Ministry of Science and ICT

The 15th Korea-U.S.
Forum on Nanotechnology

Nanotechnology Policy and R&D in Korea

July 12th, 2018

Jae Yong Song
National Research Foundation

NRF National Research Foundation of Korea

Outline

PART.1 Nanotechnology(NT) Policy in Korea

- History of NT Development in Korea
- Current Status of NT and Policy Directions

PART.2 Nanotechnology(NT) R&D in Korea

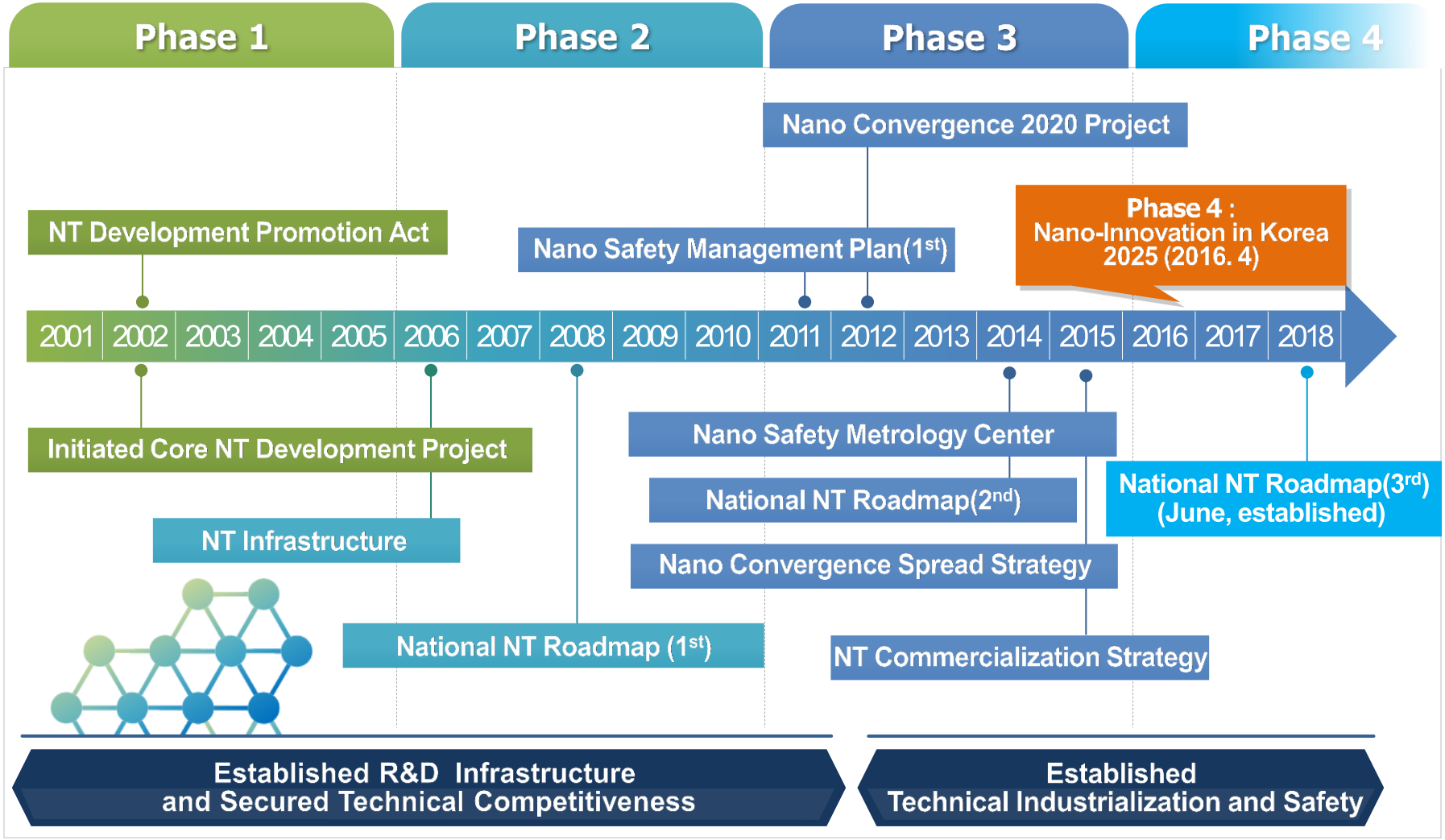
- Government R&D Investment in NT
- Key Achievements

Conclusion

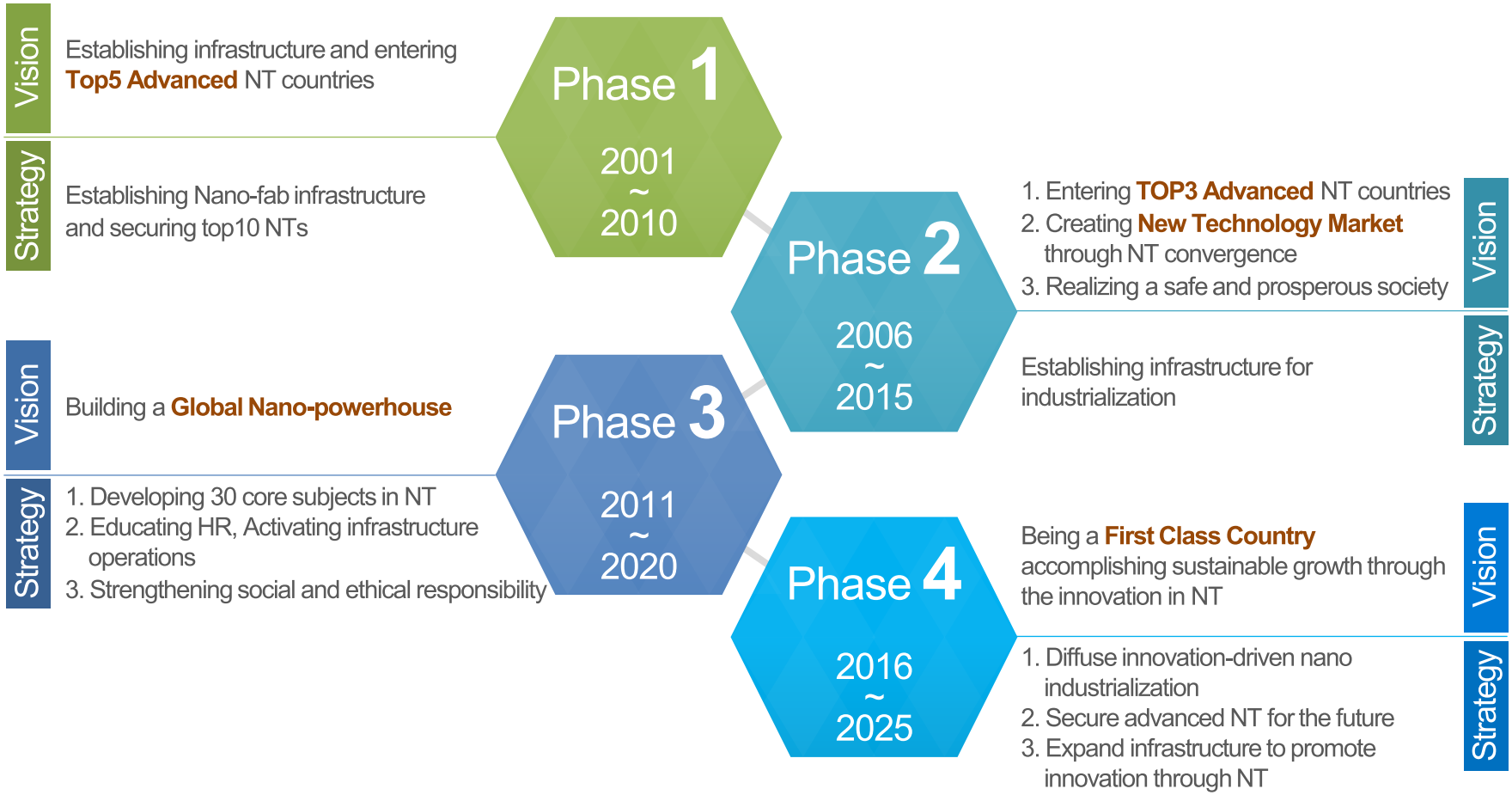
Ministry of Science and ICT

National Research Foundation of Korea

History of NT Development **in Korea**



Progress of **NNI-K**(Phase 1~4)



The 3rd National NT Roadmap

Challenges of NT toward Future Technologies that Human Beings Dream of

Development of Strategic technology map with 30 future technologies and 70 core NT, and preliminary technology map of 6 fields

Core NT derivation process

Deriving future technology candidates	Selecting future technology 30	Deriving NT applications	Deriving performance indicators and final goals	Selecting core NT
Demand base	Order of contribution	Shape	Verification of possibility	70 NTs

* Future technology selection criteria: ① Overcoming limit through nanotechnology and technological innovation need, ② Importance and urgency of securing technology, ③ Technological and industrial ripple effect, ④ Appropriateness as future technology

Convenient and Pleasant Life

Development of AI semiconductor, IoT, future display with faster, more accurate and clear performances using ultra-fine nano process technology

1. Portable human-level AI
2. Big data in my hand
3. Unlimited speed communication environment
4. Display that can freely change shape and size
5. Food tasting with smartphone
6. Cyborg feels like human
7. Drones that can fly without charge
8. Generating Electricity by walking
9. Wearable battery like clothes
10. Technology to keep young skin
11. Mask pack for automatic makeup

Life with the Earth

Achievement of high efficiency and unlimited clean energy, fine dust removal, economic water resource production technology, utilizing innovative peculiar phenomena in nano-sized materials

12. Ultra high efficiency next-generation solar power generation superior to thermal power generation
13. Fuel cell ready for blackout
14. Hydrogen vehicle
15. Electric vehicles that can be operated from Seoul to Busan in 5 minutes charge
16. Artificial leaf photosynthesis
17. Energy-independent housing without electricity supply
18. Reuse of abandoned water
19. Self-sufficient urban agriculture

Healthy and Safe Life

Secure simple, accurate and effective prevention/diagnosis/treatment, safe food and disaster safety technology, utilizing fast transfer properties at the nanomaterial interface

20. Batteries without risk of explosion
21. Preventive medicine for healthy 100-year-olds
22. Drugs that simultaneously diagnose and treat
23. Artificial organ without rejection
24. Technology to see and treat myself in my body
25. Self health monitoring at anytime anywhere
26. AI system that notifies harmful viruses
27. Germicidal clothing
28. Air purifiers that always clear the whole air of the house
29. Meals solved in one capsule even in space
30. Microbot to quickly find disaster victims

➡ Action plan: promotion of R&D for future technology realization, advanced nano-fab function, job creation focused on professional human resources, establish sustainable nano safety network

Current Status of **NT** and **Policy**

1 Current status of NT in Korea and Overseas

Global trends: Emphasis on NT industrialization and expansion of investment in original technology

USA

- Through **National Nanotechnology Initiative(NNI)**, Promote **commercialization and basic research of NT** to pursue sustainable national competitiveness and economic growth
  - The **basic research** is about **40% of the total budget of NNI '18**, increasing investment(36% in '16)

EU

- **NT** was selected as one of **the 'technologies* for future innovation'** in pursuit of development and competitiveness of the whole Europe through NT, and it is supporting **basic research** on NT

  * nano, bio tech., data analysis, global system science, green tech., medicine and neurology, quantum tech., robotics, advanced materials tech.

Japan

- Focused on **research and commercialization of the basic resources of NT** for the creation of new industries and strengthening competitiveness with **the 5th science and technology basic plan('16) and the cabinet-led initiative**
  - '17 nano, material field budget: 77.2 billion yen(ministry of education)

Korea

- In 2016, the domestic **nano-convergence industry continues to grow**
  - Compared to 2011, the number of NT convergence companies increased by 673(43.8%), sales increase by 135.98 trillion KRW(46.4%), and the number of employees increased by 150,460

2018 NT Policy Implementation Trends in Korea

Strengthen the Capabilities of **Intelligent Technology** utilizing **Basic Technologies**

Source: Human-oriented 4th industrial revolution response plans

Focus on **basic research** and **securing strategic future technology**

securing visibility of NT and preparing for industrialization through **infrastructure expansion** and **basic original technology development**

Source : 2018 Nanotechnology Development Implementation Plan

Current Status of **NT** and **Policy Directions**

2 Vision and Goal

Vision

Promoting the Human-oriented 4th Industrial Revolution by Improving the Competitiveness of NT

Implementing leading-edge technology for manufacturing industries

Global leader in nanotechnology industrialization

Goal (2025)

- **12,000** — Core Research HR
- **12%** — Ratio of the sales revenues by nano-products
- **1,000 industries** — No. of nano convergence company

3 Major Strategies and 9 Projects

1 Secure Advanced NT for the Future

① Develop future NT

② Promote strategic basic research in NT

③ Rationalize national investment in NT

2 Diffuse Innovation-driven Nano Industrialization

④ Secure core technologies for Industrialization promotion

⑤ Support technology Commercialization of the company

⑥ Strengthen infrastructure for the nano-convergence spread

3 Expand Nano Innovation Infrastructure to cope with future social change

⑦ Support core human resources and job creation

⑧ Secure nano-safety management system

⑨ Build advanced system for R&D achievement enhancement

Source : National Nanotechnology Initiative Program of Korea(2016~2025), 2018 Nanotechnology Development Implementation Plan

Current Status of **NT** and **Policy Directions**

3 Directions for Policy Promotion

Secure Advanced NT for the Future

Lead the Development of Future NT as a Nano-advanced Country

- Secure technologies for overcoming limitations to resolve future issues
  - Promote source/applied researches and Challenge Project
  - Strengthen strategic investment in basic research in NT and Build the development promotion-system
  - Rationalize national investment in NT(the 3rd National NT Roadmap, Nano-convergence industry development strategy)

Diffuse Innovation-driven Nano Industrialization

Creation of Manufacturing Innovation through the Spread of NT Applications

- Develop new markets through promotion of NT commercialization
  - Discovering NT to create new industries
- Establish support systems to reduce burdens of companies in the commercialization process
- Strengthen infrastructure for the nano-convergence spread

Expand Nano Innovation Infrastructure

Build the foundation for continuous growth of NT with future social changes

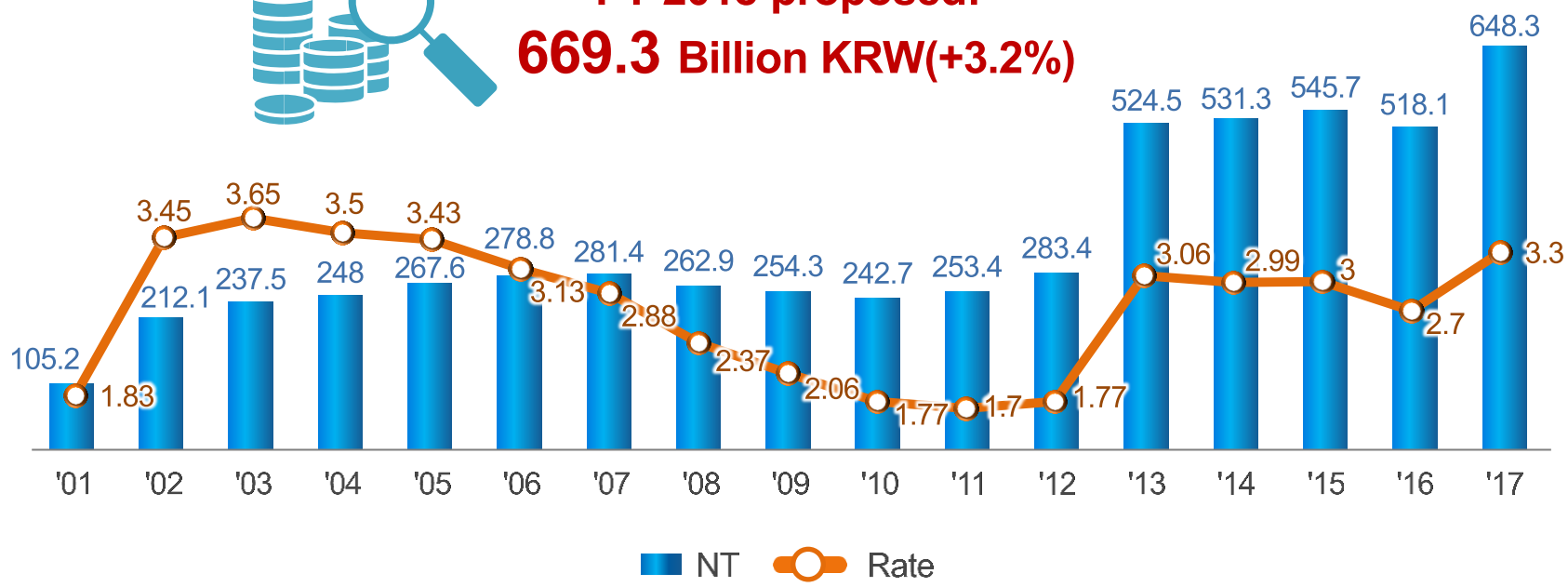
- Establish international cooperation system, Cultivate core R&D HR and on-site experts supporting job creation
- Secure Nano safety management system, System to support reduced cost and period for NT development
- Build advanced system for R&D achievement enhancement

Source : National Nanotechnology Initiative Program of Korea(2016~2025), 2018 Nanotechnology Development Implementation Plan

Government R&D Investment in **NT**

The total amount of **'17** government R&D **investment in NT**
: **648.3 Billion KRW** (**3.3**% of total government R&D investment)

FY 2018 proposed:
669.3 Billion KRW(+3.2%)



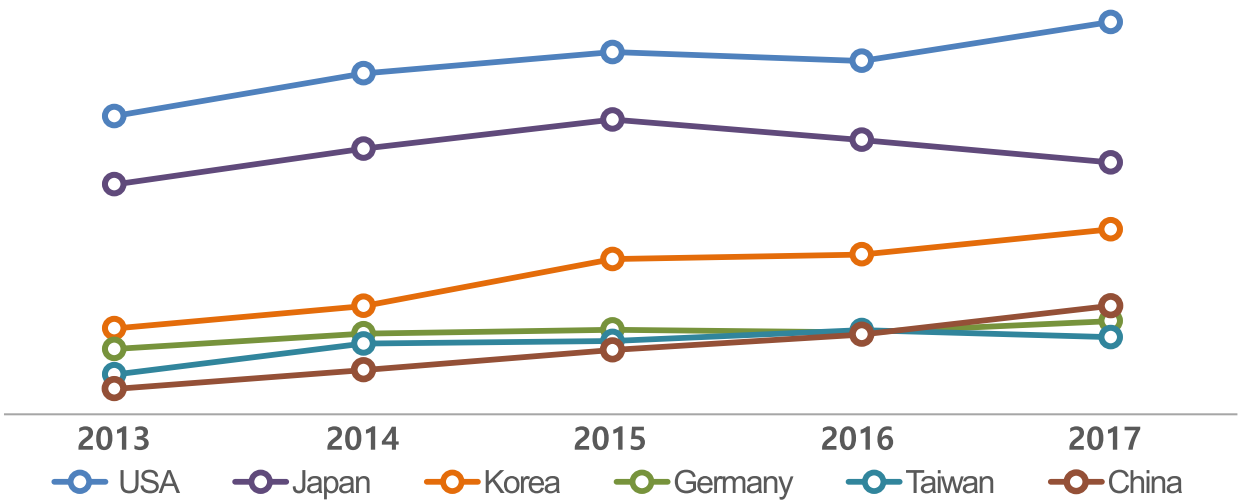
Source : 2018 Nanotechnology Development Implementation Plan

Key Achievements - ① R&D Performance(1/3)

Patents

The number of patents in NT: ranked in the **top 3** in the world since '08
(continued increase to 1,133 in '17)

Trends in NT Patent of Major Countries('13~'17)



	USA	Japan	Korea	Germany	Taiwan	China
Accumulated Total ('01~'17)	81,994	19,101	8,064	7,394	4,905	3,503
Accumulated for 5 years ('13~'17)	34,954	7,594	4,532	3,114	2,814	2,702

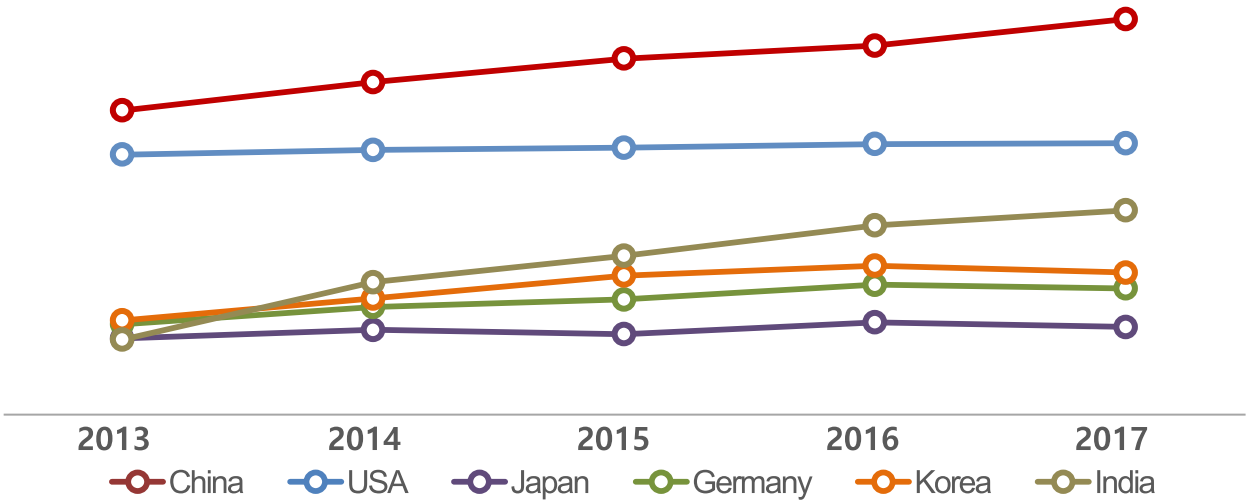
Source : 2018 Nanotechnology Development Implementation Plan

Key Achievements - ① R&D Performance(2/3)

Articles

The number of SCI articles in NT: ranked in the **top 5** in the world since '01
(published 9,022 articles in '17 (ranked in the top 4))

Trends in NT Articles of Major Countries('13~'17)



	China	USA	Japan	Germany	Korea	India
Accumulated Total ('01~'17)	366,900	277,353	106,048	102,624	87,171	77,122
Accumulated for 5 years ('13~'17)	219,805	115,766	36,844	41,082	43,114	46,540

Source : 2018 Nanotechnology Development Implementation Plan

Key Achievements - ① R&D Performance(3/3)

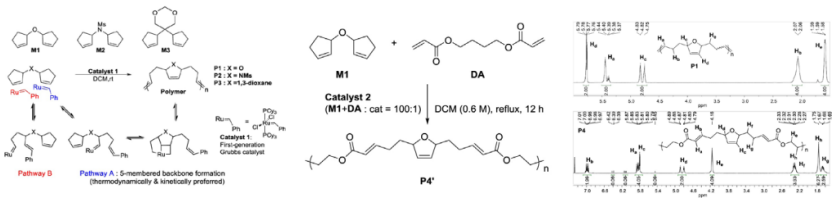
Successful example of R&D Performance

'16 Representative Performance
(Basic research field)

Tae-Lim Choi
Seoul National Univ.

Synthesis of polymer by tandem reaction

- Development of new methodology for polymer synthesis of advanced materials



Multiple Olefin Metathesis Polymerization that Combines All Three Olefin Metathesis Transformations: Ring- Opening, Ring-Closing, and Cross Metathesis, Journal of American Chemical Society, 37 (2015)

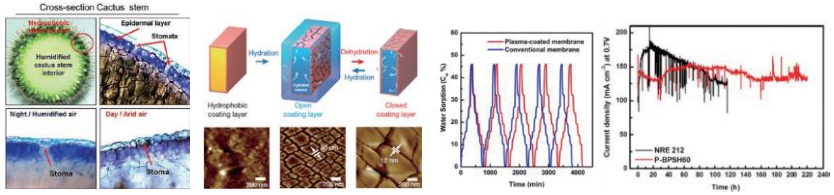
'17 Representative Performance
(Energy & environmental application field)

Young Moo Lee
Hanyang Univ.

Development of next generation polymer ion exchange membrane for fuel cell with self-humidifying effect

- Nanocrack-regulated fuel cell membrane through cactus biomimetry

*High performance with long-term stability
*Price competitiveness for commercialization



Nanocrack-regulated self-humidifying membranes, Nature, 532, 480-483 (2016)
Thermally rearranged polymer membranes for desalination, Energy Environmental Science, 9, 878-884 (2016)

Source: KIESTP 'Top 100 R&D performances' supported by Nano.Material Technology Development Program (NRF, MSIT)

Key Achievements - ① R&D Performance(3/3)

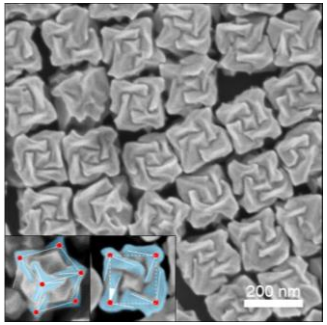
Successful example of NT R&D Performance

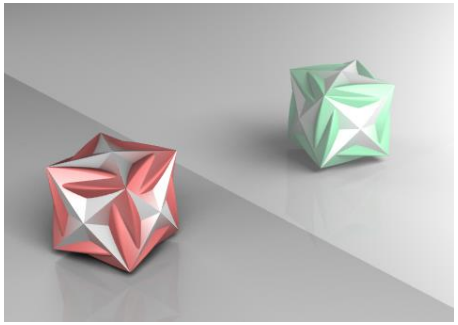
'18 Representative Performance (Basic research field)

Ki Tae Nam
Seoul National Univ.

The world's first successful synthesis of mirror symmetric 10nm gold nano-geometry using peptides

- Structures that exist in nature but can not be artificially implemented in metal
- Selected as <Nature>'s cover paper as an important research achievement attracting international attention
- Academic progress in next-generation optical materials and catalysts fields





Amino-Acid- and Peptide-Directed Synthesis of Chiral Plasmonic Gold Nanoparticles, Nature, 556, 360-365 (2018)

Supported by Creative Materials Discovery Program, Global Frontier Program, Advanced Research Center Program through NRF funded by the MSIT

Key Achievements - ② NT Convergence Industrial Core Index

In 2016, **increased** NT convergence industrial **core index** year-on-year

The number of domestic NT convergence companies
673

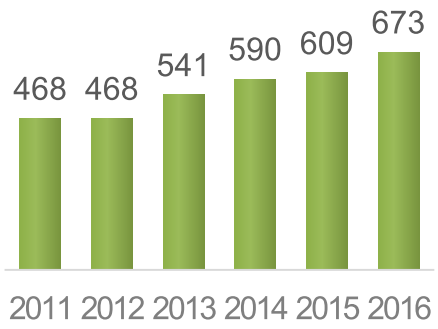
Sales
135.98 trillion KRW

The number of employees
150,460

NT Convergence Industrial Core Index ('11~'16)

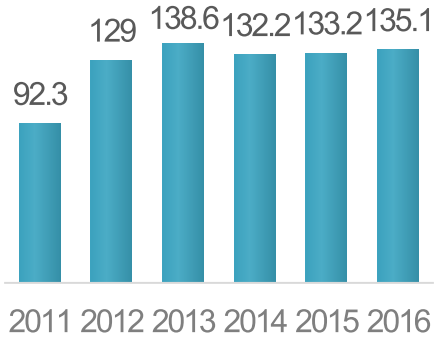
The Number of Companies (ten thousand units)

673 companies



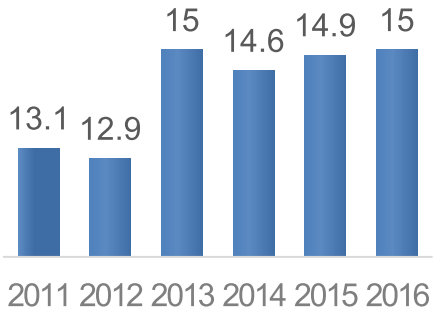
Sales (trillion KRW)

135.98 trillion KRW



The Number of Employees (ten thousand units)

150,460 jobs



Source: 2017 Nano Convergence Industry Survey

Key Achievements - ③ Commercialization Performance(1/2)

NT transfer cases
438 (10.3%↑)

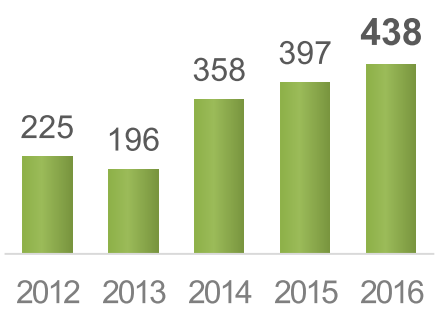
Royalty collection
16.2 billion KRW (10%↓)

Commercialization cases
1,463 (60.2%↑)

Royalty and Commercialization Performance of National NT R&D Project in recent 5 years

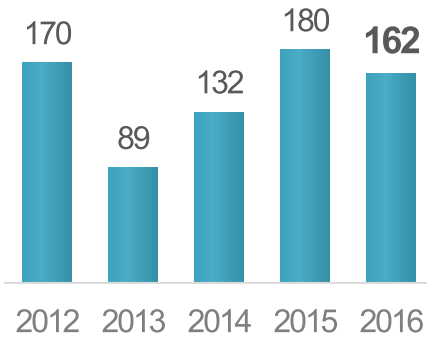
NT Transfer cases

1,614 cases



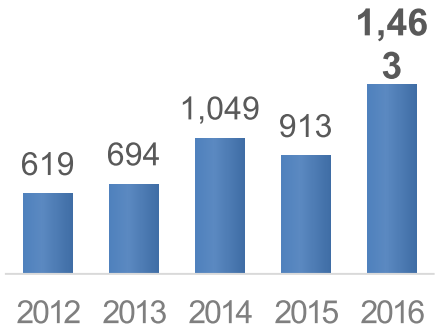
Royalty collection (100 million KRW)

733 million KRW



Commercialization cases

4,738 cases



※ source : National Technical Information Service(NTIS), 2018 Nanotechnology Development Implementation Plan

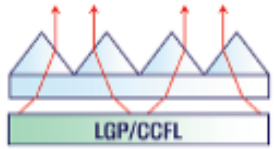
Key Achievements - ③ Commercialization Performance(2/2)

Successful NT Commercialization Performance Cases

(Nano-convergence 2020 program) promoted Joint R&BD project by Ministry of Science and ICT and Ministry of Industry to facilitate basic research performance and commercialization (20.2 billion KRW in '17)

※ Successful early commercialization of nano-convergence technology and product development(7 cases), sales(108.1 billion KRW, cumulative 382.1 billion KRW), job creation(174, cumulative 665)

'17 Representative Performances(supported by Nano-convergence 2020 program)

technology	Commercialization of flexible heat-generating smart film for harmful UV protection	Commercialization of prism coating solution using high refractive index organic/inorganic nanocomposite
performance	Developed transparent heat-generating film for ship/vehicles with non-indium nanoparticles deposited at room temperature	Developed prism coating solution for displays with improved brightness and energy consumption by applying nanocomposite
product		 The optical path through the prism film
sales	**3.8** billion KRW	**5.4** billion KRW (for medium and large size TV)

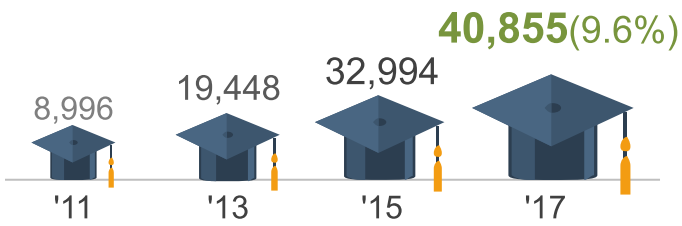
※ source : National Technical Information Service(NTIS), 2018 Nanotechnology Development Implementation Plan

Key Achievements - ④ Human Resources

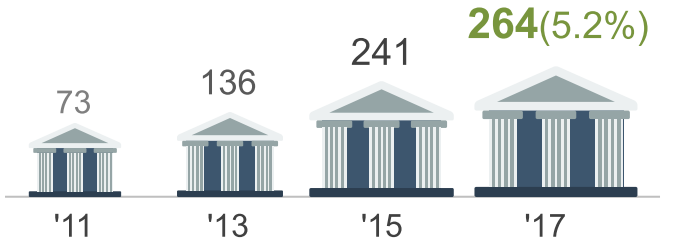
- Human resources for research communities and industries

Developing Human Resources in NT

No. of college students enrolled in NT related departments



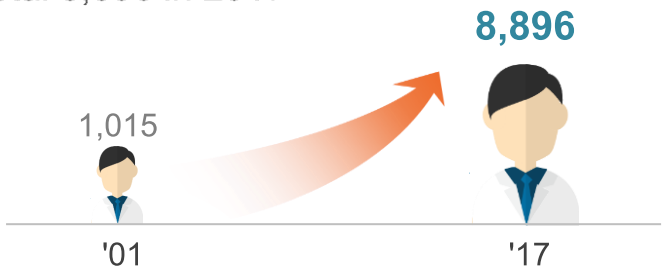
No of NT -related departments at Korean University



Researchers/Industrial Manpower

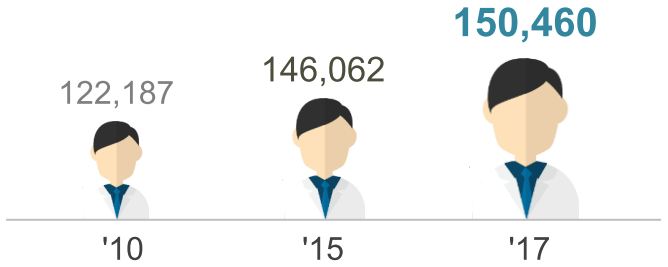
Researchers in NT

➡ Total 8,896 in 2017



Manpower in NT convergence industries

➡ Total 150,460 in 2017



Source: 2018 Nanotechnology Development Implementation Plan

Conclusion

The Korean government has **continued to invest in NT R&D**.
- **Focusing on basic research** areas, and the performances will contribute to NT industrialization.

'The NNI-K(Phase 4)' will be complemented by conducting an **Intermediate check and a New NT R&D program**

The newly established **'the 3rd National NT Roadmap'** will not only **set the direction of government policy**, but also **enhance the public's understanding of NT**.

Ministry of Science and ICT

Thank you

Nanotechnology Policy and R&D in Korea

National Research Foundation of Korea