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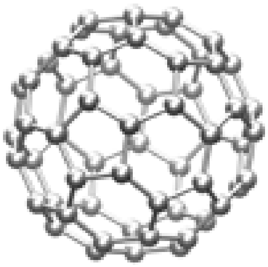

NANOTECHNOLOGY
SMALL SCALE
HIGH POTENTIAL
INDUSTRIAL TOOL BOX

_1 NANOMETER (NM) = 10^{-6} MM (1/1,000,000) = 1/2,000 THE THICKNESS OF A HUMAN HAIR

_NANOTECH IS ONE OF THE MOST IMPORTANT TECHNOLOGIES OF THIS CENTURY, OFFERING SOLUTIONS TO A VARIETY OF HEALTH (E.G. CANCER) AND ENVIRONMENTAL PROBLEMS (E.G. GLOBAL WARMING, WATER SHORTAGE).

_MARKET POTENTIAL IS ESTIMATED TO BE US$ 2,600 BN FOR 2014, OR APPROXIMATELY 15 % OF TOTAL MANUFACTURING OUTPUT, REPRESENTING A GROWTH RATE OF AROUND 70 % OF THE CAGR SINCE 2004.

_NANOTECH IS A REVOLUTIONARY FIELD OFFERING DOUBLE- AND TRIPLE-DIGIT RETURNS, AS COMPARED TO THE SINGLE-DIGIT RETURNS THAT WILL BECOME THE NORM FOR ESTABLISHED TECHNOLOGIES. IT IS EXPECTED THAT THE GREATEST VALUE WILL BE ACHIEVED IN HEALTHCARE, ENVIRONMENTAL PROTECTION, RENEWABLE ENERGIES AND THE PROTECTION AND PRODUCTION OF DRINKING WATER.

Harald Gruber, Head of Chemicals, Basic Resources and Renewable Energy
23 May 2008

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Executive summary

Nanotechnology market to reach up to US$ 2,600bn in 2014

Nanotechnology is expected to be one of the most important technologies of this century because it offers solutions to a variety of health and environmental problems. Moreover, new nanomaterials and nanodevices will have a major impact on many areas of the global economy. The nanotools of nanostructured materials are used to make items like nanotubes, nanoelectronics, nanocatalysts, nanophotonic devices, nanosensors and other nanodevices.

The scale of the nanotechnology-related industry and market is expected to undergo rapid growth during the next 10 years, leading the great expansion of global market scale. Indeed, it is estimated (according to Lux Research) that the market for nanotechnology products will increase to US $ 2,600bn by 2014, and that ten million new jobs will be created in areas of manufacturing related to nanotechnology by then.

Sound growth perspectives for nanotech products, although hard to harmonize

Forecasted values of nanotechnology industry scale by major global organisations (US $ billion)

Organisation	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008e*	*2009e*	*2010e*	*2011e*	*2012e*	*2013e*	*2014e*	*2015e*
WM Tech	86.4	95.4	106.2	118.7	134.9									
Winter Green		0.572	1.467	4.388	8.175	12.78	21.44	37.29						
Lux Research			13					292					2,600	
Hitachi General Association				91					1,244					
NSF (National Science Foundation)														1,000
Mitsubishi				70.88					159.3					
NBA (Nano Business Alliance)				225					1,000					

Source: KISTI

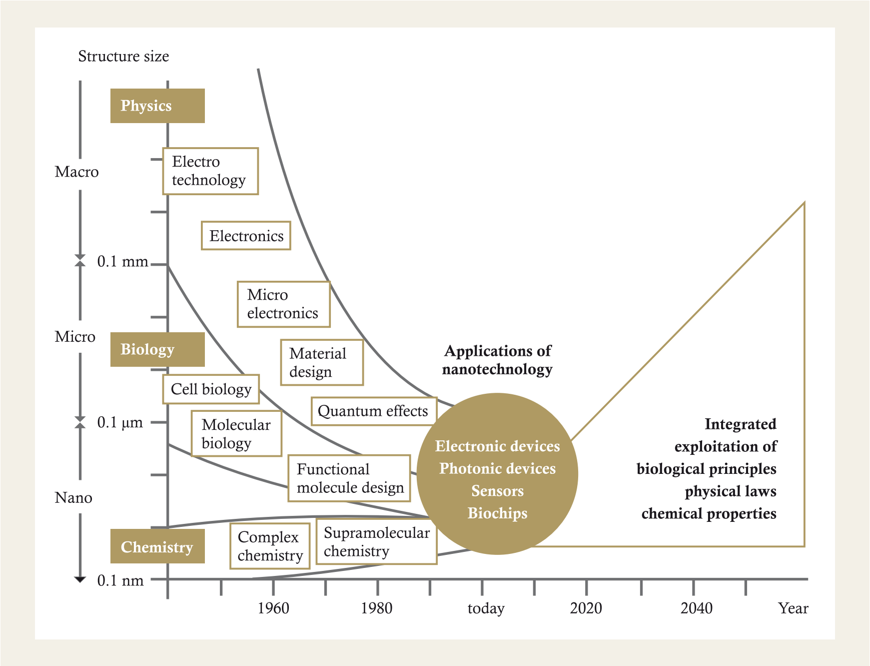
Scientists, researchers, business managers, investors, funding agencies and governments worldwide all acknowledge the huge social and economic potential of nanotechnology, which is why public funding has increased from US $ 500 m in 1999 to an estimated US $ 6 bn in 2006. Scientific publications in nanotechnology have increased by a factor of six over the past ten years, and the number of nanotechnology patents has also increased substantially. However, the rate of growth has varied across the globe, and also between different areas of nanoscience and nanotechnology.

Introduction to nanotechnology

Nanotechnology is the architecture of structures and systems on the nanometre scale

What is nanotechnology?
For over 100 years, scientists in the disciplines of chemistry, physics and biology have studied and worked with objects that have nanoscale dimensions. Nanotechnology is the manipulation or self-assembly of individual atoms, molecules, or molecular clusters into structures to create materials and devices with new or vastly different properties. Or, described differently, nanotechnology is the characterisation, design, production and use of structures and systems that require exact control of size and form on the nanometre scale.

Traditional sciences meet nanotechnology

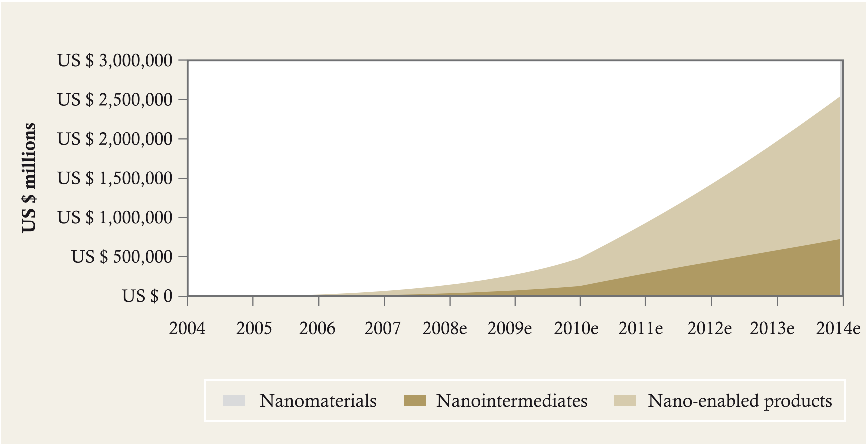


Source: VDI-technology center

Nanomaterials offer properties not found in bulk materials (for instance, used by the chemicals industry)

Materials with such minute structures are often found to exhibit different properties compared to "traditional bulk materials" made from the same chemical composition. For example, nanomaterials may offer different mechanical, optical, chemical, magnetic or electronic properties not found in the bulk materials. The ability to selectively manage the size of nanoscale materials now allows, for instance, the chemical industry to develop materials with new properties that offer significant advantages in our macroscopic world.

Global product sales including innovative nanotechnology 2004-2014e



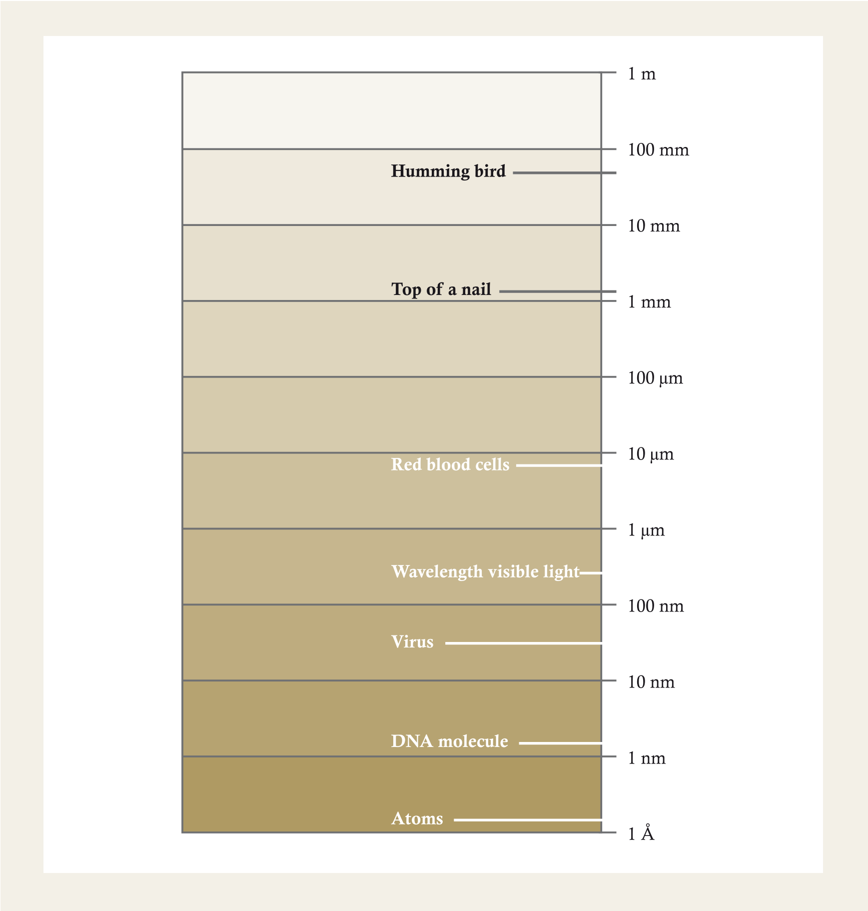
Source: luxresearch

Nanotechnologies will facilitate the development of novel applications for very different aspects of our daily lives from biomedical advances to applications in information technology. Though there is no clear definition for the term nanotechnology, as it refers to a broad range of molecular technologies, it is a revolutionary technology with immense potential that portends to become a pervasive technology by the early 2030s.

Nanotechnology is referring to materials having sizes of 0.1 to 100 nanometres

Nanotechnology aims at the design and creation of functional materials, structures, devices and systems through direct control of matter on the nanometre length scale and exploitation of novel phenomena and properties on this length scale. The word nanotechnology is generally used when referring to materials with the size of 0.1 to 100 nanometres; however these materials display inherently different properties from bulk (or micrometric and larger) materials as a result of their size. These differences include physical strength, chemical reactivity, electrical conductance, magnetism, and optical effects.

Length scale with nanometre put into context



Source: University of Twente, Netherlands

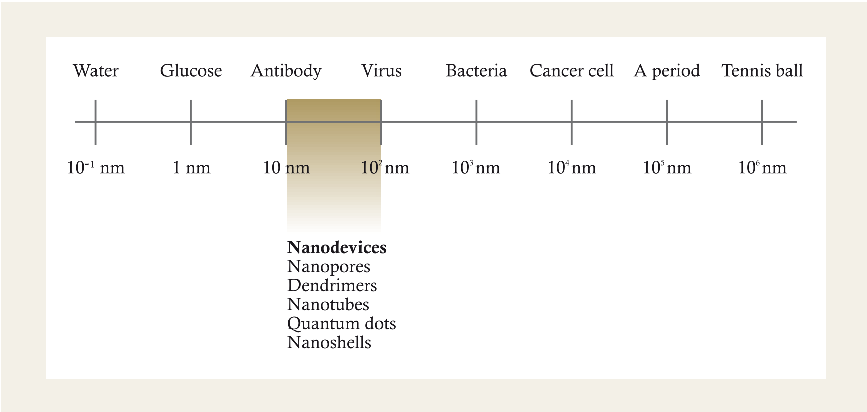
Nanotechnology research and development includes controlled manipulation of the nanoscale structures and their integration into larger material components, systems and architectures. Within these larger scale assemblies, the control and construction of their structures and components remains at the nanometre scale. It is essential in nanotechnology to have a direct control of matter either between two nano-objects, or between a micro (or macro) object and a nano-object.

Nanoscale devices are one hundred to ten thousand times smaller than human cells. They are similar in size to large biological molecules ("biomolecules") such as enzymes and receptors. As an example, haemoglobin, the molecule that carries oxygen in red blood cells, is approximately 5 nanometres in diameter. Nanoscale devices smaller than 50 nanometres can easily enter most cells, while those smaller than 20 nanometres can move out of blood vessels as they circulate through the body.

Nanoscale devices have the potential to greatly enhance transform curing and treatment of deseases

Because of their small size, nanoscale devices can readily interact with biomolecules on both the surface and inside cells. By gaining access to so many areas of the body, they have the potential to detect disease and deliver treatment in ways previously unimagined.

Nanotechnlogy put into size



Source: NCI

Nanoparticles exhibit high surface-to-volume ratio which provide yet unimagined potential for new applications

One important objective of nanotechnology is to harness the new properties tiny particles exhibit by virtue of their high surface to volume ratio, or that can be imparted to them by chemically 'decorating' their surfaces with other molecules. These new properties can be incorporated into larger devices and systems, such as new sensors that are able to rapidly detect and measure pollution in the air or water or analyse blood. Nanosurfaces are also important when it is considered that most properties of material are resident in the surface layer, and new materials can be made just by redesigning their physical and/or chemical structure at the surface. For example, only a small percentage of nanoparticulate clay minerals incorporated in the surface of a polymer can result in enhanced impermeability and heat resistance, enabling the development of new, lightweight, odour-resistant, stay-fresh packaging for food. Another application of a material in nanoparticulate form is nanosilver, which can be incorporated into textiles, coatings and wound dressings, providing remarkable anti-bacterial properties with many implications for healthcare.

Nanotechnology: evolutionary or revolutionary?
The widespread view is that nanotechnology is a holistic industry. It is not. It is an essential enabler that will impact all manufactured goods. Hence, broadly speaking, nanotechnology is evolutionary rather than boasting revolutionary techniques and materials. Its roots are simply in established materials and technologies.

Emerging nanotechnologies offer highest growth and margin potential – for those willing to accept the comparatively higher risk

Value creation depending on the evolution of nanotech processes

	Establishes nanotechnology	*Emerging nanotechnology*
Processes	Well-understood	Poorly understood
Growth rates	Single-digit	Double- to triple-digit
Profit margins	Set by entrenched competitors	Set by new entrants
Changes	Incremental	Disruptive
Level of risk	Low	Very high
Potential return	Low	Very high
Nanomaterial examples	Synthetic zeolites, naturally occuring nanoparticles	Nanotubes, quantum dots, dendrimers
Nanointermediate examples	90nm semiconductors, ferrofluids, CMP slurries, GRM hard drive heads	Nano-coated fabrics, nanostructured steel, nanoscale drug delivery carriers
Nano-enabled product examples	Ancient Eqyptian pottery (naturally occuring nanoparticles), high-end audio speakers (ferrofluids)	Appliances with silver nanoparticle coatings, bicycle frames made from nanotube composites

Source: Lux Research

However, where nanotechnology features innovative and break-through applications for the industry it certainly has the potential to transform products and industrial processes due to its uniqueness.

There is no such single nanotechnology market, but adaptation with many established industries

_There is no nanotechnology market. There is a nanotechnology value chain, going from nanomaterials (e.g. clay nanoparticles) to nanointermediates (e.g. composite materials made from the clay nanoparticles) to nano-enabled products (e.g. the 2004 Chevrolet Impala, with side body mouldings made from nanocomposite material).

The nanotechnology value chain

Nanomaterials	*Nanointermediates*	*Nano-enabled products*
Nanoscale structures in unprocessed form	Intermediate products with nanoscale features	Finished goods incorporating nanotechnology
Nanoparticles Nanotubes Quantum dots Fullerenes Dendrimers Nanoporous materials etc.	Coatings Fabrics Memory & logic chips Contrast media Optical components Orthopedic materials Superconducting wire etc.	Cars Clothing Airplanes Computers Consumer electronic devices Pharmaceuticals Processed food Plastic containers Appliances etc.

Source: Lux Research

Commodity nanotechnology is similar to speciality chemicals' profitability

_Not all nanotechnology is new. Emerging nanotechnology is developing against a backdrop of well-understood, established nanotechnology. Examples of the latter include synthetic zeolites as well as currently shipping microchips with feature sizes under 90nm.

_Many products incorporating nanotechnology will be only marginally profitable. Most nanomaterials will rapidly become commodities with operating margins capped at the high single digits typical of specialty chemicals. Profits from nano-intermediates and nano-enabled products will vary widely, following product category margins.

Nano-intermediates offer highest growth, margins among nanotech products

in US $ million	*2004*	*2006*	*2008*	*2010e*	*2012e*	*2014e*	*CAGR*
Nanomaterials	134	288	1,304	2,784	5,947	12,892	58 %
Nano-intermediates products	851	7,888	37,890	160,750	442,020	741,864	97 %
Total	12,001	43,455	110,944	344,204	962,511	1,818,126	65 %
	12,986	51,031	150,138	507,738	1,410,479	2,572,883	70 %
Nanomaterials	3.4 %	2.7 %	3.9 %	7.5 %	8.6 %	8.6 %	
Nano-intermediates	5.0 %	10.0 %	13.7 %	15.9 %	17.2 %	16.5 %	
Nano-enabled products	4.3 %	4.8 %	5.0 %	5.0 %	4.8 %	4.9 %	

Note: Column values may not add to total due to rounding.
Source: Lux Research

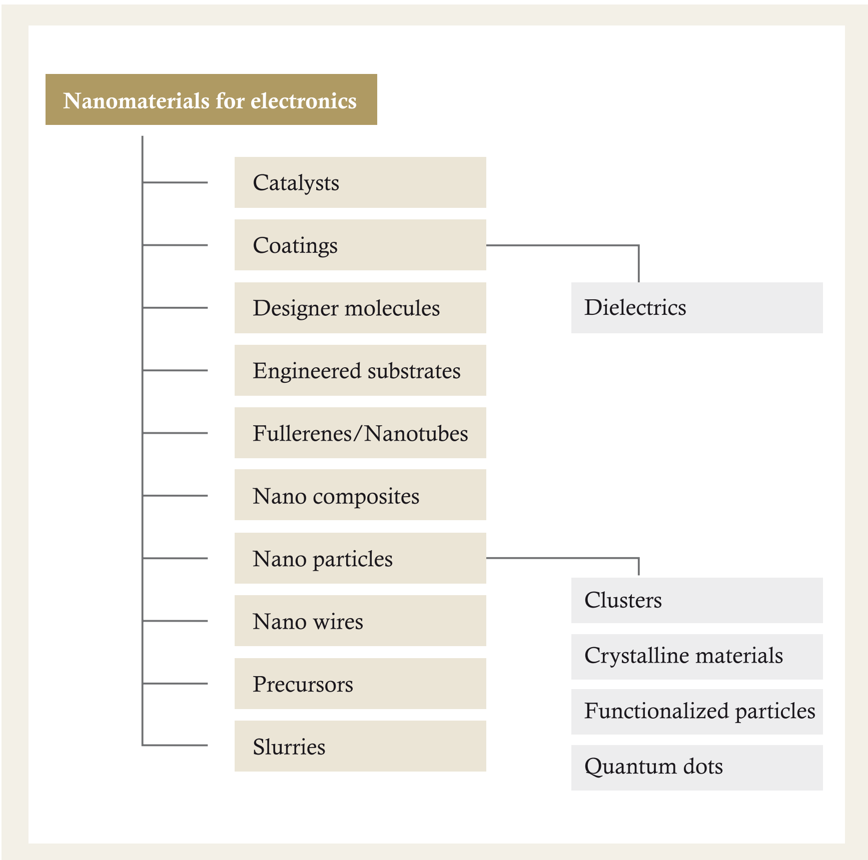
Production of nanotech products occurs either top down or bottom up

Nanotechnology can work from the top down (which means reducing the size of the smallest structures to the nanoscale e.g. photonics applications in nano-electronics and nano-engineering) or the bottom up (which involves manipulating individual atoms and molecules into nanostructures and more closely resembles chemistry or biology). The definition of nanotechnology is based on the prefix "nano" which is from the Greek word meaning "dwarf". In more technical terms, the word "nano" means 10-9, or one billionth of something. For comparison, a virus is roughly 100 nanometres (nm) in size.

Medicine set to become an important area of application that will benefit from nanotechnology

The broad range of applications that will employ and benefit from nanotechnology includes communications, the automotive industry, and medicine. However, as was the pattern in the semiconductor industry, computing devices will be the first to realise commercialisation of nanotechnology. Nanotechnology will make possible the creation of miniaturised chips, devices for communication, and computing. Nanotechnology will make it viable to embed enormous processing ability and valuable functionality into a small chip or device, thus enhancing the performance delivered. Nanotechnology is believed to have immense impact not only on the fields of electronics and computing, but is expected to usher in a new level of intelligence in the field of medicine.

Nanomaterials for nano-electronics



Source: electronics.ca publications

The creation of nanoscale chips embedded with intelligence will immensely support the diagnosis of various diseases. The advancements in medical imaging coupled with nanotechnology are likely to facilitate the early discovery of numerous life-threatening diseases and help identify advanced nonintrusive treatment mechanisms. The creation of nanorobots that can easily navigate through the human circulatory system and assist in effective patient monitoring is no longer a distant possibility.

Besides medical applications, other areas to benefit from nanotechnology are defence, avionics and automotives (for instance, nano-coatings)

Besides medicine, the other application areas that are likely to profit from the benefits of nanotechnology are defence, avionics and automotives. A growing trend towards the development of sophisticated, compact and highly accurate equipment both in the fields of defence and avionics is being witnessed. The growing penetration of electronics in automobiles, initiated by the need to increase comfort and safety in automobiles, is another driving factor for nanotechnology that will meet the requirements in these application markets.

Following the revolution created by MEMS technology (MEMS promises to revolutionise nearly every product category by bringing together silicon-based microelectronics with micromachining technology, making possible the realisation of complete systems-on-a-chip), Nanoelectronics is also believed to create similar ripples as it portends to offer unique benefits not only in terms of small form factor to the final devices, but also competent cost advantages and performance enhancements. The vast field of nanotechnology is an ever evolving one with continuous advancements being made every day toward commercialisation. Numerous companies, both well established global conglomerates as well as small start-ups, are investing large amounts in research and development of nanotubes, nanofibres, and nanowires, all of which are different manifestations of nanotechnology.

Nanotechnology is thus a truly ground-breaking industry development that is and will revolutionise not only the electronics and semiconductor industry but will have a huge impact on numerous industries, the effect of which we are just beginning to see. With a strong foundation laid in terms of years of undeterred research, it is now time for the advantageous transition of the technology from the lab to the market, and once this is achieved, the benefits of nanotechnology can be reaped, which will lead to a more sophisticated way of living.

Opportunities with nanotechnology

Example opportunities for materials company		
Product	Nanocomposite structural material	Nano-enabled functional "smart material"
Process	Forward osmosis water purification using magnetoferritin nanoparticles	Biosynthesized inorganic nanofilms
	Evolutionary	**Revolutionary**

Example opportunities for consumer electronics manufacturer		
Product	Flexible solar cell recharger	Carbon nanotube field emission display
Process	Nano-enabled microprocessor heat sink adhesive	Nanoimprint lithography
	Evolutionary	**Revolutionary**

Revolutions possible in pharmaceuticals

Example opportunities for pharmaceutical manufacturer		
Product	Nanoparticulate reformulation of existing drug	Novel therapeutic agents (gold nanoshells, fullerenes)
Process	Quantum dot biological labels	Four-dimensional elastic light scattering fingerprinting
	Evolutionary	**Revolutionary**

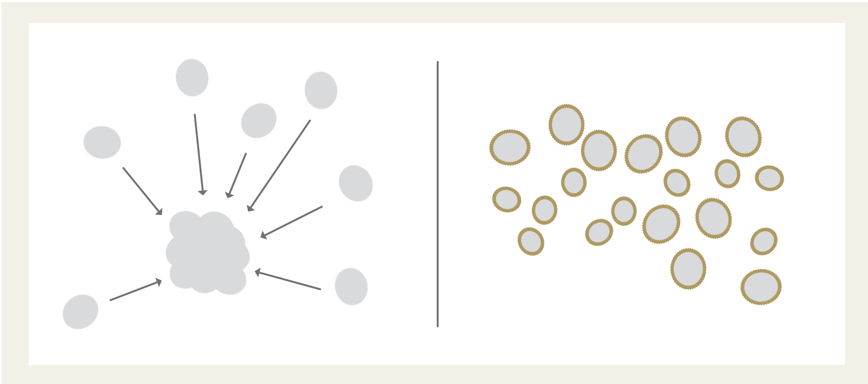
Source: Lux Research

Nano-manufacturing & the industrial application of nanotechnologies

Key in production of nanoparticles is to prevent "aggregation", to allow controlled design of properties

The key to successfully making use of the nanotech merits is to have the know-how to prevent "aggregation" in the production of nanoparticles, which may lead to the loss of their unique properties. The ability of a nanotechnology company to control the size of the nanoparticles allows it to give them the desired properties.

The trick is to avoid "aggregation"



Source: ItN Nanovation

Through understanding the properties of materials on the nanoscale, it is increasingly possible to design and make entirely new materials. The growth of civilisation has been founded on the innovative development and use of materials, from bronze and glass to tin, concrete and gunpowder – to name only a few. At first, serendipity led to the development of new materials, then an increasing knowledge of chemistry enabled a better understanding of the origins of their properties. Nanotechnology has taken this a step further and is giving us an even more profound comprehension of how materials derive their attributes, and the ability to design new materials from the scratch. It is estimated that there may be a huge amount of brand new materials possible, and nanotechnology is opening the door to the possibility of exploiting this treasure chest of almost infinite potential.

Nanotechnology develops in generations, going from product types to product types etc

Nanotechnology will develop in generations

Systematic control and manufacture at the nanoscale is likely to evolve in overlapping generations of new nanotechnology product types that start with nanoscale building blocks and evolve over time into complex heterogeneous systems. Each anticipated generation of products will provide a nanotechnology base for further innovation, leading to succeeding generations of products of increasing complexity & functionality:

Likely evolution of nanotechnology

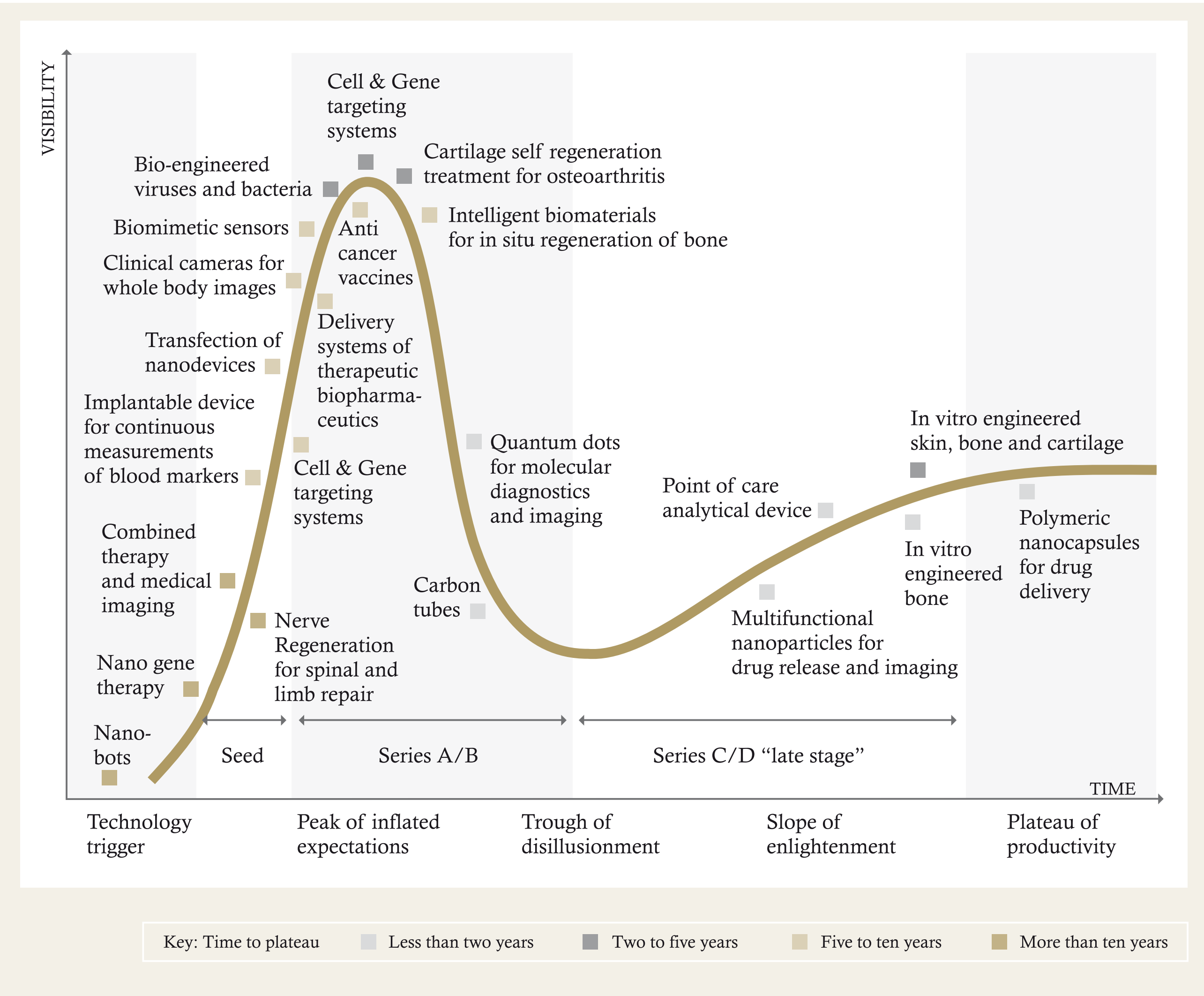
1st generation (from 2000)	Passive nanostructures, i.e. nanostructured coatings, nanoparticles, dispersion of nanoparticles, nanocomposites, and bulk nanostructured materials; nanostructures made of metals, polymers, ceramics; bio-building blocks Examples: sunscreens (zinc oxide, titanium oxide), golf balls (carbon nanotubes)	Nanoparticles (i.e. automotive industry - body mouldings, timing belts, engine covers etc, packaging industry, cosmetics) Flat panel displays, coatings, CNT-based probes in semiconductor metrology, catalysts (extension of existing market)
2nd generation (from 2005)	Active nanostructures, i.e. transistors, amplifiers, targeted drugs and chemicals, biological and non-biological sensors, actuators, and adaptive structures	Memory devices, fuel cells, batteries, biosensors (CNT, molecular, qD based), biomedical devices, advances in gene sequencing, advances in lighting
3rd generation (from 2010)	Three-dimensional nanosystems and systems of nanosystems using various synthesis and assembly techniques. i.e. bio-assembly, networking on a nanoscale, and multiscale architectures Materials by design and heterogeneous molecular nanosystems, where each molecule in the nanosystem has a specific structure and plays a different role Molecules will be used as devices, and fundamentally new functions will emerge from their engineered structures and architectures	Nanoelectronics (CNT), molecular electronics, routine use of new composites in aerospace and the automotive industry (risk-averse industries)

Source: Silvia Quandt Research GmbH

Nanotech far from having reached bubble status, only approx. 3 % of venture capital invested in this sector

Has nanotech already reached bubble status?
No. Despite the rise in media attention, there is no sign that asset prices are grossly overvalued. Nanotechnology is coming to the fore at a time when venture capitalists are wary of new start-ups. Moreover, there are few publicly traded pure plays in nanotechnology and there is no IPO market to support overvalued assets. In the last years, nanotech venture deals in the US market accounted for only approx. 3 % of the total VC capital invested which is far from signalling a state of hype in the nanotech industry.

The nanotech hype curve



Source: Gartner

Nanotechnology: a platform technology

Nanotechnology is not an industry, nor is it a single technology or a single field of research. Simply speaking, nanotechnology consists of sets of enabling technologies that are applicable to many traditional industries. Hence, it is thus fair to say that one should talk about nanotechnlogies rather than using it in the singular form, nanotechnology.

Nanotechnology a springboard or platform for other technologies

Thus we can describe nanotechnologies as a platform technology. These are technologies that are so pervasive that they serve as springboards for other technologies and as foundations for many diverse applications. They are also regarded as essential for progress in multiple fields. Computer operating systems are a good example of a platform technology. Rather than having to deal with computer hardware directly, programmers work with an abstraction of the underlying hardware (the operating systems) to build diverse applications from games to control software for nuclear power plants.

To capture value from nanotechnology, companies need to take a more systematic approach. Best-in-class firms follow a portfolio management approach that exhaustively inventories nanotech opportunities and separates them on two axes: revolutionary innovations that require new competencies to exploit versus evolutionary innovations that leverage existing ones, and product innovations that customers see versus process innovations that stop at the factory door. They then match the opportunities with one of four optimal organizational approaches:

Example: pharma companies using nano-enabled biological labels in drug discovery

_Evolutionary process opportunities should be owned by the existing R&D organization, with managers collaborating in a nanotech working group. Example: a pharma company using nano-enabled biological labels in drug discovery.

_Evolutionary product opportunities should be owned by existing line-of-business management coordinated in, for instance, a line-of-business steering group. Example: flexible solar cell re-chargers for mobile phones and nanocomposite bicycle frames.

_Revolutionary process opportunities require a separate R&D task force to implement. Example: nano-imprint lithography in the semiconductor field.

_Revolutionary product opportunities will likely be hobbled or ignored by existing line-of-business management, and can only realistically be nurtured in autonomous businesses-within-businesses or funded at arms-length through corporate venture investments in startups. Example: Samsung (former management) with carbon nanotube field-emission displays.

Nanotech fabrication techniques: top-down and bottom-up

In a similar fashion, nanotechnologies will allow precise control of individual atoms and molecules, leading to an unprecedented ability to develop new materials, devices or medical treatments in many diverse areas. There are a variety of ways of manipulating matter at the nanoscale, the methods employed being top-down and bottom-up.

Top-down
In simple terms, nanotechnology top-down methods start by taking a block of material and removing the unwanted bits and pieces until one arrives at the shape and size wanted. A relatively large amount of energy is used in the process, highly toxic chemicals are sometimes used, a large amount of waste is often produced, and the slowness of the inherent processes means that a lot of patience is needed, while results are often quite unique and not easily replicated.

Bottom-up methods in nanotechnology fabrication most demanding approach, especially molecular assembly

Bottom-up
In comparison, bottom-up methods are much more elegant and efficient. In these methods, one picks the shape and sizes needed, and many products can be built with nano atoms and molecules.

One method: self-assembly
However, challenges do exist. There are two fundamentally different ways of fabricating from the bottom up. One bottom-up method is nature's way: self-assembly. Self-organizing processes are common throughout nature and involve components ranging from the molecular (e.g. protein folding) to the planetary scale (e.g. weather systems) or even beyond (e.g. galaxies). The key to using self-assembly as a controlled and directed fabrication process lies in designing the components that are required to self-assemble into desired patterns and functions. Self-assembly reflects information coded in individual components (i.e. shape, surface properties, charge, polarizability, magnetic dipole, mass, etc). These characteristics determine the interactions among components.

On a very small scale, the processes of chemical synthesis that chemists have refined over many years are more appropriate than self-assembly. However, the stability of covalent bonds limits the synthesis of almost arbitrary configurations to less than 1000 atoms. Larger molecules, molecular aggregates, and forms of organized matter more extensive than molecules cannot be synthesized bond by bond. Self-assembly is one strategy for organizing matter on these larger scales.

The merit of the self-assembly technique is that one doesn't need to know why certain atoms and molecules self-assemble the way they do. Once it is possible to initiate and control the process, nanostructures can be built from the bottom-up – atom by atom.

Self-assembly has become an especially important concept in nanotechnology. As miniaturization reaches the nanoscale, conventional manufacturing technologies fail, because it it not yet possible to build machinery that can assemble nanoscale components into functional devices. Until robotic assemblers capable of nanofabrication can be built, self-assembly, in combination with chemical synthesis, will be the technology needed for developing bottom-up fabrication.

Exploiting nature's self-assembly tricks is real science and it's happening in labs already. As a matter of fact, it is just about to lead to real world products. IBM's announcement of self-assembling structures in their airgap processors is one example (May 2007).

Self-assembly is also the reason that nanotechnologies have such a profound impact on the chemical industry. An example is the huge area of polymers used for industrial products (i.e. plastics). Chemists are using the self-aligning tendencies of molecules to design molecular structures with specific properties. Once you know how certain nanoparticles behave and what properties they possess, you can use this knowledge in a deliberate manner to create structures with desired properties. This is much more efficient than the chemical industry's traditional approach of mixing compounds in a more or less arbitrary way based on best guesses to see what materials result, and then try to figure out what to do with them.

The other method: molecular assembly

The other approach to bottom-up nanotechnology is the no-chemicals approach: molecular assembly, which differs from the self-assembly concept. The notion of 'self-assembly' becomes relevant in this context with regard to 'self-replicating' nanomachines, i.e. machines that self-assemble themselves. This is, however, very different from the type of self-assembly found in nature. Molecular self-assembly is the spontaneous association of molecules under equilibrium conditions into stable, structurally well-defined aggregates joined by noncovalent bonds. Molecular self-assembly is ubiquitous in biological systems and underlies the formation of a wide variety of complex biological structures.

The automatic molecular assembly and selection steps exhibited by the molecules, which start as random mixtures, demonstrate a fundamental step in the evolution of life. Molecular organization is activated by instructions built into the molecules. During assembly, molecules exhibit active selection, with those in incorrect positions moving to make room for others which fit properly.

Self-assembly fabrication emerging as a new strategy in chemical synthesis

Self-assembly is emerging as a new strategy in chemical synthesis, and has the potential of generating nonbiological structures with dimensions of 1 to 10 nanometers. Structures in the upper part of this size range were previously inaccessible using chemical synthesis, and the ability to prepare them would open a way to create structures comparable in size to those that can be prepared by microlithography and other techniques of microfabrication.

Using the existing technical capabilities at hand today, the most advanced bottom-up nanotechnologies combine chemical synthesis and self-assembly. They already allow atomically precise manufacturing to be performed on a modest scale, and this will lead to vastly improved materials, much more efficient manufacturing processes and entirely new medical procedures.

Nanotechnology funding and investment

Funding issues

The actual value of the money spent, or investment in nanotechnology, depends on several factors:

_The scale of indigenous industry that will benefit from nanotechnology, and thus speed up the commercialization process through existing routes to market. In

Finland, for example, nanotechnology development is focussed on the electronics, forestry products and environmental industries.

_The extent to which industry views nanotechnology as critical to future success. For example, several major German companies such as BASF, Siemens, Beiersdorf and Henkel have embraced nanotechnology early, as they believe it offers many benefits for their future competivity.

Electronics, forestry products and environmental industries greatest beneficiaries of nanotechnology

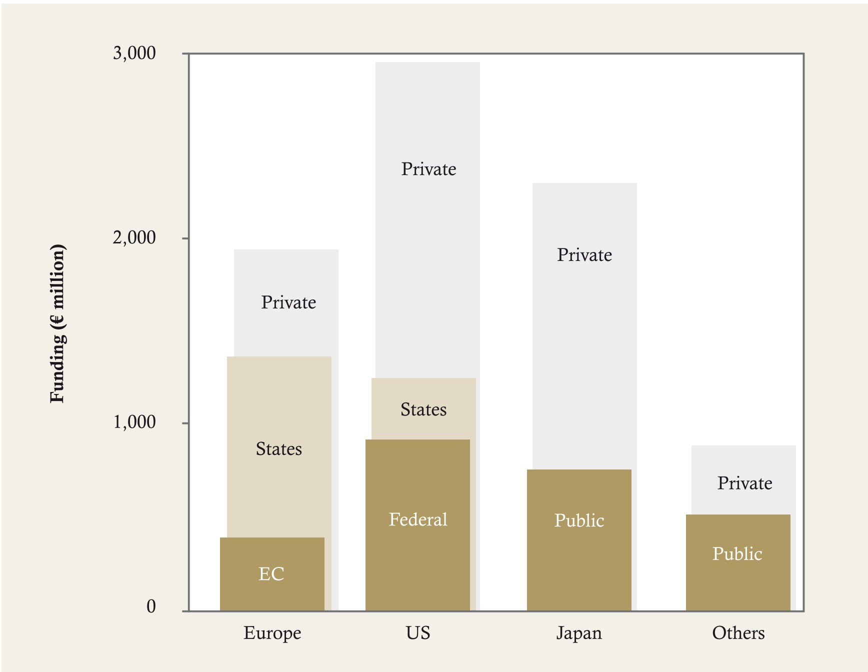
_The incremental value per Euro spent on research. In countries like China, Korea and India, for example, one finds a combination of an industrialized society but low wages. Each euro spent on nanotechnology research buys more in terms of human resources than in the West, perhaps by as much as a factor of 10x.

_Strategy: For example, goal setting by governments. The US National Nanotechnology Initiative, for instance, set clear goal-oriented outcomes for their research program.

There has been a strong increase in the number of patents filed for nanotechnology-related work in the last few years. What does this mean for investors? Patents fuel innovation and innovation creates new investment opportunities. Intellectual property is the barrier to entry, the foundation of high-tech businesses and the lifeblood of competition.

Funding of nanotech through VC investments dominates in the US and Japan, Europe still relying on public financing

Breakdown of nanotechnology start-up funding – public vs. private



Source: Nature Nanotechnology

The 1999 launch of the US National Nanotechnology Initiative is generally seen as the start of the global race to exploit the possibilities offered by nanotechnology. However, funding for nanoscience had already been established in many regions of the world by this time. Europe was already strong in nanomaterials by the mid-1980s.

As with patents and publications, the US leads the way in public spending on nanotechnology, with the federal government investing approx. US $ 1bn (2006), followed by Japan, the European Commission (EC), the individual states in the US, and Germany. Although China is ninth on this list, if purchasing power was taken into account it would rank much higher. In addition, total spending by the EC and EU member states exceeds that of the federal and state governments in the US.

Indeed, it is not well known that the EC funds more nanotechnology research than any other funding organization in the world. The EC spent some US $ 500m on nanotechnology projects in 2006, up from US $ 460m in the previous year and the US $ 370m spent in 2004. In addition, the total budget for the next Framework Program, which covers the period 2007–2013, is expected to amount to US $ 3.5bn, with further support for nanotechnology from a variety of other activity areas and programs. This money is used to fund research and networking activities at universities, research centres and industrial research labs, and related activities such as infrastructure, mobility and education of scientists, standardization and communication.

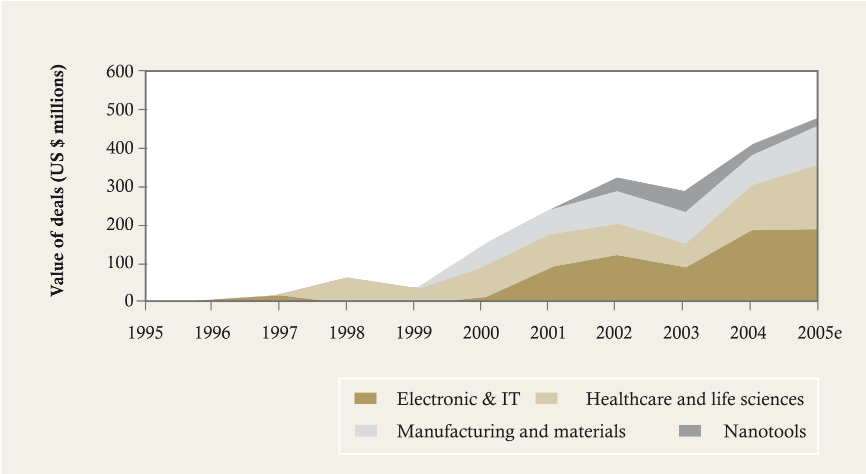
At the same time, venture capitalists also increased their investments greatly compared to previous years. Companies like Intel, IBM, DuPont, 3M, General Electric, Samsung and Hitachi, for example, spent US $ 3.8bn in 2004. 46 % of this amount was spent by nanotechnology companies in North America, 36 % by Asian companies, 17 % by European companies and about 1 % by the rest of the world. To put this into perspective, while industry sources account for around 60 % of total nanotechnology spending in the US, industry only accounts for one-third of the spending in Europe. European industry clearly has some catching up to do.

Investing in nanotechnology: venture capitalism the key to financing growth

Despite the hesitation shown by venture capitalists following the global recession early this decade, which created a highly cautious mood for investments globally, the nanotechnology industry has witnessed a consistent flow of investments, both from governments worldwide as well as private investors. Nanotechnology investment is expected to rise gradually in coming years and is a major factor promoting the emergence of numerous start-ups in the nanotech field every year.

Nanotechnolgy in healthcare increasingly attracting VC funds

VC values nanotech investment opportunities highly



Source: Lux Research

Another force sustaining nanotechnology comes from the dedicated research and development programs in place in many major semiconductor firms such as IBM, Intel, NEC Electronics, Infineon Technologies, STMicroelectronics, and Motorola, to name a few. These companies are actively involved in the commercialization of nano devices, which is now a reality (see IBM's invention of self-assembling structures in their airgap processors in 2007).

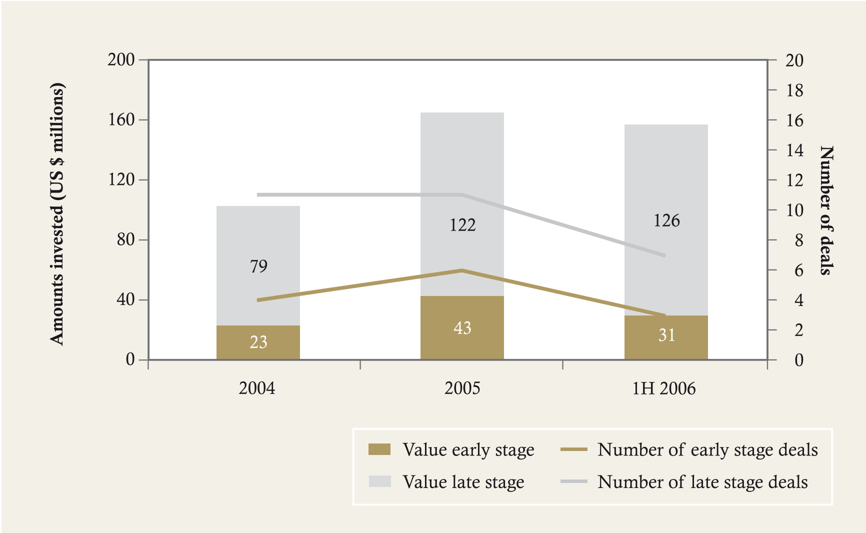
There will, however, also be very real products, from tennis racquets to fuel cell catalysts and semiconductor quantum dots used for biological tagging, products developed as a result of the nanotechnology emerging from small startups to the world's largest corporations, such as BASF.

Industry has overtaken governments as the prime financiers for nanotechnology R&D

Global funding from industry for nanotechnology R&D has now exceeded government funding. Billions of dollars are being poured into this nascent technology, slowly helping to create products stemming from nanoscale features or innovations. Much of this is driven by established corporations, but many small firms are also contributing and some may eventually generate the sales and earnings needed to survive in the long term. Many more, however, will be acquired, and even more will fail.

There are probably more than 1,300 nanotech-related start-up companies worldwide, with about half of those in the U.S. Only around 10 % have attracted any venture capital, and only 10 % of those have received more than one round of funding. Government grants have gone a long way in supporting start-ups. But prominent venture capital firms specializing in technology ventures have backed many small firms that are now considered to stand out from the rest.

Number of late stage VC deals rising



Source: Dow Jones VentureOne

German's Nanostart provides venture capital to start-up companies featuring groundbreaking nanotechnologies

The German nanotechnology company Nanostart (comparable to the US firm Harris & Harris), for example, is dividing its business into two segments, a portfolio divison and financial division. Nanostart provides venture capital to the companies belonging to its portfolio divison, financing the growth of young companies whose business is based on groundbreaking nanotechnology.

Although momentum investing can yield quick returns, value investors look for strong business plans, large potential markets, clear product and commercialization strategies, solid intellectual property positions, and good management around which companies can be built.

When evaluating companies, we feel that it makes more sense to categorize companies by end-use sector instead of grouping them under a nanotech label. Although a discussion of nanotechnology has real value on a technical level, the same is not true at the level of investments, at least not for a value investor.

In addition to traditional investment considerations, delving into nanotech-related areas also requires deep technical understanding and thus in-house expertise. Companies like Harris & Harris and Nanostart have an understanding of the science, intellectual property, and technology transfer.

Typical VC investors generally seek large-scale manufacturing concepts

The companies that have been successful in raising money so far have all been in late-stage fund-raising. Apparently, the typical VC investor is not mainly looking for ideas or prototypes, but a large-scale manufacturing concept.

After venture capital funding, the next question to arise is when companies will be ready for the IPO market. Momentum investors, who bought in a few years ago, when nanotech hype was rising, have been somewhat disappointed. They expected big near-term returns only to find that nanotech-related applications would take longer to develop and companies longer to mature. The Internet boom, where a company could move from start-up to IPO in 18 months, may have shifted expectations unrealistically.

Valuing nanotech companies, especially ones with more speculative business models, is difficult. Although nanotechnology and nanoscale innovations have great potential to change existing markets, and therefore great opportunity for growth, distinguishing between nanotechnology stocks is sometimes difficult. We believe that one has to understand both the science and the business plan in order to value these companies. Forecasting established cash flow and earnings metrics is sometimes difficult due to technical complexity and product uncertainty.

To value nanotech companies properly, we suggest separating nanotech-related companies into two groups: single-focus companies and pluripotent companies. Valuations for single-focus companies are based on more standard measures used for companies with products and strategies targeting a specific industry. Platform technology, or pluripotent, companies have the potential to impact many sectors and require a more complicated analysis. While offering more upside potential, they also present greater investment risk.

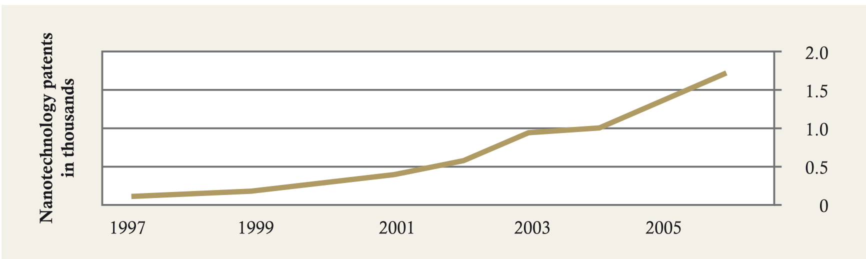
The financial future of nanotech-related companies hinges on market cycles, IPO windows, investor interest, and the flow of results out of research and product development and into the marketplace. Although investors today believe that expectations are more realistic, valuations more sensible, and analyses more grounded, they still want to avoid having a bubble form and then burst.

The technology base: patent applications

Patents best indicator for most sizable economic or commercial impact of business model

Patents reflect the ability of companies and nations to convert scientific results into technological applications and economic development. By analysing data from patent offices around the world, it is therefore possible to identify those areas of nanotechnology that are most likely to have a economic or commercial impact, and those individuals, organizations and nations that will benefit the most.

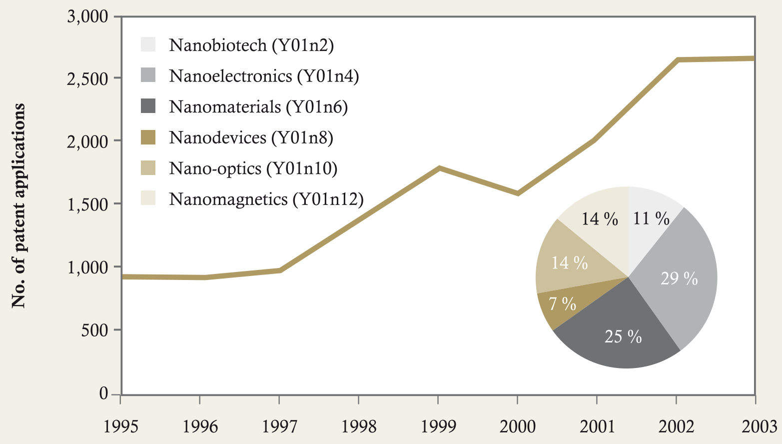
U.S. nanotechnology patents booming

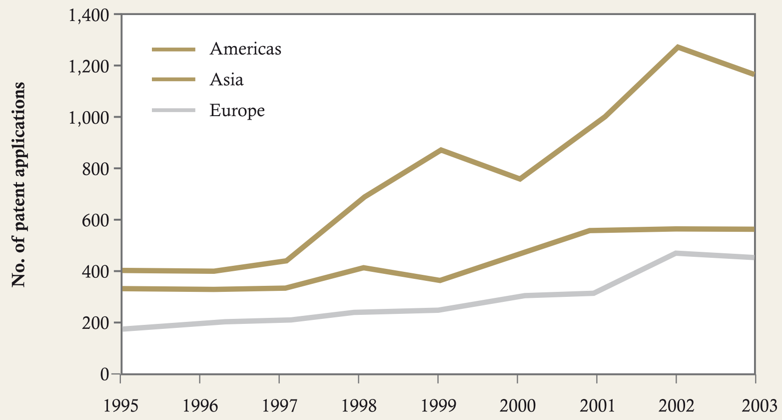


Source: Lux Research, "The Nanotech Report, 5th edition"

The European Patent Office (EPO) has developed a methodology to identify and classify ('tag') nanotechnology patents and patent families. The following chart reflects how the number of nanotechnology patents changed between 1995 and 2003. It also shows that nano-electronics and nanomaterials were the two most active areas in terms of patents, accounting for more than half the total number of patent applications. The other four areas in the EPO classification scheme are nanomagnetics, nano-optics, nanobiotechnology and nanodevices.

Patent application by type of nanotechnology
Americas most progressive





Source: Nature Nanotechnology

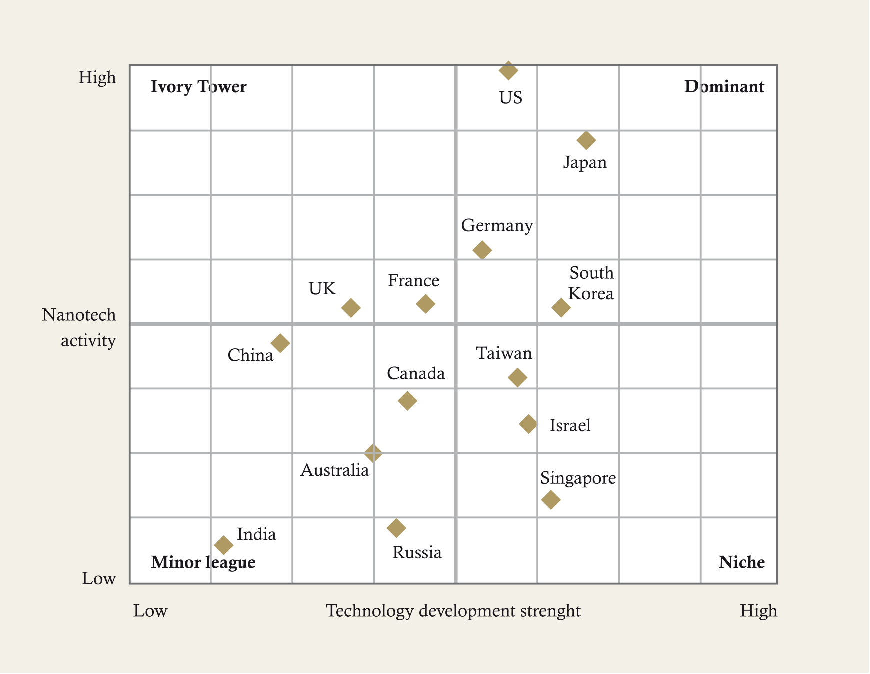
Americas feature most progressive accumulation of patent applications

The number of nanotechnology patents more than doubled between 1995 and 2003, but the growth has not been as spectacular as one might expect, with the peak of 1999 being followed by a fall in numbers, and a year of zero growth following the peak of 2002. Growth has been strongest in the Americas (mainly the US and Canada), but there have been occasional year-on-year decreases. Growth has been slower but more consistent in Asia (mainly Japan and South Korea) and Europe (mainly Germany, the UK, France and the Netherlands), as shown in the chart.

It is obvious that the Americas is by far the most active region in the world for registering patents in nanotechnology, accounting for half the patent applications each year during the period covered, and also being responsible for the peaks in global patent applications witnessed in 1999 and 2002. In the same time period, Europe's share never exceeded 20 %. When the data is analysed by nation, rather than region, the US comes out top overall, and also in each of the six subfields, followed by Japan, Germany, the United Kingdom and France. Within nanobiotechnology, Germany, France and Canada are the strongest after the US, while the Netherlands and Sweden do well in nanoelectronics. Elsewhere, Belgium and Taiwan rank high in nanomaterials, Switzerland is strong in nanodevices, and the UK performs well in nano-optics.

USA, East Asia, Germany leading the nanotech on top of the nanotech league

USA, East Asia, Gemany are most competitive regions/ countries for nanotechnology



Source: Nature Nanotechnology

The number of patent applications increased, on average, by 14 % per year between 1995 and 2003, with the growth being faster in the first half of this period. There were, however, huge differences between the six different subfields. Nano-electronics, nanomaterials, nanodevices and nanomagnetics had the highest growth rates in the 1990s, but growth slowed down between 1999 and 2003 – and even became negative for nanodevices. In contrast, nanobiotechnology and nano-optics both experienced negative growth in the late 1990s, but the rate increased to around 20 % per year after 2000. However, in absolute terms, both these areas remain much smaller than nano-electronics and nanomaterials.

Environmental aspects of nanotechnology: resource management at stake

Environmentally beneficial nanotechnologies

	Regulation	*Research funding*	*Demonstration and diffusion*	*Procurement*	*Economic instruments*	*Standards / Market transformation*	*Awareness and communication*
Hydrogen economy		Develop high level links with the automotive sector and research into hydrogen storage techniques	Expand the hydrogen bus demonstration projects				
Electricity storage	Engage on issues of end of life vehicles	Enable long term research projects		Encourage large fleet procurement of battery powered vehicles	Fiscal incentives for vehicle ownership (such as congestion charges)		Engage with stakeholders for electric vehicles infrastructure
Photovoltaics		Develop centre of excellence for PV Develop funding for pre-commercialisation		Use energy efficient stand alone products	Revise taxation regime to level micro generation playing field	Ensure that new-builds obtain certain percentage of power from renewables	
Insulation		Research novel insultants call through the DTI-TP		Advanced window procurement for governmental offices		Increase insultation requirements for Part L - windows on new builds	
Engine efficiency	Research into toxicity of airborne nanomaterials	Use DTI/EPSRC funding for catalytic converters	Trial of fuel additives				

Source: Oakdene Hollins Ltd.

Nanotechnology among future key technologies to cope with environmental problems

The planet is on an accelerating course to terminal ecological disaster as global warming due to excess green house gas emission is threatening man. While nanotechnology is not the cure-all, it may offer some solutions to finding a sustainable lifestyle for the future. Given that there are urgent issues of global importance to be addressed, especially in relation to energy, food and water, as a result of global warming and a massive reduction in available agricultural land, there follows a list of challenges, with indications of areas where nanotechnology may lead to solutions that have a more planet-friendly impact.

Benefits of nanotechnologies on CO_2

Application	*Impact of nano-tech in area*[1]	*Infrastructural changes*[2]	*Benefit (Mte CO_2 p.a.)*[3]	*Timescale for implementation (years)*[4]
Fuel efficiency	Critical	Low	< 3	< 5
Insultation	Moderate	Low	< 3	3 - 8
Photovoltaics	High	Moderate	c. 6	> 5
Electricity storage	High	High	10 - 42	10 - 40
Hydrogen economy	Critical	Very high	29 - 120	20 - 40

1) Impact of nanotechnology describes the effect nanotechnology is likely to have in the area compared to other technologies; 2) Infrastructural changes indicate the effort bring the nanotechnology to market; 3) Benefit is the estimate of the maximum potential $C0_2$ savings by implementing the technology; 4) Timescale for implementation is the projected time period (in years) before the technology will be fully implemented

Source: Oakdene Hollins Ltd.

Above all, a precondition for deploying nanotechnologies for environmental cures is that nanotechnology-based products will be cheap to produce, less resource intensive and highly adaptive in their response to the demands of their immediate environment.

Energy

In order to reduce the demand for hydrocarbon-based non-renewable energy, new techniques for generating renewable energy, energy conservation and storage are critical areas of research and development.

Nanotechnology plus solar power crucial for global energy supply

_Bio-inspired, lightweight, efficient solar power collectors

_Nanocomposites for energy efficient vehicles/ engines/ power plants (like ceramic-based coatings produced by ItN Nanovation which are capable of reducing the accumulation of slag on fireclay bricks in, for instance, coal-fired power plants)

_Fuel cells

German solar company Centrosolar produces nanotech coated solar cells, delivering superior efficiency versus traditional cells

Regarding solar energy, the high prices of solar cells have so far inhibited their widespread installation into distributed power generation, preventing increased energy generation from renewables. Nanotechnology may deliver more benefits by significantly decreasing the cost of production of solar cells. Conservatively, if a distributed solar generation grid met 1% of electricity demand, approximately 1.5 Mte per annum of CO_2 could be saved. The major barrier to this technology is the incorporation of the nanotechnology into the solar cell, not the nanotechnology itself. The German solar cell maker Centrosolar, for instance, has invented nano coating materials and (nano)techniques to apply anti-reflective coatings to solar glass to make possible improvements in transmission and therefore the effectiveness of photovoltaic solar modules.

Both hydrogen fuel cells and batteries offer solutions to remove the reliance on fossil fuels for road transport. These technologies could decouple transport from GHG emissions if the electricity generation uses low carbon sources. There are significant health benefits and efficiency savings in generating energy (either hydrogen or electricity) at a centralised location outside major population centres. Hydrogen fuel cells are likely to use nanotechnology to improve efficiencies of the fuel cell, increase storage capacity and help generate hydrogen. Nanotechnology in batteries will enable fast charge/discharge batteries and increase overall capacity.

Although these two technologies are competing, the current capabilities of hydrogen and batteries are complementary. Hydrogen use, due to limitations in space, favours large vehicles such as buses and commercial vehicles, whereas use of batteries favours smaller vehicles, such as cars, due to limits in power and safety. More generally, by measuring nanotechnology on its complexity and level of integration into a larger system, meaningful barriers can be identified and recommendations can be reached.

Water

With global warming, potable water is expected to become a more divisive issue than oil. Already the concept of local 'personal fabrication systems' is becoming a reality. Carbon nanotubes have been found to trap bacteria in drinking water by making them stick together in clumps. They can then be sieved out and destroyed.

Providing sufficient drinking water to the world key challenge in future, nanotechnology key technology to achieve that goal

_Self-calibrating nanosensors

_Point-of-sample, high-speed analytical techniques for measuring water quality

_Nano-based filtration and purification techniques, using membranes systems (for example, ItN Nanovation supplies ceramic filters and filtration systems for the processing of industrial waste, the treatment of municipal waste, the extraction of drinking water, filtering out pulp from beer and fruit juice and separating water and oil, e.g. on drilling platforms).

Environment

Environmental monitoring is needed to obtain high-quality data on the speed and levels of environmental pollution.

_Self-calibrating, cheap, fast air and water pollution sensors that can detect a wide variety of organic and inorganic chemical species.

_Novel catalysts for extracting harmful exhaust chemicals from cars, aircraft and power stations (such as those produced by BASF).

Waste
Waste reduction is vital to saving energy and resources, including water. Nano-enabled products do, on balance, require less energy and materials to produce.

_Recyclable, minimalist 'smart' packaging that uses less resources but offers more attributes.

_Monitoring and identifying contents, providing data on energy to produce and transport, and signalling its location at any time (important for reducing waste food).

Healthcare, ageing population, diseases in the underdeveloped nations
Resource-intensive, increased healthcare demands are imposing a severe strain on the economies of most countries.

Nanotech-based treatment and therapy of deseases meeting increased healthcare demand of nations, especially those of underdeveloped countries

_Fast analysis of genetic predispositions to illness leading to genome-based therapeutics.

_Nano-based imaging and drug targeting and delivery for early identification and minimally toxic treatment of disease (like MagForce's cancer treatment using magnetic particles to treat tumours with minimal side effects).

_Patient-friendly, 'smart' cochlear and retinal implants.

_Medical textiles, with health monitoring, transmission of information and therapeutic capabilities.

_Nanostructured bandages that encourage cell growth.

_Infection reduction through anti-bacterial dressings, surfaces and textiles.

_Regeneration of organ function by using nano-scaffolding with cell-friendly surfaces, and using nanomaterials that diffuse chemicals that facilitate cell growth and differentiation. These can be implanted into the body and provide a structure around which cells will grow to form a new, fully integrated organ or tissues.

Food
Studies showed that a sizeable part of all food produced (i.e. approx. one third in the UK) goes to waste, consuming huge resources of water and energy. Exporting and importing meat, fruit, vegetables and flowers out of season pollutes the air, sea and land. The excessive use of precious local water resources spreads pathogens and contributes to the poverty of countries producing cash crops.

_Less wasteful, feature-rich packaging (that can detect pesticides or spoilage, inform about origin etc.).

_Antibacterial packaging and food preparation surfaces e.g. using nanoparticulate silver.

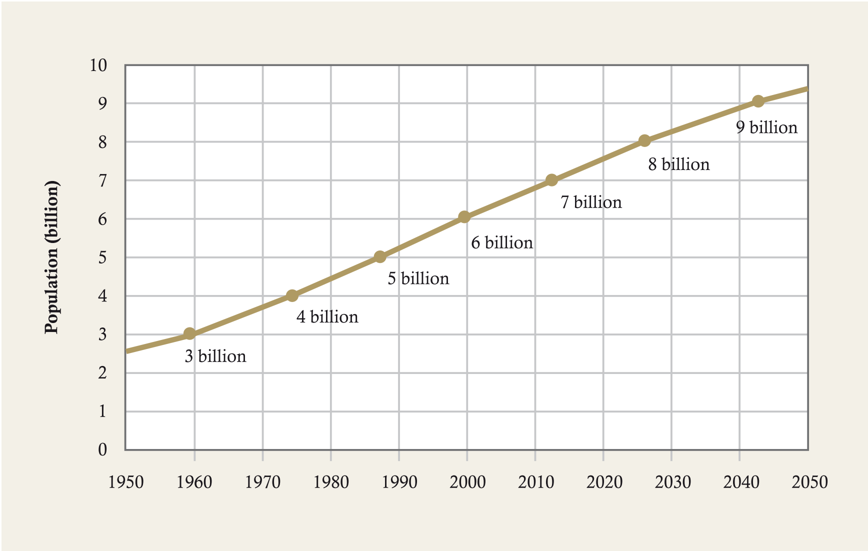
Agriculture
Diminishing food and water resources are putting pressure on the remaining agricultural land. Studies also show that soil-dwelling bacteria are critical to equilibrating the oxygen/ carbon dioxide balance in terms of the speed of response.

_nanosensors for monitoring soil health

Securing sufficient nutrition of fast growing population calls for precise farming and "smart" agriculture – nanotechnology provides solutions like molecular treatment of plant diseases etc.

By 2010 the population is expected to reach 7 billion. Providing anything close to the present standard of consumption for the approximately 1 billion inhabitants of the industrialised nations is taxing the planet's resources to the breaking point. It can be concluded that the present emphasis by nations on 'growth' and 'competitiveness' is now inappropriate. Prevention of collapse of the ecosystem has now become the overwhelming issue, and calls for the immediate implementation of a totally new strategy on which the society of the future can be based, and which must be in equilibrium with the natural world. New technologies, including nanotechnology, may provide a part of the answer on how to create alternative lifestyles for the population that will be in harmony with the planet.

Likely development of world population 1950-2050



Source: U.S. Census Bureau

However, creating a bio economy is a challenging and complex process involving the convergence of different branches of science. Nanotechnology has the potential to revolutionise the agricultural and food industry with new tools for the molecular treatment of diseases, rapid disease detection, enhancing the ability of plants to absorb nutrients etc. Smart sensors and smart delivery systems will help the agricultural industry combat viruses and other crop pathogens. In the near future nanostructured catalysts will be available which will increase the efficiency of pesticides and herbicides, allowing lower doses to be used.

Nanotechnology will also protect the environment indirectly through the use of alternative (renewable) energy supplies, and filters or catalysts to reduce pollution and clean-up existing pollutants. An agricultural methodology widely used in the USA, Europe and Japan, which efficiently utilises modern technology for crop management, is called Controlled Environment Agriculture (CEA). CEA is an advanced and intensive form of hydroponically-based agriculture. Plants are grown within a controlled environment so that horticultural practices can be optimised. The computerised system monitors and regulates localised environments such as fields of crops.

CEA technology, as it exists today, provides an excellent platform for the introduction of nanotechnology to agriculture. With many of the monitoring and control systems already in place, nanotechnological devices for CEA that provide "scouting" capabilities could tremendously improve the grower's ability to determine the best time of harvest for the crop, the vitality of the crop, and food security issues, such as microbial or chemical contamination.

Precision farming

Precision farming has been a long-desired goal to maximise output (i.e. crop yields) while minimising input (i.e. fertilizers, pesticides, herbicides, etc) through monitoring environmental variables and applying targeted action. Precision farming makes use of computers, global satellite positioning systems, and remote sensing devices to measure highly localised environmental conditions thus determining whether crops are growing at maximum efficiency or precisely identifying the nature and location of problems. By using centralised data to determine soil conditions and plant development, seeding, fertilizer, chemical and water use can be fine-tuned to lower production costs and potentially increase production – all benefiting the farmer.

Precision farming can also help to reduce agricultural waste and thus keep environmental pollution to a minimum. Although not fully implemented yet, tiny sensors and monitoring systems enabled by nanotechnology will have a large impact on future precision farming methodologies. These nanosensors could be distributed throughout the field where they can monitor soil conditions and crop growth. Wireless sensors are already being used in certain parts of the USA and Australia. The initial cost of setting up such a system is justified by the fact that it enables the best grapes to be grown which in turn produce finer wines, which command a premium price.

The global market for wireless sensors is predicted to be US$ 7bn by 2010. Combining biotechnology and nanotechnology in these sensors will create equipment of increased sensitivity, allowing a faster response to environmental changes. For example: Nanosensors utilising carbon nanotubes or nanocantilevers are small enough to trap and measure individual proteins or even small molecules. Nanoparticles or nanosurfaces can be engineered to trigger an electrical or chemical signal in the presence of a contaminant such as bacteria.

Ultimately, with the help of smart sensors, precision farming will enhance productivity in agriculture by providing accurate information, thus helping farmers to make better decisions. This is particularly important in developing countries like Africa where crop yield per hectare is seriously low compared to developed nations and regions and needs to be addressed quickly in order to reduce under-nourishment.

Smart delivery systems

The use of pesticides increased in the second half of the 20th century with DDT becoming one of the most effective and widespread pesticide in the world. However, many of these, including DDT, were later found to be highly toxic, affecting human and animal health and as a result whole ecosystems. As a consequence, they were banned. To maintain crop yields, Integrated Pest Management systems, which mix traditional methods of crop rotation with biological pest control methods, are becoming popular and are implemented in many countries, such as Tunisia and India. In the future, nanoscale devices with novel properties could be used to make agricultural systems "smart". For example, devices could be used to identify plant health issues before these become visible to the farmer. Such devices may be capable of responding to different situations by taking appropriate remedial action. If not, they will alert the farmer to the problem. In this way, smart devices will act as both a preventive and an early warning system. Such devices could be used to deliver chemicals in a controlled and targeted manner in the same way as nanomedicine has implications for drug delivery in humans.

Successful growth regulating products such as the Primo MAXX® plant growth regulator which, if applied prior to the onset of stress such as heat, drought, disease or traffic, can strengthen the physical structure of turf grass, and allow it to withstand ongoing stresses throughout the growing season.

New research also aims to make plants use water, pesticides and fertilizers more efficiently, to reduce pollution and to make agriculture more environmentally friendly. Smaller companies are forming alliances with major players such as LG, BASF, Honeywell, Bayer, Mitsubishi, and DuPont to make complete plant health monitoring systems in the next 10 years using nanotechnologies.

Other developments in the agricultural sector based on nanotechnology

Agriculture is the backbone of most developing countries, with more than 60 % of the population reliant on it for their livelihood. As well as developing improved systems for monitoring environmental conditions and delivering nutrients or pesticides as appropriate, nanotechnology can improve our understanding of the biology of different crops and thus potentially enhance yields or nutritional values. In addition, it can offer routes to added value crops or environmental remediation. Particle farming is one such example, which yields nanoparticles for industrial use by growing plants in defined soils. Similar projects are taking place elsewhere. The German chemical group BASF's future business fund has devoted a significant proportion of its US $ 105m nanotechnology research fund to water purification techniques. The French utility company Generale des Eaux has also developed its own nanofiltration technology in collaboration with the Dow Chemical subsidiary Filmtec.

Other research at the Centre for Biological and Environmental Nanotechnology (CBEN) has shown that nanoscale iron oxide particles are extremely effective at binding and removing arsenic from groundwater, something which affects the water supply of millions of people in the developing world, and for which there is currently no effective solution.

Nanotechnology can help reduce greenhouse gas emissions

Solutions are possible, if climate change is taken seriously. Studies suggest that greenhouse gas emissions could be reduced by applying nanoscience in five key areas: insulation, photovoltaics, electricity storage, engine efficiency and the hydrogen economy. Applying nanotechnology in these five key areas could contribute to reducing greenhouse gas emissions by up to 2% in the short term and up to 20% by 2050, with similar reductions in air pollution.

Nanotechnology as a weapon against greenhouse emissions

Nanotechnologies have the potential of reducing greenhouse gases and thus reducing the severity of climate change. The Stern Review (which considers existing evidence on the economic impacts of climate change itself, and the economics of stabilising greenhouse gases in the atmosphere) details improvements (and failures) in enabling the delivery of low carbon technological advances. The following table provides a detailed selection of recommendations from the Stern Review and their relevance to a report published by Oakdene Hollins.

Comparison between Stern Review comments and environmentally beneficial nanotechnologies

Stern Comments	*Relevance to environmentally beneficial nanotechnologies*
The global budget for research and development in energy should be doubled.	It is clear that further fundamental and applied research into nanotechnologies is required to deliver the benefits outlined in the report. For example there is a need for fundamental research into the development of solid wall insultation.
The public should be engaged and informed about environmentally beneficial technologies.	Toxicological studies into the effects of (for example) fuel additives is imperative if the public`s fears are to be allayed.
Development incentives should increase five fold to allow new low carbon technologies to be competitive.	The subsidy for carbon intensive electricity generation approximatley US $ 150-250bn world-wide. Reallocation of these subsidies would enable systems such as nano-enabled photovoltaics in a distributed grid to be more widely implemented.
Global pricing of carbon and energy is uncertain, which results in under-investment in low carbon technology.	Within Europe, investors in new battery technology are reputedly unwilling to commit to long range projects. The uncertainty in regulation and post-Kyoto targets are probably compounding their lack of enthusiasm to invest.
In the absence of a niche market, the research costs are borne by innovators, who are competing with established high carbon alternatives.	Most of the technologies described within the report are competing with low cost, high carbon alternatives. Intervention will probably be required to enable the deployment of these technologies.
The electricity infrastructure favours centralised plant.	This is a barrier for all microgeneration technologies.

Source: Oakdene Hollins Ltd.

Stern Comments	*Relevance to environmentally beneficial nanotechnologies*
New vehicle networks (namely hydrogen and electric refuelling points) are unlikely to be developed without government intervention.	The move to zero carbon transport is likely to involve the use of nanotechnology. However, at present there is very little market pull to invest in the infrastructure (refuelling stations) to make zero emission transportation attractive to the public.
There is a need to develop new methods of hydrogen storage and generation.	This is the key to the development of hydrogen as an alternative energy store. Nanotechnology is seen as the front runner is developing these technologies.
Hydrogen bus demonstration projects are a promising method for utilising hydrogen.	Until the issues surrounding storage are resolved the most practical use of hydrogen power is in busses where space limitations are reduced. The efficiency of the fuel cells can be improved in these studies.
A portfolio of technologies should be developed; although there is inherently a higher cost, the overall risks of developing a successful solution are minimised.	This nanotechnology report outlines several technologies which are competing within the same area. The ranking methodology has given some indication of the feasibility of the technologies, however, it would be dangerous to focus on a small selection of technologies.
Incremental changes in efficiency do not usually require support for deployment (other than institutional barriers).	Simple free nanoparticles are examples of near term technologies which may offer incremental improvements in efficiency. Barriers facing their entry are common to other product developments and launches, however, these substances may pose health risks.
More engineers and scientist will be required as the development of low carbon technologies increase.	This is crucial in nanotechnology, which uses expertise from chemistry, physics and engineering. These subjects have seen declining percentage of graduates in the UK in recent years.
The funding of demonstration projects should be used to develop new low carbon technologies.	Hydrogen bus demonstration projects should be maintained and expanded. Fuel additives demonstration project should be carried out.
Further research is required into energy storage technologies to allow the use of low carbon electricity in transport.	The development of hydrogen fuel cells and new battery technologies will contribute to this area.

Source: Oakdene Hollins Ltd.

Nanotechnology could play a key role in developing renewable hydrogen, supporting the efficiency of fueld cells etc.

In the short term, nanotechnology has the potential to improve fuel efficiency and eliminate CO_2 emissions from transport. Adding nanoparticles as a fuel additive to diesel engines could reduce emissions by 2.1 million tonnes with little infrastructure change. Nanomaterials could improve the efficiency of fuels cells, and their incorporation into batteries and supercapacitators could reduce charging time for electric cars. In the long term, nanotechnology could play a key role in the development of renewable hydrogen production. A hydrogen economy is estimated to be some decades away from potential universal deployment, but nanotech developments could be crucial to achieving efficient hydrogen storage, which is thought to be the largest barrier to large scale use.

Adverse health, environmental and safety impacts of nanotechnology: a misleading general public perception?

The logic of public calls for a moratorium on the manufacture of nanomaterial generally is that the benefits are outweighed heavily by the unknown risks. The enemy is not nanoparticles themselves, but the unpredictability of what may come from their use.

Nanoparticles and nanomaterials could prove harmful if mishandled, but so are chemicals, drugs et al.

Certain nanomaterials could certainly prove to be harmful if mishandled. Quantum Dots may be toxic if ingested, but so is Windex (trademark for a glass and light-duty hard surface cleaner manufactured since 1933). Carbon nanotubes may prove to be far more deadly than asbestos if inhaled, but so is paint thinner. The promise of nanotech is not just in developing new compounds, but in precisely manipulating them to serve a function. Chemicals are nothing new. There are safety standards for handling volatile chemicals, such as ammonia, for example, which is often used in the home. The fear factor and negative hype is related to misdirected discoveries, unintended consequences arising from incomplete knowledge and the intentional misuse of technology (which could also occur with any traditional technology). Therefore, while the science of nanotechnology is new and inspiring, the moral dilemma is not. The same debates have taken place in the past with regard to nuclear energy, hazardous chemicals, and recombinant DNA. It should always be remembered that anything entering the life-sciences market still must pass through a rigorous and expensive process for approval by the health authorities (such as the FDA), which screens for problems of toxicity and unintended side effects.

Combating cancer with potential nanotech treatments

Nanotechnology in cancer diagnosis and therapy

Cancer therapy one prime area for nanotechnology to provide much more effective and sensitive (to humans) treatment

Biological processes, including the events that lead to cancer, occur at the nanoscale. Nanotechnology offers unprecedented access to the interior of living cells, and therefore provides researchers with the opportunity to study and interact in real time with normal and cancerous cells at the molecular and cellular levels, including during the earliest stages of the cancer process.

Nanodevices can provide rapid and sensitive detection of cancer-related molecules by allowing scientists to detect molecular changes, even when they occur only in a small percentage of cells. They also have the potential to radically improve cancer therapy and dramatically increase the number of highly effective therapeutic agents. Nanoscale constructs can serve as customizable, targeted drug delivery vehicles capable of ferrying large doses of chemotherapeutic agents or therapeutic genes into malignant cells while sparing healthy cells, thereby greatly reducing or eliminating the side effects that accompany many current cancer therapies.

For instance, German firm MagForce most innovative and progressed in nano-based cancer treatment

Nanotechnology introduces unique approaches to diagnosis and treatment in the fight against cancer that are unimaginable with conventional technology. New tools engineered at sizes much smaller than a human cell will enable researchers and clinicians to detect cancer earlier, treat it with much greater precision and fewer side effects, and potentially stop the disease long before it can do any damage. For example, the German nanotech firm MagForce is developing a cancer treatment consisting of magnetic particles (iron oxide), combined with equipment and software to monitor the treatment process. The treatment aims to destroy cancer cells by converting magnetic fields into heat and allow the physician to visually track the progress of treatment.

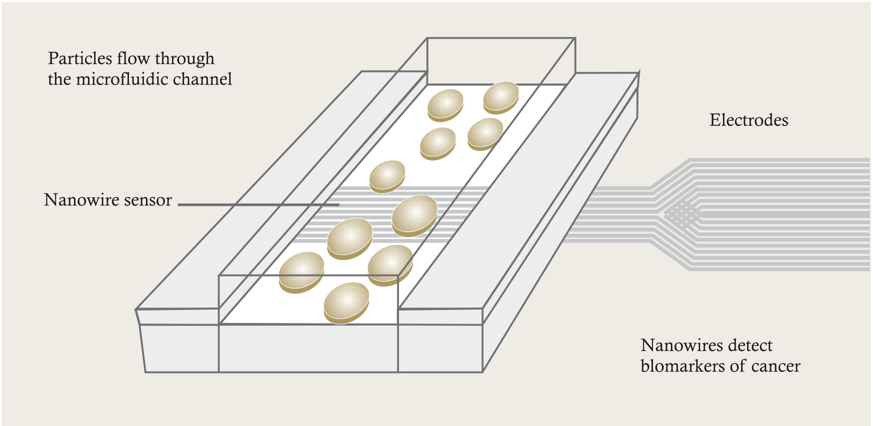
Although healthcare is an important sector for VC investments, the long cycles required for market introduction represent a particular challenge. As a result, the challenge for start-up firms is to attract financiers despite the early stage of their business. The record to date shows most of the money and deals going to later stage opportunities, where the route to revenue generation is clearer.

Examples of nanotechnologies used to treat cancer

Nanowires

Nano-sized sensing wires lie across a microfluidic channel. By nature, these nanowires have incredibly selective and specific detecting properties. As particles flow through the microfluidic channel, the nanowire sensors pick up the molecular signatures of these particles and immediately relay this information through connected electrodes to the outside world.

Nanowire sensor



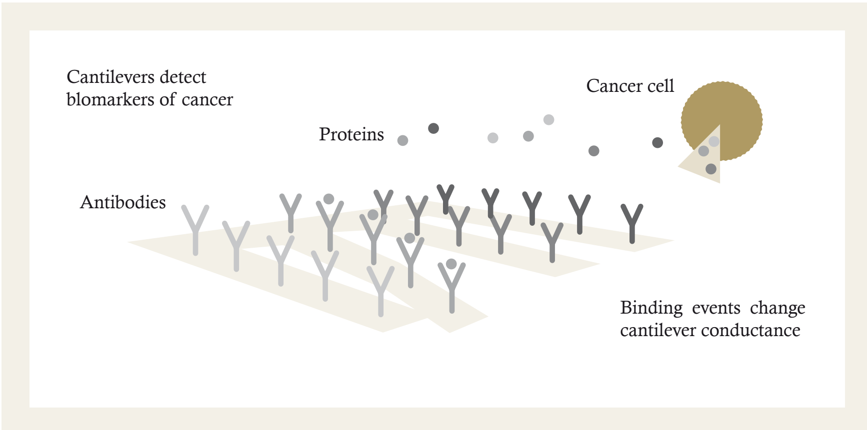
Source: NCI

These nanodevices are man-made constructs of carbon, silicon and other materials that have the ability to monitor complex biological phenomena and relay real-time information to the medical care provider. They can detect the presence of altered genes associated with cancer and may help researchers pinpoint the exact location of these alterations.

Cantilevers

Nanoscale cantilevers (microscopic, flexible beams resembling a row of diving boards) are built using semiconductor lithographic techniques and coated with molecules capable of binding to the biomarkers of cancer.

Nanoscale cantilevers

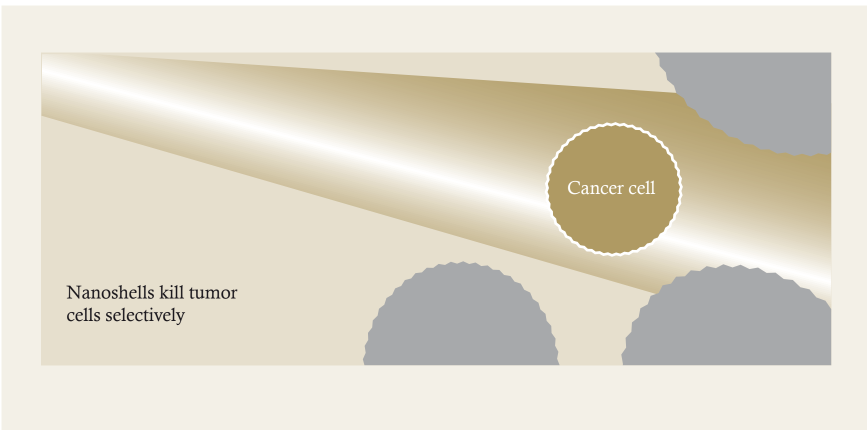


Source: NCI

As a cancer cell secretes its molecular products, the antibodies coated on the cantilever fingers selectively bind to these secreted proteins, changing the physical properties of the cantilever and signalling the presence of cancer. Researchers can read this change in real time and provide information on the presence or absence, as well as concentration of different molecular expressions. Nanoscale cantilevers, constructed as part of a larger diagnostic device, can provide rapid and sensitive detection of cancer-related molecules.

Nanoshells
Nanoshells have a core of silica and a metallic outer layer. Scientists can link the nanoshells to antibodies that recognize tumour cells. Once the cancer cells attach to them, scientists apply near-infrared light that is absorbed by the nanoshells, creating an intense heat that selectively kills the tumour cells and not neighbouring healthy cells.

Nanoshells

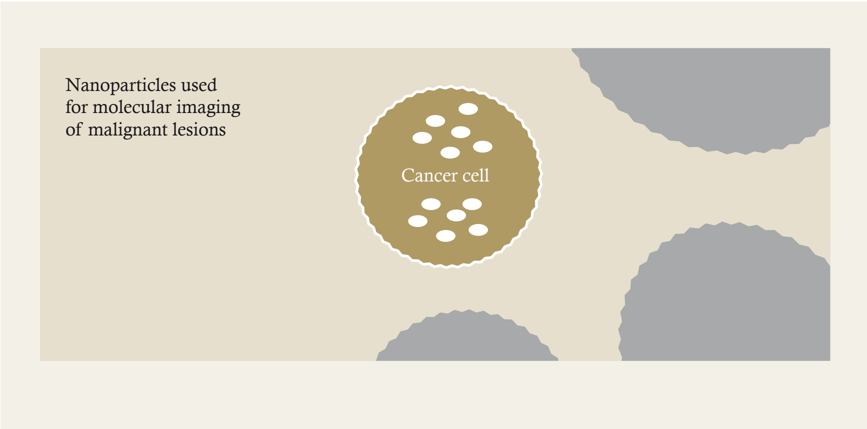


Source: NCI

The result is greater efficiency of the therapeutic treatment and a significant reduction in the number of side effects.

Nanoparticles
Nanoparticles can be engineered to target cancer cells in order to enable molecular imaging of a malignant lesion. Large numbers of nanoparticles are safely injected into the body and preferably bind to the cancer cell, defining the anatomical contour of the lesion and making it visible.

Nanoparticles



Source: NCI

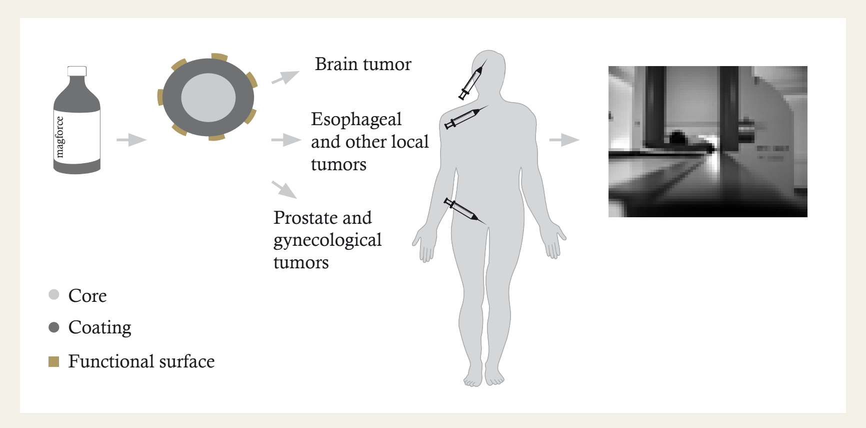
These nanoparticles give us the ability to see cells and molecules that we otherwise could not detect through conventional imaging. The ability to detect what is happening in the cell – to monitor therapeutic intervention and see when a cancer cell is mortally wounded or is actually activated – is critical to the successful diagnosis and treatment of the disease.

Nanoparticulate technology could prove very useful in cancer therapy

Nanoparticulate technology could prove to be very useful in cancer therapy by allowing for effective and targeted drug delivery that overcomes the many biological, biophysical and biomedical barriers the body creates for standard interventions, such as the administration of drugs or contrast agents.

The German nanotech company MagForce, for example, invented a nanocancer therapy in 2003 that treats patients using nanoparticulate technology (consisting of three parts: nanoparticles, software to monitor treatment process, and a magnetic field applicator). MagForce's proprietary nanocancer therapy uses magnetic nanoparticles that allow tumours to be heated and destroyed without damaging adjacent healthy cells.

MagForce's nanocancer therapy



Source: MagForce

Compared to the MagForce's proprietary technology, alternative methods of thermotherapy either produce temperatures within the tumour that are not sufficiently high or cause significant damage to healthy tissue. The commercialization of nanocancer therapy will begin in 2010. Patient trials to date have shown positive test results (for the treatment of glioblastoma).

Quantum dots (Qdots)
Quantum dots are nanometre-sized semiconductor particles made of cadmium selenide (CdSe), cadmium sulfide (CdS) or cadmium telluride (CdTe), with an inert polymer coating. The semiconductor material used for the core is chosen based upon the emission wavelength range being targeted: CdS for UV blue, CdSe for the bulk of the visible spectrum, CdTe for the far red and near-infrared, with the particle's size determining the exact colour of a given quantum dot. The polymer coating protects cells from cadmium toxicity, while also affording the opportunity to attach a variety of targeting molecules, including monoclonal antibodies aimed at tumour-specific biomarkers. Because of their small size, quantum dots can function as cell-specific and even molecule-specific markers that do not interfere with the normal operation of a cell. In addition, the availability of quantum dots of different colours provides a powerful tool for following the activity of multiple cells and molecules simultaneously.

Outlook: long-term challenges and visions

Ultimate goals for nanotechnology products are using fewer valuable, scarce, and unsustainable resources, and being more energy efficient.

Looking forward
Nanotechnology is one highly important facet of a spectrum of technologies that may offer solutions for a sustainable future. Its key selling point has been proclaimed as offering 'more for less', thereby benefiting the environment; the concept of being able to fit more features into smaller, smarter products. This should translate into

products that use fewer resources to produce (reducing waste and pollution), and are more energy efficient. In conjunction with other technologies, nanotechnology may provide alternatives to resource-intensive activities, and may also offer new opportunities without jeopardizing the environment.

The incorporation of nanotechnology into larger systems may also be a major barrier in the development of new products. It is predicted that nanotechnology will become ubiquitous in coming decades, and revolutionise the functionality of products. The near-term effects of nanotechnology are significant, yet incremental. The long-term predictions for some of the technologies are more significant, but probably underestimate technological advances in non-nanotechnological innovations. In overall terms, however, the potential advances brought by nanotechnology justify continued interest and investments in the area.

The relatively high level of public funding for nanotechnology in Europe does, however, have an advantage in that it gives the public – consumers, pressure groups, regulatory agencies, and both European and national funding agencies – some influence in setting priorities for nanotechnology research. Appropriate infrastructure and educational programs, coordinated activities in metrology, standardization and regulation, and the integration of nanotechnology into small- and medium-sized enterprises will all contribute decisively to the development of nanotechnology in Europe.

Why nano now?
Why has nanotechnology sprung into prominence now? Because scientific advances in the last thirty years (such as the scanning probe microscope) have gradually allowed us to 'see' atoms and molecules, and to manipulate them in a controlled fashion. This has led to not only a more profound understanding of the properties of materials but, even more importantly, to the ability to design materials with new properties, and even create entirely new materials previously unknown in nature, such as carbon nanotubes.

Nanotechnologies worth of products could reach 15 % of global manufacturing output in 2014, compared with a mere 1 % share in 2004

Nanotechnology is approaching a phase change that will see it spread exponentially across manufactured goods in the next 10 years. In 2004, approx. US $13bn worth of products incorporated emerging nanotechnology, less than one-tenth of 1 % of total global manufacturing output. It is projected that this figure will rise to US $ 2.6 trillion in 2014 – 15 % of manufacturing output in that year.

As always, innovation is driven by financial gain, underpinned by consumerism, legislation and contingency, such as war or plague. The automotive and aerospace industries, in parallel with the military, are early adopters. Pharmaceutical and medical firms are gradually starting following suit, although the process is still slow. There is, however, great potential in the therapy and treatment of cancer, which has now passed cardiovascular disease to become the number one enemy to human health on the planet.

Nano-enabled products will dominate revenues, but nano-intermediates, whose margins are more than three times higher, will account for the greatest share of profit.

_Between 2005 and 2009, commercial breakthroughs will unlock markets for emerging nanotechnology. High-volume, high-margin applications will drive down the cost of nanomaterials. Nanointermediates will take off in electronics and information technology (IT), driven by microchips patterned using new nanolithography techniques. Nano-enabled products will appear in automobiles, portable electronics products, and drug reformulations. In 2009, revenues across the value chain will reach US$278bn.

_Between 2010 and 2014, emerging nanotechnology will become commonplace. Nanomaterials will find new homes, both as replacement materials and as enablers of new products. Nano-intermediate products in electronics and IT will be joined by rapidly expanding applications in other product categories, from structural metal to orthopaedic implants. In 2014, manufacturing output incorporating emerging nanotechnology will total US$2,600bn – 4% of overall manufacturing output, 50% of electronics and IT production, and 16% of healthcare and life sciences.

_Revenues of products incorporating nanotechnology will exceed revenues from biotechnology by 10 times and have an economic impact on par with information technology and telecom.

SWOT analysis nanotechnology

SWOT nanotechnology

Weaknesses are mostly dealing with funding problems of new companies and start-up risks of emerging technologies

But opportunities justify more investments into this sector

Strengths	*Opportunities*
Strong basic research	**Diverse, more efficient materials:** New properties and functions for traditional materials
Elaborate research landscape: Strong involvement by universities, departmental and industry researchers	**New diversity of application:** Materials with tailored properties, particularly as a result of self-organisation processes
Good industrial base: International companies taking opportunities offered by nanotechnology serious (BASF, Dow Chemical etc.)	**Competitive advantages:** Nanotechnological innovations are possible in all sectors
	Good climate for innovation: The community is involved in discussions on opportunities and risks
	Potential for investor interest: High potential for nanotechnology
Weaknesses	*Challenges*
Difficulties for start-ups: Insufficient risk capital provided, bureaucratic obstacles	**Ensuring the quick conversion of research results into products**
Commercial information deficits : Potential investors currently lack a clear picture of the opportunities offered by nanotechnology	**Scientific risk assessment:** The potential toxic effects of nanoparticles have not been investigated sufficiently
Risk communication: The establishment of a dialogue process that includes all groups of society	**Safe, responsible handling of nanotechnology:** Consumer advice, consumer protection, occupational health and safety

Source: Silvia Quandt Research GmbH

Case studies of German nanotechnology companies

BASF

Price target
€ 96.00

Rating
Neutral

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Germany

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+49 (0) 621 604 8230

Stock data
Main Market
Dax

Market cap (€ m):
45,431

No. of outstanding shares (m)
472

Daily traded volume (3 months avg; '000s)
2,949

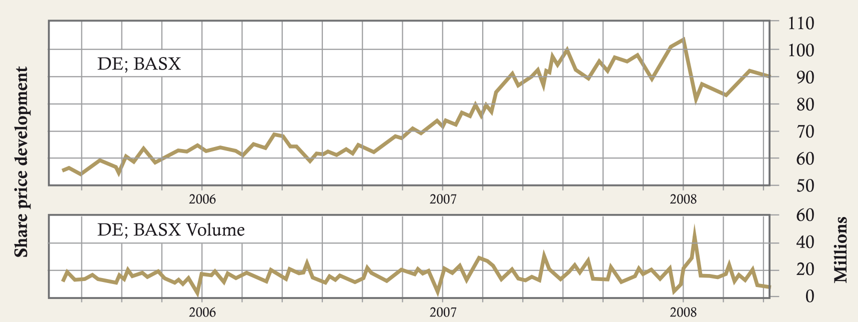
Indices
Dax

Next event
Q2 08, 31 July

Free float
100 %

Closing price
€ 93.00

FY 31 Dec (€ m)	*2006*	*2007*	*2008e*	*2009e*
Profit loss				
Sales	52,610	57,951	60,020	62,278
y-o-y	23.1 %	10.2 %	3.6 %	3.8 %
EBITDA	9,723	10,226	10,327	10,914
EBIT pre except.	7121	7,491	7,813	8,280
EBIT margin	13.5 %	12.9 %	13.0 %	13.3 %
Net income	3,215	4,065	4,116	4,425
EPS	6.37	8.32	8.72	9.42
y-o-y	11.3 %	30.6 %	4.8 %	8.1 %
EPS consensus (€)			8.35	8.19
DPS (€)	3.00	3.90	4.00	4.10
Cash flow				
Net income	3,215	4,065	4,116	4,425
Depreciation/Amortisation	-2,715	-2,648	-2,564	-2,634
Net working capital movements	-467	-1,236	-450	-350
Operating cash flow	5,463	5,477	6,230	6,709
Net capex	-9,261	4,378	-2,547	-2,825
Free cash flow	-3,798	1,099	3,682	3,884
Balance sheet / Key ratios				
Closing cash (net debt)	-10,045	-10,576	-8,565	-6,179
Gearing	41.2 %	55.5 %	46.9 %	31.6 %
Capex ratio (sales)	17.6 %	7.6 %	4.2 %	4.5 %
ROE	18.3 %	21.9 %	20.2 %	19.0 %
ROCE	22.0 %	21.2 %	22.0 %	23.1 %
Valuation				
Enterprise value	32,878	38,351	57,881	55,566
Price/Book (x)	2.0	2.3	2.2	1.9
Dividend yield	4.5 %	4.6 %	4.3 %	4.4 %
EV/Sales	62.5 %	66.2 %	96.4 %	89.2
EV/EBITDA (x)	3.5	3.8	5.6	5.1
PER (x)	10.7	10.6	10.7	9.9
FCF yield	-25.5 %	1.1 %	8.5 %	9.4 %



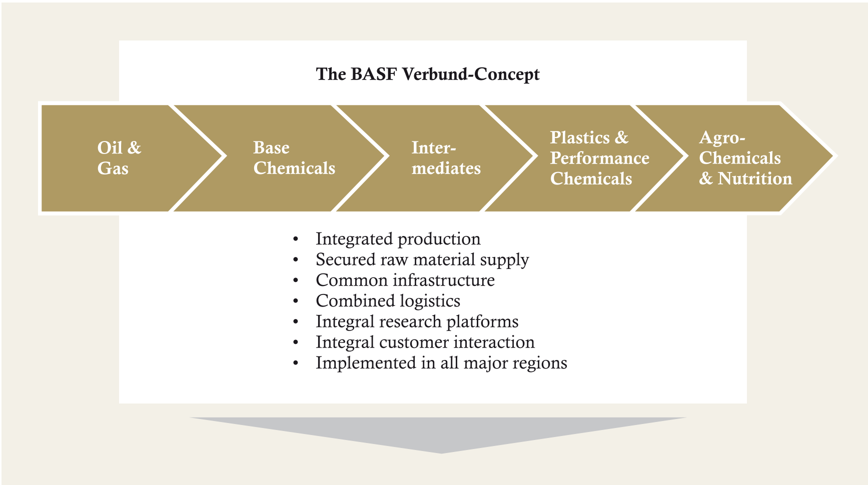
Source: Reuters

Company profile

BASF is one of the world's largest integrated chemicals companies with a portfolio ranging from chemicals, plastics, performance products, agricultural products and fine chemicals to crude oil and natural gas.

The company's concept to integrate its businesses is unique among chemical companies worldwide as it features a virtually complete coverage of the whole chemicals value chain. Thanks to the very high degree of operations the annual synergies from such structure amounts to approx. € 1bn, helped by low waste of byproducts (byproducts shall be used either in other production or being sold on the merchant market) which ensures a high degree of operational efficiency.

The merits of the "Verbund" within BASF group



Source: BASF

The commercial benefits of this "Verbund" system are

_Highly efficient production= cost leadership

_High resource efficiency and low waste reduction

_Leadership in sustainability relative to peers

_Integral knowledge management = leadership in innovations (>1,000 patents p.a.)

_Customer orientation= supplier of choice and fast adaptation to challenges and changes

BASF's divisions are:

_Chemicals offer products for pharmaceuticals, construction, textile and automotive industries, such as basic petrochemicals, inorganic chemicals, intermediates and specialties.

_Plastics provides engineering plastics (performance polymers) for plastic molders and manufacturers in various industries, as well as polyurethanes for different applications.

_Performance Products manufactures acrylics & dispersions, care chemicals, and performance chemicals, for the automotive, oil, paper, packaging, textile, sanitary care, construction, printing and leather industries.

_Agricultural Solutions supplies agricultural products to the farming industries.

_Oil and Gas explores and produces crude oil and natural gas.

_BASF has added a sixth division effective 1 January this year, Functional Solutions, which comprises coating, catalysts, and construction chemicals businesses.

BASF portfolio diversified well

BASF sales by industry, percentage of sales (other industries approx. 10 % in 2006)

> 15 %	Chemical, Energy
10-15 % each	Automotive, Construction
5-10 %	Agriculture
<5 %	Cosmetics, Electrical & Electronics, Leather & Shoes Detergents & Furniture, Health, Packaging, Paper, Textiles

Source: SWOT analysis nanotechnology

In 2007, BASF had around 95,000 employees and sales of approx. US € 58bn. In addition, BASF completed its transition to European company status, changing its name to BASF SE (Societas Europaea). The company's headquarter is in Ludwigshafen, Germany.

Strategy
In recent years, BASF has continuously streamlined its business portfolio, departing the pharamaceutical business in 2001 through selling its Knoll subsidiary and continuing thereafter with selling non-core businesses like commodity plastics (US polystyrene, polyethylene unit Basell). The focus has been on "profitable growth" which means the BASF has sought to optimise its core skills namely in chemicals and adding attractive new businesses, like in 2006 Engelhard, the US catalyst producer, and the

construction chemicals business of former Degussa, as well as Johnson Polymer, a resin producer. The integration of the new businesses went fast and was completed in 2007.

With the new acquisitions BASF has moved closer to customers, has become innovative and and as a result of increased flexibility and shorter reaction times to adapt to new challenges, more resilient to economic fluctuations.

BASF has implemented the following key strategic points that it says will align its business activities in 2007, these include:

_Strategies for value-adding growth BASF will continue to develop its strengths through innovations and acquisitions, with sustainability being a key factor in pursuing this goal, e.g. according to the management business cannot be successful in the long term if it does not act responsibly toward the environment and society.

_Growth through acquisitions Thanks to the acquisitions of new businesses in 2006, growth potential of the company has been raised in the long run. For instance, catalysts are likely to grow faster than GDP in the next years due to tougher legis-lations on environmental care by goverments. Besides adding stability to the overall business portfolio of the group the contribution from those now businesses should be disproportional, als thanks to synergies with other parts of BASF's business activities (for instance, chemical catalysts to be deployed inhouse). Still, to further bolster its market position BASF aims to continue optimising its portfolio and implement measures to restructure its businesses and reduce costs. In 2007, the company will also continue to concentrate on the organic growth of its core activities: chemicals, agricultural solutions and oil and gas.

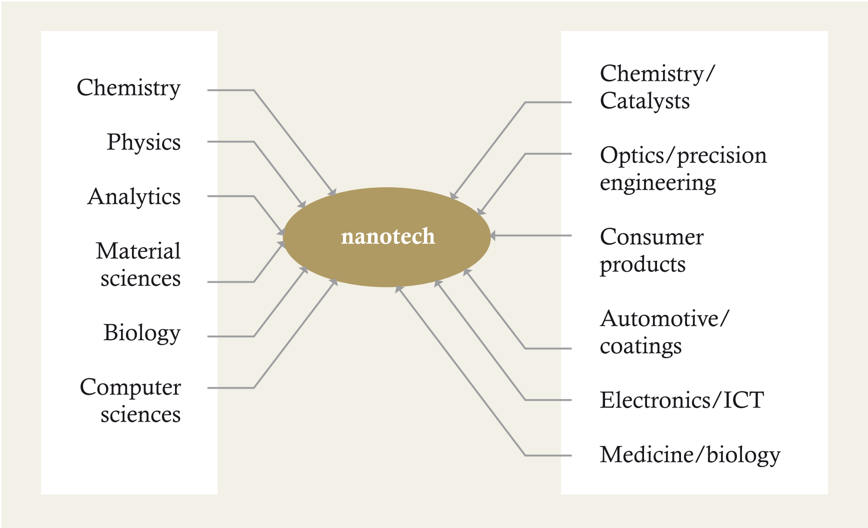
_Growth through innovations BASF will continue to purposely strengthen its research and development in 2007. It will focus on market-driven innovations, new business models and technology areas of the future. By 2010, BASF expects investment in innovation and R&D to generate annual sales of more than € 4bn. BASF further states that it has combined technology-driven issues of the future into the following five growth clusters: energy management, raw material change, nanotechnology, plant biotechnology, white (industrial) biotechnology.

Nanotechnlogy at BASF

Nanotechnology is one of the key technology-driven megatrends singled out for special development by BASF. The company has budgeted € 180m for investment in nanotechnology from 2006 until the end of 2008. BASF is focusing R&D activities in the three technology areas nanostructured materials, nanostructured surfaces and nanoparticles.

In October 2007, BASF and Harvard University announced an agreement to jointly establish the BASF Advanced Research Initiative. The joint research projects focus on understanding processes at the molecular and supramolecular level, i.e., on a nanometer scale.

Multidisclinary nature of nanotechnology, many markets to lock BASF onto



Source: BASF

In addition, BASF operates a global research center in Singapore. The company benefits in this way from the excellent local research infrastructure and strengthens its Asian research network. The center's 40 employees investigate nanostructured coatings for ship hulls that can prevent the buildup of marine organism deposits. Nanotechnology can thus help to mitigate environmental pollution on a sustainable basis, as these antifouling coatings do away with the need for biocides, for example in the form of heavy metals in paints. Ships with no biofouling can reduce their fuel consumption by up to 40 %. As well as investigating nanostructured surfaces, the Singapore center is working on organic materials for printed electronics and is investigating new and improved semiconductor materials for the production of transistor circuits.

As one of the world's leading companies in the field of chemical nanotechnology, BASF is already applying this expertise in many established areas of activity. In the cosmetics sector for example, BASF has for several years been among the leading suppliers of UV absorbers based on nanoparticulate zinc oxide and titanium dioxide. Incorporated in suntan lotions, the small particles are particularly effective in filtering the high-energy radiation out of sunlight. Because of their tiny size they remain invisible to the unaided eye. This is why the cream is transparent on the skin.

COL.9 is a new generation of binders for facade coatings. In these binders, inorganic nanoparticles are homogeneously incorporated into organic polymer particles of water-based dispersions. After application and drying, the inorganic particles form a homogeneous three-dimensional network structure. As a result, the coatings are extremely resistant to dirt and display high color tone stability.

BASF boasts the engineering plastic Ultradur® High Speed. Its flowability has been greatly improved by including a nanoadditive while maintaining the mechanical properties of the plastic. This not only makes production more cost-effective, it also saves energy and conserves resources – to the benefit for customers and the environment.

Nanostart

Price target
€ 75.00

Rating
Buy

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Stock data
Main Market
Xetra

Market cap (€ m):
120.8

No. of outstanding shares (m)
5.25

Daily traded volume (3 months avg; '000s)
1.35

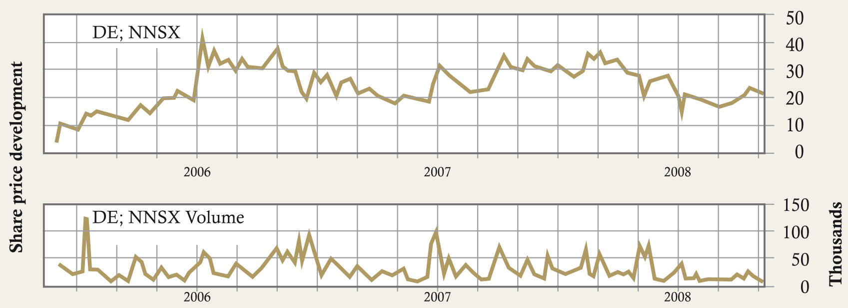
Indices
Entry Standard

Next event
AGM 08, 10 July

Free float
24 %

Closing price
€ 21.00

FY 31 Dec (€ m)	*2006*	*2007*	*2008e*	*2009e*
Profit loss				
Sales	0.6	0.4	0.5	0.6
y-o-y	N/A	-40.0 %	38.9 %	20.0 %
EBITDA	1.5	1.5	1.6	1.8
EBIT	1.5	1.5	1.6	1.8
EBIT margin	250.0 %	416.7 %	320.0 %	300.0 %
Net income	1.46	1.43	1.60	1.90
EPS (€)	0.28	0.27	0.30	0.36
y-o-y	N/A	18.2 %	19.0 %	20.1 %
EPS consensus (€)	N/A	N/A	N/A	N/A
DPS (€)	0.0	0.00	0.00	0.20
Cash flow				
Net income	1.5	1.4	1.6	1.9
Depreciation/Amortisation	0.0	0.0	0.0	0.0
Working capital movements	-0.4	-0.3	-0.3	-0.3
Operating cash flow	1.1	1.1	1.3	1.6
Net capex	0.0	0.0	0.0	0.0
Free cash flow	0.0	0.0	0.0	0.0
Balance sheet / Key ratios				
Closing cash (net debt)	-1.8	-1.7	-1.3	-1.0
Gearing	-15.1 %	-13.0 %	-10.0 %	-5.0 %
Capex ratio (tangible)	-4.8 %	0.0 %	0.0 %	0.0 %
ROE	N/A	N/A	N/A	N/A
ROCE	N/A	N/A	N/A	N/A
Valuation				
Enterprise value	94.0	106.7	116.7	111.2
Price/Book (x)	1.8	1.7	1.5	1.2
Dividend yield	0.0 %	0.0 %	0.0 %	0.1 %
EV/Sales	N/A	N/A	N/A	N/A
EV/EBITDA (x)	N/A	N/A	N/A	N/A
PER (x)	75.8	74.0	66.6	55.5
FCF yield	N/A	N/A	N/A	N/A



Source: Bloomberg, Silvia Quandt Research GmbH

Company profile

Nanostart AG is a global leader in venture capital investments specialising in start-up nanotechnology companies. As a venture capital company, the company invests in and provides managerial assistance to its portfolio companies, which have potential for growth.

While there are a few other companies featuring a similar business model as Nanostart, only US firm Harris & Harris is, in our view, comparable to it. However, only Nanostart has so far a track record when it comes to successful exits, e.g. divestiture of stakes in nanotech companies.

Nanostart unbeaten by competitors in terms of successful exits

Company	*Country*	*Portfolio companies*	*Nanotech exits*
Nanostart	**Germany**	**11**	**6**
Harris & Harris	USA	29	0
NanoDimension	Switzerland	3	0
NanoVenture	Germany	5	0
N² Nanotech	Germany	4	0

Source: Nanostart AG

Founded 2003, Nanostart AG has become the leading expert in the interface between nanotechnology and the capital markets. The company's two pillars of business are:

_Through its **portfolio division**, Nanostart provides venture capital financing for supporting growth of emerging companies who are boasting unique and innovative nanotechnologies. Nanostart also by capitalising on its management experience and expertise provides our portfolio companies with access to our global network. Professional commercialisation ensures the best chances for rapid growth and long-term company development, providing both Nanostart and its portfolio companies with the potential for high returns.

_Through its **financial division** Nanostart provides advisory support regarding investments in nanotechnology. The company is particularly experienced in transactions such as IPOs.

Nanostart's investment portfolio features products enabled by tiny technology to be applicable to a large number of industries, namely consumer goods, cleantech, life sciences, and IT and electronics. The company typically targets investments with sizes in the € 1-10m range.

The current portfolio includes seven nanotechnology companies active in fastly growing markets.

Nanostart's investment portfolio

Company	*Sector*	*Year of investment*	*Nanostart's investment (US $ m)*
BioMicro	Life sciences/diagnostics	2004	1,0
MagForce	Healthcare/medical technology	2004	12,7
Naturalnano	New materials	2004	0,5
Lumiphore	Life sciences/diagnostics	2005	0,8
ItN Nanovation	New materials/chemicals	2005	10,6
Nanodynamics	New materials/cleantech	2006	2,0
Nanosys	New materials/cleantech	2006	1,0
Holmenkol	Sports products	2007	5,2
CurioX	Life sciences/diagnostics	2007	0,6
NanoGram	New materials/cleantech	2007	1,0
Namos	New materials/cleantech	2007	0,6

Source: Nanostart

Aggregate investments in nanotech companies, as shown in the table, so far amount to approx. US $ 36m. Valuing these investments at market, e.g. taking market capitalizations and, in case of unlisted companies, book values, into account gives total net asset value of roughly US $ 290m. This contrasts with Nanostart AG's market value which is currently indicating some 64% discount to the firm's NAV.

Nanostart's investment focus is on spotting companies with innovative and emerging nanotechnologies, like MagForce's nanocancer treatment or ItN Nanovation's nanoceramic coatings products. As we have pointed out before in this report, potential returns from these companies can be very high and the level of profit margins is only set by the innovator.

Nanostart portfolio companies at a glance

BioMicro Systems, Inc

_ The company produces and markets nanotech-based analysis tools for life science markets, e.g. applications in standard microarray research (for instance, hybridization platforms and disposables, complementary hardware).

_ BioMicro Systems had US $ 5m sales in 2007.

_ Company is in the late stage.

_ Recent major company development was an OEM cooperation with Nimblegen/Roche; more than 450 systems sold in the meantime.

CurioX

_ The first spin-off of Singapore's world-renowned Institute of Bioengineering and Nanotechnology (IBN).

_ The company develops, produces and markets Nanotech-based analysis tools for life science markets, e.g. applications in all kinds of bioassays (like fully automated washing stations).

_ CurioX boasts a patented technology platform for convenient and highly cost-effective analysis of aqueous bioassays which leads to significant cost reduction through enormous reduction of processing time and amount of reagents and material used.

_ Company is in the growth financing state.

_ The DropArray LT technology platform is ready for market; two other platforms are in a prototype stage and one additional platform in the development stage.

Holmenkol AG

_ Holmenkol is a traditional sports products provider with a strong brand and a new technology platform. The company develops and produces highly innovative, nanotechnology-based surface coatings like ski waxes, slide sealants, waterproofing products, polishes, detergents and hygienic coatings; further expansion is sought into new areas like outdoor and aquatic/sailing.

_ Holmenkol's exploits emerging nanotechnologies with which it is creating totally new markets particularly in the area of aquatic/sailing.

_ The company is in the growth phase; Nanostart holds a board seat.

_ Recent company development included the initiation of several new sales and distribution partnerships as well as the streamlining of R&D, production, sales and distribution into a single location.

ItN Nanovation AG

_ See full company analysis in this report.

Lumiphore, Inc.

_ The company is a spin-off with the University of California at Berkeley. Lumiphore has developed proprietary ultra sensitive nano-based reagents.

_ Lumiphore exploits emerging nanotechnology. The compounds manufactured have break through characteristics which vastly enhance existing products or enable construction of completely new products, such used for diagnostic Point-of-Care tests.

_ Lumiphore is in the late-stage phase.

_ The company has signed an exclusive license agreement with Cisbio, a leading global developer of technologies for drug discovery using high-throughput screening (HTS) employing 600 employees. This contract is likely to lead to significant revenues already in 2008.

MagForce Nanotechnologies AG

_ See full company analysis in this report.

Namos GmbH

_ Namos is a leading research company in the area of bio-nanotechnology. Its technology is capable to reduce the amount of precious metals required for manufacturing automotive catalytic converters, by about one half compared to current production methods.

_ The company currently is in the growth-financing phase.

_ Namos boasts unique technology compared to competitors, offering high savings potential. Its platform technology is attractive for a wide range of applications in other industry sectors.

NanoDynamics, Inc.

_ Based on its proprietary nanoparticle platform, NanoDynamics develops and markets novel products for cleantech Applications, ie portable fuel cells or drinking water filters. By nature, this is potentially high-growth and high-margin emerging nanotechnology.

_ The company is in the late-stage phase.

_ NanoDynamics is the leader in the area of nanotechnology-based clean-tech products, deploying proprietary technology. The company is already selling its products in rather large markets.

_ Recent company events showed the company starting biofuel production in Australia in cooperation with Global Technex as well as initiating marketing for portable fuel cells.

NanoGram, Inc.

_ NanoGram has developed proprietary technologies for the production of nanoparticles and layers. It is commercially engaged in many large and fast-growing markets, such as solar and electronics (LCD's, battery materials, LED's, OLED's).

_ Essentially, NanoGram's platform technology offers significant business potential as demonstrated by the large number of cooperation agreements with major industrials. For instance, in the area of solar this new technology can potentially transform the traditional value chain, enabling a significantly cheaper production of highly efficient thin-film silicon solar cells. From a viewpoint of users, NanoGram's product helps containing costs.

_ The company is in the late-stage phase.

_ Recent company newsflow highlighted the initiation of build-up of solar pilot plant as well as the establishment and extension of a commercialization partnership with the global acting chemical company Nagase & Co., Ltd. in Tokyo.

Nanosys, Inc.

_ Nanosys develops and manufactures new types of complex inorganic nanostructures. Applications are, for example, in memory products, LCD's, electronic components or fuel cells for electronic products.

_ Nanosys is the global leader in the developing production and marketing of complex nanostructures. A vast range of technologies is covered via more than 450 patents and patent applications while strategic partnerships with leading global players provide superb market penetration. The company currently is transition to generate product revenues.

_ Nanosys is in the late-stage phase.

_ Recent company newsflows highlighted the conclusion of several R&D and cooperation agreements, for instance, with Sharp, Bruker Daltronics, Rochwell Collins, NTT DoCoMo, Intel.

Naturalnano, Inc.

_ Naturalnano sells unique proprietary procedures for the preparation and purification of naturally occurring nanotubes and other nanomaterials.

_ Applications of the company's products are found in various consumer products with the technologies of Naturalnano creating polymer composites with entirely new kinds of properties and functions. This particular industry is worth approx. US $ 40bn annually.

_ The company is listed (German stock exchange).

_ Recent company events featured a successful pilot production demonstration of halloysite nanotubes made of polypropylene as well as the announcement of starting a large-scale production of nylon Pleximer™.

Valuation

We have valued Nanostart by 1) appraising the target exit value for two of Nanostart's most valuable investments, as we see it, MagForce and ItN Nanovation (both are featured as case studies in our report), and 2) applying P/NAV 2008e as estimated by consensus for US nanotech company Harris & Harris.

The two valuations suggest a target price (per share) for Nanostart of € 80 and € 75, respectively.

Nanostart core investments and implied exit values

Company	*Implied target value (€ m)*	*Nanostarts share*	*Nanostart`s implied exit value (€ m)*
MagForce	1,265	81.1 %	1,026
ItN Nanovation	92	20.6 %	19

Source: Nanostart core investments

First, the two equity stakes in MagForce and ItN Nanovation represent exit values of some € 1.045bn for Nanostart, if we apply our target valuations for both companies and in relation to Nanostart's stakes. On a per-share basis this would imply a target price of € 199 per share. Plainly, this exit value is hard to justify to be realised in the short-term as both nanotechnology companies still need to establish a track record for earnings growth and visibility. Still, applying reasonably discounts to the implied exit value, alike those common for venture capital investment, for instance, 60% to represent a very prudent stance on investing into Nanostart directly (rather than buying the listed companies directly), the resulting target price for Nanostart would be approx. € 80 per share, about fourfold the company's current market capitalization.

Such finding is comfortably reflected in our appraisal of Nanostart's intrinsic value by applying price-to-net-asset-value metrics (P/VAV). As a yardstick for valuing Nanostart on these grounds we have used consensus P/NAV (2008e) estimated for the company's most comparable, Harris & Harris (although this comparison, as we made clear before, is lacking we believe, for the US company has no record in successfully exiting nanotech investments as yet, which we consider a major value driver for this type of company, from a viewpoint of investors in those stocks). On those valuation grounds Nanostart is trading at a substantial discount to Harris & Harris, which we consider unjustified. Applying the same P/NAV multiple as is reflected by the consensus view, i.e. 1.24x 2008e, Nanostart's implied value would be 3.5x higher than its current rating. As a result, the intrinsic value is approx. € 75 per share. This finding coincides comfortably with our sum-of parts analysis, taking into account two of Nanostart's most important investments.

Comparative valuation
Nanostart versus Harris & Harris on P/NAV grounds

Company	*Current share price*	*NAV per share 2008e*	*P/NAV*
Nanostart	**€ 20.10**	**€ 55**	**0.36 x**
Harris & Harris	US $ 7.99	US $ 6.45	1.24 x

Source: Silvia Quandt Research GmbH; Reuters consensus

Still, we would consider such a price target to be reached over the medium to long-term given the uncertainties regarding possible exit values for investments, which particularly hold in the nanotechnology area.

MagForce

Price target
€ 335.00

Rating
Buy

Headquarters
Spandauer Damm 130
14050 Berlin
Germany

IR
Christopher Radic
+49 (0) 30 308 380 0

Stock data
Main Market
Xetra

Market cap (€):
187.7

No. of outstanding shares (m)
3.77

Daily traded volume (3 months avg; '000s)
0.1

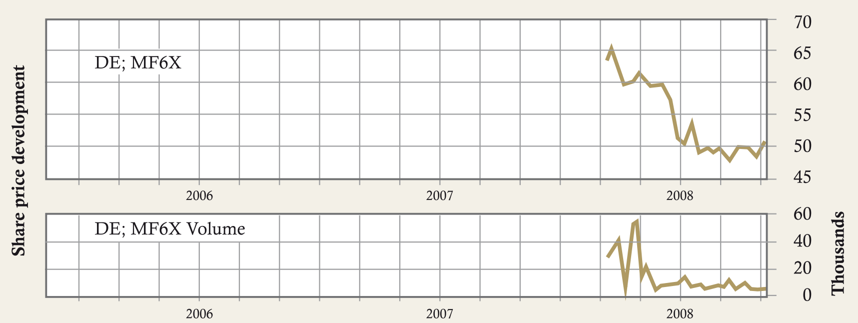
Indices
Entry Standard

Next event
N/A

Free float
3.37 %

Closing price
€ 49.80

FY 31 Dec (€ m)	*2008e*	*2009e*	*2010e*	*2011e*
Profit loss				
Sales	0.0	0.0	0.6	0.7
y-o-y	N/A	N/A	N/A	17.1 %
EBITDA	-3.9	-5.8	-6.0	3.5
EBIT pre except.	-4.5	-6.6	-6.5	2.9
EBIT margin	N/A	N/A	N/A	406.3 %
Net income	-4.8	-6.8	-6.8	2.3
EPS	-1.3	-1.8	-1.8	0.6
y-o-y	N/A	N/A	N/A	N/A
EPS consensus (€)	N/A	N/A	N/A	N/A
DPS (€)	0.0	0.00	0.00	0.00
Cash flow				
Net income	-4.8	-6.8	-6.8	2.3
Depreciation/Amortisation	-0.6	-0.7	-0.5	-0.6
Net working capital movements	0.0	0.0	-0.1	0.0
Operating cash flow	-4.2	-6.1	-6.4	2.8
Net capex	-3.0	-1.7	-1.3	-1.5
Free cash flow	-7.2	-7.8	-7.7	1.3
Balance sheet / Key ratios				
Closing cash (net debt)	-2.5	-8.6	-14.4	-15.5
Gearing	17.0 %	-74.0 %	-82.4 %	-96.7 %
Capex ratio (sales)	N/A	N/A	217 %	206 %
ROE	268.4 %	90.7 %	48.3 %	-14.6 %
ROCE	-221.2 %	-283.7 %	-314.4 %	149.4 %
Valuation				
Enterprise value	187.4	193.3	199.3	202.7
Price/Book (x)	N/A	N/A	N/A	N/A
Dividend yield	0.0 %	0.0 %	0.0 %	0.0 %
EV/Sales	N/A	N/A	N/A	N/A
EV/EBITDA (x)	-47.87	-33.1	-33.3	57.8
PER (x)	-39.0	-27.5	-27.8	83.2
FCF yield	-3.3 %	-3.0 %	-2.4 %	0.5 %



Source: Reuters, Silvia Quandt Research

Company profile

MagForce is the global leader in the field of nanotechnology cancer treatment. The company was founded in 1997 by Dr. Jordan, formerly practising at Charité University Medical Center, Berlin.

The company went public via IPO in September 2007 (Entry Standard/Open Market). Current free float is 3.37 % (3.772 million shares outstanding). Major shareholders are Nanostart (Reuters code: NNSG.DE) 81.17 %, CSO Dr. Jordan 9.79 %, Charité Stiftung 2.18 %, Dr. Uwe Maschek 0.9 %, Dr. Anne Maschek 0.9 %, Charité 0.71 % and second level management 0.98 %.

The revolutionary technology invented by MagForce enables that tumors are heated and thus destroyed without damaging adjacent healthy cells. Destroying tumours with magnetic nano-particles (produced exclusively by MagForce) whilst surrounding healthy cells remain intact means a quantum leap in drug application as this treatment means considerably decreased (adverse) side effects on patients, hence substantially increasing their quality of life.

Since the products (nanoparticles, software, applicator) is not classified as a conventional drug but a medical-technical device no phase III trials (in-vivo, in patients) is necessary to sell the product. For that matter, completing phase II trials for, for instance, treatment of glioblastoma is scheduled for December 2008 (eg finishing recruiting patients), followed by 12 months re-examination of patients. So far, the treatment of patients sampled for the trial has been successful and recruiting the minimum number of patients is obviously on schedule.

Exclusive marketing of the nano-cancer treatment in the USA, e.g. alone, would most likely require phase III trials commanded by the FDA which are rather costly and thus, at this stage, of MagForce's evolution unbearable. For this reason, the company plans to out-licence the rights to sell the product in the US market to other companies. Pending the results of the outcome of phase II trials milestone payments are factored into the business plan as part of the various cash inflows (selling Nanotherm particles, the applicators, milestone payments) for the years 2010 to 2012.

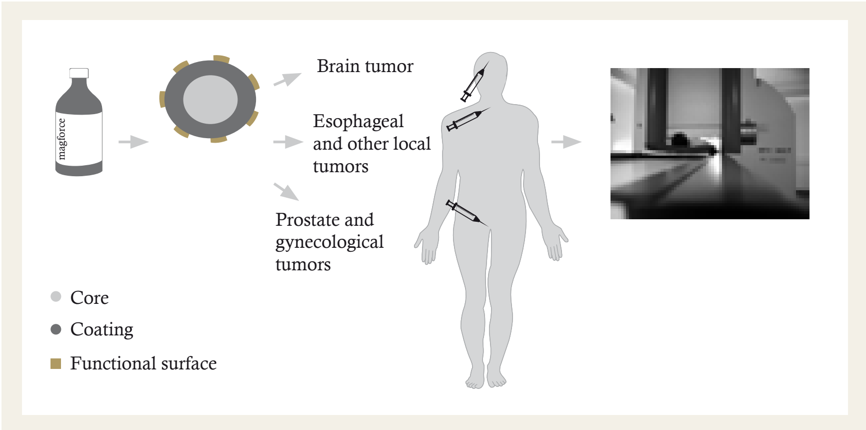
We would still expect the company to seek outright marketing of their product by their own in probably also the US market if cash flows profit generation will develop successfully over the years, following the planned start-up marketing of glioblastoma treatement in 2010, in order to cash in higher margins and cash than is common with royalties-related sales.

How MagForce's product works

Treatment of cancer via nanotherapy by MagForce is being processed in 2 steps (source: MagForce):

_Step 1 Nanoparticles are placed directly into the tumor using minimally invasive techniques, where they remain in place due to their special coating. The particles are preferentially absorbed by the tumor cells because of their greater affinity compared to normal cells.

MagForce's nanocancer therapy



Source: MagForce

_Step 2 The magnetic field applicator (price for this expected to be € 600,000, one-off investment costs for user, i.e. hospitals) causes the nanoparticles to oscillate, producing warmth (43-70 °C) which destroys the tumor cells. Since this procedure does not harm the patient and the nanoparticles remain at the tumor site for an extended time, the treatment may be repeated as often as necessary.

Management strongly believes that its therapy will establish itself as an equal forth pillar in cancer treatment next to conventional methods like surgery, radiation and chemotherapy. Needless to say that this therapy can also be used complementary to the conventional treatment methods.

Aspects of cancer treatment

Several aspects are imperative for any cancer drug or treatment to be an effective weapon against this serious disease which has already taken over as an indication cardiovascular drugs market volume. Since incidences of people suffering from cancer disease are likely to grow disproportionally in the coming years, makers of products with therapeutic breakthroughs can look for very high profits and returns.

_Survival is the most important outcome of cancer treatment. An improvement in at least disease-free survival is a prerequisite for recommending adjuvant therapy. In the case of metastastic cancer, treatment can be recommended even without an improvement in survival rates, if it improves quality of life.

_Quality of life includes overall quality of life, as well as its physical, psychological, and social dimensions. To be an outcome of cancer treatment, quality-of-life measures must be sensitive to clinically meaningful changes produced by treatment.

_Toxicity, both short and long term, is vitally important, with the latter being particularly critical in children (because of the effects of treatment on growth and development).

_Measures of cancer response include measures of tumour response (i.e. complete response, partial response, response duration, and time to progression), biomarkers, and cancer-induced abnormalities in common blood tests. The tumour response is likely to be positively correlated with improvement in quality of life when a patient is symptomatic from the cancer before treatment, the complete response rate of the tumour is relatively high, and the treatment toxicity is modest.

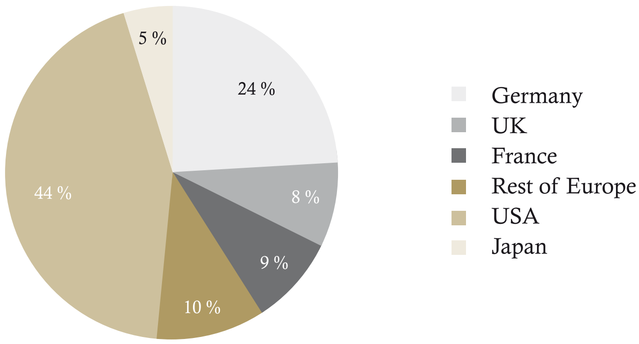
_Cost-Effectiveness is a way to evaluate cancer treatment and also to compare the benefits of cancer treatment with the benefits of other kinds of medical treatment (e.g. dialysis) that are competing for the same healthcare money. Cost-consciousness should be part of technology assessment and guideline development. For example, if two chemotherapy regimens produce the same patient outcomes but one costs more than the other, the less costly regimen should be preferred. However, a cost comparison is more than a simple comparison of the charges for the drugs and their administration. Costs associated with the ease or difficulty of administration, the treatment facility, joint medications, and adverse events must also be considered.

Investment summary and bullet points

Overall we consider the company's business plan and assumptions made therein to be based on rather prudent assumptions. We believe there is substantial headroom that MagForce will eventually exceed its business plans as it stands right now. For instance,

1. Percentage of treatment of cancer with MagForce's product is planned by management to grow from an initial rate (i.e. in the year of entering the oncology market) of 2% of total patients indicated to cancer (and treated) to peak at 8% in 2018 (according to MagForce's business plan). Still, in our appraisal of the company's future cash flows generated from selling their product we have started with 1.2% market share in 2010 climbing to 4.8% at peak (2018). Judged from recent life-cycles of life-saving (conventional) drugs from invention to reaching maturity or facing competition of generic drugs, this view appears to be too conservative, hence leaving substantial upside enhancement potential for earnings growth.

Accumulated revenues (2010-2019) by country/region



Source: MagForce, Silvia Quandt Research GmbH estimates

2. Bottom-up aggregation of carcinoma incidences in our view looks very restrictive.

3. The company's own DCF valuation based on the long-term business plan looks, we firmly believe, very prudent.

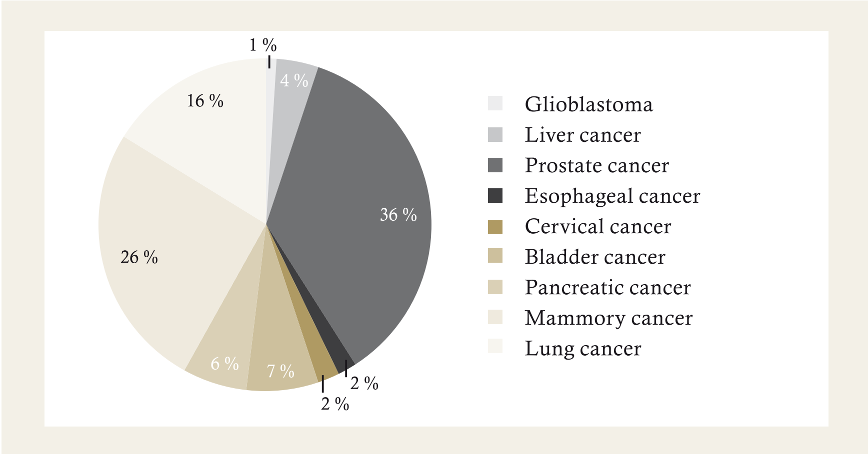
4. MagForce is not threatened at all from other companies trying to invent similar products (see table page 65). As a rule of thumb, lead time in the drug industry potentially secures a prolonged period of time for high margins to be generated.

5. Future application of MagForce's product aim to enable drug delivery functionality through the bloodstream. If the company could pioneer this, this would mark a breakthrough in cancer treatment (and possibly for other indications too) and would create a huge market for MagForce.

6. The global cancer market has nearly doubled in the last four years and is forecast to be worth US $ 65bn by 2012, while shortly over-taking cardiovascular drugs as the number one drugs segments within the industry.

7. MagForce is planning to cover all major incidences of cancer, according to the company's planning for the period 2010, the year of launchning the first treatment of glioblastoma, through 2019 by when the intended coverage as shown in the next chart will be completed.

Planned coverage of types of cancers (accumulated revenues 2010-2019)



Source: MagForce, Silvia Quandt Research GmbH estimates

8. The company currently consumes cash spent on trials, personnel, fees paid to medical institutions etc., (but the time to market is shorter than for conventional drugs because the MagForce product is classified a medical-technical device, hence requiring only 2 instead of 3 phases of test in-vivo and in-vitro) without generating any revenues. This is requiring fresh money in the coming months to proceed with trials on plan. Still, we strongly recommend investors looking for potentially high returns on investment should consider injecting cash via participation in the company at this stage because we judge business prospects of MagForce to be sound. As marketing start-up of their cancer treatment product is not too remote (2010), visibility of profit and cash generation is in our view sufficiently large.

9. Milestone payments should amount to € 25m until 2011 when MagForce expects results to become black-inked, which according to the company would limit the incremental cash requirements to some € 15m.

Compared to the proprietary technology deployed by MagForce, alternative methods of thermotherapy either produce insufficiently high temperatures within the tumor or cause significant damage to healthy tissue.

Nanocancer therapies compared

	Surgery	*Radiation*	*Chemotherapy*	*Nanotherapy*
Side effects	moderate	high	high	minimal
Precision of targeting any body region	limited	limited	no	yes
Treatment may be repeated as often as necessary until tumor is destroyed	no	no	no	yes
Treatment of large tumors (>5 cm diameter)	yes	yes	yes	no (e.g. not yet)
The therapy can differentiate between tumor tissue and healthy tissue	limited	no	limited	yes

Source: MagForce

Potential competitor, but none to be as progressed or effective a s MagForce

Country	*Company*	*Method*	*Status*	*Comments*
Germany	MagForce	Minimally invasive introduction of nanoparticles	Phase II	Over 100 patients treated
USA	Tritron Biosystems	Antibody-coated nanoparticles	Preclinical	Insufficient nanoparticle concentration to produce heat
Australia	Sirtex Medical	Magnetic microparticles	Preclinical	European patent was revoked in ist entirety
Netherlands	Philips	Coil-based thermal therapy systems	Preclinical	No expertise in nanoparticles

Source: MagForce

Valuation

We consider discounted cash flow valuation to be the appropriate model to evaluate MagForce - on such grounds we arrive at the fair value of € 335.4 per share or approx. € 2.06bn in nominal terms. Plainly, short-term share price enhancement is likely to fall short of such a target price, due to the time left until 2010 (when the company expects to receive registration for its treatment of Glioblastom) because investors are likely to apply discounts to the company's enormous value potential. However, applying higher capital costs (WACC) to mark individual hurdle rates, is common practice namely among venture capitalists. Factoring in higher WACC clearly would indicate a lower target price, for instance, € 134 per share if capital costs of 11.5% are assumed. We argue that key drivers and triggers for short-term appreciation of the share price towards this target would be positive newsflows in connection with the progress of phase II trials with patients (Glioblastom).

Major assumptions for model determinants and input are as follows:

1. Average 7.6% WACC (after tax) for the forecast period 2008-19

2. Average ROIC 35.1% (after tax) for the forecast period 2008-19
3. Equity risk premium (over 10-yr bonds) of 4% throughout forecast period
4. Long-term growth of assets (e.g. intangible/tangible assets) of 2.4% pa in 2008-19
5. Selling price for Nanotherm of € 4,500 (versus MagForce assumes € 6,000)
6. As is common with life-saving drugs (i.e. orphan drugs) which don't face compe tition as a result of their superior sum-of-merits profile, ie high efficacy plus low side effects, MagForce is capable, we believe, of reaching 67% EBIT return on sales at the height of product's life cycle, e.g. 2019 according to our estimates, when all types of cancer treatments according to the firm's planning are rolled out. The company expects peak margins, according to their business plan, not to materialise before 2019, which looks plausible due to the validity time of patents. Hence, no generic competiton expected until that year. As a result, we have assumed steady progression in revenues and profits until the end of our forecast period, e.g. 2019.

DCF MagForce

	2008	*2009e*	*2010e*	*2011e*	*2012e*	*2013e*	*2014e*	*2015e*	*2016e*	*2017e*	*2018e*	*2019e*
EBIT	-4.5	-6.6	-6.5	2.9	3.1	-5.5	16.0	46.7	82.6	104.5	125.4	140.4
Effective tax rate for EBIT	0 %	0 %	0 %	15 %	10 %	0 %	15 %	36 %	38 %	38 %	38 %	38 %
Depreciation	0.6	0.7	0.5	0.6	0.8	0.8	0.8	0.8	1.1	1.0	0.9	0.9
Additional investment – FA	3.0	1.7	1.3	1.5	3.2	1.6	1.2	3.5	5.3	5.6	3.7	1.9
Additional investment – NWC	0.0	0.0	0.1	0.0	0.6	1.6	6.8	9.7	10.6	3.1	3.9	2.3

Opening capital employed (2007)				
Fixed assets	2.1	WACC	7.6 %	Avg. 2008-2019
Net working capital	0.0	Long term growth	2.4 %	CAGR 2008-2019 fixed assets
	2.1	Incremental ROIC	35.1 %	Avg. 2008-2019

	2008	*2009e*	*2010e*	*2011e*	*2012e*	*2013e*	*2014e*	*2015e*	*2016e*	*2017e*	*2018e*	*2019e*	*TV*
EBIT	**-4.5**	**-6.6**	**-6.5**	**2.9**	**3.1**	**-5.5**	**16.0**	**46.7**	**82.6**	**104.5**	**125.4**	**140.4**	**143.7**
Tax on EBIT	0.0	0.0	0.0	-0.4	-0.3	0.0	-2.4	-16.8	-31.5	-39.8	-47.7	-53.4	0.0
NOPLAT	**-4.5**	**-6.6**	**-6.5**	**2.5**	**2.8**	**-5.5**	**13.7**	**29.9**	**51.1**	**64.7**	**77.7**	**87.0**	**143.7**
Depreciation	0.6	0.7	0.5	0.6	0.8	0.8	0.8	0.8	1.1	1.0	0.9	0.9	0.9
Additional investment – FA	-3.0	-1.7	-1.3	-1.5	-3.2	-1.6	-1.2	-3.5	-5.3	-5.6	-3.7	-1.9	2.0
Additional investment – NWC	0.0	0.0	-0.1	0.0	-0.6	-1.6	-6.8	-9.7	-10.6	-3.1	-3.9	-2.3	2.3
Enterprise cash flow	-7.0	-7.6	-7.4	1.6	-0.3	-7.9	6.5	17.5	36.3	57.0	71.0	83.7	148.9
PV of enterprise free cash flow	-6.5	-6.5	-6.0	1.2	-0.2	-5.1	3.9	9.7	18.7	27.3	31.6	34.6	2,821.6
PV cash flow in years 2008-19	102.8												
PV of terminal value	1,167.2												
Less: minorities 07e	0.0												
Less: net (debt)/cash 08e	-5.6												
Adjusted equity value	1,264.5												
No. of shares outstanding (m)	3.77												
DCF (CHF)	**335.4**												

Source: Silvia Quandt Research GmbH

Sensitivity to capital costs assumptions is large. For instance, at 11.5% WACC, the implied DCF per share would be € 133, in line with approaching MagForce's fair value from the VC angle (as described before). Factoring in 14% for WACC would yield DCF per share of approx. € 82 – still almost 70% above the current share price. It follows, that risk-averse investors may want to apply a large safety margin to MagForce's DCF appraisal. But even then the stock looks substantially undervalued judging their efforts and progress in pioneering the first effective nanocancer treatment ever launched to the market.

Equally, anticipated cash flows and DCF values are very sensitive to assumptions made for both costs per treatment per patient and the level of market shares. This is shown in the next table:

DCF sensivity to treatment costs and market share

	€ DCF / share	**Costs per treatment per patient**					
	335.4	1,000	2,000	3,000	4,000	5,000	6,000
Market share platform 2008	1.0 %	44	110	176	241	307	373
	1.2 %	60	139	217	296	375	455
	1.4 %	78	170	261	354	446	540
	1.6 %	95	199	304	410	516	566
	1.8 %	111	229	347	467	548	629
	2.0 %	128	259	390	523	585	704
	2.2 %	145	289	434	550	646	782
	2.4 %	161	318	477	567	710	860

Source: Silvia Quandt Research GmbH

Assumptions for market shares are made on the premise that subsequent the year of launch (e.g. 2010 for treatment of Glioblastom) relative market share gains are assumed to be fading through the year of 2018. That year the company's planning shows those gains to pleateau.

According to MagForce's business plan market share for its cancer treatment will peak in 2018 reaching 8 %, from where quotes will smoothly decline. While we consider this assumption, e.g. market share to climb from an initial 2 % to 8 % at peak to be realistic given the dynamics of the cancer treatment markets and the exceptional prospects for launching innovative treatments for that indication, we have still adopted a rather prudent stance in modelling the company's business performance.

According to our assumptions, we not only assume a price per treatment per patient of € 4,500 compared to MagFore's € 6,000 price tag applied in their financial planning but we also factored in a start-up market share of 1.2 %, about half of the firm's parameter, e.g. 2 %. still sticking to the fading trend for relative market share gains assumed by the company, according to our model market share will peak at 4.8 % in 2018, compared to their planning, e.g. 8 %.

CentroSolar

Price target
€ 30.00

Rating
Buy

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Stock data
Main Market
Xetra

Market cap (€ m):
128.8

No. of outstanding shares (m)
14.55

Daily traded volume (3 months avg; '000s)
28.0

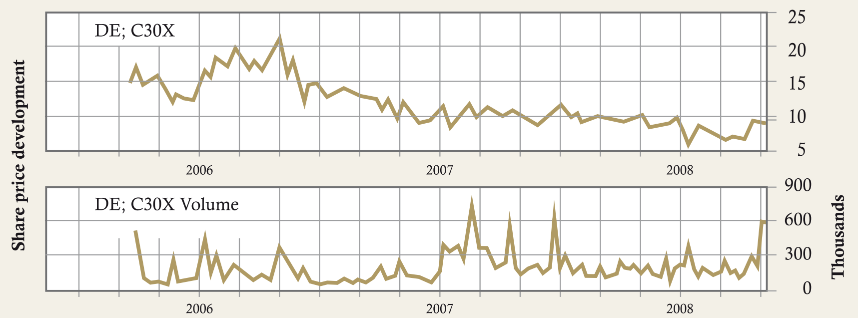
Indices
Prime Xetra

Next event
AGM FY 07, 15 July

Free float
51 %

Closing price
€ 9.20

FY 31 Dec (€ m)	*2006*	*2007*	*2008e*	*2009e*
Profit loss				
Sales	174.5	220.3	315.0	370.0
y-o-y		26.2 %	43.0 %	17.5 %
EBITDA	9.8	15.0	23.0	30.0
EBIT	8.9	13.4	15.0	22.0
EBIT margin	5.1 %	6.1 %	4.8 %	5.9 %
Net income	1.70	1.4	7.8	14.4
EPS (€)	0.14	0.10	0.52	0.92
y-o-y		28.6 %	422.7 %	76.2 %
EPS consensus (€)			0.53	0.96
DPS (€)	0.0	0.00	0.00	0.00
Cash flow				
Net income	1.7	1.4	7.8	14.4
Depreciation/Amortisation	-8.0	-8.0	-8.0	-8.0
Working capital movements	-21.0	-5.0	-25.0	-15.0
Operating cash flow	-11.3	4.4	-9.2	7.4
Net capex	-20.0	-15.0	-15.0	-13.0
Free cash flow	-31.3	-10.6	-24.2	-5.6
Balance sheet / Key ratios				
Closing cash (net debt)	-69.1	-57.2	-43.3	-29.4
Gearing	20.1 %	47.2 %	72.6 %	69.6 %
Capex ratio (sales)	11.5 %	6.8 %	4.8 %	3.5 %
ROE	2.7 %	1.9 %	9.0 %	14.5 %
ROCE	4.3 %	7.5 %	14.3 %	18.5 %
Valuation				
Enterprise value	204.1	173.1	187.2	198.9
Price/Book (x)	3.3	1.9	1.6	1.5
Dividend yield	0.0 %	0.0 %	0.0 %	0.0 %
EV/Sales	116.9 %	78.6 %	59.4 %	53.8 %
EV/EBITDA (x)	19.6	9.2	5.6	4.5
PER (x)	111.1	104.0	17.7	10.0
FCF yield	-12.5 %	16.6 %	-5.4 %	-15.6 %



Source: Bloomberg, Silvia Quandt Research GmbH

Company profile

As a systems integrator, the company produces plug and play photovoltaic systems for private houses and industrial properties. It is leading in Solar Roof Systems and Key Components.

Centrosolar businesses at a glance

Solar integrated systems	Strong product and geographical growth Unique position with roof systems To benefit from assumed cyclical price drop of crystalline solar cells from 2009 Large synergies from venture with Quimonda improves value creation along the solar business chain and stabilises future margin development
Solar key components	Global leader in nanocoated solar glass manufacturing High margin patented niche products in photovoltaic area

Source: Centrosolar businesses at a glance

Centrosolar Group is a leading provider for solar integrated systems and solar key components. The company not only offers standard grid-connected systems, but is also leader in non-grid connected solar power generators. Moreover, the company is a first mover in building integration, offering e.g. roof covers with integrated thin film solar cells. It operates through seven subsidiaries, using traditional merchants as a sales channel.

The company owns patents for most of its accessories. This includes its mounting systems for flat roofs and its nanocoating technology for solar glass which reduces sunlight reflection. The most important segment is the integrated solar systems.

Nano-anti-reflective coating

A patent has already been granted in Germany for a technique that enhances the effectiveness of photovoltaic solar modules. Patents are pending for other coating techniques with an extensive scope in Germany, the European Union and the USA.

In solar technology (photovoltaic, thermal solar glass, greenhouses) efficacy rates are the most important ratios to compare indivual performances. Efficacy rates depend on the percentage of high light to transmit the glass surface to generate energy. This happens through converting solar energy into electricity by the photovoltaic effect. The challenge for the producer is, at the same time, to shield the solar cell to weather impact, for instance, rain. Hence there is always the need to apply a protective coating which usually consist of glas or plastic. The challenge here, however, is to secure transmission of as much as sun light as possible and to prevent reflexion on the surface. Here is where Centrosolar's unique nanocoating technology excels versus conventional coating techniques.

Apart from supplying solar glasses with low iron content which are superior to the industry standard in terms of allowing more light transmission, e.g. more than 90 %, Centrosolar's new nanocoated solar glasses (brandname Centrosol HiT) further improves light transmission, to 97 %. The efficacy gain is due to an innovative coating of the solar glass. Reflexion is negligible at 0-1 % compared to some 4 % reflexion common for low iron glass.

The higher efficacy of nanocoated glass commands a higher price which is approx. € 555 compared to € 540 asked for one low iron modules (one module consists of many glasses which typically cost € 13 per module compared to € 22 Centrosolar is asking for the nanocoated glass). The other merit of nanocoated glasses is that is boasts hydrophile characteristics, e.g. nanocoated glasses are self-cleaning, hence performance is even better to traditional solar glasses.

The nanotechnological production is intellectual property of Centrosolar, e.g. patented. The nanolayer is only 150nm thin.

Joint venture with Qimonda to solve long-term silicon feedstock problems

Centrosolar lately announced to co-invest with semiconductor company Qimonda into a new solar cell production plant, located in Portugal. Centrosolar takes a 49 % share in that joint company, in return securing coverage of approx. 25 % of its total module manufacturing capacity with this supply. Initially the production plant will produce approx. 100 MWp by the end of 2009 and it planned to produce double of that output or more when running at full capacity. The total capex needed to fund that venture shall be € 70m.

The rationale for Centrosolar to team up with Qimonda is

_Securing approx. 25 % of its annual module production capacity (estimated 195 MWp in 2010) at much more favourable terms than comparable long-term contracts from cell manufacturers.

_Further expansions of the venture company to feed Centrosolar's accelerating growth in the future.

_Using the crystalline silicon technology is planned to be leveraged to achieve electrical efficiency in solar modules of more than 16 %, compared to the competitors 13 % ratios for crystalline modules and less than 10% for thin-film coated solar modules.

_Qimonda can provide access to further silicon supplies as well as providing R&D power and production and construction know-how when it comes to silicon production facilities.

Strategy

Branding and technology edge are playing a key role in the future of Centrosolar. They are market leader in nanocoated solar glass; they are close to the customer trough a service oriented business model. They got a leading position in solar roof systems and key components. The expansion of services in defendable market segments ("roof experts") is focused for the years to come. Further is the broadening in international reach a target, there's much room for further growth especially in southern European countries. On the financial side continuing profit improvements and above market top line growth is expected.

2007 and 2008 outlook

On the basis of provisional, unaudited figures Centrosolar Group AG, increased its revenue to more than € 221m (+28 %) in the past financial year. The company was able to push up its operating result (EBITDA) even more steeply to € 15m (+50 %). In view of the healthy level of earnings in the past year and the busy project pipeline, 40 % revenue growth to € 310m and disproportionately high growth in the operating result are forecast for the current year.

We expect EBITDA to reach € 23m, the operating result is forecast to rise by a faster rate of approx. 50 %. Thanks to falling depreciation and amortization, EBIT and EPS are even expected to increase multi-fold. Last year's one-off charge related to the (internal) merger of the integrated systems suppliers Solarstocc, Biohaus and Solara, reducing the operating result by around € 2m, won't recur this year. Earnings are thus expected to continue rising over proportionally in 2008 and beyond.

In the integrated systems division growth drivers will be 1) expansion in 7 countries is generating substantially higher revenue streams from international business, above all in Southern Europe, 2) extending the product range to include roof-integrated systems and large-scale facilities for industrial roofs has given the company access to new sales markets.

The "Solar Key Components" segment (solar glass and module mounting systems) is showing particularly healthy progress. The unique nanocoated solar glasses that allow higher light transmission are sold out worldwide, despite the fact that they have stepped up production considerably. Revenue from the patented mounting systems is likewise limited by production capacity.

Valuation

We have appraised Centrosolar's intrinsic value on two grounds, EVA and DCF modelling. For DCF per share we have derived a fair value of € 29.6 for the stock. We consider the EVA trends as evaluated in our model as a fair guidance for mid to long-term share price enhancement. Judged from the positive EVA progression assumed in the coming years the share price could trend up towards the € 20-40 per share range.

DCF CentroSolar

	2008	*2009e*	*2010e*	*2011e*	*2012e*
EBIT	15	22	28	32	36
Effective tax rate for EBIT	28 %	28 %	28 %	28 %	28 %
Depreciation	8	5	5	4	5
Additional investment – FA	20	15	10	10	13
Additional investment – NWC	21	5	25	15	10

Opening capital employed (2007)	
Fixed assets	75
Net working capital	54
	129

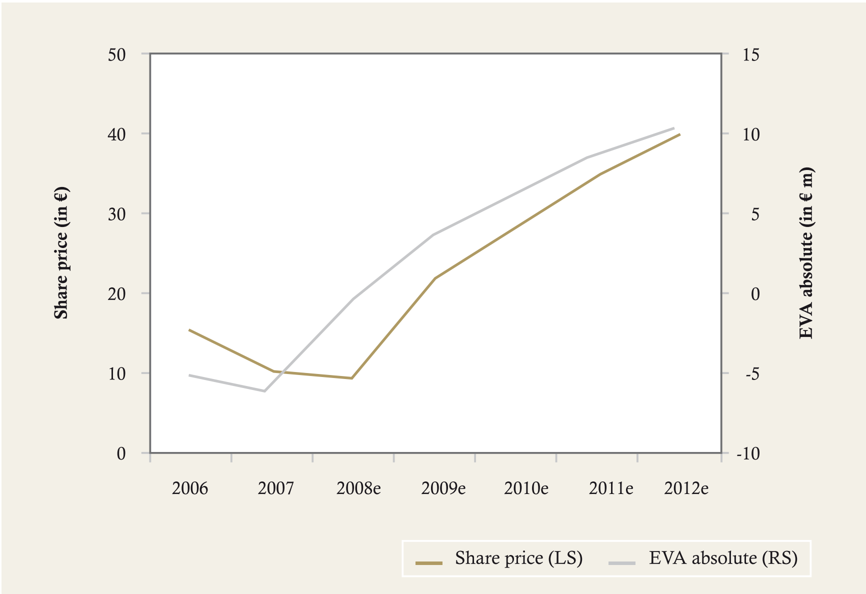
WACC	8.3 %
Long term growth	5.8 %
Incremental ROIC	17.4 %

	2008	*2009e*	*2010e*	*2011e*	*2012e*	*TV*
EBIT	**15**	**22**	**28**	**32**	**36**	**38**
Tax on EBIT	-4	-6	-8	-9	-10	-11
NOPLAT	**11**	**16**	**20**	**23**	**26**	**27**
Depreciation	8	8	8	8	8	8
Additional investment – FA	-20	-15	-15	-30	-7	-7
Additional investment – NWC	-21	-5	-25	-15	-10	-11
Enterprise cash flow	-22	1	-12	3	17	18
PV of enterprise free cash flow	-21	3	-9	2	12	745
PV cash flow in years 2008-12	-13					
PV of terminal value	501					
Estimated equity value	489					
Less: minorities 08e	0					
Less: net (debt)/cash 07	-57					
Adjusted equity value	431					
No. of shares outstanding (m)	14.6					
DCF	**29.6**					

Source: Silvia Quandt Research GmbH

For the DCF analysis we have assumed strong expansion of the asset base thanks to entering into the venture for the production of crystalline solar cells, together with Qimonda. Along with margin expansion due to lower silicon prices in the long-run to feed the solar cell production of Centrosolar the anticipated disproportional expansion of nanocoated solar glass business should add very strongly to profit growth in the coming year. Hence, return on investment numbers should considerably improve in our view, while capital costs should be kept at least stable over time.

EVA portends share price enhancement



Source: Silvia Quandt Research GmbH

ItN Nanovation

Price target
€ 17.00

Rating
Buy

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Stock data
Main Market
Xetra

Market cap (€ m):
44.7

No. of outstanding shares (m)
5.38

Daily traded volume (3 months avg; '000s)
1.48

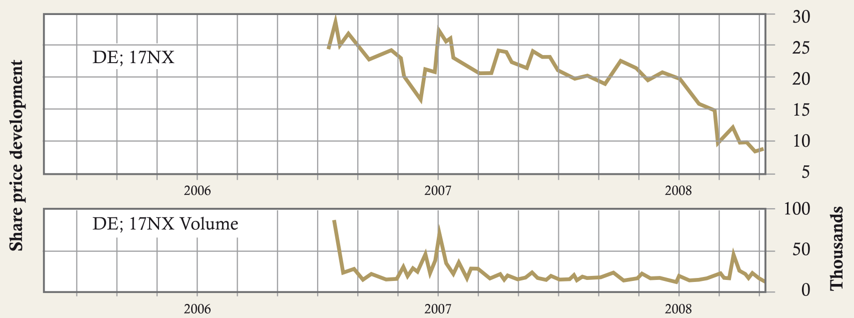
Indices
Prime Standard

Next event
Q1 08, May 2008

Free float
approx. 3 %

Closing price
€ 8.3

FY 31 Dec (€ m)	*2006*	*2007*	*2008e*	*2009e*
Profit loss				
Sales	5.8	4.8	10.9	19.3
y-o-y	N/A	-17.3 %	127.0 %	77.1 %
EBITDA	-3.9	-6.3	-0.5	3.5
EBIT pre except.	-4.4	-7.0	-1.1	2.9
EBIT margin	N/A	-146.0 %	-10.4 %	15.3 %
Net income	-5.95	-8.23	-1.73	1.92
EPS	-1.36	-1.54	-0.32	0.36
y-o-y	N/A	N/A	-78.9 %	-210.5 %
EPS consensus (€)			-0.06	0.66
DPS (€)	0.0	0.00	0.00	0.00
Cash flow				
Net income	-6.0	-8.2	-1.7	1.9
Depreciation/Amortisation	-0.5	-0.7	-0.6	-0.6
Net working capital movements	-0.2	0.5	0.0	0.7
Operating cash flow	-5.6	-7.0	-1.1	1.8
Net capex	-0.6	-0.9	-0.8	-2.0
Free cash flow	-6.2	-7.9	-1.9	-0.2
Balance sheet / Key ratios				
Closing cash (net debt)	18.6	8.7	6.5	6.8
Gearing	-53.6 %	-55.8 %	-38.2 %	-32.7 %
Capex ratio (sales)	9.9 %	18.3 %	7.4 %	10.4 %
ROE	-34.8 %	-33.6 %	-8.7 %	-9.4 %
ROCE	-49.8 %	-72.2 %	-10.9 %	24.5 %
Valuation				
Enterprise value	103.0	132.7	38.9	39.9
Price/Book (x)	5.5	4.9	2.3	2.3
Dividend yield	0.0 %	0.0 %	0.0 %	0.0 %
EV/Sales	N/A	2,768.9 %	358.0 %	207.2 %
EV/EBITDA (x)	-26.5	-21.2	-72.8	11.3
PER (x)	-15.8	-14.5	-26.8	24.3
FCF yield	-9.5 %	-8.2 %	-4.8 %	0.7 %



Source: Bloomberg, Silvia Quandt Research GmbH

Company profile

ItN Nanovation is a nanotechnology company. The company's success is founded on an extensive patent portfolio, combined with comprehensive development and application know-how. The company was founded in 2000 and currently has over 100 employees. Free float so far is tiny, e.g. approx. 3 %, however, free float is likely to rise strongly in the future as the company is seeking broadening its stakeholders base.

The Company's main activity is the development of ceramic products, such as filtration systems and coatings, for large industrial customers. ItN Nanovation is mainly operating in the ceramic nanotechnology area. This is by nature basically covering inorganic nanoparticles, namely ceramic nanoparticles. Production processes are highly automated and very flexible processes, in the sense of providing scope for scaling the output. In fact, the company stresses that up to a revenue level of approx. € 25m no incremental capex is needed to cope with even sudden increases in demand.

Since 2004 the company has generated a lot of intellectual property, raising the number of filed patents from 74 to 139 in 2007. Patent life is usually 20 years providing ample time to make full commercial use of the company's know-how. We believe ItN Nanovation is capable to successfully make use of its vast patent pipeline.

ItN Nanovation divisional sales 2005-09e

Year to 31 December (in € m)	*2005*	*2006*	*2007*	*2008e*	*2009e*
Coatings	4.4	5.0	4.2	10.2	18.3
Filter	0.3	0.7	0.4	0.6	0.8
Others	0.1	0.1	0.1	0.1	0.2

Source: ItN Nanovation divisional sales 2005-09e

The nanoscale powder needed for those products is manufactured by the company itself. ItN Nanovation AG operates in two main business segments, ceramic coatings and filtration.

The **high performance coatings** division manufactures
_NANOCOMP, e.g. nanocoatings for coal fired power plants, aluminium and brass foundries, and chemical and oil & gas-refining industries.

_NANOCAT, e.g. coatings supplied to household oven manufacturers.

The **coated ceramic membrane systems** division manufactures
_NANOPORE, e.g. tubular membranes for the pharmaceutical, food and beverage industries, as well as for the industrial waste water industry.

_CFM SYSTEMS, e.g. flat membranes for waste water and sewage treatment (low maintenance systems for small sewage systems) as well as high performance systems (medium sewage systems).

According to ItN Nanovation the aggregate world market for coated ceramic membranes (e.g. tubular and flat membranes) is worth up to approx. € 7bn. Drivers for growth (we estimate circa 50 % CAGR for sales of this division in the period 2007-2012e) are 1) replacement of traditional polymer filters which have mediocre qualities compared to ceramic filters (for example, low pressure resistance, not resistant to aggressive chemicals) and 2) general concerns about long-term availability of drinking water.

Beginning of Q1 this year ItN Nanovation is producing tubular ceramic membranes jointly (50:50) with a local partner in China. We believe this JV to become successful as China is lacking drinking water resources in the long run, given its fastly growing population. Currently, more than 300 million rural residents, nearly a quarter of China's total population, lack access to clean drinking water. A recent study of the China National Environmental Monitoring Center showed that drinking water quality in 16 out of 113 key cities is below national standards. Of drinking water sources, approx. 20 % of the total surveyed, fell short of quality requirements, while 527 million tons of drinking water, or roughly 32 % of the total, was unsuitable for drinking.

Market potential for tubular ceramic membranes is approx. US $ 18bn of which Asia accounts for about 25 %.

Global roll-out of CFM Systems is envisaged for 2008, after an extended period spent for testing, e.g. nearly 2 years. The market for ItN's CFM-Systems is split, roughly, into 30 % for Asia, EU and other Western Europe approx. 37 %, and North America approx. 29 %. The volume of waste water to be treated world-wide is assumed to be 130 billion gallons/day, which offers huge growth potential for suppliers of water filter products, those like ItN Nanovation's.

Break-through deals with industry giants RWE and BASF providing boost to future business growth

The use of Nanocomp PP reduces maintenance costs and increases the productivity of the systems. Major destruction in the combustion boiler of hard and liqnite-fired power plants occurs at the boiler tubes' surface, according to ItN every 3 to 5 years. This is due to massive residues of slurry building on the surfaces, usually reaching heights substantially in exess of 50 cm. As a result, these boiler tubes must be frequently replaced for new ones, a costly undertaking for the company. Even if these tubes are still used in the energy generation process they

_Disturb the heat transfer, reducing the plant's energy output.

_Increasing CO_2 emissions due to particles released by the slurry.

_Incure costs related to reduced operating time and unscheduled shut-downs and cleaning and maintenance.

Nanocomp PP is a unique product in the sense that ItN's nanotechnology used to produce the ceramic coatings clearly belongs, we believe, to the emerging technologies which potentially offers the highest returns on investment.

A second Nanocomp product, Nanocomp MC is offered to the aluminium and brass foundries for providing protection for coquilles and molds.

The third Nanocomp application sold by ItN Nanovation is Nanocomp AF for protecting production facilities' cooling circuit systems to prevent crystallization fouling (one type of anti-fouling, approx. 25 % of total anti-fouling incarnations). Other types of anti-fouling are corrosion fouling (approx. 32 %) and particulate fouling (approx. 19 %).

The unique production technology of Nanocomp products (PP, AF, MC) mainly rests on the fact that ItN Nanovation can manage to bond ceramic particles to a metal surface, at a lower melting point for ceramic than is typical for this anorganic material, e.g. 1,700-2,000° C). In fact, at such high temperatures the adjaced metal would melt and no bonding could occur.

The merits of Nanocomp products are:

_Significant reduction of shut-down times for maintenance work.

_Enhanced productivity of life-cyle and productivity of peripherical equipment.

_For coal-fired power plant operators saving CO_2-emission related costs will become increasingly important, the opportunity gains being less carbon credits have to be purchased in order to fulfill emission caps set by the government.

The world market for Nanocomp PP applications is worth around € 1bn while the market for anti-fouling coatings is really huge, valued at around € 100bn p.a. According to German engineer think tank VDI costs incurred by damage caused by fouling in industrialised countries can amount to 0.3 % of annual GDP. ItN Nanovation covers some 75 % of of anti-fouling incidences with its AF products.

Only lately, ItN Nanovation has signed an exclusive and extensive cooperation agreement with RWE Power, a subsidiary owned by German energy producer RWE estimates, to gradually introduce Nanocomp Powerplant (PP) product line of ItN in RWE's power plants in Germany (currently coal-fired plants in operation). The initial focus of the agreement is addressing the lignite power plants of RWE. The contract is to expire by 2012, but determined to mark only the first phase of the agreement, e.g. extension beyond 2012 is likely, we believe due to the preceding extensive and successful tests.

Apart from the RWE deal which provides a great platform for ItN to leverage its large pool of intellectual know-how amidst large-scale industry applications, the company also signed a cooperation agreement with the world's largest chemical company BASF. The deal includes the delivery of nantechnology-based high-performance coatings for BASF's cooling circuit systems. The application of such nanocoating is to prevent crystallisation fouling caused by the formation of desposits on pipe surfaces. This is a particular sensible part in, for example, ethylene crackers. The signing of the deal was preceded by a 2-years testing phase and the agreement now is covering the next five years. The first turnover to be generated with BASF is planned for 2008.

The agreement is by contract to be extended to oil & gas facilities of BASF subsequently. We believe this extension would mark another quantum leap for ItN Nanovation given the company's vast amount of gas and oil pipelines and the disproportional growth provided by the BASF/Gazprom collaboration.

Overall, our estimates for revenue growth in the coatings division, e.g. CAGR 91 % in 2007-2012, do reflect the significant impact of the RWE and BASF deals on the group's fortunes in coming years, equally reflected by the assumption of an operating loss of € 7m in 2007, improving sharply to an operating profit of € 34m in 2012.

Valuation: fair value € 17 on DCF grounds but assumed EVA trend signals share price enhancement beyond that level

We have appraised ItN Nanvation's potential for future share price enhancement on the grounds of DCF and EVA modeling. On this basis we have derived a short-term target price of € 17 while we anticipate strong enhancement of the share price beyond that level in the medium to long-term if EVA metrics are considered. The latter will materialize over time, we believe, if the company can succeed to strongly capitalize on their businesses with industry majors RWE and BASF.

DCF valuation: fair value € 17 (short term)

On DCF grounds, which in our view is the correct valuation tool to appraise the intrinsic value of start-up and emerging companies, ItN Nanovation is worth € 17 per share, offering more than double upside compared with the current price. We believe the stock will reach this target price in the short-term, e.g. within the next 6-12 months. Triggers to cause the ascend should be the company's forgthcoming disclosures for interim results as well as positive statements regarding the RWE and BASF-related businesses.

DCF appraisal ItN Nanovation – fair value € 17

	2008	2009e	2010e	2011e	2012e
EBIT	-4	-7	-1	3	7
Effective tax rate for EBIT	0 %	0 %	0 %	37 %	37 %
Depreciation	1	1	1	1	2
Additional investment – FA	1	2	1	3	2
Additional investment – NWC	0	-1	0	1	1
Opening capital employed (2007)					
Fixed assets	9				
Net working capital	1				
	10				

WACC	8.2 %
Long term growth	5.7 %
Incremental ROIC	20.0 %

	2008	2009e	2010e	2011e	2012e	TV
EBIT	**-4**	**-7**	**-1**	**3**	**7**	**8**
Tax on EBIT	0	0	0	-1	-3	-3
NOPLAT	**-4**	**-7**	**-1**	**2**	**4**	**5**
Depreciation	1	1	1	1	2	2
Additional investment – FA	-1	-2	-1	-3	-2	-2
Additional investment – NWC	0	1	0	-1	-1	-1
Enterprise cash flow	-5	-8	-2	-1	3	3
PV of enterprise free cash flow	-5	-7	-1	-1	2	129
PV cash flow in years 2008-12	-11					
PV of terminal value	87					
Estimated equity value	76					
Less: minorities 08e	0					
Less: net (debt)/cash 07	14					
Adjusted equity value	90					
No. of shares outstanding (m)	5.3					
DCF	**16.7**					

Source: Silvia Quandt Research GmbH

DCF valuation is quite sensitive particularly to the level of capital costs (WACC generally used to discount future cash flows). We argue that as soon as the company will face needs to expand its production capacity, there should also be a debt/equity mix inplace to finance asset expansion. In this event it is likely that WACC will fall due to a certain amount of debt then assumed, given that interest on debt is basically tax-deductable while equity is not. According to ItN Nanovation up to a sales level of some € 25m no capex is required, however, on our forecast the company should surpass that level in 2010 triggering more investments in new production facilities. We believe this looks fair view especially in the light of ItN's major deals with RWE and BASF which, in the medium to long-term, presumably demand considerably larger capacities to cope with the extra order flows.

DCF value very sensitive to capital costs

		WACC					
	16.7	6.0 %	7.0 %	8.0 %	9.0 %	10.0 %	11.0 %
ROIC	10.0 %	89.2	20.1	11.0	7.5	5.6	4.4
	12.0 %	108.9	24.5	13.4	9.1	6.8	5.4
	14.0 %	123.0	27.7	15.1	10.2	7.7	6.1
	16.0 %	133.5	30.0	16.4	11.1	8.3	6.6
	18.0 %	141.7	31.9	17.4	11.8	8.8	7.0
	20.0 %	148.3	33.4	18.3	12.3	9.2	7.3
	22.0 %	153.7	34.6	18.9	12.8	9.5	7.5
	24.0 %	158.1	35.6	19.5	13.1	9.8	7.7
	26.0 %	161.9	36.4	19.9	13.5	10.0	7.9
	28.0 %	165.2	37.2	20.3	13.7	10.2	8.1
	30.0 %	168.0	37.8	20.7	14.0	10.4	8.2

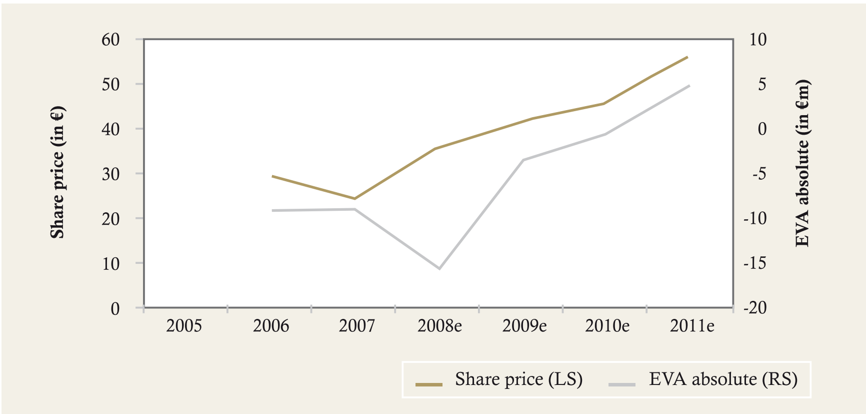
Source: Silvia Quandt Research GmbH

EVA valuation: share price to track progress in EVA, offering

We are arriving at noticeably higher target prices set for the medium to longer term for ItN Nanovation derived from an EVA analysis. Given our empirical findings with EVA development in correlation with share price trends we found that the premium a company earns over its capital costs, e.g. ROIC minus WACC, pretty good determines a firm's intrinsic value which, therefore, should be mirrored in its share price.

Given this we argue that ItN Nanovation's share price should increase gradually in the coming years as the company in our view will stage very dynamic EVA progress in future. We expect EVA to become positive next year which in our view should be linked with the anticipated strong revenue and profit growth to be generated particularly in the businesses originated with RWE (Nanocomp PP) and BASF (Nanocomp AF).

EVA progress portends share price enhancement



Source: Silvia Quandt Research GmbH

Appendix: nanotech glossary

Adsorption
Adsorption is a process that occurs when a gas or liquid solute accumulates on the surface of a solid or, more rarely, a liquid (adsorbent), forming a molecular or atomic film (the adsorbate).

Assembler
A general-purpose device for molecular manufacturing, capable of guiding chemical reactions by positioning molecules.

Atom
The smallest unit of a chemical element, about a third of a nanometer in diameter. Atoms make up molecules and solid objects.

BioMEMS
Miniaturization engineering or MEMS applied to biotechnology or medicine. In BioMEMS the number of materials involved is much larger than in a comparable electronics application. Both instruments and sensors are used in BioMEMS. Applications include: forensic science (e.g. O.J.'s DNA), clinical diagnostics (e.g. blood glucose), product development (e.g. new drugs), and quality control (e.g. pH of swimming pools).

Biomimetic
Imitating, copying, or learning from nature.

Biomimetics
The design of systems, materials, and their functionality to mimic nature.

Bottom up
Building organic and inorganic structures atom-by-atom, or molecule-by-molecule.

Buckminsterfullerene
A sphere of sixty carbon atoms, also called a buckyball. Named after the architect Buckminster Fuller, who is famous for the geodesic dome that buckyballs resemble.

Carbon black
Carbon black is a powdered form of elemental carbon. The primary use of carbon black is in rubber products, mainly tyres and other automotive products, but also in many other rubber products such as hoses, gaskets and coated fabrics. Much smaller amounts of carbon black are used in inks and paints, plastics and the manufacture of dry-cell batteries.

Catalyst
A substance that increases the rate of a chemical reaction by reducing the activation energy, but which is left unchanged by the reaction. A catalyst works by providing a convenient surface for the reaction to occur. The reacting particles gather on the catalyst surface and either collide more frequently with each other or more of the collisions result in a reaction between particles because the catalyst can lower the activation energy for the reaction.

Cell
A small structural unit, surrounded by a membrane, that makes up living things.

Chirality
The characteristic of a structure (usually a molecule) that makes it impossible to superimpose it on its mirror image.

CNT
The unique chemical and physical properties of CNT (carbon-nanotubes) have paved the way to new and improved sensing devices, in particular electrochemical biosensors. For example, electrochemical transducers based on carbon-nanotubes (CNT) offer substantial improvements over the performance of amperometric enzyme electrodes, immunosensors and nucleic-acid sensing devices.

Colloid
A mixture in which one substance is divided into minute particles (called colloidal particles) and dispersed throughout a second substance. The mixture is also called a colloidal system, colloidal solution, or colloidal dispersion. Colloid science is the study of systems involving small particles of one substance suspended in another. Suspensions in liquids form the basis for a wide variety of systems of scientific and technological importance, including paints, ceramics, cosmetics, agricultural sprays, detergents, soils, biological cells, and many food preparations.

Complementary Metal-Oxide Semiconductor (CMOS)
The semiconductor technology used in the transistors that are manufactured into most of today's computer microchips.

Composites
Combinations of metals, ceramics, polymers and biological materials that allow multi-functional behaviour. One common practice is reinforcing polymers or ceramics with ceramic fibres to increase strength while retaining light weight and avoiding the brittleness of a monolithic ceramic. Materials used in the body often combine biological and structural functions (e.g., the encapsulation of drugs).

Dendrimer
A dendrimer is an artificially manufactured or synthesized molecule constructed from branched units called monomers. Such processes involve work at the nanometer scale. Technically speaking, a dendrimer is a polymer, which is a large molecule comprised of many smaller ones linked together.

Dip pen nanolithography
A direct-write soft lithography technique that is used to create nanostructures on a substrate of interest by delivering collections of molecules via capillary transport from an atomic force microscope tip to a surface.

DNA
DeoxyriboNucleic Acid. DNA is a code used within cells to form proteins.

Dry nanotechnology
Derived from surface science and physical chemistry, dry nanotechnology focuses on the fabrication of structures in carbon, silicon, and other inorganic materials. Unlike 'wet' technology, 'dry' techniques allow the use of metals and semiconductors. While the active conduction electrons of these materials make them too reactive to use in a 'wet' environment, these same electrons provide the physical properties that make 'dry' nanostructures promising as electronic, magnetic, and optical devices. Another objective is to develop 'dry' structures that possess some of the same self-assembly features that the wet structures exhibit.

Elastomers
Cross-linked high-polymer materials with elastic behaviour.

Ellipsometry
A technique used to optically characterize material types such as semiconductors, dielectrics, metals, organic polymers and plastics in thin films, thin films stacks and nanostructures. Ellipsometry does not contact or damage samples, and is an ideal and precise measurement technique for determining optical and, hence, physical and chemical properties of materials at the nanoscale. It is most commonly used to accurately measure film thickness and optical properties.

Enzymes
Molecular machines found in nature that are made of protein and can catalyse (speed up) chemical reactions.

Fullerene
A Fullerene is a pure carbon molecule composed of at least 60 atoms of carbon. They are cage-like structures of carbon atoms. The most abundantly produced form is Buckminsterfullerene (C60), which has sixty carbon atoms arranged in a spherical structure. Because a Fullerene assumes a shape similar to a soccer ball or geodesic dome, it is sometimes referred to as a buckyball after the inventor of the geodesic dome, Buckminster Fuller, after whom the Fullerene is more formally named.

Gbps
Billions of bits per second. A measure of bandwidth in a digital data transmission medium, such as optical fibre.

Genomics
The study of the full complement of genes that make up an organism.

Hydrocarbon
An organic compound that contains only carbon and hydrogen. Hydrocarbons are classified according to the arrangement of atoms and the chemical properties of the compounds, such as alicyclic, aliphatic, and aromatic, and are derived mainly from crude petroleum, as well as coal tar and plant sources.

Ion
An atom or group of atoms in which the number of electrons is different from the number of protons. If the number of electrons is less than the number of protons, the

particle is a positive ion, also called a cation. If the number of electrons is greater than the number of protons, the particle is a negative ion, also called an anion.

LED (Light Emitting Diode)
A semiconductor device that emits visible light when an electric current passes through it. The light is not particularly bright, but in most LEDs it is monochromatic, occurring at a single wavelength. The output from an LED can range from red (at a wavelength of ~700nm) to blue-violet (~400nm).

Lithium ion (Li-Ion) battery
A rechargeable battery with twice the energy capacity of a Nickel-Cadmium battery and greater stability and safety.

Macromolecule
A complex large molecule formed from simpler molecules, usually with a diameter ranging from about 100-10,000 angstroms (10-5 to 10-3 mm).

Membrane
In biology, a thin, pliable layer of tissue covering surfaces or separating or connecting regions, structures, or organs of an animal or a plant. In chemistry, a membrane is a thin sheet of natural or synthetic material that can be penetrated, especially by liquids or gases. In environmental applications of nanotechnology a membrane can be used as a filter.

MEMS
Micro-Electro-Mechanical Systems (MEMS) is the integration of mechanical elements, sensors, actuators, and electronics on a common silicon substrate using microfabrication technology. While the electronics are fabricated using integrated circuit (IC) process sequences (e.g., CMOS, bipolar or BICMOS processes), the micromechanical components are fabricated using compatible "micromachining" processes that selectively etch away parts of the silicon wafer or add new structural layers to form the mechanical and electromechanical devices.

Microfluidics
The science of designing, manufacturing, and formulating devices and processes that deal with volumes of fluid on the order of nanolitres (denoted by nl and representing units of 10-9 litre) or picoliters (denoted by pl and representing units of 10-12 litre).

Molecular electronics
Any system with atomically precise electronic devices of nanometre dimensions, especially if made of discrete molecular parts rather than the continuous materials found in today's semiconductor devices.

Molecular-scale manufacturing
Manufacturing using molecular machinery, giving molecule-by-molecule control of products and by-products via positional chemical synthesis.

Molecular wire
A quasi-one-dimensional molecule that can transport charge carriers (electrons or holes) between its ends.

Molecule
A group of atoms held together by chemical bonds, a molecule is the typical unit manipulated by nanotechnology.

Moore's Law
The observation made in 1965 by Gordon Moore, co-founder of Intel, that the number of transistors per square inch on integrated circuits had doubled every 18 months since the integrated circuit was invented. Moore predicted that this trend would continue for the foreseeable future.

MRI
Magnetic Resonance Imaging

MWNT
Multi-Walled Nanotubes

Nano
A prefix meaning one billionth (1/1,000,000,000).

Nanoarray
An ultra-sensitive, ultra-miniaturized array for biomolecular analysis.

Nanobiotechnology
Applies the tools and processes of nano/microfabrication to build devices for studying biosystems.

Nano-bubble
An ultra-fine gas bubble of diameter less than 1µm (1µm=1/1,000,000 m). It usually occurs temporarily in the process of shrinking a micro-bubble, but quickly disappears because of its physical lability (constant change). Scientists have recently succeeded in producing stabilized nano-bubbles by collapsing micro-bubbles instantaneously in water containing electrolyte ions.

Nanocomposites
Polymer/inorganic nanocomposites are composed of two or more physically distinct components with one or more average dimensions smaller than 100nm. From a structural point of view, the role of inorganic filler, usually in the form of particles or fibres, is to provide intrinsic strength and stiffness, while the polymer matrix can adhere to and bind the inorganic component so that forces applied to the composite are transmitted evenly to the filler.

Nanocomputer
A computer made from components (mechanical, electronic or otherwise) built at the nanometre scale.

Nanocrystal
Molecular-sized solids formed with a repeating 3D pattern of atoms or molecules with an equal distance between each part. Nanocrystals are aggregates of anywhere from a few hundred to tens of thousands of atoms that combine into a crystalline form of matter known as a 'cluster'. Typically around 10nm in diameter, nanocrystals are larger than molecules but smaller than bulk solids and therefore frequently exhibit physical and chemical properties somewhere in-between. Nanocrystals are believed to have potential in optical electronics because of their ability to change the wavelength of light.

NanoElectroMechanical Systems (NEMS)
A generic term to describe nanoscale electrical/mechanical devices. Nanoscale MEMS.

Nanoelectronics
Electronics on a nanometre scale, whether made by current techniques or nanotechnology. This includes both molecular electronics and nanoscale devices resembling today's semiconductor devices.

Nanofabrication
Design and manufacture of devices with dimensions measured in nanometres.

Nanofibres
Hollow and solid carbon fibres with lengths on the order of a few microns and widths varying from tens of nanometres to around 200nm.

Nanofluidics
Controlling nanoscale amounts of fluids.

Nanohorns
One of the SWNT (single-walled carbon nanotube) types, with an irregular horn-like shape.

Nanoimprinting
See soft lithography.

Nanolithography
Nanolithography is the art and science of etching, writing, or printing at the microscopic level, where the dimensions of characters are on the order of nanometers. This includes various methods of modifying semiconductor chips at the atomic level for the purpose of fabricating integrated circuits (ICs). Instruments used in nanolithography include the scanning tunnelling microscope (STM) and the atomic force microscope (AFM). Both allow a surface to be viewed in fine detail without necessarily modifying it. Either the STM or the AFM can be used to etch, write, or print on a surface in single-atom dimensions.

Nanomanipulation
The process of manipulating items at an atomic or molecular scale in order to produce precise structures.

Nanometre
One billionth of a metre. 10^{-9} m, or one millionth of a millimetre.

Nano-optics
Interaction of light and matter at the nanoscale.

Nanopores
Nanoscopic pores found in purpose-built filters, sensors, or diffraction gratings.

Nanoscale
Between 0.1-100nm.

Nanoshells
Nanoscale metal spheres that can absorb or scatter light at virtually any wavelength.

Nanospring
A nanowire wrapped into a helix.

Nanotechnology
Areas of technology where dimensions and tolerances in the range of 0.1nm to 100nm play a critical role.

Nanotube
A one-dimensional fullerene (a convex cage of atoms with only hexagonal and/or pentagonal faces) with a cylindrical shape.

Nanowires
One-dimensional structures with unique electrical and optical properties that are used as building blocks in nanoscale devices.

NEMS
NanoElectroMechanical Systems

nm
Nanometre

NMR
Nuclear Magnetic Resonance

Organic LED
LED made from carbon-based molecules, not semiconductors.

Proteins
The chemical building blocks from which mammalian cells, organs, and tissues like muscle are made. Proteins also serve double-duty as hormones, enzymes and antibodies, which help fight off invading germs. Proteins are made of long chains of even smaller building blocks called amino acids. Amino acids determine the size, shape, and length of protein molecules. They also give protein molecules the odd ability to coil and uncoil like tiny, cellular snakes.

Quantum Computer
A computer that takes advantage of quantum mechanical properties such as superposition and entanglement resulting from nanoscale, molecular, atomic and subatomic components.

Quantum Dot (qD)
A nano-scale crystalline structure that can transform the colour of light. The quantum dot (qD) is considered to have greater flexibility than other fluorescent materials, which makes it suitable for use in building nano-scale computing applications where light is used to process information. They are made from a variety of different compounds, such as cadmium selenide.

Semiconductor
A substance, usually a solid chemical element or compound, that can conduct electricity under some conditions but not others, making it a good medium for controlling electrical current. Its conductance varies depending on the current or voltage applied to a control electrode, or on the intensity of irradiation by infrared (IR), visible light, ultraviolet (UV), or X rays.

Self-assembly
Refers to the use in materials processing or fabrication of the tendency of some materials to organise themselves into ordered arrays (e.g. colloidal suspensions). This provides a means to achieve structured materials "from the bottom up" as opposed to using manufacturing or fabrication methods such as lithography, which is limited by the measurement and instrumentation capabilities of the day. For example, organic polymers have been tagged with dye molecules to form arrays with lattice spacing in the visible optical wavelength range and that can be changed through chemical means. This provides a material that fluoresces and changes colour to indicate the presence of chemical species.

Substrate
In nanotechnology the base material where applications are built up.

SWNT
Single Walled Nanotubes

Thin films
Thin films are atomically engineered layers of a wide variety of materials including metals, insulators and semiconductors. The major applications of thin films are to modify the surface properties of solids. Individual films may be electrically conductive or non-conducting, hard or soft, thermally conducting or insulating, optically transparent, or opaque. A thin film coating can transform the electrical, mechanical and/or optical properties of a solid base material in a cost-effective way.

Top down
Refers to making nanoscale structures by machining and etching techniques.

Wet Nanotechnology
The study of biological systems that exist primarily in a water environment. The functional nanometre-scale structures of interest here are genetic material, membranes, enzymes and other cellular components. The success of this nanotechnology is amply demonstrated by the existence of living organisms whose form, function, and evolution are governed by the interactions of nanometre-scale structures.

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