



Creating the Equation for Growth

Global Nanomaterials Opportunity and Emerging Trends

Lucintel Brief

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Lucintel

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Executive Summary

- **Global nanomaterials industry reached \$1.7 B in 2010, with an average annual growth rate of 10.4% over last five years**
- **North American nanomaterials industry accelerated by ~25% in 2010 and Europe by ~22%, while Asia and other regions grew by ~32% in 2010, driven by:**
 - **Active participation of government in nanotechnology R & D funding**
 - **Advancement in production process**
 - **Heavy investment in R & D by major players**
- **By 2016, nanomaterials market is expected to reach \$ 5.8 B (23% CAGR), boosted by increasing use in health care and energy storage industry**
- **High potential applications for nanomaterials in next 5 years are: field lamination display (FED), drug delivery and biofuels**
- **Companies with innovation capability will sustain and gain market share in future**



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Applications of Nanoclay and Carbon Nanotubes

Nanoclay



Use in bottling of O₂ and CO₂ sensitive products (beer and cold drink bottles)



Use in food and packaging industries



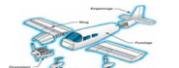
Use in motor compartment of vehicle for casting and connectors



Use in wire and cable applications



Timing belt covers in automotive



Scratch resistant coatings in automotive and aircraft frame & body



EMI/RFI shielding & coatings in electronic devices to control radiation



CMP slurries in electronic chips and wafers to enhance conductivity



Diagnostics and imaging in healthcare to enhance clarity in X-ray films

Carbon Nanotubes

Current and Potential Applications

Transportation



Engine & Fuel Systems



Scratch Resistant Exterior Parts and Coatings



Car Interior



Aircraft Structure & Framing



Wear Resistant Paints & Coatings for Defense Vehicles

Construction



Conductive Flooring



Pipes



Insulating Materials for Roofs & Thatches



House & Building Siding



Self Cleaning Windows

Packaging



Meat & Food Packaging



Computers & Electronics



Medicines & Pharmaceuticals



Beer Bottles

Current and Potential Applications

Consumer Goods



Home appliances



Sporting goods & toys



Furniture & others

Energy



Battery electrodes



Fuel cell membranes



Supercapacitors

Electrical & Electronics



Sensors



Semiconductors



Hard disk storage in computers

Health Care



Body implants



Medical devices



Dental filling materials

Others



Anti-foul coatings for marine ships



Industrial equipment to increase strength



Fire resistant clothes

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Cost and property analysis of nanomaterials with respect to other materials

Materials	Strength	Modulus	Price	Weight	Surface Area	Wear Resistance	Barrier Property	Electrical Conductivity
Nanomaterials	●	●	●	○	○	●	●	●
Ceramic	◐	◐	○	◐	◐	◐	◐	◐
Kevlar (Aramid)	◐	◐	◐	◐	◐	◐	◐	◐
Glass Fibers	◐	◐	○	◐	◐	◐	◐	◐
Carbon Fibers	◐	◐	◐	◐	◐	◐	◐	●

● High ◐ Medium ◑ Low-Medium ◒ Low ○ Least

Key Insights

- Nanomaterials have the highest strength, modulus, wear resistance, barrier property and electrical conductivity when compared with other materials

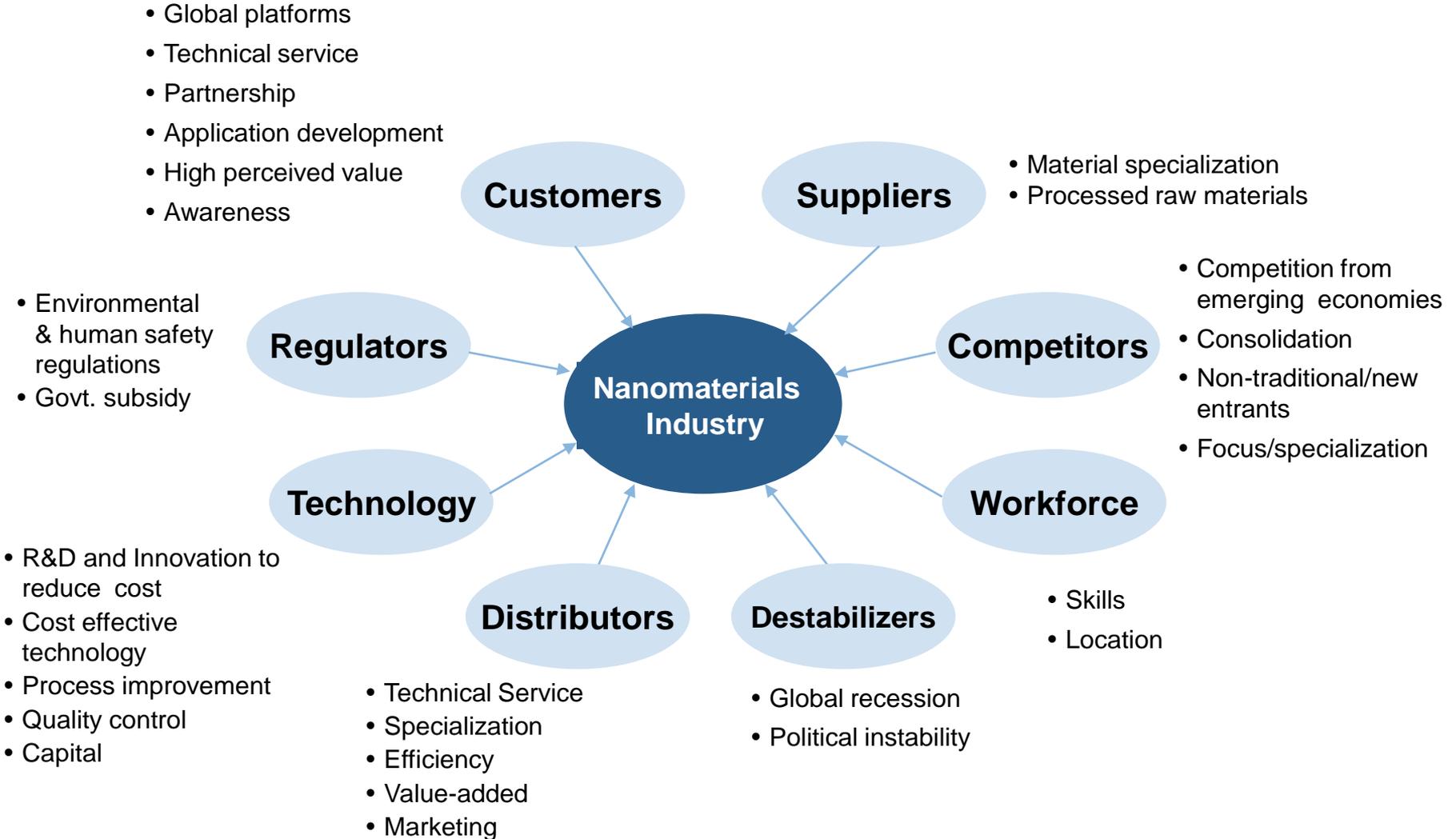


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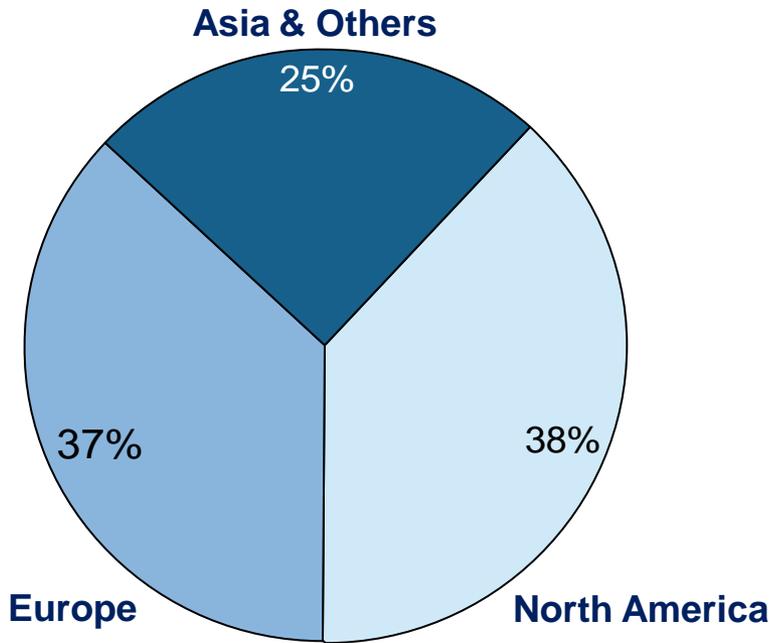


External forces shaping the Nanomaterials industry: Future innovations in this space will drive the growth of nanomaterials



Geographical breakdown for nanomaterials

Global nanomaterials distribution (\$ mil)
by regions in 2010

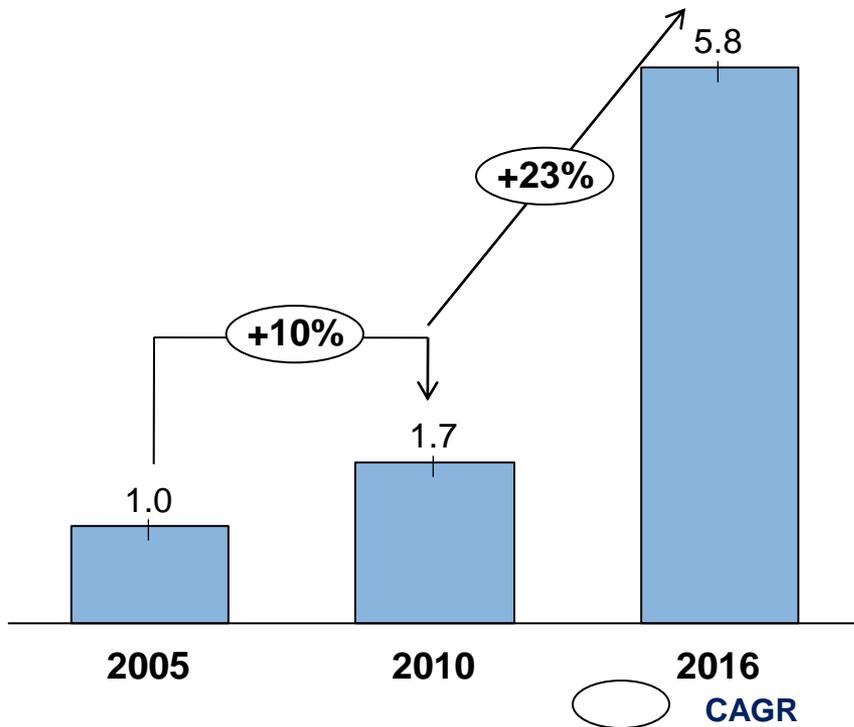


Key Insights

- North America and Europe were the two largest markets for nanomaterials in 2010
- European region has significant use of nanomaterials in pharmaceuticals, as many pharmaceutical companies are based in Europe
- Good growth of nanomaterials was witnessed in Asia region during last 5 years due to:
 - Government support
 - Continued environmental consciousness
 - Expected increase in demand for specialty materials

Nanomaterials Market: Trend and Forecast

Trend and forecast in nanomaterials shipment (\$ B): 2005-2016



Electrical & Electronics (E&E) market witnessed a robust growth due to the large price decrease of carbon nanotubes and increase in mass production of nanomaterials

Drivers For Nanomaterials Investment

Emerging Applications

- It is expected that nanomaterials to be extensively used in emerging applications like water treatment, drug delivery, nanomedicines, etc

Price

- Decrease in price of nanomaterials may take place due to advanced production techniques

Patents

- The number of patents regarding manufacturing of nanomaterials is increasing year after year

Top 3 Market Segments Region wise

North America	Europe	RoW
E&E	Health& Personal Care	E&E
Health& Personal Care	E&E	Transportation
Energy Storage Devices	Transportation	Packaging

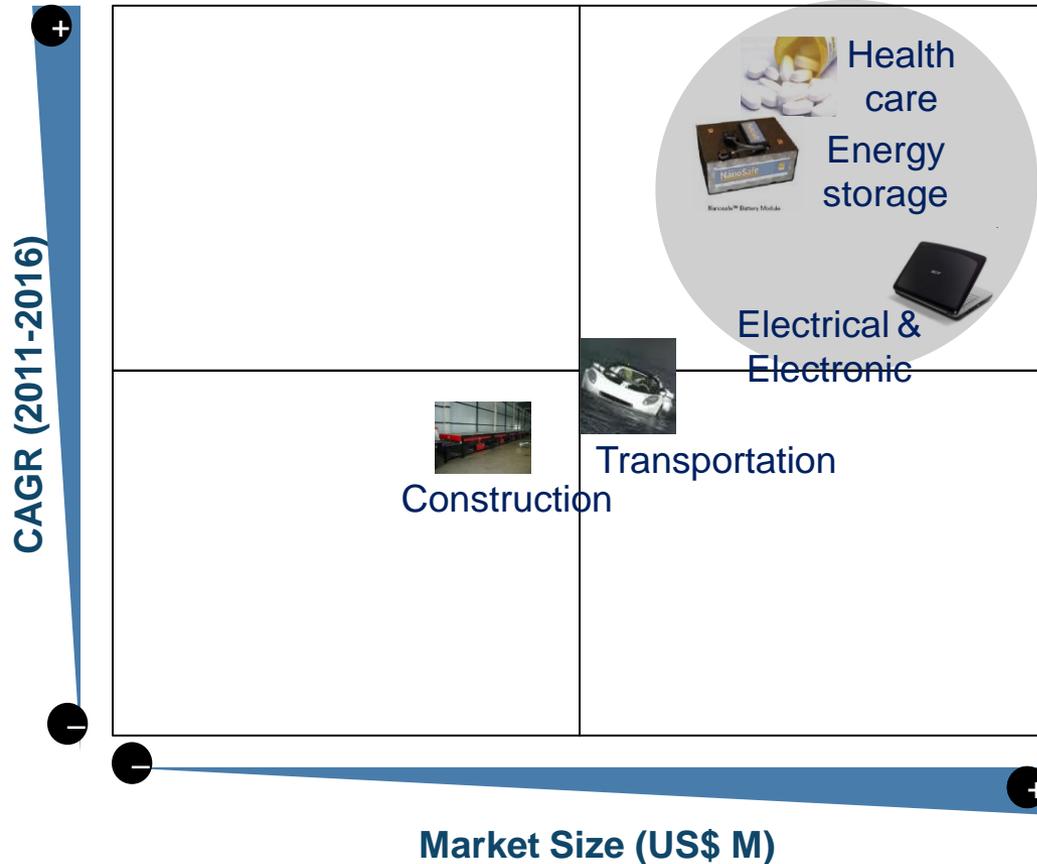
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Health care industry is expected to gain market share and overtake E & E segment in size over next five years

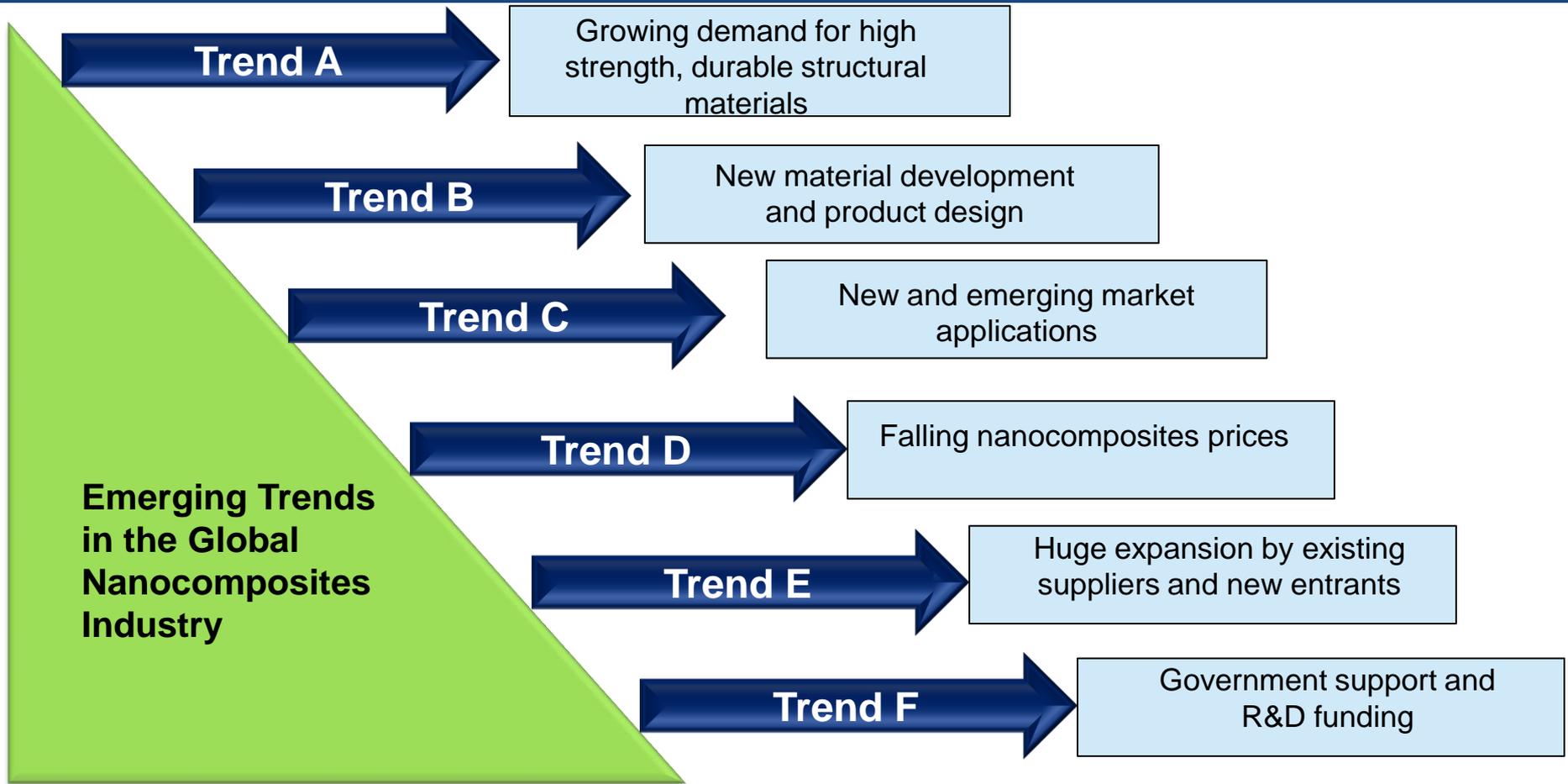
Growth opportunities for nanomaterials in various applications



Key Insights

- Nanomaterials have great potential in electrical and electronics applications because of their extraordinary electrical conductivity
- Global recession induced cost/price sensitivity in E & E segment, given its potential to reduce manufacturing costs and increase product competitiveness
- Packaging is another important segment, mainly flourishing in North America and Western Europe
- Energy segment is expected to pick up a nice pace in coming years @ double digit growth rate

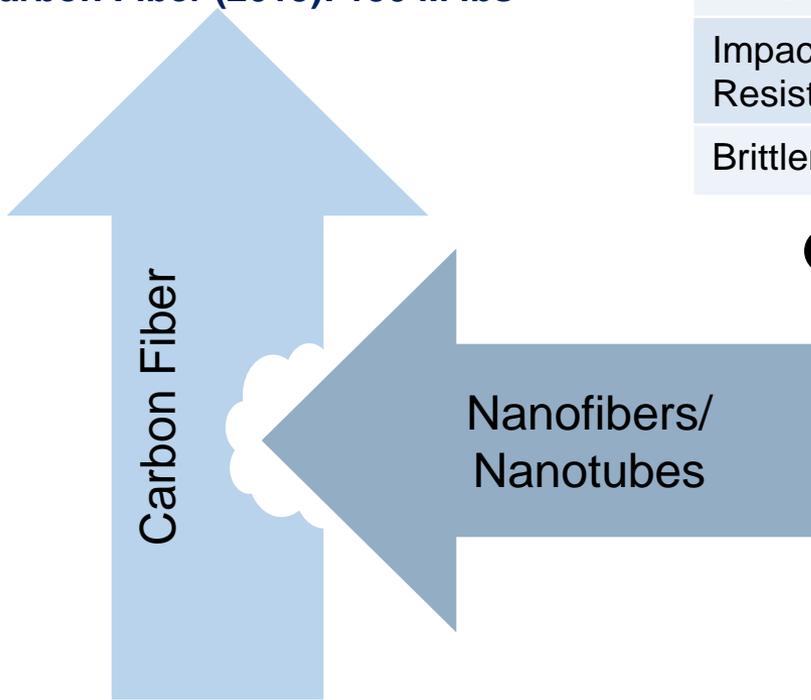
Emerging Trends in the Global Nanocomposites Industry



Growing demand for high strength, durable materials will create good future opportunities for nanocomposites



Carbon Fiber (2015): 150 M lbs



Carbon Fiber (2010): 80 M lbs

Properties	Carbon/Aramid / Glass fibers	Carbon nanotubes /nanoplatelets
Strength	Medium	Very high
Weight	Medium	Low/ NA
Impact Resistance	High	Very high
Brittleness	Medium	Low/ NA

Very high
 High
 Medium
 Low/ NA

New and exciting uses for nanotubes

- Aircraft wings and fuselages
- Boat hulls
- Sports cars
- Baseball bats, hockey sticks, and skis



New material development and product design



Nanoledge Inc. developed prepreg containing nanotubes

- Nanotubes used to boost mechanical properties
- Developed for experimental use in boat hull



New Piranha using Zyvex Nanomaterials

- Reduced weight while greatly increasing payload and cruising range



Harbor Composites designed nanotube aircraft

- Impart additional strength and durability to ordinary composites and make them even more appealing



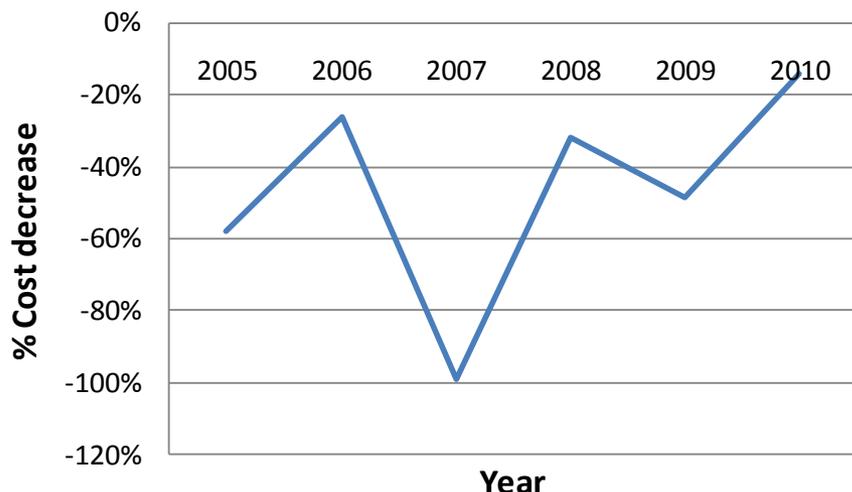
Velozzi's Supercar will use nanotube composites - structural parts

- Objective to improve properties and reduce weight



Technical developments in CNT promise further capacity expansion and price reduction

Trend in percentage fall in multiwall carbon nanomaterial cost: 2005-2010



Key Insights

- CNT prices have fallen substantially, from more than \$150 per gram in 2000 to under \$50 per gram today (2010)
- Improved manufacturing and large-scale production by CVD process enabled the drop in price
- Current technical developments in carbon nanotube fabrication may encourage further increase in production capacity and reduction in prices

Global leaders increasing manufacturing capacity



Arkema

- Arkema has scheduled a production facility for carbon nanotubes with the capacity of 400 tons per year to start in 2011 in France



Bayer

- Bayer Material Science opened a carbon nanotube pilot facility in Germany, boosting annual capacity by 200 tons

Recent raw material production expansion plans are indicative of strong demand in the sector



Arkema Group

- Fulcrum SP Materials & Arkema to jointly produce improved damage resistant nanocomposites
- Capacity expansion for CNT production in 2011



Showa Denko K.K.

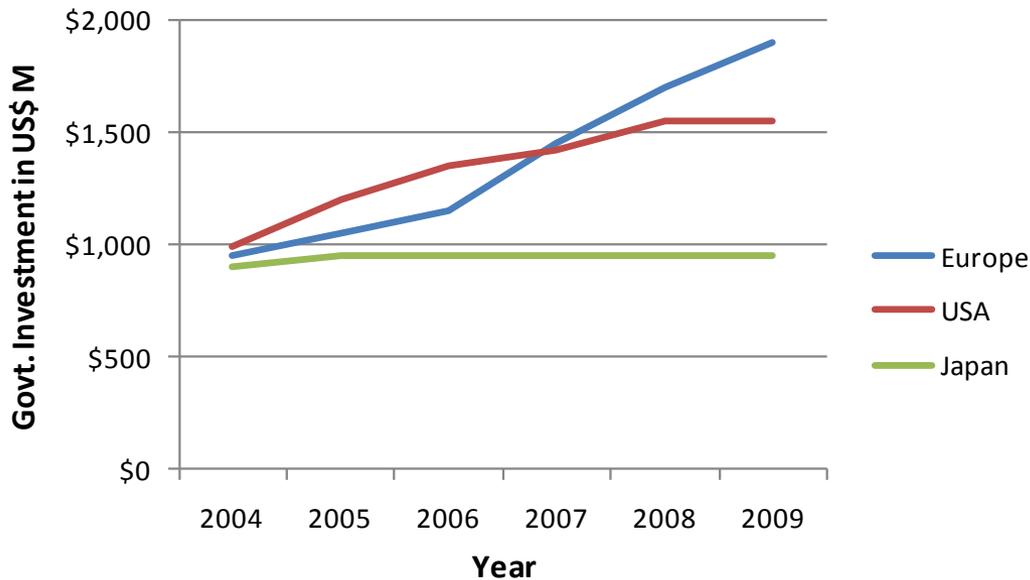
- Developed VGCFTM-X, a new grade of CNT for resin composite design
- Began construction of 400 ton/yr plant in 2009 at Oita



Bayer AG

- Opened a large carbon nanotube (CNT) pilot facility in Leverkusen, boasting annual capacity by 200 tons
- Invested €22 million in the operation located at Chempark in Leverkusen

Government funding for Nanotechnology in USD M \$ (2005-2009)



Key Insights

- In past 5 years, a huge amount has been invested in nanotechnology R&D by the USA and European countries
- Japan shows a considerable inclination towards nanotechnology development, spending ~\$1 B in nanotechnology R&D in 2010
- Global expenditures for nanotechnology R&D expected to grow @ ~23% until 2016

Growing nanotechnology market will boost the growth of nanocomposites

Global nanotechnology market is approximately \$16 billion in 2010, and is expected to grow by 11.5% average annual growth rate until 2015

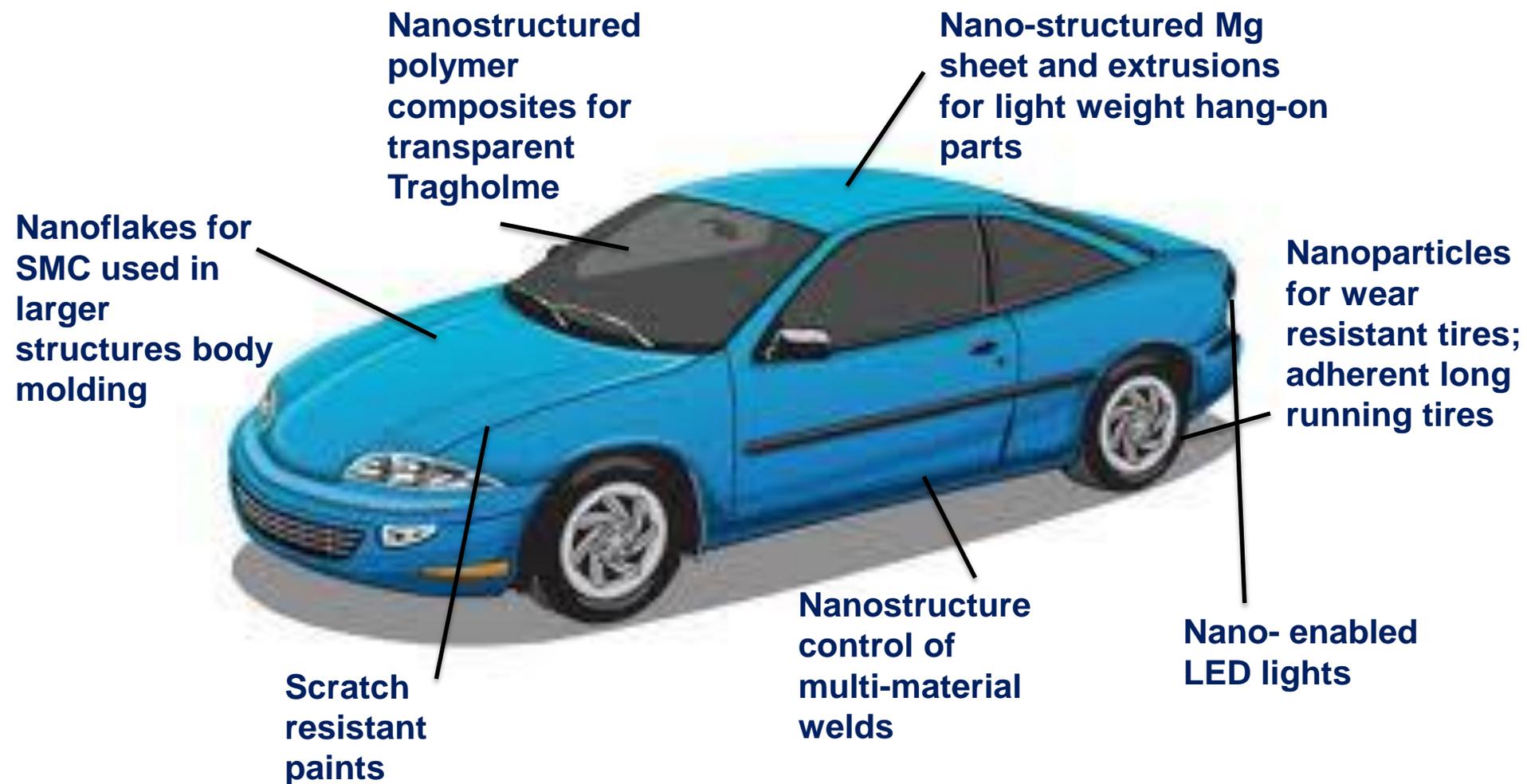
Government funding for nanotechnology is promoting R&D and driving growth in nanocomposites production

In several countries, governments are running nano-programs to promote nanotechnology

Country	Nano- program	Comments
France	Nano 2012	To develop technology to design and produce the next generation of integrated circuits
Germany	Nano Initiative Action Plan	Improve the interface between research and implementation, and to open up new markets
Finland	FinNano	Allocated fund of approx \$95 M for research and innovation (2005-2010)
Norway	NANOMAT	To develop world leading research to provide a basis for innovation and growth, and to promote commercialization (budget approx \$100 M for 2002-2016)



Growing uses of nanocomposites in transportation industry will create huge demand in future



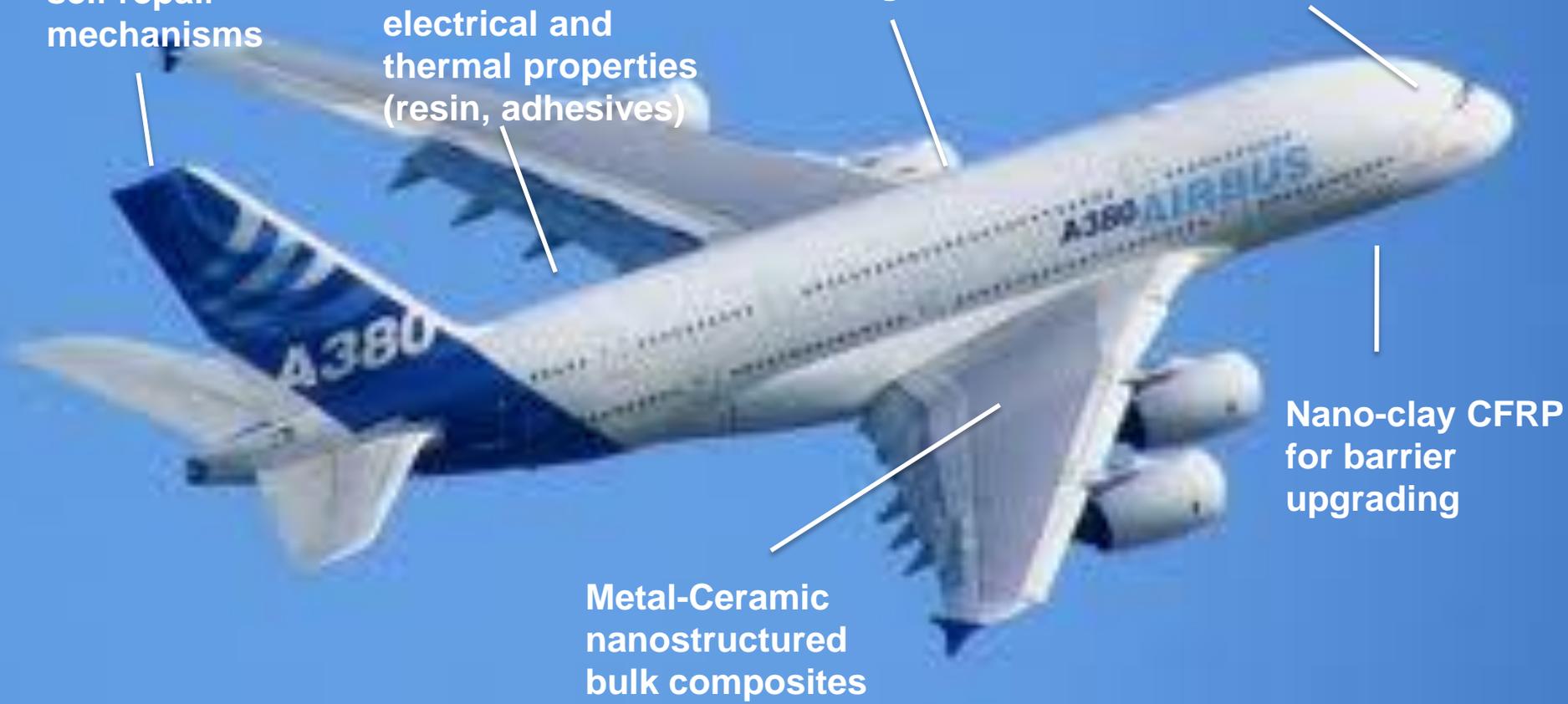
Potential Applications of Nanocomposites in Aircraft

Special coatings / adhesives with self repair mechanisms

Carbon nanotubes for improved mechanical, electrical and thermal properties (resin, adhesives)

Nanofillers for PIEZO-paints, coatings, and fibers

Micro-particle-reinforced

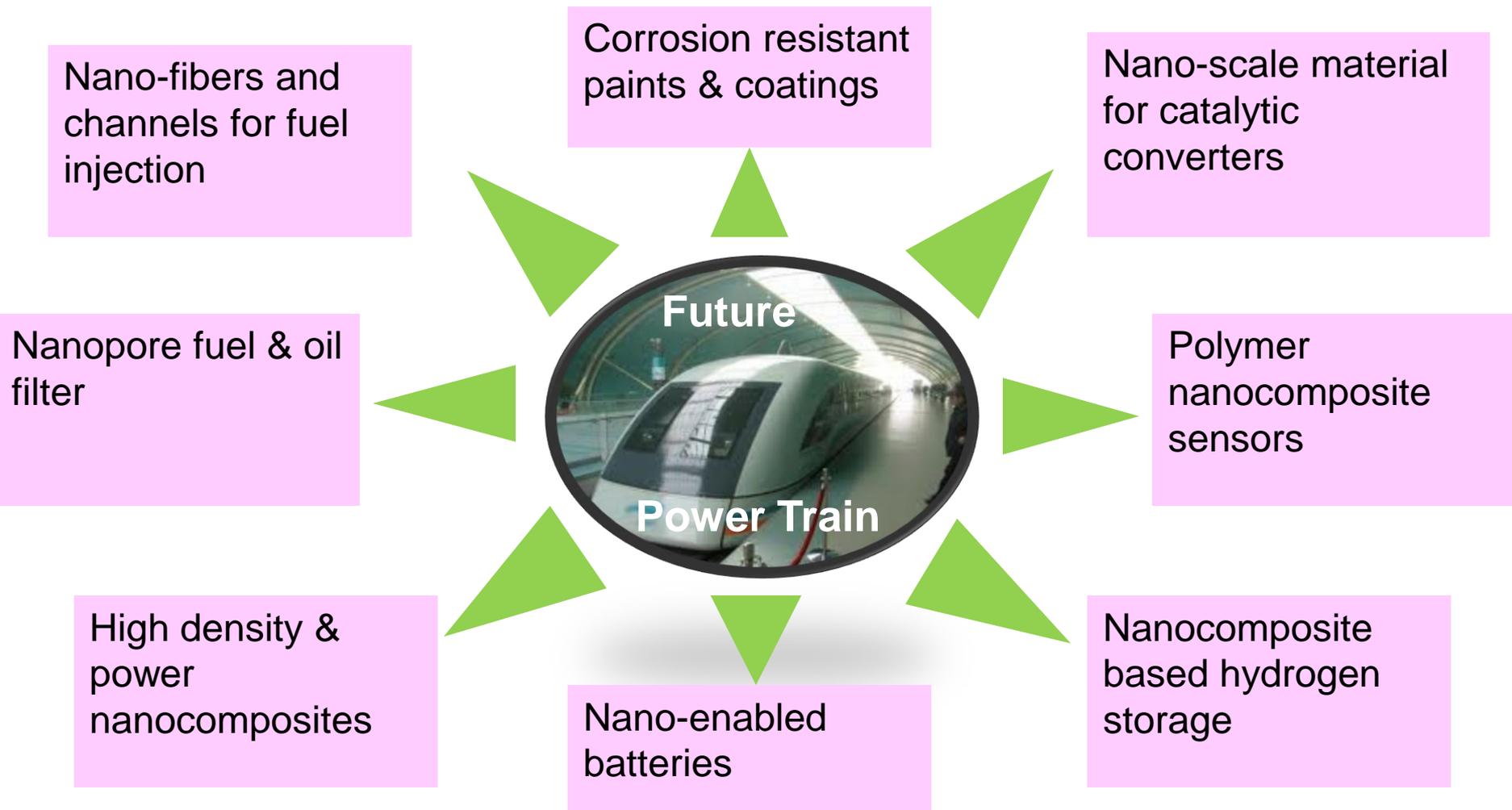


Nano-clay CFRP for barrier upgrading

Metal-Ceramic nanostructured bulk composites



Huge Potential of Nanocomposites in Future Power Trains



Emerging applications for nanomaterials

Application	Description	Size of Opportunity	Key Drivers
Field Emission Display (FED)	 <p>CNT is used as light emitter in FED</p>	Large	High luminance, high contrast, high light efficiency, wide view angle
Body Armor	 <p>Can be used for defense and military purpose for protection of body</p>	Medium	Greater safety, light weight and skid resistance
Water Purification	 <p>Used as antimicrobial agent</p>	Medium	Light weight porous materials for water filtration, enhanced performance for purification

Emerging applications for nanomaterials: Cont....

Application

Description

Size of Opportunity

Key Drivers

Drug Delivery



Used for improving the treatment of cancer

Medium

Enhanced mechanism for treating the infected cells

Bio Fuel Cell



Can be used as electrodes in bio fuel cell

Medium to Large

High enzyme loading, overcomes limitation of small dimensions and large specific surface area

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Conclusions

- The nanomaterials market is expected to grow at about 23% annual rate until 2016
- Top 6 players have secured two-thirds of global nanomaterials market shipments; high opportunity for new players to enter this growth market
- Decline in demand in 2009 for nano-enabled products in the automotive industry, such as automotive lubricants, catalytic converters, sensors and filters, among others, drove the heavy downturn in market opportunities for nanomaterials such as multi-wall carbon nanotubes (MWNTs) and ceramic nanoparticles
- Health care and energy markets were two main application areas which helped the global nanomaterial industry recover from the heavy downturn experienced in 2009.
- The healthcare industry is expected to surpass the electronic and electric industry in size over the coming 2-3 years, driven by nanotechnology advancements in biomedical field
- North America will remain the market leading region for several years as it has significant ongoing R & D activities in nanomaterials
- It is expected that nanomaterials will broaden their markets as they enter into more applications such as drug delivery, armor, defense equipment, weapons, nanomedicines and the like



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About Lucintel

- Lucintel is the leading global management consulting & market research firm for aerospace, marine, energy, construction, consumer goods, transportation, chemical, and composites industries.
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Renewable Energy



Recreational



Composite Materials

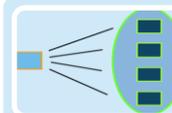
Consulting



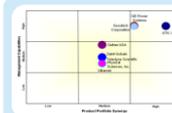
Growth and Strategic Consulting



Benchmarking



Opportunity Screening



Partner Search and Evaluation



Due Diligence and M&A



Market Entry Strategy

Lucintel has an extensive toolkit to address key strategic questions for increasing your company's profitability and market presence



Key Questions

- **Is market space / opportunity of current product offerings sufficiently robust?**
- **Markets are focus for many: how can my company profitably differentiate?**
- **Based on our core skills, where should we focus?**
- **Should we build or buy? Is build even an option?**
- **What game changer actions exist and/or is a more incremental approach best?**
- **What is the order sequence of market entry segments / products?**

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