Steven Cordovano: 203-299-0286

Independent Research Report

Lightwave Logic Inc.

Symbol	LWLG.OB
Industry	Technology
Recent Price	$1.96
52-Week Range	$2.59-$.38
Short Interest	16,750
Average Volume	75,789

Valuation	March 26, 2010
Market Cap	$77.9 Million
F/D Shares.	47.6 Million
Float	26.6 Million
Held By Insiders	35.3%
Held By Insts.	.10%

Initial Report

Reflecting on the next *new*, New Frontier

What if someone told you that they had a new material to coat the Interstate Highway system that could make it possible for you to drive from New York to San Francisco in 5 hours instead of the 50 hours it might normally take? And, what if you were informed that the cost of this material was a mere fraction of the cost of asphalt? Would you be interested to own a piece of that intellectual property?

Though the above situation is highly apocryphal, it is analogous to what is going on right now in the virtual information highway that we know as the Internet.

Currently there are a handful of companies experimenting with advanced forms of plastic polymer materials that can manipulate light waves to facilitate the transmission data at speeds of up to 16x faster than what we are experiencing. This technical evolution/revolution when achieved and implemented will be a transformative event with the potential to change the quality of life. It will foster a myriad of technologically innovative applications that heretofore were only theoretical.

To understand the societal implications of this, one only needs to look back at how productivity was positively impacted after other transformative innovations like the invention of the steam engine, the automobile and the semiconductor. And, from an investor point of view, each one of these events created an enormous amount of wealth and made a lot of people rich.

Serious growth investors always need to have their antennae up to be on the lookout for these kinds of transformative opportunities and **Lightwave Logic** is a company that should be on every growth investor's radar screen. It has distanced itself from the handful of companies in the development of these advanced polymers that could ring the bell on a new era of communication which will lead the world into the *new*, new frontier.

Corporate Background

Lightwave Logic has been around in various forms since it was incorporated in 1995 as PSI-TEC, Inc., a non-reporting publicly traded company. In July of 2004 it changed its name to Third-Order Nanotechnologies and in March 2008 the company was renamed as Lightwave, Logic, Inc. to better define the strategic business plan and to facilitate shareholder recognition of the company.

The company's key intellectual assets are the result of the work of Dr. Frederick Goetz, a recognized industrial expert in polyheterocyclic organic chemistry (the chemistry of polymers). Initially, the US Army became interested in this and for a while the company functioned as a technology consultancy to the various agencies within the Department of Defense.

Electro Optical-Polymers

Very simplistically, an electro -optical polymer (EO polymers) is plastic that has been manipulated to give it unique properties enabling it to control light. They are more aptly polymer composite materials because they are made by dissolving a chromophore, which in laymen's terms is a dye that gets dissolved into a solvent. When solidified, the molecules line up in such a way as to give the material the ability to control the path of light (photons).

At this point in the evolution of this technology, it is necessary to apply an electric charge in order to manipulate light. Next generation polymers will not need the additional layer of electronic technology but instead will use light to manipulate light. From this base matrix material, chips are made using conventional thin film technology. Thin film technology is vastly cheaper than other forms of semiconductor manufacture because unlike older, more complicated foundry type processes, the chip substrate is put into a spinning device with a solvent that dissolves it to the desired thickness.

The unique physical properties of electro-optical polymers allow them to dramatically outperform more exotic materials like gallium arsenide and lithium noibate that are used in the devices to form the current backbone of data communication networks to enable the transmission of digital information. These exotic materials are actually crystals that must be grown in ultra clean rooms, sliced like bologna, and carefully made into semiconductor chips. From a manufacturing perspective there are also formidable production challenges. Yields are low because many of the crystals have to be thrown out because of imperfections and issues of contamination.

This makes for a costly substrate. Furthermore, once they make it off the production line, and are fabricated into chips, the material's reactiveness with the environment requires specialized packaging made out of an expensive form of stainless steel. This adds another significant layer of cost to the finished product.

Furthermore, in commercial applications these materials present additional technological challenges that may ultimately limit their usage. At data rates higher than 10 Gb/sec, lithium niobate based devices become problematic due to issues like wave velocity matching which are very difficult to control. This is because it is necessary to send an electrical wave down a fiber along with the light waves. It is important to match the two because if they get out of sync the electrical wave begins to impact the light wave causing a loss of data. This technological challenge gets increasingly difficult to control proportionally with higher rates of transmission.

Electro-optical polymers by comparison require very little in the way of packaging because they are virtually impervious to environmental factors and the issues of velocity matching are easier to control at higher transmission rates.

How This Stuff Works: ***Modulation for Dummies***

Moving information down a fiber optic cable is really quite a simple concept to understand even though how it actually is accomplished is the result of two hundred years of scientific research and discovery.

Basically, a light is turned on and off in such a way as to stand for the binary values "1" or "0." All the information whether it is a picture, text or music is moved around the world in binary mode. When it reaches the intended destination, a computer reads and converts it back into information that we can understand.

This technique is called *modulation*, and the speed at which digital data can be transmitted is limited by how fast you can turn the lights "on" and "off." Up to about 2.5Gb/sec, it is possible to simply turn a laser on-an-off (known as Direct Modulation), but to accomplish greater transmission speeds, it is necessary to create a dedicated *electronic shutter* of sorts, that can perform this task. This device is a *modulator* which up to this point in time could only be made from the costly, exotic materials described above.

To meet the ever growing network demands, large telecom companies have attempted to overcome the speed and capacity limitations of the current generation of modulators by ganging them together in parallel. While this *work-around* temporarily gets the job done, it can be an expensive proposition that is not really a satisfactory long term solution to the problem.

Ultimately, the promise of using modulators made with electro-optical polymers will be to outperform the current generation technology by a wide factor and at a fraction of the cost.

- **The current data rate of 10 Gbs/sec equates to turning a modulator on-and-off 10 billion times per second. Quadrupling the speed would obviously mean that an EO polymer based modulator would have to be able to turn on-and-off an amazing 40-billion times per second.**

Phase Modulation versus Amplitude Modulation

Responding to industry needs, Lightwave Logic makes two different flavors of modulators, *amplitude* and *phase*. Amplitude is the simplest form and is currently the most commonly used. Only the intensity of the light gets changed to create a binary data stream and it works on the principle that the average power running down a fiber optic cable is *equal to 1/2* the peak power, so the signal can be either half-on or half-off. When the light is *half-on* it signals a 1 and when the light is *half-off* it signals a 0. Amplitude modulation requires the simplest form of detection which is why most 10Gb modulators used in contemporary telecom and datacom systems are of this variety.

Phase modulation is a different methodology and as the name implies, it is accomplished by changing the actual phase of the light. They work on the principle that the average power in a fiber is *equal to* the peak power, so one phase becomes a 1 and the other phase which is 180 degrees out of phase with the first becomes the 0. Generally speaking, phase modulation is more reliable than amplitude modulation, but it requires more complex and costlier detection at the other end of the signal. Typically in long haul telecom applications the goal is to keep peak power down which makes phase modulation advantageous.

To achieve huge bandwidth increases in an optical fiber, many wave lengths will be required. These wavelengths will be closely stacked and contain complex modulated signals that can transmit up to eight bits of data per symbol. This mirrors the development of radio frequency communications.

- **Each wavelength will require one or more modulators.**

All applications, optical computing, datacom or telecom use both forms of modulation depending on the particular system requirements. It is important for Lightwave Logic to have both product offerings because as we mentioned above, amplitude modulators are the basis of today's legacy systems. They will probably always be used in situations where there are no bandwidth constraints. Phase modulators will predominantly be used in the more advanced networks of the future.

It is important to understand that most of the fiber currently installed cannot handle speeds greater than 10 Gb/sec in a long haul setting because of dispersion issues. This means that at the current 10 Gb/sec data rate, any interference or lost packets of information can be corrected. At faster transmission rates, it becomes an insurmountable technological problem. So the initial market for EO polymer modulators will be at 10 Gb/sec speeds where they will have a significant cost advantage versus existing lithium niobate modulators.

Cost Advantages of Electro-Optical Polymers vs. Lithium Niobate

	Chip Cost	Packaging Cost	Final Cost*
Lithium Niobate	$200	$1,000-$2,000	$5,000
EO Polymer	$100	$100	**To Be Determined**

**Including markup*

Using Electro-Optical Polymers in Integrated Circuits

Though it is a different market segment, moving information around a computer poses similar problems that EO polymers can help solve. This represents a very formidable commercial opportunity that might be the closest source of significant revenue. Telco companies are notoriously slow to implement new technology on a large scale but Integrated (IC) manufacturers are motivated by competitive forces to keep Moore's Law in play.

The first iteration in an integrated circuit will more than likely be in the form of a hybrid solution that contains some silicon and some EO polymers. In other words, the I/O part of the central processor known as the *computer bus* will be a fiber optic cable with EO polymer modulators on each end to carry the binary information to the silicon logic part of the chip. Using photons instead of electrons will dramatically increase computing speed because instead of having one electrical pathway in and out of the central processor, the fiber will make multiple pathways of data possible with a dramatic decrease in power requirements. In real life terms, this would be the equivalent to waking up one day and realizing your local Interstate highway suddenly had 40 lanes instead of 2!

Another advantage of using photons instead of electrons to move information around inside of a computer will be the elimination of electrical interference. This is a constant challenge in the current world of metallic interconnection because of higher speeds and shrinking circuitry.

Fabricating a part silicon, part EO polymer integrated circuit will necessitate that the polymer withstand manufacturing temperatures of somewhere around 320°C. To a large extent this will depend on the specific requirements of individual chip makers themselves. At this point, Lightwave Logic has fulfilled this basic requirement.

- **Almost all of a computer chip's power consumption is spent by the I/O because electrons have to travel through the entire line of circuitry.**

The inevitability of on-chip optical interconnects has most certainly been on the agenda of the major IC manufacturers. In May of 2006, Ken Cadien, the Director of Innovative Research at **Intel Corporation** made it the entire focus of a presentation which at the time was prepared for internal purposes. In this presentation which is now part of the public domain, Cadien outlines the significant challenges in scaling with copper and announced that it was time to begin evaluating optical interconnection. (See: **"On-Chip Optical Interconnects**," www.cmoset.com/uploads/cadien.pdf).

In the future, entire computers will be made of cheaper electro-optical plastic and they will function at speeds that will make the machines of today look like Model-T Fords. At the same time, the Internet--the virtual information highway of today will look like the dirt roads of the eighteenth century.

- **Ultimately, this promise will be enabled by transistors fabricated with EO polymers .**

Transistors are the basic building blocks of all electronic circuitry and function either as switches or signal amplifiers. Once the transition is made to photons, electro-optical transistors will perform exactly like their electronic predecessors, however they will be switching photons of light, not electrons. Once this happens, electro-optical polymers will again be the enabling technology that allows computers to make a quantum leap out of silicon and into plastic.

How Lightwave Logic Has Been Able to Advance Technically

The unique properties and promise of electro-optical polymers were not lost on the large blue chip corporations. Many of the most famous: Bell, Corning, and DuPont have collectively spent billions of development dollars without solving the problem of how to make a plastic material that can be EO active, but also stable--both thermally and electrochemically. Most, if not all of these large company development programs appear to be terminated leaving Lightwave Logic not only a free runway, but also an ample source of potential partners.

Sometimes, being small and independent creates the freedom to view technical challenges from unconventional perspectives. In the beginning of this journey, Dr. Goetz took a vastly different tack that approached the conundrum from a totally different direction. Where others started with an unstable material and focused their energies on trying to stabilize it, Goetz started with a very stable material, Perkinamine™ and then tried to make it electro-optically active.

It appears that Dr. Goetz's unconventional approach to solving the problem was the correct one.

- **Recent tests have confirmed the thermal and optical stability of Perkinamine which has demonstrated the ability to withstand temperatures of up to 320°C with no degradation of effect.**

Market Opportunities

Attempting to estimate the total available market for EO polymers is a difficult task at this point given that it is so early in the development cycle. Forecasting a growth rate would be similarly impossible, inaccurate and hence a meaningless exercise. The best way at this point to approach the issue of market potential is to segment the opportunity into three basic areas: Telecom, Datacom, and Computing (we leave military applications out of the current discussion).

In telecom applications, the potential demand for EO modulators is determined by the number of modulators needed for every 10 gigabits of bandwidth. This number is an extremely large moving target that is growing daily.

In the computing segment, it is easy to see that virtually every computer could contain several EO polymer modulators and eventually numerous EO transistors. This is another astronomical number that is growing daily.

Datacom, is essentially a telecom application but moving information around shorter distances. Virtually all networks and routers will eventually contain modulators made out of EO polymers including both local and storage area networks. This is another exceedingly large number that is growing by the moment.

Suffice it to say that the above demand outline presents an opportunity so large, that to put a number on it would make it appear exaggerated and unbelievable. In the short term we can temper our enthusiasm, because the initial rollouts will likely be slow and controlled. Now that the company has working prototypes, this is merely a matter of time. Even a slow and controlled rollout will have enormous impact on the bottom line of Lightwave Logic which is essentially a virtual company with minimal overhead.

Next Generation Internets

As next generation Internets are built with more advanced forms of fiber optic cable, EO polymers will enable greater data transmission speed at a fraction of the cost of contemporary modulation technology.

This scenario is not as far off as one might imagine. Since 1997, the US government ***(See: "NGI Concept Paper" July 1997, www.nitrd.gov/ngi/pubs/concept-Jul97/pdf/ngi-cp.pdfis)*** has been funding the build out of a next generation Internet (NGI). The stated goals of the project are:

- Expansion of bandwidth
- Creation of universal high speed performance
- Construction of sophisticated distributed applications for everything from libraries to telemedicine

In addition to NGI, certain high tech companies and universities are building out another Internet known as **Internet2,** an advanced hybrid optical packet data network intended for academic use.

Internet2 is being designed to provide next generation services as well as provide a test-bed for the development of new networking technologies.

- **These advanced networks could also represent significant near term opportunities for Lightwave Logic which has a long history of working with the US Military establishment.**

How Do They Get There From Here?

As we discussed earlier, over the last 15 to 20 years, researchers have tried to attain the largest electro-optical effect by balancing the need for power against the need for thermal and photo chemical stability. Photo stability refers to how much degradation the EO material experiences after it is hit billions of times with a laser. Less stable materials will have a tendency to bleach out and lose their electro-optical properties.

Holding up under high temperatures (thermal stability) relates more to the manufacturing process than the operating environment. Telecom operating environments require that the materials be effective within a range of -4°C and +85°C. In the datacom /computing environment, operating temperatures are similarly low but the polymers have to be able to withstand manufacturing temperatures of approximately 300°C (572°F) in order to be vertically integrated into semiconductor production lines. Thermal stability is proven by putting the material into an oven of sorts where it can be scanned and weighed to check for degradation.

- **Where others have failed, Lightwave Logic appears to have been able to craft a material that has met all of the basic requirements for a commercially viable product.**

Finally, a key commercial consideration is the amount of drive voltage required to affect a 180-degree phase shift of the light (how the off-signal is created). The industry demands no more than 10 volts. While the more competitive products run at 5 volts, Lightwave Logic believes that devices made with their material will run at 3 to 5 volts (per device). The company believes they can get that down to less than 1.5 volts.

- **The ability to run at extremely low voltage will be a key technological differentiator for modulators made with the company's EO polymers.**

Lightwave Logic's Corporate Vision

The Holy Grail for Lightwave Logic will ultimately be the development of an all plastic optical chip that will be capable of transmitting a terabit of information per second.

In the recent letter to shareholders, CEO Jim Marcelli confirmed the progress that the company has made to date. The key points were:

1. The company's material has already shown that it is both thermally and photo chemically stable.

2. The company's first phase modulator has been demonstrated and the verification process is almost complete. And, the company's first amplitude modulator is nearing completion, thus giving the company two working prototypes for two major markets.

3. The company has filed its sixth patent and is working with the US Patent Office to get those patents issued.

Lightwave Logic has just announced the successful results of the electrical and optical performance testing of its prototype phase modulator.

- **This is the first time in the history of the company that they will have a working prototype. The company will move one giant step forward from being an R&D concept company to an engineering design company. Discussions with potential partners can begin in earnest.**

Competition

Not much is known about the current competitive programs as many of these types of initiatives, if underway at large companies, would be buried within R&D operations. **Gigoptix (GGOX.OB),** a Palo Alto fabless semiconductor company through its purchase Lumera, currently sells a polymer based optical modulator. Industry price estimates are in the $4,000 to $7,000 range per modulator. There has been no wide scale implementation of these devices due to the prohibitive cost.

Patent Estate

It can be said that a great product without strong patent protection is just somebody else's idea. Lightwave Logic has filed six patents which are currently under examination by the US Patent Office. These are primarily composition of matter claims along with usage claims.

The most advantageous outcome would be for the Patent Office to allow both the composition of matter claim and the usage claim to be included in the same patent. The more likely scenario however, is that the two will be split into separate patent claims. Either way, the good news for shareholders at this point is that once issued, they will extend for the full 20 years. Given the reality of a working prototype, it is highly possible that once the company's patents are issue, serious acquisition interest will begin.

Management

Lightwave Logic has assembled a formidable management team/scientific team and board of directors to lead the company out of its research and development phase into a commercial, revenue generating operation.

James S. Marcelli, President & CEO

Jim has served as an officer and director of the company since August 2008. He has actively been involved in several start-up companies after having held senior management positions at Teradyne and Sanmina.

Phillips W. Smith, Chairman of the Board

Recently appointed as the non-executive Chairman, Phil Smith has more than a quarter of a decade's worth of experience in various Fortune 500 companies. He served as the Chairman of TASER International from IPO until his retirement in 2004. Previous to his appointment at Lightwave Logic, he was Chairman and CEO of CAE Systems and Chairman of Edge Computer and Chairman of ZYCAD.

Frederick Goetz Jr., Chief Scientist and Senior Vice President
Mr. Goetz, has served as an officer and director of the company since July 2004. His specialty is coding and operation of electrostatic simulation software for non linear optic materials development. Prior to joining Lightwave Logic, Mr. Goetz began his career at Lawrence Berkley Laboratory and the Army Research Laboratory in Aberdeen, Maryland.

David Eaton Ph.D, Chief Technology Officer
Mr. Eaton has served as an officer of Lightwave Logic since May 2007. He was employed by Dupont Corporation in their chemical division. Prior to joining Lightwave, he was a principal of Light Insights, LLC, a corporate consulting firm and also served as the Vice President of Precision Cure, LLC. Mr, Eaton has a Ph.D in chemistry from the California Institute of Technology.

Terry Turpin, Optical Computing Guru
Mr. Turpin has served with the company since March of 2008. He has been a member of the UMBC College of Natural Science and Mathematics Board. He was also a director of Essex Corporation, a company that is one of the industry leaders in optical computing. From 1963 to 1983, Mr. Turpin was employed by the National Securities Agency (NSA) where he was the Chief of the Advanced Processing Technologies Division for 10 years. He holds patents for optical computers and adaptive optical components. He received a Bachelor of Science degree in Electrical Engineering from the University of Akron in 1966 and a Master of Science degree in Electrical Engineering from Catholic University in Washington, D.C. in 1970.

Mr. Andrew Ashton: Senior Vice President, Treasurer, Secretary
Mr. Ashton has served as an officer and director of Lightwave Logic since July 2004. Aside from the corporate duties he has assisted in the creation of the synthetic chemistry of our novel molecular architecture. Mr. Ashton is a computer scientist and organic chemist who began his career in 1998 at the Army Research Laboratory.

Financial Considerations

As of December 31, 2009, Lightwave Logic had approximately $460,000 in cash and a burn rate of about $100,000 per month. Total warrants and options currently exercisable are 4,687,467 of which approximately 1,780,500 are related to employee compensation.

With 300,000 in-the-money warrants expiring at the end of April, it is highly likely that the company will receive another cash infusion through the exercise of these warrants which will be enough to run the company until September. This should allow Lightwave Logic enough time to negotiate other forms of non dilutive financings.

CEO Jim Marcelli, has done a commendable job of working to clean up mistakes of previous management. With no debt and a relatively small share count for a pre-revenue company, Lightwave Logic is not in as much danger of running out of money as it may first appear—especially considering the tremendous technological progress that they have made recently. These achievements will likely attract serious institutional investor interest. It is worth noting that the company has made this progress and has spent only around $7 million in R&D (out of the $17-million in paid-in capital).

Shareholders can be further comforted by the fact that the founders still hold 13 million of the 47,578,909 million fully diluted share count. Also, most of management's stake and the board of directors' ownership is through options that have strike prices between $.72 and $1.75. This is higher than the closing price of the shares at the time of this report so their interests are perfectly aligned with those of shareholders.

Conclusion

All things considered, this is an extremely exciting time for Lightwave Logic and the rewards for investors greatly outweigh the risks at this point despite the limited cash resources. With a working prototype that can meet commercial standards, the company will be in a much better position with which to raise capital and entice potential partners.

In many respects the Lightwave Logic story is not very different from a biotech company. Started and run by scientists, it has taken a long time to move out of the discovery stage and into *clinical trials.* Where the company is now would be the biotech equivalent of having completed a successful Phase 3 trial. Investors can now anticipate the equivalent of an FDA approval which will be the first development contract from either an integrated circuit company or telecom equipment manufacturer. When that happens, the company will enter its commercial stage presumably with enough money to pursue their ultimate goal, an all plastic chip using light to manipulating light. In the scientific world, this is known as the *Third Order Effect*. When achieved it will not only transform the company, it will transform society and it will have a Third Order Effect on your portfolio if you happen to be a shareholder.

Disclosure:

This report should not be interpreted as an offer to buy or sell securities. It is intended to provide general securities information. No statement is made as to the suitability of this or any security for a particular investment objective. Before making any investment decision, an investor should consult with their advisors to evaluate whether this security is appropriate to their own needs.

Steven Cordovano has a position in Lightwave Logic.