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PROBABILISTIC VALUATION OF NANOTRONICS

Carlos Gomez, Hesam N. Motlagh and Steve H. Hanke

Johns Hopkins Institute for Applied Economics, Global Health, and the Study of Business Enterprise

Probabilistic Valuation of Nanotronics

by Carlos Gomez, Hesam N. Motlagh and Steve H. Hanke

About the Series

The Studies in Applied Finance series is under the general direction of Prof. Steve H. Hanke, Co-Director of The Johns Hopkins Institute for Applied Economics, Global Health and the Study of Business Enterprise (Hanke@JHU.EDU)

About the Authors

Carlos Gomez is a 2017 Ph.D. graduate in Cellular and Molecular Medicine from the Johns Hopkins University School of Medicine in Baltimore, MD. His doctoral work focused on crystallographic analysis of virulent factors and identification of hypervirulent pathways responsible for yeast pathogenesis. Research for this working-memo was undertaken while working as an Equity Research analyst for the Johns Hopkins Institute for Applied Economics, Global Health, and the Study of Business Enterprise. Subsequent to graduation he went on to work as a postdoctoral fellow with Arix Bioscience - a life science focused Venture Capital company in NYC.

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Hanke is also a member of the Charter Council of the Society of Economic Measurement and of Euromoney Country Risk's Experts Panel.

In the past, Prof. Hanke taught economics at the Colorado School of Mines and at the University of California, Berkeley. He served as a Member of the Governor's Council of Economic Advisers in Maryland in 1976-77, as a Senior Economist on President Reagan's Council of Economic Advisers in 1981-82, and as a Senior Advisor to the Joint Economic Committee of the U.S. Congress in 1984-88. Prof. Hanke served as a State Counselor to both the Republic of Lithuania in 1994-96 and the Republic of Montenegro in 1999-2003. He was also an Advisor to the Presidents of Bulgaria in 1997-2002, Venezuela in 1995-96, and Indonesia in 1998. He played an important role in establishing new currency regimes in Argentina, Estonia, Bulgaria, Bosnia-Herzegovina, Ecuador, Lithuania, and Montenegro. Prof. Hanke has also held senior appointments in the governments of many other countries, including Albania, Kazakhstan, the United Arab Emirates, and Yugoslavia.

Prof. Hanke has been awarded honorary doctorate degrees by the Bulgarian Academy of Sciences, the Universität Liechtenstein, the Universidad San Francisco de Quito, the Free University of Tbilisi, Istanbul Kültür University, and Varna Free University in recognition of his scholarship on exchange-rate regimes. He is a Distinguished Associate of the International Atlantic Economic Society, a Distinguished Professor at the Universitas Pelita Harapan in Jakarta, Indonesia, a Professor Asociado (the highest honor awarded to international experts of acknowledged competence) at the Universidad del Azuay in Cuenca, Ecuador, a Profesor Visitante at the Universidad Peruana de Ciencias Aplicadas (the UPC's highest academic honor), and the Gottfried von Haberler Professor at the European Center of Austrian Economics Foundation in Liechtenstein. In 1998, he was named one of the twenty-five most influential people in the world by World Trade Magazine.

Prof. Hanke is a well-known currency and commodity trader. Currently, he is a member of the Supervisory Board of Advanced Metallurgical Group N.V. in Amsterdam, Chairman Emeritus of the Friedberg Mercantile Group, Inc. in Toronto, and is a member of the Board of Directors of Airtm in Mexico City. During the 1990s, he served as President of Toronto Trust Argentina in Buenos Aires, the world's best-performing emerging market mutual fund in 1995.

Prof. Hanke's most recent books are *Zimbabwe: Hyperinflation to Growth* (2008), *A Blueprint for a Safe, Sound Georgian Lari* (2010), *Juntas Monetarias para Paises en Desarollo* (2015), *Currency Boards for Developing Countries: A Handbook* (2015), and مروري بر ادبيات تاريخی جريانهاي غيراصلی پولی هيئتهای پولي (2018).

Prof. Hanke and his wife, Liliane, reside in Baltimore and Paris.

Probabilistic Valuation of Nanotronics

By: Carlos Gomez[1], Hesam N. Motlagh[1], and Steve H. Hanke[1]
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Executive Summary

Nanotronics is a private company providing solutions to silicon wafer manufacturers via the most common inspection tool: the optical microscope. Visual inspection for defects of advanced wafer features requires scanning electron microscopes (SEM), transmission electron microscopes (TEM), or other analytical tools.[2] As the semiconductor industry shifts toward more complex 3D-chip designs and new materials, manufacturers place significant value on inspection systems. Nanotronics provides the solution in the form of a single system with an unprecedented resolution scale and software options to suit a customer's desired application. Given the superior product and service base of the company, we expect significant growth supported by tailwinds from Asia and the strong demand in advanced memory chips (DRAM, 3D NAND).

To determine how these market fundamentals translate to valuation, we built a Probabilistic Discounted Free Cash Flow (PDCF) model for Nanotronics.[3] By building different growth projections (Bear, Base, and Bull), we derived that **Nanotronics' valuation is strongly determined by its ability to create and capture market share**. Given the uncertainty in future forecasts, the most recent public post-money valuation ($350 million) falls in the ~40th percentile of our bull case distribution and is completely justified. The relationship between growth and valuation helps us interpret the importance of the **total addressable market ("top-down analysis"), which is estimated to be upwards of $10 billion.[4] Thus, Nanotronics represents a multi-billion dollar valuation opportunity if it manages to capture ≥ 10% market share, as compared to our "bottom-up analysis" through our PDCF which suggests ~2.5% market share.**

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[2] Tools including, but not limited to: Energy Dispersive Analysis of X-rays (EDAX), X-ray photoelectron spectroscopy for chemical analysis (ESCA), Auger Rutherford Backscattering (RBS) and others.
[3] This proprietary model has been used for over two decades at The Johns Hopkins University to evaluate companies. Previously published articles utilizing this approach can be found at The Johns Hopkins Institute for Applied Economics, Global Health, and the Study of Business Enterprise in the *Studies in Applied Finance Working Paper Series*.
[4] Market size is based on data analysis of 10-K filings (where available) of the top 15-20 publicly traded companies with $100 million market cap minimums.

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Company Snapshot and Analysis Overview

- To date, Nanotronics has **raised a total of $71 million** in capital and has steadily generated revenue over the past four years.[5]
- The company established working factories in California, Ohio, and New York and is developing new facilities in Singapore to address the tremendous growth opportunities in Asian technology markets.
- **Over twelve patents** have been awarded to the company, ranging from artificial intelligence's (AI) unique resolution algorithms to automated microscope processes.
- The **post-money valuation for Nanotronics sits at $350 million,**[6] which with our PDCF in conjunction with market share analysis, suggests that Nanotronics is expected to gain ~3.5% market share.

Nanotronics is pioneering the development of cutting-edge, innovative products dedicated to automated optical inspection. The future of manufacturing processes is being advanced with a combination of optical microscopy, artificial intelligence, and computational super-resolution. The company's microscopes are being integrated into the manufacturing of most advanced technologies such as semiconductors, microchips, hard drives, LEDs, and in varied industries such as automotive, advanced materials, consumer electronics, aerospace, medicine/biopharmaceuticals, and numerous other manufacturing sectors. While the company is a disruptor for multiple industry sectors our analysis focuses primarily on the current applications of products for the **semiconductor industry. We believe this is appropriate considering ~75% of sales are from the semiconductor inspections market.**

In the following section, we discuss three of the major addressable markets: semiconductors, biopharmaceuticals, and advanced materials. Our objective is not to value the company along each of those industries but to highlight and draw attention to the wide range of applications and considerable opportunities available to the company. Thus, we begin our analysis with a section on *Market Analysis: Catalysts and Risks*. Following an appreciation of the vast market potential, we highlight the specific product base of Nanotronics to meet these market demands (section entitled *Business Products*). After a brief discussion of competitors in the marketplace, we turn our attention to the financial statements and valuation model of Nanotronics to draw our final conclusions (sections entitled *Company Valuation* and *Conclusions*).

Market Analysis: Catalysts and Risks

We begin our discussion by detailing three of the major end-markets for Nanotronics: semiconductors, biopharmaceuticals, and advanced materials. In particular, it is clear that these markets have not only sustained significant historical growth but are supported by long-term secular tailwinds that we believe will lead to sustained growth

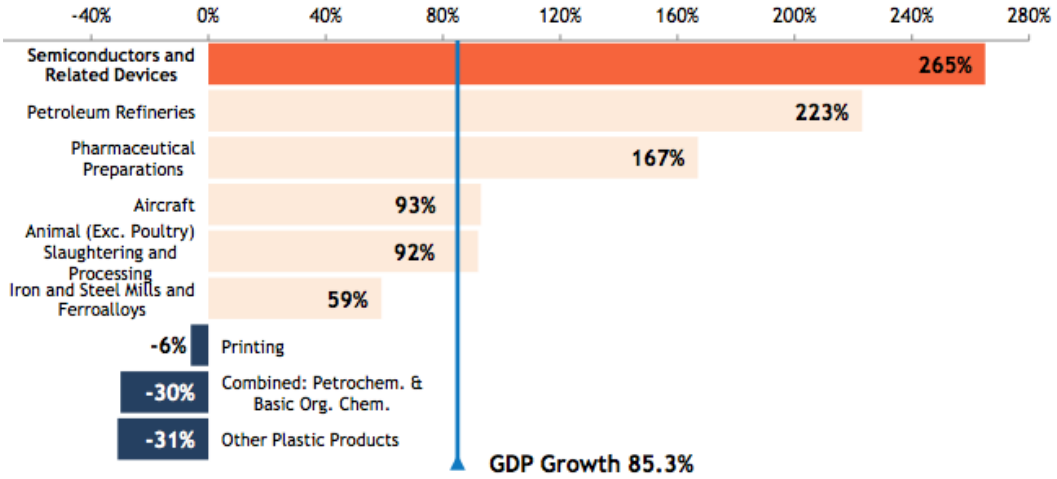
[5] Nanotronics audited financial statements
[6] Source: Pitchbook Data; accessed 8/1/2018.

during our forecasting period. This paints an optimistic picture of the market potential for Nanotronics to tap into in years to come.

Semiconductors

In absolute terms, the U.S. semiconductor industry's share of U.S. GDP is the third largest of all U.S. manufacturing industries behind the petroleum refinery and pharmaceutical industries. Pertinently, Nanotronics has established **ExxonMobil and Illumina** as initial top tier customers in their respective industries. Despite not being the largest manufacturing industry, semiconductors have been the fastest growing industry segment in the U.S., which has grown at a stunning rate of 265% from 1987 to 2011 (Exhibit 1). To emphasize its importance, the 2018 policy priorities published by the Semiconductor Industry Association[7] (SIA) recommends an increase of Federal funding in Semiconductor Research at DARPA, NST, NSF, and DOE. Notably, a vibrant U.S. semiconductor industry is strategic to maintaining America's strength and a healthy innovative economy.

Exhibit 1.



The U.S. semiconductor industry has grown more than any other manufacturing industry since 1987. *(Source: http:www.semiconductors.org/ItAllStartsHere)*

Assuming no significant losses in market share, these market dynamics provide us with a lower bound for company growth. Specifically, these growth opportunities lie in the development of Asian markets, especially in China. China's national guidelines call for ambitious targets: 1) by 2020 a compound annual growth rate (CAGR) of >20% in revenues, and 2) by 2030 a world-class integrated-circuit (IC) industry value chain including a set of tier 1 players in the global market.[1] China has already **committed $150 billion to build its domestic semiconductor industry over the next decade via the "Made in China 2025" development program** (Exhibit 2). Presently, semiconductor consumption in China outpaces the overall market, reaching about 50% of the global total (Exhibit 4b). A clear indication of the importance of China's market can be appreciated from the activities of several global industry players:[1]

[7] SIA, https://www.semiconductors.org/issues/research/research/

- Qualcomm has partnered with SMIC on 28-nm products and 14-nm process technology development.
- UMC collaborated with Xiamen government and FuJian Electronics and Information Group on a $6.2 billion investment in a foundry (Fab).
- Intel invested $1.5 billion in a subsidiary of Tsinghua Unigroup, which owns the two largest fabless design companies.

Adding to China's motivation to become a technological powerhouse, the recent trade disputes with the U.S. only highlight Chinese dependence on foreign microchip technology.[2] Direct engagement in pursuit of shaping the semiconductor market is China's goal, and Nanotronics is poised to become a major partner for that growing market.[8]

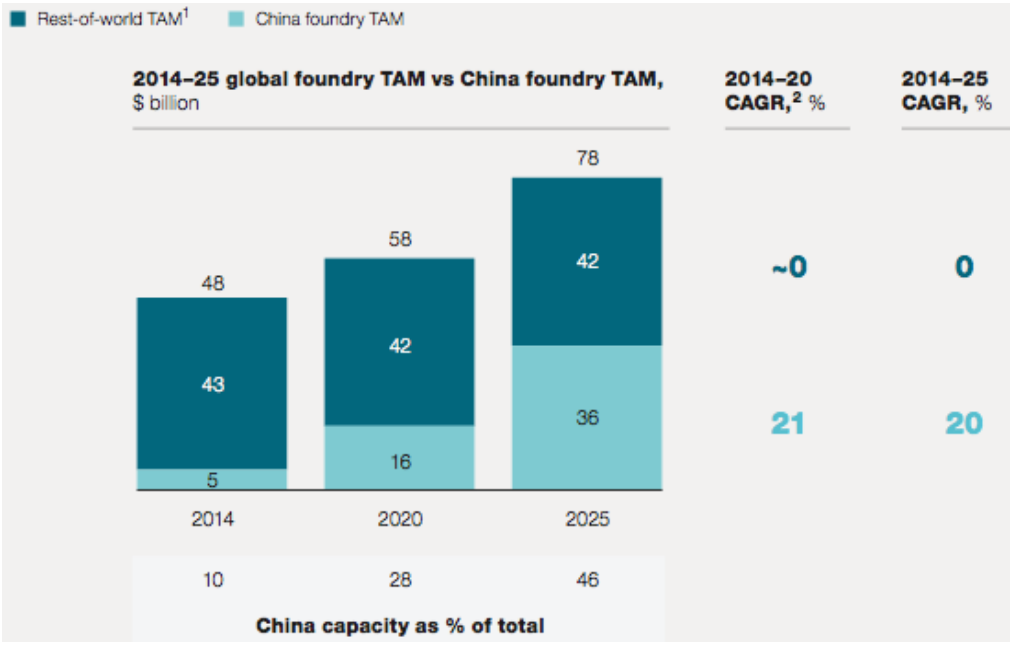


Exhibit 2. All incremental foundry capacity globally would have to be made in China in the next 10 years to meet "Made-in-China-2025" targets. *(Source: HIS Application Forecast Tool 2015, Mckinsey analysis)*

Yet another development in the semiconductor industry supporting long-term growth is the demand for automotive chips. Revenues from this market have increased from $7 billion to ~$30 billion from 1996 to 2015 (Exhibit 3). If this trend continues, the market is forecast to grow at a CAGR of 8.2% between 2016 and 2021 and is ultimately projected to reach $39 - $42 billion in 2021.[3] Applications for automotive semiconductors include radar chips, advanced driver assistance systems, hybrid and electric vehicle systems, in-vehicle networking, LED lighting, as well as fuel economy, emissions reduction, and general body

[8] The current tariff impositions may actually be detrimental to the U.S. semiconductor industry. Because of complex supply chains, U.S. companies are more exposed than their counterparts. (*Financial Times July 4 & 11, 2018*) Concerns and challenges regarding China's forced technology transfer and intellectual property practices will not be addressed here.

and interior elements. Moreover, the growth of electric vehicles (EV) is shifting demand in device segments as well. Hybrid electric vehicles (EV) contain $900 worth of semiconductors, standard EVs contain $1000 worth, while conventional cars carry only $330 worth of semiconductors. We can easily recognize that as cars become more and more complex combined with a push toward autonomous driving, the demand for semiconductors in the automotive industry will continue to rise steadily and provide a new major long-term growth engine.

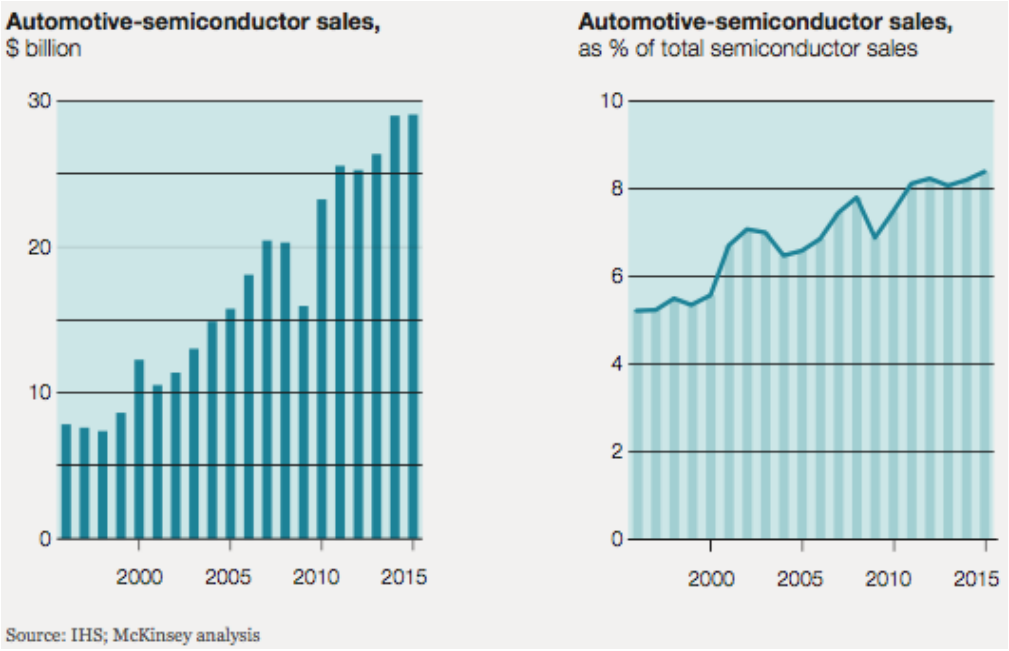


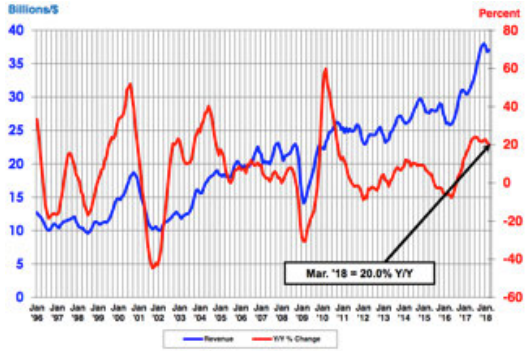
Exhibit 3. Automotive market generates an increasing portion of semiconductor sales.

Recently, the SIA announced worldwide sales of semiconductors reached $111.1 billion during the first quarter of 2018, an increase of 20% compared to the first quarter of 2017 (Exhibit 4a). Year-over-year sales increased across all regions in March: the Americas (35.7%), Europe (20.6%), China (18.8%), Asia Pacific/All Other (13.3%), and Japan (12.4 %).[5] One final key-contributing factor to market growth is the increased **demand for memory chips** (NAND, 3D-NAND).[9] Altogether, the various factors applying pressure on supply-demand conditions are resulting in new Fabs being built in 2018 to accommodate production needs. Therefore, we also expect increased sales for semiconductor manufacturing related equipment. For our purposes, **the semiconductor industry represents a baseline level growth opportunity for the company.** Our model weighs substantially along these assumptions for parallel growth.

[9] Due to space constraints, "demand on memory " will not be discussed or elaborated here.

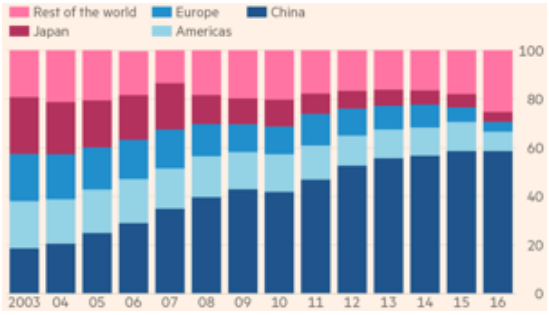
Exhibit 4a,b.

a. Worldwide Semiconductor Revenues



Year-over-year % growth. (*Source: WSTS)*

b. Global Semiconductor Industry



Market share by consumption
(Source: PWC, ANZ Research, Financial Times)

A critical aspect of investments in the semiconductor industry requires us to be cognizant of the fact that profits are typically generated over longer time frames than expected, especially in the process and manufacturing segments that are on the order of 5, 10, and even 15-year time frames[1] due to the cyclical nature of the business. As the Chinese focus on design innovation and improved capabilities, their total demand for components including semiconductors will increase from $350 billion in 2016 to $500 billion by 2020.[6] Substantial optimism about China both as a market and a source of partnership, as well as with the general automotive market allays our risk concerns and helps provide a long-term view of growth for the next 10 – 15 years. Current headlines signal a potential peak in the market, especially as the next technological node approaches; nonetheless, our long-term sentiment remains anchored in company fundamentals with a substantial growth outlook.

Positive market catalysts:

- Record equipment spending with projected growth 14% 2018 YoY and 9% in 2019.
- An increase in 2017 CAPEX has created a pickup in semiconductor supply for 2018/19.
- Fully autonomous cars by 2021 requiring a tremendous increase in semiconductor content.
- Connected devices growth ~ 20% through 2020, expected 1 Trillion cumulative IoT devices by 2035.
- Fab investments: (300mm - Infineon, Vanguard, Bosch), Rohm, and Micron.

Potential market Risks:

- Potential excess supply in 2018/19.
- Semiconductor debt levels have increased post mergers, interest rates up too.
- **The disconnect between end-market unit growth, high inventory on balance sheets, and semiconductor unit growth.**[4]

Medicine / Biopharmaceuticals

One of the most essential tools in biotechnology/science is the use of the microscope. Advanced imagery analyses along with the introduction of atomic force microscopy (AFM) have allowed the characterization of subcellular structures, viruses, protein-protein interactions, and small molecules. Even the 3D-architectures of DNA and proteins are knowable at the atomic level. Much like the miniaturization of microchips has advanced the semiconductor industry, nanotechnology will be transformative for the biopharmaceutical market and medicine in general. Tools functioning at the nanoscale range will undoubtedly accelerate the commercialization of products with applications from drug discovery, diagnostics, and drug delivery. These tools fall into 3 major categories: process development, product development, and personalized medicine[8] - all accessible to the company's products. In 2016, total U.S. prescription **drug expenditure was estimated at $450 billion[10]** and is estimated to reach $610 billion by 2021, presenting a tremendous market opportunity.

Nanotronics can become the ideal partner to push forward several new technologies and devices that will bring important new therapies and diagnostic tools to areas of unmet medical need. The power of this technology is illustrated with a few brief examples:

- One ongoing effort is the reduction of multiple polio vaccine doses down to a single injection by utilizing FDA approved polymers (PLGA-PEG nanoparticle encasement) as delivery vectors. These polymers can be designed to degrade at a defined time-rate resulting in controlled vaccine release to ultimately achieve global polio eradication.
- Diagnostic pathological screenings for diseases like cancer could be performed in a high-throughput fashion. Machine learning, a cornerstone of Nanotronics technology, can be leveraged to identify validated disease features at the cellular and subcellular level.
- Pill size reductions to the nanoscale will impart different pharmacokinetic/ pharmacodynamic profiles allowing for better solubilization and reduced drug concentrations. This approach opens the door to promising therapies that were previously unable to move forward in clinical trials because of poor bioavailability characteristics or undesired toxicity profiles.

Monitoring, imaging, validation, screening, and QC are but a few of the functions suitable for the company's microscopes. Nanotronics anticipates establishing a strong customer base throughout the entire healthcare/biotech market industry. Current customers include **Illumina,** the industry leader in DNA sequencing and DNA/RNA microarray chips. **Pfizer**, **Allergan, GSK, and Astra-Zeneca** (top-20 companies by market cap) are strong prospective clients.

One of the more exotic nanoscale solutions to emerge is due to the exponential proliferation and accumulation of "Big Data." Companies like **Twist Bioscience** are developing DNA applications as a new medium for high-density long-term digital data storage with a greater half-life than current storage devices and higher rates of reproducibility. **Almost a zettabyte of data can fit in one gram of DNA that can last for**

[10] https://www.reuters.com/article/us-usa-drugspending-quintilesims

10,000 years at a fraction of the cost of cloud computing solutions. DNA has a molecular diameter of ~ 2 nm and an average length of 45-50 nm (140-150 bp) in aqueous solutions; at the operational range of Nanotronics' microscopes.

The nanodrug delivery market just exceeded $20 billion while the overall **nanomedicine market is forecast to reach $293.1 billion by 2022** [11] primarily addressing the following areas of impact: cancer, CNS disorders, cardiovascular disease, and infectious disease control. From small molecules to biologicals and from **device diagnostics to drug-delivery technologies like nanoparticles**[12] (PLGA-polymers, metalloid or lipid-based), the tools developed by Nanotronics will be in high demand to help ensure product consistency, reliability, and cost-effectiveness that will enable these medical products to come to market.

Overall, the biopharmaceutical industry presents an exciting area where significant technological developments are occurring and long-term growth should be supported by current investment levels. Nanotronics is well positioned to benefit from both of these tailwinds, which leads us to be optimistic about the growth prospects for the company.

Advanced Materials

Another industry where Nanotronics anticipates adding value along the manufacturing process is advanced-materials (consumables to industrial applications). Advanced materials affect a wide range of markets, including everyday clothing and electric vehicles. From stain-resistant fabrics to the revolutionary impact on lithium-ion battery technology (a market that is forecast to reach $30 billion by 2020) – nanotech materials are essential.

Exhibit 5. Carbon Nanotubes spun

(Source: Nanocomp)

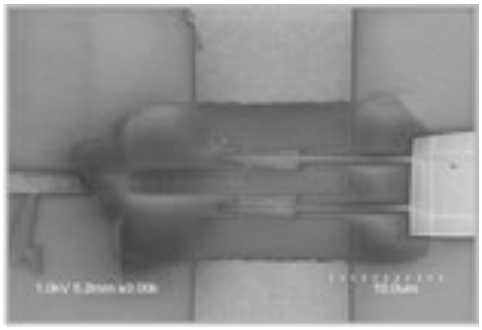


Exhibit 6. Graphene transistor with

Nanocenter).

Nanoscale chemical industry players are constantly investing in research and development for the latest and innovative technologies in the nanoscale market. Due to increasing demand from industries such as medical, construction, and electronics, the global nanoscale chemicals market is expected to expand at a CAGR of around 10-12% from 2015-2025.[9] The **availability of high-throughput, in-line metrology to enable closed-loop process control and quality assurance is a critical prerequisite for the development of cost-effective nano-manufacturing**. High-performance structural carbon-based nanomaterials, optical metamaterials, and cellulosic nanomaterials are key sustainable materials with the potential to affect multiple industry sectors with significant economic impact.

[11] https://www.bccresearch.com/
[12] Global nanoparticles market in biotechnology and pharmaceutical sectors is expected to grow at CAGR of close to 22% during the period 2017-2021. (*www.businesswire.com*)

One leading innovator - **Nanocomp Technologies,** is the only player to successfully develop processes that generate carbon nanotubes (macro-format) into bundles and networks to ultimately make sheets, yarns, and tapes suitable for commercial, industrial, aerospace, and military applications – real products manufactured at scale, imparted with high strength, highly efficient electrical conductivity and thermal conductivity (Exhibit 5).

Interestingly, the silicon-based semiconductor industry itself is undergoing a revolution of sorts marked by a critical inflection point – Moore's Law is unsustainable. However, this presents a growth opportunity for Nanotronics. Gallium Nitride (GaN) is the new material of choice to enable high-powered applications found in industrials, consumer, solar, AC drive, UPS inverters, and hybrid and electric cars. One such innovator – **EpiGaN** is already a Nanotronics customer. The GaN **substrate market is estimated to grow past $4 billion in 2020** with LED devices making up about 70% of the market share. In fact, the GaN power business is projected to grow exponentially at 79% CAGR until 2022.[10]

The nanomanufacturing process can create more powerful nanoscale transistors (Exhibit 6) and numerous materials that are stronger, lighter, durable, water-repellent, anti-reflective, self-cleaning, UV/IR resistant, anti-fog, antimicrobial, or scratch-resistant among other traits. Current nanotechnology-enabled products range from baseball bats and tennis rackets to catalysts for crude oil refining and ultrasensitive detection and identification of biological and chemical toxins.[8] The engineering of these materials will require tools to ensure process control efficiencies.

Concluding Thoughts on End-Markets

The three discussed end-markets for Nanotronics are all exhibiting exciting technological development and are undoubtedly areas where businesses are investing significant capital. Which specific products and technologies will be the winners in the marketplace are difficult to forecast. However, one thing is abundantly clear: failure inspection and analysis from products akin to what Nanotronics offers will be integral in the manufacturing development process. As a result, we turn our attention to the specific products that Nanotronics offers in the following sections, which guides our financial forecast of company performance.

Business Products

Given the market trends we discussed, we now turn our attention to the specific products that Nanotronics produces that will help meet these market demands. The following brief product descriptions[13] represent the main product line-up offered by the company and are the primary source of sales revenues. Additional business operating segments such as service contracts, standalone software, and components would have been too cumbersome to model especially without the benefit of any historical data to attempt projected estimates. Therefore, we assume a conservative tilt to our model by not explicitly modeling these components. The historical contribution to total revenue for each product is indicated below the title name.

[13] Descriptions provided by *https://nanotronics.co/*

nSpec
(55% of revenue)

The nSPec is a fully automated inspection system for analyzing opaque, transparent, and semi-transparent wafers for defects.[14] The system offers quantitative and qualitative reporting on an unprecedented scale. Multiple magnifications allow for a complete characterization of defect type and frequency on substrate, epi wafers, and diced wafers including devices. Various configuration options are available for specific needs including resolution level of scans. Nanotronics has proprietary artificial intelligence algorithms to classify features according to morphology using positive identification from relatively sparse data sets. The inspection system will be a major disruptor for fabrication processes in a number of varying industries (electronics, aerospace, advanced materials, automotive), which demand a high degree of engineering tolerances in quality control.

nSpec 3D
(5 % of revenue)

The nSPec 3D is an automated, rapid optical microscope that provides surface topographies and quantitative roughness measurements. It offers a new way of quality control inspection being demanded by a range of industries, including the tire, medical devices, steel, battery, aerospace and automotive manufacturing industries. An unmatched tool with rapid, reproducible, and easy to use manner for capturing measurements and features in three-dimensional space to optimize a process and transfer data to a production platform. It uniquely offers an atomic force microscope (AFM) attachment to visualize samples in nanometer resolution scale.

nPLACE
(30 % of revenue)

Nanotronics' bench-top wafer loaders are designed to handle a wide range of wafer sizes and can be integrated with other machines. The highlights of the loader includes the control software for group and individual wafer handling for generating reproducible analysis in the quality control process, as well as built-in versatility with end effectors for customizable applications.

Competitors

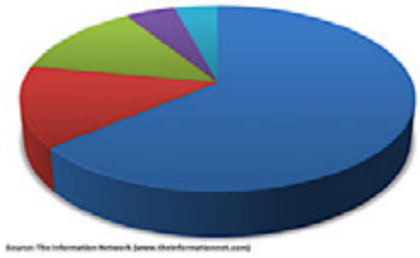
The valuation analysis posed an unusual challenge given that the company does not have specific direct competitors in the nascent markets described. Nonetheless, in the business segment for wafer inspections, there are certainly several automated optical inspection (AOI) players, but none that offer the level of computer processing power

[14] Wafers are the thin slices of semiconductor material like silicon used in electronics for the fabrication of microelectronic devices, integrated circuits, and photovoltaics. *Phillip A. Laplante (2005). Comprehensive dictionary of electrical engineering (2nd ed.). CRC Press. ISBN 978-0-8493-3086-5.*

merged with AFM capacity available to generate nanoscale resolution renderings. In addition to the various system options and configurations, a VR 3D-tomography output is available to meet a user's analytical goals. Traditional or current inspection systems offer solutions of sorts with a combination of tools that remain mostly unautomated.

The ~$10 billion semiconductor metrology/inspection market is dominated by **KLA-Tencor** (Exhibit 7),[15] **Applied Materials, Hitachi Tech, Nanometrics, and Rudolph Technologies,** which represent a combined 87% market share (Table 1). Mergers have resulted in consolidation from 37 companies to about 20 companies from 2002 to 2017. Demand from Chinese manufacturers drove up sales in 2017 and will continue to do so in 2018 and beyond. Notably, **KLA-Tencor** equipment orders to Chinese customers almost tripled in 2017 and **Rudolph Technologies** revenues from China more than doubled in the past two years. In general, the global semiconductor equipment market grew 12.5% QoQ, indicating another strong year of growth. And while the Chinese AOI equipment market is dominated by foreign companies, their market will likely maintain an **8.9% CAGR between 2017 and 2022**.[11]

Exhibit 7



KLA Tencor Applied Materials Hitachi High Tech Nanometrics Rudolph Technologies

Top 5 Semiconductor Metrology/Inspection Companies 2017.

Microscopy innovators like Zeiss and Nikon are not direct competitors as only a small segment of their businesses, ~5-10% is dedicated to inspection systems. At least this was the case until several weeks ago when **Zeiss announced its entry into 'process control solutions' leveraging their proprietary microscope technologies including a non-destructive 3D X-ray microscope system.** We believe it is too early to tell the overall impact of this news, but costs will surely be a determinant factor. To this point, there are two types of purchases being made by customers: purchases for capacity or purchases for technology. As **new technology nodes** appear imminent, an update on old equipment will not be a viable option if companies expect to remain competitive. Of note, Rudolph Technologies, which sells Fab automation software, led the back-end inspection market. In contrast, we believe that Nanotronics' market opportunity lies in the front to mid-end range of the supply chain.

[15] In March 2018, KLA Tencor acquired Orbotech for $3.6B at ~ 15% premium.

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[1]The Johns Hopkins Institute for Applied Economics, Global Health, and the Study of Business Enterprise

Table 1.

Bloomberg (Peer Group Comparables)							
millions (USD)	Price $	Market Cap	Enterprise Value (EV)	Revenue	Rev Growth	EV / EBITDA	EV / Revenue
ASML Holding	$212.75	91,794	80,136	10,000	33.23%	25.58	7.48
Applied Materials	$46.76	47,136	45,176	14,540	34.29%	9.30	3.11
Lam Research	$177.81	29,170	25,952	8,020	36.19%	11.69	2.52
KLA Tencor °	$120.80	16,640	16,598	3,480	16.60%	12.55	4.22
Nikon Corporation	$17.31	6,939	4,282	6,931	9.85%	5.40	0.62
Carl Zeiss AG	$60.50	6,902	6,878	1,315	8.10%	23.56	3.65
Hitachi High Tech	$39.97	5,506	3,674	5,783	6.69%	7.30	0.64
Brooks Automation	$25.70	2,260	2,210	693	23.60%	19.60	2.39
LaserTec	$28.52	1,376	1,228	157	13.58%	25.33	6.40
FormFactor	$12.80	1,000	987	548	26.88%	10.77	1.84
Rudolph Technologies	$29.75	970	789	255	9.59%	10.80	2.70
Nanometrics	$29.72	908	783	259	16.95%	12.10	2.98
Nova Measuring Instruments	$28.49	790	630	222	35.44%	9.70	2.59
Camtek	$6.71	292	244	94	9.41%	16.28	2.10
Estimated market size *		**20,569**					

°**KLA Tencor** recent March acquisition of Orbotech for $3.6B a ~ 15% premium.
***** Specific business segment data (SEC-EDGAR) was gathered, though companies many times do not disaggregate optical inspection from the diversified general metrology equipment segment; the target market is about half of our estimates ~ **$10 B**. Color highlighted companies represent the majority (85%) of the semiconductor inspection systems market.

The company also competes with manual inspections and Big Data analytic software, making it difficult to identify head to head competitors. **Irlynx** (France-based)**, Xore** (Sweden-based), and **FreePoint Technologies** (Canada-based) are reasonable peers (Table 2) but are currently in accelerator stage or VC backed early stage development that only offer niche solutions to specific industry sectors. For example, Xore is developing automated on-line elemental analyzers for the mining industry based on X-ray Fluorescence systems. IRlynx designs and sells advanced human activity-sensing modules. Their first product is an optronic module including a far IR reactive matrix combined with optic and embedded processing capable of delivering presence, position, motion direction and number of people data. The young company is based on disruptive technology with various applications for smart buildings, energy saving, safety, and assisted living. FreePoint Technologies, a true peer competitor, offer solutions for machine monitoring for today's manufacturing environment at all levels, utilizing advanced software and analytics with patent-pending systems indicating on/off machine status. All the same, we are confident in Nanotronics' superior product performance to deliver substantial market share gains in the wafer inspection business segment and beyond. (See "COMPS" in Excel file)

Table 2.

Source: Pitchbook Data:	**Peer group Early Stage Companies**					
Competitor	Financing Stage	Location	Growth Rate	Size Multiple	Last Financing Date/Type	Financing Amount
Robosense	Accelerator/ Incubator	Shenzhen, China			Accelerator/ Inc	
Irlynx	VC-Backed	Montbonnot, France	0.0029	1.05x	2016/Accelerator/Inc	$0.02M
Xore	VC-Backed	Skellefteå, Sweden	0	0.20x	2015/Early Stage VC	$0.49M
FreePoint Technologies	VC-Backed	London, Canada	0.0094	0.30x	2017/Early Stage VC	
Soft Robotics	VC-Backed	Cambridge, MA. USA			2018/Series A1	$20.2M

Company Valuation

Some basic semiconductor industry information and statistics helped provide some limits and assumptions for the model (Exhibit 8). These values helped us guardrail our market assumptions which ensured that we did not forecast Nanotronics' growth too optimistically. Furthermore, the idiosyncrasies of the PDCF allowed us to ensure that growth was accompanied by proper investment into the company's asset base.

Semiconductor Industry Info:	market size ($B)	growth 2011 - present		
suppliers	113 B			
front end manufacturing	51 B	10%		
back end	11 B	20%		
assembly and testing	15 B	4%		
wafers materials	11 B	5%		
Semiconductor Manufacturing	Y-o-Y growth month to month basis (12mo.)			
	Max	Avg	Min	
Wafer processing equipment	53%	32%	8.7%	
Top Peers YoY	2014	2015	2016	2017
EV/Sales growth	21.1%	-21.6%	39.7%	13.4%

Exhibit 8. Semiconductor industry and statistics

Balance sheet and Income statement

Due to a relatively limited historical window of operations, it was difficult to make substantial claims or assumptions from the data.[16] Nevertheless, analyses of the company's financial statements show a steadily growing asset base on a YoY basis as sales continue to push forward for the past four years with some fluctuation as expected. Notably, inventories

[16] The model's starting point is based on Nanotronics' internal best sales estimates, which we rely upon to extrapolate revenue projections. We need to acknowledge the fact that our model may be somewhat underdetermined due to the sheer early stage in development of the company and more importantly the lack or limiting level of historical data available. Additionally, the semiconductor market is almost perfectly cyclical however we did not accommodate this prototype in our model as the semiconductor industry is but one industry being featured. Consequently, any expected revenue interruptions will likely be covered by numerous diverse industries adopting the latest process control technologies – **growth is our thesis**.

have risen at a CAGR of 43% since 2014, while net income remains negative as the company expands and establishes a customer base. Encouragingly, the company is tracking a continuous reduction of operating expenses as a margin on total revenues and an uptick in sales. We can gather a sense of the operational efficiencies by charting Sales and R&D as shown in the figure below (Exhibit 9a). The model continues to lower costs and ultimately levels off at 15 – 20% margins for all expense line items (Exhibit 9b, refer to Excel file). OPEX was averaging ~50% margins and was brought in line with benchmarked historic averages.

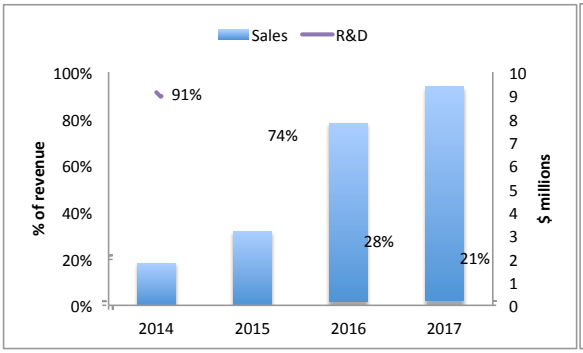
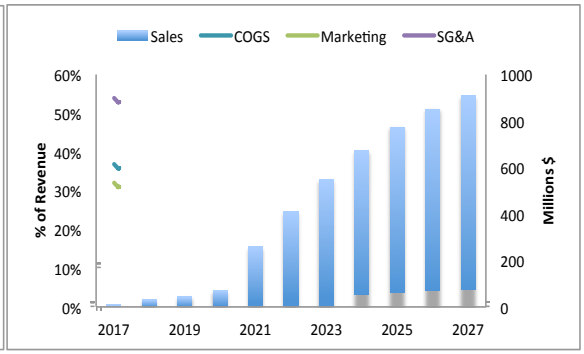


Exhibit 9a. Sales, and R&D as % of Revenue



9b. Best Case – Estimated Sales and OPEX

Of some concern is the continued rise in bad debt expense, which is about 50% higher than the sales rate (no notes were provided for the apparent losses). Depending on the scenario, the model's sales projections indicate an aggressive profile or very modest gains derived primarily by the customer base. In general, peer group analysis of YoY revenue growth ranged between mid-single digits up to 40% with exceptional years indicating two, three and even 400% while OPEX ranges between low teens and 25%. We highlight the company's bullish estimates that are substantially above expectation yet are justified by broad product applications and assumed performance beyond the currently referenced peer group. Regardless, projected estimates are tethered to an initial strategy aimed at 3 – 5 % potential market share capture and eventually plateaus around ~ 10% of our current market estimates. The best-case "bull" scenario estimates project revenues approaching the $1 billion mark which follows our general assumptions of strong revenue gains accompanied by improved operating margins as can be appreciated in Exhibit 9b, 10a, and 10b.

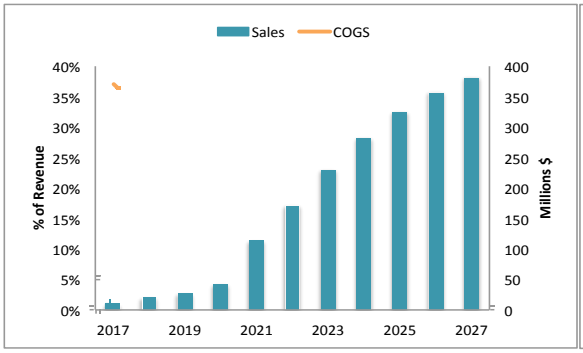
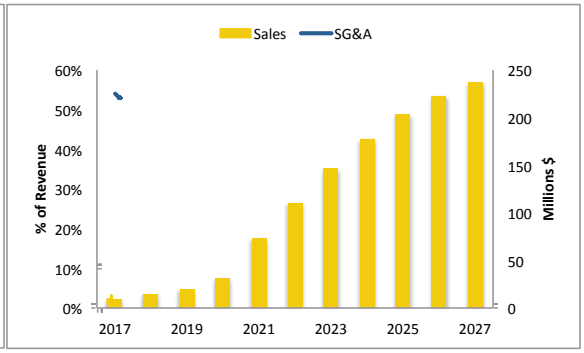


Exhibit 10a. Base Case - Estimated Sales (All OPEX margins range 15-20%)



10b. Bear Case – Estimated Sales

Value Drivers

As mentioned above, OPEX margins were gradually lowered to peer group historical levels and we kept depreciation and amortization (D&A) at an 8.85% margin as a maintenance value estimate given the product level sophistication. There will be some tax forward carryover years given the company's burn rate and net operating income, however, we assumed a 21% corporate rate (to be adjusted according to geographical exposure of the company) starting from years where deferred tax assets became exhausted. Key cash flow drivers: working capital (WC) and capital expenditures (CAPEX) are declining but remain at somewhat high margins in order to maintain the appropriate amount of assets to sustain the company's high-growth forecast.

Monte Carlo Simulation Analysis

We present 3 potential scenarios representing different tranches of customer base growth. Exhibits 10, 11, and 12. (Details can be found in the "PDCF" and "MC" tabs in the accompanying Excel file Nano_valuation_final).

1) The bullish case gathers up all current customers and prospective customers from all tier groups along with aggressive sales estimates.

2) The base case features current customers along with tier one prospects.

3) Finally, the bear case scenario depicts a flat customer base and modest sales trends.

The unique aspect of Monte Carlo (MC) analysis is that it takes into consideration the stochastic nature of company development; explicitly in this case the model is weighted heavily on our revenue assumptions. Essentially, the growth rates for each scenario are somewhat similar but what we ultimately derive for sales estimates are a range of possibilities indicative of discrete starting points for each scenario defined by a different customer base (bull, base, bear) as can be appreciated below in Exhibit 11. All other modeling parameters are reasonable approximations of benchmarked historical performance statistics (OPEX, non-OPEX, CAPEX, WC) of comparable companies.

Revenue projections for each product were determined manually and sales assumptions were guided by data gathered from over half-dozen peer group companies in the wafer inspections/semiconductor equipment market. Our PDCF model uses an 11% discount rate and a 1.5% terminal growth value to generate an **estimated company value of $418 million, $223 million, and $110 million for the bullish, base, and bear case scenarios respectively**. 100,000 MC simulations were performed to ensure an unbiased estimate of fundamental value. In all, the company does not begin to generate profits until 2022-23 (~halfway) in our projections as indicated in the breakeven analysis depicted below with free cash flow (FCF) estimates.

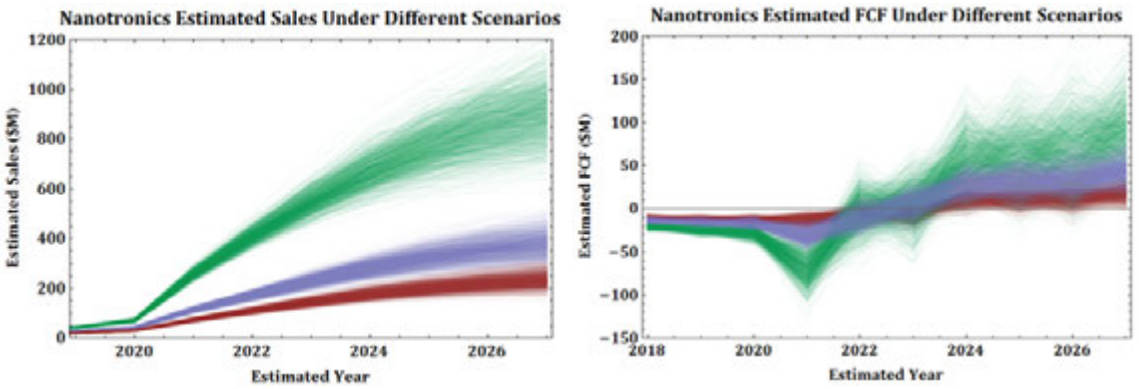


Exhibit 11. Estimated Sales and FCF breakeven points (Bull-green, Base-blue, Bear-red).

Implied company valuations or a theoretical takeover price is described by the Gaussian distributions with the following mean values of **$110 ± 34 million for the bear case, $223 ± 56 million for the base case, and $418 ± 131 million for the bull case** (Exhibit 12). It is important to highlight that there is significant uncertainty in our estimates due to the nature of modeling a high growth business: the company will not be profitable until ~2022-2023 which is the most uncertain portion of our forecast. However, this emphasizes an important point that must be elaborated: the most recent post-money valuation of $350 million seems to be justified but falls in the upper decile of our base case model. We, therefore, believe that an ~8.0x-10.0x sales multiple on 2019E is the approximate fair value of the company. Investors can readily appreciate the caveat here by observing the broad distribution of value ranges and the large standard deviation (SD) in each case. These valuations are also strongly tied to the projected revenue growth of the company as well, which can be appreciated by the sales growth values on the left-side panel of Exhibit 11.

This under-determination is not derived from the model's inherent uncertainty but originates from a number of sources: our input parameters regarding sales growth assumptions, OPEX efficiencies, and the limited historical data due to the company's dynamic growth leaves us with large variances in all our input variables. The results can also be somewhat expected by a cursory view of the model tuning parameters (not shown for brevity). We have very limited insight from historical analysis of our tuning parameters as we can see that the model is currently forecasting beyond any previous operating levels – again expected from a high-growth company. MC sensitivity analysis (data not shown) does allow us to adjust the model, however, we will not be able to improve upon the level of variance in our inputs. While the distributions may be broad we are confident in the accuracy of convergence to the mean values. Therefore, given the total cash invested thus far **($71 million)** we estimate a multiple of approximately **10x 2019E sales** corresponds to the fair value of the company. We believe that the current sales multiples are optimistic and are more than likely discounting ~10% market share gain as previously discussed.

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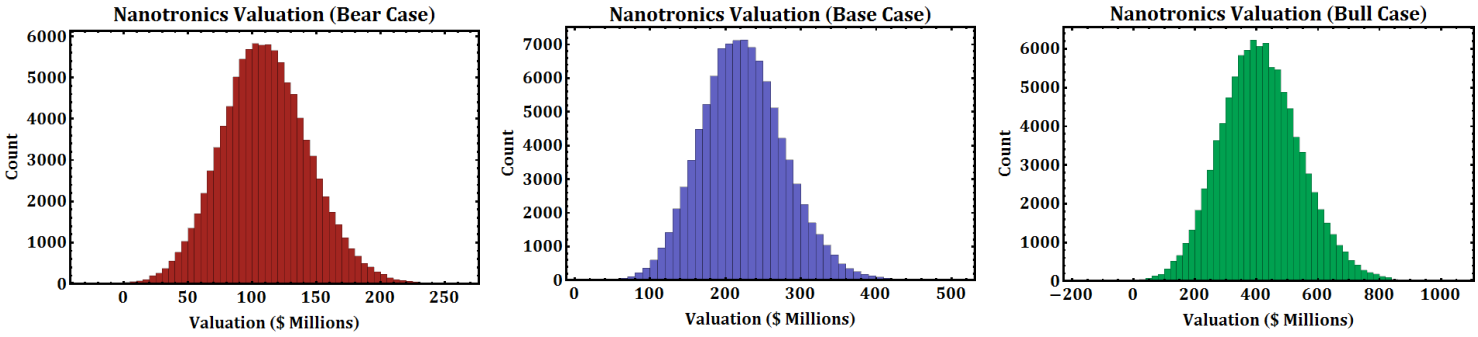

Exhibit 12. Company Valuations from three different customer bases (Bear, Base, Bull).

One final note for clarity: apart from the product sales we have a separate revenue segment representing growth in Asia alone that is projected to account for 20% to 30% of sales in the bear case and bull case respectively. We kept this figure intentionally low, as sales throughout Asia will eventually account for upwards of half the company revenues. Consequently, increasing the fractional margin projections would otherwise lead to a double counting of sales estimates.

A steadily expanding customer base is the primary factor that impinges upon the model. Undoubtedly, we expect the company to achieve substantial market share accompanied by a tapering of customer growth in due time. As those revenue margins narrow they will likely be offset by a rise in demand in software updates, stand-alone components, and service contracts that will eventually represent the bulk cash flow streams. These sales streams are not directly modeled in our assumptions but we can reasonably attach a 20-30% premium on our valuations. Current and expected market conditions provide strong confidence for company performance.

As mentioned, we estimate that Nanotronics will be competing for a ~$10 Billion market in the end-markets we have explicitly modeled. Thus, our valuation estimate of $223 million (base case) suggests ~2.25% market share from our bottom-up analysis scenario and a potential ~4.2% share with a $418 million estimate in the best-case scenario. Given the uncertainty, it is illuminating to consider that a top-down analysis would suggest that the $350 million post-money valuation implies ~3.5% market share. Given limited visibility in future market share, we should note that if the company is able to exceed our conservative estimates and achieve ~10% market share, the company would easily attain a fair value in excess of $1 billion. The current post-money valuation of $350 million may be modestly overvalued with respect to our base case scenario at this time, however, our outlook for the company remains overwhelmingly positive. We would be particularly interested in updating our PDCF with new numbers (when available) from financial statements to gain more certainty in our value estimates.

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Conclusions

Nanotronics is set to become the leader in automated optical inspection in high-tech manufacturing. As the semiconductor market continues to grow we can indirectly extrapolate a substantial growth valuation and market penetrance as Nanotronics continues to gather a prominent list of partners and clients that function at the leading edge of technology. An expanding customer base supported by favorable market conditions and a wealth of growth indicators drives our model. Being mindful that the valuation represents but one of several industries open to Nanotronics' market disruption opportunities, we recognize the transformative potential of merging artificial intelligence, automated nanoscale resolution, and virtual reality to revolutionize manufacturing processes that may eventually yield a stronger valuation. Overall, we provide a conservative outlook given the absent participation in major industries like biopharmaceuticals, materials, and aerospace where the company will likely experience continued growth. Given the sizeable market landscape and level of applications for the company, our model denotes a positive investment recommendation for the business opportunity.

- *High demand for AOI equipment market in China ~ 9% CAGR forecast to 2022*
- *Projected growth in robotics, and IoT – with ~ 20% growth through 2020.*
- *Cloud computing and mobile devices drive demand in advanced memory chips.*
- *Demand in automotive chips forecast ~ 8.2% CAGR to 2022.*
- *Growth in EVs and autonomous vehicles in China and India.*
- *18 global semiconductor chipmakers increased CAPEX R&D over $1 billion, of which 10 companies increased R&D by ~ 6% over previous year.*[17] [4]
- *Multiple markets remain to be accessed: Biopharmaceuticals, materials, aerospace.*

[17] http://www.eenewsanalog.com/news/18-chip-companies-over-1bn-2017-rd-spending/page/0/1

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Supplemental Bloomberg information

S-1. Comparative Returns: Comparable companies (RTEC, NANO) versus S&P 500 (SPX)

S-2. Peer Group Ratios: Semiconductor Equipment Services and Components

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S-3 Comparative Returns: BI Global Composites and Advanced Materials Competitive Peers versus S&P 500 Index

S-4 Comparative Returns: SGI Global Nanotech Index versus S&P 500 Index

References

1. Christopher Thomas. A new world under construction: China and semiconductors, 2015 McKinsey & Company.

2. Edward White, Hsinchu, June 18, 2018. Financial Times, https://www.ft.com/content/a1a5f0fa-63f7-11e8-90c2-9563a0613e56

3. Stefan Burghardt, Seunghyuk Choi, and Florian Weig. 2017 McKinsey & Company. Mobility trends: What's ahead for automotive semiconductors,

4. Daniel T. Niles, Alpha One Capital Partners, NexGen Tech Fund, 2018

5. Semiconductor Industry Association, https://www.semiconductors.org/news/2018/07/02

6. How semiconductor companies can win in China's new product development landscape, 2017 McKinsey Quarterly.

7. Challa S.S.R. Kumar. Materials Today, Nanotechnology Tools in Pharmaceutical R&D. Vol.12 Electron Microscopy special issue, Elsevier 2010.

8. National Nanotechnology Initiative, https://www.nano.gov/

9. Yole Developpement, Power GaN 2017: Epitaxy, Devices, Applications, and Technology Trends 2017

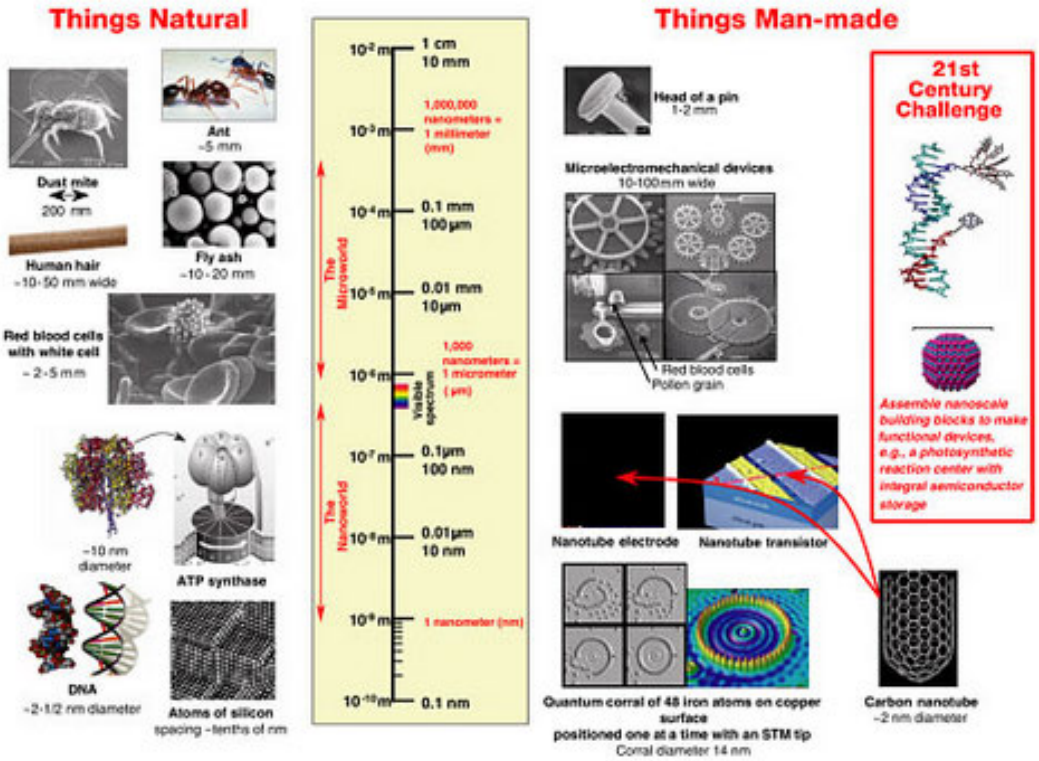
10. Robert Castellano. Semiconductor Equipment Companies Are Heading To Semicon West As Applied Materials Sputters. https://seekingalpha.com

11. Global Nanotechnology Market 2018 – 2024. Globe Newswire May 2, 2018. https://markets.businessinsider.com/news/stocks/global-nanotechnology-market-2018-2024

Citations

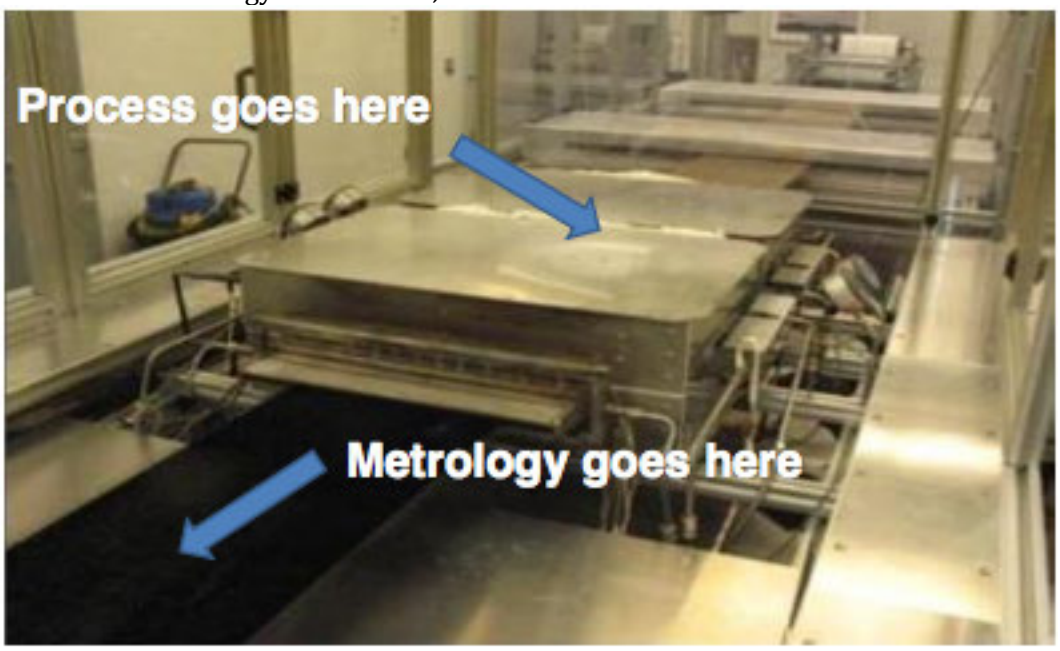
1. Thomas C. A new world under construction: China and semiconductors. *McKinsey Co*. 2015.
2. White E. China seeks semiconductor security after ZTE ban. *Financial Times*. https://www.ft.com/content/a1a5f0fa-63f7-11e8-90c2-9563a0613e56. Published June 18, 2018.
3. Stefan Burghardt, Seunghyuk Choi, and FW. Mobility trends: What's ahead for automotive semiconductors. *McKinsey Co*. 2017.
4. Niles DT. A Golden Age for Global Growth Semiconductor revenues up over 20% y/y. In: Alpha One Capital Partners, LLC.; 2018.
5. Semiconductor Industry Association. https://www.semiconductors.org/news/2018/07/02. Published 2018.
6. Chesnais T, Thomas C. How semiconductor companies can win in China's new product development landscape. *McKinsey Co*. 2017.
7. Global Nanotechnology Market 2018 – 2024. Globe Newswire. https://markets.businessinsider.com/news/stocks/global-nanotechnology-market-2018-2024. Published 2018.
8. Kumar CSSR. Nanotechnology Tools in Pharmaceutical R&D. *Mater Today, Elsevier*. 2010; Vol.12(Electron Microscopy special issue).
9. National Nanotechnology Initiative. https://www.nano.gov/ . Published 2018.
10. Villamor A. Power GaN 2017: Epitaxy, Devices, Applications, and Technology Trends. *Yole Development*. 2017.
11. Castellano R. Semiconductor Equipment Companies Are Heading To Semicon West As Applied Materials Sputters. https://seekingalpha.com.

Appendix



Courtesy of Office of Basic Energy Sciences, Office of Science, U.S. Department of Energy

Production metrology must be fast, economical and sensitive to the nanoscale.



Carbon nanotube nano-composite pilot line at Applied Nanostructured Solutions – nanostructures generated on meter wide web moving at meters/minute (Nano.gov US National Nanotechnology Initiative). *https://www.nano.gov/NSINanomanufacturing*