GILDER TECHNOLOGY REPORT

January 2007 / Vol. XII No. 1

Ten Laws of the Telecosm Redux

FormFactor is one of those rare Druckerian missing-element vendors that has a decisive technology lead. It is on the way to upside surprises for bold investors.

Inside:

I owe law number one to Peter Drucker.

The last time I saw Drucker, he was keynoting a Forbes conference in Seattle for CEOs. In the auditorium at the International Trade Center next to the bay, they had wheeled out the great man to the middle of the stage in a great fluffy easy chair. Close to 90 years old—at the end of the previous century gazing toward the next—he was the numinous name and Delphic presence at the conference. Everyone leaned forward to hear what he had to say.

Then a gasp shook the rows of CEOs. The conference management stood there stricken, unable to move: "For the Love of Malcolm's motorcycle…What is this?" The CEOs sat popeyed.

The hoary sage's balding pate flopped back in the chair as if he had fallen asleep…or worse.

Perhaps *Forbes* had erred in staking a major conference on an aging guru seemingly well over the hill and in parlous health.

Then his entire body fell forward. I was ready to run up to catch him if he should tumble toward the crowd. But he somehow caught himself. His eyes

(CONTINUED ON PAGE 3)

FEATURED COMPANY: FormFactor (FORM)

FormFactor Passes the Test

Peter Drucker once wrote that, "Profits go to the supplier of the missing element that completes a system."

In seeking companies for our list, we look for suppliers of missing elements that enable fulfillment of the telecosmic paradigms.

Remember Xanoptix, John Trezza's company in Nassau, NH that was set to revolutionize all of electronics by banishing all pins, busses, and printed circuit boards and creating a new industry of stacked chips or wafers communicating through optics? The pins that connect chips to printed circuit boards were going to disappear, replaced by combinations of bare chips with "vias" down their sides linking to other bare chips below and with vertical cavity surface emitting lasers communicating with fiber optic networks.

This paradigm is still on its way—with multichip modules, chip-scale packages, memory dongles, and other ways of stacking necessary in most compact portable devices such as cellphones, iPods or other teleputers. But the full Trezza vision turned out to be a bridge too far for the industry. Renamed CubicWafer, Xanoptix was forced sharply to cut back on its revolutionary agenda. One of the key problems was finding what the industry calls KGD (known good die). Unless you are sure that the chips are free of defects, you cannot stack them in a module. One defect would force you to throw out the entire system.

In the past, engineers could not usually identify known good die until the electrical testing of the circuitry at the test and assembly stage, when the device was put in a plastic package with pins or balls that could be attached to the tester. This process often happened at places like Penang in Malaysia or Manilla in the Philippines far from the front end processing in Taiwan or Silicon Valley.

With cellphones and other teleputers becoming the largest market for chips, however, the old order is breaking down. With chips increasingly devoid of conventional pins or packages, the industry

has been forced to contrive ways to test the devices on wafers—to find the precious KGD before they are cut or "diced" into chips. This has brought the wafer probe industry to the fore as the latest supplier of a crucial Druckerian "missing element" that completes a system.

For more than a decade, FormFactor (FORM) has been a premier producer of advanced probe cards. These complex devices test chips electrically while they are still part of a wafer comprising hundreds of chips. In this pre-packaged or unpackaged form chips are called die under test (DUT), with the transistors and other devices in the center and connective pads around the outside. Probe cards are the crucial interface that applies an array of cantilevered probe pins to the die and links them to the test head, which computes the results of the probe.

The test head, in turn, connects to the automated testing equipment. As chips become smaller and more complex and increase their performance, pins on the probe cards proliferate while needing to make more precise and firmer contact with the wafer to ensure that reliable signals are sent to the tester. Along with the chips, tester technology is also advancing, enabling the evaluation or more and more die at one time. This is further increasing the demand for advanced probe cards.

Leaping ahead in this market several years ago, FormFactor introduced a single touchdown probe card that could connect to all of the die on a wafer simultaneously. Customers could buy these more expensive cards and still save money because they would need to buy fewer testers and could shorten their test time. The savings are most pronounced where the cost of testing chips is highest, most notably in DRAM (dynamic random access memory) fabs.

For example, in a classic 300-millimeter DRAM fab producing 30 thousand wafer per month, manufacturers pay $3m more per year on Form's probe cards compared to competing cards. But Form tests four times as many devices per touchdown, saving the manufacturer $15m per year in testers and probers. Moreover, customers report that Form improves yields 1–4% by enabling more accurate reads earlier in the process, boosting their aggregate annual savings to an average of $47m with Form.

Growing down market and up wafer

Some 77% of FormFactor's sales come from the DRAM market followed by 13% from Flash memory (largely NOR flash memory) and 10% from logic (largely Intel—INTC). In 2005, Form claimed 52% of a rapidly rising advanced probe card market, and the company expects to continue to take share as its enters the NAND flash memory and low-end logic industries and as it helps to shift more tests to the wafer level.

Traditionally, most of the call for advanced probe cards in flash memory has come from the NOR segment. Testing costs in the faster growing NAND flash market are lower since the chips run slower and require shorter test times, dampening the economic advantage of the more expensive advanced cards. Now Form has begun a major march into NAND territory with its low-cost Harmony one-touchdown platform, which shortens the time it takes manufacturers to set up test equipment. Three early customers reported that Harmony reduced downtime from 11% to 3% compared to another one-touchdown product, saving them a potential 20% per year. Form expects revenue from Harmony to begin ramping early in 2007.

Far more challenging are logic chips such as microprocessors with thousands of on-chip pads microns apart in varied patterns. But logic chips also are increasingly incorporated in modules and other forms of joint packaging that require on-wafer testing. From its inception, FormFactor engaged the flip-chip logic market where, in a scenario similar to the DRAM example above, it claims to save customers an average of $32m annually per fab, both on testing equipment and by improving yields. Beginning in 2007, Form will hugely expand its opportunities in logic by moving its advanced technology down to the peripheral pad or fine pitch (low-end) portion of this market, which in 2007 is expected to sell an order of magnitude more devices than the flip-chip portion. Form is already working with an early adopter of these new parallel probe cards and should see meaningful sales later in 2007.

FormFactor lives at the rear of the front-end fab process where chips are sort tested on the wafer. In addition to sort tests, manufacturers perform burn-in and speed tests at the back-end, after the chips have been packaged. Now, rising packaging costs and proliferating multichip packages are beginning to drive some of the back-end testing up to the wafer level. The savings derived from not packaging defective parts can be significant. In cellphones, for instance, between four and seven memory devices can be stack-packaged together. With yields on single devices of around 85%, devastatingly low yields result on stacked chips (from 52% in a stack of four to 32% in a stack of seven) if you delay testing to the end.

In response to this opportunity, Form is beginning to offer probe cards that enable burn-in and speed tests at the wafer level. Since each test requires an additional card, the migration of more testing to the front-end could greatly enlarge Form's market by the end of the decade, when the advanced probe card market is expected to reach $1.3 billion after ascending an average 30% per year from 2005–2009. Growth drivers include **Microsoft**'s (MSFT) Vista operating system, which requires up to a nine-fold increase in PC memory; next-generation game consoles that demand up to an eightfold increase in memory, and 3G cellphones with up to a gigabyte of memory by 2008.

Barring the gates

Since Form leapfrogged its advanced probe card technology, fetching 50% gross margins compared to single-digit to mid-30s gross margins for the traditional probe card business, rivals haven't been able to mount a meaningful comeback. In 2005, Form's nearest competitor, **JEM** (Japan Electronic Materials Corporation), took 13% of the advanced probe card market compared to Form's 52%, followed by half a dozen or so others in the single digits. Form has likely further increased its market share lead in 2006 by several percentage points, while many of its rivals' sales continue to decline. This reflects Form's masterful solution to a very difficult technological challenge.

To handle surging demand now approaching $100m per quarter, Form needs to add manufacturing capacity, beginning at the Livermore facility, where capacity is currently being increased to $150m per quarter simply by adding machinery to free up bottlenecks (as opposed to adding complete new lines). To further support up to $200m of quarterly sales, Form plans to expand the back-end process at its Singapore plant next year, with production slated to begin during the first half of 2008. After that, Form will need to build a second wafer fab. Among its options, management is considering building a facility next its current Singapore

back-end operation.

Scale enhances Form's decisive technology lead by giving the company a huge advantage in cost and in response time over its minichallengers. Pressured by rapidly evolving market demands, customers have been clamoring to get their orders within 6–8 weeks so they can quickly switch multiple times per month and even per week among process nodes, density, architectures such as DRAM and SRAM (static random access memory), chip speed, and industry segments such as mobile and gaming. Recently, market research firm Gartner warned that memory manufacturers will soon need to be able to switch back and forth between DRAM and NAND flash production to remain competitive. The condensed product cycle is quite a challenge for Form since it must customize every probe-card design to match both wafer geometry and the customer's specific application. Management reports that it is close to attaining the shortened cycle times, helped in part by its expanded and modernized facilities.

Become an inFORMed investor

The outlook for Form is bright. Customers are facing more complex testing requirements as process shrinks accelerate, as package costs rise and multichip packages become more common, as new device features proliferate, as product mix per customer increases, and as retooling time decreases to enable higher up times. All of this is hitting while average selling price per bit tested continues to fall 30–35% per year. Driving Form deeper into this rapidly evolving and expanding market is a team of seasoned semiconductor veterans, including founder, CEO, and tech guru Dr. Igor Khandros; president Joseph Bronson, former CFO of **Applied Materials** (AMAT); and CFO Ronald Foster, previously CFO of **JDSU** (JDSU) and operations controller for Applied Materials.

Near term, management expects sales to trend flat during the fourth quarter due to a brief delay in DRAM shrinks. Early adopters had initially planned to progress to 70 nm near the start of the quarter. However, DRAM prices have been unusually strong recently and the changeover would have reduced capacity during a short-term price spike. The transition is finally beginning, propelled by the need for Form's customers to relentlessly lower their costs and economically to produce gigabit DRAM chips for Vista PCs.

Long term, this veteran team believes it can increase sales 25–30% annually over the next few years while maintaining a 25% operating margin and fully funding required capacity expansion with about 11% of sales. But if Form is taking share in a market that is growing 30% per year, then this scenario is certainly conservative. With swelling capacity, speedier cycle times, and successful foray's into its new markets, life will become even more difficult for Form's chasers. Icing on Form's cake includes $454m of net cash with no long-term debt and positive free cash flow. And as the company opens up manufacturing plants in the lower tax regions of Asia, its current 36% tax rate should begin to decline.

Assuming the company merely keeps pace with the industry, sales would reach $804m by 2009 with an after tax profit of about $2.77 per share. That's an average 23% annual increase over this year's expected earnings of $1.49. At a corresponding multiple of 23 times earnings, the stock price would appreciate to $63.71.

A company that we found through an alert from a subscriber, "Hepcat" on our Telecosm Lounge subscriber message board, FormFactor is one of those rare Druckerian missing-element vendors that has a decisive technology lead in consummating the Telecosm. It is on the way to upside surprises for bold investors.

— George Gilder and Charles Burger

(CONTINUED FROM PAGE 1)

opened, and he looked out intently at the throng of CEOs. Everyone sighed with relief. He was awake. He had their attention.

Drucker growled: "I have just one thing to tell you today. Just one thing…"

Wow, I said to myself, it better be good.

"No one," he continued, "but no one in your company, knows less about your business than your *See Eff Oh*."

Huh?

This was the era of the heroic Chief Financial Officer (CFO). Scott Sullivan of Worldcom, Andy Fastow of Enron, clever, inventive folk like that. You remember them. Across the country, CFOs were in the saddle. CEOs would not move without consulting them.

What could Drucker have meant?

He was stating law number one of the Telecosm.

Knowledge is about the past. Entrepreneurship is about the future. CFOs deal with past numbers. By the time they get them all parsed and pinned down, the numbers are often wrong. In effect, CFOs are trying to steer companies by peering into the rearview mirror. Past numbers do not have anything much to do with future numbers. As Ken Fisher puts it in his new book *The Only Three Questions That Count*, "Stock prices [and by extension other business numbers] are not serially correlated."

Moreover, CFOs tend to focus on internal problems. But most internal problems cannot be solved internally. Determining business outcomes are decisions made by customers and investors and both are outside the company and not directly managed by the company. Their views can change in an instant, casting all the existing numbers into oblivion. To reach customers and investors takes outside vision and leadership, not internal problem solving.

Tech companies should not try to solve problems. Solving problems sounds good, but it is a loser. You end up feeding your failures, starving your strengths and achieving costly mediocrity. Don't solve problems—that's the CFO's forte and pitfall. Pursue opportunities.

One of our erstwhile companies that has been solving problems for the last five years is **JDSU** (JDSU). It

Advanced Micro Devices	(AMD)
Altera	(ALTR)
Anadigics	(ANAD)
Analog Devices	(ADI)
Broadcom	(BRCM)
Cepheid	(CPHD)
Corning	(GLW)
Energy Conversion Devices	(ENER)
Equinix	(EQIX)
EZchip	(LNOP)
Finisar	(FNSR)
Flextronics	(FLEX)
FormFactor	(FORM)*
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)
Semitool	(SMTL)
Sprint Nextel	(S)
Synaptics	(SYNA)
Taiwan Semiconductor	(TSM)
Texas Instruments	(TXN)
Xilinx	(XLNX)
Zoran	(ZRAN)

*Added this month

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

DECEMBER 20: 3.27; 52-WEEK RANGE: 1.90 – 5.49; MARKET CAP: 1.01B

The only news arising from Finisar's second fiscal quarter (ending October) report was announcement of an internal review of past stock option granting practices. Finisar has come late to the options party and we can only hope that its stay will be brief. We hope the same for CFO Steve Workman's stay in the hospital, wishing him a quick recovery from the sudden illness, which apparently struck him a day or so before the quarterly call. Steve is expected back in a few weeks, only to descend, we suspect, into a den of inquisitors.

Otherwise, Finisar is still on track to glom a record $430m to $460m of sales this fiscal year, following its thirteenth consecutive quarterly revenue rise, the last nine of which were records themselves. Particularly bullish in the latest quarter were sales of 4-gig long-wavelength transceivers for long-distance (metro) storage backups and sales of 10- and 40-gig products. Sales of down-market transceivers into enterprise and storage networks trended flat due to inventory overstocks that are expected to last another quarter, after which sales should begin ramping again.

Boding well for the future, the company is winning more and more designs at telecom equipment vendors with products that should boost margins over the next two years. During the recent quarter alone Finisar increased to 28 the number of telecom customers to whom they shipped over $100k in products, up from 21 the previous quarter. Finisar ascended to the top of the enterprise market through its technology and sales lead in pluggable optics. Until recently, telecom wasn't interested in pluggable transceivers. Now Finisar is changing that in the metro with pluggable 10-gig products for Ethernet and Sonet that give systems houses greater flexibility in designing line cards compared to the traditional method of soldering in components supplied by a potpourri of vendors.

Sales of network tools fell 10% sequentially during the quarter to 8.5% of total revenue, on its way to a flat year as expected. CEO Jerry Rawls still sees a surge here beginning next year when the rollout of new 6- and 8-gig storage networks should generate interest in network test and monitoring equipment. Finisar is the largest manufacturer of test and measurement tools for Fibre channel, but has traditionally sold these products only to big storage operators and equipment vendors. Rawls is now starting to sell directly to enterprises using his own sales force and industry partners, but the fruit from this move won't begin to ripen until next year.

The move to the new VCSEL fab in Allen, Texas, from the old fab in nearby Richardson, should be completed by spring, thereby doubling the company's capacity to produce VCSELs and photodetectors. Meanwhile, installation of automated production equipment in the Malaysian assembly plant continues, and yields are improving there. Better efficiencies along with a trend toward sales of higher-margin long-wavelength products helped push gross margin up a bit more than expected during the quarter. Overhead held within guidance, and Rawls expects all pro forma operating expenses to continue to hit his fiscal-year targets. Thus we keep our earnings forecast at 15 cents per share despite the scarcity of financial figures that were released due to the options review.

Finisar gained time on the repayment of $100m of their $150m of 2.5% converts due in 2010 by eliminating a put option which allowed holders to force Finisar to repurchase the notes next October. In return, the new notes require that the principal be paid in cash and any additional amounts to settled in shares of common stock. The remaining $50m of the original notes have been classified as a current liability as a result of the put option. Separately, another $100m of converts come due in 2008. If Finisar's recent win in its patent infringement case with DirecTV is upheld next year, the award of $104m will allow Rawls to retire a chunk of this debt.

Darkened only by the options shadow, Finisar's long-term prospects remain essentially as bright as we have been forecasting. In particular, with online applications pushing 10-gig Ethernet into enterprise and metro networks, sales of 10-gig Ethernet transceivers into the metro are expected to rise 44% per year for the next three years. Finisar is an emerging player in the space and that market is just starting. Rawls sees even greater upside potential for 10-gig sales to enterprises. And storage networks should continue strong as well, as online users generate and retrieve ever growing piles of data.

As we reasoned in September, if Finisar attains its long-term sales and margin guidance (which we think is conservative), by later next year management will be projecting a 47% increase in earnings to $0.22 for fiscal 2008, with a bonus of no tax penalty—the company has accumulated $350m of operating losses. A growth price-to-earnings multiple of 30 would send the stock to $6.60; a multiple of 25 yields $5.50. But investors who recognize the potential of Finisar's markets in the emerging online and digital media world will expect to see even greater gains by the end of the decade.

Let us hope Finisar doesn't option out of the bash.

— Charlie Burger

FormFactor (FORM)

PARADIGM PLAY: SINGLE TOUCHDOWN CHIP TEST PROBE CARDS

DECEMBER 20: 35.86; 52-WEEK RANGE: 23.84 - 49.71; MARKET CAP: 1.67B

As a probe test pioneer, with a decisive technology lead in producing advanced probe cards used to test chips while they are still on the wafer, FormFactor joins our list this month.

Online Bonus Material: For additional analysis on **Sigma Designs (SIGM)** and **Microvision (MVIS)** logon with your GTR subscriber ID at *www.Gildertech.com*

has been cutting back, and pruning, and shrinking costs. But as Charlie Burger says you cannot prevail by shrinking. Moore's law does not apply to companies.

2. Moore's law ordains that for a given level of performance prices routinely drop 50 percent every 18 months. As Caltech's Carver Mead explained to Moore when the Caltech professor named Moore's law, smaller transistors run cooler and faster and cheaper. This law rules the world of technology because of what economists call price *elasticity* of demand. In the sometimes slow moving world of conventional business, price collapses may crash your margins and profits. But in the tech world, users and uses multiply when prices drop. You get positive elasticity, which means that revenues rise when prices decline.

Broadwing benefited from Metcalfe's law. So will all our networking plays, such as EZchip and NetLogic.

All our semiconductor companies benefit from Moore's law: **Intel** (INTC), **Advanced Micro Devices** (AMD), **Texas Instruments** (TXN), **Qualcomm** (QCOM), **Broadcom** (BCRM) and our copper-plating gear maker **Semitool** (SMTL), our board level digital power innovator **Power-One** (PWER), and our newly listed probe test pioneer **FormFactor** (FORM).

Moore's law, though, is reaching a crisis as power levels drop below a volt toward irreducible electron volts and power sources multiply, with one volt, 3 volt, 5.5 volt, and 11 volt feeds often necessary. Meanwhile mixed signal devices proliferate with both analog and digital components on a single chip. Digitizing and consolidating analog power sources that require a separate wire for each voltage, Power-One will ultimately be a major beneficiary of this trend.

3. Metcalfe's law asserts that the value of a network rises by the square of the number of compatibly connected users. As the namer of Metcalfe's law, I like to add a power factor: Metcalfe's law works in part because the linked devices on the edge are increasing their power and versatility at the pace of Moore's law. After the millennial telecom crash, it has become fashionable to point out the various flaws in Metcalfe's law. Andrew Odlyzko of the University of Minnesota has done a recent critique. Metcalfe's law is not literally true all the time, but it offers a rough and useful guide when contemplating the value of companies such as YouTube. Don't forget it.

Our **Broadwing** (BWNG), now captured by **Level 3** (LVLT), benefited from Metcalfe's law. So will all our networking plays, such as **EZchip** (LNOP) and **NetLogic** (NETL).

4. Dumb networks will prevail over smart networks. The future is all-fiber networks that do nothing but transmit bits. Intelligence belongs at the edges and endpoints.

This is our "Life After Television" paradigm. It separates content from conduit. If you have the best conduit, you will want everyone's content on it. You won't want to restrict it to your own content. On the other hand, if you have the best content, you will want it on everyone's conduit. You won't want to keep it on your own network. Players that try to combine content and conduit will eventually split apart and often bleed financially in the process (e.g. AOL-Time Warner).

5. Software hardens at the core of a network—hardens into glass—pure fiber. Hardware softens at the edge into programmable forms. Consider the change from hardwired TVs and telephones into programmable PCs and handheld teleputers.

On the network, this law favors **Corning** (GLW), **Finisar** (FNSR), and **PMC-Sierra**/Passave (PMCS) supplying key optical components (also optical inventor **Essex**—KEYW—in the process of being purchased by **Northrop Grumman**). On the edge, the law benefits programmable logic vendors **Altera** (ALTR) and **Xilinx** (XILX) and programmable node makers EZchip and NetLogic.

6. The edge of the network is analog, because that's where humans live, in an analog world. But the analog world is one of shortages, because there is a shortage of great analog engineers in the U.S. and throughout the world. Therefore, great analog design will often produce great profits.

Our analog stars are **National Semiconductor** (NSM), **Anadigics** (ANAD), **Synaptics** (SYNA), and power interface innovator Power-One.

7. Law of Abundance. Far-seeing entrepreneurs waste what is abundant in order to save what is scarce. Today, processing power is abundant. Bandwidth is becoming abundant. Electrical power, on the other hand, is becoming scarce. So invest in chips and computer architectures designed to save on power.

Our analog stars are National Semiconductor, Anadigics, Synaptics, and power interface innovator Power-One.

8. Law of Scarcity. *Speed of light* is the scarcity that governs networks, whether on the surfaces of chips where signals move nine inches a nanosecond through miles of minuscule copper wires or across continents and oceans where latencies reach 60 milliseconds. *Span of life* is the scarcity that will govern human interactions and consumer businesses. Consumers hate to have their time wasted. That's why broadcast TV is a failing model—it wastes the consumer's time.

9. Schmidt's law. When the network becomes as fast as the backplane of your computer, the computer hollows out, its components dispersing across the web, its value migrating to search and sort functions. This law was put forth by Sun's Eric Schmidt a decade and a half ago. Schmidt, of course, is now the CEO of **Google** (GOOG), where search and sort has paid off rather nicely.

10. Gordon Bell's corollary to Moore's law. Every ten years

there is a hundredfold drop in the cost of computing, leading to a new paradigm in computing. Google-like server farms are the new computing paradigm. But Ray Kurzweil's codicil to Bell's corollary is that everything is accelerating. Within five years, a newer and more radical computer architecture will take the place of the current datacenter model.

These are ten laws for understanding the technology. But the key law is Drucker's *Don't Solve Problems, Pursue Opportunities*.

How do you identify opportunities? Drucker has the answer to that also. By looking for *upside surprises*.

This is the final entropy law from the fertile mind and mathematics of Claude Shannon of MIT and Bell Labs, who defined information as unexpected bits. (Predictable bits convey no information content, no entropy.) Information entropy is measured by its *surprisal*.

Predictable returns are discounted by the market. What we are seeking on the *GTR* is unexpected returns, the upside surprises of creativity and profit.

My summation of this law is, "High entropy messages (full of surprise) require a low entropy (no-surprises) carrier." Only if the carrier itself is predictable can the information be distinguished from the noise at the other end. Thus the key insight of the telecosm is that in an information age information and value will migrate to the perfect sine waves of the electromagnetic spectrum.

I believe that this is a more general law than Shannon perceived. The heart of capitalism is creativity. Creativity, as Albert Hirshmann of Princeton once wrote, always comes as a surprise to us. If it didn't we would not need it. Socialism would work. But the upside surprises of creativity require a low entropy environment of predictable property rights, taxes, and other business laws ultimately based on trust in a moral order. All these conditions are essential to an entrepreneurial economy.

Upside surprise is another way of saying "profit." Profit is entropy—unexpected returns. Predictable returns are all discounted by the market and diminish to the interest rate. What we are seeking on the *GTR* is unexpected returns, the upside surprises of creativity and profit.

— *George Gilder*

A new vision for Microvision

By combining its proprietary silicon micromirror with modulated light sources, **Microvision** (MVIS) enables higher-intensity, finer-grained imagers and displays using a fraction of the size and power of rival systems. Though it possesses the single most potent display technology in the industry, Microvision has for years been foundering in uncharted waters, steered by a Magellan management pursuing too many difficult applications too early.

Now, new management fresh out of **General Electric** (GE) appears to be steadying the ship. After a decade filling key marketing, operations, and product development roles at GE, Alexander Tokman jumped to Microvision a year ago July as operations chief. Quickly gaining the CEO spot last January, he brought in marketing and sales chief, Ian Brown, and R&D head, Sid Madhaven, with a combined 26 years of experience at GE.

Finally, Microvision becomes as focused as its photons

The key goal of the new team is development of an integrated photonics module (IPM) or microprojector to be used as a common display engine in its new products. Small enough to integrate into a cellphone or iPod, the microprojector will include the silicon micromirror (about a square millimeter in size) and light sources, electronics to wiggle the mirror and modulate the light, a controller, and memory.

Three separate beams of red, blue, and green light from either LEDs (light emitting diodes) or semiconductor lasers shine on the mirror. Gimballing on two axes, it flickers to project 30 million pixels a second onto a surface such as a wall. Even though the mirror reflects one pixel at time in raster fashion, it does it so quickly that our brains "see" a static image or continuous movie. To produce different colors during the scan, the light sources are modulated to emit beams at varying combinations of intensities.

Microvision enables higher-intensity, finer-grained imagers and displays using a fraction of the size and power of rival systems.

In addition to functioning as a projector, Microvision's display technology can be turned into a scanner or near-field camera that works well over distances that are about the same as those for a barcode reader. In this case, the light sources that bounce off the moving mirror are used

to illuminate an object. A detector receives the scattered light energy and converts it to electrical signals stored in the appropriate memory locations based on the corresponding pixel position, thereby reproducing the object. Because the time the beam remains on any given spot is a very short 20 nanoseconds, there's virtually no motion blur.

Tokman is focusing on three specific product areas: (1) miniprojectors, including embedded projectors inside cellphones and standalone models that will work with portable devices; (2) head-up displays (HUDs), now making their way into luxury cars, that shine an image directly in front of the driver, just above the steering wheel, displaying information about the engine, weather, navigation, and traffic; (3) eyewear that creates immersive experiences for gamers and movie buffs, giving them a virtual screen equivalent to an 80- to 100-inch display.

Management is focusing on potent markets. By 2008, some 80–90 percent of all cellphones—some 800 million shipped that year—are expected to have megapixel cameras and/or be capable of receiving broadband video. **Nokia** (NOK) is already looking at technologies to integrate projectors into mobile devices, and several large consumer electronics companies are reportedly developing microprojectors based on very small display technologies. And head-up displays are becoming popular in cars for safety, for convenience, and as a differentiator for luxury models. Automakers installed several hundred thousand units last year and could increase that to 4 million units a year by 2010.

But when the consumers and manufacturers arrive, will Tokman be there to meet them?

Tokman plays Beat the Clock

Two years ago Microvision entered into an agreement with **Ethicon Endo–Surgery** to integrate its scanned-beam technology into Ethicon's medical products. Prototype units have finally been delivered, but the challenge to mass-produce these devices remains. The same challenge faces Tokman with his microprojector module, still under development. A workbench model is far from a reliable "assembly-line" device that phone-makers can integrate into products that consumers may then buy without mortgaging their homes. The difficulties are formidable. A rapidly gyrating mirror must synchronize with light sources flickering at varying intensities 100 million times a second. Integrated into the mirror are silicon mechanical structures that measure strain in order to detect the mirror's position. This information is fed back to the modulator, which determines the intensity of light emitted. The feedback loop allows the system to constantly adjust to produce the desired image.

To help move the module from workbench to assembly line, Tokman in November entered into a joint design agreement with a large Asian consumer electronics manufacturer. He also began working with Fraunhofer Institute for Photonic Microsystems to augment Microvision's design and production of the tiny scanning mirrors that are the key to the microprojector platform.

Green laser light presents another challenge. Near-eye systems such as head-up displays can use LEDs, but projectors need lasers. Compact red and blue lasers have become commodities, but Microvision is still waiting for affordable, green semiconductor lasers with the power and modulation speeds required for its integrated photonics module. The development of such a mass produced green laser has challenged researchers for years, and Microvision reportedly had been working with **Corning** (GLW), **Osram**, and **NovaLux** on the issue. Finally, in July, Tokman entered into an agreement with one of these firms to hasten the design and development of such a laser.

Becoming more proactive in head-up displays as well, Tokman has begun joint development work with a major global tier-1 automotive supplier. Microvision's crisp, high-contrast displays are less than half the size of competitive offerings and are easier to install. But current products are more mature and have already been designed into many models in an industry that requires long lead times. It will be tough for Tokman to displace the entrenched players in this slow-growing market.

The first two products based on Microvision's integrated photonics module will be a standalone miniprojector (for media players, cellphones, laptops, and other portable devices) and an embedded projector for a smart phone. Tokman doesn't expect to release these products before 2008, and much of their success will depend on the cost and on the energy efficiency of the lasers; using existing technology, a phone with an embedded microprojector would drain power about 50 percent faster than average while the projector is running.

Cash countdown continues

The new crew has done a great job simplifying Microvision's financial jumble. Since the end of the third quarter, Tokman has sold the last of his unrestricted shares in **Lumera** (LMRA), has raised $7.9 million through the sale of stock, and has seen his restricted shares of Lumera appreciate by some $10 million. (Restricted shares can be sold after Microvision retires $5.8 million of convertible notes in March; Tokman plans to pay the holders in cash.) The company should end the year with some $22 million of net cash, assuming Lumera's valuation holds.

With cash burning at a rate of $6 million per quarter, Tokman will need to go back to the market during the second half of 2007, long before the expected

release of the first standalone projector. During the first nine months of this year, Microvision's revenue dropped dramatically to $5.2 million from $12 million for the same period in 2005. Tokman expects full-year sales to reach $8 to $9 million, significantly short of the previous year's $14.7 million.

Over the past decade, most of Microvision's revenue has come from the U.S. Army's support of projects to build head-mounted displays for helicopter pilots, and the company may need to rely on the military to continue to nurse it along until its projectors and displays begin their hoped-for ascent in several years. In September, **General Dynamics** (GD) awarded Microvision a $5.95 million subcontract to develop a new, light-weight see-through helmet-mounted display which will enable a combat vehicle crew member to see real-time data and video from multiple sources, in full-color. Earlier last summer, Microvision signed a $900k contract with the Air Force to develop a portable eye-wear display. This contract will help Tokman reach his goal of commercializing a see-through display the size of a pair of eyeglasses.

Microvision's only current commercial product is the Flic handheld laser barcode scanner. Based on the company's scanned-beam micromirror technology, Flic consumes less power and costs less than many other barcode scanners. Yet despite these advantages, sales have slumped to $1.5 million so far this year from $2.8 million over the same period in 2005. This highly-competitive market is dominated by **Symbol Technologies** (SBL), and is yet another area in which Tokman has become more actively involved.

In November, he entered into an agreement with **Network Systems & Technologies** to establish an offshore development center that will complement Microvision engineers working on Flic. During the summer, Microvision released three software products for Flic that allow the scanner, including Bluetooth enabled cordless models, to capture barcode data directly into a variety of business and consumer household applications running on Windows. Now individuals can scan barcodes from their book and media collections into spreadsheets for personal asset management. In addition, more companies are releasing products which bundle application software with the Flic. On the strength of these developments, Tokman expects the Flic line to revive over the coming quarters.

Potent potential … and potent pitfalls

The stock closed at $3.11 on 21 December 2005 when we said it was worth about 46 cents. A few weeks later shares surged to $4.25 before suffering a slow decline to $1.16 in August. The stock has now recovered back to around $3 largely because of Lumera's upside surprise and Tokman's focus. Based on a fully diluted share count of 56 million (including outstanding warrants) and net cash of $22 million, investors are giving Microvision an enterprise value of $146 million. That's a whopping valuation for a company expecting $8.5 million of sales this year. Clearly, investors are anticipating revenue to increase by at least an order of magnitude long before they die, and quite a few times that if they want their shares to appreciate from here.

Tokman may well pull the feat off, and we are much more hopeful about Microvision under his direction than we were a year ago. Unfortunately, he has not revealed anticipated selling pricing of any pipeline products. However, even if he makes it into a tenth of the 3G and 4G cellphones in several years, he would clearly have made good on the current valuation. Add to that a million or so head-up displays in few luxury models and a successful miniprojector business, and he would likely become a hero to his investors.

The potential is worth the bet. But remember the looming challenges and pitfalls and use only your spare cash on this one.

– George Gilder and Charles Burger,
December 21, 2006

Got Questions?

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