citing a report by RHK. Ten days later, Ciena claimed first place, comparing its revenues to the $1.2 billion worldwide WDM market figure announced by Ovum. Last month, Lucent flashed a Frost and Sullivan report to claim the top spot. Fueling the competing claims are different measures of the various (US, North America, World) WDM markets, ranging from estimates circa $1 billion using a narrow definition of WDM gear (Trans-Formation, CIR, and Insight Research), to estimates some $400 million larger that include some high-priced SONET components integrated with WDM gear (IGI Consulting). Frost and Sullivan market figures (**Chart 1**), sensibly exclude unnecessary SONET interfaces, but include all crucial components, such as optical amplifiers, cross-connects and optical add/drop multiplexers, of entire end-to-end WDM systems.

Chart 1

US WDM Market Revenues



Source: Frost & Sullivan

As for market share, Lucent's 30 percent share of the US market, based on Frost research, was within spitting distance of Nortel's 29 percent lead, noted by RHK using the slightly larger North American market of $1.86 billion ($2.2 worldwide). As for Ciena, both IGI and RHK segment the WDM market and credit the company with leading the market for "pure" WDM-only systems, followed by Lucent, while Nortel leads the WDM-with-integrated-SONET segment, with Lucent in second. Using the broadest market definition, Ciena holds a 20-25 percent share.

What is certain is that the three Telecosm Technology WDM companies, Ciena, Nortel and Lucent, each with its own expertise, together account for some 80-85 percent of sales.

Telecosm in favor of gigantic mainframe bit processors and packet switches. The very abundance of optics could become a roadblock in the way of the optical economy.

WDM offers a cheaper and simpler alternative. It promises to break down the bit stream into hundreds of separate message-bearing wavelengths that can be processed by simple passive filters and waveguides from **JDS Fitel** (Toronto Exchange) rather than by massive electronic switches and add-drop muxes from Nortel, Lucent, and **Tellabs** (TLAB). This goal moved dramatically closer at the Optical Fiber Conference, when Lucent reaffirmed that it had widened the fiber optic communications window–and thus potentially the number of wavelength channels–by as much as 60 percent by flattening the attenuation spike that prevents use of frequencies near 1400 nanometers. This breakthrough will enable metropolitan and campus WDM networks with cheap and passive add drop functions.

In the past, a further showstopper for WDM was that every fifty kilometers or so the system would have to remove each color of light from the fiber and convert it into an electronic bitstream in order to amplify and regenerate the signal. Each opto-electronic conversion entailed nine expensive bipolar transistors and a host of other devices.

JDS+Uniphase=Intel

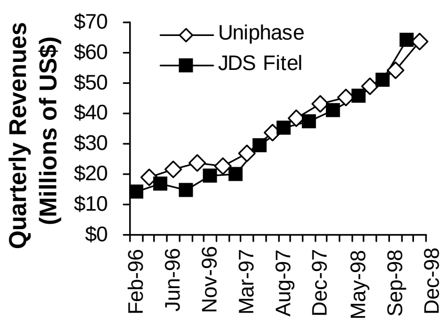
The crucial breakthrough that made WDM attractive was the invention of the erbium doped fiber amplifier (EDFA), which could amplify all the colors at once without removing them from the fiber at all. Uniphase became the key producer of lasers and modulators for WDM and of lasers for erbium doped fiber amplifiers. So powerful was this development that we dubbed Uniphase the **Intel** (INTC) of the Telecosm. JDS Fitel makes most of the key passive devices for WDM and grew as fast as Uniphase. Also using the electronic analogy of microprocessors, we dubbed JDS Fitel the **AMD** (AMD) of the Telecosm. But the name was not quite right. AMD made the same devices that Intel made, while JDS Fitel produced complementary passive components. Since the WDM ideal is to use passive processing as much as possible, shifting and shuffling wavelengths as they pass through the network, JDS Fitel's products might even end up more important than Uniphase's. What we really had was two potential Intel's.

The contest for that title could not have ended better for Telecosm investors than it did when these preeminent optical components companies announced their impending merger. As Tony Muller, the Uniphase CFO explained the proposal, the two companies "have essentially zero overlap of products and 100 percent overlap of customers." Both companies have grown explosively, with revenues from each up roughly 200 percent over the past two years, and the two now boast total combined revenues approaching $600 million. (See Chart 2) The power of their technology has been reflected in the companies' equity value. Uniphase's stock is up more than 200% since we first placed it on the Telecosm table in June, 1997 and JDS Fitel has more than doubled since it first appeared on the list in May, 1998.

Their customers, moreover–such firms as Lucent, Nortel, **Corning** (GLW), Ciena, and **Alcatel** (ALA)–are all buffeted by continual upheaval in their markets of Regional Bells, Long Distance Carriers, Internet Service Providers, Competitive Local Exchange Carriers, and undersea consortia. These telecom capital equipment providers no longer have time or inclination to put together a variety of components and contrive proprietary subsystems of their own. They want their components served in prefab modules–ideally, packaged combinations of Uniphase lasers and modulators and JDS passive isolators and multiplexers. The merger will greatly facilitate the rapid creation and testing of such modules as EDFAs and transponders and the development of crucial new products such as optical add drop multiplexers and cross connect switches.

Chart 2

With Complementary Products Uniphase and JDS Fitel are In Sync



Source: Company Reports

Telecom capital equipment providers now want their components served in prefab modules which the JDS Uniphase merger will greatly facilitate.

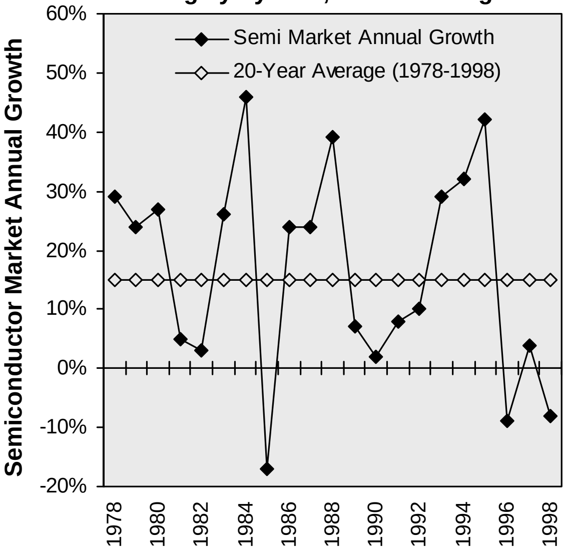
Ultimately these devices can fulfill the dream of an all optical network, in which messages travel from origin to destination entirely on wings of light. Critical to this goal are gratings, arrays of tiny mirrors or transparent grids that select particular colors like a prism does. As WDM depends upon identifying and locking into specific wavelengths and maintaining them precisely as they pass down the fiber, gratings are a vital part of the technology. The distributed feedback lasers, for example, that create precise WDM frequencies, incorporate gratings in the device itself. Gratings can be used to create filters that select a particular frequency or set of frequencies, add-drop devices that can pick up an outside signal or split off a signal, and devices to compensate for dispersion or blurring of the signal in the fiber.

Silica Seines, Silicon Dreams

The dream of an all optical network leads to two mostly complementary ideals of integrated circuitry–telecosmic and microcosmic. The telecosmic view sees the entire system in glass (silica)–whole communications networks in seines of silica spread out across the mostly silicon substrates of continents and seabeds. The microcosmic view recapitulates the history of electronics, with minuscule optical systems integrated on tiny slivers of material, ideally silicon.

Chart 3

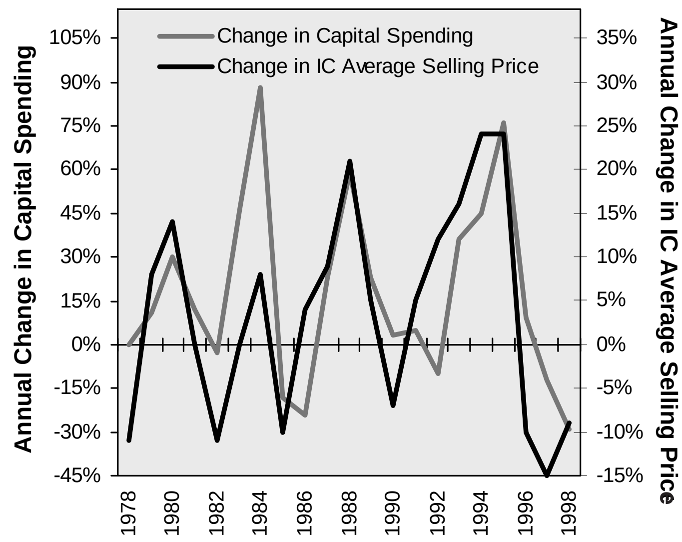
Semiconductor Industry Growth is Highly Cyclical, Never Average



Source: IC Insights

Chart 4

IC Prices and Semiconductor Capital Spending Track Closely



Source: IC Insights

The Semiconductor Industry Grows an "Average" of 15% per Year…But No Year is Average

*The semiconductor industry has enjoyed an average growth of 15% per year since 1978. Yet, the industry has been battered by wild swings in market growth from -18% to near 50% (***Chart 3***).*

Revenues, Average Selling Prices of ICs, and Capital Spending are Linked in Dramatic Cycles

*With integrated circuit production constrained by the capacity of billion dollar fabrication facilities, strong chip demand leads to rising IC prices and dramatic revenue growth. The strong revenues bring increased capital spending on fabs and a subsequent over-capacity, followed by price cuts and retrenched capital spending, setting up the next up cycle. The IC price rise from 1990 to 1994 was followed by enormous annual increases in capital spending of 36%, 45% and 76% from 1993-1995, creating over-capacity and our recent down market. (***Chart 4***)*

The Key Measure of Average Selling Price Began to Climb Last Summer And January's Sequential Growth Over December Suggests a Strong Year

*The up cycle began last summer when demand caught up to capacity and average selling prices began to climb, boosting revenues. We begin 1999 with the expectation of sequential growth in January following higher than expected growth in the second half of 1998. Companies such as Micron, which continued to invest in capacity throughout the down turn, stand to benefit from the up cycle. Telecosm Technology chip companies, focused on ascendant markets, should also benefit. (***Chart 5***)*

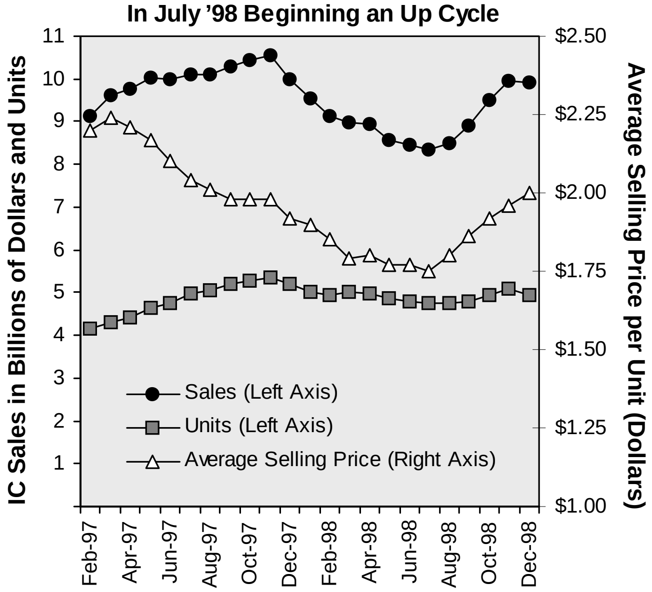
Following the Usual Cycle, Semi Equipment Bookings Are Climbing

*While the North American semiconductor capital equipment market has yet to register strong gains in shipments, bookings for new equipment have soared since September, providing further evidence that historic patterns are repeating in a new up cycle. (***Chart 6***)*

-KE

Chart 5

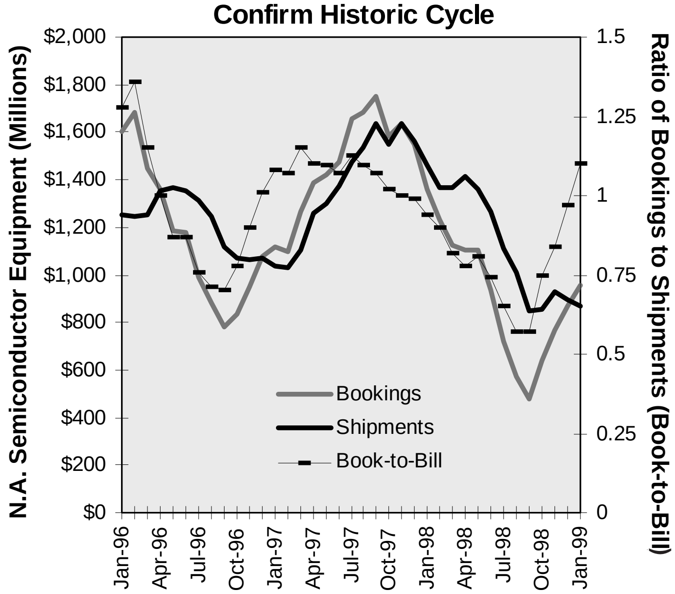
IC Average Selling Price Hit Bottom In July '98 Beginning an Up Cycle



Source: IC Insights 3-Month Moving Average

Chart 6

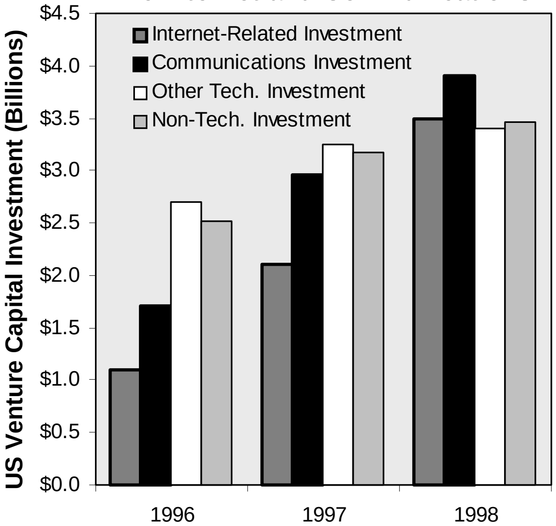
Rising Semiconductor Equipment Orders Confirm Historic Cycle



Source: SEMI

Chart 7

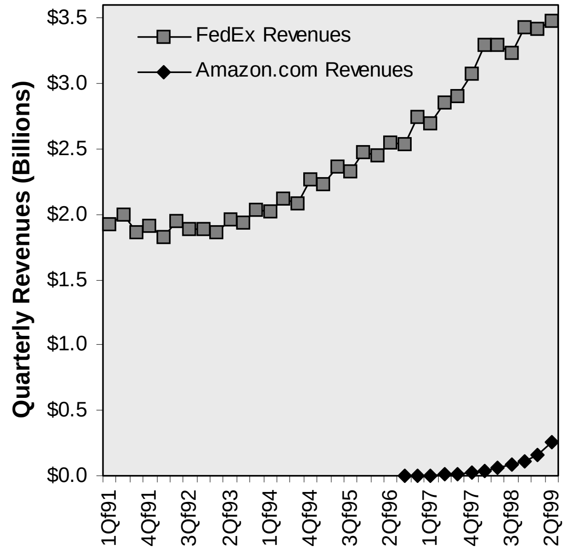
Venture Capital Is Flowing Toward The Internet and Communications



Source: PricewaterhouseCoopers

Chart 8

FedEx is an E-Commerce Winner with Net Sites' Reliance on Shippers



Source: Company Reports

Internet Tornado's Low Pressure Zone Sucks in Investment

*GTR veterans are familiar with Andrew Kessler's (Velocity Capital Management) insight that the plummeting price of a key resource— the sudden evacuation of costs— creates a "low pressure zone" in the economy, creating spirals of growth and twisters of creative destruction. (See GTR 1997.) The bandwidth boom is sucking in investment, placing Internet and communications ventures ahead of all categories in attracting venture capital (***Chart 7***).*

FedEx Soars With E-Commerce

*As stocks of e-commerce companies twist toward the stratosphere, others should be caught in the updraft. FedEx, with flat sales through the early 90s, has seen revenues rise with growth in e-commerce. FedEx's ability to deliver products within the span of time one might need to organize a trip to the local mall makes it a key enabler and beneficiary of the explosion of Internet commerce.(***Chart 8***)*

Internet Advertising is Growing Fast, But Potential Remains Largely Untapped

*The Internet tornado has torn Dorothy and millions of others away from TV and print. More than half of American homes have PCs, most with Internet connections. Ad revenues for Internet sites have just begun to soar, lifting the shares of popular web sites, but huge potential remains for cutting into the American ad market of more than $100 billion for TV, newspapers, and radio alone. (***Chart 9***).*

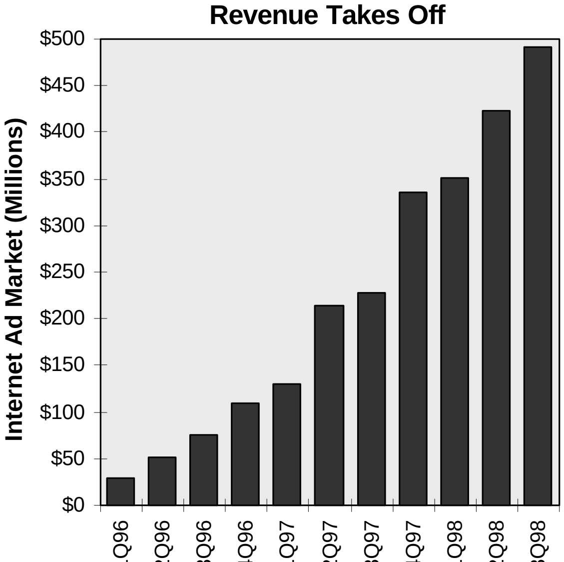
But MCI WorldCom's Internet Revenues Loom Larger

*WorldCom's Internet revenues shot above the whole of the Internet ad market following WorldCom's purchase of Compuserve's (CNS) and AOL's (ANS) Internet networks. While MCI was forced to sell its Internet businesses to Cable & Wireless before merging with WorldCom, MCI WorldCom is positioned to maintain Internet revenue growth as the low pressure zone expands.(***Chart 10***)*

-KE

Chart 9

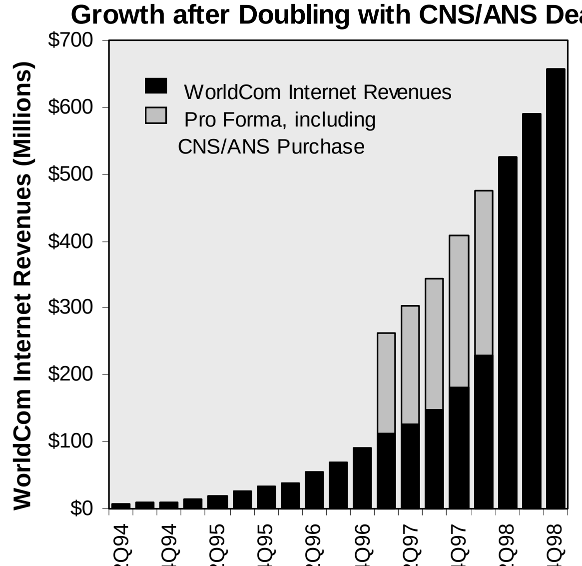
Internet Advertising Revenue Takes Off



Source: PricewaterhouseCoopers for Internet Ad. Bureau

Chart 10

WorldCom Internet Revenue Continues Growth after Doubling with CNS/ANS Deal



Source: Company Reports

Bookham is set to fulfill the micro-cosmic ideal of photonics with new integrated optical circuits on silicon chips.

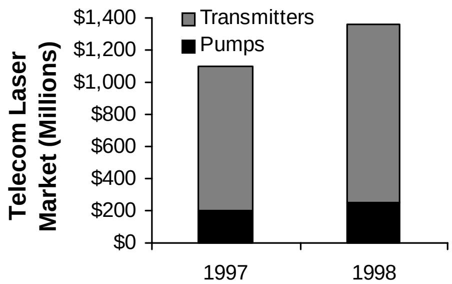
On the one hand, crucial to the telecosmic vision of all glass networks are in-fiber gratings and other devices inscribed within the core or cladding of the fiber itself. Gratings inscribed by ultraviolet light in the fiber itself would define the wavelengths. EDFAs and other in-fiber processes would enhance the signal. Fibers pared on the side for a short span and spliced together would couple signals or split them. Combining these couplers and splitters into tree and branch or other patterns would create multiplexers or demultiplexers to add or drop wavelengths passively, all without removing the light from the fiber. A merged Uniphase/JDS Fitel has truly Intel-like salience for this half of the all-optical vision.

On the other hand, crucial to the microcosmic vision–optical integrated circuits resembling the silicon "ICs" that launched the microelectronics revolution–is the creation of tiny optical chips that can perform many different functions on a silicon substrate. Manufactured in the millions, such devices ultimately could be sold for a few dollars and incorporated into every personal computer or other internet terminal.

Cheap optical integrated circuits could allow the movement of photonic communications down into the last mile of the network, into campus links, and even into local area networks (LANs). Conceivably these chips could bring broadband photonic communications into the backplanes of PCs themselves. In the end, gigabit networks capable of high resolution video, video teleconferencing, and complex visualizations and simulations would become as cheap and prevalent as megabit networks are today. All the electronic bottlenecks would shatter at once and floods of light would stream into the innermost reaches of your computer.

Chart 11

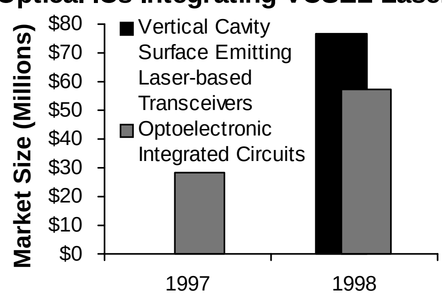
Transmitter and Pump Lasers for Telecom are Uniphase's Forte



Source: Strategies Unlimited

Chart 12

Bookham Hopes to Score with Optical ICs Integrating VCSEL Lasers



Source: ElectroniCast

Bookham's Silicon Disruptor

For this microcosmic consummation of the optical revolution–necessary for the continued success of my investment paradigm–my search for a company spearhead took me to a motley industrial mall in Abingdon, Oxfordshire. There, just off M-4, lurks a potentially disruptive venture called **Bookham** after some equally obscure small British town that once took the fancy of the CEO Andrew Rickman. A spruce, dashing young man, he dawdled through three cotangent degrees–in mechanical engineering, business, and an optics PhD–before taking up work on Fast Fourier technology at **GenRad** (GEN) in the US. Introduced to the magic of the frequency domain, he became a somewhat dilatory entrepreneur, setting out to fund his photonic fancies with a series of government grants, like the professor he seemed likely to become.

Bookham raises the issue: Will electronic history be repeated in optics? Will optical modules be integrated on silicon substrates like the semiconductor integrated circuits created by Noyce at Fairchild and Intel? For Rickman and his rapidly growing team are literally creating integrated optical circuits on silicon slivers. So far, Bookham has contrived silicon on insulator prototypes for many of the key devices that stand between any two computers and a Wavelength Division Multiplexed backbone.

Included are multiplexers and demultiplexers at the two ends, semiconductor optical amplifiers to enhance the signal, gratings to fix the desired frequency, variable attenuators to flatten out any unevenness in the wavefront (caused, for example, by EDFAs), all cooking along at OC-48 (2.5 gigabit per second) rates. As this is written, the company has yet to integrate the mux and demux in a commercial product, but they were already well demonstrated in prototype.

Although Bookham claims that their microcosmic devices meet the specs of the industry, they have yet to announce a major order. The in-fiber devices of the telecosmic vision in general have lower losses than off-fiber devices, easier coupling to fiber systems (being inscribed in fibers themselves), much lower sensitivity to temperature without active thermal controls, immunity to polarization, and lower complexity. By contrast, the off-fiber, all-silicon devices of Bookham promise merely adequate performance for metropolitan and campus networks but hugely lower costs.

Conspicuously missing from Bookham's silicon palette are lasers and photodetectors. Because silicon will not lase, these components are necessarily done in gallium arsenide, indium phosphide or some other III-V chemical compound with an appropriate "band gap" to emit or receive optical infrared. Bookham has contrived ingenious ways to bond microscopic lasers and photodetectors onto their silicon insulator substrate without untoward losses that weaken the signal too much to be read down the line. (An innovation to be introduced later this year is the "adiabatic taper" connection for lasers which Bookham asserts retrenches insertion losses–losses at the coupling of the laser to the fiber–to levels comparable to the best discrete devices).

Nonetheless, an indium phosphide laser or detector attached to a silicon chip is a hybrid or module not an integrated device. Since these key active elements must be manufactured in separate wafer fabs, with separate testing modes and then must risk breakdown on attachment, Bookham's critics wonder what advantage the company gains by joining these devices with a number of silicon functions that are inferior in several respects to current in-fiber devices.

In the *Innovator's Dilemma*, Clayton Christensen tells us that cheaper, inferior devices can prevail at a time of technology overshoot, when the industry is giving customers products that exceed the needs of the bulk of the market. At present, optics offers a condition of technology undershoot. At a time of explosive expansion of Internet traffic, the optics industry cannot supply either the bandwidth or the easy add-drop and switching functions demanded by the market. Therefore Bookham *today* poses no threat to the Uniphase/JDS Fitel concert.

As long as the critical measure of success in the industry is the reduction toward zero of the cost per transmitted bit per second, the telecosmic, all-silica, integrated-on-the-fiber vision will prevail. But for penetration toward homes and LANs, the critical measure will not be cost per bit per second. It will be cost per terminal connection and cost per router port. While typical WDM products command markets of tens of thousands of units a year, **Cisco** (CSCO) currently sells some 60 thousand routers a month and PC chips sell by the hundreds of millions. A cheap, effective silicon technology might well prevail in these lower end uses.

Over the next five years, the result of cheap integrated optical circuits on silicon will be to expand the markets for leading edge telecosmic devices by further expanding Internet traffic, thus supporting and complementing the telecosmic vision. But the history of such disruptive, low-end devices suggests that integrated silicon optics will ultimately dominate many up-market slots as well. The producers of high-end optical devices are premature in dismissing the Bookham threat.

A homogeneous, single-crystal material, silicon is the best known, most thoroughly tested, most widely manufactured, most microscopically manipulated substance on the face of the earth. The specific technology used by Bookham is silicon-on-insulator, which has recently been adopted by **IBM** and **Motorola** (MOT) for next-generation processors. Already, Bookham's all-silicon multiplexer/demultiplexer devices operate at 16 wavelength channels with an insertion loss within the required window for WDM, and by the end of the year will offer acceptable wavelength isolation as well. The company is ready to manufacture cost effective receiver-transmitters with eight channels.

In existing technologies, such as those supplied by Lucent, JDS Uniphase, **ETEC** (ETEC), Ciena, **Pirelli**, and Corning, the functions Bookham is placing on a single chip may comprise scores of separate devices. These discretes suffer from sometimes lossy interfaces cumulatively and costs mounting to hundreds of thousands of dollars in deployed WDM systems (some $10,000 per channel).

Between 1995, when Rickman got off the government needles, to 1999 when the company began to explore a niche providing SONET extenders and cable TV modem chips (markets mostly unnoticed by the optical giants), Bookham raised $65 million from a variety of celebrated venturers, including $10 million from Cisco and finally late in 1998 $10 million from Intel itself (each owns an estimated six percent of Bookham). Bookham also built a wafer fab and assembly facility using conventional semiconductor capital gear and hired 170 people, including Peter Ballantyne from Bell Labs and **AT&T** (T) to head the engineering and Kevin Ford of **National Semicon-**

AllWave Boosts WDM

A recent Lucent technical breakthrough may take us closer to the real promise of WDM: a network that minimizes slow and expensive detours off the fiber and into electronic processors by creating what may appear to many be a surfeit of channels in fiber. Lucent's AllWave fiber will increase the available spectrum by over 50 percent and enable more than 400 channels using standard 100 GHz spacing. 50 GHz spacing is being used in the newest systems, and 10 GHz has been demonstrated in the lab, promising an enormous increase in number of channels, and a granularity in transmissions essential to the effective switching and delivery of messages in metropolitan areas.

Residual water in the fiber has caused the wavelengths around 1400 nm to be unusable. But Lucent found a way to dry things out, making this band serviceable for WDM and other transmissions. AllWave will cover a range of wavelengths from 1280 nm to 1620 nm, which includes the 1310 nm and 1550 (extended to 1620) nm bands traditionally used for CATV and WDM, as well as the 1400 nm band, on one fiber.

AllWave can carry bi-directional CATV traffic and IP over gigabit Ethernet simultaneously with WDM. An advantage for CATV is in making more capacity available for Internet traffic, video-conferencing, or video on demand. While the CATV industry is more cost sensitive than is the telecom industry, with dropping prices and the convergence of entertainment and communication domains, it shouldn't be long before this fiber's utility is seized upon.

At the Optical Fiber Conference Lucent announced a joint development group to explore the possibilities of AllWave, including **Hewlett Packard** (HWP), Uniphase , JDS Fitel and **Scientific-Atlanta** (SFA). Lucent's All-Metro Network is being optimized for AllWave and is to be released later this year.

Lucent announced it had widened the fiber optic communications window by as much as 60 percent.

ASCENDANT TECHNOLOGY	COMPANY (SYMBOL)	Reference Date	Reference Price	February Month-end
Cable Modem Service	@Home (ATHM)	7/31/97	19 1/2	106 1/8
Silicon Germanium (SiGe)	Applied Micro Circuits (AMCC)	7/31/98	22 11/16	39 1/4
Analog to Digital Converters (ADC), Digital Signal Processors (DSP)	Analog Devices (ADI)	7/31/97	22 3/8	25 1/16
Dynamically Programmable Logic, SiGe, Single -Chip Systems	Atmel (ATML)	4/3/98	17 11/16	17 3/16
Single-Chip Broadband Data Transmission	Broadcom Corporation (BRCM)	4/17/98	12 *	60 3/16
Digital Video Codecs	C-Cube (CUBE)	4/25/97	23	18 3/4
Erbium Doped Fiber Amplifiers, Wave Division Multiplexing (WDM)	Ciena (CIEN)	10/9/98	8 9/16	27 7/8
Fiber Optic Cable, Components, Wave Division Multiplexing (WDM)	Corning (GLW)	5/1/98	40 15/16	53 1/2
Submarine Fiber Optic Networks	Global Crossing (GBLX)	10/30/98	29 5/8	59
Low Earth Orbit Satellites (LEOS)	Globalstar (GSTRF)	8/29/96	11 7/8	15 9/16
Business Management Software	Intentia (Stockholm Exchange)	4/3/98	29	24 1/2
Wave Division Multiplexing (WDM), Fiber Optic Equipment	JDS Fitel (Toronto Exchange)	5/1/98	19 1/4	42 3/4
Broadband Fiber Network	Level 3 (LVLT)	4/3/98	31 1/4	56
Single Chip ASIC Systems, CDMA Chip Sets	LSI Logic (LSI)	7/31/97	31 1/2	25 7/8
Telecommunications Equipment, WDM, CDMA, SiGe	Lucent Technologies (LU)	11/7/96	23 9/16	101 9/16
Telecommunications, Fiber, Internet Access	MCI WorldCom (WCOM)	8/29/97	29 15/16	82 1/2
Single-Chip Systems, Silicon Germanium (SiGe)	National Semiconductor (NSM)	7/31/97	31 1/2	10 1/2
Nationwide Fiber and Broadband Wireless Networks	Nextlink (NXLK)	2/11/99	40 7/8	45 3/4
Telecommunications Equipment, WDM, CDMA, SiGe, Cable Modems	Nortel Networks (NT)	11/3/97	46	58 1/16
Point to Multipoint (7-50 Ghz), Spread Spectrum Broadband Radios	P-COM (PCMS)	11/3/97	22 3/8	6 11/32
Code Division Multiple Access (CDMA)	Qualcomm (QCOM)	9/24/96	38 3/4	73
Broadband Fiber Network	Qwest Communications (QWST)	8/29/97	20 3/8	61 7/16
Linear Power Amplifiers	Spectrian (SPCT)	7/31/98	14	11 11/16
Nationwide CDMA (Code Division Multiple Access) Wireless Network	Sprint PCS (PCS)	12/3/98	15 3/8	32
Java Programming Language, Internet Servers	Sun Microsystems (SUNW)	8/13/96	27 1/2	97 5/16
Broadband Wireless Services	Teligent (TGNT)	11/21/97	21 1/2 *	39 5/16
CDMA Cable Modems	Terayon (TERN)	12/3/98	31 5/8	31 1/16
Digital Signal Processors (DSPs)	Texas Instruments (TXN)	11/7/96	23 3/4	89 3/16
High-Speed Copper Networking	Tut Systems (TUTS)	1/29/99	18 *	48
Wave Division Multiplexing (WDM) Modulators	Uniphase (UNPH)	6/27/97	29 3/8	88 1/8
Field Programmable Gate Arrays (FPGAs)	Xilinx (XLNX)	10/25/96	32 7/8	69 3/4

*** Initial Public Offering**

Note: This table lists technologies in the Gilder Paradigm, and representative companies that possess the ascendant technologies. But by no means are the technologies exclusive to these companies. In keeping with our objective of providing a technology strategy report, companies appear on this list only for these core competencies, without any judgement of market price or timing.

ductor (NSM) and AMD to run the fab.

Bookham is set to fulfill the microcosmic ideal of photonics with new integrated optical circuits on silicon chips. The real new integrated circuit, however, is the net itself, integrated not on silicon slivers but across mostly silicon continents and seabeds, a global seine of silica that can capture all the glittering profits in the ball of radiance. It is this radiance, doubling every hundred days that explains the apparently peculiar finances of Internet companies. When your market is doubling at this pace, profits are an actual negative; they suggest that you are sacrificing future market share. They suggest you are responding chiefly to existing customers, who necessarily represent a small portion of the future market. They suggest that you are ready to be microwaved as the radiance increases in power and frequency.

The enablers of this radiance are JDS Uniphase, Ciena, and the other optical stars of the Telecosm who are overthrowing the central office mainframes of existing telecom gear. They are providing the crucial technologies for the new era. For the next five years or so, this will be enough for a spectacular business. But the warning flags are up. In order to avoid a meteoric career in the minicomputer mode, these brilliant companies must remain resolutely alert to the threats and opportunities from below. The Lucent AllWave fiber breakthrough, the Nortel purchase of Cambrian Systems and its metropolitan area WDM technology for $300 million, and the successes of Bookham all signify the opening of an era of microcosmic silicon optics in metropolitan and local area networks. Telecosmic investors should watch for these opportunities. The possible IPO of Bookham and the emergence of **Tellium** as a Cambrian rival may well provide investors with exciting rides in the future.

The future belongs to companies that are unprofitable, growing rapidly, and reinvesting every available dollar of cash flow, companies that are moving from the manipulation of heavy materials to the shuffling of massless photons. Look to the ascendancy of the light.

George Gilder, March 5, 1999

Gilder Technology Report *is published by*
Gilder Technology Group, Inc. *and* ***Forbes Inc.***
Editor: George Gilder; Publisher: Richard Vigilante;
Director of Research: Kenneth Ehrhart; Technology Analyst: Jeff Dahlberg
Monument Mills P.O. Box 660 Housatonic, MA 01236 USA
Tel: (413) 274-0211 Toll Free: (888) 484-2727 Fax: (413) 274-0213
Email: gtg@gildertech.com