New and Emerging Strategies for R&D in Nanotechnology in Korea:

Nano-Innovation of Korea 2025

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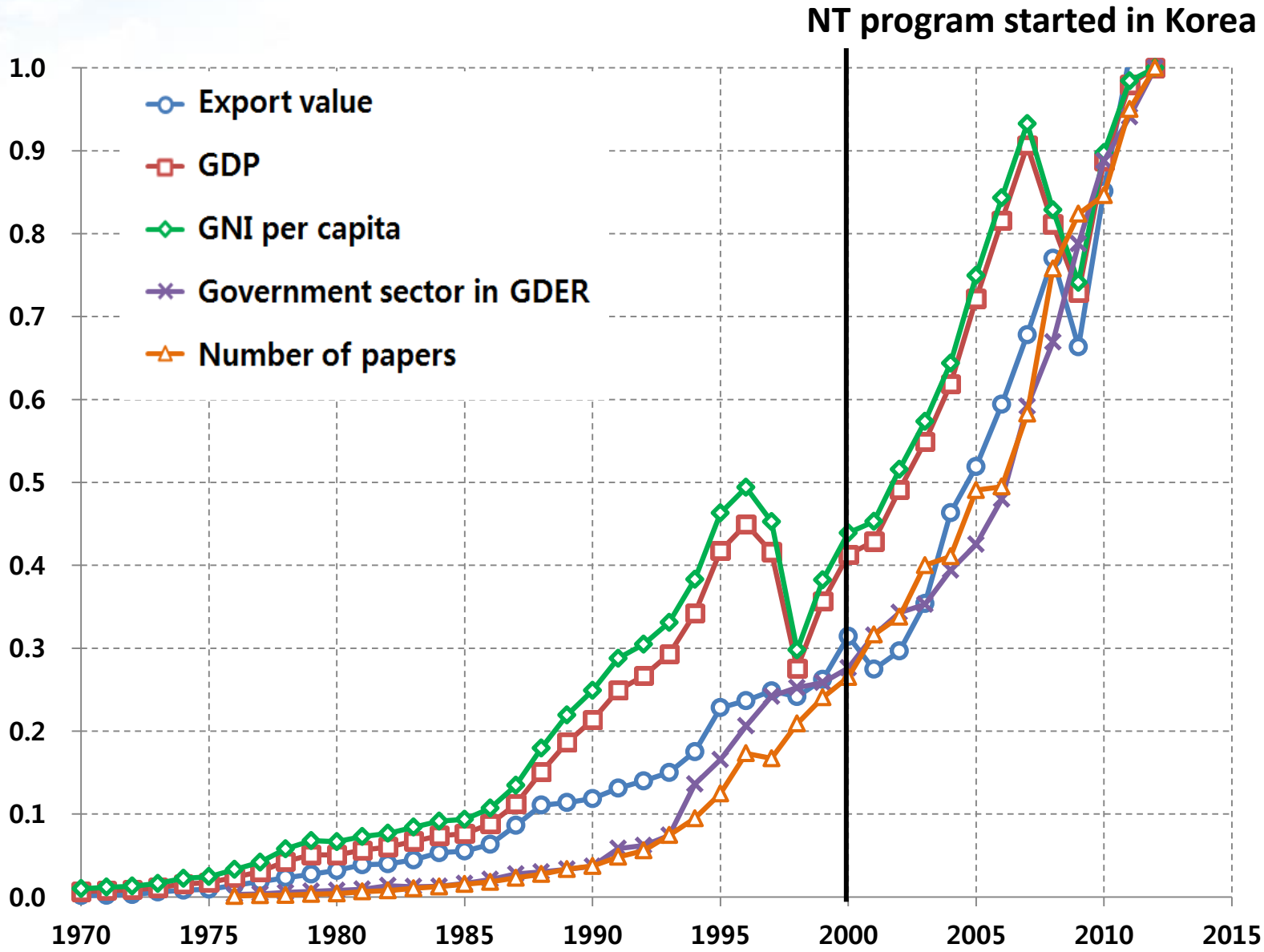
1. History of Korea Growth (1960 – 2012)



1 Nano-Innovation of Korea 2025

Ministry of Science, ICT and Future Planning

I. Vision and Goals

Ministry of Science, ICT and Future Planning

Vision

Being a First Class Country accomplishing sustainable growth through **the Innovation in NT**

Realization of innovative technology for manufacturing industries

92%
Technology Level (U.S standard 100)

12,000
Core Research HR

Goal (2025)

Global leader in nanotechnology industrialization

12%
Ratio of the sales revenues by nano-abled products

1,000 industries
No. of nano convergence company

3 Major Strategies and 12 Projects

1 Diffuse Innovation-driven Nano Industrialization

① Secure core technologies for Industrialization promotion
② Support technology Commercialization of the company
③ Strengthen infrastructure for the proliferation of nano-convergence
④ Overcome the barriers for commercialization

2 Secure Advanced NT for the Future

⑤ Promote strategic basic research in NT
⑥ Develop 30 core subjects in NT
⑦ Promote 「Nano Challenge」 projects in 4 majors categories of NT
⑧ Rationalize national investment in NT

3 Expand Nano Innovation Infrastructure

⑨ Cultivate on-site type 'Nano specialists'
⑩ Build neo-global cooperation system
⑪ Secure nano-safety management system
⑫ Build information system for innovation support

II. Tasks

Ministry of Science, ICT and Future Planning

1 Innovation-driven Nano Industrialization

▶ Facilitating Commercialization of Highly Matured Technological Fields

Task 1 Secure core technologies for industrialization promotion

➡ Expansion of nano consolidated growth model by securing core technologies in strategic areas

Promotion industrialization of 7 Key Technology

- Securing core technologies for developing new global markets

7 Key Technology

① 3D nano-electronics device
② Environmental IoT nano-senor
③ Food safety nano-sensors
④ Functional nano-fibers
⑤ Preciousmetal-free catalysts
⑥ Rare earth-free nano-materials for industrial use
⑦ Low-energy water treatment system

Expected results

Sales revenue of USD 13 billion

Graphene commercialization promotion

- Preoccupying global markets by establishing the supply chain of graphene and through strategic commercialization of applied products*

* Electromagnetic shield film, corrosion-resistant, multi-functional coating, high performance barrier film, graphene-based touch panel, graphene-based OLED panel and super capacitor electrode

Create **20** Global companies

Goal of **2025**

Sales revenue of USD 17 billion

Task 2 Support technology commercialization of companies

➡ Facilitating new businesses by commercialization of excellent technologies and attracting investment into SMBs

Support to R&D for commercialization

- Support to resolution of issues regarding commercialization and product development

Facilitating private investment of SMBs·venture companies

- Establishing and operating dedicated organizations for attracting investment

IV. Tasks

Ministry of Science, ICT and Future Planning

▶ Establishing Industrial Ecosystem for Reinforcing Competitiveness of SMBs

Task 3 Strengthen infrastructure for the proliferation of nano convergence

➡ Establishing foundation to complement lacking R&D infrastructure of companies

Expanding nano fab processes and improving their efficiency

- Development/support to new process platforms to enable IoT

Vitalization of nano innovation cluster

- Vitalization of nano clusters for nurturing companies and promoting technical consolidation

Task 4 Overcome the barriers for commercialization

➡ Establishing environment for industrial growth in nano materials and bio industries

Establishing a supply chain by linking nano material manufacturers with companies in demand of such materials

- Developing nano material industry by vitalizing cooperation and linking among companies

Linked support to commercialization of nano bio technologies

- Eliminating obstacles to commercialization and support per type of technology

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2 Secure Advanced NT for the Future

▶ Securing Leading Technologies for Creating Future Demand and Reinforcing Strategic Investment

Task 5 Promote strategic basic research in NT

➡ Establishing base research ecosystem and promoting strategic investment

- Preparing development strategy for base nano research
- Reinforcing private/governmental cooperation

Task 6 Develop of 30 core subjects in NT

➡ Commencing base/applied researches of promising technologies per nano based industry

- R&D in consideration of market and reinforcing connection among departments

Future NanoTechnology 30

Nano electronics (6)	Nano-bio (5)	Nano-energy and environment (7)	Nano-materials (6)	process, measurement & equipment (6)
▪ Ultra-low power memory	▪ Advanced production in agricultural and fishery products	▪ Nano solar cell	▪ Quantum dot	▪ Flexible element process
▪ High speed, low power logic elements	▪ Healthy products	▪ A secondary battery of the nanostructures	▪ Nano-carbon material	▪ Nanostructure patterning
▪ Environmental nano-sensors	▪ Nano-diagnostics	▪ Nanostructured fuel cell	▪ Printed electronics biomimetic materials	▪ High-resolution measurement
▪ New concept nanomaterials	▪ Nano-analysis of bio-molecules	▪ Nano structured membrane	▪ Environmental catalyst materials	▪ Nano-lamination process
▪ Flexible element	▪ Intelligent medical nano treatments	▪ Thermoelectric device	▪ Rare-earth catalyst	▪ Hybrid inspection
▪ Optical nano-devices		▪ Energy harvesting	▪ Rare-earth free materials	▪ Smart process
		▪ Sea water energy conversion		

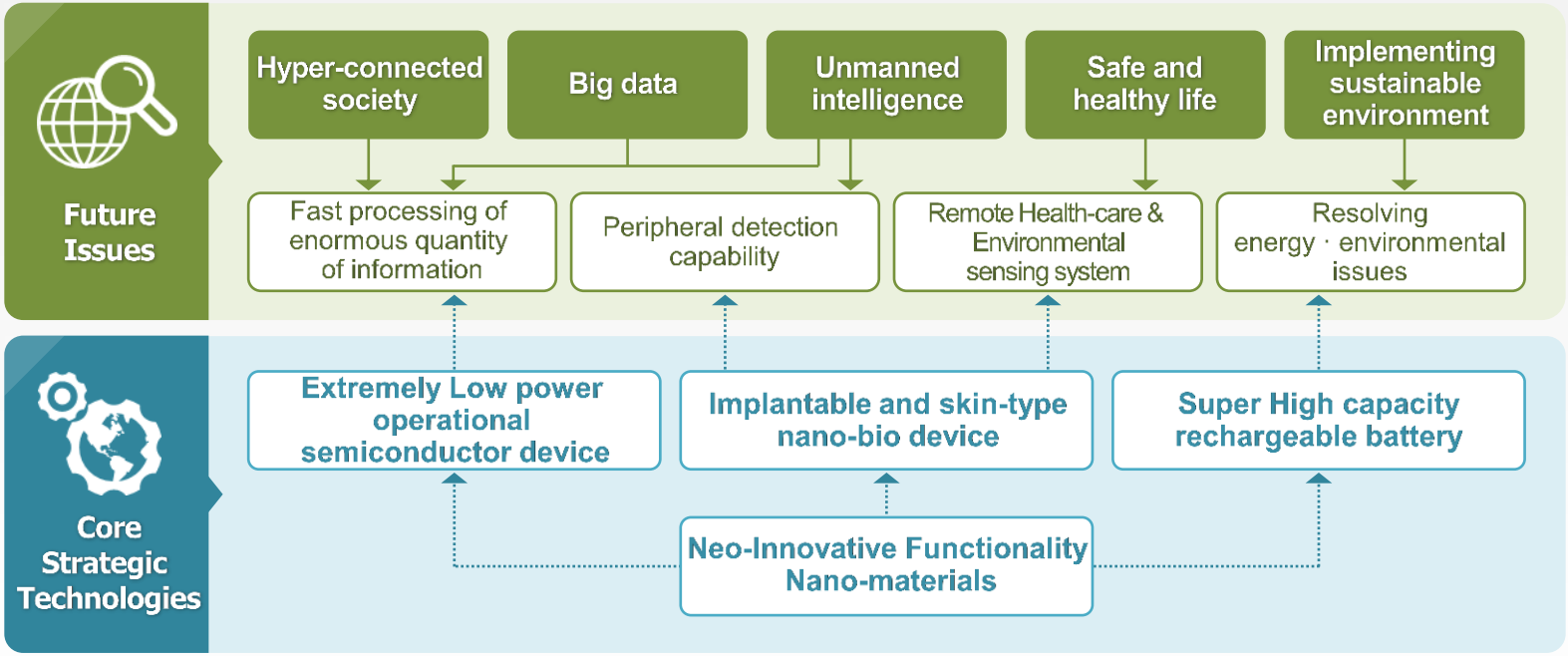
II. Tasks

Ministry of Science, ICT and Future Planning

▶ Securing Technologies to Overcome Limitations to Create Future Demands

Task 7 Promote「4 nano challenge」projects in 4 major categories of NT

➡ Preemptive development of core strategic technologies to resolve future issues and innovating manufacturing industry



Task 8 Rationalize national investment in NT

➡ Systematic and efficient securing leading technologies and improving effectiveness of application to industries

- Reinforcing strategic features of national nano technological map and connection among nano-based industries

II. Tasks

Ministry of Science, ICT and Future Planning

3 Expand Infrastructure to Promote Innovation through NT

▶ Establishing Foundation for Advancement of NT and Related Industries

Task 9 Cultivate on-site type 'Nano-Specialists'

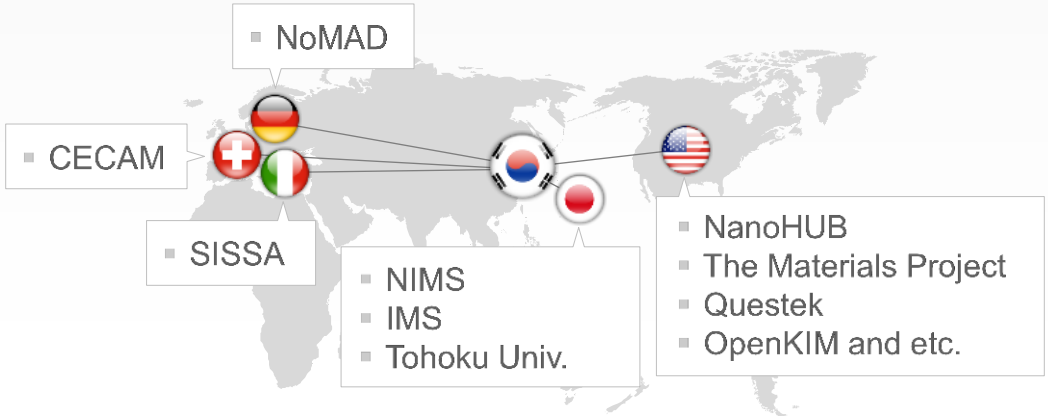
➡ Training professional HR to meet demands and improving camaraderie

- Training next-gen professional HR
- Training HR for customized to industrial demands
- Improving public familiarity of NT

Task 10 Build neo-global cooperation system

➡ Leading establishing process of international operation as a leading country of NT

- Evolution into a leader from global cooperator
- Providing cooperation for nano based industrialization and support for entry into global markets



II. Tasks

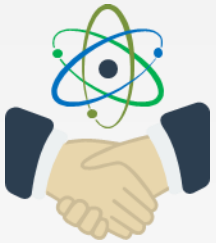
Ministry of Science, ICT and Future Planning

▶ Establishing Support System to Reduce Burden on Companies in the Commercialization Process

Task 11 Secure nano safety management system

➡ Establishing management system for safe society and industrial growth

- Standardization of nano safety assessment technology and expanding international cooperation
- Establishing corporate support system to respond to nano safety regulations
  ※ Operation of EU **Nano Safety Cooperation Center**(Established in 2015, KIST-In Europe)
- Establishing foundation for systemization of nano safety management
  ※ Established 2nd Nano Safety Management Plan(2016)



Task 12 Build an information system for innovation support

➡ Establishing support systems to reduce burdens on companies in the commercialization process

- Unifying and improving nano information system
  ※ Establishing nano knowledge information system(Linkinng Nanonet and Nanoin)
- Establishing open calculation nano science platform

Phase 1 Developing and public opening of test platform for secondary batteries(2015~)

Phase 2 Building a platforms for non-precious metals and non-rare elements nano-materials, environmental/food nano sensors(2016~)

Phase 3 Expansion into promising industries

III. Expected Improvements

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▶ Relate Nano Technology R&D Results To Industries

- Improving competitiveness of domestic manufacturing by commercializing nano technologies and R&D results
- Creating new growth initiative by intensive facilitation of core strategic technologies

▶ Creating Nano-based New Industries

- Creating new jobs through growth of nano-related companies and facilitating manufacturers
- Improving quality of jobs by adding values to corporate activities

▶ Development of NT for Future Generations

- Establishing sustainable society living with future generations by securing nano-based energy/environmental technologies

12%
Ratio of nano-convergence products

5,000 cases
Number of patents approved in U.S.

1000 industries
No. of nano-convergence companies

250,000 people
No. of people in nano-related industries

92%
Technical level

12,000 people
Core R&D personnel

Goals designated for 2025

2 Commercialization Strategies

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1. NT Commercialization Strategy (1/5)

Overview

To realize the vision of “a global Leader for NT industrialization” , MSIP, MOTIE, ME and other relevant ministries agreed to develop “NT Commercialization Strategy” and its implementation plans.

Designated 7 key NT technologies to be commercialized → Cultivating NT-based companies → Securing four key infrastructures

Vision

Vision

Top 2 country for NT industrialization by leading NT commercialization

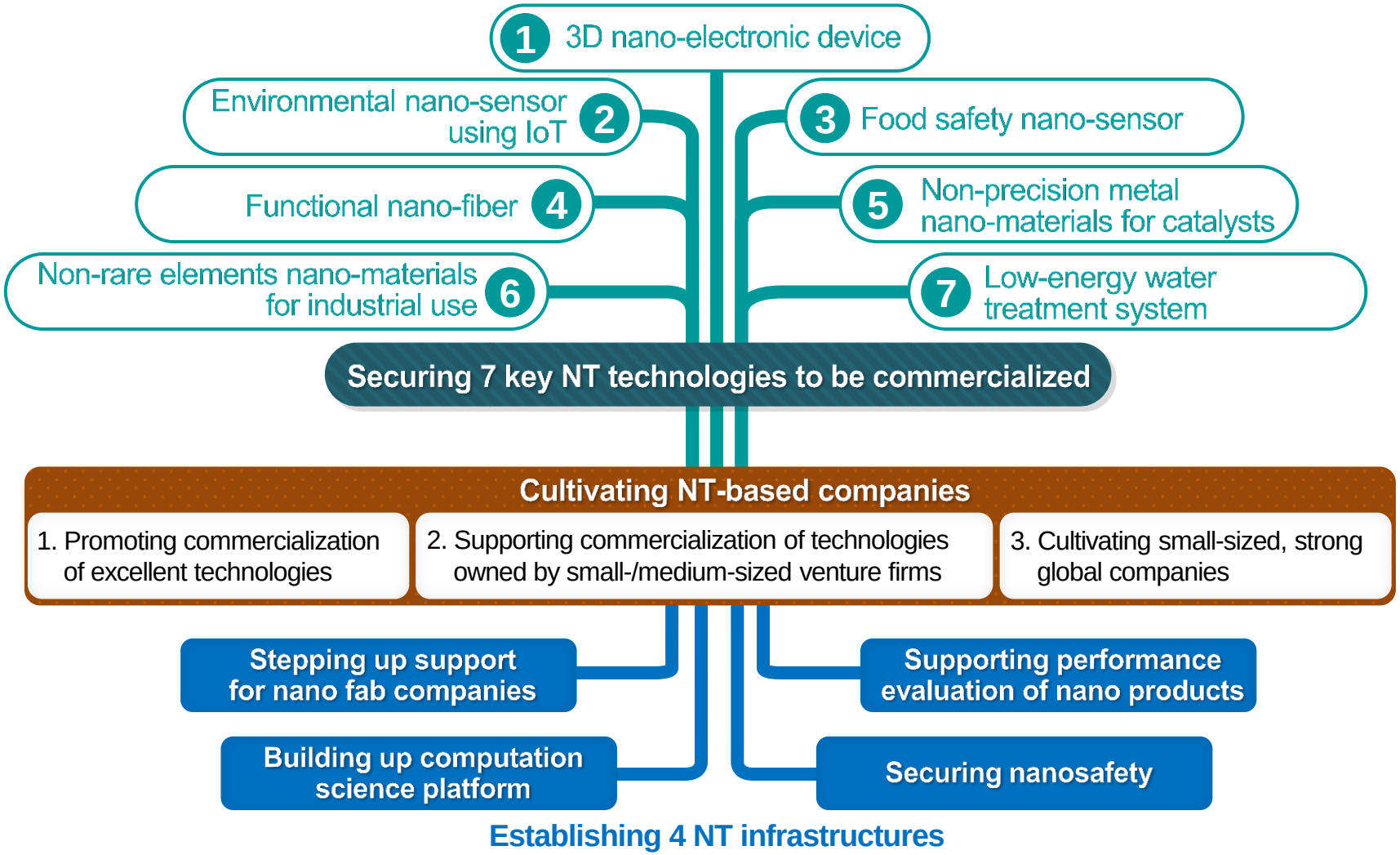
Goal

20% market share in global NT market

- Create new global market through NT industrialization
- Diffuse corporate growth model using NT
- Establish optimal support system from development to commercialization

2. NT Commercialization Strategy (2/5)

Key implementation strategy



2. NT Commercialization Strategy (3/5)

7 key NT technologies to be commercialized

3D nano-electronic device

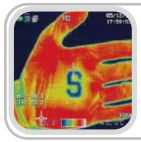
3 dimensional nano-electronic devices attached to the surface of objects or living matters

Environmental nano-sensor using IoT

Ultra small and low power intelligent sensor to collect, analyze and transmit environmental information (e.g. air, water, and soil) in a real-time mode

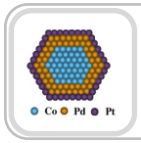
Food safety nano-sensor

Sensor to detect and monitor pernicious ingredients emitted from foods during storage, processing and distribution



Functional nano-fiber

Nano fiber materials that react to biometric information (e.g. body temperature, heart beat, muscle activity, sweat, skin humidity, and human body fat)



Non-precision metal nano-materials for catalysts

Nano-materials replacing precious metals (e.g. platinum) whose reserve is small and biased in certain regions

Non-rare elements nano-materials for industrial use

Sustainable functional nano-materials replacing rare elements (e.g. indium) or environmentally harmful elements (e.g. cadmium)

Low energy water treatment system

Water purification and desalination system using nano-filtration membrane or nano-electrode to significantly lower the energy consumption

2. NT Commercialization Strategy (4/5)

Cultivating NT-based companies

Cultivating NT- based companies

By 2020, 100 companies to take part in commercialization, creating more than 700 billion won sales

Increase the potential for product transactions, generate profits and enhance competitiveness

「Strategy to Develop Small, Strong Global NT Companies」to be drawn up (July, 2015)

Commercialization of Excellent Technologies

- Commercialize nanotechnologies, the outcomes of research, and resolve key issues of companies in developing products

Commercialization of Technologies owned by Venture Company

- Discover excellent NT products owned by Venture companies, support their commercialization,

Developing small, strong global companies

- Select key strategic products owned by NT venture companies and promote their global competitiveness to become small, strong global companies

2. NT Commercialization Strategy (5/5)

Establishing 4 Key NT infrastructures

Integrated information and infrastructure service for supporting technology development and commercialization by researchers and industries
“NT Commercialization Support Centers” to provide customized consulting tailored to users’ needs

Stepping up support for nano fab companies

Building up computation science platform

Securing nano safety

Supporting performance evaluation of nano- products

3. Graphene Commercialization Strategy (1/2)

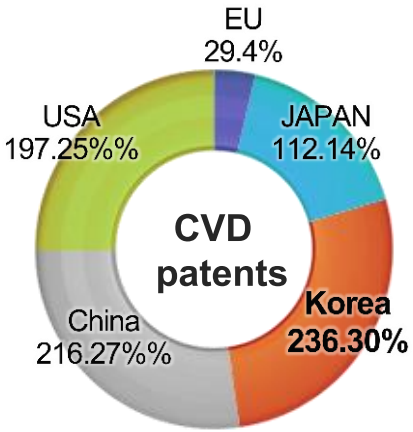
Using technological advantage and strong demand base,

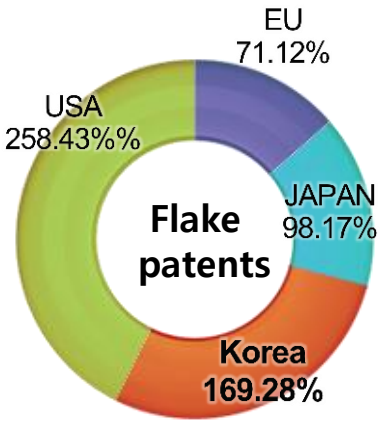
pursue raw materials mass production technologies and strategic commercialization,

key success factors for leading the global market

Technological advantage

- **CVD patents**
  - a leader in technology development (30%) followed by the U.S. (25%) and China (27%)
- **Flake patents**
  - 2nd (28%) after the U.S. (43%) in graphene flake production technology



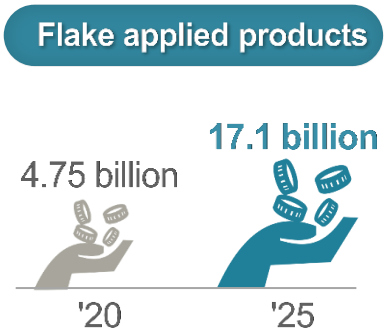


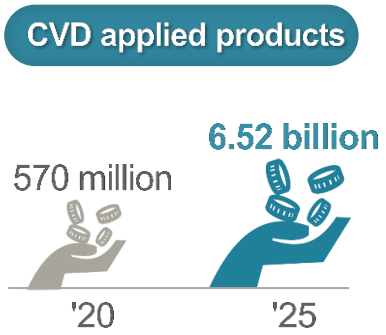
Demand base

- **Flake applied products market**
  - $4.75 billion (2020) → $17.1 billion (2025)
- **CVD applied products market**
  - $570 million (2020) → $6.52 billion (2025)

(SNE Research, 2014)

- **Key application areas**
  - display, energy and semiconductor, where Korea has high market share





3. Graphene Commercialization Strategy (2/2)

Overview

National strategic roadmap to become a global leader in future materials industry
by securing next – gen growth engine and dominating the graphene market in advance (MSIP/MOTIE)

- Mass production and synthesis system technologies
- Standardization and real-time measurement technology
- Applied products in 6 strategic areas

Vision and strategy

Vision

A global leader in future materials industry by dominating graphene market as an early-comer

Goal

- **Dominate graphene market as an early-comer through early commercialization**
  - 6 world no. 1 products and 20 global companies
- **Achieve 1.9 million won sales and create 52,000 new jobs by creating novel markets**

Implementation strategy

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- Mass production and synthesis system technologies
- Standardization and real-time measurement technology

MOTIE
MINISTRY OF TRADE, INDUSTRY & ENERGY

- Applied products in 6 strategic areas

3 Conclusion

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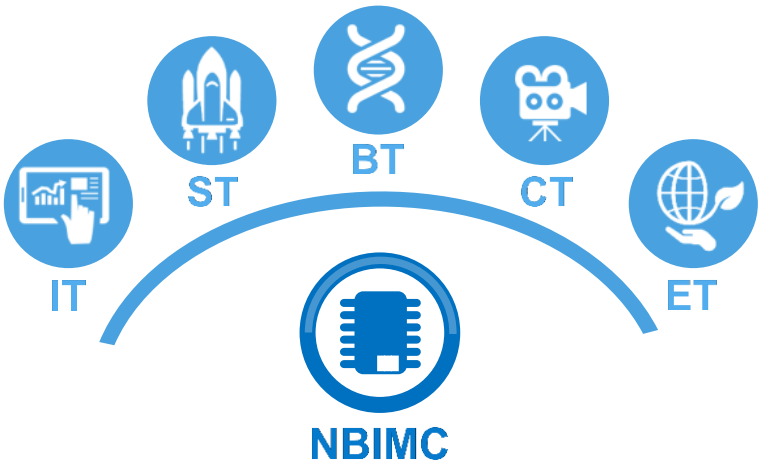
Future Planning

Conclusion

Need to strategically promote NT at national level for realizing **"Creative Economy"** and improving quality of life

Convergence

- Synergistic convergence by NBIMC* collaboration, create new industries, realize "Creative Economy" and dramatically enhance national competitiveness



Strategically promoting NT

- To realize "Creative Economy" and establish new growth engine
  - Phase 4 NCDPN at national level
    *including : Commercialization, Fundamental technology development, Human resources development, Nano-safety, International cooperation)

NBIMC* : Nano, Bio, Info, Med, Cog

Thank you!

Nanotechnology (NT) Policy in Korea and Key Challenges