EQUITY RESEARCH COVERAGE

HARRIS & HARRIS GROUP: NANOTECH PHASE CHANGE AHEAD

[NASDAQ: TINY $3.81]

Research 2.0
Boston | New York | Paris

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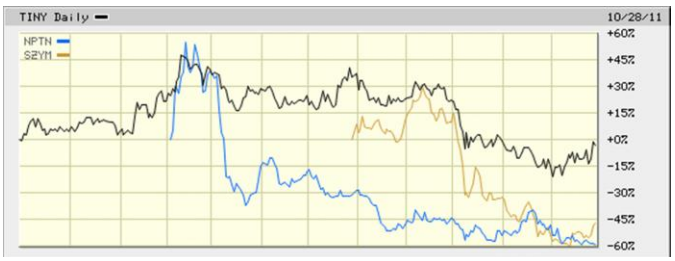
HIGHLIGHTS

- **Investors seeking to participate in the innovation and wealth creation potential associated with nanotechnology are advised to take a close look at Harris & Harris Group (H&H) in the current market environment.** The company offers investors a unique vehicle in which to invest in a diverse group of emerging technology companies bringing nano-enabled products to market.
- Nanotechnology is entering a new phase of evolution driven by accelerating commercialization activity and rising market penetration of game-changing technologies. **We are at an early stage of commercialization today. The phase change underway in nanotechnology is not yet appreciated by many investors, and therein lies the opportunity for gain.**
- **H&H portfolio companies showcase the accelerating nature of nanotech in the marketplace.** Previous reports have illustrated this trend in key sectors including health care, electronics/semiconductors and cleantech. In this report, we provide analysis of two additional H&H portfolio companies – Nanosys and D-Wave Systems. Both companies have been working for a decade or more in their respective areas of expertise to bring innovative, nano-enabled products to markets: Nanosys in LED displays and energy storage technology, and D-Wave in quantum computing.
- Nanosys may be a name investors recognize from the past, having been branded early on as the "Netscape of Nano" during a more ebullient time. Under new leadership that is intensely focused on commercialization, the Palo Alto, CA-based company is ramping up production of its LED display and energy storage products**. There is a multi-billion dollar opportunity for Nanosys in the market today as it seeks to leverage its valuable patent estate, extensive strategic partnerships and deep research expertise across a range of scientific disciplines.** Solid execution in the months ahead would set the stage for another S-1 filing and perhaps a successful public offering sometime in 2013.
- **The first commercial sale of a quantum computer occurred in May of this year. Portfolio company D-Wave is a clear leader in this brave new frontier of computing.** We provide an overview of quantum computing and the D-Wave approach to commercialization.
- **H&H's current valuation reflects a state of fear and "risk off" in financial markets.** TINY is currently trading at a 25% discount to the reported June 30, 2011 NAV of $5.43. Our on-going analysis of H&H portfolio companies suggests that H&H is currently understating the intrinsic value of its portfolio companies by 40-50%. Historically, the stock has traded at a premium of 2x NAV. **Our analysis suggests there is compelling value in TINY currently with a fully valued share price of $12.**
- H&H founder Charlie Harris was a contrarian at heart. During times like these in the markets, he was fond of quoting Warren Buffett, who said: "Be fearful when others are greedy; be greedy when others are fearful." **For investors seeking exposure to nanotechnology and its game-changing potential, now seems a propitious time to listen to the wise counsel of Charlie Harris and heed Warren Buffett's sage advice.**

The financial markets have been anything but hospitable since the summer. Soaring volatility in equity markets has cast a pall over capital markets, with many investors wondering if recessionary conditions and prospects for severe financial dislocations lurk just around the corner. After a flurry of activity earlier in the year, new issuance of equity in the public markets ground to a halt. The lack of demand for IPOs over the past several months reflects a "risk off" investor mindset. The harsh financial market environment has taken a toll on the valuations of emerging technology companies and small capitalization stocks in general. H&H's stock price performance hasn't been immune from the heightened equity market volatility witnessed over the past quarter. TINY's share price has declined sharply by nearly 40% from its 52-week high of $6.30.

TINY Stock Price Performance Over Past Year



The steep drop in TINY comes on the heels of an impressive rebound earlier in the year that reflected four liquidity events for H&H in the span of six months. As noted in our previous report on H&H, the liquidity events were significant and most welcome after a drought of five years. In looking at the performance of H&H's stock over the summer, it is analogous to everybody forgetting the amazing, historical accomplishment of New York Yankee captain Derek Jeter achieving 3,000 hits earlier in the season after the team failed to advance to the ALCS and World Series this fall.

Part of the rationale for the weakness in H&H's stock price since last summer is associated with some of the liquidity events that occurred during the first half of the year. During that time, H&H portfolio companies NeoPhotonics (NPTN) and Solazyme (SZYM) came public. Both companies had successful IPOs with their respective stock prices rising well above their initial offering prices following the deals. However, the stocks of both NeoPhotonics and Solazyme have sold off sharply during the stock market swoon. NeoPhotonics' stock price has declined a 70% from its high following the IPO, while Solazyme has fallen 65%. From our perspective, it doesn't get much more "risk off" than watching two-thirds of a promising emerging technology company's market capitalization evaporate over a three month period.

The steep decline in the market valuations of NeoPhotonics and Solazyme during such a short period of time has had an impact on H&H's NAV. As of the last 10-Q filing, H&H was holding 450,907 shares of NeoPhotonics and 2.3 million shares of Solazyme, with total net assets of $168 mm. From their peak stock prices registered early this year (which we note were not captured in the last reported NAV), H&H has seen a reduction in the value of its combined investments in NeoPhotonics and Solazyme of over $40 mm. That is a relatively large swing in value for a company with $168 mm of total net assets.

The recent performance of NeoPhotonics and Solazyme's share prices has cast a cloud over H&H's market value in the near term. H&H has indicated that it has no plans to sell shares in either position at their respective current valuations. The company believes NeoPhotonics and Solazyme have further upside and are content to hold the shares for the foreseeable future. Our analysis supports this portfolio position. Our financial models for NeoPhotonics and Solazyme show considerable scope for value creation in the future. Our intrinsic value (IV) estimates for NPTN and SZYM in 2012 are $11 and $25, respectively.[1]

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[1] It should be noted that our IV for NeoPhotonics excludes any value associated with the company's recent acquisition of privately held Santur Corporation. NeoPhotonics agreed to pay an estimated $39.2 million in cash for Santur, after deductions for closing costs and other adjustments, plus up to $7.5 million additional cash contingent on the financial performance of Santur products subsequent to closing of the transaction through the end of 2012. Santur generated approximately $21 million in revenue for the six months ending June 30, 2011.We

There are additional factors that likely account for a reduction in H&H's market value in the current "risk off" environment. One is investor expectations of H&H increasing the non-performance discount – a measure of risk used to assess valuation – in its portfolio when determining reported NAV. H&H is relatively conservative in their approach to valuing their portfolio of privately held securities. In the past, "risk off" periods have prompted the company to increase the non-performance discount to reflect a riskier investing environment. Other things constant, the allowance for an increase in non-performance discount risk in the portfolio leads to a reduction in NAV. Another factor is related to valuation markdowns associated with selected portfolio companies that H&H values using comps of publicly traded companies during "risk off" periods. Such markdowns would lead to a decrease in reported NAV.

If global economic and financial market conditions normalize in coming months – and there are indications that that process may be now occurring – we would expect to see a rebound in the share prices of both publicly traded and privately held portfolio companies in the months ahead. It goes without saying that an increase in the market capitalization of NeoPhotonics and Solazyme back toward our IV estimates would have a favorable impact on H&H's NAV. Additionally, a "risk on" market environment would justify a lower non-performance discount, and rebounding share prices would likely increase the valuation of comps relevant to H&H portfolio companies.

At some point in the future, we would expect H&H to sell its positions in NeoPhotonics and Solazyme and reinvest the proceeds in early stage privately held companies focused on developing and commercializing nanotechnology. At the present time H&H has nine investments in companies classified as early stage investments and ten more that are mid-stage maturity, having completed multiple VC rounds. Additionally, there are seven more companies classified as late-stage investments, including publicly traded NeoPhotonics and Solazyme.

Over the past year we have conducted in-depth analysis of several H&H portfolio companies and continue to delve more deeply into the company's portfolio with the objective of ascertaining the value-creating potential that lies within.[2] It is evident from the analysis we have completed thus far that there is a wide scope for value creation in the months and years ahead for the H&H group of portfolio companies. Our ongoing research and analysis, which began a decade ago, indicates that nanotechnology is entering a new phase of evolution – one that isn't yet appreciated by many investors.[3] Whereas the previous decade was focused intensely on research and product development, the decade ahead will be a time of commercialization and accelerating nano-enabled product penetration in the marketplace. The new dynamic associated with the phase change promises to drive increasing corporate revenues and profitability in the months and years ahead.

This phase change in the evolution of nanotech was evident at this year's NanoBusiness Summit held in late September in Boston, MA. The entire second day of the event was focused on nano commercialization – the first time this was done in the 10 years of the annual event. Two H&H portfolio companies – Contour Energy Systems and Metabolon – presented their companies to participants at the event. Both emphasized that they were entering a time of accelerating product commercialization, which we have documented in previous H&H company reports. This theme is also evident elsewhere in the announcements and activities of the broader group of H&H portfolio companies (see exhibit on the next page for selected announcements during the past quarter).

will be updating our NPTN financial model as more information on the acquisition becomes available.

[2] To read our previous published reports on Harris & Harris Group, see http://www.research2zero.com/sample-research.html

[3] See "Quantum Investing: Quantum Physics, Nanotechnology and the Future of the Stock Market," by Stephen R. Waite, Thomson/Texere, (2002-2004).

SELECTED H&H PORTFOLIO COMPANY DEVELOPMENTS

CLEANTECH

Bridgelux/Late Stage: Announced it has surpassed its previous industry record for highest Lumen per Watt values for Gallium Nitride on Silicon (GaN-on-Si). Growing GaN on larger, low-cost silicon wafers that are compatible with modern semiconductor manufacturing may deliver a 75 percent improvement in cost over current approaches. The company also announced its new line of Décor ultra-high CRI LED arrays which were developed in cooperation with Martini Lighting, a division of Martini SpA of Milan, Italy.

Solazyme (SZYM): Launched its microalgae-based luxury skincare line *Algenist* into 146 Sephora inside JC Penny stores. The expansion into Sephora inside JC Penny is the sixth major distribution agreement for *Algenist*. In addition, Solazyme and partner Unilever renewed and expanded their two-year joint development agreement that includes offtake terms for targeted oils for use in soap, personal care and nutritional products. The company also announced Jeffrey Webster as its Chief Operating Officer. Mr. Webster joins Solazyme from Tyson Foods where he served as Group Vice President and General Manager of the Renewable Products business. During his career, Mr. Webster has successfully established partnerships with a multitude of top energy and nutrition companies.

Contour Energy Systems/Mid Stage: Successfully raised over $20 million in a Series C round of financing. The proceeds from this financing are expected to support further expansion of Contour Energy's research and development efforts in carbon-fluoride chemistries.

ELECTRONICS/SEMICONDUCTORS

NeoPhotonics (NPTN): Completed the acquisition of privately held Santur Corporation. Santur sells high-performance tunable laser arrays for metro and long haul DWDM systems and is a developer of PIC-based products for 40Gbps and 100Gbps client side and coherent line side applications. The acquisition better positions NeoPhotonics as a vendor of client side components for the cloud.

Xradia/Late Stage: Announced the signing of a joint partnership agreement with VSG to provide unprecedented 3D imaging and analysis solution. Xradia will offer VSG's *Avizo Fire* software as their primary product offering for high-end 3D visualization and analysis that is used in conjunction with the company's 3D X-ray imaging solutions. Xradia also announced a partnership with Diamond Light Source, the UK's national synchrotron facility, on first lab-to-synchrotron solution for Cryo Transmission X-Ray Microscope imaging of biological cells.

Adesto/Early Stage: Announced the appointments of Michael Van Buskirk as Chief Technology Officer and Ravi Sunkavalli as Vice President of Product Development to help the company move towards ramping up production of its first CBRAM devices slated for later this year.

HEALTHCARE

Metabolon/Late Stage: Announced it raised $13.1 million in a Series D round of financing. The proceeds from this financing are expected to support further growth of the company's global biochemical profiling services and ongoing development of its oncology diagnostic product portfolio. The company also announced that it opened a new metabolomics lab in Shanghai, China, in collaboration with Shanghai Jiao Tong University (SJTU), one of the oldest and most prestigious public research universities in China. Metabolon has licensed its proprietary metabolomics platform technology to SJTU to enable a world-class biochemical profiling laboratory at the university.

In this report, we continue to dive deeper into the phase change underway in nanotechnology and provide in-depth analysis of two long-time H&H portfolio companies – Nanosys and D-Wave Systems. Both companies have been working for a decade or more in their respective areas of expertise to bring their nano-enabled products to markets – Nanosys in LED displays and energy storage technology, and D-Wave in quantum computing. As the ensuing analysis shows, both companies are ramping up their commercialization efforts and entering a new phase of growth that is likely to be characterized by accelerating top line growth and rising profitability in the years ahead.

NANOSYS: ARCHITECTING THE NEXT INDUSTRIAL REVOLUTION

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.[4] For a variety of reasons, the Nanosys IPO was cancelled and the hype surrounding nanotechnology began to subside 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

[4] 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.

of artificial nanostructures and quantum dot technology, and one of the principal scientific drivers behind the use of nanoscience-based 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 commercialization. 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.

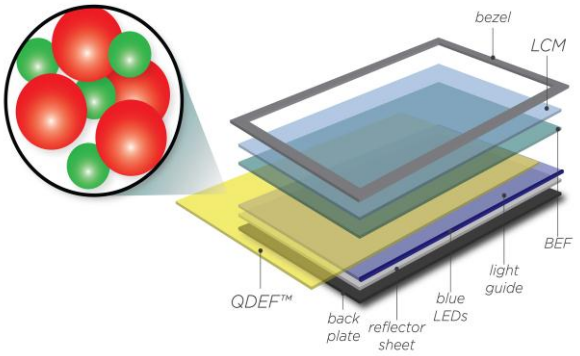
DOTS AND WIRES

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.[5] 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 emit shorter wavelengths (green).

Nanosys' QDEF™ For LCDs



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,

[5] 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.

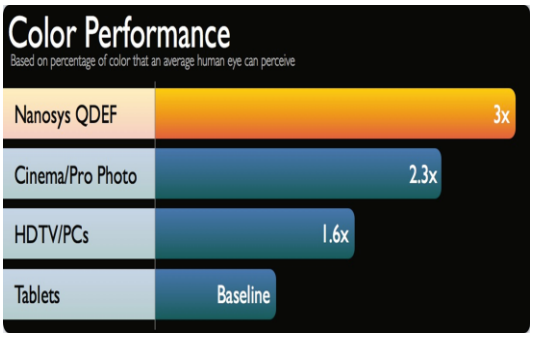
QDEF significantly elevates the color performance of a LED screen and enables a more vibrant and exciting viewing experience.

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.[6] One can easily see how the technology would be 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 definition viewing on any LCD display, be it an iPad, tablet, notebook, monitor, or large screen TV.

QDEF Boosts Color Performance



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

[6] 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."

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 advancing 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.

Nano-enabled Li-ion Batteries

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™.[7]

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 manufacturers 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.

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

[7] 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.

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.[8] 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

[8] To read our previous published reports on Harris & Harris Group, see http://www.research2zero.com/sample-research.html

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 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.

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

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. 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.

> "[Quantum] computing is not an impossible dream; it is a possible dream. It is a dream that can be held without flouting the laws of physics as currently understood. It is a dream that can stimulate an enormously productive collaboration of experimenters and theorists seeking deep insights into the nature of decoherence. It is a dream that can be pursued by responsible scientists determined to explore, without prejudice, the potential of a fascinating and powerful new idea. It is a dream that could change the world."
> – John Preskill, Richard P. Feynman Professor of Theoretical Physics, CalTech

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.

QUANTUM COMPUTING WITH D-WAVE

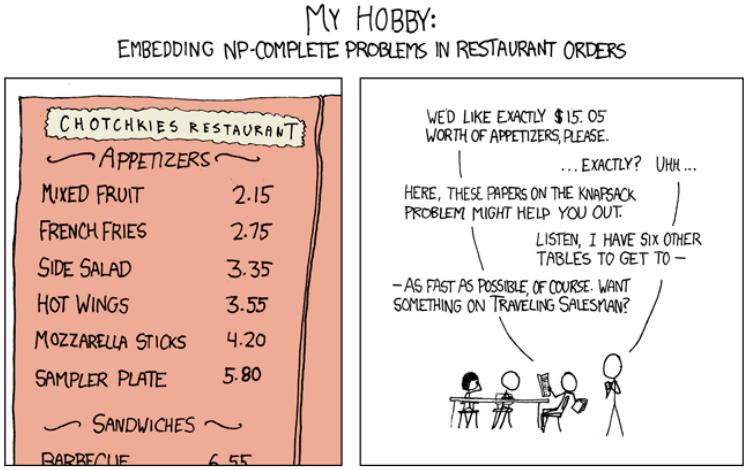
The last time we wrote about quantum computing was in 2005.[9] At that time, scientists were at the stage of applying some of the theory in labs to create rudimentary but demonstrable computers. In that note we stated, "viable quantum computers should be available in the next 5 to 10 years." Skip forward to today and one company, D-Wave, has been driving the science towards a viable technological solution. In fact, D-Wave made the first commercial sale of a quantum computer in May of 2011, just six years after our note appeared.

Quantum computing (QC) holds promise for tackling some classes of problems that don't yield to conventional computing approaches. Focus areas include processing images, natural language understanding, general unassisted machine learning, financial markets, search, and defense/intelligence. Thus, the implications of larger, commercially viable quantum computers, if they can be made, could be far-reaching. One problem we've worked on in some depth in-

[9] R2 2005 MIT Corporate R&D Conference Summary

volves transportation optimization. Airlines begin every day with a detailed operating plan. The number of airplanes, crews, schedules and facilities make this a hard problem. Adding to the complexity are additional constraints on the hours crews and pilots can work, and mandatory maintenance that can only be performed at specific locations. IBM provided early solutions to this problem using large mainframes running specialized optimization software called LINPACK. Since most commercial airlines don't operate for several hours between midnight and six in the morning, the computers had time to generate an optimal schedule. But at 6:05am every day the events of the real world invalidated the optimized plan. Airlines and transportation companies can only cope by making many sub-optimal decisions until they have time to rerun their optimization software.

This note is no treatise on quantum computing from a scientific or technical standpoint. Nor does it debate the "meaning" of quantum phenomena. But we will delve into the applied aspects of quantum computing as it is envisioned and implemented by D-Wave. There is debate over the "quantumness" of the D-Wave technology and how effective it will be in problem solving, but there is real potential in what D-Wave is doing and the company is entering the commercial phase of development. Investors will appreciate their leadership position, management team and recent product developments.



VERY HARD PROBLEMS

Computers have proven very useful in solving lots of problems. The world spends about $1T/year on computers, including the related software, services and networking. Thanks to Moore's Law the power of these systems grows quickly. Scientists have been building ever-faster supercomputers that commonly feature 100,000 to 200,000 cores10 with some, like the Fujitsu "K," having over 500,000. The K is getting close to reaching a goal of 10 quadrillion operations per second. These supercomputers can solve hard problems.

As most problems grow in size and scope, we simply upgrade our computing resources to tackle them. For example, if rendering the graphics for one film requires one core and we need to do ten films in the same amount of time, we use ten cores. It's a major upgrade but simple and manageable.

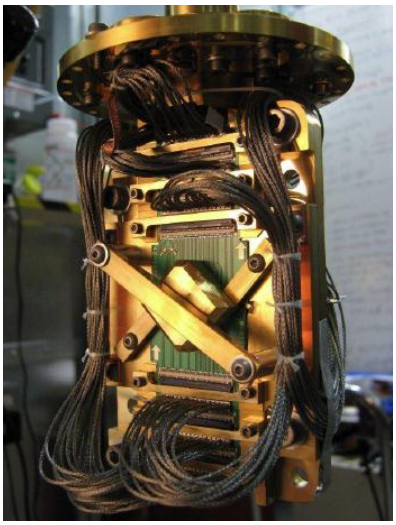
But there are some common types of problems for which the difficulty of finding a solution increases quickly. The amount of computing resources and/or time required to solve them multiplies or even grows exponentially. For example, if it takes 2 cores to compute a solution using two variables, it might take 16 cores to handle 4, 256 cores to handle 8, over 65,000 cores to handle 16, etc. These problems quickly outstrip all the computing power in the world.

It turns out that many meaningful problems have this "exponentially harder" characteristic. Experts might list about 30 foundational problems that fall into this category. But for each one of these there are many applications. Two easier to understand examples are the famous traveling salesman problem and the knapsack problem.

[10] We use the term "core" to describe a discrete processing unit. The word "processor" has become very ambiguous since each processor can have one or multiple cores inside. Cores are not all the same so it's still not a perfect unit of comparison but it is better than "processor."

In the traveling salesman problem we are given a set of destinations with the distances between each one and asked to plan a route for the salesman in which he visits each destination one time and travels the shortest distance overall. It's easy to solve for a few destinations but becomes impossible as the number of locations gets larger. This sort of problem comes up often in planning, logistics, microchip design and DNA sequencing. In these cases "destinations" might represent customers, connection points or the distances between molecules.

The knapsack problem is one we encounter all the time. Fundamentally, the knapsack problem is about maximizing something under a constraint. For example, maximizing the value of items you can fit into a fixed-size knapsack with each item having a different value and size. Like the traveling salesman problem, it's easy to solve for small numbers of items but becomes impossibly hard as it scales up. This type of problem comes up in resource allocation, including financial investment selection, cutting materials to minimize waste, and even the restaurant business, if you read XKCD.



Of course, the industry has come up with "solutions" to these problems through a combination of applying general rules, probability-based approaches and approximations. These "good enough" solutions are practical even if they may not be optimal. When time and resources are limited we make do.

In 1994, the quantum "shot heard round the world" came from Peter Shor who discovered that it was possible to tackle some of these problems using quantum algorithms. For the first time this suggested that problems requiring exponential resources might be reduced to problems solvable on a quantum computer in linear or even constant time. The tantalizing ability to solve previously unsolvable problems in an instant has been driving intense research and experimentation to build such computers.

The economics of quantum computing is similarly compelling. Conventional supercomputers are very expensive – the cost to build and run a 500,000 core computer is high; power alone costs several million dollars a year. Quantum computers are challenging to develop and engineer but not expensive to build and operate. If they help solve new problems and provide more efficient methods, their build cost and lower operating costs would generate sales at high gross and net margins.

D-WAVE TECHNOLOGY - HOW IT "WORKS"

The bulk of the D-Wave system is actually cooling and shielding for the small processor inside. In order to reach a quantum state the material must be cooled down close to absolute zero. The processor must also be heavily shielded from all other forces which would interfere with operations. The infrastructure needed to create an ultra-chilled and super-shielded environment is a key part of being able to create the superconducting quantum state for the processor.

It's difficult to talk about quantum computing operations without discussing the fundamental building block of the quantum bit, or "qubit." Unfortunately, our existing knowledge of "bits" in conventional computers interferes with understanding how quantum computers operate. Qubits are really not like digital bits and the quantum computer doesn't operate like a digital computer. The key aspect of qubits that makes them so different is that the value of one influences another. Qubits are more of a collection or cluster of discrete physical elements coupled together. Their interrelationships are essentially the "program" that the processor uses to generate a solution to a problem. The overall process works like this:

The qubits are cooled down to very close to absolute zero. At this point the qubits enter a quantum state, which can be thought of as a kind of "tabula rasa" or blank slate. Going a bit further, the qubits can be said to be "in all pos-

sible states" at this point. It's completely "unsettled." The system is in the lowest energy state.

Now imagine a very complex set of constraints and interrelationships that represent a problem that needs a solution. These can all be represented using fairly standard frameworks and notations. This representation is imposed on the system for a solution.
The solution is achieved by slowly bringing up the temperature just enough to push it from the quantum or unsettled state into one where all the qubits have a single value and the overall system has the lowest possible energy. This is basically a complex optimization computation that happens in one step.

Programming for a QC is very different. A computer scientist would describe the style as "declarative" rather than "procedural." Because what the QC really does is solve a large complex optimization, the declarations are more mathematical than other types of declarative programming. But these optimization problems have been around for a long time and are solvable with traditional computers, within limits. So the notation and even tools for expressing these problems are standard. In technical communities, terms like "Markov Random Field" and "Ising Model" are well understood.

These algorithms are commonly used in applications like computer vision, financial markets, and bioinformatics. D-Wave has made progress in building bridges between programmers and these techniques with software and libraries that developers can use to express their problems using familiar tools (like the Python programming language.) D-Wave plans to formalize and extend their tools with a more comprehensive developer portal that will also make a quantum computing as a service (QCaaS) approach more viable.

THE D-WAVE COMPANY

D-Wave was founded in 1999 and spent the first several years assiduously building and consolidating the knowledge and intellectual property of quantum computing. Since QC is a very new technology, this patent portfolio provides strong protection of their industry position. The current patent portfolio stretches from the base QC technologies through manufacturing and programming as illustrated below:

- **QC Technologies**: making qubits from Josephson junctions, quantum logic from energy levels, coupling and controlling qubits, methods for quantum processing, encoding and error suppression, reading and copying qubits, adiabatic quantum computation with superconducting qubits

- **Manufacturing**: fabrication of superconducting integrated circuits, methods for cryogenic refrigeration, methods for measuring magnetic fields, superconducting magnetic shielding, bus architecture for quantum processing, quantum processor packaging, electrical filtering

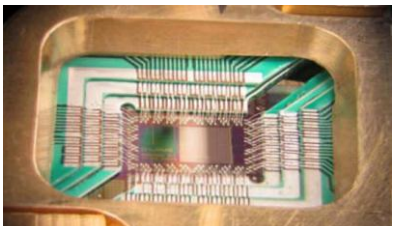
- **Programming**: number factoring, methods for solving computational problems, relational database processing, graph embedding techniques, solving integer programming and discrete optimization problems using analog processors

The point isn't to offer a comprehensive IP analysis but rather to show that D-Wave has covered a number of elements that apply to quantum computing. A look at the patent database shows that some large companies have patents in QC but it's generally just a smattering. IBM has only a few. Both NEC and Toshiba have more meaningful portfolios but many of these deal with alternative methods of quantum computation, optics, communication or cryptography. In short, D-Wave has effective IP protection and knowledge to execute their plan and protect shareholder interests.

Five years after its inception, D-Wave began to focus on building working quantum computers. Their first was 4 qubits in 2005 followed by a 16 qubit version in 2007, 28 qubits in 2008 and 128 qubits in 2010. This 128 qubit machine was packaged into a complete system with interfaces,

an operating system and other software and called the "D-Wave One." The first sale of a D-Wave One was to Lockheed Martin in May of 2011 for a price reported to be in the $10M range.

In order to build the computers, D-Wave has developed their own superconducting foundry operating between British Columbia and Silicon Valley. This helps explain the nearly-$100M in venture capital the company has needed. Although much of the process and equipment required are standard, there are specialized aspects involved. The sensitive nature of quantum computer manufacturing at 128 qubits and higher makes outsourcing to external fabricators unsuitable. By combining standard tools and technologies with a specialized process D-Wave can scale up and still control their IP and competitive position.



The D-Wave One is the first system to cross the 100 qubit threshold that many scientists feel represents "useful" scale for quantum computers. D-Wave is working with other potential customers who are interested in their own applications in machine learning, pattern recognition, risk analysis, and defense/intelligence. D-Wave has had public collaborations with Google on machine learning, so it's safe to assume that D-Wave has been working on a sale there.

The 512-qubit version of the D-Wave is due sometime in 2012. If the system comes out on schedule it will be another major step forward. Today critics would focus on the sale of the D-Wave One to Lockheed Martin as a "one-off that won't scale." The combination of new customers and delivery of a 512-qubit machine would be a vindication of D-Wave. We expect more advances in the software tools and developer resources as well and more steps to delivering QC as a service.

MANAGEMENT TEAM

By now it should be clear that a technology so technically challenging, long-term in nature, and of such high potential would require an especially well equipped management team. D-Wave has built such a team, and several of the senior members are very well known inside the industry and have proven both their mettle and commitment to overcoming the many challenges on the path to commercialization. Here are some of the more key ones:

Geordie Rose, Ph.D., Founder & CTO – Geordie is a rare combination of scientific vision, commercial aspirations, charisma and communication ability. All of these traits are on display in his blog, Hacking the Multiverse.11 As the CTO, Geordie is in the ideal role for his abilities. He has been a tireless builder, evangelist, defender and explainer of the D-Wave technology and a respectable, if slightly controversial, member of the scientific community.

Vern Brownell, CEO – Vern brings the leadership the company needs in the business of selling unique and powerful computers, and of using computers in a business setting. Vern founded and was CEO of Egenera, which was a pioneer in very high performance blade servers long before the technology went mainstream and became the province of HP, Dell and IBM. Individuals who have worked closely with Vern say "if you want to build a company selling high end systems early in the development lifecycle, Vern is your man."

Bill Macready, Ph.D. VP Software Development – Bill has a Ph.D. in physics and four years of post-doc work at the Santa Fe Institute. He subsequently combined his education with varied work experience that included five years in a company implementing business intelligence and performance optimization problems for commercial customers using standard software. After two years at NASA, Bill joined D-Wave in April of 2005. In the past few years Bill has emerged as a very important contributor in solv-

[11] http://dwave.wordpress.com/

ing the mapping, programming and implementation challenges facing quantum computing. Our experience suggests that Bill's ability stems from the combination of a deep background in physics (and the requisite math), commercial applications in data and optimization, and quite a few years immersed in quantum computing at D-Wave.

This is by no means a complete list of the important members of the senior management team, but illustrates a few that are very closely associated with the company. D-Wave derives some benefit from being a magnet for individuals who are keen on the commercial potential of quantum computing. There are jobs at universities and the R&D departments of a few large companies but they don't offer the type of applied orientation, singular focus and commercial promise that D-Wave can.

QUANTUM CONTROVERSY

Quantum computing has been a magnet for hype and criticism and D-Wave has often been in the middle of it all. QC is a very tricky subject to cover for the media. The details are impossibly technical and it's easy for popular press (such as The Economist) to publish articles that gloss over important challenges and instead write about the outrageous potential of quantum computers. This cycle tends to discredit the technology and the companies associated with it.

Back in 2007 there was a major fracas between the management of D-Wave and members of the academic community, particularly the well-versed gentlemen professors from MIT. The crux of the matter was that during some presentations of early results, some individuals at D-Wave made statements that were too general, optimistic and unproven. One shouldn't do this lightly when the pioneers of the science and inventors of the technology are in attendance.

If there were any blame to be assigned, it would fall on senior management at the time who went a little overboard with promises and plans that were inconsistent with how rapidly the science and technology team could deliver. For example, Herb Martin, the CEO at the time, claimed that the technology would "scale to a 512-qubit machine later [in 2007] and to a 1024-qubit computer in the middle of 2008."12 They were right about getting to 512 qubits but were four years too early on the date. That kind of major slip casts doubt over the whole operation.

There were some changes in the tenor and make-up of the team at D-Wave years ago with the replacement of Herb Martin with a new CEO, Vern Brownell. The core members of the team were preserved but surrounded with upgraded senior management. In addition, the company changed its orientation to what we would describe as "let's put our resources on making solutions that help customers" versus responding to every criticism from the scientific community. Since then D-Wave has tended to avoid hyperbole or generating too much excitement in the press.

Lingering impressions of quantum computing and D-Wave being a "scam" still exist in the market but are held by those who have failed to keep up with the events of the last few years. Those that have kept up still harbor some skepticism but acknowledge that the team at D-Wave has steadily advanced the science and technology, albeit at a slower pace than originally (and irresponsibly) promised.

Consistent with making performance and results their top priorities, D-Wave will probably generate more controversy even if they make additional sales and continue to improve the power and scale of their solutions. Their commercial focus means that D-Wave is making design decisions that make their products better and cheaper at the expense of generating more research papers.

OPPORTUNITIES

Potential: If D-Wave can achieve success with early customers of the D-Wave One and successfully deliver the 512 qubit model in 2012, the market for quantum computers will become

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[12] MIT Technology Review, Friday April 6, 2007: http://www.technologyreview.com/computing/18495/

real. Because these machines can deliver new computing capabilities for currently unsolvable problems, they will have high ROI for industries like financial services, internet, and defense/intelligence, as well as create new application areas.

Margins: There's a high fixed development cost in the design, development and engineering of these systems but the production cost promises to deliver high gross margins and meaningful net income with only a handful of systems sold per year. Given the cost, approximate gross margins, and limited size of the company we believe management when they state that the company can be profitable with three sales per year.

Management and technology team: The company has assembled a high caliber management team with key members ideally suited to commercializing this technology. They have been at it for some time and combine both scientific and operational backgrounds. If anyone can do it, they can.

Manufacturing infrastructure: Although costly the company has made the investment in process technology and manufacturing capability to allow the company to scale and preserve their competitive position.

Knowledge and IP protection: D-Wave has built a significant patent portfolio and is, for better or worse, viewed as the leader in commercial quantum computers. Their industry position would be difficult to dislodge as the market develops.

RISKS

Validation: The progress D-Wave has made is widely (sometimes begrudgingly) acknowledged but the company has not yet crossed the line of "proving" their model and ability to have a successful business in quantum computing. It appears, however, that this line may be crossed in the next 12 to 18 months.

Scalability unknowns: We already know that scaling up the number of qubits has been more difficult than was believed in 2007. There are still unknown properties of quantum materials that could make future increases in the number of qubits much harder than expected. In the worst case, nasty exponential costs could resurface here. The laws governing increasing scale in quantum computers won't be clearer until we move beyond 512 qubits.

D-WAVE CONCLUSION

Quantum computing in general, and D-Wave in particular, remains a work in progress, especially in terms of commercial success. But D-Wave has been at the forefront and has made impressive advances. At this point the company and their technology has entered the commercial phase. What's not yet known is how steep the slope of adoption will be. The next 12 to 18 months will be very illuminating.

From an investment standpoint we are encouraged by D-Wave and would suggest that even failure could result in some success. With $95M invested, a failure would not generate 10x returns but the knowledge and IP precipitated from these efforts is likely to result in useful technology that would generate real value in the marketplace.

The company, however, is still very much striving for total success which would have an important impact on the computing industry and reward investors with potentially very large gains.

D-WAVE ACKNOWLEDGEMENTS

Getting a grip on the current state of quantum computing is slightly more complicated than many of our other typical emerging technology research efforts. We relied on a variety of available published scientific material but received invaluable help from one-on-one conversations with Seth Lloyd, Professor of Mechanical Engineering and Engineering Systems, MIT, Alexi Andreev, Ph.D., Executive VP and Managing Director at Harris & Harris and Board Member D-Wave Systems, and Vern Brownell, CEO of D-Wave Systems. In addition many insightful detractors and fans of quantum computing and D-Wave have made their positions and support-

ing information open to the world for critical analysis. D-Wave founder Geordie Rose and MIT Associate Professor Scott Aaronson are good examples.13

NEW INVESTMENT ACTIVITY

H&H participated in the financings of two portfolio companies - Contour Energy Systems and Metabolon - that completed rounds during Q3. In addition to these financings, H&H announced a new investment in Salt Lake City, Utah-based HzO, Inc. The company recently completed a $7 million Series B Preferred financing of which H&H invested $1,666,667. HzO is developing a unique process to create a nanoscale coating that protects electronics against damage caused by exposure to water, which is the leading cause of lost function in electronics. The coating is transparent and can be applied via conventional chemical vapor deposition (CVD) to a variety of surfaces including plastic, metal and glass. In addition to water repellence, HzO's nanoscale coating can repel oils, synthetic fluids, hazardous materials, dust and dirt. The company sees applications for its technology in a wide variety of industries including automotive, first responder devices, military devices and vehicles, solar energy, and industrial applications. HzO is planning to roll out its first HzO-coated consumer electronic devices with its partner ZAGG, Inc., in the months ahead. We plan on providing additional coverage of HzO and ZAGG in the near future. Suffice it to say we think the partnership is intriguing and has potential given HzO's technology and ZAGG's marketing prowess.

CONCLUSION

H&H founder Charlie Harris was a contrarian at heart. During times like these in the markets, he was fond of quoting Warren Buffett who said: "Be fearful when others are greedy; be greedy when others are fearful."[14] The sell-off in equity markets around the world during the past quarter indicates a time a fear. We imagine Charlie would be putting Buffett's advice into practice were he still around today.

Nanotechnology is a General Purpose Technology (GPT) that has game-changing potential in the same way of the Internet and electricity. GPTs often take many years and decades to evolve and penetrate the market in a powerful and significant way. Investing in companies that are harnessing the science of nanotechnology and creating innovative, game-changing products based on the science of nanotech requires taking the long view. Nano-enabled products do not march to the beat of a quarterly drummer. They evolve over the course of years, require relatively large amounts of capital ($100 mm or more) and extensive research and development.

There is a mismatch evident in the markets today between a seemingly rising share of investors eyeing short-term trading opportunities around quarterly performance versus companies focused on longer term development of innovative products that have the potential to change the way people live, work and play. The mismatch of short-term trading and longer-term product development creates a difficult environment for companies such as H&H who are focused on nanotech and the investors that back them. This mismatch isn't going away soon.

What we do see is nanotech commercialization activity accelerating in the future. Along with this acceleration, we see the potential for considerable wealth creation and out-sized absolute investment returns. H&H's current valuation reflects a state of fear and "risk off" in financial markets. The stock is currently trading at a 25% discount to the reported June 20, 2011 NAV of $5.43. Even if we assume that H&H will revise down its estimate of NAV for the September 30, 2011 reporting period by 20-25%, the current share price would represent a discount to NAV. Our on-going analysis of H&H portfolio companies suggests that H&H is currently understating the intrinsic value of these companies by 40-50%. Historically, the stock has traded at a premium of 2x NAV. Our analysis

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[13] http://www.scottaaronson.com/blog/

[14] For more investment wisdom from Charlie Harris, see "Some Lessons Learned in 42 Years of Business," *Journal of Investment Management*, Volume 8, Number 3, Third Quarter 2010.

suggests there is compelling value in TINY currently with a fully valued share price of $12.

For investors seeking exposure to nanotechnology and its game-changing potential now seems a propitious time to listen to the wise counsel of Charlie Harris and heed Warren Buffett's sage advice.

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