T2+2™ Market Overview

Nanomaterials Used in the Automotive Industry

May 4, 2009

Foresight Science & Technology, 430 Angell St., Providence, RI 02906
Voice: 401-273-4844; Fax: 401-273-4744; Web: http://www.foresightst.com/

Nanotechnology has had a significant impact on a wide range of industries and appears to be especially promising for developing stronger, more efficient and lighter weight materials for the automotive industry. While market sizes are hard to estimate, the following describes how we arrived at a figure for the total addressable market for nanomaterials used in the automotive industry. We estimate the market size to be approximately:

Market Niche Size			
Market Size in Dollars	***Growth Rate***	***Base Year***	***Detailed Basis for Estimate***
$1.6 billion	28%	2007	This estimate is from a 2007 Cientifica report that forecasts the automotive nanomaterial market to reach $51 billion by 2014.[1]

New developments in nanotechnology have widespread applications in the automotive industry that include: "lubricants, lightweight fuel cells, catalysts, nanoporous filters, self-cleaning windshields, self-repairing and color changing paints, corrosion protection and lighter and stronger structural materials for the car of the future."[2] In the automotive industry, the growing desire for "better performance depends on superior engine efficiency and the use of lightweight, high strength materials, all of which will be influenced by nanotechnology."[3] The numerous benefits of nanomaterials are particularly promising to the automotive sector as they could provide much improved corrosion resistance, noise dampening, parts consolidation, and recyclability.[4]

The market size and growth rate is a function of the number of people in the market and the anticipated rate of buying. As markets transition between emerging, growth, shakeout, mature, and declining, the basis for competition and the number of competitors usually changes, along with the factors influencing adoption of innovation. The number of and growth rate for customers suggests how many units might be sold.[5]

Our Current View on the Phase of the Market	
Today	***Trend***
Growth	Growth

[1] "Nanotechnologies for the Automotive Energy Market." Cientifica Reports web site, 2007. http://cientifica.eu/index.php?page=shop.product_details&flypage=shop.flypage&product_id=15&category_id=5&option=com_virtuemart&Itemid=80 (accessed May 4, 2009).
[2] "Global Markets and Applications of Nanotechnology in the Automotive Sector Revealed." M2 Presswire. 2009. HighBeam Research web site (subscription required). http://www.highbeam.com (accessed May 4, 2009).
[3] "World Analysis of Nanotechnology in the Automotive Market." September 2004. Frost & Sullivan web site (subscription required). http://www.frost.com/ (accessed May 1, 2009).
[4] Bidmon, Marcus. Et al. "SWOT Analysis Concerning the Use of Nanomaterials in the Automotive Sector."September 2005. http://www.nanoroad.net/download/swot_ai.pdf (accessed May 4, 2009).
[5] For a detailed discussion of the "innovativeness dimension," see Everett M. Rogers, *Diffusion of Innovations*, 4th ed. (New York: Free Press, 1995). For further readings related to market phases and innovation, see also James Utterback, *Mastering the Dynamics of Innovation* (Boston: Harvard Business School Press, 1996) and Vijay K. Jolly, *Commercializing New Technologies: Getting from Mind to Market* (Boston: Harvard Business School Press, 1997).

With an estimated compound annual growth rate (CAGR) of 28%, the market for automotive nanomaterials appears to be in a robust growth phase. Nanocomposite materials are predicted to have the greatest impact on the automotive industry between now and 2014,[6] and numerous new applications of nanomaterials will enter cars in the next 5 years as almost all car components can be improved by nanotechnology.[7] Continued growth is expected as "Ford estimates that by 2015, some 70 percent of automotive materials will be modified or redefined by nanotechnology."[8]

Markets can also be described in terms of the basis for competition (best technological performance, best value or the price/performance tradeoff that best matches the end-users' preferences, lowest cost, or best availability or the ability to get the product quickly). This dimension helps to define the context in which a commercialization strategy must be developed.

Basis for Competition in the Arena	
Today	***Trend***
Best Value	Best Value

Currently the market for automotive nanomaterials appears to be driven by best value as "automotive manufacturers are keen to utilize technologies which offer cost-effective improvements in vehicle performance as well as enabling them to meet stricter legislation regarding emissions and safety."[9] Furthermore, "the automotive industry is torn between trying to reduce costs on the one hand and, on the other, dealing with the high price of performance-enhancing technology and environmental compliance."[10] This balancing act between performance and cost considerations is a common descriptor for Best Value markets.

In each market there may be stakeholders and companies with significant market share that will influence the introduction of your technology. Some organizations or companies that will likely influence the introduction of this technology are the following:

---

[6] "Applications in Transportation Will Increase to $50 Billion by 2014 with a CAGR of 72." Business Wire. 2007. HighBeam Research web site (subscription required). http://www.highbeam.com (accessed May 4, 2009).

[7] "Nanotechnology is the Key for the Automotive Industry for Sustainable Development and Growth." Helmut Kaiser Consultancy, October 2007. http://www.prlog.org/10034469-nanotechnology-is-the-key-for-the-automotive-industry-for-sustainable-development-and-growth.html (accessed May 4, 2009).

[8] "Coming by 2015: Nanotech Cars."April 2008. U.S. News & World Report web site. http://usnews.rankingsandreviews.com/cars-trucks/daily-news/080417-120437/ (accessed May 4, 2009).

[9] "Global Markets and Applications of Nanotechnology in the Automotive Sector Revealed." M2 Presswire. 2009. HighBeam Research web site (subscription required). http://www.highbeam.com (accessed May 4, 2009).

[10] Bidmon, Marcus. Et al. "SWOT Analysis Concerning the Use of Nanomaterials in the Automotive Sector." Nanoroad.net web site, September 2005. http://www.nanoroad.net/download/swot_ai.pdf (accessed May 4, 2009).

Examples of Major Competitors in the Arena		
Competitor	***Relevance***	***Web site***
Altair Nanotechnologies	"Altairnano is a leading provider of energy storage systems for clean, efficient power and energy management. Designed for power-dependent applications, Altairnano's family of advanced lithium-ion energy storage systems and batteries is responding to changing demands in energy generation, utilization, and policy."[11]	http://www.altairnano.com
CerMet Lab Co.	"CerMet Nanotechnology improves metal surfaces and in turn reduces friction and provides protection that will extend the life of your engine, gears, bearings and parts. CerMet Lab and many top independent testing facilities world-wide have proven its reduction in friction, protectiveness, effectiveness, and many other benefits."[12]	http://www.cermetlab.com/
NanoEner Technologies	"NanoEner, Inc., a subsidiary of Ener1, Inc., has developed a proprietary technology for the production of nanostructured thin and thick coatings. The company's technology was initially developed for the production of nanostructured coatings for high charge/discharge rate battery electrodes for hybrid electric vehicles, handheld power tools, super thin low cost primary and rechargable batteries for active tags and other applications."[13]	http://www.nanoener.com/
Nanovere Technologies	"Nanovere Technologies specializes in the research, development and manufacturing of multi-functional nanocoatings. The Zyvere nanocoating platform was specifically developed to provide Self-Cleaning & Extreme Scratch Resistant coatings based on nanotechnology materials and concepts."[14]	http://www.nanocoatings.com/
Nanocor Inc.	"Nanocor is a new operating subsidiary of AMCOL International Corporation. We are the largest global supplier of nanoclays specifically designed for	http://www.nanocor.com/

[11] "About Us." Altair Nanotechnology web site. http://www.altairnano.com (accessed May 4, 2009).
[12] "About Us." CerMet Lab Co. web site. http://www.cermetlab.com/about_us/our_guarantee.html (accessed May 4, 2009).
[13] "About Us." NanoEner Technologies web site. http://www.nanoener.com/about.html (accessed May 4, 2009).
[14] "Home Page." Nanovere Technologies web site. http://www.nanocoatings.com/ (accessed on May 4, 2009).

	plastic nanocomposites. Over the past decade Nanocor has developed patented technologies for producing nanoscale clays suitable for incorporation into plastics and technologies for making nanocomposites themselves. Commercial nanoclay production began in 1998 and today we offer a variety of products under the Nanomer® trademark."[15]	
NanoSteel	"The NanoSteel Company is an advanced materials company which has created a unique and proprietary portfolio of nanotechnology based and environmentally friendly steel alloy solutions that greatly increase the value of steel in most of today's industrial applications."[16]	http://www.nanosteelco.com/

Examples of Key Stakeholders or Networking Channels with Contact Information		
Stakeholder	***Relevance***	***Contact Information***
National Nanotechnology Initiative (NNI)	"The NNI provides a vision of the long-term opportunities and benefits of nanotechnology. By serving as a central locus for communication, cooperation, and collaboration for all Federal agencies that wish to participate, the NNI brings together the expertise needed to guide and support the advancement of this broad and complex field."[17]	4201 Wilson Blvd., Stafford II, RM 405 Arlington, VA 22230 Tel: 703-292-8626 http://www.nano.gov/
The International Association of Nanotechnology (IANT)	"The International Association of Nanotechnology (IANT), is a non-profit organization with the goals to foster scientific research and business development in the areas of Nanoscience and Nanotechnology for the benefit of society."[18]	1290 Parkmoor Avenue San Jose, CA 95126 Tel. 408-280-6222 http://www.ianano.org
The Society of Automotive Engineers (SAE)	"SAE International has more than 121,000 members - engineers, business executives, educators, and students from more than 97 countries - who share information and exchange ideas for advancing the engineering of mobility systems. SAE is your one-stop resource for standards development, events, and technical information and expertise used in designing, building, maintaining, and	400 Commonwealth Drive Warrendale, PA 15096 Tel. 724-776-4841 http://www.sae.org

[15] "About Us." Nanocor web site. http://www.nanocor.com/ (accessed on May 4, 2009).
[16] "Company Page." Nanosteel web site. http://www.nanosteelco.com (accessed on May 4, 2009).
[17] "About Us." National Nanotechnology Initiative web site. http://www.nano.gov (accessed on May 4, 2009).
[18] "About Us." The International Association of Nanotechnology web site. http://www.ianano.org/aboutus.htm (accessed on May 4, 2009).

	operating self-propelled vehicles for use on land or sea, in air or space."[19]	
The Nano Science and Technology Institute (NSTI)	"The Nano Science and Technology Institute (NSTI) advances and integrates nano and other advanced technologies through education, conventions, business publishing, and research services. NSTI produces the annual Nanotech conference and trade show, which attracts more than 5,000 industrial, academic, business and governmental attendees from around the world. It is the largest gathering of the nanotechnology industry in the U.S."[20]	696 San Ramon Valley Blvd., Ste. 423 Danville, CA 94526 Tel. 925-901-4959 http://www.nsti.org

Users' abilities to buy the technologies they want are constrained by relevant government regulations and by relevant industrial standards and certification requirements. These requirements indicate test and evaluation procedures that can speed market acceptance if incorporated into concurrent engineering.

Examples of Regulations, Standards, and Certifications		
Identifier and Promulgator	***Description***	***Comments***
ASTM E2456-06 ASTM International	Standard Terminology Relating to Nanotechnology	"Nanotechnology is an emerging field; this standard defines the novel terminology developed for its broad multi- and interdisciplinary activities. As the needs of this area develop, this standard will evolve accordingly; its content may be referenced and/or adopted, in whole or in part, as demanded by the needs of the individual user."[21]

It is important to note that there is a current lack of standards for nanotechnology and nanomaterials. Please see Market Entry Barriers, below, for further information.

Entry barriers are obstacles that remove customer segments from the market for some period of time. They limit the size of the addressable market in general or the market share that can be captured. These barriers must be overcome or avoided to have a successful market entry. Our work to date suggests the following entry barriers may prevent customer segments from buying this type of technology for some period of time.

Market Entry Barriers

[19] "About Us." The Society of Automotive Engineers web site. http://www.sae.org (accessed May 4, 2009).
[20] "About Us." The Nano Science and Technology Institute web site. http://www.nsti.org (accessed May 4, 2009).
[21] "Detail Results." NSSN Search Engine for Standards web site, http://www.nssn.org/search/DetailResults.aspx?docid=475588&selnode= (accessed May 4, 2009).

Name of Barrier	***Description/Why***
Lack of Standards	The lack of nanotechnology standards poses several major challenges to the overall market. The need for standardization exists in order to support commercialization and market development, provide a basis for procurement, and support appropriate legislation/regulation.[22]
Health and Environmental Concerns	"Nanoparticulate additives are known to improve diesel engine efficiency by 5%, resulting in annual UK savings of 2-3m t of CO_2. However, these gains must be tempered by the uncertainties surrounding the health and environmental impacts of nanoparticles in exhaust emissions."[23] The potential danger of nanoparticle emissions is presently unclear and will likely make new product development and growth difficult.
High Productions Costs and Long Development time	The production of nanomaterials requires high costs and extensive development time,[24] and will likely be a barrier to market entrants who may lack extensive technical and capital resources.
Lack of Fundamental Understanding of Nanoparticles	Currently there is a "lack fundamental understanding of the nature and behavior of most nanomaterials. We have not yet determined the methods or developed the tools that might enable us to measure nanoparticles or accurately gauge their presence in the air, soil or water."[25] This lack of understanding could further complicate competition in the market. as technological uncertainties could potentially hamper or delay successful entry.

The main barriers discussed above all appear to be important issues that may be problematic in the short term. These barriers are likely to decline in the long term however, due to continued research and development of nanomaterials, and with further penetration and implementation in the mainstream automotive industry.

Market drivers are forces that strengthen or weaken the importance of end-user needs over time. Practice level drivers are micro-economic; they affect the end-user directly. They influence the selection of substitutable goods and thus affect market share. Arena level drivers affect the organizations and industrial sectors in which the end-users work. They influence the overall demand for goods like this technology and its substitutes. They affect when and how much of the total addressable market is actually going to be in the market and buying.

Market Drivers	
Name of Driver	***Why Significant***

[22] Berger, Michael. "Nanotechnology Standards." May 2008. Nanowerk web site. http://www.nanowerk.com/spotlight/spotid=5736.php (accessed May 4, 2009).
[23] Rooker, Jeff. "A small solution to a big problem: nanotechnologies promise major environmental benefits, but concerns over health and safety issues need to be resolved first.(Nanotechnology)." Chemistry and Industry. 2007. HighBeam Research web site (subscription required). http://www.highbeam.com (accessed May 4, 2009).
[24] Smock, Doug. "Nano Materials: Why Size Will Matter." Design News, January 2007. http://www.designnews.com/article/14666-Nano_Materials_Why_Size_Will_Matter.php (accessed May 4, 2009).
[25] Rooker, Jeff. "A small solution to a big problem: nanotechnologies promise major environmental benefits, but concerns over health and safety issues need to be resolved first.(Nanotechnology)." Chemistry and Industry. 2007. HighBeam Research web site (subscription required). http://www.highbeam.com (accessed May 4, 2009).

Increased Battery Life	Nanotechnology is playing a key role in the "development of nanostructure electrodes that enable batteries to have extremely high discharge rates and extended cycle life."[26] The increased popularity and demand for electric and hybrid-electric vehicles is likely to further augment the market for innovative nanomaterials.
Reduced Material Costs	"Nanomaterials are slated to reduce the quantity of rare metals used in the catalytic converters and fuel cells. Considering the prices of these metals, this could mean a cost cutting of at least $1 billion for the automotive industry."[27] The cost benefits of nanomaterials will likely drive demand further as reducing overall production costs is very important in the auto industry. [28]
Increased Efficiency	A "key revenue generator is anticipated to be the use of nanotechnology in lightweight structures."[29] "The automotive industry estimates 6 to 8 per cent reduction in fuel usage with a mere 10 per cent reduction in vehicle weight [through the use of nanomaterials]. This translates into a reduction of around 20 kilogram of carbon dioxide per kilogram of weight reduction over the vehicle's lifetime and also improves the dynamic characteristics of the vehicle such as stability and handling."[30]

The market for nanomaterials in the auto industry is likely to see robust growth due to diverse and wide ranging end use applications. Nanomaterials can be used in a wide range of areas including "power train, light-weight construction, energy conversion, pollution sensing and reduction, interior cooling, wear reduction, driving dynamics, surveillance control, up to recycle potential and much more."[31] Due to rather impressive performance characteristics, nanomaterials are poised to provide the automotive industry with a novel and effective means to reduce costs,[32] and are seen by some to be major global opportunity.[33]

Here is some additional data and sources that can help you better understand the market.

---

[26] "Ener1 CEO Interviewed on CEOCast; Highlights Strategy to Penetrate Hybrid and Electric Car Market and New Nanotechnology Subsidiary." PR Newswire. 2004. HighBeam Research web site (subscription required). http://www.highbeam.com (accessed May 4, 2009).
[27] "World Analysis of Nanotechnology in the Automotive Market." September 2004. Frost & Sullivan web site (subscription required). http://www.frost.com/ (accessed May 1, 2009).
[28] Bidmon, Marcus. Et al. "SWOT Analysis Concerning the Use of Nanomaterials in the Automotive Sector." Nanoroad.net web site, September 2005. http://www.nanoroad.net/download/swot_ai.pdf (accessed May 4, 2009).
[29] "Promise of High Performance, Cost-effective Solutions Underlines Growing Appeal of Nanotechnology in Automotive Industry." PR Newswire Europe. 2004. HighBeam Research web site (subscription required). http://www.highbeam.com (accessed May 4, 2009).
[30] "World Analysis of Nanotechnology in the Automotive Market." September 2004. Frost & Sullivan web site (subscription required). http://www.frost.com/ (accessed May 1, 2009).
[31] Presting, Hartmut. Konig, Ulf. "Future Nanotechnology Developments for Automotive Applications." Elsevier B.V., 2003. http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6TXG-49W36TW-6&_user=10&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=2ac4bfc678721e2073019760710658e8 (accessed May 4, 2009).
[32] "Promise of High Performance, Cost-effective Solutions Underlines Growing Appeal of Nanotechnology in Automotive Industry." PR Newswire Europe. 2004. HighBeam Research web site (subscription required). http://www.highbeam.com (accessed May 4, 2009).
[33] "Energy Saving Technologies Will Exhibit Rapid Growth, Accounting for 75 of the Market for Nanotechnologies in 2014, up from 62 in 2007." Business Wire. 2007. HighBeam Research web site (subscription required). http://www.highbeam.com (accessed May 4, 2009).

Name	*Description*
Roadmap of Nanotechnology used in Automobiles	This study provides an overview on the use and developments of nanomaterials in the automotive sector. For more information please see the below URL: http://www.nanoroad.net/download/swot_ai.pdf
The Project on Emerging Nanotechnologies web site	"The Project on Emerging Nanotechnologies collaborates with researchers, government, industry, NGOs, policymakers, and others to look long term, to identify gaps in knowledge and regulatory processes, and to develop strategies for closing them. The Project will provide independent, objective knowledge and analysis that can inform critical decisions affecting the development and commercialization of nanotechnologies."[34] For more information please see the below URL: http://www.nanotechproject.org/
Nanotechnology Now (NN)	"NN was created to serve the information needs of business, government, academic, and public communities. And with the intention of becoming the most informative and current free collection of 'nano' reference material. We will cover: related future sciences, issues, news, events, and general information, and make this a place to come for information, stimulating debate, and research info."[35] For more information please see the below URL: http://www.nanotech-now.com/
nanoHUB	"The nanoHUB is a rich, web-based resource for research, education and collaboration in nanotechnology. The nanoHUB hosts over 1600 resources which will help you learn about nanotechnology, including Online Presentations, Courses, Learning Modules, Podcasts, Animations, Teaching Materials, and more."[36] For more information please see the below URL: http://nanohub.org/

[34] "About Us." The Project on Emerging Nanotechnologies web site. http://www.nanotechproject.org/ (accessed May 4, 2009).
[35] "Mission Info." Nanotechnology Now web site. http://www.nanotech-now.com (accessed May 4, 2009).
[36] "About Us." nanoHUB web site. http://nanohub.org/ (accessed May 4, 2009).