The Future Nano Compound Business based on Carbon Nanotube – Polymer Composite with High Performance
0. General Information

I. Management Status

II. Business Outline

III. Business Status and Growth Engines
Nanomirae is

Toward to World Best Nano Material of Light Weight, EMI, Heat Dissipation, and Anti-static

- The professional company of multi-functional carbon nanotube – polymer compound
- Major Research and Development
  - Development of CNT-polymer compound with high transparent and conductive
  - Development of CNT-polymer compound with heat dissipation and EMI for automotive

- Patent

<table>
<thead>
<tr>
<th>Division</th>
<th>Patent name</th>
<th>Patent NO.</th>
<th>apply/register</th>
<th>etc.</th>
</tr>
</thead>
</table>
I. Management Status

1. Company General Information
2. Company History
3. Main Business Areas
4. The Company's Vision
## I-1. Company Summary

<table>
<thead>
<tr>
<th>ITEM</th>
<th>CONTENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company Name</td>
<td>Nanomirae Co., Ltd</td>
</tr>
<tr>
<td>Address</td>
<td>7-6, Yodang-ri, Yanggam-myeon, Hwaseong-si, GyeongGi-do, Korea.</td>
</tr>
</tbody>
</table>
| Contact information | • Tel : +82-31-352-4331 / 4473  
                        | • Fax : +82-31-352-4995                                                  |
| Homepage and E-mail | [www.nanomirae.co.kr](http://www.nanomirae.co.kr) ,  shyun@nanomirae.co.kr |
| Manufacturing       | Carbon Nanotube – Polymer Composites, Nano Composites                   |
| Major products      | Functional carbon nanotube - polymer composites                         |
| Employee            | 11                                                                       |
| Established date and Capital | October 26, 2001, 1.16 billion (based on accounting requirement in 2011) |
| Business Items      | • manufacturing and sales antistatic carbon nanotubes, polymer composites  
                        | • Development of EMI shielding of carbon nanotubes-polymer composites  
                        | • Development of multifunctional carbon nanotube-polymer composites    |
| President (CEO)     | Chan-young Chung                                                         |
I–2. Company History

- October 2001 - Established of NANOMIRAE Co., Ltd.
- March 2002 - Development of production techniques that graphite nano fiber and carbon nano tubes
- September 2003 – production of carbon nano fibers(GNF) and carbon nano tubes
- February 2004 - The Small and Medium Business Administration, Technology Innovation Project
  subjective.(Preventing static electricity, conductive coatings.)
- February 2005 - Supervised localized business improvement in ministry of Commerce
  (Anti static conducting fiber)
- February 2006 – Developed of dispersion technology for anti-static carbon nano tubes - polymer composite
- September 2006 - Developed of Anti-Static carbon nanotube-polymer composites manufacturing process
- March 2007 - Manufacturing and sales of carbon nanotube-polymer composite (NMC, NMO, NMT)
- June 2007 - R & D of fundamental planning in Ministry Knowledge Economy
- December 2008 - Signed a contract for MOU of ATM components co-development with Hyosung technology research center
- April 2009 - R&D for automobile components with carbon Nanotube-polymer composite
I-2. Company History

- October 2009 - R&D Planning Project of exterior material of electric controlling part for Electric car with carbon nanotube-polymer composite (Ministry of Knowledge Economy)
- January 2010 – R&D of Heat transferable carbon nanotube-polymer composite for LED light of heat dissipation part (Korea Institute of Machinery)
- March 2010 – Registered and supplied Hyosung first association company and Anti-Static Carbon Nanotube-polymer composite for automated teller machine (ATM)
- September 2010 – Participated in R&D project for automobile part (ECU) based on carbon nanotube-polymer composite in Hyundai MOBIS
- November 2010 – Developed of carbon nanotube-polymer composite with high wear abrasive and anti-static function for TFT-LCD/OLED/LED transfer system (NMPA)
- April 2011 – Developed of carbon nanotube-polymer composite with high electrical dissipation function for TFT-LCD/OLED/LED transfer system (NMC1525, NMC1550)
- May 2011 – R&D of injection molding and mass production for carbon nanotube-polymer composite with heat dissipation and wear abrasion (Korea Institute of Machinery)
- November 2011 – Supplied Anti-Static Carbon Nanotube-polymer composite for automated teller machine (ATM) to LG Ensys.
## 1-3. Major business area

### Under development

<table>
<thead>
<tr>
<th>Items</th>
<th>Applied Field</th>
<th>Potential Customers</th>
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<tbody>
<tr>
<td>Electromagnetic Interference Shielding (EMI) of Carbon nano tube - polymer composites</td>
<td>Exterior mobile devices, Exterior automotive parts, medical equipment enclosure, etc.</td>
<td>Samsung Electronics, LG Electronics, Hyundai Mobis Man-Do Samsung SDI GE, etc.</td>
</tr>
<tr>
<td>Thermal conductivity of Carbon nanotube - polymer composites</td>
<td>LED lamp for Materials heat dissipation, Exterior automotive parts, Next Generation Battery enclosure, etc.</td>
<td>LED lamp company, Hyundai Mobis, Man-Do, Samsung SDI, SKC, Samsung mobile display((SMD), etc.</td>
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<tr>
<td>EMI - Thermal conductivity of carbon nanotube – polymer composite.</td>
<td>Exterior automotive parts, Exterior airplane parts, Computer equipment enclosure such as server, etc.</td>
<td>Hyundai Mobis, Man-Do, Samsung Electronics, LG Electronics, etc.</td>
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<tr>
<td>Carbon nanotube - polymer composite for Lightweight - High Voltage power lines</td>
<td>Semi-conductive materials for High voltage power line</td>
<td>LS Cable, Taihan Electric Wire, Iljin Electric, etc.</td>
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### Products on the market

<table>
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<th>Potential Customers</th>
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<tbody>
<tr>
<td>Electrical conductivity (ESD) Carbon nanotube - polymer composite materials</td>
<td>Banking automation equipment parts materials, TFT-LCD process equipment parts materials, Semiconductor Packaging, Ticket vending machines and vending machine parts materials, Wafer Packaging, etc.</td>
<td>HYOSUNG(Nautilus HYOSUNG), LG CNS, CHUNG-HO, Samsung Electronics, Samsung mobile display(SMD), LG display, etc.</td>
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I-4. Commercialization strategies and goals

<table>
<thead>
<tr>
<th>Item/Year</th>
<th>2009</th>
<th>2010</th>
<th>2012</th>
<th>2015</th>
<th>2017</th>
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<td>functional classification</td>
<td>Electrical conductivity</td>
<td>EMI Shielding</td>
<td>Thermal conductivity</td>
<td>Multifunctional</td>
<td>Superconductivity</td>
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<td>Automated teller machine (ATM)</td>
<td>ATM and TFT-LCD</td>
<td>ATM TFT-LCD</td>
<td>ATM TFT-LCD</td>
<td>ATM TFT-LCD</td>
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<td>manufacturing equipment components.</td>
<td>Manufacturing product Electronics parts LED light heat transfer panel Automobile components</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Battery part, medical machine part</td>
<td>Battery part, medical machine part</td>
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<td></td>
<td></td>
<td>Supercritical pressure wire part, Aircraft part</td>
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<td>Applied product</td>
<td>Automated teller machine (ATM)</td>
<td>ATM and TFT-LCD</td>
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<td>ATM TFT-LCD</td>
<td>ATM TFT-LCD</td>
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<tr>
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<td>Manufacturing product Electronics parts LED light heat transfer panel Automobile components</td>
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<td>Battery part, medical machine part</td>
<td>Battery part, medical machine part</td>
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<td></td>
<td>Supercritical pressure wire part, Aircraft part</td>
<td>Supercritical pressure wire part, Aircraft part</td>
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<td>Potencial Sales (hundred million)</td>
<td>2</td>
<td>12</td>
<td>30</td>
<td>200</td>
<td>500</td>
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<td>Strategy</td>
<td>strategic alliances with Large corporations : HYOSUNG Corporation</td>
<td>• Supply to major company: Registering Hyosung’s first associated company • Participating in R&amp;D Project in Korea Institute of Machinery : material of heat dissipation structure for LED lamp.</td>
<td>•Participation in government R &amp; D projects, Lightweight, Ultra High Voltage power lines semi-conducting parts materials. • KOTRA commercialization and sales of international co-completion task Korea/ Japan (the parts of Precision machine.)</td>
<td>•Government R &amp; D projects completed and the results of the sale. : Lightweight, Ultra High Voltage power lines semi-conducting parts materials. (Superconductivity)</td>
<td>•Government R &amp; D projects completed and the results of the sale. : Lightweight, Ultra High Voltage power lines semi-conducting parts materials. (Superconductivity)</td>
</tr>
</tbody>
</table>
II. Business outline

1. Carbon nano tube - Polymer Composites
2. Overview of Core Technology
3. Present State of Research and Development.
4. Applicable Product
5. Market Figure
II-1. Carbon nano tube – Polymer Composite

- Carbon atoms are arranged in the form of a tube with multiple layers that are formed nano scale.
- Electrical conductivity is similar to copper, and Thermal conductivity of diamond with the same
- The strength is 100 times than steel and endure 15% deformation.
- Applied to high valued Cutting-edge industry
- will take place industry and will be ranking top 10 neo-material

(MWCNT : Multi Wall Carbon Nano Tube)

- Super engineering / engineering plastic (polymer)
- Likely PEEK, PBT, mPPO, PA, etc.
- Insulator, non-heat transfer.

- Carbon nano tube - polymer composite materials.
- Electrical conductivity : $10^2 - 10^6$
- Thermal conductivity : ~ 1.0 W/m K
- Better strength.

- Nano-scale dispersion processing
- Processing with high tech between nano-particles and micro-material
- Melting dispersion and compounding processing.
II-2. Core Technology outline.

- Dispersion of carbon nano tubes with the isotropic direction
- Nano-scale control technology
- Dispersion control technology based on carbon nano tubes as the viscosity of polymer.
- Carbon Nano tube - Polymer compounding technology related transfer, and buffing.

Mass Production Technology

- The first dispersion process
  - Dispersant.
  - Nano Carbon Filler
  - Polymer
  - Dispersion Equipment

- Second Melting dispersion process
  - Interface Control Technology between CNT & Polymer
  - CNT stabilization technology in molten polymer

1st storage of products

Pelletizer

Cooler

Extrusion Equipment

Electrical Equipment

Packaging
## II-3-1. State of Research and Development

<table>
<thead>
<tr>
<th>Categorization</th>
<th>R&amp;D Project</th>
<th>Details</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>R&amp;D Project of The Small and Medium Business Administration</td>
<td>Conductive coating developed by MWCNT</td>
<td>Electromagnetic Shielding coating material</td>
<td>August 2004 to July 2005</td>
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<tr>
<td>Projects of the national Ministry of Commerce.</td>
<td>Conductive fiber developed by MWCNT.</td>
<td>For preventing static electricity nylon fiber</td>
<td>September 2004 to August 2006</td>
</tr>
<tr>
<td>Internal Project.</td>
<td>Conductible transparent composite with high anti-static and beam <em>Transmittance</em> using MWCNT</td>
<td>Conductive CNT composites</td>
<td>June 2004 to December 2006</td>
</tr>
<tr>
<td>University-Industry Co-development project</td>
<td>Nano fluids using carbon nano tubes to improve the cooling performance of the study.</td>
<td>Nano fluid through the improvement of cooling efficiency</td>
<td>October 2006 to October 2007</td>
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<tr>
<td>Internal Project.</td>
<td>Conductive CNT-polymer composite for the semiconductor industry by developing mass production.</td>
<td>MWCNT+mPPO, MWCNT+PC.</td>
<td>January 2007 to August 2007.</td>
</tr>
</tbody>
</table>

*Transmittance*
## II-3-1. State of Research and Development

<table>
<thead>
<tr>
<th>Division</th>
<th>R&amp;D Project</th>
<th>Details</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Korea Institute of Machinery and Materials</td>
<td>Using the conductive nano materials, development for high efficiency of light energy components</td>
<td>Thermally conductive composite material developed using the MWCNT.</td>
<td>January 2010 to December 2010.</td>
</tr>
<tr>
<td>Co-development of industry</td>
<td>Development of TFT-LCD/OLED/LED transferring part. with anti-static and wear abrasion properties.</td>
<td>Development of composite High abrasion and low electric resistance using the MWCNT.</td>
<td>June 2010 to February 2011.</td>
</tr>
<tr>
<td>Joint Development of Industry Research Institute.</td>
<td>Development of Heat dissipation structure for LED lamp.</td>
<td>Thermally conductive composite using the MWCNT.</td>
<td>June 2010 to June 20112</td>
</tr>
</tbody>
</table>
II–3–2. Current R & D status and future plans

Year

2015
2014
2013
2012
2011
2010

Source Technology Research
Development of Commercialization and preproduction
Development of Application testing and Mass production
Mass Production Technology

2015
2014
2013
2012
2011
2010

Depth of research and development
Electromagnetic shielding field
Electromagnetic shielding + Thermal conductivity field
Thermal conductivity field
Superconducting field
Anti-static + High abrasion resistance field

LS Cable, Taihan Elect & wire
Korea Electronics Technology Institute
Korea Institute of Machinery & Materials
Hyundai Mobis
Korea Institute of Machinery & Materials
VITECH, LED lamp Manufacturer
Korea Institute of Machinery & Materials
Hyundai Mobis

VITECH, TFT-LCD Company, JAPAN KAMO, KOTRA

Korea Institute of Machinery & Materials
VITECH, LED lamp Manufacturer
II-4. General applications of CNT-polymer composite

- Printer base (ESD)
- Hard disk tray (ESD)
- Car Bumper (ESD)
- TFT-LCD cassette (ESD)
- Automobile fuel tank (ESD)
- IC Chip tray (ESD)
- Cell Phone housing (EMI)
- Sensor housing (EMI)
- A Measuring instrument (EMI)

* EMI : Electro Magnetic Interference
* ESD : Electro Static Discharge
Functional Carbon Nanotube - Polymer Composites

Applications
1. Anti-static field
2. Electromagnetic shielding field
3. Thermal conductivity field
4. High Strength field
5. Multifunctional field

- CNT : Carbon Nano Tube
- MWCNT : Multi Wall Carbon Nano Tube
- Thin MWCNT : Thin Multi Wall Carbon Nano Tube
## II-5. Market Figure of relevant product

<table>
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<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical Conductivity Area (ATM/Office Equipment, etc.)</td>
<td>Korea</td>
<td>1,757</td>
<td>1,837</td>
<td>1,931</td>
<td>2,028</td>
<td>2,139</td>
<td>2,272</td>
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<tr>
<td></td>
<td>Overseas</td>
<td>17,114</td>
<td>18,629</td>
<td>20,325</td>
<td>22,252</td>
<td>24,483</td>
<td>27,134</td>
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<tr>
<td>Electromagnetic Shielding Area (Mobile devices, etc)</td>
<td>Korea</td>
<td>5,000</td>
<td>6,000</td>
<td>7,000</td>
<td>8,000</td>
<td>10,000</td>
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<td>10,000</td>
<td>15,000</td>
<td>25,000</td>
<td>30,000</td>
<td>40,000</td>
<td>65,000</td>
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<td>Thermal conductivity Area (LED Heatsink, etc.)</td>
<td>Korea</td>
<td>500</td>
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<td>20,000</td>
<td>30,000</td>
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<td>100,000</td>
<td>250,000</td>
<td>300,000</td>
<td>500,000</td>
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<td>Electromagnetic Shielding/Thermal conductivity Area (Car Parts, etc)</td>
<td>Korea</td>
<td>46</td>
<td>65</td>
<td>85</td>
<td>120</td>
<td>175</td>
<td>260</td>
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<td>800</td>
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<td>1430</td>
<td>2,000</td>
<td>3,000</td>
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<td>Superconductivity Area (super high voltage Power line, etc.)</td>
<td>Korea</td>
<td>700</td>
<td>1,000</td>
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<td>1,600</td>
<td>1,700</td>
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<td></td>
<td>Overseas</td>
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<td>70,000</td>
<td>85,000</td>
<td>95,000</td>
<td>105,000</td>
<td>125,000</td>
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</table>

Source: Ministry of Knowledge Economy, BCC Report, Automotive Industries Association of Domestic

Unit: one hundred million
III. Products & New materials in the future

1. Electrical Conductivity materials
2. Thermal Conductivity materials
3. EMI / thermal conductivity materials
4. Super conductive material
5. Products of NANOMIRAE
III-1. Electrical Conductivity materials – ATM

- The main function of ATM is for depositing, transferring, withdrawing bills.
- Bills have a tendency to be overlapped with electromagnetic interruption by varied humidity or external environment when transferring.
- Therefore, solve the overlapping situation of bills by dispersing electric statics swiftly when static outbreaks.
- For these functions, manufacture static-dispersive functional material in Bill transmitting components.
- Basically used carbon nanotube-polymer composite and manufacture with injection molding method.

- Technology for ATM has developed with multi-functioning system.
- Added depositing function from simply storing or withdrawing.
- Has developed auto-circulation system for deposited bills to withdrawn area.
- Staffs don’t have to directly withdraw at bank safe, but in front of the door of the safe.
- These various and sophisticated functions make bill transferring components increase to lengthen bill circulation.
- Has tendency to be substituted from metal parts to carbon nanotube-polymer composite in order to simplify maintenance and distribution.
- This contributes production cost-reduction for ATM.
III-1. Electrical Conductivity materials –

TFT-LCD/OLED/LED transferring components

- In TFT-LCD/OLED/LED production process need that electrostatic has to cut off its source.
- due to occurring electrostatic, it is possible that bad products are produced.
- Also, because of continuous friction between the rollers between panel due to a scratch, products Is leading to bad.
- As Rollers, Sleeve and Bearing Cab are made of electrically conductive composites such as carbon nanotube-polymer composite
- Carbon nanotube-polymer composite can be minimized if the scratch and electrostatic has occurred.

Model of TFT-LCD/OLED/LED transferring components

Roller

Bearing Cab

Sleeve
III-2. Thermal Conductivity materials – LED Lamp

➢ Heat sink designing
  ▪ Aluminum material possessing over 40% of lighting weight
  ▪ increase durability of LED chip increasing effectiveness of heat sinking
  ▪ High powered heat sink is heavier, hard to install and control
  ▪ substituted functional Plastic for Weight reducing and Cost-effectiveness
  ▪ will be replaced Nanomiraee's heat transferable CNT-Highpolymer plastic

Thermal performance of Aluminum

Thermal performance of CNT-polymer composite

Analysis thermal performance for the heat sink of LED lighting.(2010) : Korea Institute of Machinery and Materials
III-3. EMI/ thermal conductivity compound functional areas

Application on Automotive ECU system

- External physical shock protection
- Electromagnetic shielding / absorption
- Circuit boards to prevent the temperature to rise

Electrical and electronic control part (Circuit boards + Exterior)

- Engine Control Unit
- ABS
- ECS
- MDPS
- TMS
- EMS
- VDC
- BMS
- EWB
- EMB

Number of ECU in Toyoda, Hyundai, BMW, Benze etc: 70 -100 EA

Reference: Hyundai Mobis / Ministry of Knowledge Economy

Increases Fuel-efficiency due to cost-reduction and weight reduction By substituting Graphite Nanotubes high polymer complex material from aluminum steel ECU housing
III-4. Super conductive – Lightweight, high voltage power cable

1. Semi-conductive shield layer in high voltage power cable
2. Good adhesion between conductors and insulators, the air gap and the occurrence of water trees is minimized.

To develop material of Semi-conductive Shield layer in high voltage power cable
1. Conventional conductive additive, carbon black is added to 40%.
2. Using Nano-sized carbon nanotubes, surface smoothness of Semi-conducting layer improves dramatically. (Insulation thickness is reduced by 10%.)
3. Excellent thermal conductivity increase of the current permit.

Figure: Power System Laboratory, Seoul National University
### NMO series

<table>
<thead>
<tr>
<th>Model Name</th>
<th>Proportion (w%)</th>
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<tbody>
<tr>
<td></td>
<td>CNT</td>
</tr>
<tr>
<td>NMO 2015</td>
<td>1.5</td>
</tr>
<tr>
<td>NMO 2015H</td>
<td>1.5</td>
</tr>
<tr>
<td>NMO 3015</td>
<td>1.5</td>
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<tr>
<td>NMO 3015H</td>
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### NMPA series

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<tr>
<td>NMPA2025</td>
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### NMC series

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<td>CNT</td>
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<td>NMC 2010</td>
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<tr>
<td>NMC 3010</td>
<td>1.0</td>
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<td>NMC 0050</td>
<td>5.0</td>
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<tr>
<td>NMC 1550</td>
<td>5.0</td>
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</tbody>
</table>

The material of anti-static and abrasion resistance function.

EMI (Electromagnetic Interference) Shielding Effect is about 20db within 1 – 1.8 GHz.