

**NANOSYS: ARCHITECTING THE
NEXT INDUSTRIAL REVOLUTION**

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Those who have been following nanotechnology over the past decade are undoubtedly familiar with the name Nanosys. The company became a poster child for nanotech in the opening years of the 21st century. Investors may recall that Nanosys filed for an IPO in April 2004 amid a great deal of hype, with some analysts touting the IPO as the “Netscape of nanotech.” Nanosys’ IPO was viewed by many analysts as marking the liftoff of the next major revolution in technology in the same way Netscape’s IPO kicked off the dot-com boom.

At the time, Nanosys’ poster-child status for nanotechnology seemed well deserved. The company had assembled a top-notch team of researchers and was building a world-class nanotech patent estate to be mined for future commercialization. Nanosys had assembled an impressive list of partners and was backed by a credible group of early-stage VCs, including Harris & Harris Group, Venrock Associates, Arch Venture Partners, Polaris Ventures Partners and Lux Capital.

As we now know, the Nanosys IPO that was going to create a Netscape moment for nanotech in 2004 never happened. There were several reasons for the IPO being pulled, some of which were related to the lingering fallout from the dot-com IPO bust. Skeptics and nanotech naysayers voiced concerns that Nanosys had no products on the market and was at too early a stage for the public markets.¹ For a variety of reasons, the Nanosys IPO was cancelled and the hype surrounding nanotechnology began to sub-

side to the point where nanotechnology fell off investors’ radar screen several years later.

Some might consider a company with a history of pulling an IPO after an extreme period of hype a has-been, not worthy of investor attention. In the case of Nanosys, we believe such behavior would be a mistake. It has taken a while for Nanosys to find its way to commercial markets, but new leadership is intent on bringing innovative products to market in the months ahead. The company has two products ready for launch, one in LED displays and another in energy storage. Unlike several years ago, there are real products hitting the market and little hype surrounding Nanosys. The company is ramping up production and sees the coming year as a time to begin driving meaningful top line growth. Our analysis below suggests a large market opportunity for Nanosys’ nano-enabled products. It will be incumbent upon the company’s management team to execute and capitalize on the opportunity in the months and years ahead.

BACKGROUND

Palo Alto, CA-based Nanosys was founded in 2001 by a talented and impressive group of individuals, including Larry Bock and Drs. Charles Lieber and Paul Alivisatos. Bock is a serial entrepreneur who has started up and taken several emerging technology companies public during his long and successful career. Dr. Lieber is a distinguished nanoscientist at Harvard University who has co-authored over 300 research publications and 25 U.S. patents, and was awarded the Feynman Prize for Nanotechnology and the World Technology Award for Materials. Alivisatos is a recognized leader in the synthesis of artificial nanostructures and quantum dot technology, and one of the principal scientific drivers behind the use of nanoscience-based

¹ In its S-1 filing, Nanosys stated that it might be several years before its first products would be commercially available. The S-1 also noted that the company had a history of net losses and expected to continue to incur net losses in the foreseeable future, and may never achieve profitability.

technologies to create a new generation of solar photovoltaic cells.

Nanosys' charter early on was to harness its deep pool of intellectual capital to drive a revolution in advanced materials and design products based on a technology platform that incorporates high performance inorganic nanostructures. The company's mission was to help manufacturers overcome limits associated with currently available materials by harnessing the power of nanoscience and architecting new materials from naturally occurring, abundant elements with properties that enable innovative products across different industries. To help accomplish this task, Nanosys began building a patent estate. A wealth of intellectual property would provide a strong foundation to foster innovation and bolster the company's competitive advantage in the market.

It is notable that Nanosys' nanotechnology, processes, and nano-enabled products today are covered by one of the largest nanotech patent portfolios in the world. Nanosys has over 750 patents and patent applications that address a wide range of industries including LED displays, LED general lighting, power (batteries and fuel cells), medical applications, next generation NAND Flash memories, Solar, Flat Panel Display driver transistors, and specialized nano-surface coatings (e.g., super-hydrophobic, super-adhesive, super-hydrophilic, super-hemostatic).

There was never any reason to question the intellectual prowess or academic pedigree at Nanosys. The company was stacked with talent that included pioneers in the science of nanotechnology – the kind of talent that could attract quality institutional capital. The major challenge facing the company was its ability to turn its intellectual capital and property into innovative products that created revenues and profits. Nanosys' revenues at the time of the IPO filing were minimal (\$3 million) and were mainly the byproduct of various government agency grants and not from product sales. If Nanosys was going to create a sustainable business, the company would need to crank up the commercialization engine. Nanosys' Board and investors recognized the need to focus on com-

mercialization. In the fall of 2008 they brought Jason Hartlove in as President and CEO.

Hartlove's appointment to the helm of Nanosys was noteworthy and timely. He had a track record of building and leading innovative companies by driving emerging technology from R&D to market applications. Prior to joining Nanosys, Hartlove was president of MagnaChip Semiconductors and before that served as VP and General Manager for the Sensor Solutions Division of Agilent Technology and its parent company, Hewlett-Packard. He is an inventor himself, having authored more than 20 patents. Hartlove has worked in a variety of manufacturing, R&D and market roles in semiconductor technologies, including MEMS, III-V, bipolar, CMOS and BCD process technologies. With Hartlove at the helm, Nanosys was viewed as being in prime position to go from R&D lab to market, which is just what the doctor ordered.

Hartlove and his team understand that, while the science of nanotechnology gives Nanosys a great platform to develop innovative materials, customers require something more. Manufacturers today need not just a new set of raw materials but also ready-to-use solutions that can be integrated into their products – for example, inks that can be printed or films that can be deposited, using commercially available tools and processes. To help manufacturers, Nanosys has to be proficient in a variety of disciplines encompassing organometallic, polymer, and organic chemists; physicists, optics experts, and more. A multi-disciplinary R&D team gives Nanosys the ability to do some of the heavy lifting for customers, which Hartlove views as one of the company's main value propositions.

Nanosys' business model revolves around taking its innovative materials science and engineering capabilities and packaging them into process-ready components or components that fit seamlessly into existing manufacturing paradigms. There is a large market opportunity for architected nano-intermediates in the years ahead, with Nanosys citing industry analyst estimates of 60% compounded annual growth to nearly \$500 billion in 2015.

Hartlove believes that nanotechnology has the potential to fuel another industrial revolution led by innovations in architected materials. Nanosys is strategically focused on developing products based on the company's proprietary, architected materials that solve tough problems in high growth-potential markets. The company is targeting two markets currently: LED display and energy storage. Consumers and manufacturers alike have expressed great need for better quality, high efficiency color displays and longer lasting batteries. Nanosys is gearing up to bring two new products to market in the months ahead – one that is based on its proprietary quantum dot technology for solid state lighting (“Dots”) and another involving the company's proprietary silicon nanowires for next generation lithium-ion batteries (“Wires”). Below we take a closer look at these two nano-enabled products.

DOTS AND WIRES

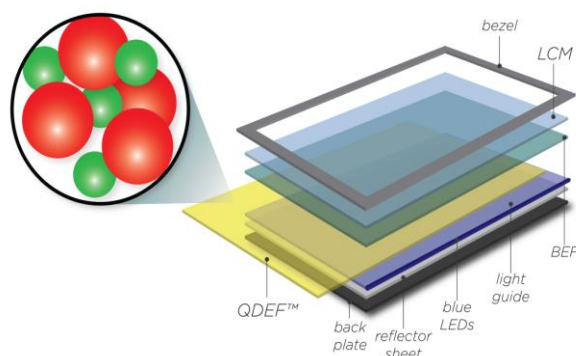
Lighting (Dots)

Nanosys has a large patent estate that focuses on the development and use of quantum dots. Quantum dots are semiconductors whose electronic characteristics are closely related to the size and shape of the individual crystal. They are inorganic, highly efficient phosphor crystals grown through a standard wet chemical manufacturing process. Governed by their size, quantum dots have the unique capability to precisely generate a specific wavelength of light. They can either produce pure saturated colors or be blended to a precisely defined white point. Quantum dots were discovered in the early 1980s and since then there has been a great deal of research on them. Researchers have studied quantum dots in transistors, solar cells, LEDs and diode lasers. There have also been investigations into the use of quantum dots as agents for medical imaging and as qubits in quantum computing systems. We are in the early stages of seeing commercial applications of quantum dot technology and Nanosys is one of the companies leading the way.

Nanosys has developed a product called Quantum Dot Enhancement Film (QDEF™). QDEF

is an optical film component for LED backlit LCD displays.² QDEF enables a new level of LCD display performance by providing a high quality, tri-color white light from a standard blue LED light source. The QDEF's active material is composed of Nanosys' proprietary, high efficiency quantum dot phosphors. Larger than a water molecule, but smaller than a virus, these tiny phosphors convert blue light from a standard Gallium nitride LED into different wavelengths based upon their size. Larger dots emit longer wavelengths (red), while smaller dots

Nanosys' QDEF™ For LCDs



emit shorter wavelengths (green).

By blending together a mix of dot colors, Nanosys can engineer a custom spectrum of light. This allows LCD manufacturers to accurately match their LED backlight to their LCD color filters to achieve the best possible color and performance and efficiency. Nanosys has quantified the color performance of QDEF relative to existing technology on the market today. QDEF provides 3x the color performance relative to a conventional tablet. We saw a recent live demonstration of Nanosys' QDEF technology, and the display appeared to us as “High Definition on steroids.” The quality difference when compared with a conventional LCD was easily discernable and striking. Put simply, QDEF significantly elevates the color performance of a LED screen and enables a more vibrant and exciting viewing experience.

² QDEF is a registered trademark ™ and noted as such in this document even though it is not specified directly with each mention of the product. The same convention is applied below with respect to Nanosys' SiNANOde energy storage product.

Technically speaking, QDEF significantly increases the color gamut of a LCD. Color gamut refers to the range of colors that a display can show. Performance is measured by a variety of standards, typically defined by groups like the National Television System Committee (NTSC), as a way of maintaining consistent color from capture to broadcast to end viewer. Creative professionals such as graphic designers and Hollywood cinematographers rely on these standards to make sure that their work looks the way they intended it to across a variety of screens and print media. The most common gamut standard, developed by the NTSC in 1953 in anticipation of color television, covers about 50% of what your eye can see. The color gamut performance of even high end, professional displays is still a far cry from the capability of the human eye, which can detect wavelengths of light from 380 nm to 740 nm. Most high end displays can only display 25-35% of what a human eye can see. On a tablet product (e.g., Apple's iPad), a display with QDEF provides an impressive 3X increase in the range of colors visible to human eyes.

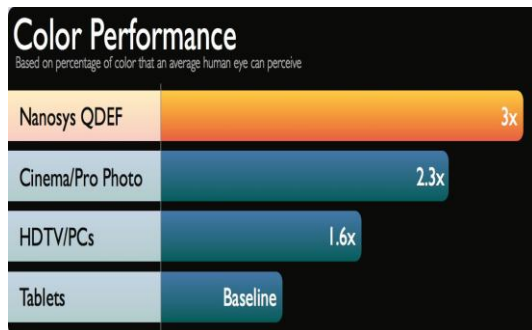
It is noteworthy that roughly 400 of Nanosys' patents and applications for various technologies and processes have gone into the development and commercialization QDEF technology.

There is clear value proposition for LCD manufacturers with Nanosys' Quantum Dot Film Enhancement technology. QDEF enables LCD display manufacturers to deliver a better visual experience using their existing manufacturing processes and do so at a fraction of the cost of alternatives. Architected from quantum dots, Nanosys' QDEF improves color gamut, saturation and brightness from LED sources using widely available material, while delivering higher power efficiency and lower cost than alternatives such as Organic LED (OLED). Displays with QDEF promise to be brighter even than OLEDs and may displace them completely.³ One can easily see how the technology would be

³ For more on this issue, see the article "[Dotting the Eyes](#)," published in *The Economist* earlier this year. Readers might also be interested in another related article published in *The Economist* last year titled, "[A Quantum Leap for Lighting](#)."

appealing to consumer electronics manufacturers such as Samsung (a strategic investor in Nanosys) and LG Electronics (a commercialization partner) and companies such as Apple. QDEF technology enables greater high defini-

QDEF Boosts Color Performance



tion viewing on any LCD display, be it an iPad, tablet, notebook, monitor, or large screen TV. Nanosys is gearing up to bring QDEF to market in first quarter of next year. The company has several strategic partnerships (e.g., Samsung and LG Electronics) that will assist in bringing the technology into the marketplace. The year ahead has the potential to be a breakout year for Nanosys in lighting technology, and we will be monitoring developments closely.

Energy Storage (Wires)

The second piece of Nanosys' near-term commercialization strategy is in the area of energy storage and advanced battery technology ("Wires"). The company is developing an innovative, lithium ion (li-ion) battery cell that offers dramatic improvement over existing technology in the market today. Li-ion batteries are the technology of choice for many consumer electronics products and also for the first generation of all-electric and plug-in hybrid electric vehicles (EVs). In general, there is a growing demand for greater energy performance and lighter and smaller batteries.

Improvements in battery capacity have historically been quite slow, far outpaced by our demand for more features in our mobile devices and, now, range in our cars. In the battery business, people talk about a "Moore's Law", which equates to approximately a decade per doubling of capacity. Li-ion performance has been ad-

vancing at 3-4% per year in recent history, which is hardly anything to write home about.

Part of the problem of boosting the performance of batteries is that some of the best elements in terms of energy storage potential are also the hardest to work with. For example, although it has the highest capacity of any element for lithium insertion, no one has been able to make a stable battery using bulk silicon. Thus, manufacturers have been limited to making process improvements using graphite, with techniques like squeezing more materials onto their electrodes by compressing them or using thinner and thinner electrode substrates. It should be noted, however, that there is a practical limit to process improvements and the rate with which they can be made.

Nanosys views the process improvement problems facing the battery industry today as an opportunity for innovation and is architecting new materials to solve them. While many battery manufacturers are focusing on the historically deficient cathode side of the battery equation, Nanosys is taking a different approach and focusing on the anode with a new material it calls SiNANOde™.⁴

Architected from a mix of the abundant elements silicon and carbon, SiNANOde can double the capacity of a li-ion battery and last for hundreds to thousands of cycles, all without changing existing manufacturing processes. With SiNANOde, consumer electronics manufactur-

⁴ Typically the anode is the negative contact on a battery where electrons flow out to a circuit, and a cathode is the positive contact where electrons are accepted. In discharging Li-ion and Li-polymer batteries, lithium ions carry the current from the negative electrode (anode) to the positive electrode (cathode). During recharging they migrate from the positive electrode back to the negative electrode where they become embedded in the “anode material.” High surface area and stability of the anode material is vital for multiple recharge cycles and increased efficiency of lithium-ion batteries.

ers could offer thinner devices with the same energy performance as today’s products, or offer the same size devices but with double the battery performance. In the automotive market, batteries with Nanosys’ SiNANOde will enable future EVs to travel 300 miles or more on a single charge versus around 100 miles today.

Nano-enabled Li-ion Batteries



This kind of dramatic change in energy performance means that manufacturers can start thinking about surpassing the industry’s cost goal of \$250/kWh and taking EV adoption to the next level. The value proposition with SiNANOde for both consumer electronics and auto manufacturers is compelling.

There is still a considerable amount of development planned for SiNANOde. Earlier this year in August, the U.S. Department of Energy (DOE) awarded Nanosys funds to refine and bring to scale its SiNANOde materials for the automotive market. Nanosys was awarded a primary grant of \$4.8 million from the DOE. In addition, the DOE and Nanosys will spend approximately \$6 million through sub-awards and matches on the development and commercialization of advanced material technologies and manufacturing in the U.S. The funding for the further development of Nanosys’ energy storage technology is a part of the DOE’s larger mission to accelerate the development and deployment of advanced vehicle technologies through targeted programs aimed at increasing vehicle efficiency. Energy density remains a critical problem for the electric car. A typical EV today wastes a lot of energy just carrying the weight of the batteries down the road.

Energy storage represents a medium term market opportunity approaching \$5 billion for Nanosys, an amount considerably larger than the market opportunity for its lighting technology. Assuming greater adoption and accelerating growth of EVs in the years ahead, the li-ion battery market could be greater than \$50B per year by 2020. Nanosys’ strategy is to partner with li-

ion manufacturers and incorporate their SiNANOde into next generation batteries. Nanosys is co-developing battery solutions with several of the world's largest li-ion battery makers today. There is the potential for great strategic partnerships for li-ion manufacturers who are innovating on the cathode side of the battery equation.

Over the past several years we've seen a number of new entrants into the li-ion battery space, including A123 Systems and numerous manufacturers in China (e.g. BYD, China BAK, China Aviation Lithium Battery). Research to date with one of the emerging li-ion battery manufacturers (name withheld at company's request) that involves optimizing with 20 nm silicon nanowires has shown increases of capacity of 100%, which is impressive. Nanosys believes there are further gains to be made with additional research and development in the months and years ahead.

There is a good deal of enthusiasm around Nanosys' energy storage technology given the results achieved today and the relatively large market opportunity for SiNANOde. Market penetration with SiNANOde in the near term is likely to be driven by li-ion batteries for consumer electronic products. Consumer electronics manufacturers are constantly searching for more powerful and thinner li-ion batteries. Nanosys sees immediate applications for SiNANOde in electronic devices such as mobile phones, digital cameras, and laptop computers and is expecting to generate revenues from SiNANOde in the coming year. There is a significantly bigger medium-term opportunity for the company in automotive applications such as EVs, plug-in hybrids (PHEVs) and personal mobility (LEV). New product qualification times are longer in the automotive market than consumer electronics, so we should expect to see a longer ramp for market penetration from SiNANOde in energy storage.

VALUATION AND SUMMARY

Nanosys has come a long way since the early days of nanotech hype on Wall Street. Invested capital in the company is around \$130 million

and the business has generated more than \$75 million in revenues. As mentioned earlier, Nanosys is backed by a credible group of VCs and has a distinguished list of strategic corporate partners including Samsung, Intel, LG Electronics, Hynix, SAIC, NTT Do Co Mo and Medtronic. The company has a deep intellectual property portfolio consisting of some 750 patents and pre-grant applications. The patent portfolio has broad coverage, from composition of matter, to nanocrystal assembly and material integration, all with multiple industry applications. While each of Nanosys' patents has an inherent value, the company believes the real value is in taking the technology to market. CEO Jason Hartlove often notes that every one of Nanosys' patents plays a role in the commercialization of the company's products.

As we have noted in our previous Harris & Harris Group reports, it is early days for the commercialization of nanotechnology.⁵ There is the potential for a 10-fold increase in the final market value of nano-enabled products in the decade ahead. We see companies such as Nanosys playing an important role in the evolution of nanotechnology in the marketplace in coming years. Nanosys has consolidated world leading nanotechnology and IP to enable fundamental and disruptive architected material designs for a wide range of applications across large global markets, including lighting, energy storage, medical devices and non-volatile memory. Jason Hartlove envisions Nanosys-enabled products in the hands of hundreds of millions of consumers, providing higher quality and efficient displays, longer lasting electronics, and being a part of EVs that match combustion vehicles in range capacity.

Our base case Intrinsic Valuation (IV) model for Nanosys incorporates the company's plans to ramp up in lighting and energy storage in the year ahead. Nanosys sees the addressable markets for its lighting solutions growing to nearly \$1 billion in 2012. The address market for Nanosys' energy storage products in our modeling

⁵ To read our previous published reports on Harris & Harris Group, see <http://www.research2zero.com/sample-research.html>

period are in excess of \$5 billion. Thus, there is a combined \$6 billion market opportunity for Nanosys in the medium term.

In our base case IV model, Nanosys' revenues begin to accelerate next year as the market penetration of QDEF and SiNANOde increase. While there is a multibillion-dollar market opportunity for the company in the medium term, our IV model assumes a conservative penetration of around 5% during the forecast period. Gross margins are around 50% today and we have modeled some expansion over time as additional capacity comes on-stream and revenues ramp.

As a component manufacturer, Nanosys is likely to have only a dozen or so end customers and the company won't have to incur large marketing and sales expenses. This will help keep a lid on SG&A in the years ahead. Expenditures on R&D are expected to rise in coming years to facilitate the future development of new products based on Nanosys' deep patent portfolio. We have factored in additional dilution, as Nanosys will need more capital to fund its operations. Using a P/E multiple of 20 and our standard 15% discount rate, we derive an IV for Nanosys of \$7.17/share for 2012. At that share price, the company's market capitalization is just over \$700 mm. In our base case model, Nanosys

becomes net income positive in 2014.

In terms of risks, Nanosys' biggest challenge in our view lies in execution and being able to scale up manufacturing. The company's facility in Palo Alto is more than capable of meeting current customer demand, but there are plans to increase capacity in the months ahead while keeping a close eye on quality control and distribution. Last year, Nanosys opened an office in Korea specifically for this purpose. The company believes very strongly in maintaining its core operations in the U.S., but also wants to operate globally with the largest automobile and electronics manufacturers in the world.

Another key risk is associated with the state of the global economy and financial markets in 2012-13. Recessionary conditions around the world would likely dampen the pace of market penetration of Nanosys QDEF and SiNANOde products. The company currently has around \$18 mm in cash on the balance sheet, and slower than expected revenue growth would heighten the need for additional capital sooner rather than later.

Our base case IV model of Nanosys suggests the potential for meaningful value creation that is not currently captured in H&H's NAV. H&H typically uses the share price of the last round as

a guide to estimating the value of its portfolio investments in private companies. The last round for Nanosys was at \$1.15/share. As of June 30, 2011, H&H's investment in Nanosys consisted of 2.25 million shares of Series C, D and E convertible preferred stock. H&H is currently valuing its investment in Nanosys at \$2.2 million, which is 44% below cost of \$5 million.

Our analysis of Nanosys suggests there is unlikely to be a further reduction of the value of H&H's investment in the company, and quite possibly an upward assessment in the future. All other things constant, this would have a positive impact on H&H's NAV.

Nanosys, Inc.

11/2/2011

Base Case

Dec YE	2010	2011	2012	2013	2014	2015	2016
YoY Change \$	\$6	\$6	\$18	\$25	\$60	\$60	\$125
Total Revenue	\$6	\$12	\$30	\$55	\$115	\$175	\$300
YoY Growth	NA	100%	150%	83%	109%	52%	71%
COGS %	50%	50%	50%	49%	48%	46%	43%
COGS \$	\$3	\$6	\$15	\$27	\$55	\$80	\$130
Gross Profit	\$3	\$6	\$15	\$28	\$60	\$95	\$168
Gross Margin	50%	50%	50%	51%	52%	54%	56%
SG&A %	133%	67%	50%	42%	26%	19%	13%
SG&A	\$8	\$8	\$15	\$23	\$30	\$33	\$38
R&D %	200%	100%	50%	38%	23%	19%	13%
R&D \$	\$12	\$12	\$15	\$21	\$27	\$34	\$40
Operating Margin	-567%	-233%	-100%	-57%	5%	29%	54%
Operating Income	(\$17)	(14)	(15)	(16)	3	28	90
Other Income	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Taxes	0	(5)	(5)	(6)	1	10	32
Tax Rate	35%	35%	35%	35%	35%	35%	35%
Net Income	-\$17	-\$9	-\$10	-\$10	\$2	\$18	\$59
Net Margin	-283%	-76%	-33%	-19%	2%	10%	20%
Market Value Using P/E	-\$340	-\$182	-\$195	-\$208	\$39	\$364	\$1,170
Cash Position	\$4	\$25	\$15	\$5	\$7	\$25	\$84
Shares (M)	80	96	100	110	112	114	115
Period Share Price	-\$4	-\$2	-\$2	-\$2	\$0	\$3	\$10
PV of MV 4 Years Out	\$22	\$208	\$669				
PV of Cash 4 Years Out	\$4	\$14	\$48				
PV MV + Cash	\$26	\$222	\$717				
PV Value Per Share	\$0.33	\$2.32	\$7.17				

Private	Ticker
NA	Exchange
94%	Rev Growth
\$1.14	Current Price
100	Shares Out (M)
4%	Avg. Dilution
\$114	Cap (M)
\$18	Cash (M)
\$0	LT Debt (M)
\$100	NOL (M)
35%	Tax Rate
20	P/E Multiple
15%	Discount Rate
\$7.17	Intrinsic Value
529%	Up/Downside

How much of a positive impact Nanosys could have on H&H's NAV in the quarters ahead is difficult to say at this juncture. Much will depend on how well Nanosys executes in the market going forward.

Nanosys' inability to do an initial public offering back in the summer of 2004 may have been a blessing in disguise; at that time there was no clear path or timetable to commercialization. The years since the IPO was pulled have been a productive period for the company. The new management team has put Nanosys on a clear commercialization track – one that has the potential to create a profitable business with significant upside.

Rising visibility of revenues bodes well should Nanosys choose to raise additional capital through the public markets in the future. We would not be surprised to see the company file an S-1 within the next 12-18 months and pursue

an IPO. If Nanosys does file for an S-1, it will be difficult for naysayers to argue against the merits of a Nanosys IPO this time around. After all, the company has entered its second decade of operation and, as we have seen, has built a solid operating foundation under new management. An IPO would be a natural course of action for a company like Nanosys that is revving up its commercialization engine and bringing innovative, nano-enabled products to large and growing markets.

It is still early days for nanotechnology. Whether Nanosys has what it takes to usher in the next industrial revolution led by architected nanomaterials and solutions remain to be seen. The coming year will be an important one. There is nothing like commercial success in the marketplace to create the dynamics necessary to lead a technology revolution. Apple's recently departed founder and CEO, Steve Jobs, is testimony to that fact.

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