2025년 상반기 국가전략기술 혁신포럼 자료집

ITIF-KAIST Forum 2025
on National Strategic Technology & Innovation

2025. 5. 22 목 13:30~17:10
KAIST 학술문화관(E9) 5층 정근모콘퍼런스홀

Organizers KAIST Future Institute for National Strategic Technology & Policy (FINST&P) KAIST 국가미래전략기술 정책연구소 ITIF INFORMATION TECHNOLOGY & INNOVATION FOUNDATION
Sponsor Ministry of Science and ICT

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Organizers

KAIST Future Institute for National Strategic Technology & Policy (FINST&P)
KAIST 국가미래전략기술 정책연구소

ITIF INFORMATION TECHNOLOGY & INNOVATION FOUNDATION

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Contents

목 차

Session II / 2부 Key Technology Areas for U.S.-ROK Cooperation
한·미 과학 기술협력: 주요 세부 기술 분야

세부 일정 (Program Schedule)

MC | Sejin Kim, Associate Director, Center for Korean Innovation and Competitiveness, ITIF
사회 | 김세진 ITIF 한국혁신경쟁력센터 부소장

Session I U.S.-ROK Science and Technology Cooperation

13:30~13:35	Photo Op	기념사진 촬영
13:35~13:40	**Opening Remarks**	Kwang-Hyung Lee, President, KAIST **이광형** KAIST 총장
13:40~13:45	**Welcome Remarks**	Sang-Im Yoo, Minister of Science and ICT, Republic of Korea **유상임** 과학기술정보통신부 장관
13:45~14:15	Keynote Speech	**Korea's Growth Reset in the Trump 2.0 Era** 트럼프 2.0 시대, 한국의 새로운 성장 전략 Robert D. Atkinson, President, Information Technology and Innovation Foundation (ITIF) **로버트 앳킨슨** 미국 정보기술혁신재단(ITIF) 회장
14:15~14:25	Topic Presentation I	**Repercussions of U.S.-China Tensions for the ROK and Beyond** 미·중 갈등: 한국의 대응과 글로벌 시사점 Stephen Ezell, Vice President for Global Innovation Policy, Information Technology and Innovation Foundation (ITIF) **스티븐 에젤** 미국 정보기술혁신재단(ITIF) 글로벌혁신정책 부회장
14:25~14:35	Topic Presentation II	**Advancing U.S.-ROK Cooperation through Strategic Technology Partnerships** 한·미 전략기술 파트너십 협력 강화 Kyungjin Song, Country Representative, The Asia Foundation Korea Office **송경진** 아시아재단 한국본부 대표
14:35~14:45	Topic Presentation III	**The Value of Humanities, Arts, and Social Sciences (HASS) in the Age of AI** 인공지능시대, 인문사회예술의 가치 Jaemin Jung, Dean, College of Liberal Arts and Convergence Science, KAIST **정재민** KAIST 인문사회융합과학대학장
14:45~15:25	Panel Discussion	Moderator | So-Young Kim, Vice President, International Office, KAIST (**김소영** KAIST 국제협력처장) Panelists | Stephen Ezell, Vice President for Global Innovation Policy, ITIF Kyungjin Song, Country Representative, The Asia Foundation Korea Office Jaemin Jung, Dean, Liberal Arts & Convergence Science College, KAIST Jeonghee Kang, Esq., Partner, BAE, KIM & LEE LLC (**강정희** 법무법인 태평양 변호사)
15:25~15:35	COFFEE BREAK	

Session II Key Technology Areas for U.S.-ROK Cooperation

15:35~15:50 Topic Presentation I

ROK-U.S. Collaborations for Truly Sustainable Next Generation Nuclear Energy

진정 지속가능한 차세대 원자력을 위한 한·미 협력

Yonghee KIM, President, Future Institute for National Strategic Technology and Policy (FINST&P), KAIST

김용희 KAIST 국가미래전략기술 정책연구소장

15:50~16:05 Topic Presentation II

Scalable Graphene Production: A Breakthrough in Material Innovation

그래핀 소재 양산기술이 이끌 전략산업 혁신

Byung Hee Hong, Professor, School of Chemistry, Seoul National University

홍병희 서울대학교 화학부 교수

16:05~16:20 Topic Presentation III

The Present and Future of AI Semiconductors

AI 반도체의 현재와 미래

Hoi-Jun Yoo, Director, Graduate School of AI Semiconductor, KAIST

유회준 KAIST 인공지능반도체대학원장

16:20~17:10 Panel Discussion

Moderator | Ji Woong Yoon, President, Science and Technology Policy Institute (STEPI) (**윤지웅** 과학기술정책연구원(STEPI) 원장)

Panelists | Yonghee KIM, President, Future Institute for National Strategic Technology and Policy (FINST&P), KAIST

Byung Hee Hong, Professor, School of Chemistry, Seoul National University

Hoi-Jun Yoo, Director, Graduate School of AI Semiconductor, KAIST

Soo-Keun Kwak, Deputy Editor & Editorial Columnist, The Chosun Daily (**곽수근** 조선일보 기자)

Yongkyu Kim, Vice President, Doosan Enerbility (**김용규** 두산에너빌리티 상무)

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Keynote Speech / 기조연설

트럼프 2.0 시대, 한국의 새로운 성장 전략

Korea's Growth Reset in the Trump 2.0 Era

Robert D. Atkinson
미국 정보기술혁신재단(ITIF) 회장

Robert D. Atkinson
President, Information Technology and Innovation Foundation (ITIF)

Korea's Growth Reset in the Trump and CCP 2.0 Era

Robert Atkinson
President, ITIF

May, 2025

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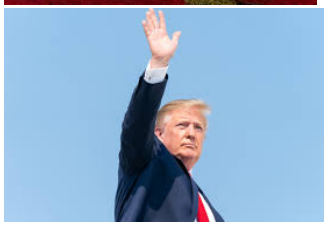
@ITIFdc @ratkinsonITIF

Korea and Global Economy Face a Fork in the Road

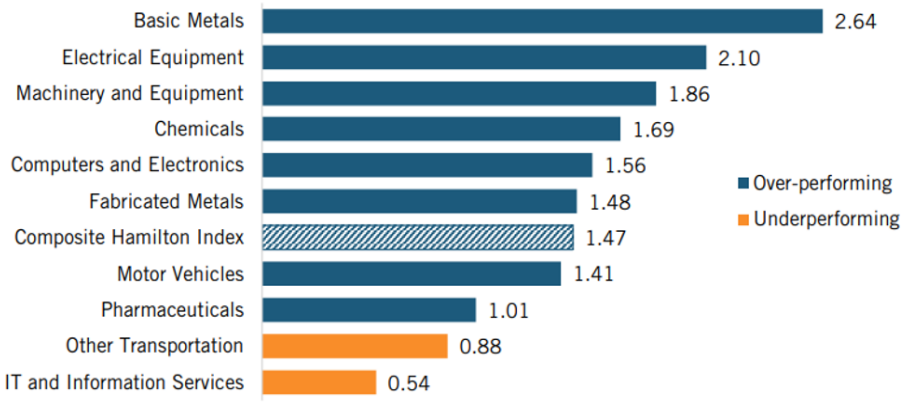
Korea and Global Economy Face a Fork in the Road



China

China's Advanced Industry Performance

China's Relative Performance in Hamilton Industries, (2020 LQ)



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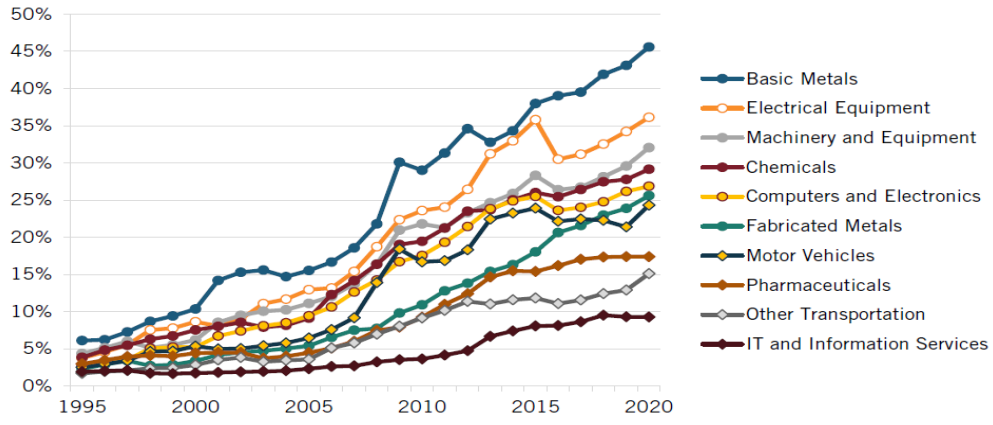
China's Growth in Global Market Share



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China Can Innovate

- 2 Chinese industries are leading-edge innovators
- Most are gaining fast
- On a 10-point scale, from copier to leader:
  - Mean score = 6
  - Lagging by ~2 years
  - With some original innovation

Industry	Position vs. Leaders	Pace of Progress
Robotics	Near	Rapid
Chemicals	Lagging	Rapid
Nuclear	Ahead	Rapid
EVs/Batteries	At Par	Rapid
Machine Tools	Lagging	Rapid
Biopharma	Lagging	Rapid
Semiconductors	Lagging	Modest
AI	Near	Rapid
Quantum	Near	Modest
Displays	Near	Rapid

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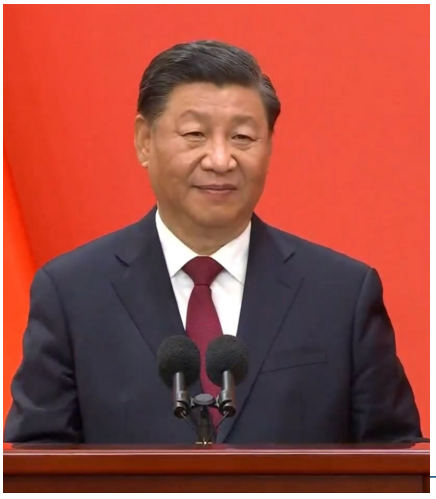
7

The Battle



"Technological innovation has become the main battleground of the global playing field, and competition for tech dominance will grow unprecedentedly fierce." – President Xi Jinping

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America

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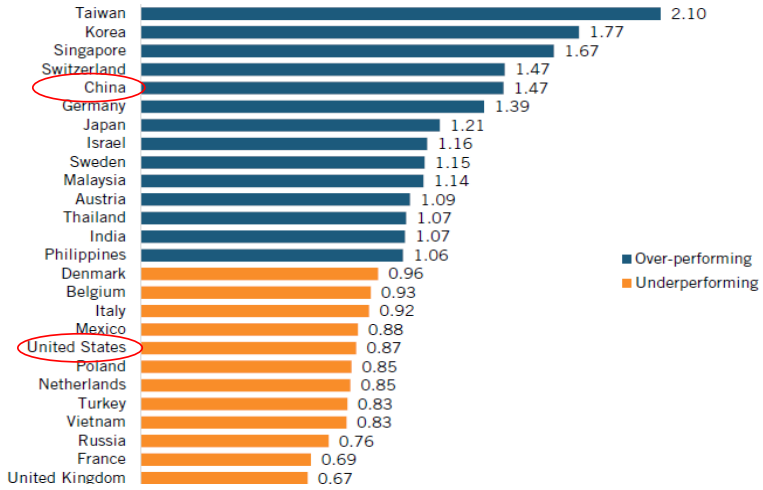
Countries' Relative Performance



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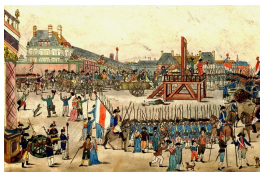
Explaining Trump

- US can no longer afford to be the leader.
- Globalization hurts American workers.
- Massive trade deficit hurts U.S.
- Trade deficit from other nations not playing fair.
- US market is so large US doesn't need global market access.
- Tariffs are easier than techno-industrial policy.



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Korea's New Path? Broad-Based Technological Innovation, Not Just Export-Led Growth

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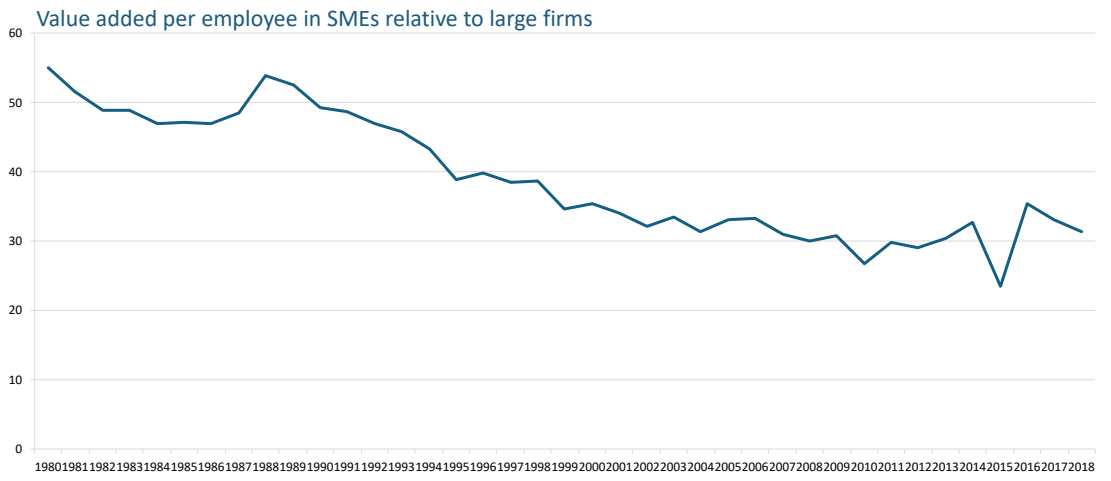
Reduce Firm Size Dualism



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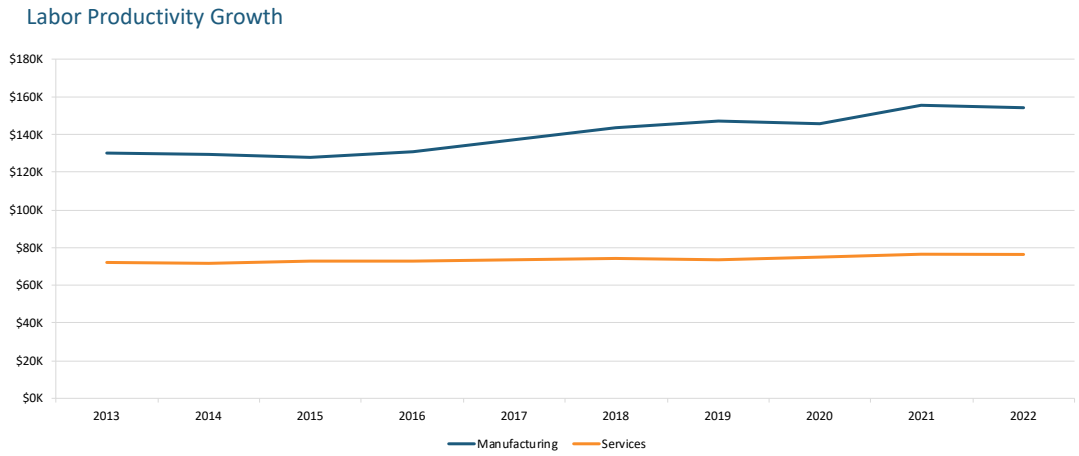
Reduce Industry Dualism



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The Path to the Path

- Radically reduce small business subsidies and regulatory protections.
- Software everywhere.
- Shift “positive regulation” and “shadow regulation” to “permissionless innovation.”
- Scale tech startups.

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A policy hub linking Korea and the U.S. on emerging tech and competitiveness

CENTER FOR KOREAN INNOVATION AND COMPETITIVENESS

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Thank You!

Rob Atkinson | ratkinson@itif.org

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Session I / 1부 U.S.-ROK Science and Technology Cooperation / 한·미 과학 기술협력

Topic Presentation I / 발제 1

미·중 갈등:
한국의 대응과 글로벌 시사점

Repercussions of U.S.-China Tensions for the ROK and Beyond

Stephen Ezell
미국 정보기술혁신재단(ITIF) 글로벌혁신정책 부회장

Stephen Ezell
Vice President for Global Innovation Policy
Information Technology and Innovation Foundation (ITIF)

Repercussions of U.S.-China Tensions for Korea and Beyond

ITIF-KAIST 2025 Forum on National Strategic Technology & Innovation

Stephen Ezell
VP, Global Innovation Policy, ITIF

May 22, 2025

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Korea's (China) Export/Manufacturing-Dependent Economy

- Korea's $683 billion of exports in 2024 accounted for 50% of GDP.
- Korean exports to China: 52% of semiconductor exports (62% 2020).
  40% of all high-tech exports.
  23% of total Korean exports.
- U.S. exports to China: 53% of semiconductor exports (2024).
  43% of chip equipment exports.
- China: "Achieve 75% self-sufficiency in semiconductors by 2030."

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China Seeks to Phase Out Foreign Tech Companies

China Tells Telecom Carriers to Phase Out Foreign Chips in Blow to Intel, AMD

Beijing's move is the latest installment in a U.S.-China technology war that is splintering the global chip industry

By Lisa Lin Follow
Updated April 12, 2024 4:35 pm ET

China is Intel's largest market, accounting for 27% of the company's revenue last year. PHOTO: CFOTO/ZUMA PRESS

SINGAPORE—China's push to replace foreign technology is now focused on cutting American chip makers out of the country's telecommunications systems.

Officials earlier this year directed the nation's largest telecom carriers to phase out foreign processors that are core to their networks by 2027, a move that would hit American chip giants Intel INTC -5.16% ▼ and Advanced Micro Devices AMD -4.23% ▼, people familiar with the matter said.

The deadline given by China's Ministry of Industry and Information Technology aims to accelerate efforts by Beijing to halt the use of such core chips in its

China Intensifies Push to 'Delete America' From Its Technology

A directive known as Document 79 ramps up Beijing's effort to replace U.S. tech with homegrown alternatives

By Lisa Lin Follow
March 7, 2024 12:01 am ET

For American tech companies in China, the writing is on the wall. It's also on paper, in Document 79.

The 2022 Chinese government directive expands a drive that is muscling U.S. technology out of the country—an effort some refer to as "Delete A," for Delete America.

Document 79 was so sensitive that high-ranking officials and executives were only shown the order and weren't allowed to make copies, people familiar with the matter said. It requires state-owned companies in finance, energy and other sectors to replace foreign software in their IT systems by 2027.

American tech giants had long thrived in China as they hot-wired the country's meteoric industrial rise with computers, operating systems and software. Chinese leaders want to sever that relationship, driven by a push for self-sufficiency and concerns over the country's long-term security.

The first targets were hardware makers. Dell, International Business Machines and Cisco Systems have gradually seen much of their equipment replaced by products from Chinese competitors.

Document 79, named for the numbering on the paper, targets companies that provide the software—enabling daily business operations from basic office tools to supply-chain management. The likes of Microsoft and Oracle are losing ground in the field, one of the last bastions of foreign tech profitability in the country.

The effort is just one salvo in a yearslong push by Chinese leader Xi Jinping for self-sufficiency in everything from critical technology such as semiconductors and fighter jets to the

The Economist ≡ Menu My Economist

Business | Chipping in

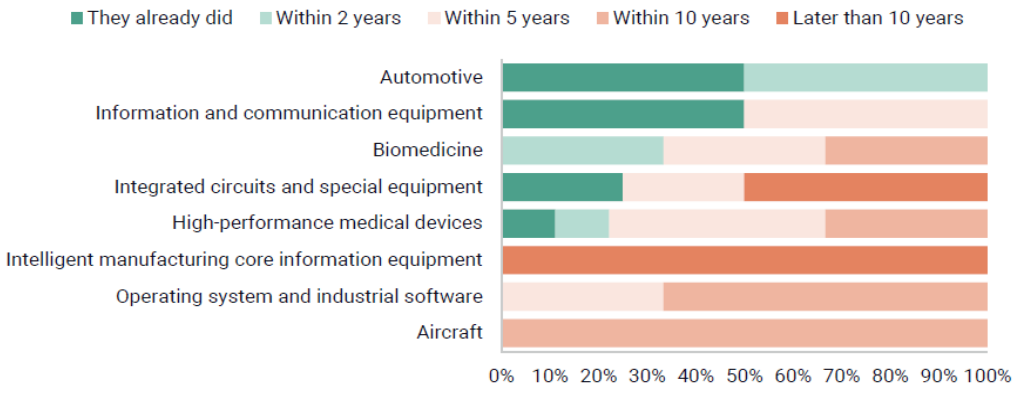
China is quietly reducing its reliance on foreign chip technology

Firms such as Huawei are cultivating local suppliers

ILLUSTRATION: GUILLEM CASASUS

China Increasingly Developing Indigenous Innovation Capability

Chinese Competitors Will Catch Up Technologically Within How Many Years?



Source: Rhodium Group, "Was Made In China Successful?"

How Innovative Is China in Semiconductors?

- Overall, China is probably 3-5 years behind in semis.
- China will add more chipmaking capacity than rest of the world combined in 2024; selling legacy chips 30% less.
- China strongest in design of logic chips for mobile/AI; CXMT and YMTC have fallen off in memory chip sector.
- China weakest in semiconductor mfg. equipment and in semiconductor fabrication. Exports controls have affected.
- China's share of global value-added in the semiconductor industry grew four-fold from 2001–2016, 8% to 31%.

Source: ITIF, "How Innovative Is China in Semiconductors"

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HAMILTON CENTER ON INDUSTRIAL STRATEGY

How Innovative Is China in Semiconductors?

STEPHEN EZELL I AUGUST 2024

Chinese competitors stand about five years behind global leaders in high-volume manufacturing of leading-edge logic semiconductor chips and continue to trail in memory chips and semiconductor manufacturing equipment, although Chinese firms have made inroads in semiconductor design and production of legacy semiconductor chips.

KEY TAKEAWAYS

- China seeks to achieve self-sufficiency in all facets of the semiconductor industry, simultaneously reducing its reliance on foreign competitors while attempting to build competitive enterprises.
- Chinese "catch up" across semiconductor subsectors is uneven: In the design of logic chips, such as for mobile devices or artificial intelligence (AI) applications, Chinese enterprises remain behind global leaders, though perhaps only by two years.
- However, in other subsectors of the semiconductor industry, notably in memory chips, semiconductor manufacturing equipment (SME), and assembly, test, and packing (ATP), Chinese enterprises are innovating but several years more behind global leaders.
- In 2021–2022, 55 percent of global semiconductor patent applications were Chinese in origin (and China's number of applications doubled America's) while Chinese entities surpassed U.S. and Japanese ones for semiconductor patents granted in 2022.
- However, in terms of semiconductor industry research and development (R&D) intensity, China's rate of 7.6 percent was just 40 percent of America's (18.8 percent), and below European Union firms' 15 percent.
- China's intense efforts to develop a fully fledged, indigenous, "closed loop" semiconductor industry have spurred a great deal of ingenuity and innovation, but a "go-it-alone" strategy will be very difficult in such an extremely complex tech ecosystem, especially in the face of semiconductor export controls.

Allied Countries Need to Rearchitect the Global Economic Gameboard

- Half Korean and U.S. semiconductor sales go to China.
- Need to architect a world where that's 15-20% in a decade.
- Because much more of the world's ICT goods are being produced in SE Asia, India, Central America, Africa.
- UBS: "71% of U.S. companies with manufacturing in China either in the process of or planning to shift operations to other countries."

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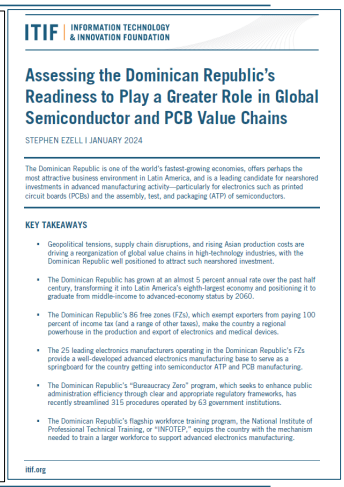
Assessing India's Readiness to Assume a Greater Role in Global Semiconductor Value Chains

STEPHEN EZELL I FEBRUARY 2024

India has the potential to play a much more significant role in global semiconductor value chains, provided the government upholds its investment policies, maintains a conducive regulatory and business environment, and avoids measures that create unpredictability.

KEY TAKEAWAYS

- Considering India's large and growing consumer and business marketplace, its strengths in electronics production, and global supply chain rebalancing, India should seize this moment to expand its presence in global semiconductor value chains.
- In the next five years, India has the potential to expand its presence in the semiconductor assembly, test, and packaging (ATP) segment to as many as five facilities and to attract fabs producing legacy semiconductors at 28 nm or above.
- Expanding its presence in semiconductor manufacturing would build on India's decades-long experience in semiconductor design, where it accounts for 20 percent of the world's integrated circuit (IC) design workforce, over 125,000 workers.
- The semiconductor industry faces a global shortage of talent; the over 800,000 engineers India graduates annually could help, but better courses, training, and preparedness are needed, as only a small fraction are industry ready upon graduation.
- Multinational investors seek stability, certainty, and predictability. So, India must continue to deepen recent improvements it has made to its business and policy environments, while avoiding policies that create business uncertainty.



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Assessing the Dominican Republic's Readiness to Play a Greater Role in Global Semiconductor and PCB Value Chains

STEPHEN EZELL I JANUARY 2024

The Dominican Republic is one of the world's fastest-growing economies, offers perhaps the most attractive business environment in Latin America, and is a leading candidate for nearshored investments in advanced manufacturing activity—particularly for electronics such as printed circuit boards (PCBs) and the assembly, test, and packaging (ATP) of semiconductors.

KEY TAKEAWAYS

- Geopolitical tensions, supply chain disruptions, and rising Asian production costs are driving a reorganization of global value chains in high-technology industries, with the Dominican Republic well positioned to attract such nearshored investment.
- The Dominican Republic has grown at an almost 5 percent annual rate over the past half century, transforming it into Latin America's eighth-largest economy and positioning it to graduate from middle-income to advanced-economy status by 2060.
- The Dominican Republic's 86 free zones (FZs), which exempt exporters from paying 100 percent of income tax (and a range of other taxes), make the country a regional powerhouse in the production and export of electronics and medical devices.
- The 25 leading electronics manufacturers operating in the Dominican Republic's FZs provide a well-developed advanced electronics manufacturing base to serve as a springboard for the country getting into semiconductor ATP and PCB manufacturing.
- The Dominican Republic's "Bureaucracy Zero" program, which seeks to enhance public administration efficiency through clear and appropriate regulatory frameworks, has recently streamlined 315 procedures operated by 63 government institutions.
- The Dominican Republic's flagship workforce training program, the National Institute of Professional Technical Training, or "INFOTEP," equips the country with the mechanism needed to train a larger workforce to support advanced electronics manufacturing.

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An Allied Approach to Technology Competitiveness

Collectively advance the competitiveness of like-minded nations' advanced-tech industries through:

1. Coordinated technology development.
2. Coordinated ecosystem support.
3. Coordinated technology protection.
4. Supportive trade policy, regimes, and practices.


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An Allied Approach to Semiconductor Leadership

STEPHEN EZELL | SEPTEMBER 2020

Many countries rightly seek to maximize their value added in the global semiconductor industry. But like-minded allied nations can also advance their leadership collectively by collaborating on technology and ecosystem development, intellectual property, and trade liberalization.

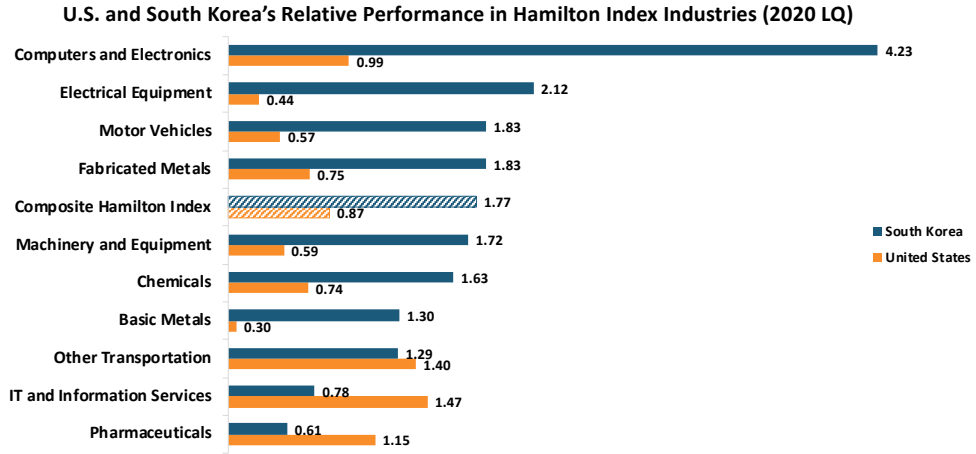
KEY TAKEAWAYS

- The semiconductor sector constitutes one of today's most important industries, providing the core technology that powers the modern digital world and spurs innovation and productivity across virtually every sector of the economy.
- The increasing expense, complexity, and scale required to innovate and manufacture semiconductors means that no single nation or enterprise can go it alone. In the face of challenges from China, allied cooperation in semiconductors is critical.
- Successful semiconductor innovation depends on scientists, researchers, and engineers working together internationally across companies, universities, government agencies, research institutions, and public-private research consortia.
- Each segment of the global semiconductor value chain has, on average, enterprises from 25 countries involved directly, and enterprises from 23 countries in support functions.
- Some nations have focused on building their domestic semiconductor ecosystems, but the U.S. industry's track record of success shows how to effectively leverage global supply chains for mutual benefit.
- Countries that would seek self-sufficiency in the sector, especially through unfair mercantilist means, risk inflicting considerable damage on the industry, slowing global semiconductor innovation.
- The United States should increase funding for collaborative, pre-competitive R&D and incentives for greater domestic production.

INFORMATION TECHNOLOGY & INNOVATION FOUNDATION | SEPTEMBER 2020

Source: ITIF, "An Allied Approach to Semiconductor Competitiveness"

U.S. and Korea Have Complementary Technological Strengths



Deepening U.S./Korea Collaboration on Advanced Semiconductor R&D

- ✓ Identify long-term semiconductor sector moonshots and encourage allied participation therein (with benefits proportionate to investment).
  - Develop affordable desktop semiconductor fabrication facilities;
  - Beyond silicon: carbon nanotubes or DNA for computation and storage.
- ✓ Collaborate to address challenges identified in the SRC-led "Decadal Plan for Semiconductors."
  - Achieve exponential decreases in compute energy required to execute computations;
  - Address dramatic increase in global data storage requirements.
  - Addressing emerging security challenges, from hardware and AI to cloud.

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Collaboratively Advance U.S.-Korea Semiconductor Sectors

- Korean semiconductor companies have committed $45B to U.S. semi. mfg.
- U.S./Korean SIAs MOU on bilateral technology cooperation in semis/AI.
- MOTIE has launched four Global Industrial Technology Cooperation Centers.

NYCREATES NANO — Develop joint semi tech hubs, supporting bilateral research, testbeds, and workforce development.

bridg — Bridging the Innovation Development Gap — Advance semi packaging capabilities of Korean SMEs through access to fab facilities and help them enter U.S.

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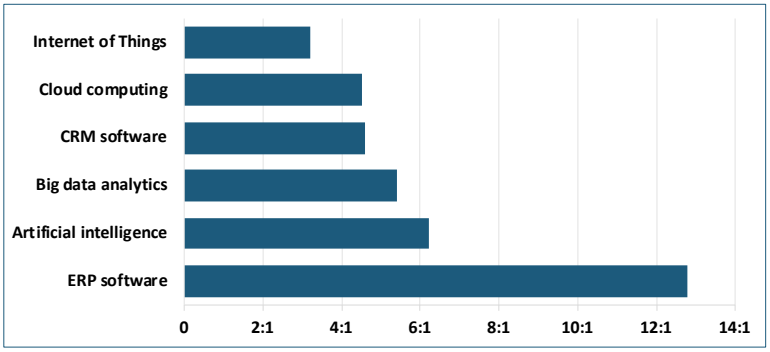
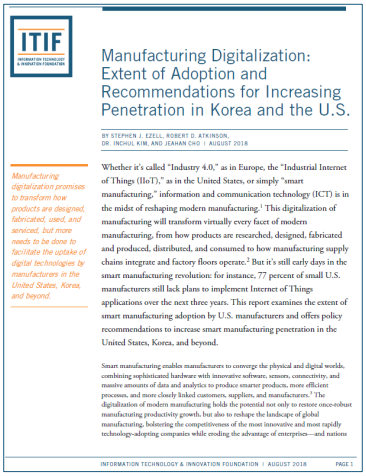
Collaborate to Support SME Manufacturing Digitalization

- U.S./Korea should launch a joint initiative to exchange best practices/technologies for SME mfg. digitalization.

Odds of Adopting Digital Tools in Large vs. Small Korean Enterprises

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Manufacturing Digitalization: Extent of Adoption and Recommendations for Increasing Penetration in Korea and the U.S.

BY STEPHEN J. EZELL, ROBERT D. ATKINSON, DR. INCHUL KIM, AND JEAHAN CHO | AUGUST 2018

Manufacturing digitalization promises to transform how products are designed, fabricated, used, and serviced, but more needs to be done to facilitate the uptake of digital technologies by manufacturers in the United States, Korea, and beyond.

Whether it's called "Industry 4.0," as in Europe, the "Industrial Internet of Things (IIoT)," as in the United States, or simply "smart manufacturing," information and communication technology (ICT) is in the midst of reshaping modern manufacturing.[1] This digitalization of manufacturing will transform virtually every facet of modern manufacturing, from how products are researched, designed, fabricated and produced, distributed, and consumed to how manufacturing supply chains integrate and factory floors operate.[2] But it's still early days in the smart manufacturing revolution: for instance, 77 percent of small U.S. manufacturers still lack plans to implement Internet of Things applications over the next three years. This report examines the extent of smart manufacturing adoption by U.S. manufacturers and offers policy recommendations to increase smart manufacturing penetration in the United States, Korea, and beyond.

Smart manufacturing enables manufacturers to converge the physical and digital worlds, combining sophisticated hardware with innovative software, sensors, connectivity, and massive amounts of data and analytics to produce smarter products, more efficient processes, and more closely linked customers, suppliers, and manufacturers.[3] The digitalization of modern manufacturing holds the potential not only to restore once-robust manufacturing productivity growth, but also to reshape the landscape of global manufacturing, bolstering the competitiveness of the most innovative and most rapidly technology-adopting companies while eroding the advantage of enterprises—and nations

INFORMATION TECHNOLOGY & INNOVATION FOUNDATION | AUGUST 2018 PAGE 1

U.S.-Korea Collaboration in the Bioeconomy

- NSF and Science Ministry launched collaboration on bioeconomy R&D supporting more than $10M in research collaborations.
- Enhance cooperation on Cancer Moonshot Initiative 2.0, with MOU between U.S. NCI and Korean National Cancer Center.
- Expand MD-PhD talent exchange programs and cooperation between research hospitals on cell and gene therapies and treatments for rare diseases.
- Collaborate to develop new technologies for API/generic drug development through AI-driven continuous mfg. technologies.

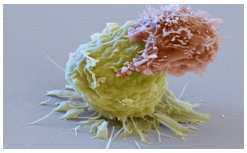

Image of a CAR-T cell (reddish) attacking a leukemia cell (green)

Coordinate on U.S.-Korea Technology Protection Regimes

- ✓ U.S. should work with allies to the maximum extent possible in promulgation and enforcement of AI/semiconductor/tech export controls.
- ✓ Enhance information-sharing efforts to combat foreign economic espionage and IP/technology/trade secret theft.
- ✓ U.S./Korea should launch “Seven Eyes-like” alliance focused on combatting state-sponsored economic espionage in advanced-technology industries.
- ✓ Develop and exchange lists of foreign enterprises/individuals engaged in IP theft and restrict them from competing in allied nations’ markets.
- ✓ Work with like-minded nations to coordinate investment screening proce
  add Korea to the list of “excepted foreign states.”

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Deepen U.S.-Korea Trade Relations

- ✓ Commit to at least halving 2024 $66B trade surplus in 2025.
- ✓ Resolve digital trade issues: data localization barriers, targeting of U.S. tech platforms in the Fair Trade Act, foreign access to mapping data.
- ✓ Join CPTPP and the Digital Economy Partnership Agreement (DEPA).
- ✓ Collaborate with allies to block Chinese participation in CPTPP/DEPA.
- ✓ Expand subsidies disciplines within WTO rules.

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Thank You!

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@sjezell

ITIF-KAIST Forum 2025
on National Strategic Technology & Innovation

Session I / 1부 U.S.-ROK Science and Technology Cooperation / 한·미 과학 기술협력

Topic Presentation II / 발제 2

한·미 전략기술 파트너십 협력 강화

Advancing U.S.-ROK Cooperation through Strategic Technology Partnerships

송경진
아시아재단 한국본부 대표

Kyungjin Song
Country Representative, The Asia Foundation Korea Office

The Asia Foundation

Advancing U.S.-ROK Cooperation through Strategic Technology Partnerships

Kyungjin Song
The Asia Foundation

for

ITIF-KAIST Forum 2025
On National Strategic Technology & Innovation

May 22, 2025, KAIST

70 Years of Korea-TAF Partnership

1951 Donation of newsprint for textbooks

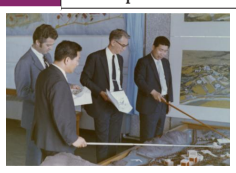
1963 Establishment of the Korean Foreign Service Training Institute

1980s Women's political participation

2011 The Way Forward: Korea for Asia

1954 TAF Korea formally opened

The Asia Foundation



1970s Seoul National University's Ten-Year Development Plan

1990s Local autonomy and election

2025 TAF-Google.org APAC Cybersecurity Fund Program

Korea's GDP and Growth Contribution, 2001-24

(%, %p)

Period	Annual Average	Labor	Capital	TFP
2001-10	4.7	0.8	2.0	1.9
2011-19	3.1	0.9	1.4	0.8
2015-24	2.5	0.6	1.3	0.6

Source: KDI, May 8, 2025

Korea's Growth Potential, 2025-50

(%, %p)

Period	Annual Average		Labor	Capital	TFP
	Base	Optimistic			
2025-30	1.5	1.7	0.1	0.9	0.5
2031-40	0.7	1.1	-0.4	0.6	0.6
2041-50	0.1	0.5	-0.8	0.3	0.6

Source: KDI, May 8, 2025

Reinvent the Economy through Innovation

or

Face Low Growth, Sluggish Economy (Japanification)

S&T: Essential Component of Balance of Power

Lee Kuan Yew, 2013
"In the old concept balance of power meant largely military power. In today's terms, it is a combination of economic and military, ands I think the economic outweighs the military."

Dario Gil, chair of the US National Science Board, 2025
"The currency of power is increasingly becoming science and technology."

S&T and Digital Policy Priorities to Tackle Low Growth

Outcome of MSICT Survey (January 2025)

1. [13.8%] Foster national strategic technologies (i.e., AI, advanced biopharmaceuticals, quantum, etc.)
2. [12.4%] Accelerate acquisition of leading technologies such as future energy
3. [10.4%] Transition to leading R&D system
4. [9.2%] Cultivate S&T, digital talent/workforce
5. [8.3%] Better treatment for S&T workforce

Competitive Industrial Performance (CIP) Ranking

Country	1990	2000	2010	2020	2022
Korea	16	12	4	4	4
US	3	1	3	6	6
Germany	1	2	1	1	1
China	35	28	6	2	2
Japan	2	3	2	5	8

Source: STEPI Brief Vol. 47, April 21, 2025

ROK-U.S. Partnership in Strategic Technologies

- AI Semiconductors
- Robotics
- Biopharmaceuticals
- Shipbuilding (MRO): ROK-US, ROK-US-India, etc.
- Clean & Nuclear energy (SMR, MMR)
- Space
- [Critical minerals]

Critical Enabling Conditions

- Joint R&D: Enhance R&D productivity and technological entrepreneurship
- People-to-people exchange: multi-layered partnerships
- Regulatory innovation in tandem with global standards
- Jointly establish digital trade rules (eg. DEFA)
- Beware of short-termism

감사합니다.
Thank You.

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Topic Presentation III / 발제 3

인공지능시대, 인문사회예술의 가치

The Value of Humanities, Arts, and Social Sciences (HASS)
in the Age of AI

정재민
KAIST 인문사회융합과학대학장

Jaemin Jung
Dean, College of Liberal Arts and Convergence Science, KAIST

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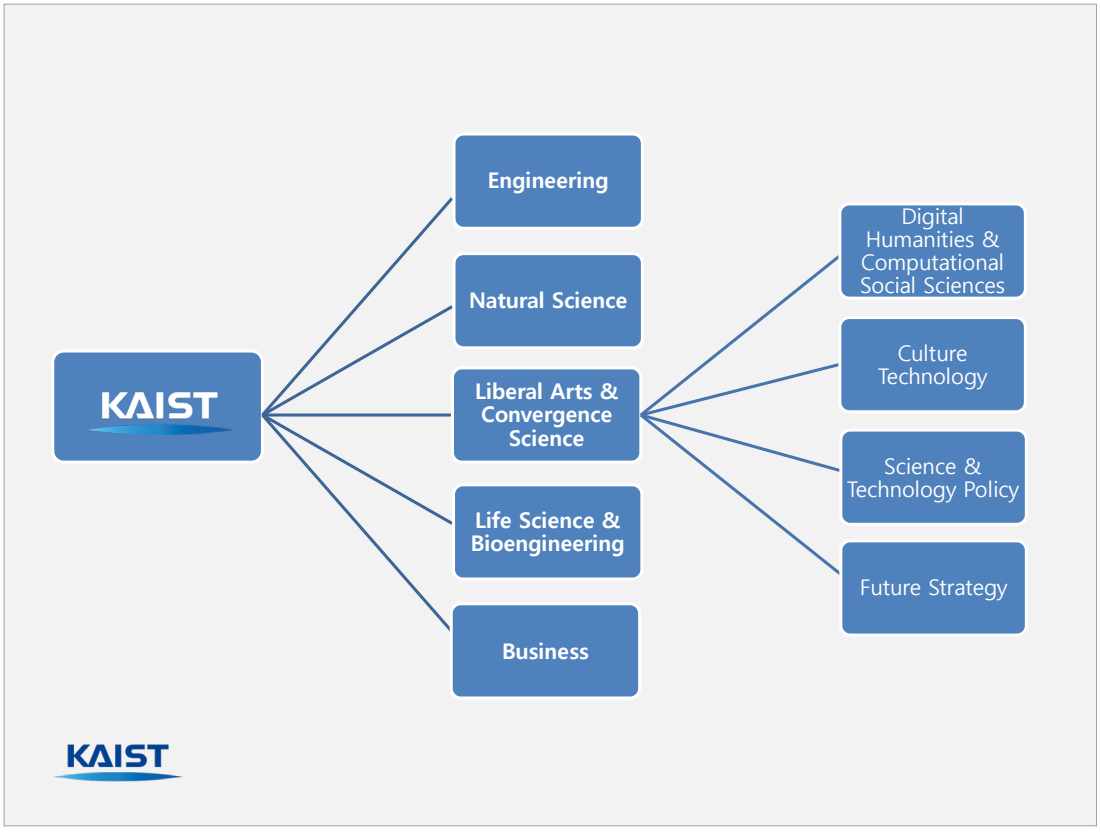
The Value of Humanities, Arts, and Social Sciences (HASS) in the AI Era

Jaemin Jung



Agustín Rayo
Dean, School of Humanities, Arts, and Social Sciences (SHASS), MIT

When he meets someone new, the conversation often goes like this:

"I'm a professor."
"Which school?" (kind of indifferent)
"MIT"
"Wow! MIT. What do you teach?"
"Philosophy."
And then comes the confused look...
"Wait... MIT has philosophy?"

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Why HASS Matters in the KAIST and MIT

- **Humanities & Arts:**
  Explore the essence of human existence
- **Social Sciences:**
  Study human relationships and societal structures
- **Science & Engineering:**
  Discover and invent — for humanity and society

To lead in the AI era, we need more than technical skills. We need ethics, philosophy, history, literature, and a broad worldview.

HASS are not just supplements—they are driving forces for a responsible and sustainable society.

True leadership begins with understanding both **technology** *and* **humanity**

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Beyond Traditional HASS — Toward Convergence & Impact

🧠 **School of Digital Humanities & Computational Social Sciences**
- ✓ Digital Humanities
- ✓ Computational Social Science
- ✓ Cognitive Convergence Science (Linguistics & Psychology)

🎯 **Graduate School of Science & Technology Policy**
- ✓ History & Philosophy of Science
- ✓ AI, Science, & R&D Policy

🤹 **Graduate School of Culture Technology**
- ✓ Arts, Games, & Culture × Technology
- ✓ Creative Industries

🌍 **Graduate School of Future Strategy**
- ✓ Demographics · Technology · Climate Futures
- ✓ Science Journalism, Intellectual Property, Strategic Foresight

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EDUCATION: Innovation through Integration

🧠 **True Co-Teaching Across Disciplines**
- ✓ "The Human Being in Science and Philosophy"
- ✓ Co-taught for 16 full weeks by a philosopher and a physicist
- ✓ Joint appointments with science and engineering departments for newly hired faculty

🎓 **Graduate Program Revamp**
- ✓ School of Digital Humanities & Computational Social Sciences (2023)
- ✓ About 5:1 graduate admission competition rate
- ✓ A rare success in Korea's declining HASS graduate enrollments

📚 **Expanding Learning Opportunities**
- ✓ 5 interdisciplinary minors across 4 departments
- ✓ High-quality HASS education for all majors

📖 **Building a Reading Campus**
- ✓ <Book Club> program with students, staff, and faculty
- ✓ School-supported book purchases + reflection sharing
- ✓ Annual awards for top readers (individual & group) — President's Prize

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RESEARCH: Breaking academic silos to solve problems together

🔬 **Monthly Convergence Forums**
- ✓ Co-presentations by professors across disciplines
- ✓ (e.g., STP × Chemistry / Future Strategy × Civil & Environmental Engineering)
- ✓ Open to all interested students and faculty

💰 **Collaborative Grants to Expand HASS Funding**
- ✓ ₩6B for Climate Change Policy (Hydrology, Politics, Int'l Dev., Urban Design...)
- ✓ Law × Complex Systems → Post-AI Legal Networks
- ✓ Journalism × AI → Journalism value based News Recommender
- ✓ HCI × Music × Cognitive Science → Immersive Sound Experience
- ✓ Global Health × Climate Change → AI for Refugee Mobility,

🏢 **Industry Collaboration Highlights**
- ✓ EBS: Real-time XR performance education platform
- ✓ Samsung: Data-driven organizational culture modeling
- ✓ Kakao Entertainment: Deep learning for music tagging
- ✓ KT: Human-AI dialogue interaction & sound design
- ✓ Troy / BUEY: IP & metaverse strategy, digital heritage systems

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Towards a Human-Centered Future in the Age of AI
HASS × Science & Technology

🌐 **Today's challenges are complex and uncertain.**
- ✓ No single discipline can solve them alone.

👥 **Every issue is rooted in human relationships and society.**
- ✓ By combining critical thinking and creative imagination with scientific rigor and technological power, we can build a future that protects human dignity, democracy, and social inclusion.

🤝 **We pursue open and integrative research.**
- ✓ KAIST CLACS and MIT SHASS' Joint Seminar in KAIST (June 13)
- ✓ To explore HASS-based S&T collaboration between Korea and the U.S.

There is no one "right" answer to human life.
Everyone's life is different and every culture has different patterns.
In the age of AI, the value of human insight will shine even brighter.

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Towards a Human-Centered Future in the Age of AI
HASS × Science & Technology

Let's make a better future together.

Thank you.

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ITIF-KAIST Forum 2025
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Session Ⅱ / 2부 **Key Technology Areas for U.S.-ROK Cooperation**
한·미 과학 기술협력: 주요 세부 기술 분야

Topic Presentation Ⅰ / 발제 1

진정 지속가능한 차세대 원자력을 위한 한·미 협력

ROK-U.S. Collaborations for Truly Sustainable Next Generation Nuclear Energy

김용희
KAIST 국가미래전략기술 정책연구소장

Yonghee KIM
President, Future Institute for National Strategic Technology and Policy (FINST&P), KAIST

IFIF-KAIST Forum 2025 on National Strategic Technology & Innovation

Daejeon, KAIST

ROK-USA Collaborations for Truly Sustainable Next Generation Nuclear Energy

May 22, 2025

Yonghee Kim

yongheekim@kaist.ac.kr

Department of Nuclear & Quantum Engineering

The Future Institute for National Strategic Technology and Policy

Korea Advanced Institute of Science and Technology

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Humanity's Top Problems

Humanity's Top Ten Problems for next 50 years

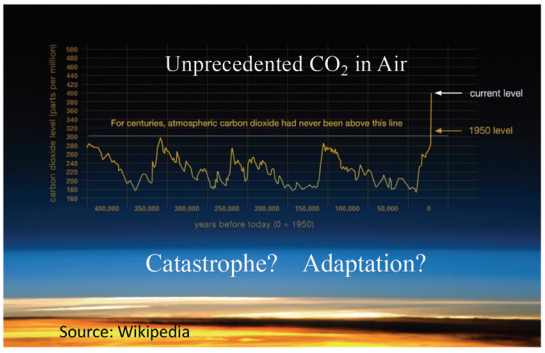
1. ENERGY
2. WATER
3. FOOD
4. ENVIRONMENT
5. POVERTY
6. TERRORISM & WAR
7. DISEASE
8. EDUCATION
9. DEMOCRACY
10. POPULATION

Richard Smalley (2003)

2003 6.3 Billion People
2050 8-10 Billion People

+ Climate change Due to Global Warming

+ AI (Artificial Intelligence)



Everybody's problem is nobody's one?

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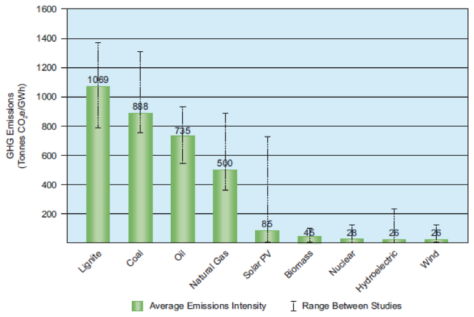
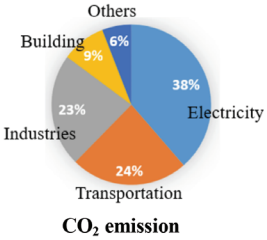
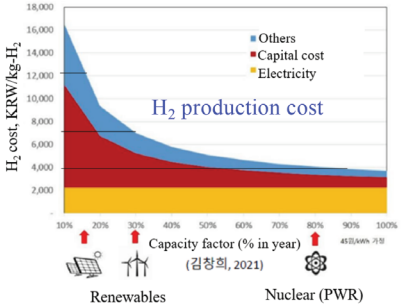
Why Nuclear (Fission)-Renewable (SUN) Synergy?

❑ **Urgent decarbonizaion** for human civilization





CO_2 emission

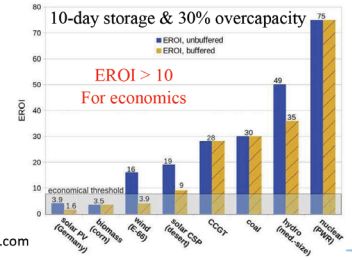


Smaller emission with advanced reactors

❑ **Tripling** of **Nuclear** by 2050 for carbon neutrality

- **Nuclear load-follow to complement RE's intermittency**

❑ EROI (Energy Returned On Invested)



D. Weissbach et al., https://sciencedirect.com

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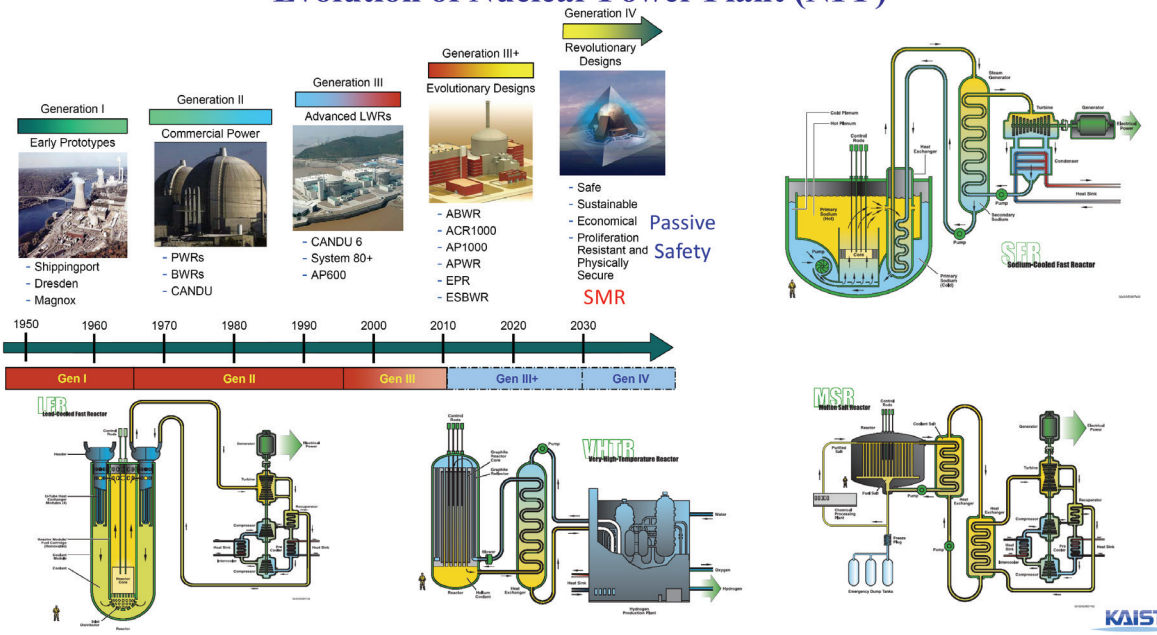
Evolution of Nuclear Power Plant (NPP)



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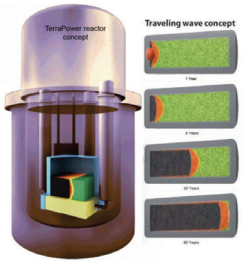
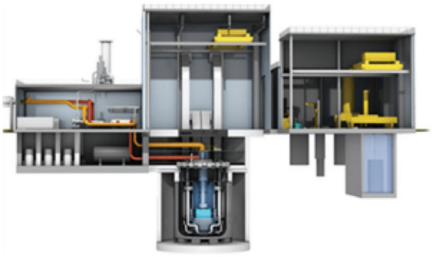
Advanced Reactors from TerraPower

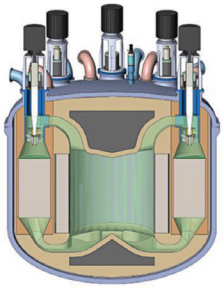
We need energy miracle
to solve the climate crisis.



Traveling Wave Reactor (TWR)



Natrium system (SFR)
to be built in Wyoming by 2029



[TerraPower - MCFR]

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New Perception for Nuclear

- Bipartisan supports for nuclear in USA
- Trump announces 4 times nuclear expansion.

- 'Dow Chemical' for nuclear

- Italy, Swiss, and Belgium abandoned 'nuclear phase-out'.
- Denmark & Spain also reconsider nuclear!
- In Germany, over 55% are pro-nuclear in recent poll and nuclear is reconsidered as a possible option.
- Painful impacts of nuclear phase-out and intermittent renewables in Germany
- Sweden blames Germany for high electricity cost.

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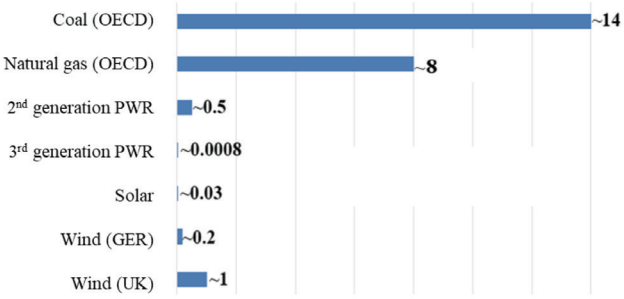
Are We Ready for the Big Nuclear Expansion?

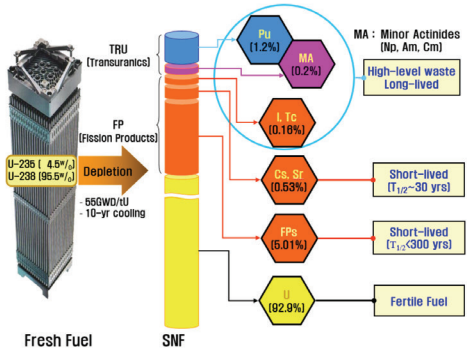
KAIST

Trilemma of Current Nuclear Energy

- **Safety**



Accident fatality rate by energy source (person/TWh)



- **Accumulation of spent nuclear fuel (SNF)**
  - Difficulty in on-site and interim storages
  - Long disposal in deep geological repository

Spent Fuels in Korea
LWR: ~9,000 tons
HWR: ~9,400 tons

Accumulated amount of SNF and Saturation point of storage tank

Power plant	Expected SNF accumulation	Storage tank saturation point
Kori	12,290 FA	2032
Hanbit	13,051 FA	2030
Hanul	27,401 FA	2031
Saeul	15,660 FA	2066
Shin Wolsong	3,633 FA	2042
Wolsong	721,920 FA	2037

<Reference: Ministry of Trade, Industry and Energy>

- **Limited 'affordable' U resource**
- **Economics**

How can we address them all together?

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Possible Resolution of Trilemma Using Ultimate Reactor for Sustainable Nuclear

E. Lee, T. Oh, and Y. Kim, "Breakeven Molten Salt Fast Reactor Based on a Simple Closed Fuel Cycle for Sustainable Nuclear Energy," **Under review in Progress in Nuclear Energy.**

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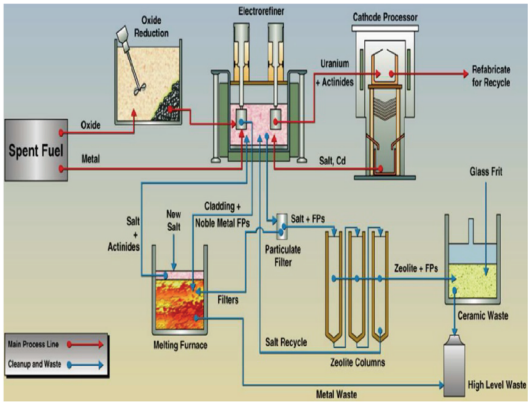
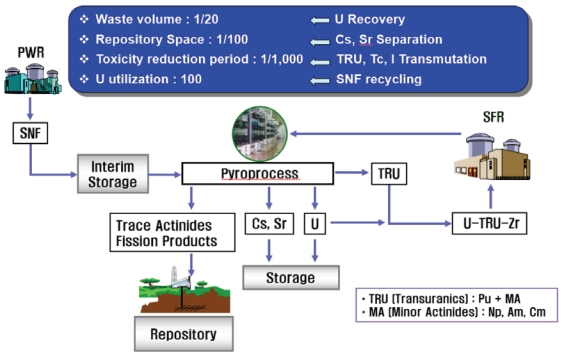
Conventional Pyro-SFR TRU Transmutation in Korea

- **Proliferation-resistant** pyro-processing of spent nuclear fuel to recover '**dirty**' TRUs (Transuranics)





- **Collaborative researches with USA over 15 years**
  - To be finished in 2026.
  - Relatively low public acceptance for SFR in Korea

Any other more affordable, reliable, and competitive closed fuel cycles?

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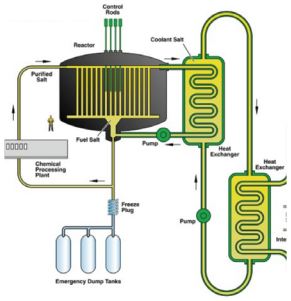
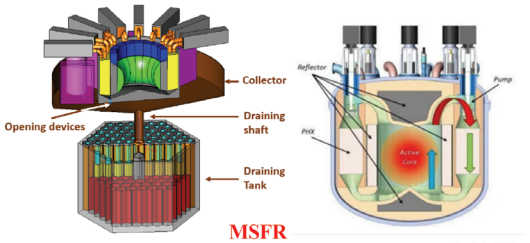
Promises and Challenges with MSR

- **Motivations** for MSRs
  - Possible '**elimination of severe accidents**' due to **liquid fuel**: LiF-BeF_2-UF_3, NaCl-UCl_3, NaF-KF-UF_4
    - No pressurization & efficient removal of decay heat
    - Very limited release of toxic fission products like Cs and I
  - **No accumulation of spent fuels** due to liquid fuel
  - Extremely high fuel utilization
  - Effective recycling of spent nuclear fuels
  - **Unparalleled inherent safety**
  - **High thermal efficiency**
  - Possibility of **much better economics**
- **Molten Salt Fast Reactor (MSFR)** for **sustainable nuclear**.
- Major **Challenges**
  - Material corrosion, uncertain salt properties, proliferation concerns, new licensing philosophy, etc.



Conventional Thermal MSR



MSFR

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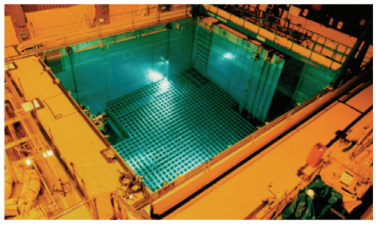
Energy Potential of SNF (Spent Nuclear Fuel)

- Spent nuclear fuel (SNF) in Korea
  - ~9,000 tons from LWR & ~9,400 tons from PHWRs
  - **Equivalent to total electricity in Korea over 300 years**
- **~90,000 tons of SNF in USA**
  - **Equivalent to total electricity in USA over several hundreds years as well!**



- **SNF can be effectively reused in fast reactor such as MSFR!**
  - → **Resolution of SNF issue and long-term sustainable nuclear without relying on natural U anymore**

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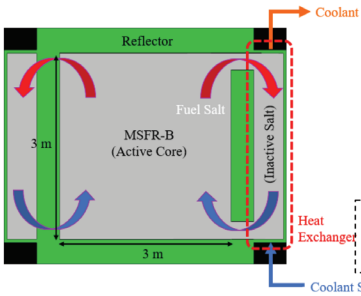
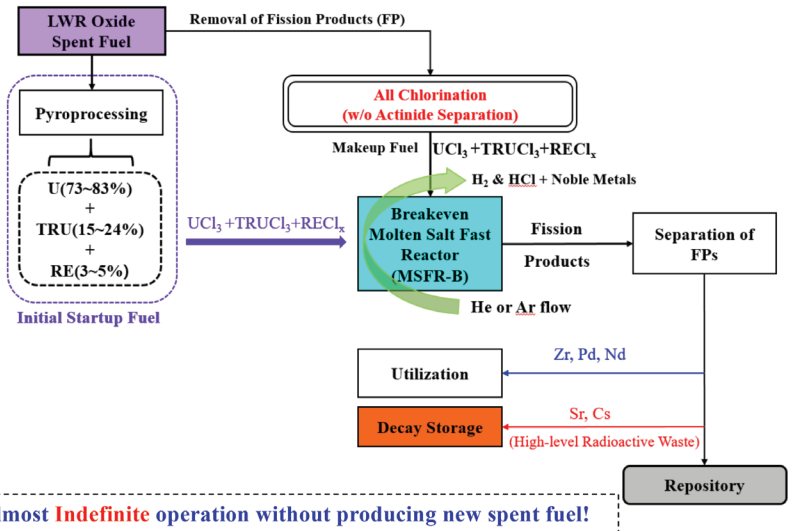
Breakeven MSFR (BeMFR) and Associated Closed Fuel Cycle

- **Breakeven** MSFR (**MSFR-B**)
  - KCl-$TRUCl_3$-UCl_3-$RECl_3$
- **Initial fuel** from **SNF**
  - Pyro-processing
- **Partial** fission product removal
- **Spent fuel feeding**

- **Medium to big (3 GW) size power**
  - **Scalable passive safety**





Almost Indefinite operation without producing new spent fuel!
Valuable rare earth (RE) fission products can be used in industry!

KAIST

Korea-USA Collaborations for Advanced Reactors

- **Strong collaborations in basic R&Ds for advanced reactors**
  - **ANL (Argonne National Lab.) – KAERI (Korea Atomic Energy Research Institute) for SFRs**
  - **INL (Idaho National Lab.) - KAERI for pyro-processing**
    : The ongoing 15-year R&Ds for the pyro-processing is to be ended in 2026.

- **Commercial collaborations for advanced reactor development**
  - **TerraPower-HD group, SK, and others for SFR and MSFR**
  - **Terrestrial Energy with Daelim E&C for IMSR**
  - **ARC with KHNP for SFR**
  - **NuScale with Doosan and a few others for SMR (VOYGR)**
  - **Others**

- **Team Korea is the only nuclear vendor with the 'On time and on Budget' construction capability.**

KAIST

Possible Strategic Korea-USA Collaborations

- The BeMFR could be a **strategic approach to address the trilemma** in both USA and ROK.
- And collaborations are required for the closed fuel cycle for a truly sustainable nuclear.
- Several SNF recycling R&Ds supported by DOE
- **Draft 'Executive Order' for nuclear independency**
  - 4 times nuclear by 2050 & SNF to be reused in advanced reactors

  - New supply chain for the **rare earth elements** dominated by China

Oil in middle east, while China has RE. (Deng)
"중동에 석유가 있다면, 중국에는 희토류가 있다(中東有石油, 中國有稀土)."

- **Collaborations** for **BeMFR** & **simplified pyro-processing** **in both ROK and USA**
  - ARDPs (advanced reactor demonstration programs) for SFR & MSFR in both countries
  - France & Japan and others can be invited to join the R&DDs.

  → **Globally sustainable nuclear!**

KAIST

Thank You!

ITIF-KAIST Forum 2025
on National Strategic Technology & Innovation

Session Ⅱ / 2부 **Key Technology Areas for U.S.-ROK Cooperation**
한·미 과학 기술협력: 주요 세부 기술 분야

Topic Presentation Ⅱ / 발제 2

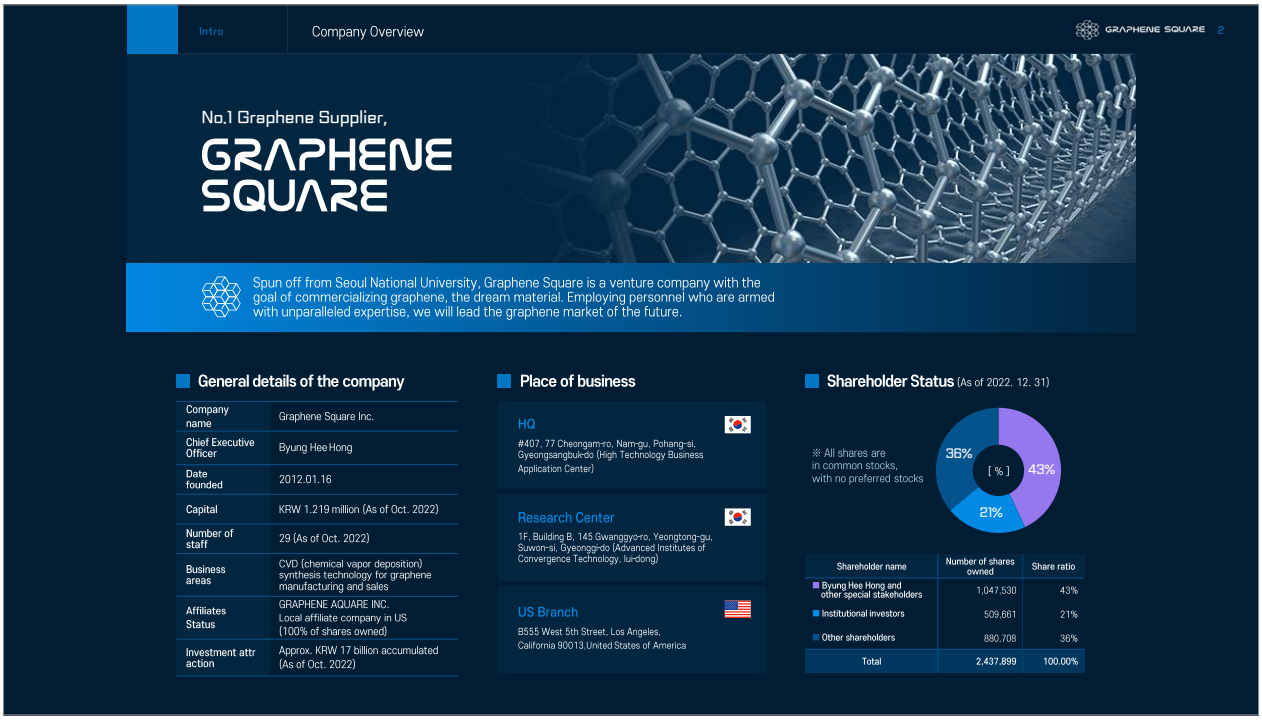
그래핀 소재 양산기술이 이끌 전략산업 혁신

Scalable Graphene Production: A Breakthrough in Material Innovation

홍병희
서울대학교 화학부 교수

Byung Hee Hong
Professor, School of Chemistry, Seoul National University


ITIF-KAIST Forum 2025 on National Strategic Technology & Innovation
Scalable Graphene Production:
A Breakthrough in Material Innovation
Byung Hee Hong
Seoul National Univ. & Graphene Square Inc.
GRAPHENE SQUARE
www.graphenesquare.com


Intro
Company Overview
GRAPHENE SQUARE 2
No.1 Graphene Supplier,
GRAPHENE SQUARE
Spun off from Seoul National University, Graphene Square is a venture company with the goal of commercializing graphene, the dream material. Employing personnel who are armed with unparalleled expertise, we will lead the graphene market of the future.
General details of the company
Company name | Graphene Square Inc.
Chief Executive Officer | Byung Hee Hong
Date founded | 2012.01.16
Capital | KRW 1.219 million (As of Oct. 2022)
Number of staff | 29 (As of Oct. 2022)
Business areas | CVD (chemical vapor deposition) synthesis technology for graphene manufacturing and sales
Affiliates Status | GRAPHENE AQUARE INC. Local affiliate company in US (100% of shares owned)
Investment attr action | Approx. KRW 17 billion accumulated (As of Oct. 2022)
Place of business
HQ
#407, 77 Cheongam-ro, Nam-gu, Pohang-si, Gyeongsangbuk-do (High Technology Business Application Center)
Research Center
1F, Building B, 145 Gwanggyo-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do (Advanced Institutes of Convergence Technology, Iui-dong)
US Branch
B555 West 5th Street, Los Angeles, California 90013,United States of America
Shareholder Status (As of 2022. 12. 31)
※ All shares are in common stocks, with no preferred stocks
36%
[%]
43%
21%
Shareholder name | Number of shares owned | Share ratio
Byung Hee Hong and other special stakeholders | 1,047,530 | 43%
Institutional investors | 509,661 | 21%
Other shareholders | 880,708 | 36%
Total | 2,437,899 | 100.00%

Intro | Biz Overview

GRAPHENE SQUARE 3

Next-gen applied products will be developed **utilizing graphene's physical excellence**

Development plans for applied products

Classification	Areas	Main applications	Expected buyer demand	Technological characteristics	Status	Remarks
01 Initial business expansion	Semi-conductor	Extreme ultraviolet pellicle wafer heating	Semiconductor-related company	High EUV passing, uniform heating, mechanical durability, high heat conductivity	Collaboration with Pohang Accelerator Laboratory EUV line and National Institute for Nanomaterials Technology	2023 1H: PoC planned
	Home appliances	Transparent heater	Home appliance manufacturer	Excellent heating features, low power	Prototype development complete and development plans underway	2022: Chosen as one of Time's Best Inventions of 2022 2023 2H: Product launch
		Transparent display combined heating apparatus	Home appliance and parts manufacturers	Applied product with transparent display	Submission of product proposal	2023: Received CES 2023 Innovation Award
	Mobility	Camera defrost heating	Parts manufacturer	Energy-saving, quick defroster and dehumidifier	Supplying test samples	2024: Mass production planned
		Windshield defrost heating	Parts manufacturer	Quick energy-saving defogging	Commercialization and mass production tasks underway	2024 1H: 30,000 units contracted 2025: Anticipated contract scale of 300,000 units
		LiDAR defrost heating	Part manufacturer	Excellent infrared passing	PoC project underway (2021.12)	2024: Commercialization
	Rechargeable battery	Current collector	Battery manufacturer	Functionally excellent, long battery life	Supplying test samples	2024: Electric car battery applications
02 Next-gen markets	Wearables	Bulletproof clothing	Munitions industry	Reinforcing or replacing existing materialsR	2018-2021: Two deliveries complete 2022: Reliability tests underway	-
	Biotech	Medicine for neurocerebral illnesses	US National Institutes of Health	Fundamental cure for neurocerebral illnesses	GQD production Pilot line construction contracted	Combining cosmetics and health functional food products (planned)
	Display	Encapsulation (hydrogen) gas barrier	Hydrogen energy companies	Process simplification and thin-flexible encapsulating film	Completed 2 support projects for Ministry of Trade, Industry and Energy	2023: Applied development of hydrogen storage device 2025: Market entry

Procuring applied source patent for graphene utilizing heating, thermal protection, gas barrier, electromagnetic shielding, etc.

Intro | CEO

GRAPHENE SQUARE 4

GRAPHENE SQUARE

Powerful teamwork to commercialize graphene

- CEO of Graphene Square Inc.
- Professor of Chemistry at Seoul National University
- Director of Graphene Research Center, Advanced Institutes of Convergence Technology, Seoul National University
- Post-Doc., Columbia University (Advisor : Philip Kim)
- Visiting Scholar, Harvard University
- Former CEO of Graphene Square Chemical Inc.

Byung Hee Hong

Founder & CEO

Large-Scale pattern growth of graphene films for stretchable transparent electrodes

K. S.. Kim et al Nature 457, 706 (2009)

- No. 1 Citation in Chemistry among the papers published since 2009.

Roll-to-roll production of 30 inch graphene films for transparent electrodes

S. Bae et al. Nature Nanotech. 5, 574 (2010)

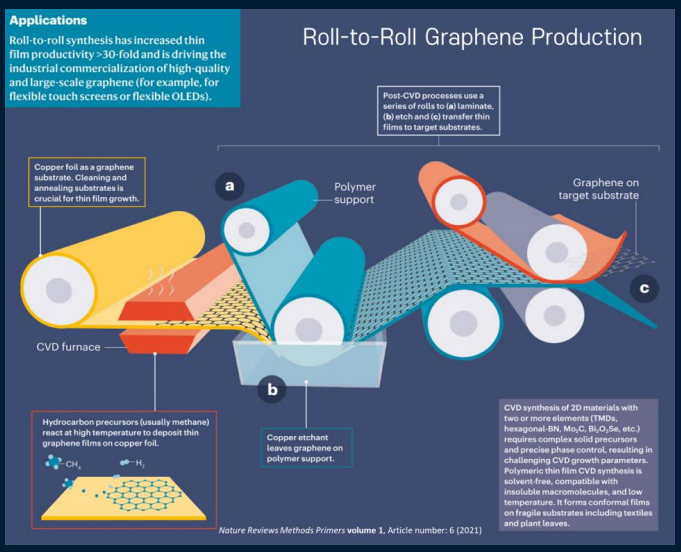
- No. 6 Citation in Materials Science among the papers published since 2009

Tech Highlight | Process Technology | GRAPHENE SQUARE 5

Chemical vapour deposition. *Nature Reviews Methods Primers* 1, 5 (2021)

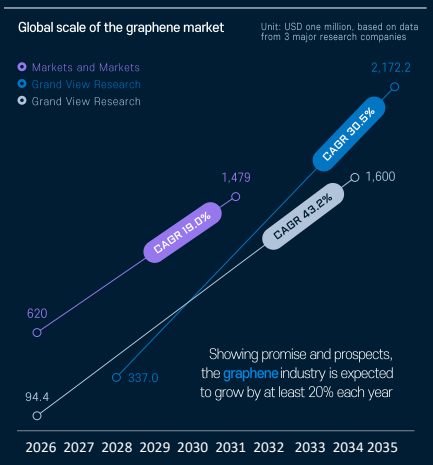
Applications

Roll-to-roll synthesis has increased thin film productivity >30-fold and is driving the industrial commercialization of high-quality and large-scale graphene (for example, for flexible touch screens or flexible OLEDs).



The potential of graphene

Sought after in various industries for its physical excellence, considerable growth for graphene is expected



Showing promise and prospects, the graphene industry is expected to grow by at least 20% each year

Tech Highlight | Process Technology | GRAPHENE SQUARE 6

Roll-to-Roll technology maximizes efficiency in graphene production

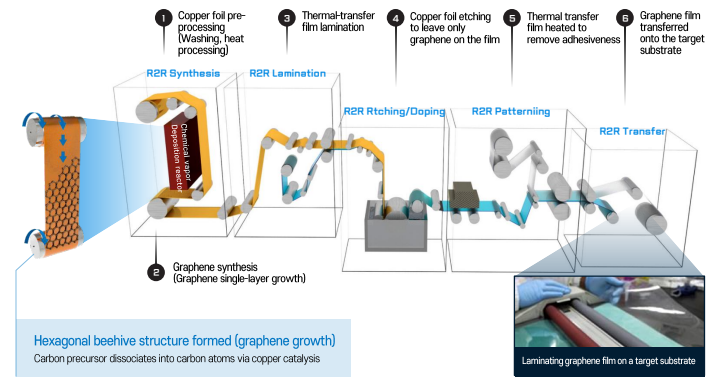
Roll-to-Roll CVD thin-film graphene mass production technology

A consecutive synthesis-etching-transfer process that is similar to newspaper printing for high-quality thin-film graphene production

As of 3Q 2022	Korea	Overseas	Total
Registered	31	28	59
Submitted for patent	4	18	22

Core technology rights procured

Process



Hexagonal beehive structure formed (graphene growth)

Carbon precursor dissociates into carbon atoms via copper catalysis

Production efficiency increased by 38 times

Compared to non-continuous process

Large-area graphene mass production

Up to 150,000 ㎡/h

Tech Highlight | Equipment Technology

GRAPHENE SQUARE 7

Core technology for the mass production of graphene

CVD graphene equipment technology

Graphene
hBN synthesizer
TCVD

TMDC
Synthesizer
MOCVD

Roll-to-Roll
Continuous synthesizer

Can synthesize a width of up to 500 mm

Delivered worldwide
to prestigious universities

United States, Japan, Italy, Brazil, Spain, Saudi Arabia, Denmark, Thailand, etc.

▪ United States	Middle East MIT, Harvard, Boston U, UT Dallas, Columbia, University of North Texas, etc.
▪ United Kingdom	Cambridge, Oxford, University of Manchester
▪ Europe	ETH, IBM (Switzerland), TNU (Norway), DTU (Denmark), University of Bari (Italy)
▪ Middle East	KAUST (Saudi Arabia) / Technion (Israel)

Enhanced credibility of our in-house technology by delivering it to prestigious universities worldwide

Flake graphene equipment technology

Air Jet Mill Equipment

- Can produce up to a ton a day
- Various chemical functions according to the gas injected

Universal use

Applicable to battery anode materials, lubricants, reinforced plastics, etc.

Maximized influence of our in-house graphene technology

Tech Highlight | Equipment Technology

GRAPHENE SQUARE 8

Roll-to-Roll technology maximizes efficiency in graphene production

Roll-to-Roll CVD thin-film graphene mass production technology

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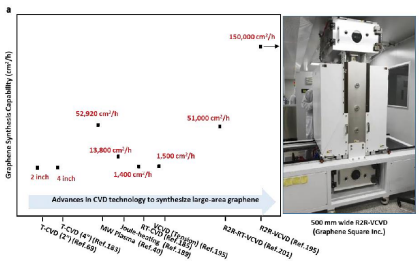
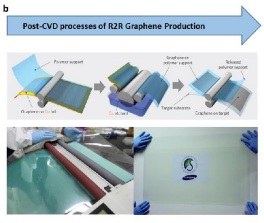
Process





Production efficiency increased by 38 times

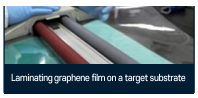
Compared to non-continuous process

Large-area graphene mass production

Up to 150,000 ㎠/h

Hexagonal beehive structure formed (graphene growth)

Carbon precursor dissociates into carbon atoms via copper catalysis



Laminating graphene film on a target substrate

Nature Reviews Methods Primers **volume 1**, Article number: 5 (2021)

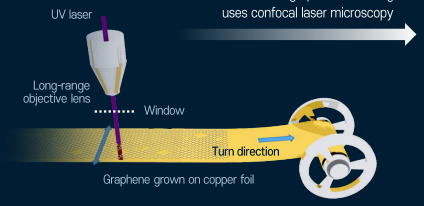
Tech Highlight | Quality Assessment | GRAPHENE SQUARE 9

Excellent quality and manufacturing efficiency of roll-to-roll technology

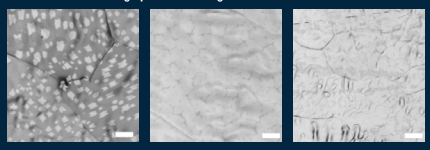
Quality assessment technology applied

Patented

Real-time graphene scanning uses confocal laser microscopy



Graphene is formed on the copper foil,
and the graphene's coverage is assessed in real-time

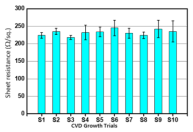


The current CVD technology's limits (flaws due to foreign material input) **areeffectively addressed to improve output quality**

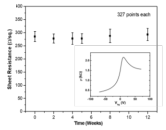
High-quality graphene production w/ reliability

The most suitable technology for the mass production of wide-area thin-film graphene

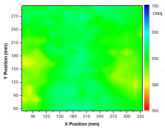
Repetition
Maintaining a stable product quality



Continuity
Maintaining its quality for a long period after production

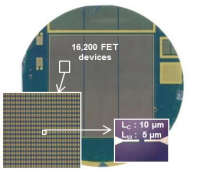


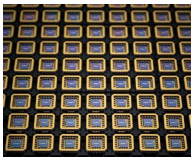
Uniformity
Maintaining a certain quality level across the entire production surface

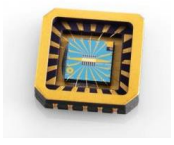


Tech Highlight | Pilot Production Line | GRAPHENE SQUARE 10

Pilot R2R Production Line in Pohang (Sensors & EUV Pellicles)







Tech Highlight | Technology Overview

GRAPHENE SQUARE 11

Developing graphene sensor **for medical diagnosis & environmental sensors**

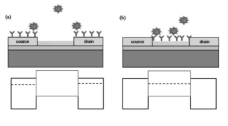
Quick diagnosis sensor using graphene-based sensor

About product

Business introduction

Efficient, sensitive, and quick diagnosis sensor using graphene transistor

Using the sensitivity to electric conductivity of graphene Infection is determined using the voltage changes in the object of measurement

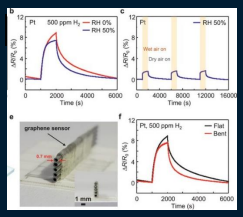


Chemical Sensing by Dirac Shift

Versatility	Able to develop diagnosis kits targeting COVID-19 and other ailments
Functional excellence	Higher precision compared to chemical methods
Speed	Shortened time of measurement

LG Electronics

Status & plan



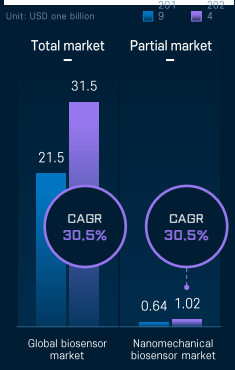
Ultra-Sensitive H2 Sensor (Adv. Mater. 2020)

Core technology	secured
▼	
Product (sensor, diagnosis kit) development	complete
▼	
Commercialization (Improving the process for mass production)	underway
▼	
Actual mass production of products	2023 ~

Analysis of target market for each product

Scale of the global biosensor market

Unit: USD one billion



※ INNOPOLIS "Biosensor Market", Apr. 2020 (Source: Markets and Markets)

Tech Highlight | Technology Overview

GRAPHENE SQUARE 12

Functionally excellent **EUV pellicle development & product development**

EUV pellicle using thin-film graphene

Unmet needs

EUV pellicle concept

Material attached to the EUV photomask to prevent harm from intrusion of foreign matters during semiconductor wafer production

NEEDS 1	NEEDS 2
Suppressing temperature increase and effectively discharging energy absorbed	Requiring a material with mechanical durability and chemical stability

Discharging temperature rise from EUV light absorption

Status & plan

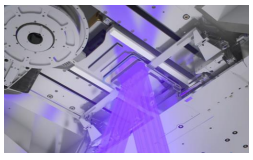
Business introduction: Developing EUV photomask pellicle using Graphene Square's thin-film graphene with excellent transmittance

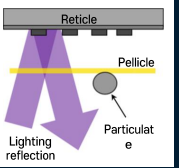
Development goals

Mechanical durability	Extreme ultraviolet transmittance of 90% or higher	Chemical stability
Accomplished	93% accomplished	Accomplished

Potential Collaborators: FST [1] | ASML | PAL 포항가속기연구소 | INANET 나노융합기술원

Reference video

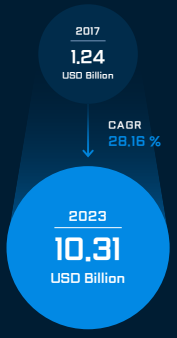




※ 1) Collaborative Infrastructure: Collaborative project completed between the participating companies through the Ministry of Trade, Industry and Energy's 2019-2021 projects

Analysis of target market for each product

EUV lithography market



※ Source: Markets and Markets "EUV Lithography Market-~" (2018.07)

Tech Highlight | EUV Pellicle

GRAPHENE SQUARE 13

Atomic Layer-by-Layer Transfer Technology

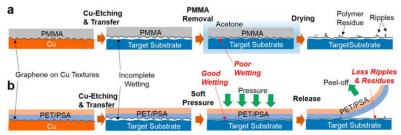


Figure 1. Schematic representation for PMMA- and PSAF-assisted transfer processes. (a) A wet-transfer process using PMMA supporting layer. The morphology of the PMMA layers is rigid and reverse to the rough surface of Cu. The unmatched morphologies between PMMA and target surfaces (incomplete wetting) result in occurrence of ripples and tears during the dissolution of PMMA. (b) A dry transfer using PSAF includes the complete wetting step, where the liquid-like PSA layer adapts its morphology to target surface as soft pressure is applied to it.

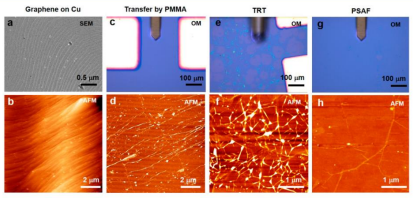
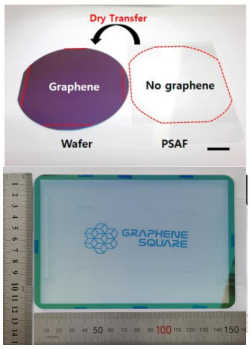
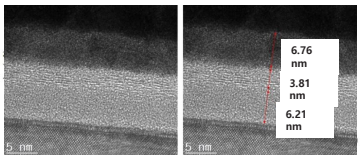


Figure 2. Comparison between PMMA-, TRT-, and PSAF-transferred graphene. (a,b) SEM and AFM images of as-grown graphene on Cu, showing periodic steps of Cu. (c,d) OM and AFM images of PMMA-transferred graphene on SiO_2, showing PMMA residues and ripples reversely templated by Cu steps. (e,f) OM and AFM images of TRT-transferred graphene on SiO_2. The large thermal deformation of the release and target films at the temperature close to their T_g (glass transition temperature) resulted in the occurrence of ripples on polymer residues. (g,h) OM and AFM images of PSAF-transferred graphene on SiO_2, showing ultraclean surface without residues and periodic ripples. The thick ripples originate from the negative thermal expansion of graphene.





Nano Lett. 2015, 15, 3236–3240

Tech Highlight | Electrothermal Applications

GRAPHENE SQUARE 14

Transparent heater into products using thin-film graphene

Transparent surface heater | Additional development plans

Applicable to home appliances, construction materials, and parts using transparent, wide-area heating materials

1 Defrost heater for cameras and windshields

Low-power heater to defrost and dehumidify automobiles

- Status: ▪ Supplying test samples
- Active plans: ▪ Commercialization and 30,000 unit orders in 2023 1H; ▪ 500,000 unit orders in 2025

2 LiDAR defrost heating

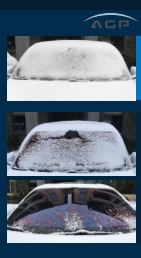
Heater managing the cover of the LiDAR sensor

- Status: ▪ Dec. 2021 - PoC project underway
- Active plans: ▪ Commercialization in 2023 (objective)

3 High-efficiency, low-power transparent radiator

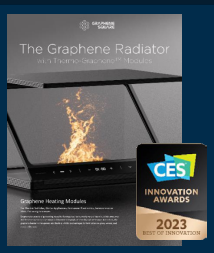
Novel home appliance combining graphene-based heating module and display

- Status: ▪ Test production within 2022
- Active plans: ▪ Joint development agreement with Korean home appliance companies underway; ▪ Launching in 2023 1H



- Technology : Patented for energy-saving defogging
- Durability : Inserted between double-layer glass for the windshield
- Efficiency : More efficient than the existing interior air heater method (15 min. → 5 min.)

Developing heating sensors with excellent infrared (IR) permeability for automobiles



- Utilization : Potential development of diverse products in various sizes
- Eco-friendliness : High-efficiency, low-power heating products
- Functionality : Foldable structure for portability Hologram display combined

Tech Highlight | Electrothermal Applications | GRAPHENE SQUARE 15

Transparent heater into products using thin-film graphene

Cooking and heating apparatus using transparent surface heater

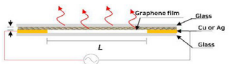
About product

TIME BEST INVENTIONS 2022

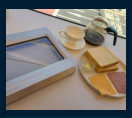
Graphene Kitchen Styler

Novel cooking apparatus using graphene-based transparent surface heater (Time's Best Invention of 2022)

Graphene film layered between two glass boards to make a transparent heating module



Feature

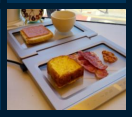


Speed
200 ℃ within 70 sec. (For 200 v)

Aesthetics
Refined design with a slim frame

Convenient
Information provided via display

Economical
Low power consumption



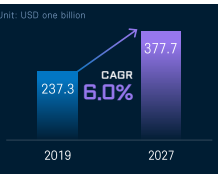
Trendy design and excellent quality

to achieve a paradigm shift in kitchen and heating appliances

Analysis of target market for each product

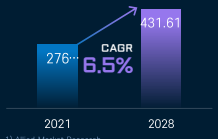
Kitchen and home appliance market [1]

Unit: USD one billion



Home cooking appliance market [2]

Unit: USD one billion



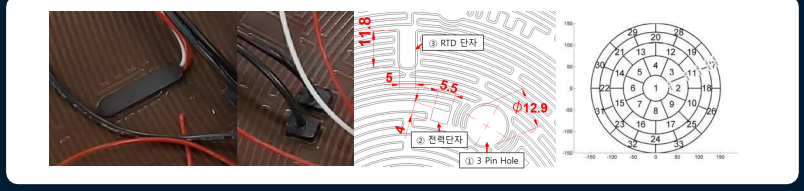
1) Allied Market Research "Kitchen Appliances Market…" (Mar. 2020)
2) Grand View Research "Household Cooking Appliance Market…"

Tech Highlight | Electrothermal Applications | GRAPHENE SQUARE

History of Electric Heating

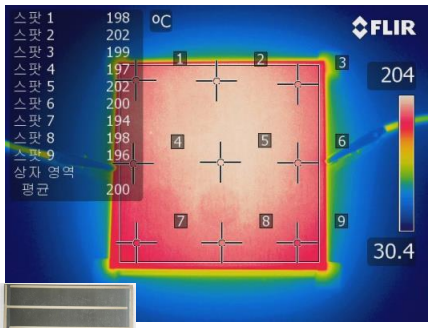
19C | 1910 GE D-12 Nichrome (Albert Marsh) 1905 | 1913, 1921 Double-side, Pop-up (Copeman, Charles Strite) | 2015~ BALMUDA

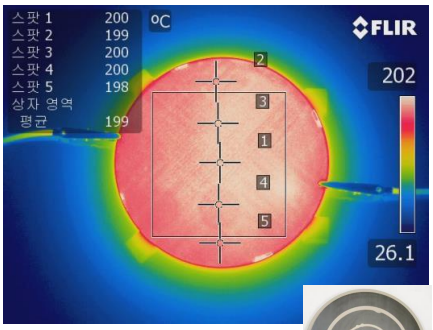
Wafer Heating Stage w/ 35-zone Heating

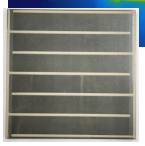


Tech Highlight | Electrothermal Applications | GRAPHENE SQUARE

Homogenous 2D Heating by Graphene







ΔT <1°C without multi-zone heating

Target T= ~ 250°C, max T = ~ 450 °C

(PoC in progress)

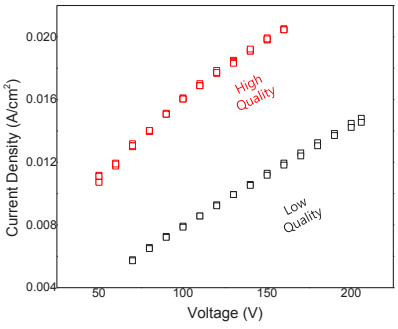
Tech Highlight | Electrothermal Applications | GRAPHENE SQUARE

Voltage-Dependent Electrical Characteristics

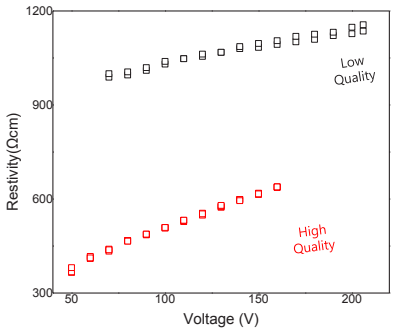
Conduction Convection Radiation

$$I^2R = \left(m_1C_1 + m_2C_2\right)\frac{dT(t)}{dt} + A\left(h_1 + h_2\right)\left(T(t) - T_0\right) + \sigma A\left(\varepsilon_1 + \varepsilon_2\right)\left(T(t)^4 - T_0^4\right)$$

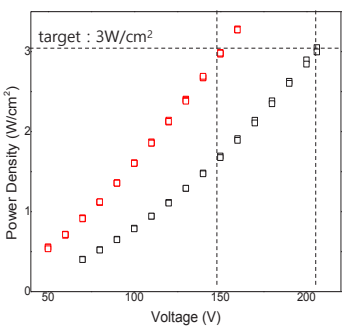
Current Density



Resistivity



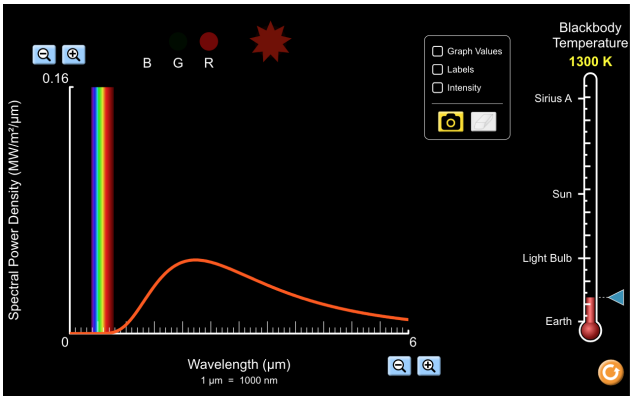
Power Density



Tech Highlight | Electrothermal Applications | GRAPHENE SQUARE

Origin of Red Color Emission from Joule-Heated Graphene on Glass in Air

Blackbody Radiation?

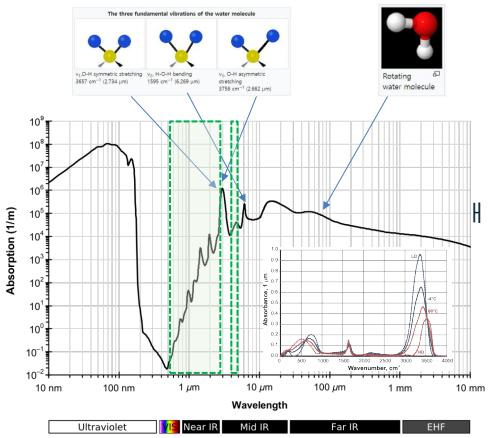


https://phet.colorado.edu/sims/html/blackbody-spectrum/latest/blackbody-spectrum_en.html

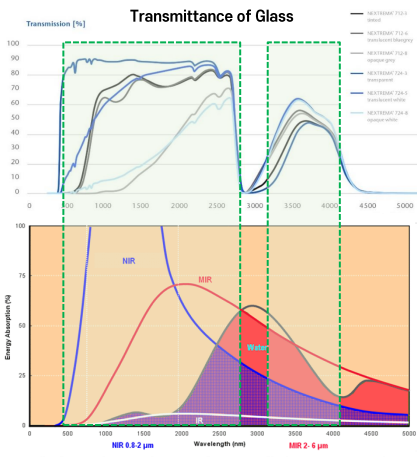
Tech Highlight | Electrothermal Applications | GRAPHENE SQUARE 20

Magic Mid-IR Windows for Water

Absorption Spectrum of Water



Transmittance of Glass



NIR from the Graphene Heater overlaps more with the absorption of water.

Tech Highlight | Electrothermal Applications | GRAPHENE SQUARE

Infrared Heating Applications in Food Processing

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Food Chemistry 94 (2006) 489–493

Food Chemistry
www.elsevier.com/locate/foodchem

Short communication

Effect of far-infrared radiation and heat treatment on the antioxidant activity of water extracts from peanut hulls

Seung-Cheol Lee [a,*], Seok-Moon Jeong [a], So-Young Kim [a], Hae-Ryong Park [a], K.C. Nam [b], D.U. Ahn [b]

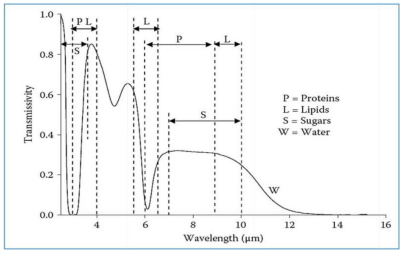
[a] Division of Food Science and Biotechnology, Kyungnam University, 449 Wolyoung-Dong, Masan 631-701, Republic of Korea
[b] Department of Animal Science, Iowa State University, Ames, IA 50011-3150, USA

Received 9 September 2004; received in revised form 22 November 2004; accepted 2 December 2004

Abstract

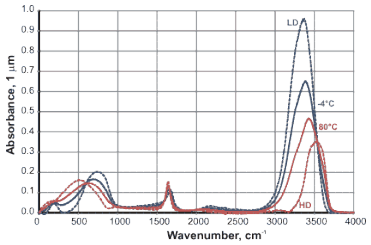
The antioxidant activities of peanut (*Arachis hypogaea* L.) hull extracts were evaluated after far-infrared (FIR) radiation or heat treatment. Peanut hulls in petri dishes were FIR-irradiated or heat-treated (150 °C) for 5, 10, 15, 20, 40 or 60 min. The water extracts (300 mg/10 mL) of peanut hulls (WEPH) were prepared and their total phenol contents (TPC), radical scavenging activity (RSA), and reducing power were determined. The antioxidant activities of WEPH increased as the time of heating or FIR-radiation increased. When peanut hulls were FIR-irradiated at 150 °C for 60 min, the values of TPC, RSA, and reducing power of WEPH increased from 72.9 to 141.6 μM, 2.34% to 48.83%, and 0.473 to 0.910, respectively, compared to the untreated controls. Heat treatment of peanut hull under the same conditions (150 °C for 60 min) also increased the TPC, RSA, and reducing power of WEPH from 72.9 to 90.3 μM, 1.90% to 23.69%, and from 0.471 to 0.718, respectively. The result indicated that FIR-radiation or heat treatment on peanut hulls increased the antioxidant activities of WEPH.

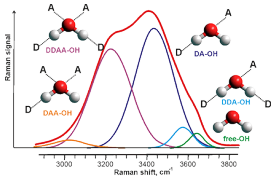
Hakko Electric Machine Works Co., Ltd., Nagano, Japan), which emitted radiation at the wavelength range from 2 to 14 um in a FIR-dryer (A-Sung Tester, Korea)

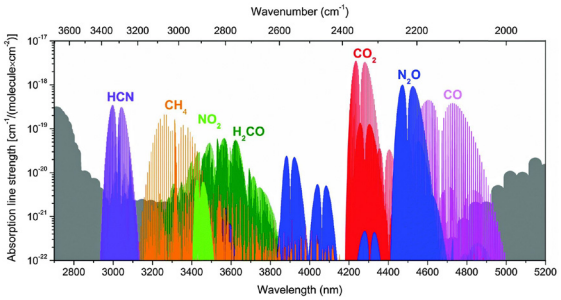


Tech Highlight | Electrothermal Applications | GRAPHENE SQUARE

Mid-IR Absorption Spectra of Water & Gas Molecules







wavelength (um)	wavenumber (cm-1)
0.5	20,000
0.75	13,333
1.00	10,000
1.25	8,000
1.50	6,667
1.75	5,714
2.00	5,000
2.25	4,444
2.50	4,000
2.75	3,636
3.00	3,333
3.25	3,077
3.50	2,857
3.75	2,667
4.00	2,500
4.25	2,353
4.50	2,222
4.75	2,105
5.00	2,000
5.25	1,905
5.50	1,818
5.75	1,739
6.00	1,667
6.25	1,600
6.50	1,538
6.75	1,481
7.00	1,429
7.25	1,379
7.50	1,333
7.75	1,290
8.00	1,250

GRAPHENE SQUARE

Transparent Rice Cooker

- For 4~5 persons
- 400 W
- Heating time = 20 min
- 133 Wh

> 40% Energy Saving

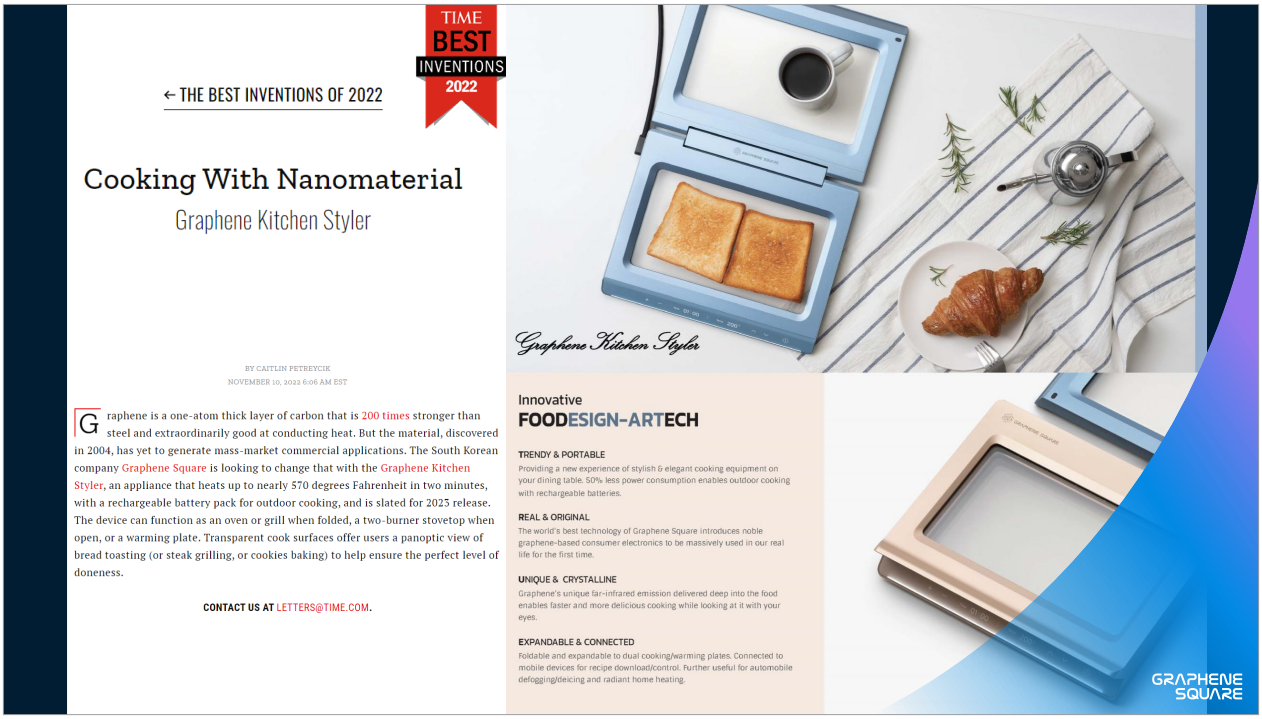
vs.

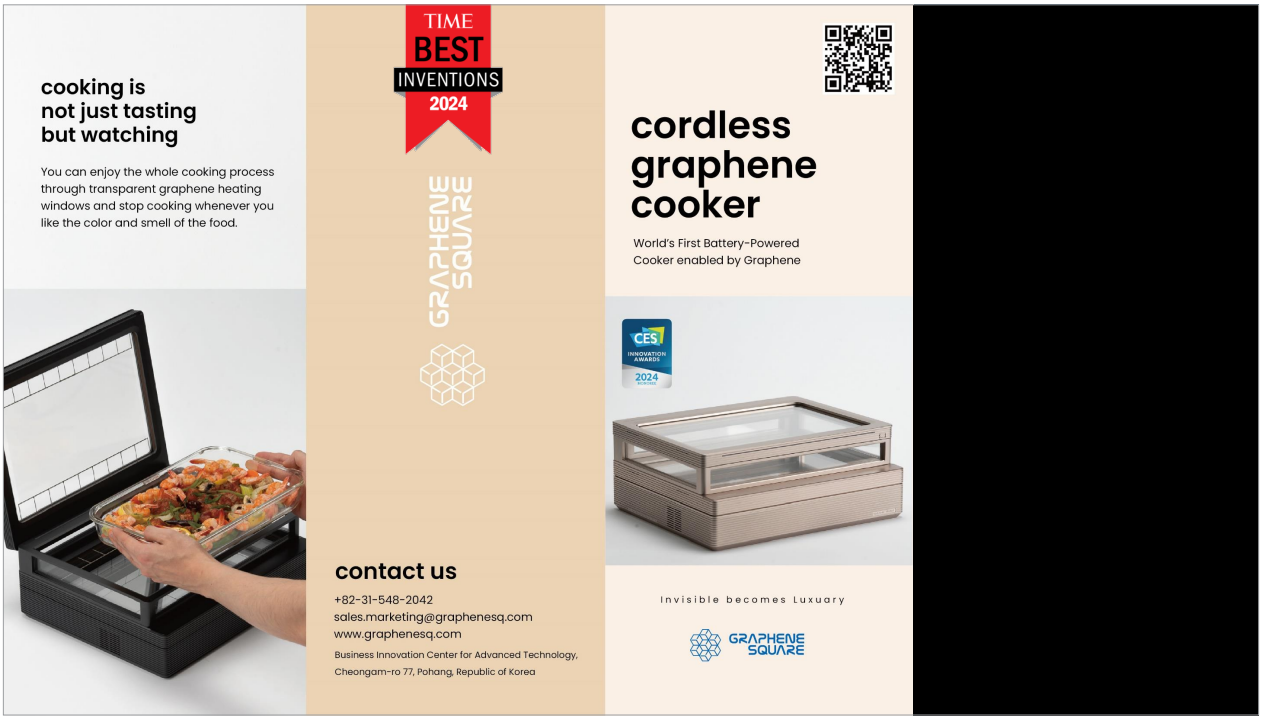
Induction Cooker

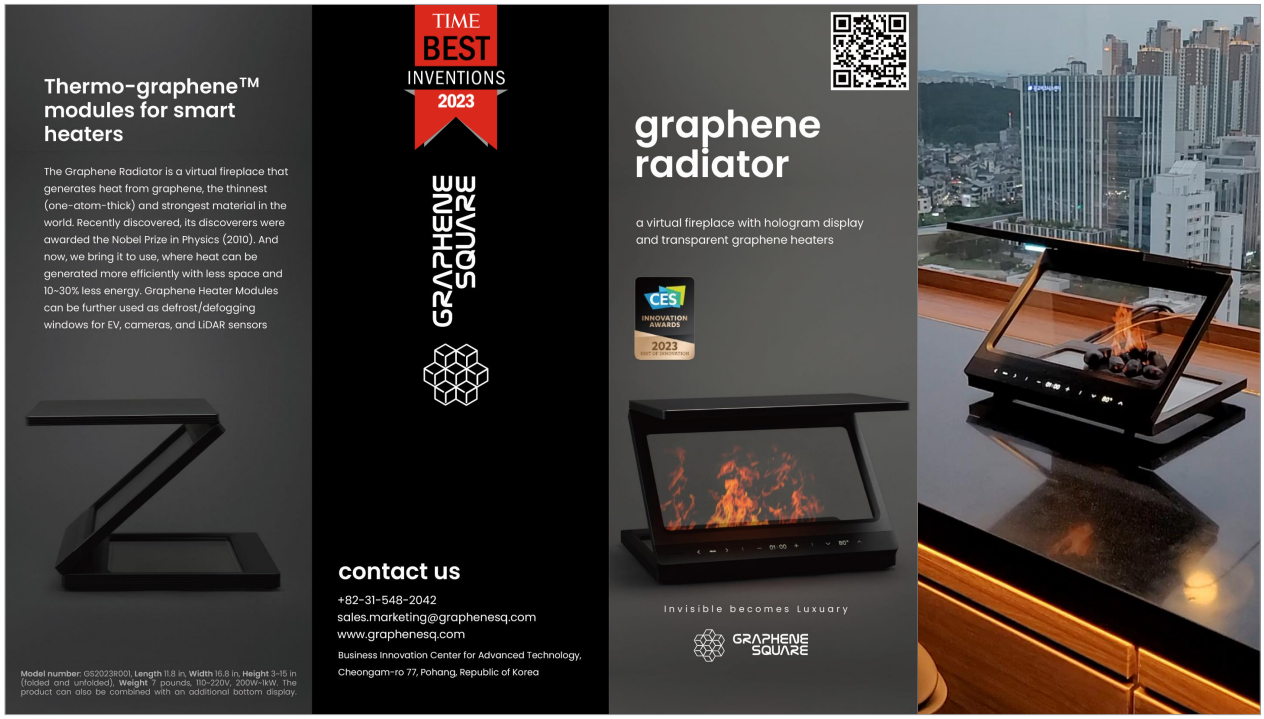
- For 6 persons
- 1000 W
- Heating time = 25~40 min
- 250 ~660 Wh

GRAPHENE FOODTECH

GRAPHENE SQUARE


← THE BEST INVENTIONS OF 2022
TIME BEST INVENTIONS 2022
Cooking With Nanomaterial
Graphene Kitchen Styler
BY CAITLIN PETREYCIK
NOVEMBER 10, 2022 6:06 AM EST
Graphene is a one-atom thick layer of carbon that is 200 times stronger than steel and extraordinarily good at conducting heat. But the material, discovered in 2004, has yet to generate mass-market commercial applications. The South Korean company Graphene Square is looking to change that with the Graphene Kitchen Styler, an appliance that heats up to nearly 570 degrees Fahrenheit in two minutes, with a rechargeable battery pack for outdoor cooking, and is slated for 2023 release. The device can function as an oven or grill when folded, a two-burner stovetop when open, or a warming plate. Transparent cook surfaces offer users a panoptic view of bread toasting (or steak grilling, or cookies baking) to help ensure the perfect level of doneness.
CONTACT US AT LETTERS@TIME.COM.
Graphene Kitchen Styler
Innovative
FOODESIGN-ARTECH
TRENDY & PORTABLE
Providing a new experience of stylish & elegant cooking equipment on your dining table. 50% less power consumption enables outdoor cooking with rechargeable batteries.
REAL & ORIGINAL
The world's best technology of Graphene Square introduces noble graphene-based consumer electronics to be massively used in our real life for the first time.
UNIQUE & CRYSTALLINE
Graphene's unique far-infrared emission delivered deep into the food enables faster and more delicious cooking while looking at it with your eyes.
EXPANDABLE & CONNECTED
Foldable and expandable to dual cooking/warming plates. Connected to mobile devices for recipe download/control. Further useful for automobile defogging/deicing and radiant home heating.
GRAPHENE SQUARE


cooking is not just tasting but watching
You can enjoy the whole cooking process through transparent graphene heating windows and stop cooking whenever you like the color and smell of the food.
TIME BEST INVENTIONS 2024
GRAPHENE SQUARE
cordless graphene cooker
World's First Battery-Powered Cooker enabled by Graphene
CES INNOVATION AWARDS 2024
contact us
+82-31-548-2042
sales.marketing@graphenesq.com
www.graphenesq.com
Business Innovation Center for Advanced Technology, Cheongam-ro 77, Pohang, Republic of Korea
Invisible becomes Luxuary
GRAPHENE SQUARE



Graphene Heat Dissipation

Based on high thermal conductivity and excellent mechanical properties, a key item in the heat dissipation market

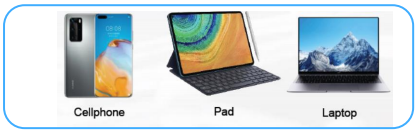
■ Unmet Need

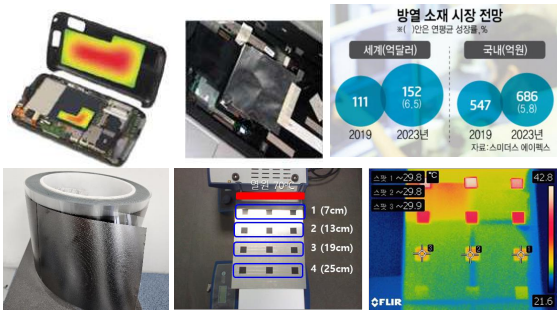
- Need to solve the problem of heat generation, which is directly related to the decline in the quality and lifespan of electronic devices
- the development of better heat dissipation materials is required as the electronic devices become nanoscale and integrated

■ Status and Plan

Research of graphene heat dissipation film, securing intermediate materials and raw materials	Complete ('23 Q1)
Service project to develop a heat dissipation cable for charging electric vehicles (Company G)	Complete ('23 Q3)
Joint research with Company L / Company S → heat dissipation film for laptop and TV display applications	Underway ('24 Q2)
Establishment of mass production facilities for graphene heat dissipation film	'26 Q4
Securing demand companies and producing/supplying heat dissipation films	'27 Q1~

Applications





Cathode/Anode Composite in Batteries

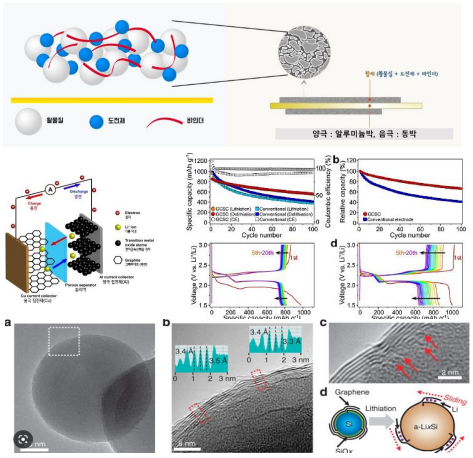
Energy density of batteries can be improved due to large specific surface area and high conductivity

Unmet Need

- High capacity and fast charging can be developed through the development of an anode composite using highly conductive graphene.
- (Core-Silicon, Shell-Graphene) composite structure can improve electrical conductivity, reduce silicon fracture (breakage), and suppress electrolyte side reactions.

Status and Plan

High-speed dry graphene flake production process development and facilities	Complete ('22 Q2)
Discussed research and development of batteries using graphene with company L and Company P	Complete ('23 Q2)
Research and development of high-capacity secondary battery anode composite using graphene	Complete ('23 Q4)
Prototype production, performance evaluation, stability evaluation	Underway ('25 Q4)
Conduct follow-up research, revise feedback, and discuss production with customers	'26 Q1~



4. Vision | 01. Pohang Graphene Valley

GRAPHENE SQUARE

Robust **collaborative infrastructure** for **rapid growth**

Pohang Graphene Valley

Building infrastructure for rapid mass production with R&D through research infrastructure for industry-academia collaboration led by local governments

Pohang Graphene Valley

The biggest graphene research infrastructure for industry-academia collaboration in Korea

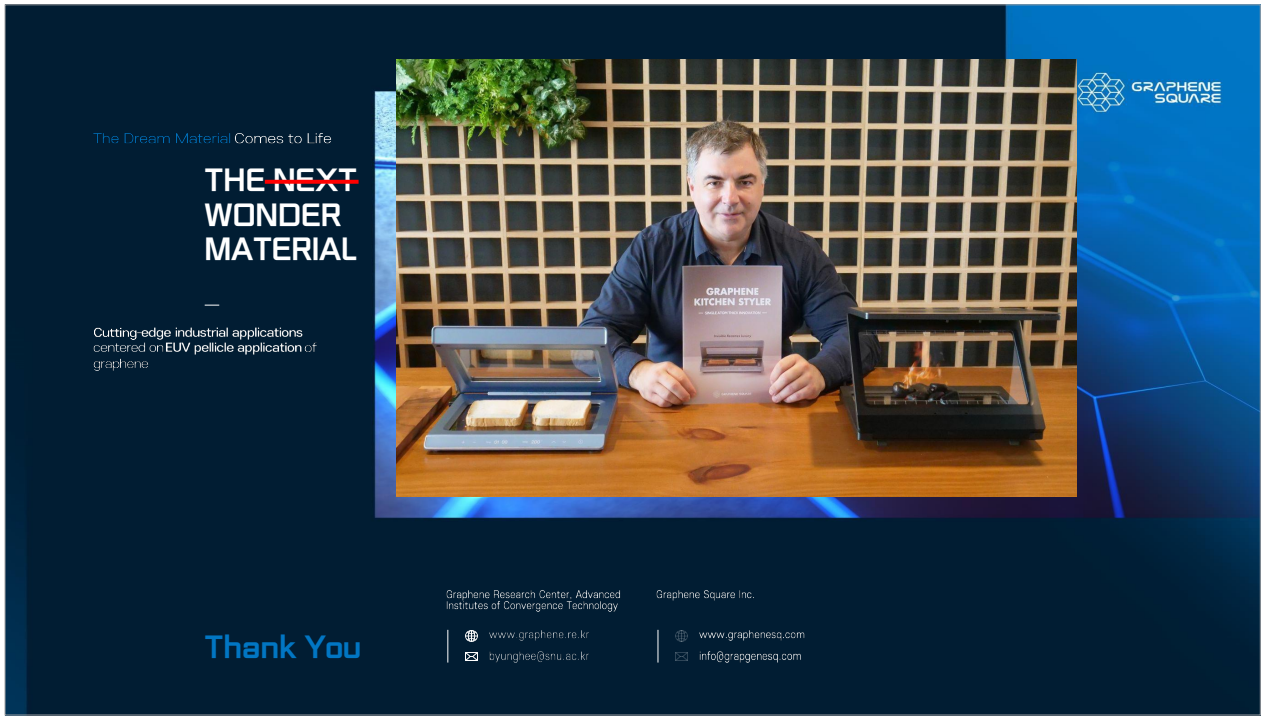
- **Graphene Square Inc.** — Building a graphene mass production system based on roll-to-roll continuous synthesis
- **POSCO** — Support for building graphene material/application mass production facilities
- **Pohang City** — - Building a special zone for graphene - Attracting materials and applied technology companies
- **Research Institute of Industrial Science & Technology (RIST)** — - Developing graphene mass production technology - Support for building mass production facilities
- **Pohang University of Science and Technology (POSTECH)** — - Support for graphene research and development
- **National Institute for Nanomaterials Technology (NINT)** — Pursuing international standardization of applied graphene products and function analysis of the material
- **Pohang Accelerator Laboratory (PAL)** — Product and materials analysis supported using synchrotron

Tech collaboration network

The future market is created in collaboration with the core participants of the graphene industry

Object of collaboration	Contents of collaboration	Projected effects	Current status
RIST	Wastewater processing technology / copper recovery technology	Cost reduction, environmental improvement	Technological development complete
Seoul National University	Graphene application	Improving in-house technological capabilities	Joint national projects underway
Company A	Mobility applications (LiDAR, defrosting, etc.)	Entry into the field of mobility	Technological development underway
Company B	Diagnosis sensor (detailed specifications developed and determined)	Accelerating mass production	Technology developed (Ready for mass production)


4. Future Directions
01. Graphene Valley
GRAPHENE SQUARE 31
Industrial Production Factory in Pohang
33,000 m² Factory Site in Pohang
1st Factory (6,600 m²)
Investment from Samsung
+ α (60M USD) in 3 years
Today


The Dream Material Comes to Life
THE NEXT
WONDER
MATERIAL
Cutting-edge industrial applications centered on EUV pellicle application of graphene
GRAPHENE KITCHEN STYLER
GRAPHENE SQUARE
Thank You
Graphene Research Center, Advanced Institutes of Convergence Technology
www.graphene.re.kr
byunghee@snu.ac.kr
Graphene Square Inc.
www.graphenesq.com
info@grapgenesq.com

ITIF-KAIST Forum 2025
on National Strategic Technology & Innovation

Session II / 2부 **Key Technology Areas for U.S.-ROK Cooperation**
한·미 과학 기술협력: 주요 세부 기술 분야

Topic Presentation III / 발제 3

AI 반도체의 현재와 미래

The Present and Future of AI Semiconductors

유회준
KAIST 인공지능반도체대학원장

Hoi-Jun Yoo
Director, Graduate School of AI Semiconductor, KAIST

Contents

1. 인공지능 반도체 국제 정세 및 경쟁력 확보
2. 대한민국 인공지능 반도체 기업 현황
3. 대한민국 인공지능 반도체 경쟁력 확보 정책
4. 인공지능 반도체의 미래

Contents

치열한 세계 AI 전쟁

한국 반도체 산업의 지속적 우위 유지 전략

❑ 세계 최고의 반도체 산업을 **AI반도체**로 전환 및 지속성 확보 ➔ **글로벌 경쟁력 강화**

- 세계 최대의 산업 ➔ **세계최고의 R&D 및 인력양성 시스템 구축**
- 미국, 일본 등의 선진국 모델과 차별화된 한국 고유의 반도체 전략 수립
- AI 반도체(PIM 등)로 최고의 메모리 산업을 IC 산업으로 전환
- 대기업의 후방(인력양성), 전방(R&D, IP), 측면(중소기업)의 종합 지원 전략

AISG AIPIM 5/27

대한민국의 경쟁력 강화 요소

01 반도체 제조 강국 — 세계 최고 반도체 인프라

세계최고 메모리 반도체 / 세계 2위 파운드리 역량 / 우수한 고급인재 축적 ➔ 세계1위 메모리 역량 → 신기술 선점 ← 초미세 공정 활용

02 AI기반 제조 + 서비스 수요 — 대규모 소유 기업 보유

AI 제조 (스마트폰, 자동차, 가전) ⊕ AI 인프라&서비스 (클라우드, 포털, 통신)

03 혁신성장 전략투자 — 민,관의 전략투자 확대

민간
- ▶ 자체 연구개발 가속화
- ▶ 독자 기술력을 보유한 펩리스 스타트업 등장

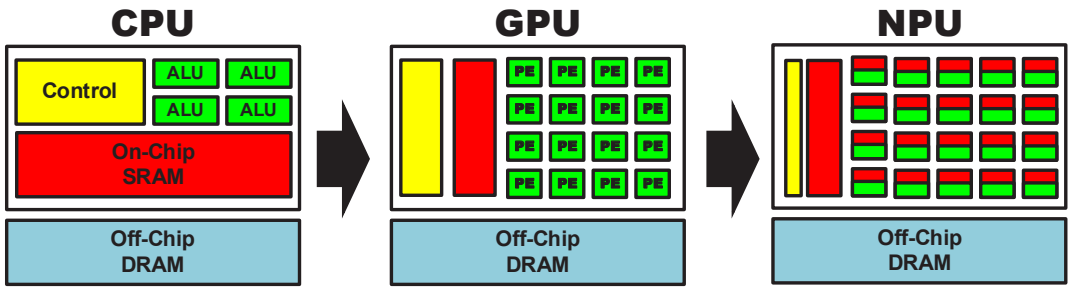
정부
- ▶ 혁신 과제 추진 (AI 반도체)
- ▶ 대형 국가 R&D 투자 및 금융 지원

AISG AIPIM 6/27

Contents

대한민국 AI 반도체 기업 현황

DNN 프로세서의 진화



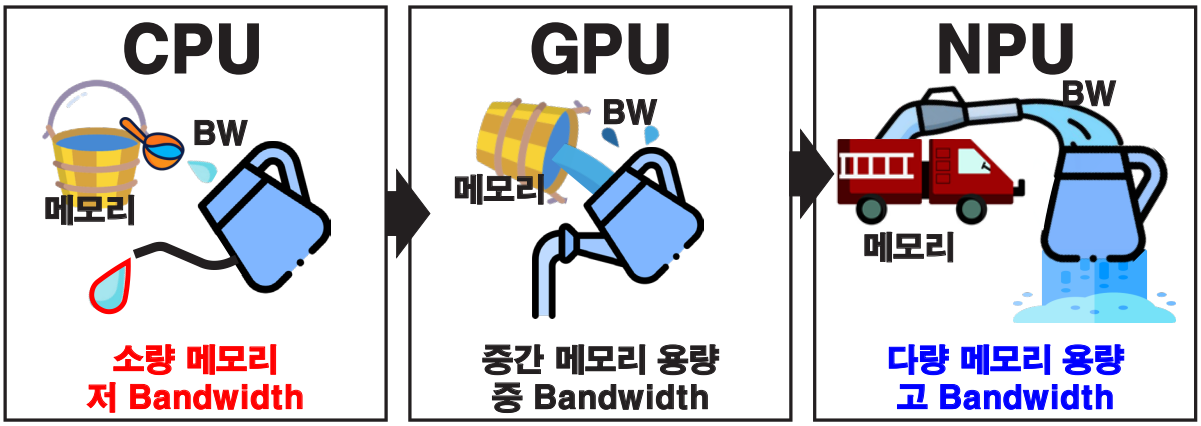
- <10 Processing Cores
- General Purpose HW
- SW-Programmable

- ~1K FP Processors
- Opt. for Matrix Calculation
- CUDA Programming

- <10K Integer Processors
- Optimized for DNN
- High Energy Efficiency

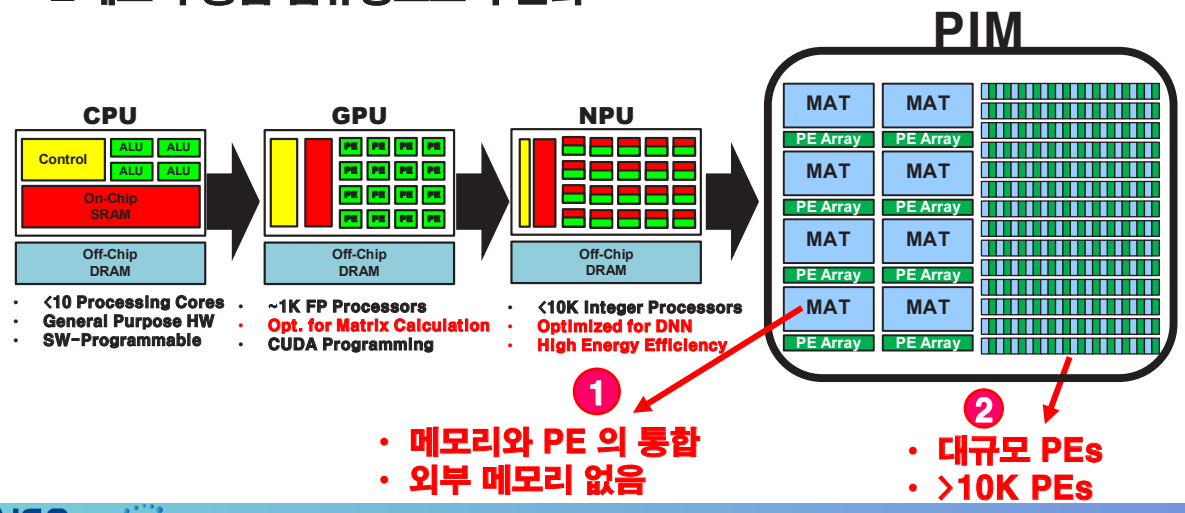
DNN 프로세서의 발전

❑데이터 처리 속도 : CPU << GPU <<< NPU

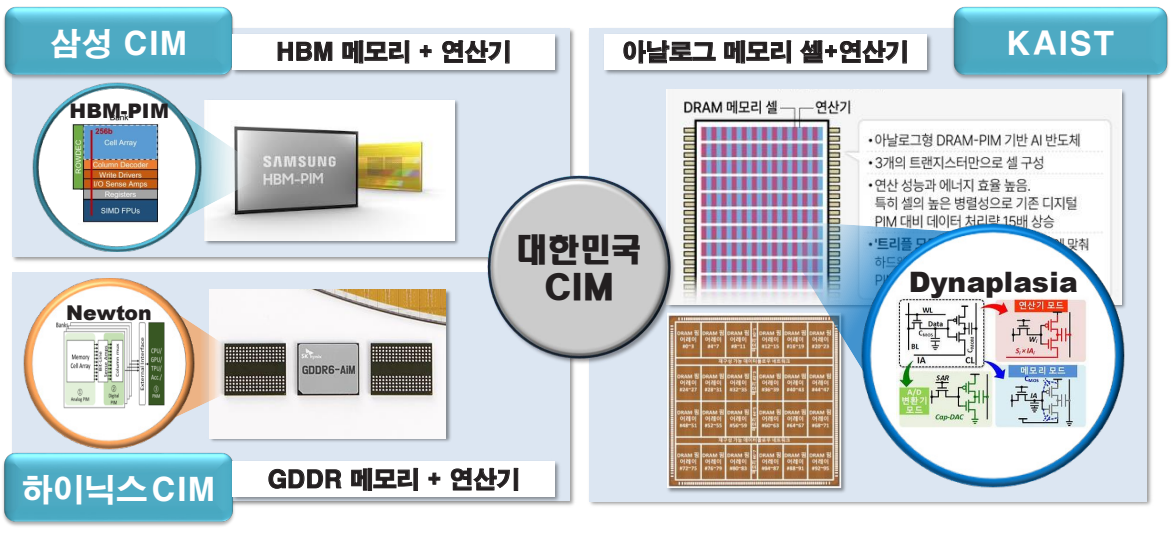


NPU에서 PIM으로

❑ 메모리 중심 컴퓨팅으로의 진화



대한민국 CIM 개발 현황



Contents

AI 반도체 이니셔티브

❑ AI-반도체 이니셔티브, 인공지능 G3 도약

– 2024년 4월 25일, AI-반도체 이니셔티브 안건 심의 및 의결

– AI 반도체 9대 기술혁신 과제 ➔ K-반도체 새로운 신화 창조

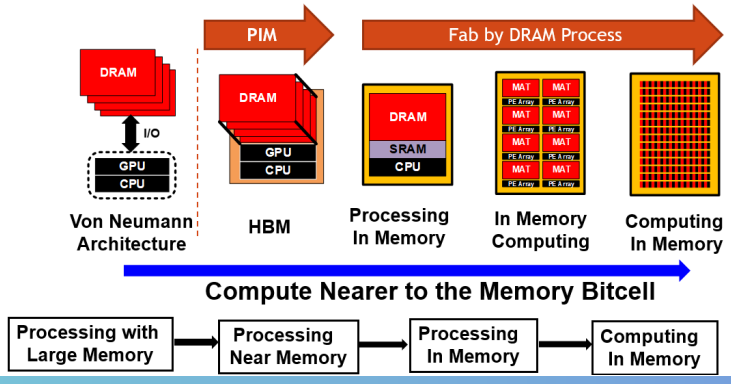
AI 반도체 이니셔티브 – AI 반도체 개발

❑ AI 반도체 개발을 통한 초격차 · 신격차

– Processing in Memory(PIM)을 통한 메모리 혁신

– 저전력 K-AP 등 한국형 AI 프로세서

1) 뉴로모픽 프로세서 2) 한국형 NPU 스케일업 3) 고정밀 연산용 슈퍼컴 가속기 개발 등



AI 반도체 이니셔티브 – HW/SW 공동 연구

❑ AI 반도체 HW · SW 기술 생태계

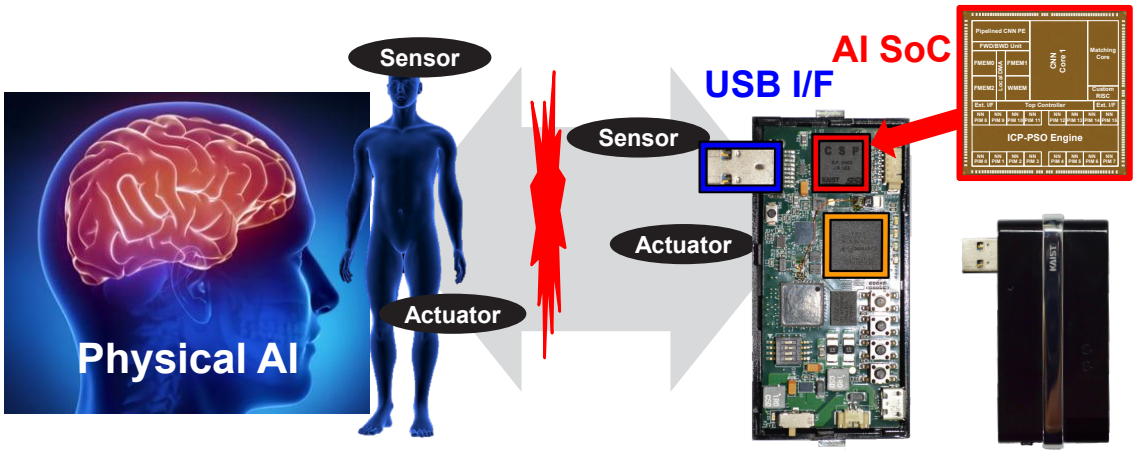
– K-클라우드 2.0 : AI 반도체 고도화와 연계하여, HW·SW 풀스택 핵심 기술 개발

– AI 일상화 주요 분야 중심의 공공수요 창출로 대규모 시장수요 확보

Contents

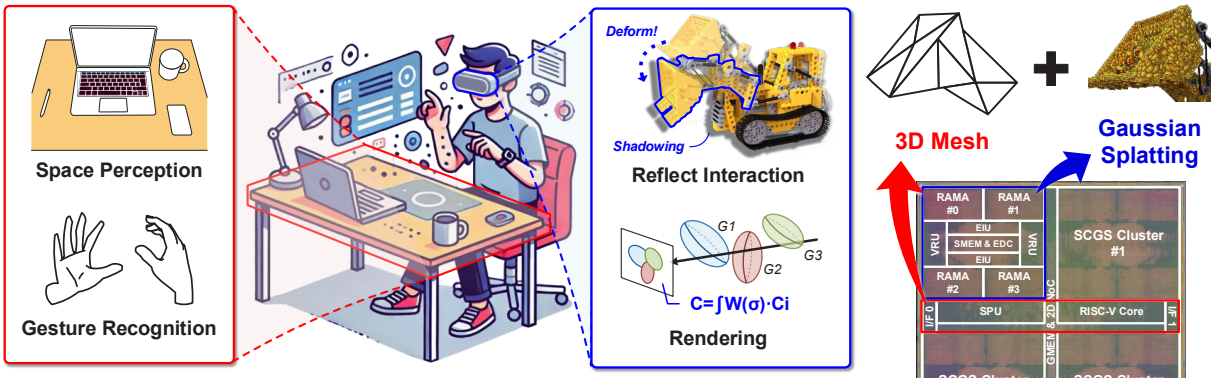
Generative → Physical & Social AI

❑ 동작을 수행하고 감정적 교류가 가능한 AI 시스템



2025 IRIS: 공간 컴퓨팅 SoC

❑모바일 기기를 위한 실시간 고 에너지 효율 인터렉티브 렌더링 SoC



< Mobile Spatial Computing >

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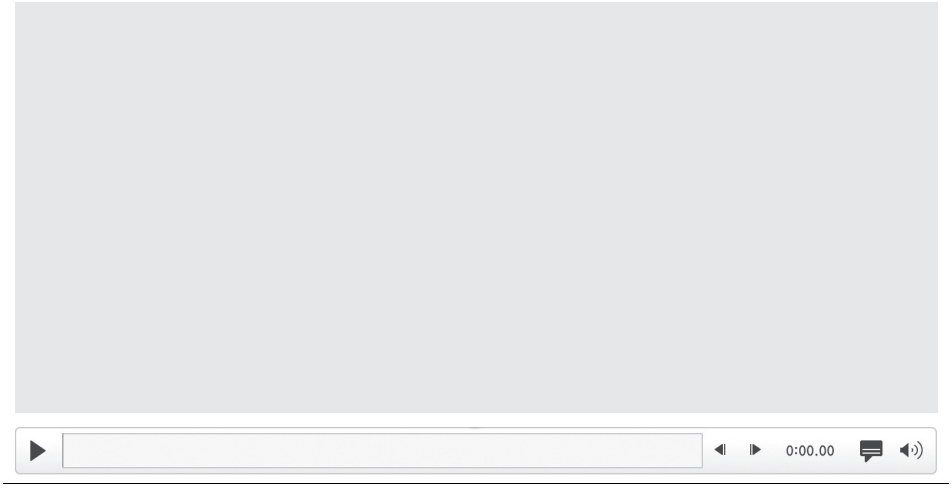
2025 IRIS: Demonstration Video



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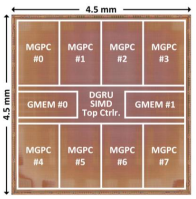
2025 EdgeDiff: 이미지 생성 프로세서

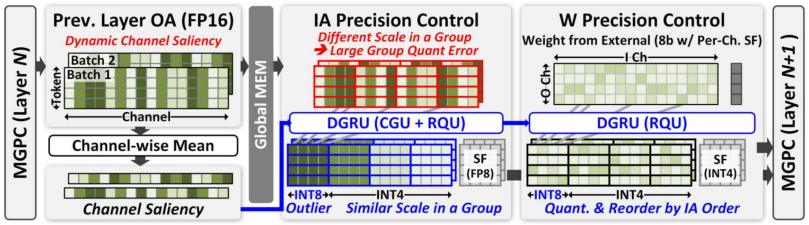
❑모바일 기기를 위한 멀티모달 Few-Step 이미지 생성 지원

멀티 모달리티를
포함한 이미지 생성

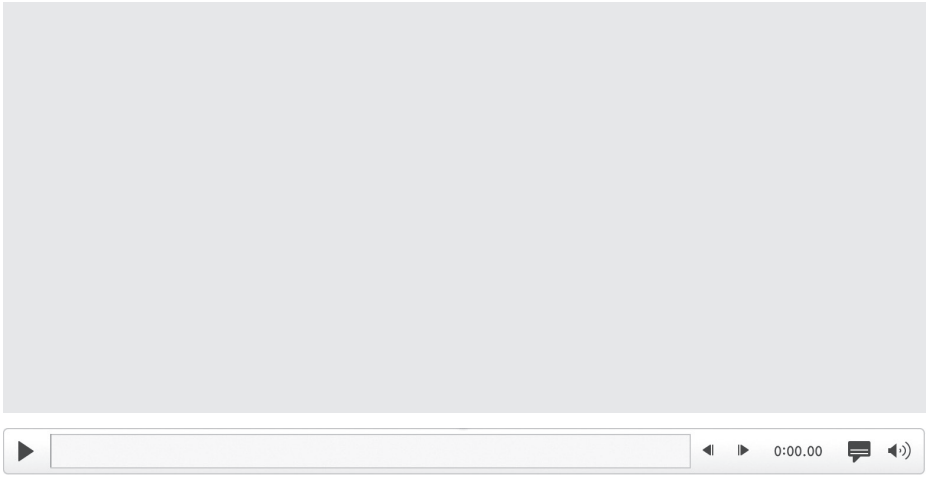


Chip
Photo

Group Quant +
Mixed Precision



2025 EdgeDiff: Demonstration Video

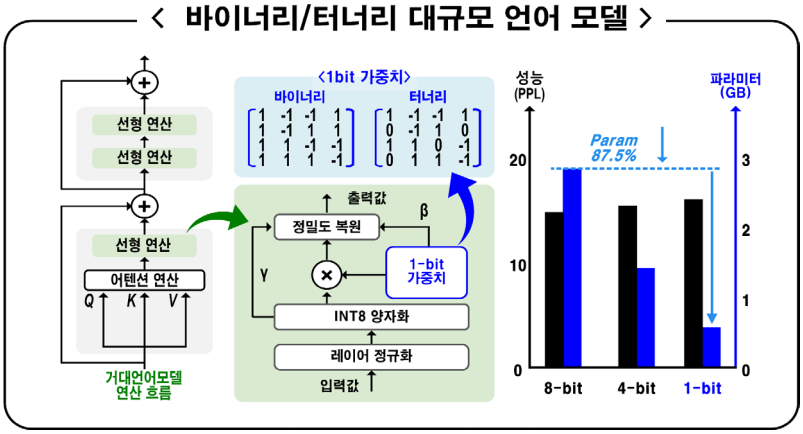


2025 Slim-Llama: 초저전력 LLM

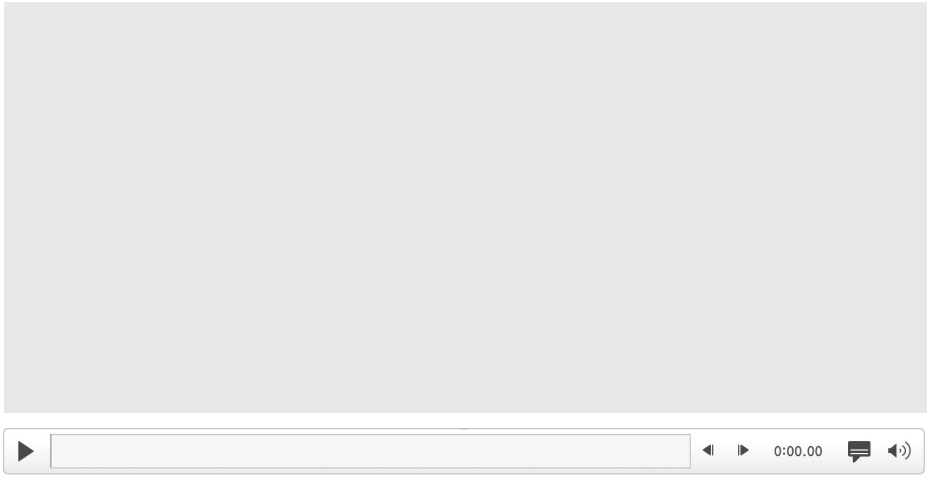
❑ Binary/Ternary Weight 기반의 최초 **초저전력 LLM 프로세서**

❑기존 대비 에너지 소모 87.5% 절감 4.69mW로 실시간 Llama 구동에 성공

< 바이너리/터너리 대규모 언어 모델 >



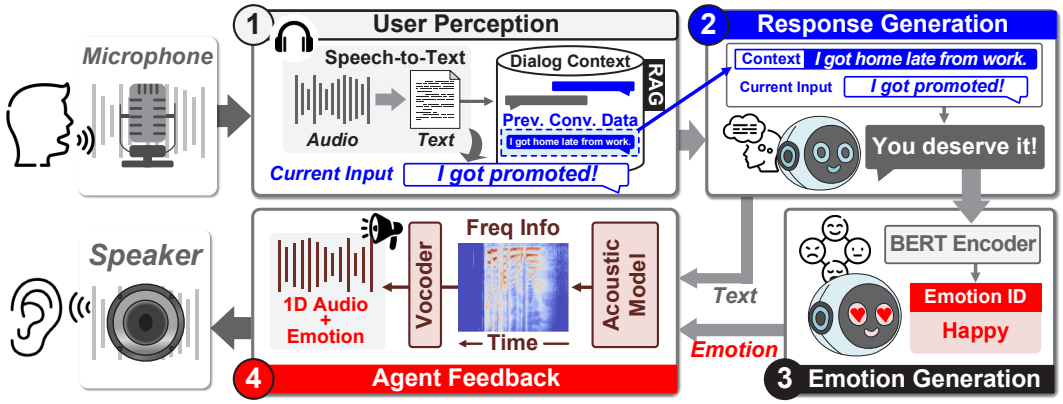
2025 Slim-Llama: Demonstration Video



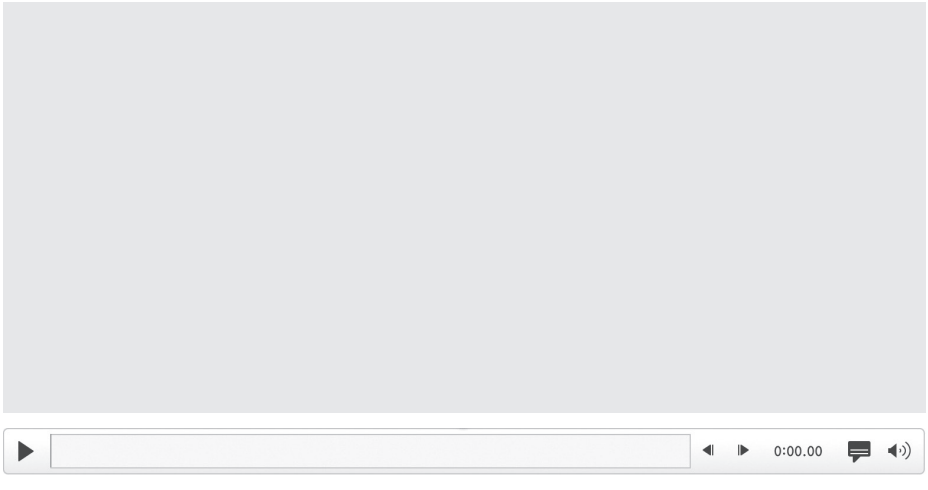
2025 BROCA: 모바일 소셜 에이전트 SoC

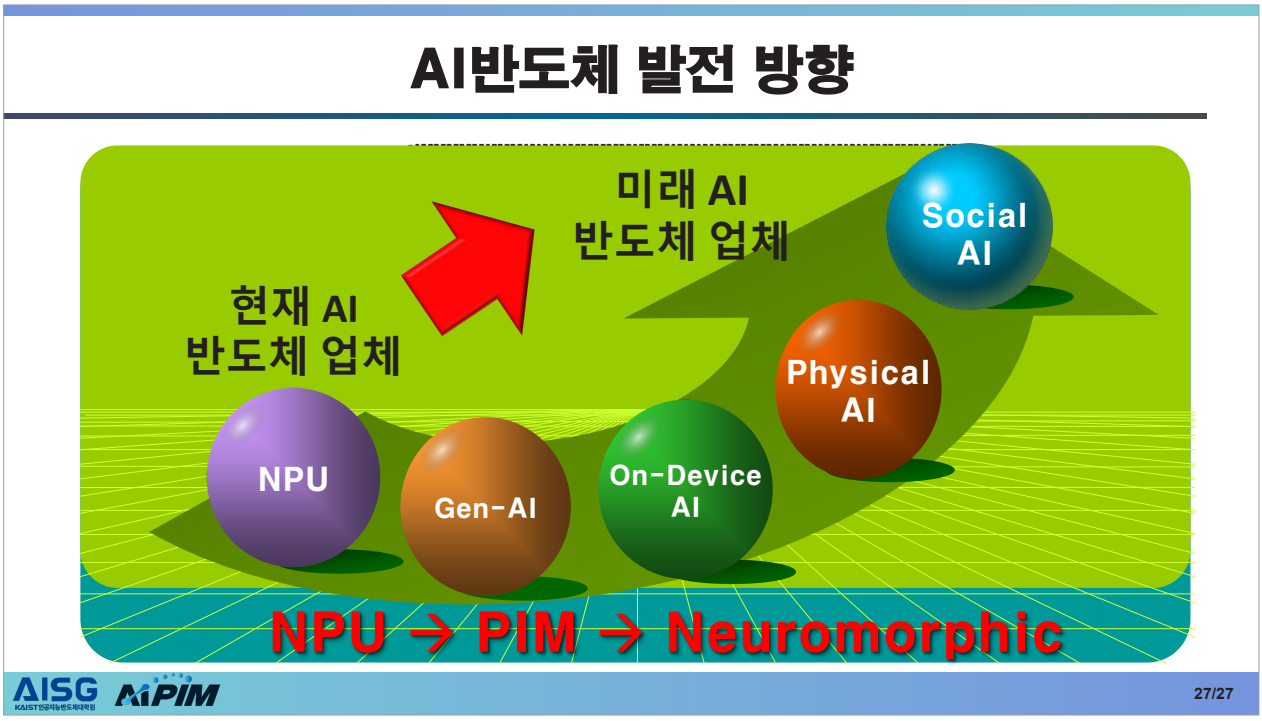
❑ 저전력, 저지연 모바일 대화형 소셜 AI SoC

– 적절한 감정을 담은 공감적인 음성 응답 생성



2025 BROCA: Demonstration Video




AI반도체 발전 방향
미래 AI
반도체 업체
현재 AI
반도체 업체
Social
AI
Physical
AI
NPU
Gen-AI
On-Device
AI
NPU → PIM → Neuromorphic
AISG
PIM
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28/27

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