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• Executive Summary
• Nanomaterials Market Outlook
• Market Trends and Opportunities
• Growth Opportunities in 2019 and Beyond
• Strategic Growth Opportunities
• About Lucintel
Executive Summary

- Global nanomaterials market was estimated at $8.4 B in 2019, and is likely to grow at a CAGR of ~13% in the next six years to reach $17.5 B in 2025
  - Carbon Nano Tubes (CNTs) and nanoclay materials holds major percentage share in the global nanomaterials market, followed by metal nanopowders and quantum dots
  - Graphene market is gaining wider acceptance, and is growing rapidly, driven by better price performance ratio compare to that of other competing materials
  - Major market drivers for healthy growth of the nanomaterials market in the different end use industries such as healthcare, E&E, Automotive and many more.

- Major drivers and trends shaping the global nanomaterials market are:
  - Government funding to encourage nanotechnology
  - Ongoing research & development to identify new and emerging applications and materials
  - Collaborations and joint product development between material suppliers, universities and Government bodies
  - Healthcare industry is increasing utilization of nanomaterials in different applications

- Major suppliers having significant contribution in the development of the nanomaterials market are Clariant, Showa Denko, Arkema, Nanocore, Umicore, and many more
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Nanomaterials Market Overview

Carbon Nanotubes
- Excellent mechanical properties
- Reduce weight
- Radio transparency
- Crack/vibration resistant

Nanoclay
- Excellent thixotropic agent
- Improve gas & liquid barrier properties
- Enhance flame retardant

Fullerenes
- Reduces weight
- Provide flexibility

Quantum Dots
- High extinction co-efficient

Metal Nanopowders
- Good mechanical properties
- Improved chemical properties
- Resist deformation

Graphenes
- Excellent optical & thermal, electrical and mechanical properties

Benefits
- • Excellent mechanical properties
- • Reduce weight
- • Radio transparency
- • Crack/vibration resistant
- • Excellent thixotropic agent
- • Improve gas & liquid barrier properties
- • Enhance flame retardant
- • Reduces weight
- • Provide flexibility
- • High extinction co-efficient
- • Good mechanical properties
- • Improved chemical properties
- • Resist deformation
- • Excellent optical & thermal, electrical and mechanical properties

Industry
- • Energy
- • Sporting Goods
- • Aerospace
- • Polymer & Ceramics
- • Medical
- • Automotive
- • Plastics
- • Pipe & Tank
- • Packaging
- • Paint & Coating
- • Consumer goods
- • Energy
- • E&E
- • Automotive
- • Medical/Health Care
- • Sporting Goods
- • Computing Devices
- • Medical
- • E&E
- • Solar Energy
- • Industrial
- • Healthcare/Medical
- • Energy
- • E&E
- • Consumer Goods
- • Energy
- • Bio Medical
- • Devices
- • Energy Storage Devices
- • E&E
Nanomaterials Value Chain

Nanomaterials
- Nanoclays
- CNTs
- Fullerenes
- Graphene
- Metal Nanomaterial

Nano-Intermediates
- Nanocomposites
  - Paints/Coatings
  - Ceramics & MMC

Nano-enabled Products/Components
- Auto Tier 1 Suppliers
- Aero Tier 1 Suppliers
- E&E

End Market/OEMs
- Automotive
- Aerospace & Defense
- Sporting Goods
- Medical
- E&E
- Construction

- BMW
- Daimler
- Boeing
- Airbus
- Easton Sports
- Yonex
- GE Health Care Siemens
- Samsung
- Nokia

- Clariant
- Nanocore
- Nanocyl
- Cnano Technologies
- Alfa Aesar
- Frontier Carbon
- Ningbo Morsh
- Umicore

- Basell Polyolefins
- BASF
- Akzo Nobel
- PPG Industries
- Nissin Kogyo
- NKK

- ArvinMeritor
- Borg-Warner
- Spirit AeroSystem
- Triumph Aerospace
### Current and Potential Applications of Nanomaterials

<table>
<thead>
<tr>
<th>Transportation</th>
<th>Construction</th>
<th>Packaging</th>
<th>Aerospace &amp; Defense</th>
<th>Consumer Goods</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Engine, Powertrain &amp; Fuel Systems</td>
<td>• Conductive Flooring</td>
<td>• Meat &amp; Food Packaging</td>
<td>• Aircraft Structures</td>
<td>• Home appliances</td>
</tr>
<tr>
<td>• Scratch Resistant Exterior Paint and Coatings</td>
<td>• Pipes</td>
<td>• Packaging</td>
<td>• Wear Resistant Paints &amp; Coatings for Defense Vehicles</td>
<td>• Sporting goods &amp; toys</td>
</tr>
<tr>
<td>• Car Interior</td>
<td>• Insulating Materials for Roofs &amp; Thatches</td>
<td>• Computers &amp; Electronics</td>
<td></td>
<td>• Furniture &amp; others</td>
</tr>
<tr>
<td>• LED Lights</td>
<td>• House &amp; Building Siding</td>
<td>• Medicines &amp; Pharmaceuticals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Batteries</td>
<td>• Self Cleaning Windows</td>
<td>• Beer Bottles</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Engine, Powertrain & Fuel Systems**
- **Scratch Resistant Exterior Paint and Coatings**
- **Car Interior**
- **LED Lights**
- **Batteries**
- **Conductive Flooring**
- **Pipes**
- **Insulating Materials for Roofs & Thatches**
- **House & Building Siding**
- **Self Cleaning Windows**
- **Meat & Food Packaging**
- **Computers & Electronics**
- **Medicines & Pharmaceuticals**
- **Beer Bottles**
- **Aircraft Structures**
- **Wear Resistant Paints & Coatings for Defense Vehicles**
- **Home appliances**
- **Sporting goods & toys**
- **Furniture & others**
### Current and Potential Applications of Nanomaterials

<table>
<thead>
<tr>
<th>Electrical &amp; Electronics</th>
<th>Energy</th>
<th>Health Care</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Sensors</td>
<td>• Battery electrodes</td>
<td>• Body implants</td>
<td>• Anti-foul coatings for marine ships</td>
</tr>
<tr>
<td>• Semiconductors</td>
<td>• Fuel cell membranes</td>
<td>• Medical devices</td>
<td>• Industrial equipment</td>
</tr>
<tr>
<td>• Hard disk storage in computers</td>
<td>• Supercapacitors</td>
<td>• Dental filling materials</td>
<td>• Fire resistant clothes</td>
</tr>
</tbody>
</table>
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**Market Trends and Opportunities**

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Key Insights

- Global nanomaterials market was estimated at $8.4 B in 2019 and is likely to grow at a CAGR of 13% in next six years to reach $17.5 B in 2020.
- Carbon Nano Tubes (CNTs) holds major percentage share in Global nanomaterials market and is expected to grow at double digit growth in the next six years.
- Increasing penetration and awareness in the end use industries, growing Government support and funding, expanding ongoing research and development to identify newer applications and new materials are the major drivers shaping nanomaterials market.

Global Nanomaterials Market Trend and Forecast ($B) 2014-2025

<table>
<thead>
<tr>
<th>Year</th>
<th>Market Size ($B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>4.9</td>
</tr>
<tr>
<td>2019</td>
<td>8.4</td>
</tr>
<tr>
<td>2025</td>
<td>17.5</td>
</tr>
</tbody>
</table>
Light Weight, High Strength are the Major Drivers for Nanomaterials To be Used in Different Industries

**Major Drivers**
- Light weight
- High strength
- Electrical conductivity
- Diagnostics
- Efficient drug delivery
- Increase efficiency
- Efficient Storage
- Strength to weight ratio
- Crack & vibration resistance

**Major Applications**
- Engine & Powertrain
- FEDs
- Medicines
- Wind Energy
- Racquets
- Archery

**Nanomaterials Market**
- Automotive
- E&E
- Health/Personal Care
- Energy
- Others (Sporting Goods, etc.)
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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 Industries

<table>
<thead>
<tr>
<th>Key Insights</th>
</tr>
</thead>
<tbody>
<tr>
<td>➢ Nanomaterials have great potential in electrical and electronics applications because of their extraordinary electrical conductivity</td>
</tr>
<tr>
<td>➢ Significant developments in healthcare technology, growth in the medical diagnostics industry, and medicinal imaging applications creating space and gaining market of nanomaterials</td>
</tr>
<tr>
<td>➢ Packaging is another important segment, flourishing mainly in North America and Western Europe</td>
</tr>
<tr>
<td>➢ Energy segment is also expected to grow at a double digit growth</td>
</tr>
</tbody>
</table>
Lucintel Predicts Five Key Emerging Trends Shaping the Global Nanomaterials Market

- **Trend A**: Growing demand for high strength, durable structural materials
- **Trend B**: New material and product development
- **Trend C**: Existing and emerging applications driving nanomaterials market
- **Trend D**: Government support, R&D funding and Joint Product Development
Trend A: Continuous Focus on Property Improvement and Part Performance Will Drive the Usage of Nanomaterials in Future

![Graph showing the comparison of different materials based on their strength-to-weight ratio and temperature. The graph includes categories such as Nano Composites, Ceramic Matrix Composites, Steels, Aluminum, Nickel-based Alloys, Titanium Alloys, Titanium, Aluminides, and Fiber-reinforced plastics. The graph indicates future requirements, suggesting an upward trend in performance.](image-url)
Continuous Focus on Property Improvement and Part Performance will Drive the Usage of Nanomaterials in Future
Lockheed Martin Incorporated CNRP into F35 Lightning II Wingtip Fairings Resulting in Significant Cost & Weight Reduction

Advanced Polymers Engineered for the Extreme (APEX) Technology: A Light-weighting Initiative

Carbon Nanotube Reinforced Polymer (CNRP) Wing Tip Fairings Benefits over CFRP

<table>
<thead>
<tr>
<th>Benefit</th>
<th>CNRP</th>
<th>CFRP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upto 30% of light weight as compared to CFRP component</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The new wingtip fairing is being made for one-tenth of the cost of the equivalent CFRP component</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Light-weighting Cost Saving

| Cost Saving | 30% | 90% |

Typical CNRP Property Comparison with CFRP

<table>
<thead>
<tr>
<th>Property</th>
<th>CFRP</th>
<th>CNRP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strength (MPa)</td>
<td>2,505</td>
<td>15,220</td>
</tr>
<tr>
<td>Stiffness (GPa)</td>
<td>140</td>
<td>147</td>
</tr>
<tr>
<td>Density (g/cc)</td>
<td>2.7</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Lockheed Martin has identified more than 100 additional parts for potential APEX insertion into the F-35 to achieve additional cost savings.
<table>
<thead>
<tr>
<th>Application</th>
<th>Nanomaterial Used</th>
<th>Unmet Needs</th>
<th>Industry Served</th>
<th>Benefits Derived</th>
<th>Relative Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>LED Lights</td>
<td>• Nano Ceramic Aluminum</td>
<td>• Low cost LED devices</td>
<td>• Automotive &amp; Mass Transportation</td>
<td>• 25% cost reduction of LED devices</td>
<td><img src="Icon.png" alt="Medium" /></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Temperature performance</td>
<td>• Construction &amp; Infrastructure</td>
<td>• 43% Component count reduction</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• 24% assembly cost reduction</td>
<td></td>
</tr>
<tr>
<td>Application Developer: Cambridge Nanotherm</td>
<td></td>
<td></td>
<td></td>
<td><strong>High</strong></td>
<td></td>
</tr>
<tr>
<td>Batteries</td>
<td>• Carbon Nanotubes</td>
<td>• Environmental friendly</td>
<td>• Transportation</td>
<td>• Reduction in toxicity of electrolyte solution</td>
<td><img src="Icon.png" alt="Medium" /></td>
</tr>
<tr>
<td></td>
<td>• Carbon Nanowires</td>
<td>• Smaller in size</td>
<td>• Energy</td>
<td>• Significant reduction in size of the batteries</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Low cost</td>
<td>• Healthcare</td>
<td>• Prevents ice formation</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Defense</td>
<td>• Improves efficiency</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Electronics</td>
<td>• Sustain &amp; improves corrosion resistance property of a blade</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>Low</strong></td>
<td><img src="Icon.png" alt="Low" /></td>
</tr>
<tr>
<td>Application Developer: mPhase Technologies</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blade Paint</td>
<td>Not Available</td>
<td>• Anti-Icing solution with improved resistance to corrosion</td>
<td>• Wind Energy</td>
<td>• Prevents ice formation</td>
<td><img src="Icon.png" alt="Low" /></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Improves efficiency</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Sustain &amp; improves corrosion resistance property of a blade</td>
<td></td>
</tr>
<tr>
<td>Application Developer: Gamesa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Trend B(i): Increasing Adoption of Nanomaterials to Improve Mechanical & Chemical Properties of End Parts at Reduced Weight and Prices**
# Trend B(ii): Product Launches in Nanomaterial

## Attractive product launches in intermediates

<table>
<thead>
<tr>
<th>Innovation Description</th>
<th>Material Name</th>
<th>Company Launched</th>
<th>Market Served</th>
<th>Innovation Attractiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hybrid glass/carbon fiber nanofabric</td>
<td>Not Available</td>
<td>Carbon Composite Technologies</td>
<td>Wind-Energy, Aerospace, Armor, Marine and Automotive</td>
<td><img src="" alt="High" /> <img src="" alt="High" /> <img src="" alt="High" /></td>
</tr>
<tr>
<td>Nano Adaptive Hybrid Fabric</td>
<td>Fuzzy Fiber</td>
<td>URDI, Goodrich, Owens Corning, Renegade Materials</td>
<td>Wind-Energy</td>
<td><img src="" alt="High" /> <img src="" alt="High" /> [NA]</td>
</tr>
<tr>
<td>Nanocomposite Prepreg</td>
<td>Arovex HT</td>
<td>Zyvex</td>
<td>Sporting Goods</td>
<td><img src="" alt="High" /> <img src="" alt="High" /> <a href="">Low</a></td>
</tr>
</tbody>
</table>

**Degree of Attractiveness**
- **High**
- **Low**
Trend C: Applications driving Opportunities in the Automotive, Healthcare and Energy Industries

Key Insights

- Nanocomposites exhibit excellent mechanical properties, dimensional stability, impact and scratch resistance, better thermal properties, etc.
- One of the fastest growing applications of nanomaterials is healthcare. Nanomaterials help in delivering drugs, heat, light, and other substances to specific types of cells for treatment purposes.
- Energy industry can also be benefitted with the nanotechnology ensuring better efficiency in energy production and storage.
- Major driver in increasing usage of nanocomposites in automotive applications are reduction in vehicle weight and improved engine efficiency (ensuring better mileage and emission reduction).
Trend D: Collaborations and Joint Product Development between Materials Suppliers, Universities and Government Bodies

- Park Systems are the manufacturer of Atomic Force Microscopes. They announced $1 million Nano Research to support researchers who are starting new nanoscience labs in North America. Systems

- The Massachusetts Institute of Technology researchers have produced carbon fibers coated with carbon nanotubes that sustain the mechanical properties of the base fibers.

- The U.S. Department of Energy (DOE) Grant to Georgia Institute of Technology to develop an additive manufacturing technique for fabricating three-dimensional (3D) nanoscale structures from a variety of materials.

- University of Sussex developed a new way of producing nanomaterial inks and assembling them into coatings. Dalton expanded his lab to find nanomaterial technological solutions collaborating with different end use industries.
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Three Growth and Profit Scenarios in Nanomaterials Market

Scenario 1: Expand Core Business

- Identify unmet needs in existing applications
- Strategic alliances across value chain nodes

Scenario 2: Growth Segments and Application Development

- Target growing segments such as automotive, medical
- Focus on growing Graphene market
- Develop cost effective solutions for composites

Scenario 3: Emerging Region

Growing paint and Coatings, composites, and E&E market in Asia will drive the higher consumption of nanomaterials
Three Growth and Profit Scenarios in Nanomaterials Market

1. **Identify Growth Applications based on Synergy**
   - Identify new opportunities with good synergy and profitability
   - Identify growing regions

2. **Cost Reduction and Improved Processes**
   - Reduce cost of Nanomaterials to make it cost effective alternative against conventional materials by improving manufacturing process
   - Improve process characteristics, such as stability in processing

3. **Strategic Alliances (M & A)**
   - Develop strategic alliances to gain competitive advantages with material suppliers, nano intermediaries, universities and Government bodies, etc.
   - Enter into emerging markets and regions
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Lucintel - At a Glance

- Premier management consulting and market research firm. Founded in 1998.
- Deep global insights into major industries. Team of over 120 analysts/consultants across the globe.
- Management comprised of PhDs, MBAs, and subject matter experts. Headquarter in Dallas, USA.

Conducted 500+ consulting projects across industries for 3M, Audi, Dupont, Carlyle, GE, etc.

Consulting Services

Why Lucintel

- Clients we serve: Over 1000 clients from 70 countries – Fortune 500 companies
- Strategic advice: Over 20 years of proven global strategic management consulting experience

Industries Served
1000+ Clients in 70 Countries Value Our Service
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