Gwangju Institute of Science and Technology

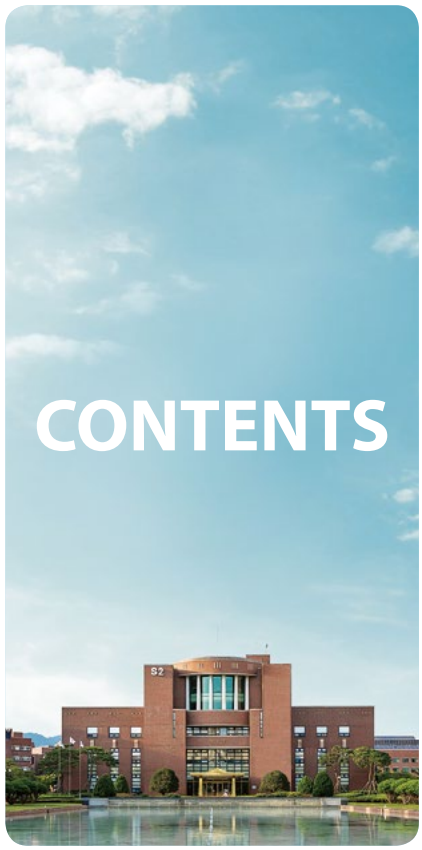
2021 ANNUAL R&D REPORT

True satisfaction is knowing
that your research at GIST will
make a world of difference

Gwangju Institute of
Science and Technology

Gwangju Institute of Science and Technology

The credle of creative science and future technology



CONTENTS

“

The promise to be the best
is the promise of GIST for the future of
our society and mankind

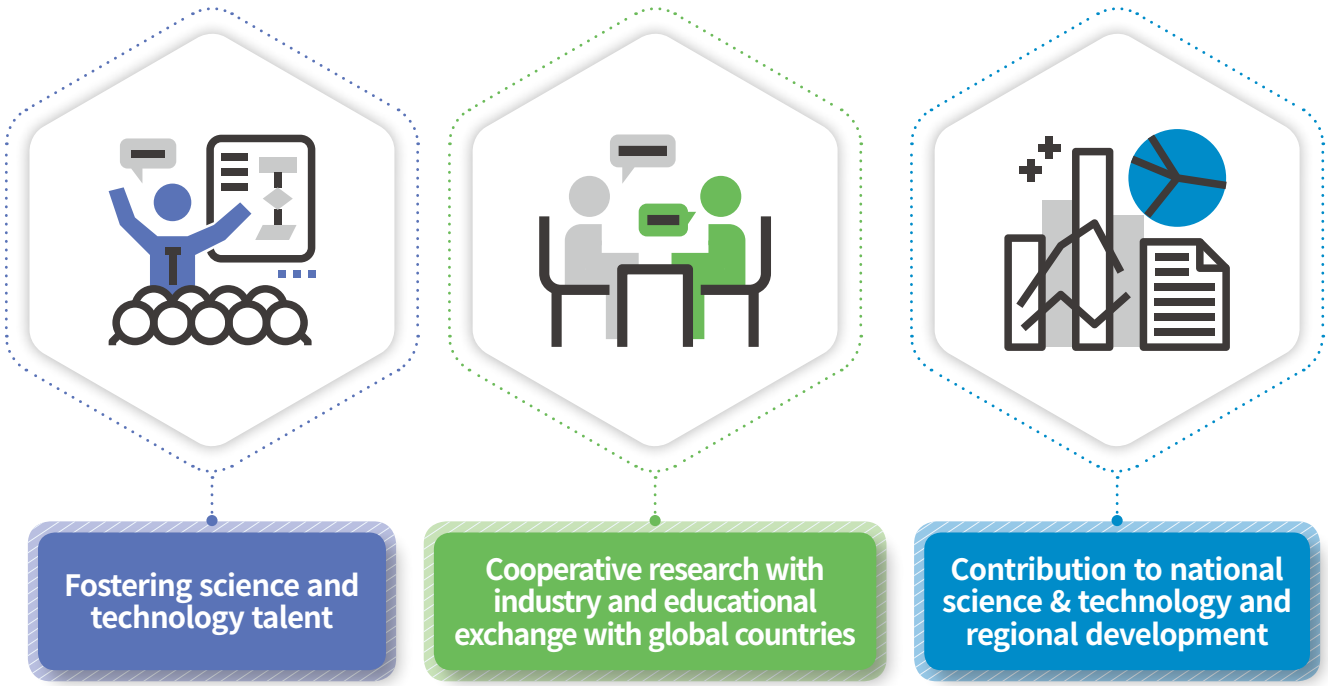
”

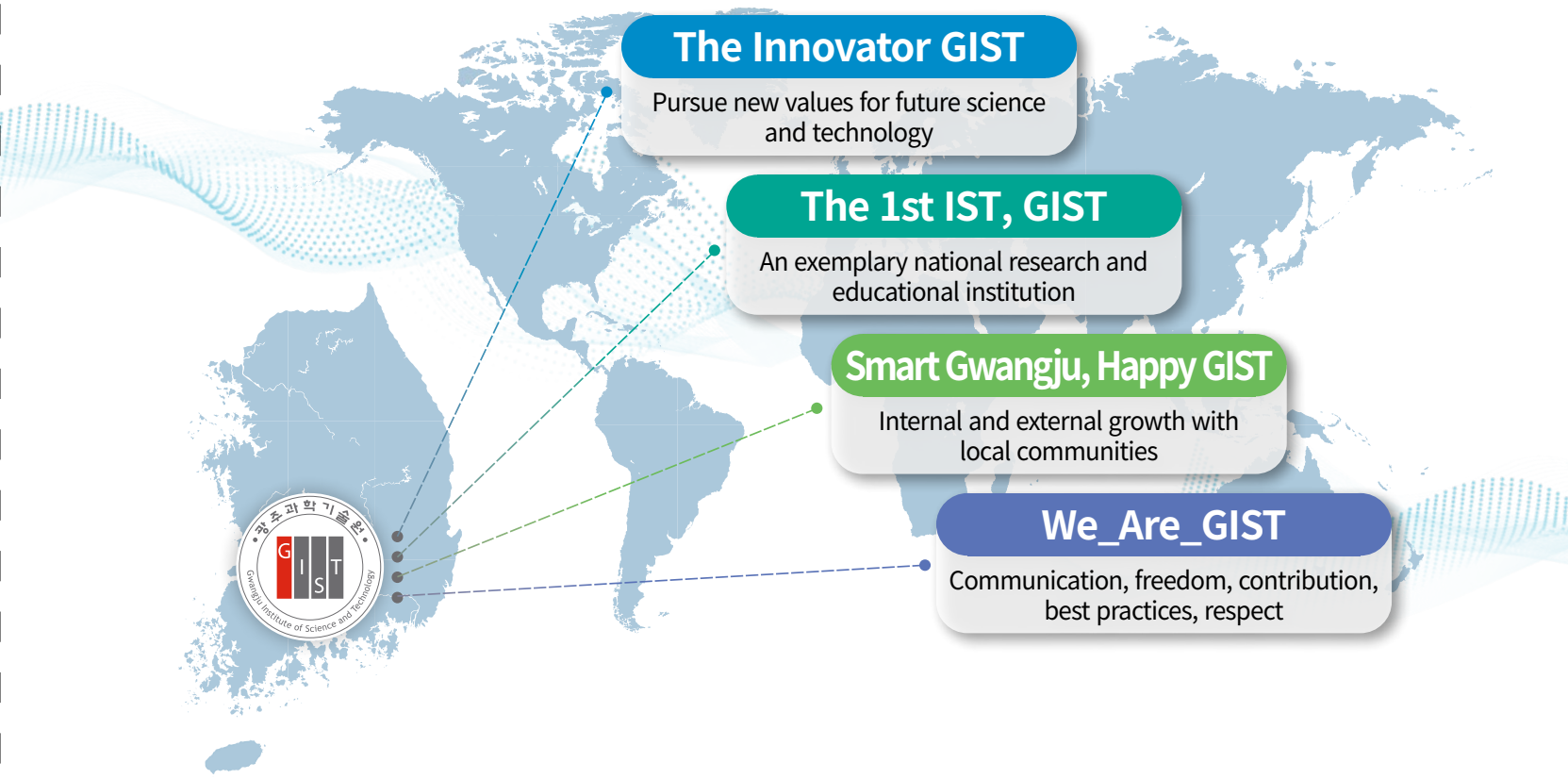
GIST

Gwangju Institute of Science and Technology

GIST Vision

GIST is Key


Fostering science and technology talent
Cooperative research with industry and educational exchange with global countries
Contribution to national science & technology and regional development


The Innovator GIST
Pursue new values for future science and technology
The 1st IST, GIST
An exemplary national research and educational institution
Smart Gwangju, Happy GIST
Internal and external growth with local communities
We_Are_GIST
Communication, freedom, contribution, best practices, respect

Main Achievements

2021 QS World University Rankings
for citations per Faculty

4th in the world

1th in Korea
(for 12 consecutive years)

2021 QS
Top 50 Under 50

30th in the world

3rd in Korea

2020 THE
Young University Rankings

68th in the world

4th in Korea

Edcation — Utilizing the University Education Innovation System

- **Infinite Challenge Project_** Supports independent student-led projects → Training specialists for 4th Industrial Revolution
- **Major Concept Creation_** Students organize their own courses to design their own major program
- **Education Innovation Center_** Develops teaching methods to improve the quality of education lectures

Start -ups — Promoting Start-up Technologies

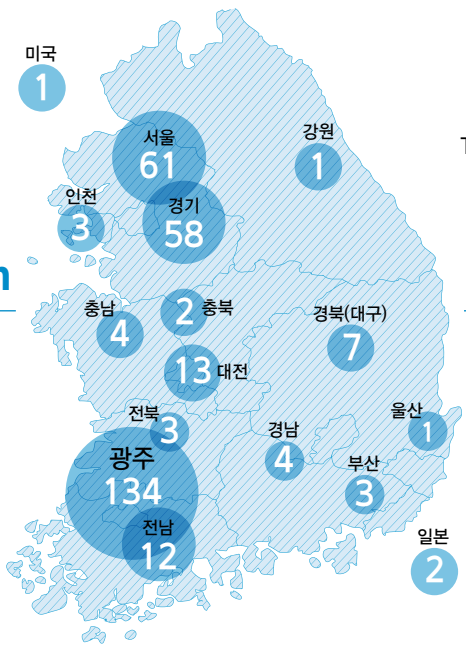
- Conducts various programs and activities to support student start-ups
- Operates student entrepreneur exchange program with Technion-Israel Institute of Technology
- Ranked 1st in the 2020 Best Universities for Start-ups in Korea(Maeil Business newspaper)

Research — Research Innovation: International Exchanges

- AI education and research cooperation with the Massachusetts Institute of Technology
- Young Scientists' Building(YSB): Providing accommodations to support post-doctoral researchers to grow into independent researchers

Technology commercialization

Technology transfer performance (cumulative)
2021.5.1. standard



Total number of technology transfer contracts
336cases

Number of technology transfers to Gwangju and Jeonnam, Jeonbuk
149cases

Total technology transfer income (cumulative)
20.1billion

Total technology transfer contract (cumulative)
51.4billion

GIST Research Institute

Advanced Photonics Research institute — APRI

- Established in 2001, to develop science and technology by focusing on outstanding R&D in photonics and photonic technologies and fostering photonics experts
- Built on the world's best research facilities that includes a 4.2 PW laser system, conduct basic studies on laserplasma interactions, elec trons, par ticle acceleration, x-ray generation, femtosecond laser spectroscopy, and THz optics

Research Insitute for Solar and Sustainable Energies — RISE

- Established in 2009 to secure original technologies for new and renewable energies and to promote their commercialization
- Respond to climate change, future energy crisis and environmental problems, carry out R&D activities and convergence study for next-gen smart energy community including next-gen solar cells, energy storage/operation system as essential technologies for the future

Korea Culture Technology Institute — KCTI

- Established in 2013
- To conduct research and development activities on combined technologies with cultural industries based on interdisciplinary exchange and convergence among science and technology, design, culture and arts, humanities and social sciences in accordance with article 17-5 (Designation, etc. of Supervising Institute for Research of Cultural Technology) of the Framework Act on the Promotion of Cultural Industries

Integrated Institute of Biomedical Research — IIBR

- Established in 2013 under the name of Life Aging Convergence Research Institute, expanded and reorganized into Aging Research Institute in 2015 and renamed as Integrated Institute of Biomedical Research in 2020
- Understanding the nature of life phenomena and promoting human welfare through multidisciplinary convergence research in the field of biomedical science, developing proprietary technologies for prevention/diagnosis and overcoming and promoting quality of life through multidisciplinary convergence technologies

International Environmental Research Institute — IERI

- Established in 2001 as a UN University Institute at GIST
- IERI has conducted multiple joint international environmental studies to foster environmental experts, support the development of technologies to tackle challenges of climate change at home and abroad, and contributed to the improvement of the global environment and human well-being

GIST Institute for Artificial Intelligence — GIAI

- Established in 2017 to serve as a leading research institute in future AI R&D efforts
- GIAI leads global R&D in the era of 4th Industrial Revolution and aims to solve various social issues based on AI research and drive innovative growth of Korea and local communities by successfully completing the 'creation of an AI-based industrial convergence complex (national agenda for local communities)'

GIST Technology Institute — GTI

- Established in 2005, GIST Technology Institute supports IPRs and R&D for commercialization of promising technologies owned by GIST, technology transfer and commercialization, and serves as a hub for startups to contribute to the national economy and industrial development by spreading GIST research outcomes.

Technology Commercialization Center | GIST Business Incubator | Business Support Center

Center for Relativistic Laser Science — CoReLS

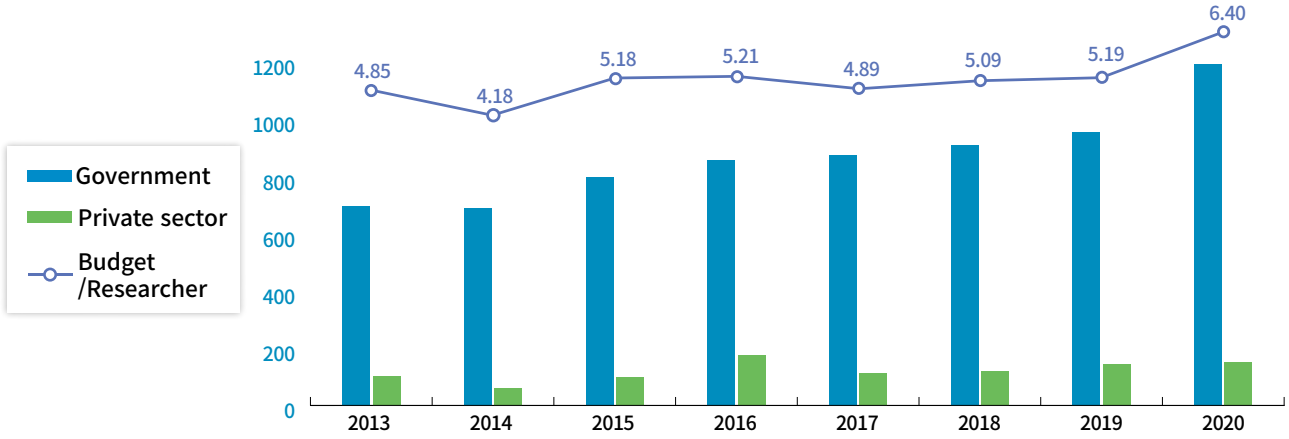
- Established 2012, Center for Relativistic Laser Science (CoReLS) of IBS has studied femtosecond PW laser technologies, relativistic laser-material interaction, physical symptoms transcending in time and space
- In 2016, CoReLS developed a 4PW laser system for the first time in the world, resulting in remarkable progress in research, including high-energy particle acceleration of electrons and photons, and attosecond atom and molecule kinetics

R&D Budget and Projects

R&D Budget and Projects

GIST is conducting inclusive R&D with the people and local communities to lay the foundation for job creation by conducting research on solving social problems to improve the quality of life for the people.

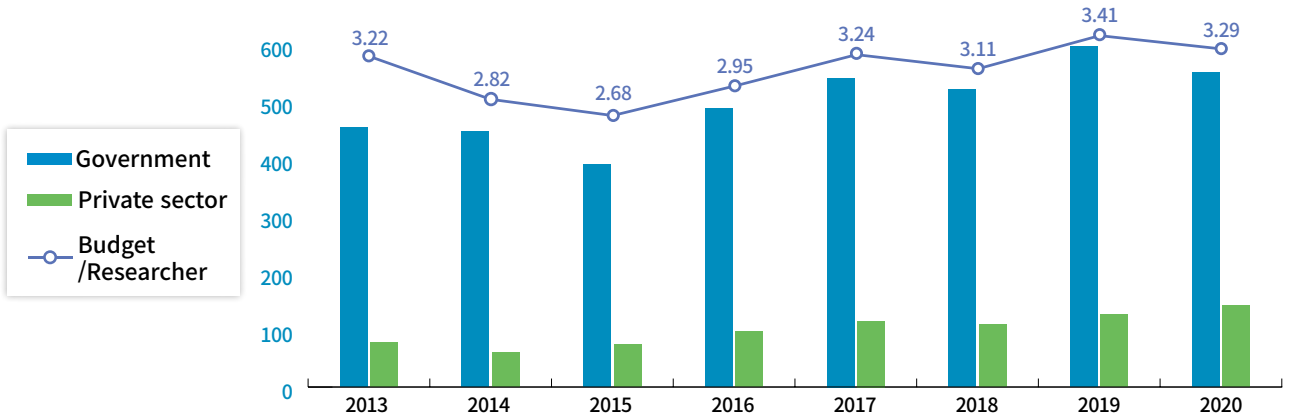
Trend of recent research budget (2013~2020)



(Unit: 100 million won)

Year	2013	2014	2015	2016	2017	2018	2019	2020
Government	701	692	802	860	878	913	959	1198
Private sector	104	61	99	177	115	120	147	152
Budget/Researcher	4.85	4.18	5.18	5.21	4.89	5.09	5.19	6.4

Trend of recent research project (2013~2020)

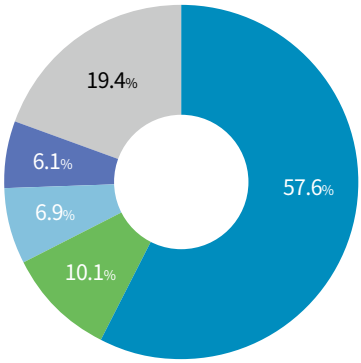


(Unit: No. of research projects)

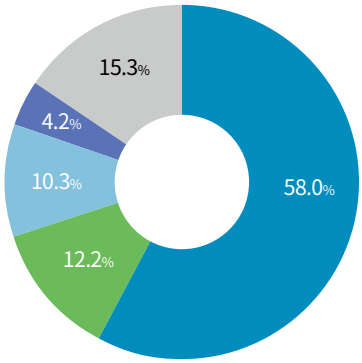
Year	2013	2014	2015	2016	2017	2018	2019	2020
Government	456	448	391	489	542	522	598	552
Private sector	78	60	75	98	116	110	128	143
Budget/Researcher	3.22	2.82	2.68	2.95	3.24	3.11	3.41	3.29

Trend of composition ratio by ministry

2016 composition ratio by ministry (Budget)

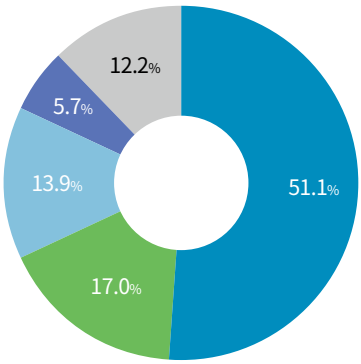


2020 composition ratio by ministry (Budget)

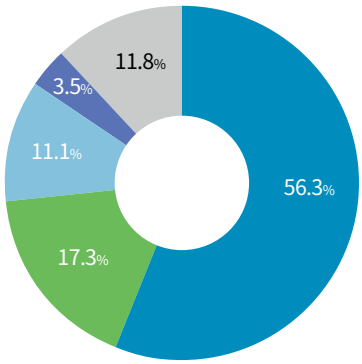


Ministry of Sci. and ICT
Ministry of Trade, Industry and Energy
Ministry of Education
Ministry of Environment
Others

2016 composition ratio by ministry (No. of project)



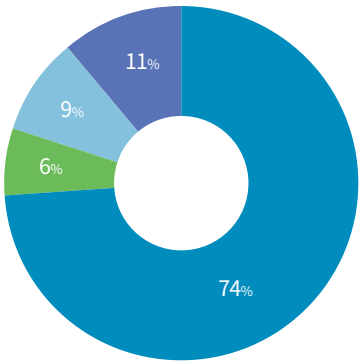
2020 composition ratio by ministry (No. of project)



Ministry of Sci. and ICT
Ministry of Trade, Industry and Energy
Ministry of Education
Ministry of Environment
Others

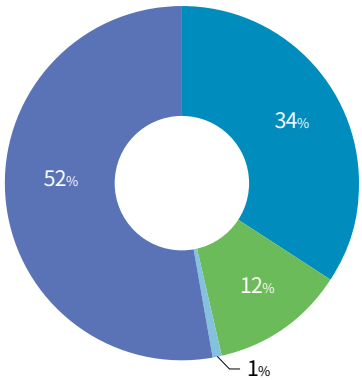
R&D Step and cycle status for last 5 years (2016~2020)

R&D step ratio (2016~2020)



Basic Research
Applied Research
Developmental Research
Others

R&D cycle ratio (2016~2020)



Introduction Phase
Growing Phase
Maturity Phase
Others

*출처 : http://www.ntis.go.kr(국가과학기술정보서비스)

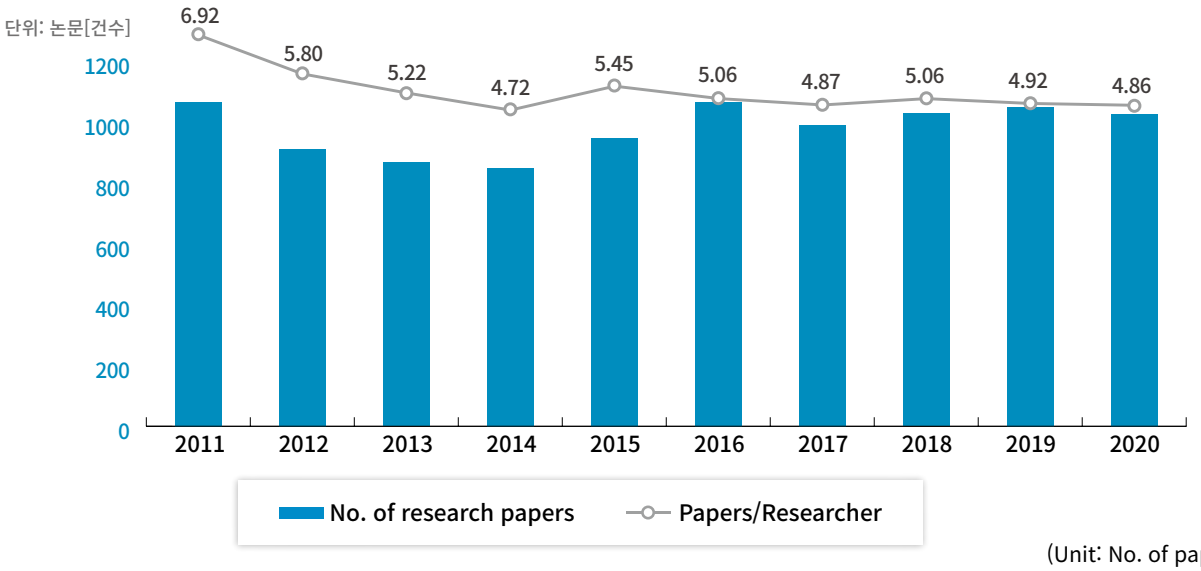
R&D Categories for last 5 years (2016~2020, Based on Research project)

* 출처 : http://www.ntis.go.kr(국가과학기술정보서비스)

Research Performance

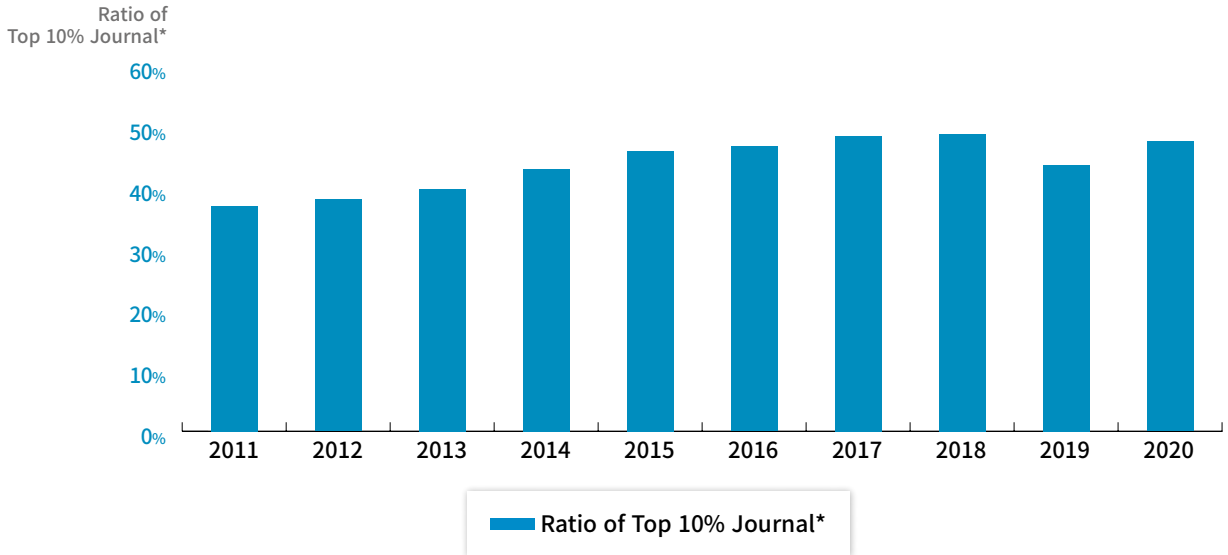
Research Performance

Trend of Scholarly Output (Research Paper)



(Unit: No. of papers)

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
No. of research papers	1,066	911	867	849	948	1006	989	1,028	1,049	1,025
Papers/Researcher	6.92	5.8	5.22	4.72	5.45	5.06	4.87	5.06	4.92	4.86

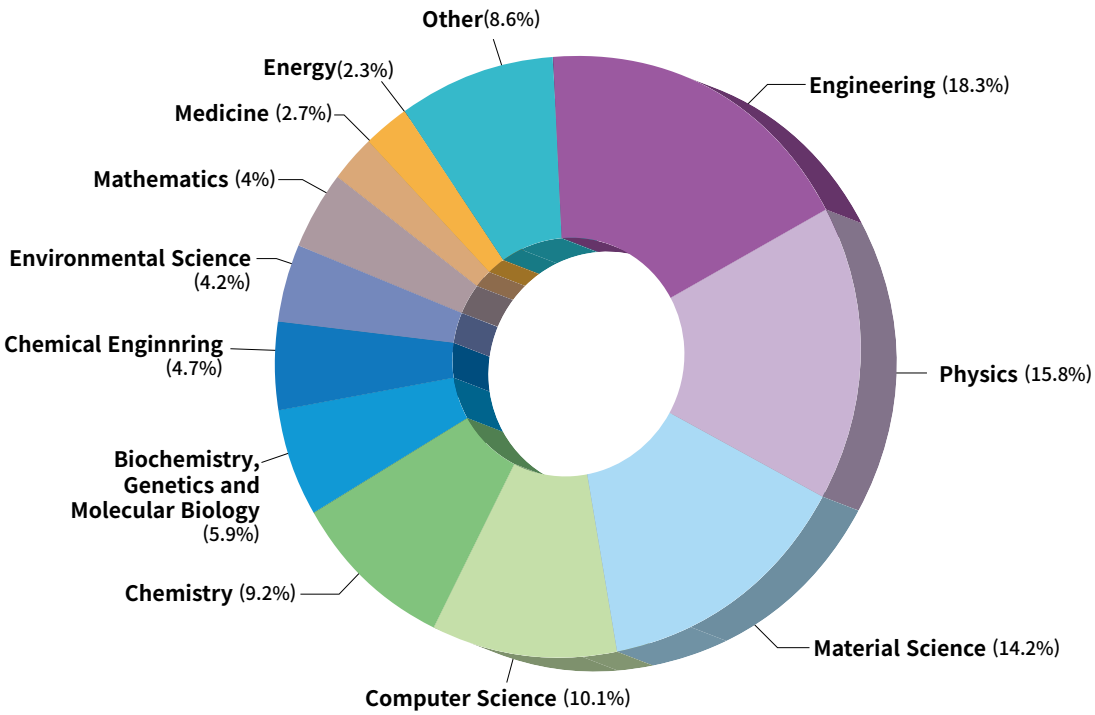


(Unit: %)

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Ratio of Top 10% Journal*	37	38.1	39.8	43.1	46.1	46.8	48.5	48.9	43.7	47.6

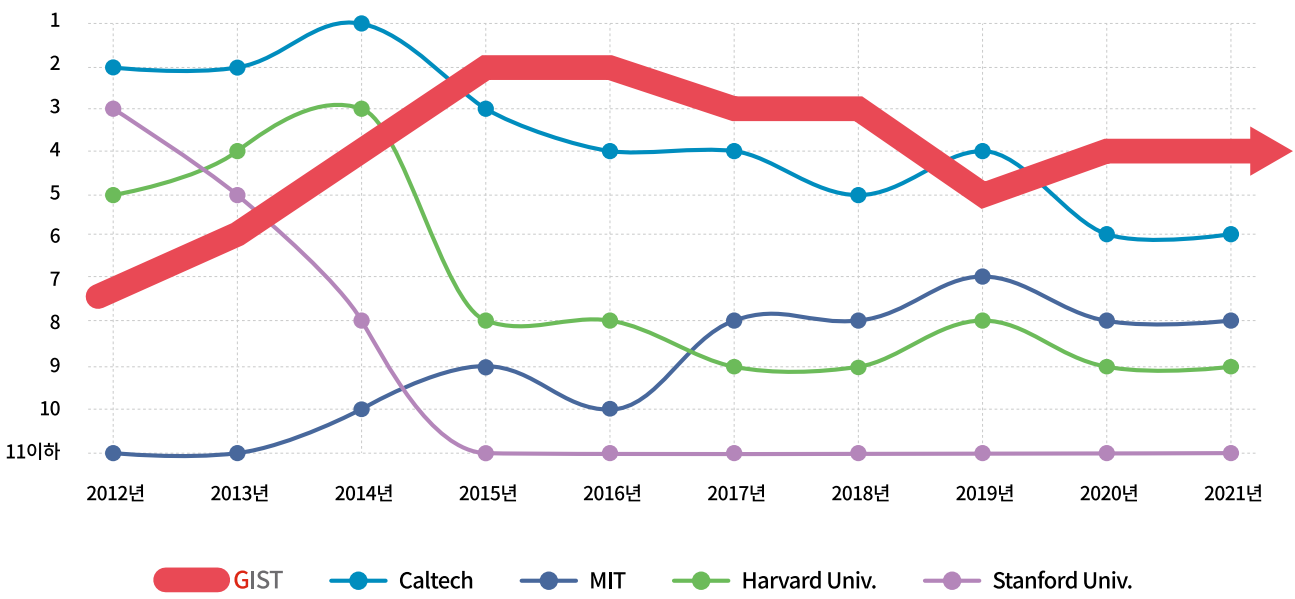
* No. of publications in the top 10% jourlnals by Cite Score (Source: www.scival.com)

Representative research area (Based on research paper)



*출처: www.scival.com

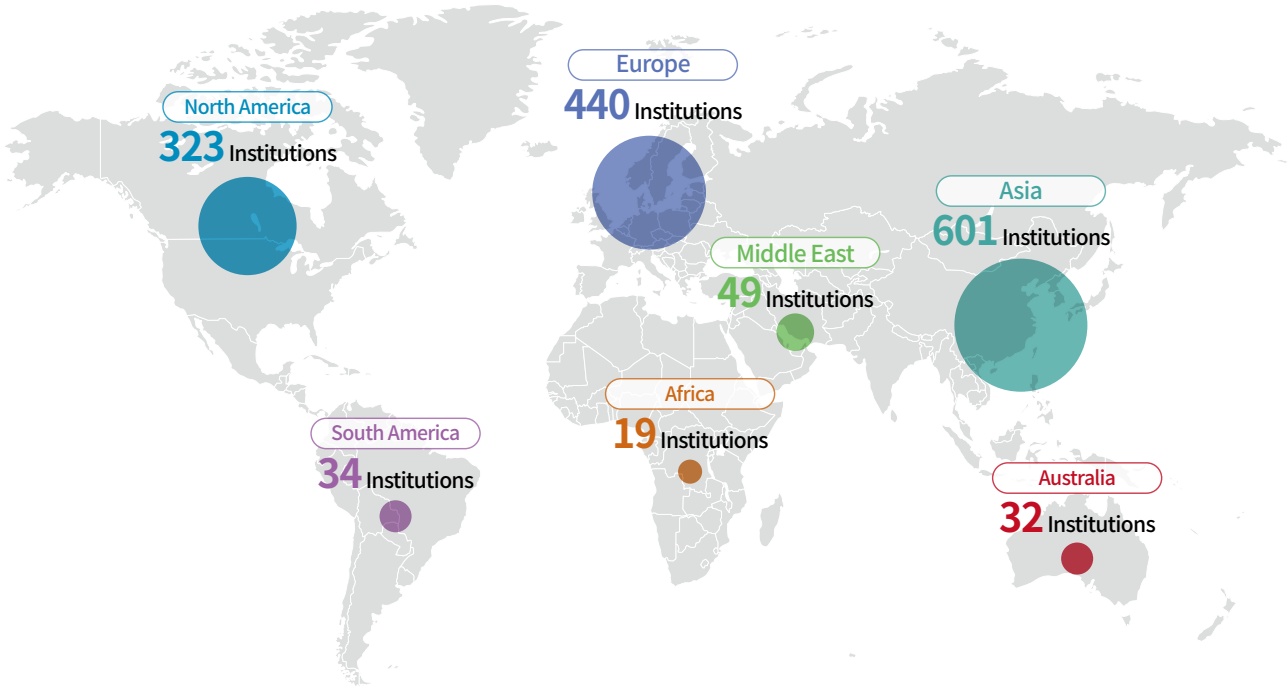
Trend of World University Ranking (Citation per faculty)



*출처: www.topuniversities.com(QS World University Ranking)

International Collaboration

No. of International Collaboration Institutions (2015~2020)



Main International Collaboration Institutions (2015~2020)

NO	Institution	Country	Research Theme
1	CNRS (Centre National de la Recherche Scientifique)	France	Physics, Material Science
2	The University of Tokyo	Japan	Physics, Computer Science
3	United States Department of Energy	USA	Physics, Material Science
4	Chinese Academy of Sciences	China	Physics, Engineering
5	University of California at San Diego	USA	Physics, Chemistry, Material Science
6	University of California at Berkeley	USA	Physics, Material Science
7	Stanford University	USA	Physics, Material Science, Chemistry
8	Imperial College London	England	Physics, Material Science, Chemistry
9	University of Washington	USA	Physics, Engineering
10	Harvard University	USA	Biochemistry, Medicine

* 출처 : https://www.scival.com

- School of Electrical Engineering and Computer Science
- School of Materials Science & Engineering
- School of Mechanical Engineering
- School of Earth Sciences and Environmental Engineering
- School of Life Science
- School of Integrated Technology
- Graduate School of Energy Convergence
- Department of Physics and Photon Science
- Department of Chemistry
- Department of Biomedical Science and Engineering
- AI Graduate School
- Division of Liberal Arts and Sciences
- Advanced Photonic Research Institute
- Research Institute for Solar and Sustainable Energies
- Korea Culture Technology Institute(KCTI)
- Intergrated Institute of Biomedical Research
- International Environmental Research Institute
- GIST Institute for Artificial Intelligence(GIAI)

GIST ANNUAL R&D REPORT

Gwangju Institute of Science and Technology

Main Research Achievements of 2020

School of Electrical Engineering and Computer Science

Young Min Song

ymsong@gist.ac.kr

A Janus emitter for passive heat release from enclosures

Current cooling technologies mostly rely on vapor compression and fluid cooling systems, accelerating the problems of fuel depletion and carbon emissions. As the demand for the development of next-generation energy systems increases, researches on passive radiative cooling that lower the surrounding temperature without supplying external power are being actively studied globally. However, the passive radiative cooling structure studied so far is a method of cooling by maximizing the thermal emissivity of a device only facing the atmosphere. This is a structure that is difficult to cool when heated enclosures or when the inside is heated due to the greenhouse effect because only the attached surrounding location is cooled. In this study, Janus double-sided heat radiation characteristics were optimized, implemented and applied to cool the inside temperature of the sealed car model by 4°C compared to the existing passive radiation cooling material without using energy.

Background

The importance of eco-friendly cooling system is being emphasized amid fossil fuel depletion and global warming, the passive radiative cooling method using the radiation phenomenon, which is a natural heat emission, is drawing attention. However, since the existing cooling method only radiates heat from one side from the surface, it is difficult to discharge heat from the space only by cooling the attached surface. In order to effectively utilize the passive radiative cooling technique, it is essential to develop a new type of structure that can effectively control the heat trapped in enclosures.

Contents

In the study, a *Janus* thermal emitter with different radiation characteristics from the top and bottom surfaces was fabricated. The proposed structure is a multi-layered panel with a thickness of about 500 μm made of polymer (PDMS), silver (Ag), and quartz (SiO_2) in order from the top. By separating the radiation characteristics from the upper and lower surfaces by metallic silver (Ag) layer that strongly reflects sunlight (more than 90%), the bottom surface absorbs heat from an enclosed space and releases the absorbed heat through the top surface (Fig. 1). The developed structure absorbs heat (broadband emitter) from the enclosed space with the bottom quartz structure, and the polymer structure at top radiates it while preventing being absorbed from the surrounding air (selective emitter) to lower the temperature of the confined space. As a result of measuring in an molded shape of a car, the conventional passive radiation cooling material※ cools only the 'surface', whereas the Janus thermal emitter can reduce the temperature of the vehicle 'inside' by about 4°C from 43°C to 39°C.

*Existing passive radiation cooling material: An ideal broadband emitter made of aluminum (Al) substrate that reflects sunlight, and a polymer (PDMS) with a thickness of 100 μm.

Expected effect

The Janus radiation cooling structure reported by this research team showed the highest level of passive radiation cooling characteristics reported so far, and functionally, it broke the limitations of the existing concept by proposing a new application. Since integrated research between the fields of electronics, physics, and materials is conducted, academic synergies can be expected and convergence-type talents will be fostered.

Janus thermal emitter that utilize double-sided radiation characteristics have no domestic/overseas research reports, so if the proposed structure is successfully developed, it is possible to secure a line of original technologies for passive radiation cooling/heating systems. It can have a great ripple effect and is expected to contribute greatly to enhancing national competitiveness.

Research Outcomes

[Paper] Heo, S. Y., Lee, G. J., Kim, Y. J., Ishii, S., Kim, M. S., Seok, T. J., Lee, B. J., Lee, H., Song, Y. M.*, "A Janus emitter for passive heat release from enclosures." Science advances 6.36 , eabb1906 (2020) .

[Patent] Passive radiant cooling panel with Janus characteristics with different top and bottom thermal radiation characteristics 2020-0024454

[Press release] Introduction of 17 domestic media outlets including Chosun Ilbo and 26 overseas media including Eureka Alert and Nanowerk

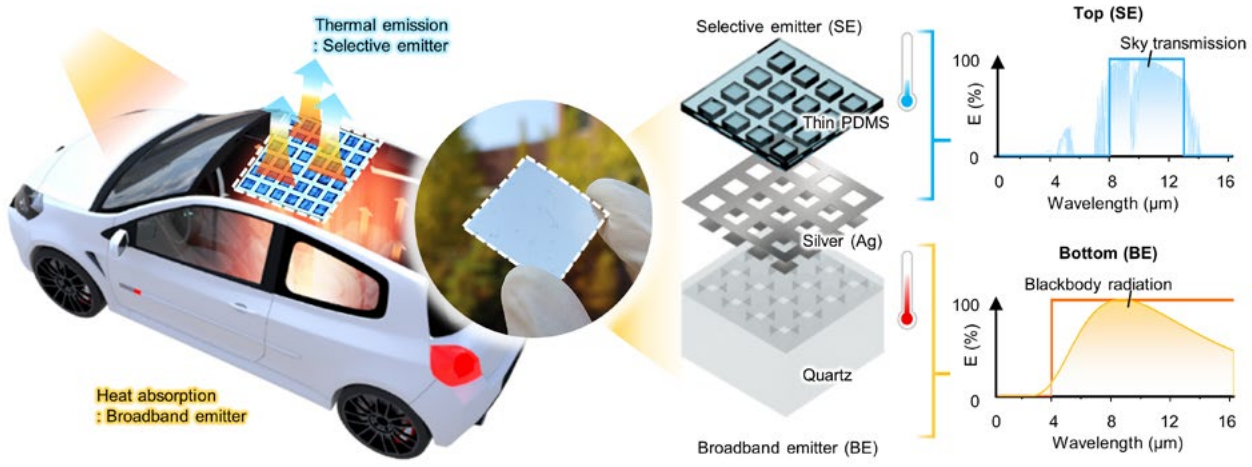
[Technology Transfer] (Passive radiant cooling panel with Janus characteristics with different top and bottom thermal radiation characteristics 2020-0024454) FOEL Corp. technology transfer

Research Funding

This work was supported by the National Research Foundation (NRF) of Korea(NRF-2020R1A2C2004983/ NRF-2018M3D1A1058997/NRF-2018R1A4A1025623) and by GIST Research Institute (GRI) grant funded by the GIST in 2020. This work was also supported by JST, PRESTO Grant Number JPMJPR19I2, Japan. G.J.L. acknowledges support from the NRF (NRF-2017H1A2A1042138).

Fig. 1

Janus for cooling enclosed space. (left) Schematic of JET applied to a stationary automobile under direct sunlight, where heat is trapped by the greenhouse effect. The Janus thermal radiation property allows broadband absorption of IR waves from the enclosure and selective emission to the ultracold space. (middle) Magnified structural view. From top to bottom: PDMS, silver, and micropatterned quartz(SiO_2). (right) Emission spectra of the ideal Janus emitter with broadband emission (BE) on the bottom and selective emission (SE) on the top. [Heo, Se-Yeon, et al. "A Janus emitter for passive heat release from enclosures." Science advances 6.36 (2020): eabb1906.]

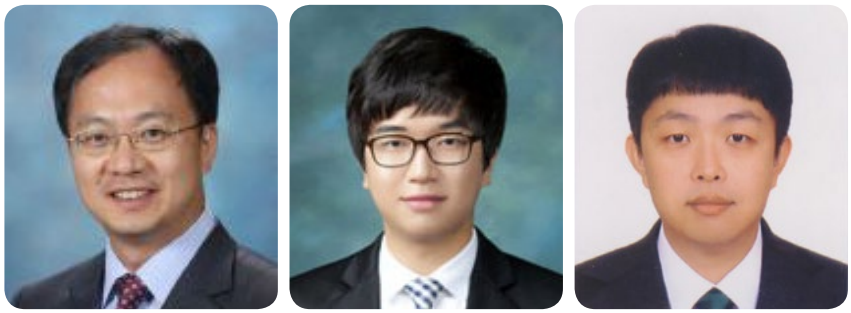


School of
Materials Science & Engineering

Heung Cho Ko

heungcho@gist.ac.kr

Development of electronic devices that can be automatically transformed into three-dimensional form



In order to shape wearable devices, biorobots, etc. into a desired shape, a three-dimensional electronic device technology is important. This study presents a methodology that can fabricate a thin film-type flexible electronic device and automatically transform it into three dimensions. First, a thin-film electronic device that is thinner than 10 micrometers is manufactured. Such an element can be easily deformed, but a variable auxiliary frame is required to maintain the shape after deforming into a specific shape. To this end, a variable frame was manufactured with acrylonitrile butadiene styrene (ABS) copolymer, and a technology that could be automatically changed into a desired shape through extrusion shear printing and thermal relaxation processes was developed. ABS printed through the extrusion shear method has the property of shrinking when heat is applied. In addition, when the ABS is heated above the glass transition temperature, it becomes a rubbery form through which the polymer can flow. The shape transformation is automatically achieved by combining the shrinking force of ABS by extrusion shear printing and the thermal relaxation process in which the polymer can flow. When printing a directional ABS line on an ABS film without shrinkage by extrusion shear, it will bend along the direction. At this time, the direction and degree of deformation can be controlled by controlling the ABS line that is extruded, sheared, and printed on the variable polymer frame, so that a desired three-dimensional shape can be freely implemented.

Background

In this laboratory, research has been conducted on the technology of transforming the shape of a flat thin film electronic device to develop a 3D electronic device. However, in the existing research, the shape is not automatically transformed, but it is made into a state that can be transformed and then folded by hand to create a three-dimensional structure. In order to cause deformation into a complex shape that is difficult to control by hand, a study was conducted on a method that can be transformed automatically.

Contents

3D electronic devices are highly utilized, such as image sensors, display devices, antennas, energy devices that require omnidirectional communication, wearable devices that need to be implemented in various forms, and biorobots, and many studies are being conducted. In order to construct a 3D electronic device, a lot of research is being conducted to develop a process technology for directly manufacturing an electronic device on a 3D structure, but it is very difficult to keep up with the level of the conventional semiconductor process based on a flat silicon substrate. On the other hand, when a planar electronic device is manufactured in a three-dimensional form through a shape modification technology, a high-performance, highly integrated planar electronic device manufactured using the existing semiconductor process technology can be used as it is. A thin film-type flexible electronic device having a thickness of 10 micrometers or less is easy to change in shape, but a shape change

control technology is required to secure the stability of the electronic device when the desired shape is realized and deformed. In addition, in order to implement a very small size or complex structure, it must be automatically changed into a desired shape. Through extrusion-based 3D printing, the research team printed ABS lines with shear stress on the ABS polymer frame, heated them above the glass transition temperature, and then changed from a flat shape to a three-dimensional shape through a thermal relaxation process to give fluidity. A flexible polymer frame was developed (Fig. 1,2,3). When the metal-based electrode and the indium gallium zinc oxide-based thin film transistor element, which is an oxide semiconductor, is mounted on the developed variable polymer frame and the shape is transformed, the stress acting on the electrode and the element during the thermal relaxation process is significantly reduced, and the electrode and the element It can be confirmed that the is operated stably (Figs. 4 and 5). The direction and degree of deformation can be controlled by varying the length, thickness, and distance between the ABS line and the position of the ABS line, which are extruded and shear printed on the variable polymer frame, rather than by hand, realizing the desired 3D structure. The degree of freedom is very high. In addition, when looking at the stress distribution of the electrode, element, and polymer frame when the shape of the polymer frame is deformed through computer simulation, it was confirmed that it has mechanical stability without deviating from the allowable ranges of the electrode, element, and polymer frame.

Expected effect

The shape modification technology through extrusion, shear printing and thermal relaxation process enables the implementation of a high-performance electronic device in a flat shape into a desired three-dimensional shape. In particular, this technology automatically changes to a pre-designed shape, so it is possible to implement a very small size or complex structure that is difficult to control by hand. This technology is expected to play a major role in the development of platforms such as sensors, displays, communication equipment, wearable devices, and biological robots that require three-dimensional structures.

Research Outcomes

[Paper] • H. S. Jang, S. Yoo, S. H. Kang, J. Park, G.-G. Kim, H. C. Ko, “Automatic transformation of membrane-type electronic devices into complex 3D structures by extrusion shear printing and thermal relaxation on acrylonitrile-butadiene-styrene frameworks”, Adv. Funct. Mater. 30, 1907384 (2020)

Research Funding

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (No. 2018R1A2B2005067).

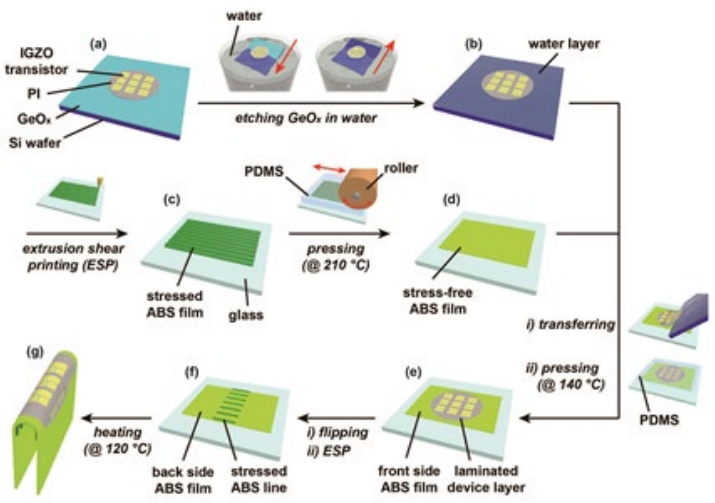


Fig. 1

Schematic diagram of the shape transformation process of a thin-film electronic device through extrusion, shear printing and thermal relaxation process.

School of
Mechanical Engineering

Solkeun Jee

sjee@gist.ac.kr

Turbulent Transition Modeling: from Subsonic to Supersonic Speed

Turbulent transition in boundary layer flow is a critical flow phenomena. In this research, a cost-effective approach, called PSE+LES, is developed for high-fidelity simulation of turbulent transition. The PSE+LES method is applied to a broad range of the flow speed, i.e., covering subsonic incompressible and high-Mach supersonic flows. It is expected that the PSE+LES method leads to the design of next-generation high-speed vehicles which are national interests.

Background

Laminar-to-turbulent transition is a critical flow phenomena because it determines (1) aerodynamic forces on aircraft and (2) aerodynamic heating on the aircraft surface in high speeds. The prediction capability of turbulent transition is required in designing high-speed vehicles, particularly space launch systems and supersonic/hypersonic aircraft. In our nation, a high-fidelity simulation method is required for designing such advanced aircraft. In this research, an innovative approach is developed towards the cost-effective and high-fidelity simulation of turbulent transition in both subsonic and supersonic flows.

Contents

An innovative approach is developed for the accurate prediction of turbulent transition and the subsequent turbulent region in wall-bounded flow. This approach combines the stability analysis method called parabolized stability equation (PSE) and large-eddy simulation (LES). The PSE+LES method allows high-fidelity computations with a much reduced computational cost, compared to direct-numerical simulation.

Unstable modes in laminar boundary layer are accurately provided from PSE because PSE is based on the stability theory. Non-linear interactions between various instability modes are captured in the current PSE. Because PSE is limited in a late non-linear stage which leads to complete turbulent flow, the LES approach takes over the non-linear region and the subsequent turbulent flow.

The PSE+LES method has been validated in subsonic flow first. Then, a canonical turbulent transition in supersonic flow with Mach 3 is tested. As the flow speeds varies, the primary and secondary instabilities in the laminar region change, which is well captured in PSE. The current PSE+LES provides DNS-like fidelity with a fractional computational cost of DNS. Appropriate sub-grid-scale models are determined from theoretical and computational assessment on various models for transitional flow, which is a cutting-edge research in the field of turbulent transition.

Expected effect

High-performance high-speed aircraft

Supersonic and hypersonic aircraft is a national interest. In order to design such high-speed vehicles, turbulent transition needs to be accurately predicted for aerothermodynamics analysis. The high-fidelity and cost-effective prediction method from this research would enable ones to simulate transitional flow in real aircraft configuration, which would leads to innovative designs for high-speed vehicles.

Data-driven flow modeling

Transition flow modeling is one of the least explored areas in fluid dynamics due to a lack of high-fidelity data. The current PSE+LES approach already provided DNS-like computational results in both subsonic and supersonic speeds. Various transition mechanisms can be simulated in the current method, which would help to develop data-driven, low-order transition model for practical approaches.

Research Outcomes

[Paper]
- Kim, M., Lim, J., Kim, S., Jee, S., & Park, D. (2020). "Assessment of the wall-adapting local eddy-viscosity model in transitional boundary layer". Computer Methods in Applied Mechanics and Engineering, 371, 113287.
- Lim, J., Kim, M., Kim, S., Jee, S., & Park, D. (2021). "Cost-effective and high-fidelity method for turbulent transition in compressible boundary layer". Aerospace Science and Technology, 108, 106367.

[Press release]
- Dongascience, 2020.09.21. http://dongascience.donga.com/news.php?idx=39984
- Newsworks, 2020.12.22. http://www.newsworks.co.kr/news/articleView.html?idxno=514327

[Other]
- Excellent research project in the Space Core Technology Development Program selected by the Ministry of Science and ICT (MSIT) of Korea.

Research Funding

This research was supported by the National Research Foundation of Korea (NRF) grant funded by the Ministry of Science and ICT (MSIT) of Korea(Grant No. 2017M1A3A3A02016810) under the Space Core Technology Development Program.

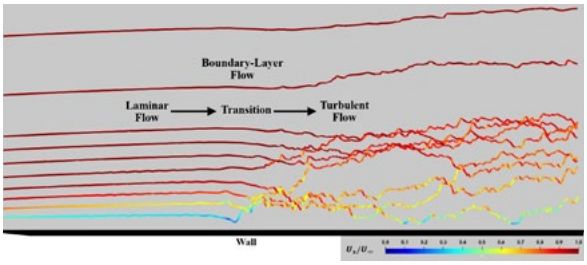


Fig. 1 Schematic diagram of turbulent transition in boundary layer flow. Streamlines are visualized with the PSE+LES computational data of [Kim, M., Lim, J., Kim, S., Jee, S., & Park, D. (2020). Computer Methods in Applied Mechanics and Engineering, 371, 113287].

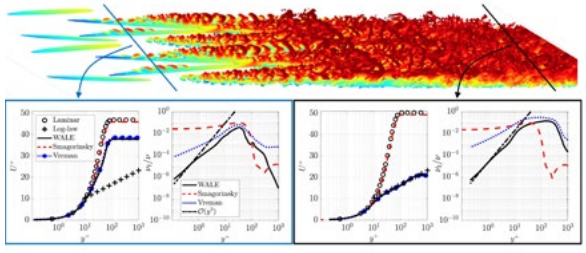


Fig. 2 Assessment of the prediction capability of sub-grid-scale models for transitional boundary layer flow [Kim, M., Lim, J., Kim, S., Jee, S., & Park, D. (2020). Computer Methods in Applied Mechanics and Engineering, 371, 113287]

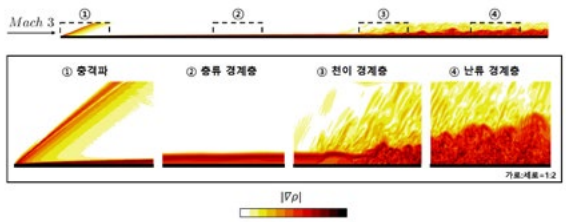


Fig. 3 Overall view on the simulation of turbulent transition in supersonic boundary layer flow. ① Shock wave, ② laminar, ③ transition, ④ turbulent flow. Flow is visualized with the high-fidelity computational data of [Lim, J., Kim, M., Kim, S., Jee, S., & Park, D. (2021). Aerospace Science and Technology, 108, 106367].

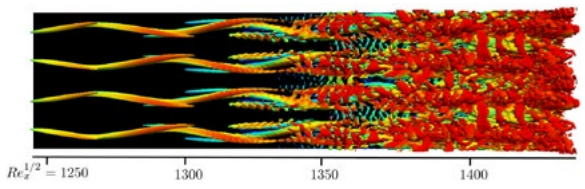


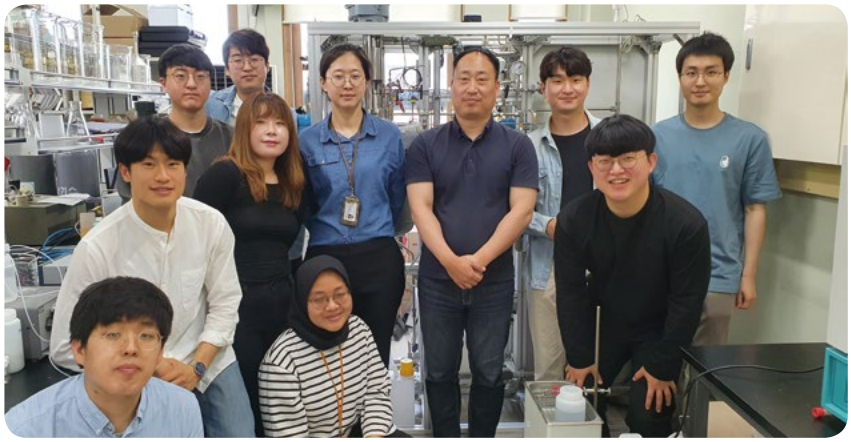
Fig. 4 Vortical structures in transitional boundary layer on a flat plate at Mach 3 supersonic condition [Lim, J., Kim, M., Kim, S., Jee, S., & Park, D. (2021). Aerospace Science and Technology, 108, 106367].

School of Earth Sciences and Environmental Engineering

Youngjune Park

young@gist.ac.kr

Novel carbon dioxide capture technology by using gas hydrate for carbon neutral society



sH hydrate has a deal of attention as an attractive medium of gas storage and separation due to its relatively milder formation condition and higher storage capacity, and thus sH hydrate has focused on the potential application in the post-combustion CO_2 capture. Nonetheless, in-depth investigations on the thermodynamic stability of sH hydrate of N_2 + CO_2 and the possible occurrence of structural transformation during the process have not yet been addressed. Since the gas hydrate-based CO_2 capture technology involves stepwise enrichments of CO_2 through iterative formation-dissociation processes of CO_2 hydrate, knowledge about the thermodynamic stability between sI and sH hydrates in the presence of various N_2:CO_2 ratios and their kinetic properties is important for designing the gas hydrate-based CO_2 separation process. Here, we explored sI and sH hydrates of 3,3-dimethyl-1-butanol + N_2 + CO_2 focusing on their structural stability and structure-dependent kinetic properties. The experimental data including $P - T$ phase equilibria, induction time, gas uptake, and CO_2 separation factor are provided with a structural analysis via synchrotron high-resolution powder diffraction.

Background

With the accelerating of global warming, variety of CO2 capture schemes linked to carbon capture, utilization and storage (CCUS) technologies, have been extensively investigated so far. Among the options, gas hydrate-based CO2 separation is recognized as an emerging technology due to its potential benefits to an energy-efficient CO2 regeneration process. Gas hydrate is an inclusion compound of well-known three crystalline structures of sI, sII, and sH. Each structure of gas hydrate exhibits distinct thermodynamic stability and formation kinetics. Since the milder P – T phase equilibrium and higher CO2 uptake (i.e., less number of H2O molecules for CO2 capture) with faster formation kinetics are mostly necessitated properties for the practical application to gas hydrate-based CO2 capture, the appropriate selection and/or combination of the structures of gas hydrate (i.e., sI, sII, or sH) should be thoroughly decided according to the factors such as operational P – T, targeting final CO2 purity, operational duration, etc. For sH hydrate-based CO2 capture application, in particular, the effects of the CO2 molecule on the stability of sH hydrate should be more closely investigated since it acts as a help gas for sH hydrate under a limited condition. Despite that CO2 plays the most critical roles in the thermodynamic stability of sH hydrate, in-depth investigation into the occupation patterns of N2 + CO2 mixtures in sH hydrate and their effects on the structural transformation have not been reported to date. Here, we explored the distinct thermodynamic and kinetic properties of sH DMB hydrates of N2 + CO2 to provide fundamental information toward potential application to gas hydrate-based CO2 capture technology.

Contents

In this study, the thermodynamic and kinetic properties of DMB + N2 + CO2 hydrates were investigated for potential application to the CO2 capture process. HRPD analyses identify the formation of structure H in DMB + N2 + CO2 (80:20, 50:50, or 20:80 mol%) hydrates. The four-phase equilibria of DMB + N2 + CO2 + water systems suggested that all gas composition of N2 + CO2 gas mixtures, which include the range of flue gas composition, can form sH hydrate in the presence of DMB with structural transformation. Meanwhile, the trend of quintuple points (TIH, PIH) and consideration of cage asymmetry and size of sH hydrate verified that the CO2 concentration can play an important role for determining the structural transformation and stability of sH hydrate in the presence of DMB.

It was confirmed that the induction times of sH hydrates are shorter than those of sI hydrates. Total gas uptakes of hydrate which were normalized by the amount of water at the sH region are almost identical to those of the sI region in the gas compositions of N2 + CO2 (80:20, or 50:50 mol%), whereas the total gas uptake of hydrate at the sH region was larger amount in the N2 (20%) + CO2 (80%) gas composition. CO2 separation factors of sH hydrates are larger than those of sI hydrates in the gas compositions of N2 + CO2 (80:20, or 50:50 mol%). Therefore, with a comprehensive consideration of the thermodynamic stability and kinetic performances, it was confirmed that the formation of gas hydrate under the sH stable region in the DMB + N2 + CO2 systems is essential to enhance the performance for a sH hydrate-based CO2 capture and separation process with respect to mild formation conditions, gas uptake, nucleation speed, and selectivity of CO2.

Expected effect

Our study provides that unlike other well-known sH formers such as neohexane (NH) and methylcyclopentane (MCP) that cannot form the sH hydrate at CO2-rich condition in N2 + CO2 system, DMB molecules are expected to stabilize the all gas composition of N2 + CO2 system at below the quintuple point. In addition, these results imply not only to alleviate the pressure and temperature requirement by forming sH hydrate in the composition range of flue gas (10-20% CO2 + 90-80% N2) in the presence of DMB but also to maintain the mitigating conditions until pure CO2 concentration is reached in gas hydrate-based N2 + CO2 separation process. Furthermore, this study suggests a key factor for sH hydrate-based application that the property of structural transformation point of sH hydrate should be investigated to estimate the performance and determine the operating conditions with good performance in sH formers + CO2 with other help gases systems. We believe that the findings of this study provide significant insight into the gas-hydrate based CO2 capture process involving stepwise enrichment of CO2 through iterative formation-dissociation of gas hydrates.

Research Outcomes

[Paper] • Y. Lee, S. Moon, S. Hong, S. Lee, Y. Park*, "Observation of Distinct Structural Transformation between sI and sH Gas Hydrates and Their Kinetic Properties during CO_2 Capture from N_2 + CO_2", Chemical Engineering Journal, 389, 123749 (2020)

[Patent] • Y. Park, Y. Lee, "A gas hydrate promoter and Method of carbon dioxide separation by using gas hydrate", Application No. KR 10-2020-0012693

Research Funding

This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (NRF-2015R1D1A1A02061741), and Gist Research Institute (GRI) grant funded by the GIST in 2019.

School of Life Science

Daeho Park

daehopark@gist.ac.kr

Crbn modulates calcium influx by regulating Orai1 during efferoytosis

School Of Life Science

This study shows that Orai1 is a novel endogenous substrate of Crbn. At the steady state, Crbn interacts with Oria1, ubiquitinates and degrades it through the ubiquitin-proteasome pathway. Interestingly, Orai1 is upregulated during phagocytosis of apoptotic cells which results from decreased ubiquitination of Orai1. The changes in the ubiquitination and expression level of Orai1 are caused by weakened interaction between Crbn and Orai1, resulting from competitive binding between Stim1 and Crbn to Orai1. In sum, During phagocytosis of apoptotic cells, Orai1 invovled in SOCE (store-operated calcium entry) is upregulated to increase calcium influx, which eventually causes phagocytic cup closure

Background

Calcium flux regulating intracellular calcium levels is essential and modulated for efficient efferocytosis. However, the molecular mechanism by which calcium flux is modulated during efferocytosis remains elusive.

Contents

We report that Orai1, a Crbn substrate, is upregulated via its attenuated interaction with Crbn during efferocytosis, which increases calcium influx into phagocytes and thereby promotes efferocytosis. We found that Crbn deficiency promoted phagocytosis of apoptotic cells, which resulted from facilitated phagocytic cup closure and was nullified by a CRAC channel inhibitor. In addition, Orai1 associated with Crbn, resulting in ubiquitination and proteasomal degradation of Orai1 and alteration of SOCE-mediated calcium influx. The association of Orai1 with Crbn was attenuated during efferocytosis, leading to reduced ubiquitination of Orai1 and consequently upregulation of Orai1 and calcium influx. Collectively, our study reveals a regulatory mechanism by which calcium influx is modulated by a Crbn-Orai1 axis to facilitate efferocytosis.

Expected effect

Crbn is a druggable target, and defects in clearance of apoptotic cells are related to autoimmune-related diseases. Our findings may provide an approach to develop a drug that can be used to treat diseases caused by defects in engulfment of apoptotic cells.

Research Outcomes

[Paper] • Moon H, Min C, Kim G, Kim D, Kim K, Lee SA, Moon B, Yang S, Lee J, Yang SJ, Cho SK, Lee G, Lee CS, Park CS, Park D. Crbn modulates calcium influx by regulating Orai1 during efferocytosis. Nat Commun. 2020 Oct 30;11(1):5489.

Research Funding

This work was supported by the National Research Foundation of Korea funded by the Korea government (MSIP) (2019R1A2C1006480, 2019R1I1A1A01057419, and 2019R1A4A1028802) and by Aging Research Institute at GIST.

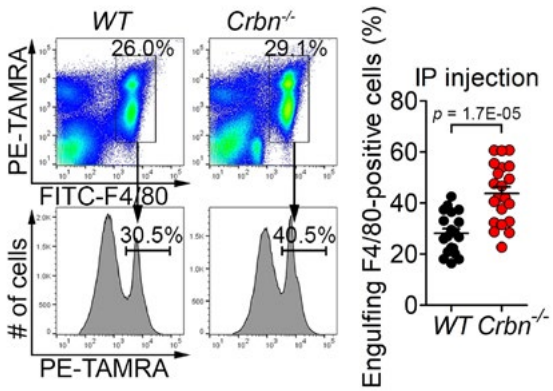


Fig. 1 Crbn depletion promotes phagocytosis of apoptotic cells

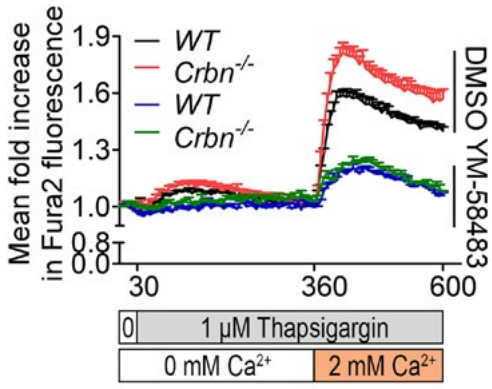
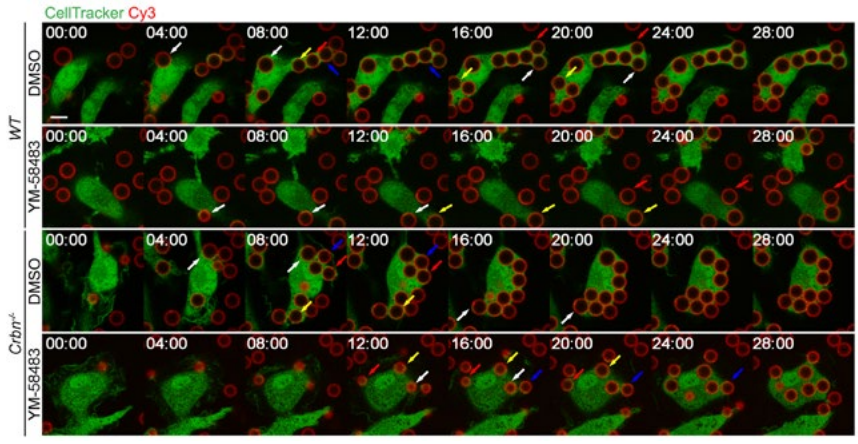


Fig. 2 Crbn depletion increases store-operated calcium entry

Fig. 3

Increased calcium entry during efferocytosis enhances phagocytic cup closure



School of
Integrated Technology

Seung Jun Kim

seungjun@gist.ac.kr

Human-AI Interaction for Human-Centered Automotive Systems and Crowdsourcing Platforms

Human-Vehicle Interaction design of autonomous vehicle system requires iterative testing in various situation. To this end, we developed a on-road mixed-reality autonomous driving simulator, which is better than the conventional driving simulation systems in terms of immersion, realism, and simulator sickness. We also propose a new interaction system(Gaze-Head Input) and holistic view through the comparison of five basic interaction modalities of drivers(touch, air gesture, speech, gaze, and buttons). In addition, we propose an appropriate gamification system considering the situation of a particular population to prevent bias in collection data and algorithms through worker group expansion of the crowdsourcing platform.

Background

In autonomous vehicles, drivers' in-vehicle experiences are increasingly important. Thus, driving simulators have been developed to study human-centered interaction systems in AVs. However, these simulators are limited: Virtual simulators fail to fully create a sense of immersion, and real-vehicle simulators fail to address the heterogeneity between the graphical environment and the actual movement of the vehicle.

While most crowdsourcing tasks are easy enough to allow widespread participation and many incorporate gamification factors to improve worker engagement, crowdwork generally does not consider the motivation of elderly or disabled persons nor provide an adequate platform or interaction method for their participation. As such, research on user experience of human-centered interaction perspectives is required on platforms that include interaction with systems.

Contents

(Research 1) We proposed a new autonomous driving simulator based on a real vehicle and mixed reality that provides a real road environment to the subject to increase immersion. For validation, we constructed six simulators with different visual and motion settings and investigated how those different settings increased or decreased the perceived ① visual fidelity, ② motion fidelity, ③ presence, and ④ simulator sickness.

(Research 2) We compared five single modalities commonly used for NUIs (touch, mid-air gesture, speech, gaze, and physical buttons located in a steering wheel) to provide a more holistic view of driver distraction.

(Research 3) We developed an image labeling platform with graphical icon-based labeling methods and introduced gamification to increase engagement.

(Research 4) We demonstrate a process for designing crowd work for older adults; ① identifying their needs, ② designing an approach to foster their participation, and ③ verifying its effectiveness.

Expected effect

In this work, we propose a real-vehicle-based mixed-reality autonomous driving simulator and provide a holistic view of driver distraction by comparing five single modalities commonly use for NUIs in vehicles. We expect our design to inform future virtual autonomous simulator development and to advance in-vehicle human-centered interaction systems. It is also expected to improve the design of interaction systems for elder populations by proposing important considerations and opportunities for crowd work designed for them.

Research Outcomes

[Paper]

- Yeo, D. H., Kim, G. B., Kim, S. Toward Immersive Self-Driving Simulations: Reports from a User Study across Six Platforms. Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems. Honolulu, HI, USA, Association for Computing Machinery: 1–12, DOI:https://doi.org/10.1145/3313831.3376787 . [pdf, link, presentation] (Top-tier publication venues in Human-Computer Interaction field)
- Kim, M., Seong, E., Jwa, Y., Lee, J. and Kim, S. "A Cascaded Multimodal Natural User Interface to Reduce Driver Distraction," in IEEE Access, vol. 8, pp. 112969-112984, 2020, doi: 10.1109/ACCESS.2020.3002775. [pdf, link]
- Lee, J., Yi, J. H. and Kim, S."Cultural Heritage Design Element Labeling System With Gamification," in IEEE Access, vol. 8, pp. 127700-127708, 2020, doi: 10.1109/ACCESS.2020.3008270. [pdf, link]
- Seong, E., Kim, S. Designing a Crowdsourcing System for the Elderly: A Gamified Approach to Speech Collection. Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems. Honolulu, HI, USA, Association for Computing Machinery: 1–9, DOI:https://doi.org/10.1145/3334480.3382999. [pdf, link] (HCI 분야 Rank 1 게재지, 한국정보과학회 HCI분야 최우수학술대회)

[Patent] 2 Patents Application (USA, South Korea)

- Mixed reality based experience simulator. US17015242: US patent App. filed 2020-09-09, KR1020200056099: KR patent App. filed 2020-05-11

Research Funding

This research was supported by the Korea Institute of Energy Technology Evaluation and Planning (KETEP) and the Ministry of Trade, Industry and Energy (MOTIE) (No. 20204010600340) in 2020

This work was supported by GIST Research Institute(GRI) grant funded by the GIST in 2020.

This research was supported in part by Ministry of Culture, Sports and Tourism (MCST) and Korea Creative Content Agency (KOCCA) in the Culture Technology (CT) Research & Development Program 2020.

Fig. 1 Implementation of real-vehicle-based mixed-reality autonomous driving simulation platforms with the highest visual·motion fidelity and presence.

Fig. 2 (Research 4) Experiment setting and contents for reading fairy tales and crowdsourcing

Graduate School of Energy Convergence

Yun-Su Kim

yunsukim@gist.ac.kr

Single-Variable-Input Active Side Lobe Suppression Method for Synthesized Magnetic Field Focusing Technology and its Optimization

In this work, a novel method to calculate current distribution, which enables active side lobe suppression of the magnetic flux density in synthesized magnetic field (SMF) system, is proposed for the first time. The proposed method calculates the current distribution, which enables further side lobe suppression and keeping the resolution at the same time, by changing the target magnetic flux density distribution with only one varying parameter. The proposed calculation method is very intuitive and time-efficient compared to other calculation method, as it only changes one variable to control the side lobe with one step of matrix multiplication. With the finite element method simulation, it is verified that the proposed method can suppress the side lobe with any target Rx point, when the SMF system has 14 coils with size of 10 cm x 10cm, and the synthesis distance is 30 cm. When the field is synthesized at the center, over 90 % of the side lobe was suppressed for maximum case. A figure or merit (FoM) was constructed to optimize the system between the resolution increment and the side lobe suppression, and 79 % of the side lobe was suppressed for optimized case, while keeping the resolution increment ratio below 30 %. In addition, it is verified that the method can be also applied to 2-D SMF systems. The experimental results were in good agreement with the simulated results, when the experimental prototype of same condition with simulation was utilized, including a case in which the magnetic field was focused at Rx point other than center.

Background

when the field is synthesized with SMF, a side lobe with a rather high value appears around the synthesis target point, as shown in Fig. 1(b). This phenomenon opposes the objective of SMF, as the magnetic field of the side lobe still may cause the problems of regarding magnetic field as mentioned above. In addition, as SMF utilizes multiple number of coils, it requires complicated coil control method and increment of power loss.

Although various selective charging systems have been developed in WPT field, the systems deliver power selectively to the target receiving (Rx) device by controlling multiple number of frequencies, or only when the device is adjacent to the Tx coils. When multiple frequencies are adopted in selective WPT system, the system needs complicated control and it still has large electromagnetic interference (EMI) issue for non-target area. When the Rx device moves far away from the Tx, the system cannot control the magnetic flux density to be high only in the position of the target device properly. Therefore, in order to control the magnetic flux density in non-target area actively even though the Rx device is far from Tx without adopting multiple frequencies, more powerful side lobe suppression of SMF system is required.

In this work, a current distribution calculation method, which enables further active side lobe suppression of SMF technology while keeping the synthesis resolution, is proposed for the first time. The method utilizes an input variable to conventional current distribution calculation method of SMF, which results in monotonic side lobe suppression as the absolute value of input variable increases within specific range. Therefore, an active side lobe suppression becomes available intuitively with the proposed method, as it only requires an absolute value adjustment of input variable to control the side lobe value. In addition, the proposed method does not require any complicated algorithms or additional equations.

Contents

As various receiving devices which must receive a magnetic field from the transmitting side are likely to move in 2-D space rather than 1-D space, SMF technology is essential for these devices to be applicable in 2-D space. In order to utilize 2-D SMF technology in practical applications such as WPT or magnetic induction tomography (MIT), the proposed side lobe suppression method must also be applicable to a 2-D system in order to avoid unwanted EMI issue or ignition of metal objects caused by eddy current.

The proposed side lobe suppression method is verified as to whether it is applicable to a 2-D SMF system, as proposed in earlier work. It was found that the magnetic flux density distribution in the row and column directions in the 2-D SMF system can be assumed to be mostly independent.

Fig. 2 shows the magnetic flux density distribution of the 2-D SMF system for both cases of when the side lobe is not suppressed and when it is suppressed with s = -0.4, where the value is the optimum suppression parameter value for the 1-D SMF system with (n, m, k) = (10, 5, 3). Fig. 2(a) shows the non-suppressed magnetic flux density distribution when the side lobe is larger than 24%. However, the distribution in Fig. 2(b) has a side lobe lower than 5%, verifying that the side lobe suppression method is also applicable on 2-D SMF systems.

The comparison results showed that the proposed algorithm is more time efficient in 20 %-level, compared to the current distribution algorithm with loop condition, which is the simplest algorithm without the inverse matrix calculation. The time efficiency of the proposed algorithm is verified and its efficiency will be maximized when the number of coils increase for sophisticated applications.

Expected effect

The proposed method enables magnetic flux density control without any multiple frequency control, even though when the synthesis distance is rather large compared to the Tx coil size. The input variable of the proposed algorithm is set with the normalized magnetic flux density of Rx point, which are neighboring to the target point. An optimum input variable value is found out by calculating an FoM of the system for each synthesis cases. With the proposed algorithm, the side lobe was suppressed more than 79 %, when the SMF system is constructed with 14 Tx coils with 10 cm x 10 cm size, while keeping the resolution still under 30 cm. The proposed method can be applied to any wireless power charging field where the device is very small and the distance between Rx and Tx coils are under 30 cm.

Research Outcomes

[Paper] • J. H. Kim; B. H. Choi; H. R. Kim; C. T. Rim; Y.-S. Kim*, "Single-Variable-Input Active Side Lobe Suppression Method for Synthesized Magnetic Field Focusing Technology and its Optimization", IEEE Transactions on Industrial Electronics, vol. 67, no. 11, pp. 9813-9823, Nov. 2020.

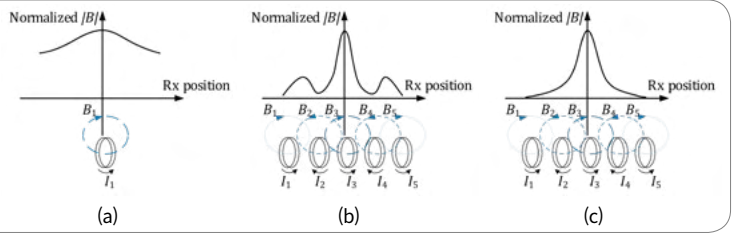


Fig. 1
Concept diagram of SMF system with examples of side lobe suppression (a) Non-synthesized (b) Synthesized without side lobe suppression (c) Synthesized with side lobe suppression. [Kim et al., IEEE Trans. Ind. Electron. 67, (2020)]

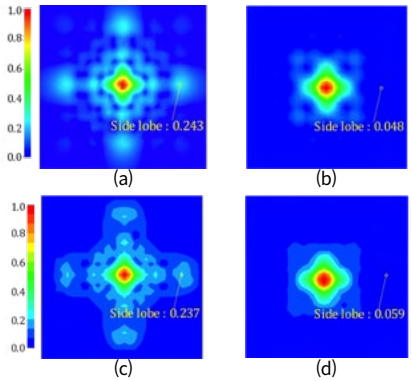


Fig. 2 FEM simulation results ((a) and (b)) and experimental results ((c) and (d)) with 2-D SMF system of 100 Tx coils and 25 Rx points (a, c) with no side lobe suppression and (b, d) with side lobe suppression with s = -0.4. [Kim et al., IEEE Trans. Ind. Electron. 67, (2020)]

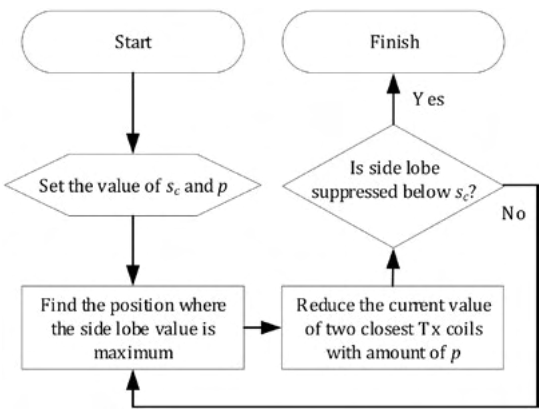


Fig. 3 Flow chart of the current distribution calculation algorithm with loop condition [Kim et al., IEEE Trans. Ind. Electron. 67, (2020)]

Department of Physics and Photon Science

Jong Seok Lee

jsl@gist.ac.kr

Polar Metal Phase Induced by Oxygen Octahedral Network Relaxation in Oxide Thin Films

Perovskite materials having the chemical formula of ABO3 have inherent flexibility due to the crystal structure that shares vertices of the BO6 octahedron, and various interesting phenomena occur due to the strong coupling between lattice and charge/spin degrees of freedom along with various structural changes. In this study, the effect of strain relaxation on the change of physical properties in transition metal oxide thin film samples was investigated in depth, and the polar metal phase stabilized by the asymmetric rotation of the oxygen octahedron was demonstrated in SrRuO3 thin films grown on the SrTiO3 substrate.

Background

In general, polarity cannot appear in metals because free electrons inside the metal fundamentally block polarity from appearing. Nevertheless, there have been a few recent reports about polar conductors in which both metallicity and polarity coexist may exist in the natural world. And, researchers have been continuously attempting to artificially implement polar metals by weakening the path to which the polarity is blocked by free electrons. In transition metal oxides, strong interactions between lattice, electrons, and spin can lead to emergence of new physical properties, and are widely used in application studies including the fabrication of electrical and magnetic functional devices. When these oxides are manufactured in the form of a thin film, a strain effect, compressing or increasing the in-plane structure of the thin film grown on the substrate, appears due to the difference in lattice size between the substrate and the material. In this study, we tried to experimentally and theoretically verify the emergence of new physical properties related to electrical and magnetic properties by utilizing the strain engineering in transition metal thin films.

Contents

Strontium ruthenium oxide (SrRuO3) thin film is a representative transition metal oxide having electrical conductivity and ferromagnetic properties, and has an orthorhombic structure as a bulk structure. When grown on a strontium titanium oxide (SrTiO3) substrate in the form of a thin film, the strontium ruthenium oxide thin film subjected to compressive strain stabilizes the tetragonal structure according to the change of the oxygen octahedral rotation pattern. In this study, the strain effect in the strontium ruthenium oxide thin film subjected to compressive strain was systematically traced using the optical second harmonic generation technique, and X-ray diffraction and scanning transmission electron microscopy, it was confirmed that orthorhombic and tetragonal structures are spatially separated, and that the ruthenium atoms of the crystal structure were located non-centrally symmetrically in the heterointerface region (Figure 1).

Expected effect

This result shows that polarized phase can appear in ferromagnetic conductor of a perovskite-structured oxide thin films in the course of the strian relaxation. Such a novel polar ferromagnetic metal phase can open new application possibilities for next-generation magnetic and electronic devices. In addition, it is of great significance that the strain relaxation phenomenon can be used as a method of controlling the structure of transition metal oxides.

Research Outcomes

[Paper] • Chang Jae Roh, Myung-Chul Jung, Jeong Rae Kim, Kyoung-June Go, Jinkwon Kim, Ho Jun Oh, Yong-Ryun Jo, Yeong Jae Shin, Jeong Gi Choi, Bong-Joong Kim, Do Young Noh, Si-Young Choi, Tae Won Noh, Myung Joon Han, and Jong Seok Lee, "Polar Metal Phase Induced by Oxygen Octahedral Network Relaxation in Oxide Thin Films", Small 16, 2003055 (2020)

Research Funding

This research was supported partly by a National Research Foundation of Korea (NRF) grant funded by the Korean government (Grant No. NRF- (Nos. 2015R1A5A1009962, 2018R1A2B2005331, 2018M3D1A1058754, 2018R1A2B2005204).

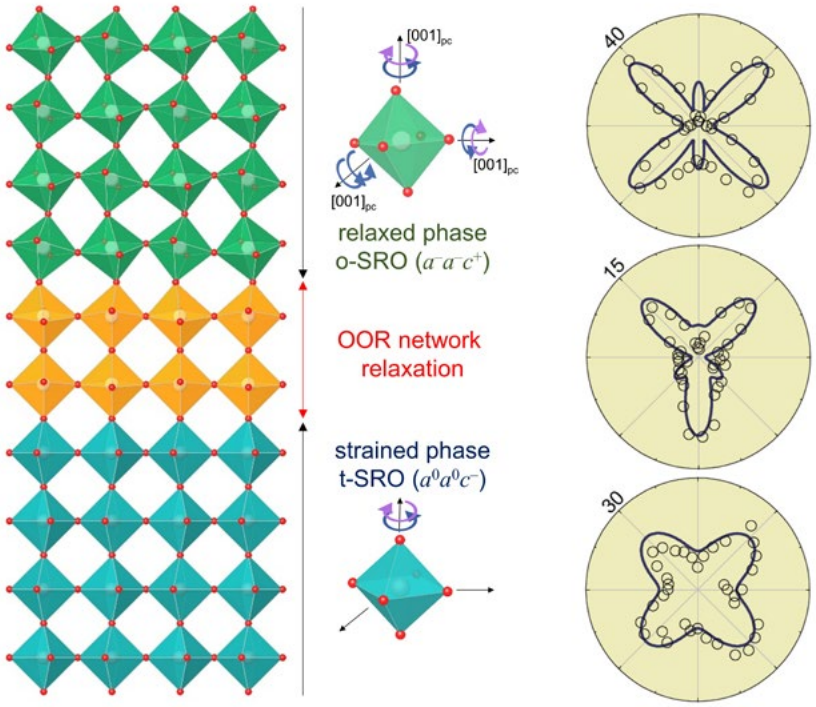


Fig. 1

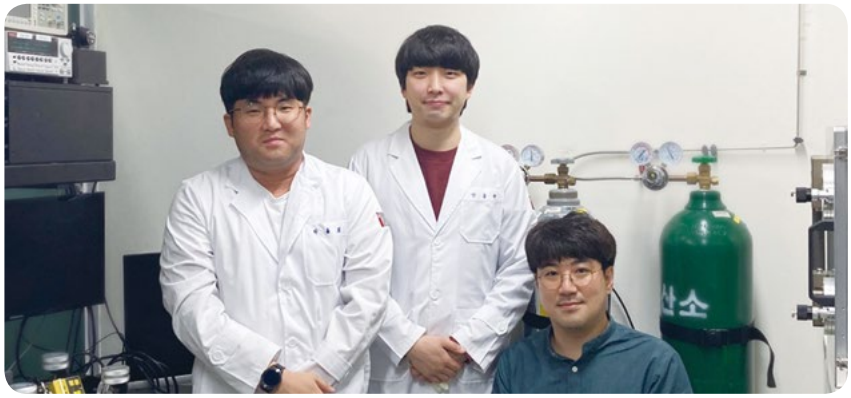
Polar phase formed at the heterointerface of distinct structural phases in $SrRuO_3$ films and the second-harmonic generation results.

Department of Chemistry

Hyunseob Lim

hslim17@gist.ac.kr

Centimeter-Scale and Highly Crystalline 2D Alcohol: Evidence for Graphenol (C_6OH)



Since a graphene sheet consists of unsaturated sp^2 carbon bonds, the addition reaction for the saturating aromatic bonds can lead to a variety of non-natural two-dimensional (2D) materials. However, despite many interests and numerous efforts, it has not been possible to synthesize a noble 2D crystal. Here, we report a chemical route to synthesize centimeter-scale stoichiometric *'graphenol (C_6OH)'*, 2D crystalline alcohol via vapor phase hydroxylation of epitaxial graphene on Cu(111). Atomic resolution scanning tunneling microscopy revealed this highly-ordered configuration of graphenol and low energy electron diffraction studies on a large-area single crystal graphene film demonstrated the feasibility of the same superstructure being achieved at the centimeter length scale.

Background

Most of two-dimensional (2D) crystals are isolated form their own parents-natural crystals, i.e., three-dimensional (3D) layered materials. The 2D carbon allotrope, graphene, with extremely high crystallinity can be obtained not only by exfoliation from 3D graphite but also by various synthetic strategies. On the other hand, the graphene in natural 2D crystalline form consisting of unsaturated chemical bonds is suggested to be artificially extended to non-natural 2D materials. However, despite many interests due to their unique electric and magnetic properties, numerous experimental attempts only produced the non-stoichiometric graphene derivatives with the disordered functional groups so far. The exquisite chemical control to create the periodic functional group array on the surface of graphene therefore remains an important challenge for synthesizing highly crystalline 2D graphene derivative at large scale enough to be applied to practical application fields.

Contents

In order to realize the periodic functionalization on graphene, monolayer and single-oriented epitaxial graphene (EG) islands were first synthesized on Cu(111). Then, the gas phase hydroxylation was carried out by exposure of the EG sample to thermally cracked H_2O vapor, and thereby atomic hydrogen and -OH groups only are introduced on graphene (Figure 1). In an atomic resolution STM image and 3D-STM image obtained after the reaction, a highly-ordered hexagonal pattern of bright protrusions was observed. The two-dimensional Fast Fourier Transformed (2D-FFT) images before and after reaction show that the smaller hexagonal pattern of a $(\sqrt{3}\times\sqrt{3})R30°$ superstructure ($C_6(OH)$) was additionally formed to the typical (1×1) hexagonal pattern of pristine graphene. (Figure 2). Periodic density functional theory (DFT) calculations were carried out to further understand the formation of $C_6(OH)_1$ and its electronic structure. The optimized geometries of EG, $C_6(OH)_1$, and $C_6(OH)_2$ that were observed by

STM, have been predicted by DFT calculation. The hydroxylation in the manner of bonding at the meta positions with respect to the other -OH group can be understood in terms of the favorable interfacial interaction between EG and Cu. The formation of a C-OH σ bonding induces sp^3 character not only to the carbon atom bonding with -OH but also to its neighboring carbon atoms which may, therefore, interact more strongly with the Cu atoms beneath them.

Beyond the atomic-scale studies by STM, we extended our study to the vapor phase hydroxylation on a large-scale and single-oriented monolayer epitaxial graphene (*L*-EG) film on a single-crystal Cu(111) foil using LEED to demonstrate the feasibility of synthesizing functionalized graphene.

a hexagonal LEED pattern was observed on the pristine *L*-EG surface. After the hydroxylation, a smaller hexagonal pattern appears in the LEED pattern, corresponding to a $(\sqrt{3}\times\sqrt{3})$R30° superstructure, and it is completely matched with the 2D-FFT pattern. Therefore, the superstructure of -OH groups is uniformly distributed over the entire L-EG surface (Figure 2).

Expected effect

A synthesis of highly-ordered functional groups at large scale on graphene has never been reported to the best of our knowledge. Our method of hydroxylation yields a centimeter-scale quasi-single crystal $C_6(OH)_1$ and it would seem likely that this can be scaled to be much larger. Highly-crystalline graphenol achieved with periodic hydroxylation opens many exciting opportunities. First and most obviously, further studies of the properties of the $C_6(OH)_1$ (optical, electrical, biological, chemical) are called for. Perhaps even more importantly, follow on studies are reasonably likely to show that the *further functionalization* of the hydroxyl group that is present in such a periodic arrangement on graphene, can lead to an enormous variety of periodically functionalized graphene substrates, that might have exceptional physical and chemical properties, could find use in a variety of sensing modalities, be useful for studies in biology and medicine, and so on.

Research Outcomes

[Paper] • Lim, H.*; Park, Y.; Lee, M.; Ahn, J.-G.; Li, B. W.; Luo, D., Jung, J.*; Ruoff, R. S.*; Kim, Y.* Centimeter-Scale and Highly Crystalline 2D Alcohol: Evidence for Graphenol (C6OH), Nano Lett. 20, 2107, (2020)

Research Funding

This work was supported by National Research Foundation of Korea (NRF) grant (No. NRF-2018R1C1B6004029 and NRF-2019R1I1A3A01041239.

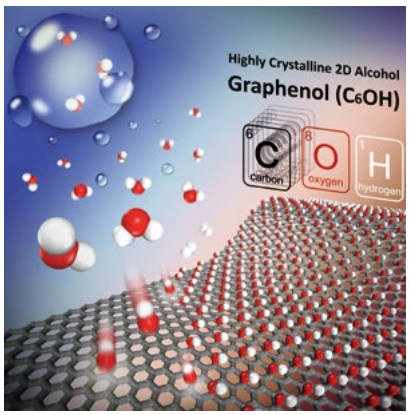


Fig. 1

Schematic illustration of synthetic process for graphenol

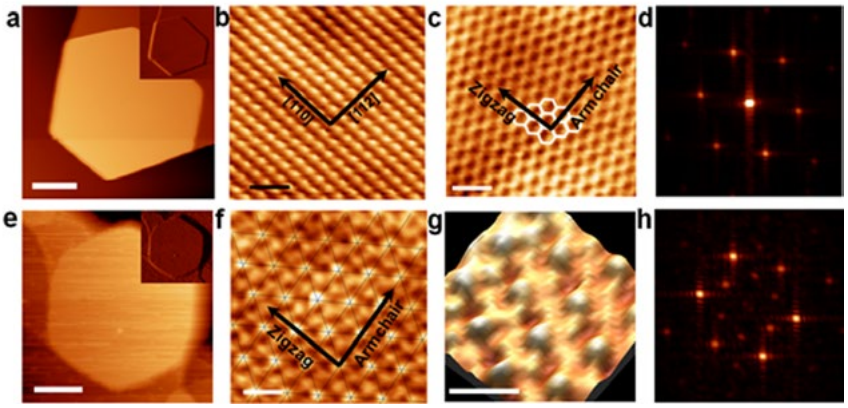


Fig. 2

Atomic scale investigation with STM. (a,b) Graphene, (c,d) Grapheneol (C6OH). LEED patterns of (e) L-EG/Cu(111) and (f) L-EG-OH/Cu(111). (Bottom) A scheme showing consistency between the STM-2D-FFT pattern (atomic scale) and the LEED pattern (bulk scale). [Lim, H. et al. Nano Lett. 20, 2107, (2020)]

Department of Biomedical Science and Engineering

Chang-Myung Oh

cmoh@gist.ac.kr

PRMT1 Is Required for the Maintenance of Mature β-Cell Identity

Loss of functional β-cell mass is an essential feature of type 2 diabetes, and maintaining mature β-cell identity is important for preserving a functional β-cell mass. However, it is unclear how β-cells achieve and maintain their mature identity. Here we demonstrate a novel function of protein arginine methyltransferase 1 (PRMT1) in maintaining mature β -cell identity.

Background

Maintaining the functional β-cell mass is crucial for preventing diabetes, which develops when β-cells fail to meet the insulin demand. Although β-cell death is thought to be the major mechanism of β-cell failure, recent studies indicate that β-cell dedifferentiation can decrease the functional β-cell mass and thereby deteriorate systemic glucose homeostasis.

Histone arginine methylation, which is regulated by protein arginine methyltransferase (PRMT), can affect chromatin structures to facilitate the recruitment of protein complexes that regulate gene transcription (17,18). PRMT4-dependent histone H3 arginine 17 asymmetric dimethylation (H3R17me2a) in β-cells has been reported to regulate glucose-stimulated insulin secretion (GSIS) (19). However, the role of PRMT-induced histone arginine methylation in regulating β-cell identity has not yet been elucidated. Here, we explored the role of PRMT1-dependent H4R3me2a in mature β-cells.

Contents

Prmt1 knockout in fetal and adult β-cells induced diabetes, which was aggravated by high-fat diet–induced metabolic stress. Deletion of Prmt1 in adult β-cells resulted in the immediate loss of histone H4 arginine 3 asymmetric dimethylation (H4R3me2a) and the subsequent loss of β-cell identity.

HFD exacerbated the glucose intolerance in Prmt1 βKO mice without perturbing compensatory β-cell expansion (Fig. 1G and Supplementary Fig. 6B). Interestingly, the islets of HFD-fed Prmt1 βKO mice contained polyhormonal cells that coexpressed insulin and glucagon (GCG) (Figure 1).

Prmt1 βKO mice grew normally and showed normal glucose tolerance until they developed glucose intolerance at 12 weeks of age. Despite this glucose intolerance, Prmt1 βKO mice showed no defects in insulin sensitivity and insulin production. Instead, GSIS was impaired in Prmt1 βKO islets (Figure 2).

Deletion of Prmt1 in adult β-cells resulted in the immediate loss of H4R3me2a, which induced robust changes in the transcriptions of genes necessary for the maintenance of mature β-cell function and identity. PRMT1-dependent H4R3me2a worked as an active histone code that increased chromatin accessibility at the binding sites for CTCF and β-cell TFs, including NKX6.1, MAFA, PDX1, and NEUROD1 (Figure 3).

Expected effect

Our phenotypic, transcriptomic, and epigenomic analyses of stage-specific Prmt1 KO in β-cells provide a new mechanistic insight into the regulation of mature β-cell identity.

Research Outcomes

[Paper] • Kim, H., Yoon, B. H., Oh, C. M., Lee, J., Lee, K., Song, H., ... & Kim, H. (2020). PRMT1 Is Required for the Maintenance of Mature β-Cell Identity. Diabetes, 69(3), 355-368.

Research Funding

This work was supported by grants from the National Research Foundation funded by the Ministry of Science, ICT and Future Planning, Republic of Korea (grants NRF-2013M3A9D5072550 to J.K.S., NRF-2017M3C9A5028693 to M.K., and NRF-2014M3A9D5A01073546, NRF-2018R1A2A3074646, and NRF-2015M3A9B3028218 to Hail. Kim), the Korea Research Institute of Bioscience and Biotechnology Research Initiative (to M.K.), and the Korea Advanced Institute of Science and Technology Institute for the BioCentury (grant N10180027 to Hail. Kim).

Fig. 1

Representative islet images obtained by immunofluorescence (IF) of PRMT1 KO mice.

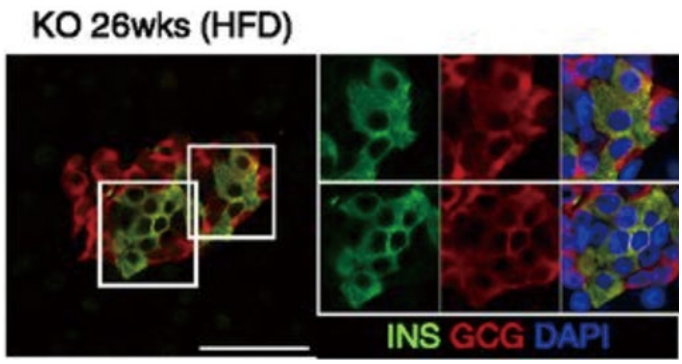


Fig. 2

(A, B) Intraperitoneal glucose tolerance test (IPGTT) of 6-week-old male control and Prmt1 βKO mice. (C) In vivo GSIS assay after a 16-h fasting.

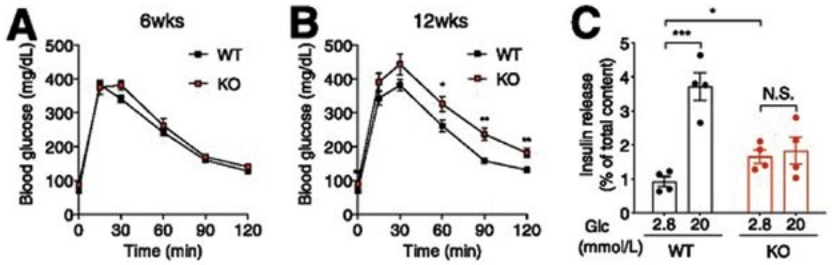
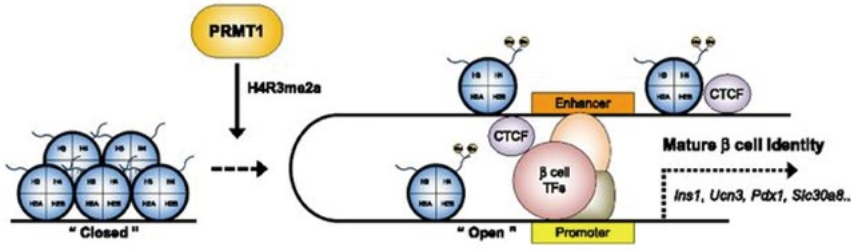


Fig. 3

Schematic representation describing the physiological role of PRMT1-dependent H4R3me2a in mature β-cells.

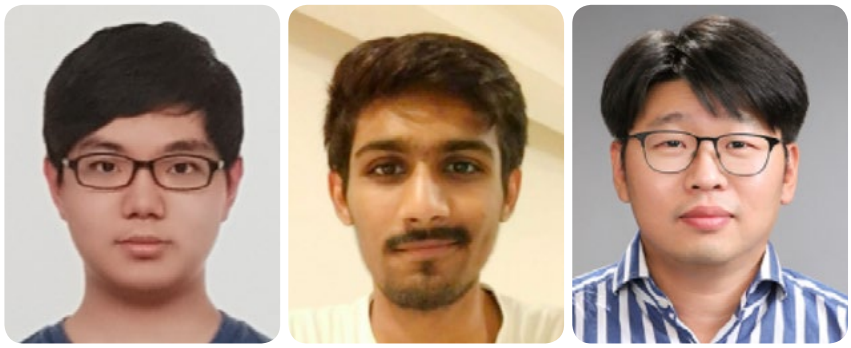


AI Graduate School

Jonghyun Choi

jhc@gist.ac.kr

Binary neural network architecture search



We develop a neural architecture search method for binary networks which may solve a bottleneck in AI deployment to edge devices.

Background

Architecture design for binary network has been hand-crafted thus not perform well. As a remedy, we may think about the architecture search methods. Unfortunately, previously proposed neural architecture search methods are not applicable to binary networks with trivial modification.

Contents

To enable neural architecture search for binary network, we propose three techniques as follows.

(1) Modifying cell template

To reduce the quantization errors to be propagated through the layers, we modify the cell template as following illustration:

(2) New search space

To reduce the quantization error in search, we design a new search space as follows. The proposed search space includes Zeroise layer which has been used to model "no connection" thus not used in the final architecture. But we use it for reducing quantization error.

Layer Type	Bin Conv.		Bin Dil. Conv.		MaxPool	AvgPool	Zeroise
Kernel Size	3×3	5×5	3×3	5×5	3×3	3×3	N/A

(3) New objective function to reduce search bias in early search stage by increasing diversity of layer types

Binary network is slow to train thus the search algorithm tends to pick the "non-trainable" layers at the early search stage. This causes artificial accuracy drops. To prevent it, we design a novel objective by using entropy of selected layer types as follows:

$$\tilde{\mathcal{L}}_S(D;\theta_{\alpha_B}) = \mathcal{L}_S(D;\theta,p) - \lambda H(p) e^{(-t/\tau)}$$

$H(\cdot)$ is the entropy, λ is a balancing hyper-parameter, t is the epoch, and τ is an annealing hyper-parameter.

Expected effect

Binary networks consume very small amount of space in memory and energy. They are suitable for deploying AI systems in edge devices, which enables our daily life fruitful.

Research Outcomes

[Paper] • D Kim, K P Singh, J Choi, "Learning Architectures for Binary Networks," ECCV 2020

[Patent] • Application No KR. 10-2140996 "Neural architecture search method and apparatus for binary neural network"

[Press release] •(artificial intelligence newspaper) "AI Graduate School Professor Choi Jong-hyun's team, Presenting a binary deep learning structure search method that greatly improves the performance of AI algorithms" (2020.8.30.)

•(techworld online news) "Gist develops binary neural network structure discovery method" (2020.8.28.)

[Award] • 2020 Samsung Humantech Paper award – Bronze Prize

Research Funding

This work was partly supported by the National Research Foun- dation of Korea (NRF) grant funded by the Korea government (MSIT) (No.2019R1 C1C1009283), Institute of Information & communications Technology Planning & Evaluation (IITP) grant funded by the Korea government (MSIT) (No.2019-0-01842, Artificial Intelligence Graduate School Program (GIST) and No.2019-0-01351, Devel- opment of Ultra Low-Power Mobile Deep Learning Semiconductor With Compres- sion/Decompression of Activation/Kernel Data), "GIST Research Institute(GRI) GIST-CNUH research Collaboration" grant funded by the GIST in 2020, and a study on the "HPC Support" Project, supported by the 'Ministry of Science and ICT' and NIPA.

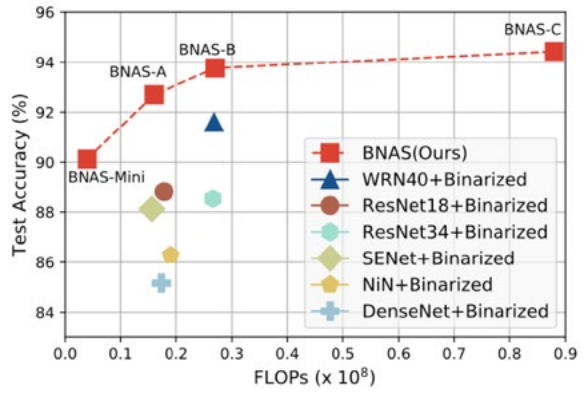


Fig. 1 Accuracy comparison to other binary networks

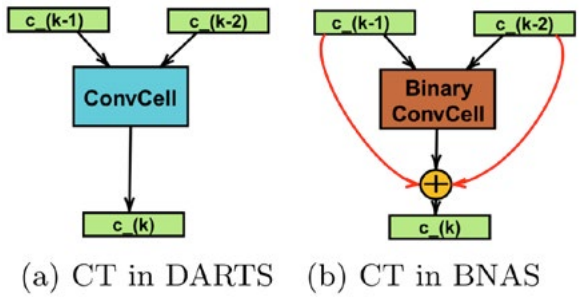


Fig. 2 Proposed Cell Template Structure (Right)

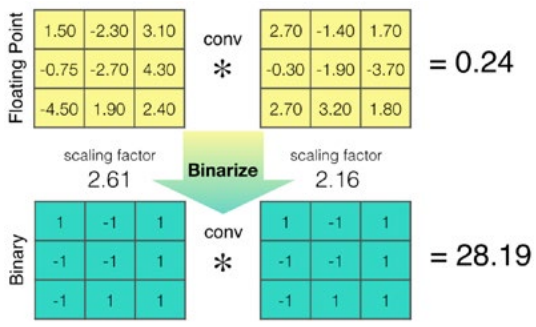


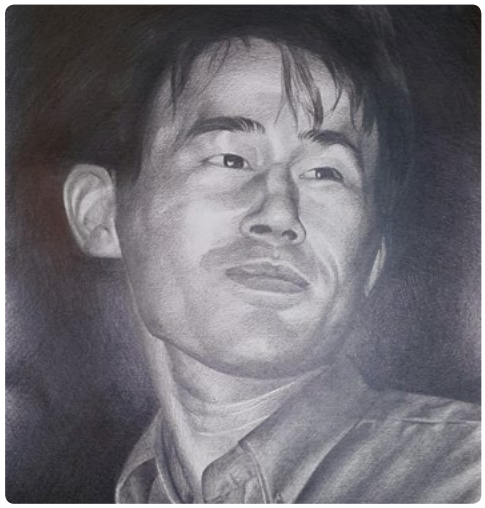
Fig. 3 Example when Zeroise layer is helpful

Division of
Liberal Arts and Sciences

**Mingyo Kim
and Chi-Ok Hwang**

https://clabs.gist.ac.kr/~chwang/

Infinite Parallel Plates Algorithm



This research was done together with Mingyo Kim, who was an undergraduate student intern (2016~2017) at that time when this research was done and now after obtaining master degree from GIST is working at Hynix Semiconductor Company.

In GIST Research Lab. for Mathematical Sciences, there have been published some SCI journal research papers, including "Off-centered "Walk-on-Spheres" (WOS) Algorithm" in Journal of Computational Physics, which were done by undergraduate intern students. This paper is on the same tradition.

Background

In 2003, I published a paper of last-passage algorithm with my research advisor and later in 2006 developed an application of the last-passage algorithm, mutual capacitance algorithm. In the mutual capacitance algorithm, I have to use an ε-layer for the convergence of the diffusion simulation, which induced another error the algorithm. To remove the ε-layer, I developed this infinite parallel plates algorithm.

Contents

In a diffusion Monte Carlo simulation, when diffusion starts between two parallel planes, the “walks-on-spheres” (WOS) algorithm is usually used. In this case, an absorption *e*-layer is used to terminate the diffusion. Here, based on isomorphism between the electrostatic Poisson problem and the corresponding diffusion motion expectation of the first passage, a new parallel-plates algorithm is developed without an absorption layer, which induces another diffusion error in addition to the intrinsic Monte Carlo error.

As there is not an analytic closed solution for the induced charge density on the parallel plates by a charge at the center between them, a series solution is used, combined with the acceptance–rejection sampling method. Using this algorithm, even though a series solution is used, it is shown that an exact sampling can be performed, which means that the random walk jump can be performed to the parallel planes without using the detailed WOS random walk jumps. It is verified that the proposed parallel plates algorithm is significantly more efficient than the current WOS algorithm.

Expected effect

In GIST, there are many undergraduate research intern students. This SCI paper result in cooperation with an undergraduate can encourage intern students to participate in intern programs more actively aiming high. In addition, this result shows the world-level research capacity of GIST.

Research Outcomes

[Paper] • C.-O. Hwang, M. Kim, " Infinite Parallel Plates Algorithm'" , Advanced Theory and Simulations, 3(6), https://doi.org/10.1002/adts.202000014 (May 5, 2020)

Research Funding

1. National Research Foundation of Korea (NRF) funded by the Ministry of Science, ICT, and Future Planning (2017R1E1A1A03070543).

2. the GIST Research Institute (GRI) in 2018.

Fig. 1

Parallel conducting planes with spacing D and unit point charge q located at z_0.

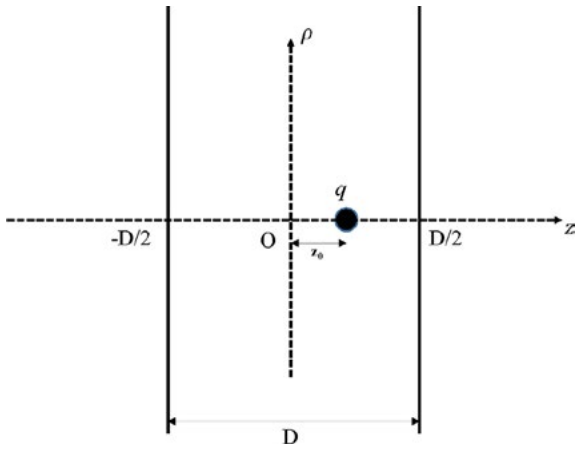
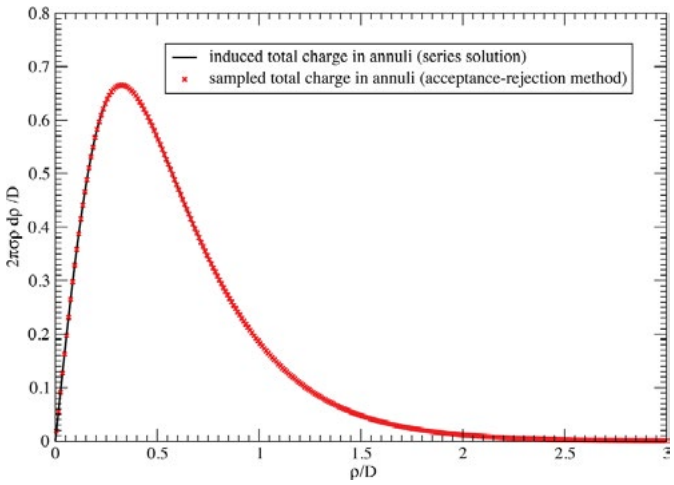


Fig. 2

Sampled charge distribution (red cross symbols), obtained from 272 independent runs with Carlo random walks N=107, each using the acceptance-rejection method, and the series solution (black solid line) on the plate. The error is too small to be shown.

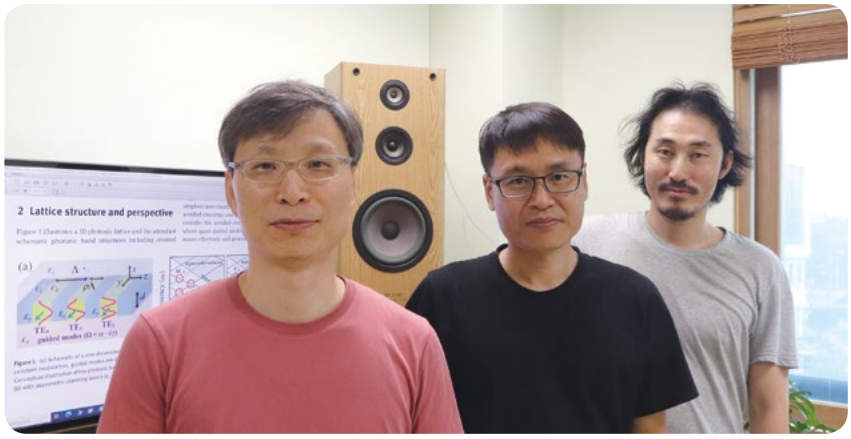


Advanced Photonic Research Institute

Chul-Sik Kee

www.apri.gist.ac.kr

Principle of bound states in the continuum to trap light almost forever in photonic crystals



Dielectric structures that can effectively trap light in spaces smaller than wavelengths are expected to serve as the basis for realizing high-capacity optical communication and high-speed data processing technologies required by future societies. However, natural light energy leakage in dielectric structures significantly reduces the interaction efficiency between light and matter, hindering optical applications. Recently, research that traps light almost forever using bound states in the continuum (BIC) formed within photonic crystals, periodic dielectric structures, has received great attention. We theoretically established the principle of generation of bound states in the continuum (BIC) to trap light in a space less than one-thousandth the size of hair in thin film slab photonic crystals. The proposed theoretical model can be useful in realizing photonic crystal nanolasers, super-sensitivity optical sensors and developing quantum communication technologies.

Background

In the late 1970s, it has been theoretically predicted that leak modes of a photonic crystal can have no radiation into the air, but the characteristics of these modes were not associated with the BIC concept of quantum mechanics. In 2008, French scientists proposed the BIC theory of photons using waveguide arrays, and in 2011, Israeli scientists experimentally demonstrated the BIC phenomenon of photons for the first time using a waveguide array and a pair of waveguides. BIC mode has theoretically infinite quality factor because it has no radiation loss. In 2013, American scientists also discovered an accidental BIC mode with infinite quality factors independent of symmetry in photonic crystals. However, although there has been a lot of research on BICs using photo-crystal crystals, no theoretical models have been presented for BIC formation and no systematic theoretical exploration has led to difficulties in the design of photonic crystal structures implementing BICs and their application

Contents

We systematically have established a theoretical model for BICs in thin film slab photonic crystals to trap light in a thin film less than 1 micron thick. The guiding modes of the thin film slab photonic crystal have even and odd modes with the spatial distribution of the magnetic field relative to the center of the slab photonic crystal. BICs are generated by destructive interference between same symmetry modes, and incomplete destructive interference between different symmetry modes only emits light above or below the thin film.

Expected effect

Physical understanding and theoretical models of the BIC generation principles in photonic crystals are expected to broaden knowledge of optical properties of photonic crystals and deepen understanding of the interactions of periodic optical structures and electromagnetic waves. In addition, the proposed theoretical model is expected to be utilized for ultra-high-quality high-efficiency nanolasers, high-sensitivity spectroscopy sensors, and high-resolution optical filters using BICs.

Research Outcomes

[Paper] • Sun-Goo Lee, Seong-Han Kim, Chul-Sik Kee, "Bound states in the continuum (BIC) accompanied by avoided crossings in leaky-mode photonic lattices," Nanophotonics 9(14), 4373 (2020)

[Press release] • 2020. 8. 19자 Electronic Times (전자신문), Dong-A Science (동아사이언스) 외 5건

Research Funding

This research was supported by the grant from the National Research Foundation of Korea (NRF) funded by the Ministry of Education (No.2020R1I1A1A01073945) and Ministry of Science and ICT (No. 2020R1F1A1050227). This work was also supported in part by the Gwangju Institute of Science and Technology (GIST) Research Institute (GRI) in 2020.

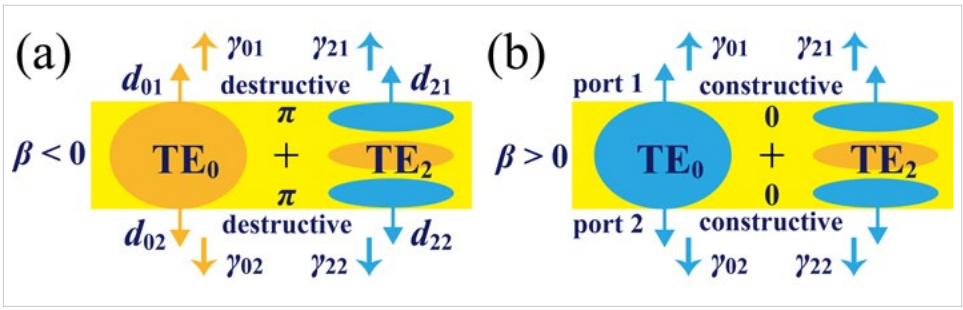


Fig. 1

Conceptual illustration of far-field coupling of radiating waves due to TE0 and TE2 modes. Radiating waves originating from different modes interfere (a) destructively when β < 0 and (b) constructively when β > 0 at the two radiation ports simultaneously.

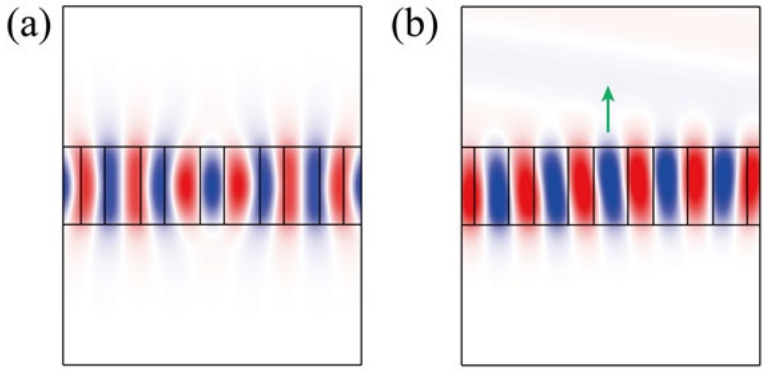


Fig. 2

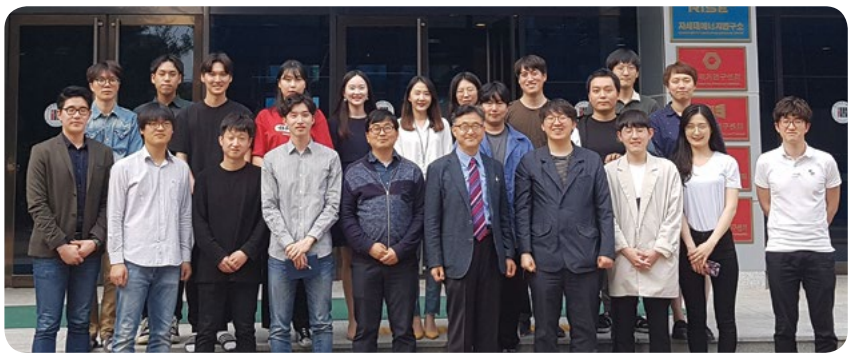
Finite element method simulated radiation powers of (a) BIC and (b) unidirectional mode in a leaky-mode slab photonic crystal.

Research Institute for
Solar and Sustainable Energies

Kwanghee Lee

https://rise.gist.ac.kr

Highly stable inverted methylammonium lead tri-iodide perovskite solar cells achieved by surface re-crystallization



Planar-type inverted perovskite solar cells are one of the most promising solar cells for cost-effective energy generation because they can be manufactured through a solution-based process at low temperatures. However, they intrinsically suffer from poor operational stability. This is known as “burn-in loss,” which is important to minimize, but its causes are not fully understood. In this work, we explored the origin of burn-in loss in “methylammonium lead tri-iodide-based perovskite” solar cells We found that the problem arises due to the presence of amorphous regions in the interface between the electron transport layer and the methylammonium lead tri-iodide film. Using this technique, highly stable perovskite solar cells can be produced, which show nearly unchanging performance even after one thousand hours of solar irradiation and high temperature storage.

Background

The perovskite solar cells (PeSCs) are one of the most promising energy devices due to the superior opto-electrical properties of the organic–inorganic metal halide perovskite materials and their facile solution processability even at low temperature. However, despite the promising advantages, their intrinsic operational stability, known as notorious ‘burn-in loss’, has been a central issue to be overcome for their successful commercialization. In this work, we reveal the origin of the burn-in loss, which is related to the stoichiometric defects and the correlated amorphous regions on the perovskite surface. Such amorphous surface can be re-crystallized even in solid-state film form.

Contents

In this work, by applying a vacuum-assisted solid-phase re-crystallization process to the MAPbI3 layer with the PCBM, we were able to successfully remove the amorphous region at the surface of the MAPbI3 layer, resulting in a reconstructed surface stoichiometry, approaching to an ideal stoichiometry for the MAPbI3 layer. The PCBM layer holds the ionic defects extracted from the MAPbI3 layer during the vacuum process and facilitates stoichiometric recrystallization of MAPbI3. After subsequent removal and redeposition of the PCBM layer on the vacuum processed MAPbI3 layer, we demonstrated a long-term operational and thermal stability in the p-i-n planar-type inverted PeSCs, which maintain over 80% and 90% of their initial power conversion efficiencies even after 1000 hours of real operation (under AM 1.5G irradiation) and continuous heating conditions (at 85 1C in the dark), respectively.

Expected effect

Our study showed the existence of a nonstoichiometric amorphous phase on the MAPbI3 surface and confirmed that such ionic imperfection leads to fast burn-in degradation of the operational performance of perovskite solar cells at their maximum power points (MPPs) under operation condition with A.M. 1.5G irradiation. Therefore, our new method, which recrystallizes the amorphous surface to the MAPbI3 crystal in solid phase, could fabricate an ideal stoichiometry for the surface of MAPbI3 layer and demonstrate "burn-in loss-free PeSCs based on MAPbI3" with the long-term operational and thermal stability of PeSCs. These long-term stabilities have never been achieved before in MAPbI3-based thin-film PeSCs and also indicates that notoriously weak MAPbI3 based PeSCs can be 'intrinsically' stable with a stoichiometric defect-free condition. We expect our approach provides new way for fabricating the highly stable perovskite solar cells.

Research Outcomes

[Paper] • "Highly stable inverted methylammonium lead tri-iodide perovskite solar cells achieved by surface re-crystallization:, Energy & Environmental Science, 13, 840-847, 2020

[Press release] • (Hankyungmedia) "Discovery of clues to increase the lifespan of perovskite solar cells" 2020.03.10.(https://www.hankyung.com/it/article/202003100255Y)

Research Funding

- GIST Research Institute Grant
- The Global Research Laboratory Program of the National Research Foundation (NRF)
- The Basic Science Research Program (NRF)

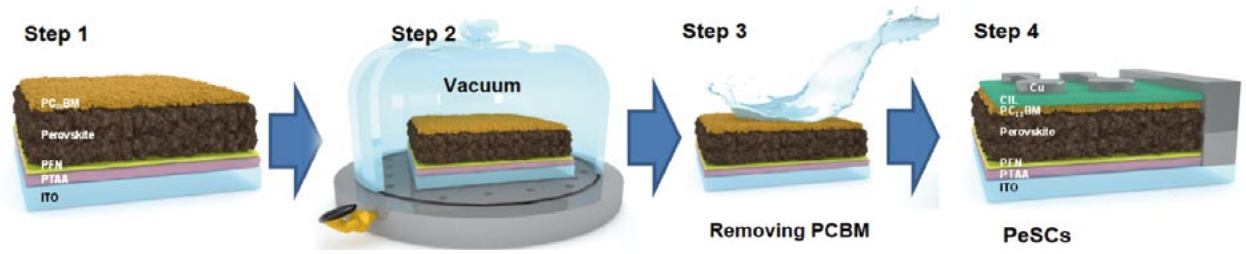
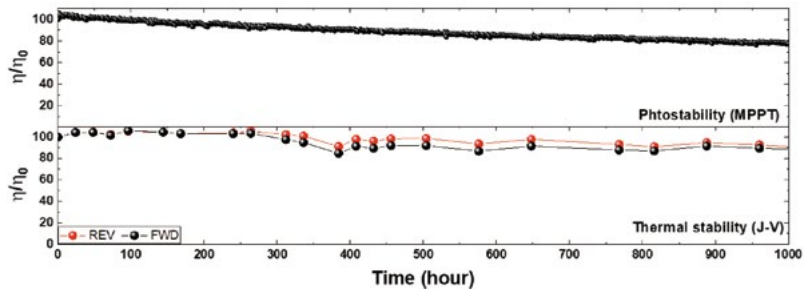


Fig. 1 Fabrication process of surface re-crystalization of perovsktie solar cells.

Fig. 2

Photo- and Thermal-stability data of surface re-crystallized perovskite solar cells.



Korea Culture Technology Institute

Moongu Jeon

mgjeon@gist.ac.kr

Development of Smart Media Wall Platform Using User Gesture and Behavior Recognition Technology

With the advent of the Fourth Industrial Revolution, the culture and arts scene is changing rapidly, and as result, interest and demand for large scale exhibitions/events/festival utilizing advanced technologies such as IoT and artificial intelligence are on the rise. Futhermore, there is emphasis on artworks that invite audience interaction by promoting participation and communication with the artists and event organizers. Based on this social trend, we have developed gesture recognition techniques, multi-object detection and tracking techniques for user interaction in exhibition environments, and applied the development results to smart media walls. The developed technology was implemented in an interactive experience exhibition 'Asia Cultural Map - The Road of Ramayana' at the Asia Culture Center, hence securing a platform for commercialization of the technology in cultural and artistic infrastructure.

Background

The culture and arts sector focuses on creation, exchange, and experience, making it difficult to invest preemptively large budgets in technology development. Therefore, it is necessary to discover the demand for experimental exhibition platforms with advanced technologies such as AI at public cultural and artistic institutions and demonstrate the development results, in order to introduce them to the private sector. In particular, it is necessary to develop smart media wall systems that utilize hand gestures and face recognition technology that can enhance the interaction between exhibition contents and the audience.

Contents

For deep learning-based user gestures and action-aware technology development, we first implement a baseline model of three modules: multi-object detection and tracking, hand gesture recognition, and body action recognition. The performance was self-evaluated and targeted via a specific public dataset for each module.

In order to develop smart media wall platform modules and production tools, the first prototype was designed and used to build a smart media wall at the Asia Culture Center. User-responsive data was designed for an interactive experience exhibition called 'Asian Culture Map – The Road to Ramayana', using Media Wall, to reflect content that will be expanded in the future.

Expected effect

This research can provide various experiential exhibitions to the public through interactive smart media wall platforms. In particular, it is expected to be commercialized in the private sector as it can offer an advanced exhibition experience environment such as intelligent content recommendation, data augmentation and visualization by utilizing Art DB and data from cultural and art institutions.

Research Outcomes

[Paper] • Younkwan Lee, Hyeongjun Yoo, Yechan Kim, Jihun Jeong and Moongu Jeon, "Self-Supervised Attribute-Aware Refinement Network for Low-Quality Text Recognition", European Conference of Computer Vision (ECCV) Workshop, Online, Aug. 23-28, 2020

[Press release] • Asian Cultural Resources and Culture Technology Convergence Exhibition (ETnews)

[others] • Program registration 4 cases (image style generation deep learning algorithm for new media art production)

• Asia Culture Center Exhibition (Operation of the Asian Cultural Map Interactive Experience Exhibition)

Research Funding

Supported by the Ministry of Culture, Sports and Tourism's R&D Policy Designation Task (Development of Intelligent Agent-based Smart Stage Exhibition Dynamic Space Cognitive Media Wall Platform)

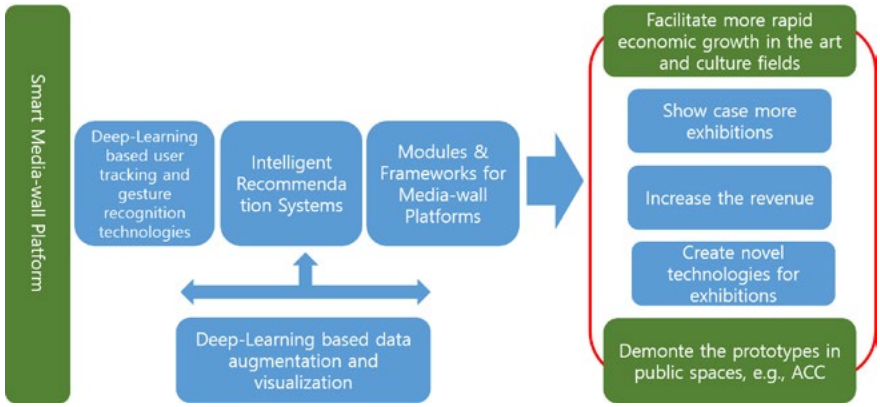


Fig. 1
Project Development Stages

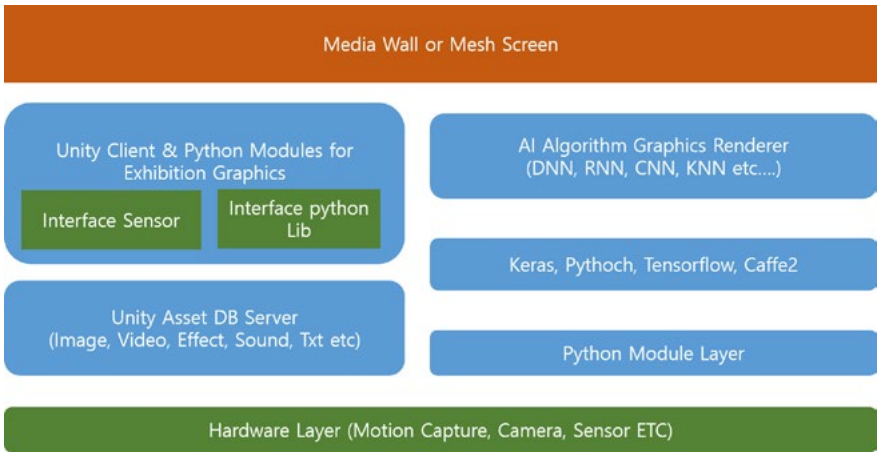


Fig. 2
Intelligent Media Wall Design Summary

Fig. 3
Demonstration of Gesture-aware Interactive Content Using Asian Cultural content, the great epic 'Ramayana'. (Asia Culture Center)

Intergrated Institute of Biomedical Research

Darren R. Williams

daehopark@gist.ac.kr

Inhibited inositol monophosphatase and decreased myo-inositol concentration improve wasting in skeletal muscles

Our research shows that ebselen, a clinically safe drug, may be developed to treat skeletal muscle wasting. Inositol monophosphatase is the biological target of ebselen. Preventing the accumulation of myo-inositol in wasting skeletal muscle using ebselen reduced the expression of atrogenes that mediate muscle wasting and reduced protein degradation. The effects of ebselen and inositol monophosphatase inhibition on skeletal muscle wasting was demonstrated in animal models and muscle tissues derived from human donors.

Background

Skeletal muscle wasting occurs in numerous degenerative diseases associated with aging. It is linked to higher morbidity and mortality, and reduced capacity for independent living. Thus, muscle wasting produces a major economic burden for society. Because there are currently no approved drugs for muscle wasting, there is an urgent need to discover new target-based drugs and therapies. Furthermore, the need for new drugs to treat muscle wasting is increasing due to population aging. Many large pharmaceutical companies have withdrawn from this research due to excessive costs and high-profile failures, leading to concern about the development of lead compounds for treating muscle wasting. A potential solution is to repurpose drugs from their original clinical application. Consequently, our team has identified inositol monophosphatase as a new drug target and the clinically safe drug, ebselen, as a candidate for repurposing (Figure 1).

Contents

The dexamethasone model was used to measure skeletal myotube wasting. Myotubes treated with ebselen and dexamethasone had higher average diameter and increased proportion of larger myotubes compared to those treated with dexamethasone alone (Figure 2). The role of inositol monophosphatase (termed IMPase) in myotube wasting was confirmed by gene knockdown. Increased skeletal muscle wasting is associated with increased expression of E3 ubiquitin ligases, atrogin-1 (MAFbx), and MuRF-1 (TRIM63), which are targets of the master transcription factor, forkhead box O3 (FoxO3a) that is upregulated in muscle wasting. Immunocytochemistry analysis indicated that FoxO3a expression was increased in dexamethasone-treated myotubes and decreased in ebselen-treated myotubes.

The effect of IMPase inhibition by ebselen in vivo was assessed in the mouse dexamethasone treatment model. Myo-inositol concentration was increased in the gastrocnemius muscle of mice receiving dexamethasone and lowered in those receiving ebselen. Dexamethasone treatment significantly reduced quadriceps muscle mass, which was recovered by ebselen treatment. Skeletal muscle performance was

assessed using the inverted hanging and grip strength tests. Ebselen therapy significantly enhanced hanging time and grip strength compared to dexamethasone alone. To assess whether ebselen has potential as an anti-wasting compound in human skeletal muscle, differentiating human primary myoblasts were treated with dexamethasone with or without ebselen. Dexamethasone produced a decrease in both myotube diameter and the proportion of larger diameter myotubes (Figure 3).

Expected effect

Ebselen was studied in numerous clinical trials as a treatment for psychological disorders, while our results present ebselen as a potential drug for improving muscle wasting. The identification of IMPase as a potential new target for drug discovery can also facilitate efforts to develop novel chemical entities for the effective treatment of muscle wasting disorders.

Research Outcomes

[Paper] • Lee et al, "Inhibited inositol monophosphatase and decreased myo - inositol concentration improve wasting in skeletal muscles", Clin Trans Med. Lett. e251, 2001-1326 (2020) IF=7.919, JCR ranking=상위 7.6% 이내

[Patent] • Composition for the treatment of skeletal muscular muscular atrophy comprising organoselenium chemical, Application No. KR 10-2020-0074322

Research Funding

This research was supported by a National Research Foundation of Korea (NRF) grant funded by the Korean government and Institute for Information and Communications Technology Promotion funded by the Korea government. This work was supported by "GIST Research Institute (GRI) ARI" grant fund.

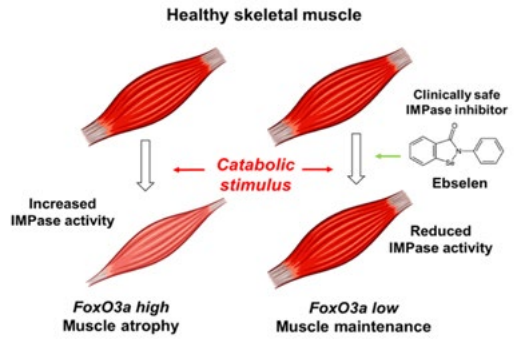


Fig. 1 Schematic illustration of the role of inositol monophosphatase (IMPase) and the preventative effect of the clinically safe inhibitor drug, ebselen, on skeletal muscle atrophy.

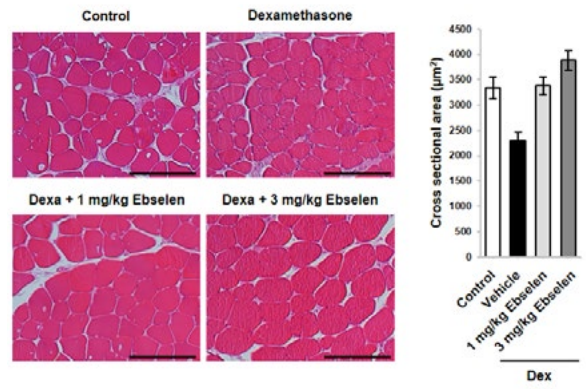


Fig. 2 Cross sectional analysis and representative images in quadriceps muscle dissected from mice.

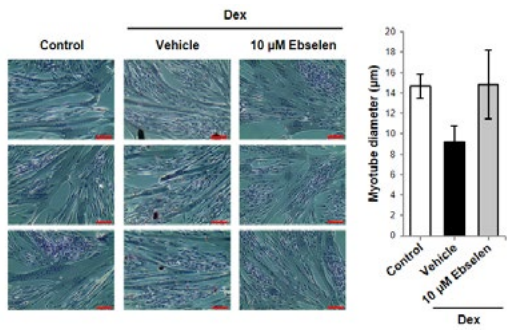


Fig. 3 Myotube diameter analysis and representative images in human primary myotubes.

International Environmental Research Institute

Kyoung-Woong Kim

https://ieri.gist.ac.kr/ieri/

The impacts of Himalaya's glacier melting on arsenic mass balance and its mobility in Mekong and Salween sub-region groundwater

The main focus of this study is to measure and monitor arsenic pollution in the Mekong River and Salween river together with its nearby groundwater (Thailand, Myanmar, Laos, and Cambodia) as a consequence of the rapidly melting Himalaya glaciers due to climate change. On-site samples (groundwater, surface water, and soil) collection and analysis will be conducted. Data collected will apply to environmental modeling tools. Data collection on arsenic concentration along the Salween and Mekong River sub-region groundwater and the estimation on arsenic mass balance in groundwater can act as a supporting database for regional climate mitigation plans.

Background

The glaciers in the Lancang River Basin had decreased by 98.50 ± 26.61 km2 from 328.16 ± 20.29 km2 in 1968–1975 to 229.66 ± 16.48 km2 in 2005–2010, indicating a loss in total glacier area of about 30% ± 8% during the past 40 years (Qiao et al., 2014). A -39 to -68% relative reduction in Mekong glacial area and –44 to –67% relative reduction in Salween glacial area is expected by 2050 (Pravettoni, 2015). It is well-known that arsenic contamination of well water in the Mekong sub-region has been carried by large volumes of arsenic contaminated sediment flow from major mountain ranges (i.e. Himalayas). Fendorf et al. (2009) reported that transformation products of ferrihydrite reduction can lead to iron (hydr)oxide reductive dissolution which promotes dissolved concentration of arsenic. In addition, organic matter (co-deposited, incorporated, or dissolved) promotes anaerobic conditions in soils/sediments residing below the water table. The mechanism governing the aqueous concentrations arsenic concentration along the groundwater of Mekong and Salween sub-region in Cambodia, Laos, Myanmar, and Thailand remain unknown.

Contents

The receding of glaciers as a consequence of global warming is predicted to severely impact human life. Rapid reduction in the glacial area of the third pole, Himalayan was reported and a relative reduction of -39 to -68% and –44 to –67% for Mekong and Salween basin is predicted by 2050, respectively. It is well agreed that arsenic contamination in Southeast Asia is featured by contaminated sediments naturally eroded from Himalayan. The mechanism governing the concentrations and the release of arsenic to pore water along the Mekong and Salween river sub-region groundwater remain unknown. Given the transboundary nature of both Mekong and the Salween Basin further limited access to arsenic concentration and its data collection. In this study, sample collection will be conducted along the

Mekong and Salween rivers, sub-region groundwater, sub-region soils, and sediment. Data collected will be run with several modeling tools to predicts arsenic mobility. It is expected that the mass balance of arsenic in the aquifers will be affected by the shift in the monsoon trend and increase in discharge due to climate change.

Expected effect

1. The data analyzed will create a database for background arsenic concentration in the Mekong river to support the government in making more specific regulations and solutions regarding the drinking water issues in their country. The arsenic concentration will be detected not only in the groundwater but also in the surrounding soil and sediment samples.
2. The mechanisms of the release of arsenic especially in Holocene deltaic and organic-rich surface sediments are very common in Southeast Asia. In anaerobic conditions, organic-rich surface sediment is going to promote the transformation products of ferrihydrite reduction leading to iron (hydr)oxide reductive dissolution and enhanced the release of dissolved concentration of arsenic.
3. The modeling software will act as a prediction and estimation on the capacity of arsenic in the groundwater and the potential release of arsenic due to climate change, such as an increase in discharge, rapid reduction in the glacier of eastern Himalayan, etc.

Research Outcomes

[Press release] • https://www.gist.ac.kr/kr/html/sub07/070104.html?mode=V&no=197257
[Award] • https://www.apn-gcr.org/ /07/28/approved-new-projects-for-fiscal-year-2020/
[Others] • Reinforcement in international collaboration and networking

Research Funding

This research was supported by the Asia-Pacific Network for Global Change Research (APN) grant funded under the 2019 Collaborative Research for Early-Career Scientists (CRECS) Small Grants Programme (CRECS2020-03MY-Seah).

Table 1

IERI 2012 Annual Research Report – Groundwater quality verification for construction of Arsenic treatment technology in Cambodia.

Water Quality Parameters	CNDWQ	Sampling Dates			
		23-Sep-11	6-Oct-11	18-Oct-11	23-Nov-11
As (ppb)	50	200	135	40	170
Fe (ppm)	0.3	0.637	0.295	0.257	0.837
Mn2+ (ppm)	0.1	0	0	0	0
DO (ppm)	n/a	4.1	5.9	7	2.7
pH	6.5 – 8.5	7.69	7.77	8.14	7.08
E-Coli	0	0	0	0	0
Total Coliform	0	0	0	0	0
PO_4^{3-} (ppm)	n/a	n/a	n/a	n/a	0.06
NO_3^- (ppm)	n/a	n/a	n/a	n/a	1.65
Turbidity (NTU)	5	n/a	n/a	n/a	1.55

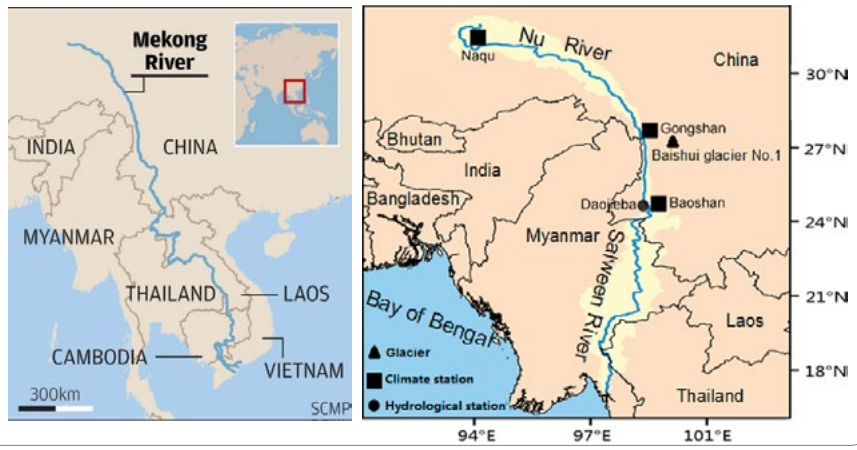


Fig. 1

Map of the study area; Mekong river (left) and Salween river (right).

GIST Institute for Artificial Intelligence

Heung-No Lee

giai@gist.ac.kr

2020 Artificial intelligence-centered industrial convergence complex development project (start-up field): 'Dream AI' project promotion

Overview
- The 'Dream AI' project is the "Demand-Linked AI Preliminary Startup Support (Stand Up) Project" of the "Artificial Intelligence Centered Industrial Convergence Complex Project (Startup Field)". Organized by the Artificial Intelligence Industry Cluster Agency in cooperation with the Ministry of Science and ICT, Gwangju Metropolitan City, and the National IT Industry Promotion Agency (NIPA) and conducted by GIST Institute for Artificial Intelligence.

Project goal
- Using AI products and services, data for AI learning, and AI talent to match the demands of the company and strengthen the competitiveness of the company
- Identification and development of AI talent by establishing and operating a problem-solving AI-specific education system
- Consulting training to support successful commercialization of prospective entrepreneurs through matching AI technology with demand enterprises
- Discover global competitive AI technologies through leaderboard-based tournament competition

Background

Qualitative goal

(Securing new innovation engines) Establishing the foundation for AI convergence industry innovation through the establishment of an artificial intelligence industrial convergence complex (data center, demonstration support, infrastructure to support startup and commercialization, etc.)
(Creating an AI industrial convergence ecosystem) Creation of an industrial innovation ecosystem by linking artificial intelligence technology with major industries (mobility, energy, healthcare, etc.)

Quantitative goal

- Year1 (Target for 2020)

1) AI Industry Convergence Infrastructure Building: Space architecture, Data center infrastructure and service platform ISP, Data Center Building, Establishment of demonstration support equipment, Establishment of AI integrated support service platform
2) AI-specialized start-up support and corporate growth support: Fostering AI startups and discovering excellent AI companies
3) AI Convergence Manpower Training: AI College Education: AI+X Convergence Campus, AI Job Transition and Job Competency Enhancement: AI Do Dream

사업 내용

Project promotion goal

1) Establishment of business infrastructure: Establishment of training practice grounds and related infrastructure that can provide AI specialized training and competitions(Space construction, 1 GPU, 16 PCs)
2) AI technology start-up training: Identify and foster problem-solving AI talent that can connect to business and entrepreneurship by integrating AI in various fields through D.A.M. (beginner to advanced) education(170 graduates, with a satisfaction level of 4.0 or higher)

3) Startup and corporate support:: Entrepreneurship induction and corporate support, (preliminary) start-up solving current problems(Mentoring / Consulting 25 cases)
4) AI demand survey: Develop and utilize educational programs that apply the demands of corporate AI, and connect and apply them as AI demonstration-based competition tasks(90 cases)
5) AI demonstration-based competition

Expected effect

Laying the foundation for a leap forward to an AI powerhouse	Building an innovative AI base by strengthening domestic AI R&D capabilities through the creation of an innovative AI ecosystem.
Creation of AI Convergence Demonstration Environment	Promote "AI Industrial Convergence Technology Development → Commercialization" by creating a demonstration environment for AI convergence technologies in three areas.
Activation of AI startups	Activation of AI startups and promotion of job creation through linkage between startup ideas and corporate demand and support for customized startups specialized in AI
Activation of regional economy	Activation of Gwangju regional economy and provision of future growth engines by linking AI technology with flagship industries (energy, healthcare, mobility)
Improvement of AI convergence R&D technology competitiveness	Securing AI technology competitiveness in the flagship industry

Research Outcomes

[Establishment of education center] • Establishment of AI Studio in AI Graduate School
[AI-specialized technology start-up training] • 170 AI training graduates, education satisfaction 4.0
[Start-up and corporate support] • 42 cases of start-up and corporate support
[AI Demand Survey] • Demand Survey Progress: 292 Total Demand (KPI: 90)
[AI demonstration-based competition]
• Fields: Mobility(Intel, AWS), Healthcare(NVIDIA), Energy(LG Electronics), Open Challenge(CJ Olivenetworks & KOPTI)
• A total of 29 teams competed in two finals, and 4 teams won the Gwangju Metropolitan City Mayor's Award for 20 million won.
[Press release]
• The Korean economy, etc.(2020.6.27.), "GIST, Dream AI will be held next month for the largest AI competition in Korea."
• Dong-A Science (2020.8.12), [Human·Empathy·AI] ⑦ Success or failure lies in problem definition and market understanding rather than coding
• Maekyung (2020.8.27.), [GIST leading the future society] GIST taking a quick step toward internationalization and convergence... cultivating global AI talent
• Veritas Alpha, etc. (2020.12.17.), "GIST, AI Entrepreneur Contest Successfully Finished"

Research Funding

2020 Artificial intelligence-centered industrial convergence complex construction project; KRW 1,800 million (Ministry of Science and ICT -Information communication broadcasting business project)

Fig. 1 AWS DeepRacer

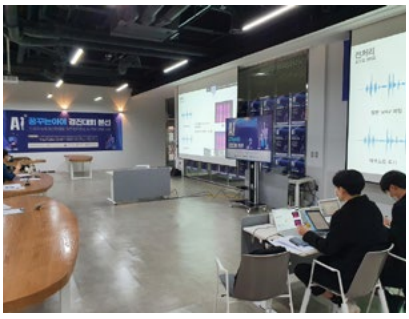


Fig. 2 Final Competition

Fig. 3 Final winners and GIST President, GIAI Director

- School of Electrical engineering and Computer Science
- School of Materials Science and Engineering
- School of mechanical engineering
- School of Earth Science and Environmental Engineering
- School of Life Science
- School of Integrated Technology
- Graduate School of Energy Convergence
- Department Of Physics and Photon Science
- Department Of Chemistry
- Department Of Biomedical Science And Engineering
- AI Graduate School
- Research Institute for Solar and Sustainable Energies
- Korea Culture Technology Institute
- Intergrated Institute of Biomedical Research
- International Environmental Research Institute
- GIST Institute for Artificial Intelligence

GIST ANNUAL R&D REPORT

Gwangju Institute of Science and Technology

GIST's Research Highlights of 2020

School of Electrical engineering and Computer Science
Solid State Lighting Lab

Dong-Seon Lee

http://ssll.gist.ac.kr

Impact of Na doping on the Carrier Transport Path in Polycrystalline Flexible $Cu_2ZnSn(S,Se)_4$ Solar Cells

This research explained that Na doping could have good effect on fill factor(FF) of CZTSSe thin film solar cells and proposed a specific model design about optimized selection of carrier transport path. Flexible CZTSSe thin film solar cells were fabricated on molybdenum foil and their performance was optimized by NaF doping in range of 5 to 30 nm thickness. The Flexible CZTSSe thin film solar cell showed best performances when the thickness of NaF was 25 nm, which were 8.7% of PCE (Photoconversion Efficiency) and 62.63% of fill factor (FF). In this research a specific and differentiated model has been designed for optimized carrier transport paths. The designed model can clearly explain that the best carrier transport path is determined by high-potential difference between intragrain (IG) and grain boundary (GB). Through the optimization based on this model we could achieved the improved perfomances of the CZTSSe thin film solar cell with low series resistance and reduced harmful recombination of carriers, leading to 62.63% in FF, which was the one of highest value at the point of the paper submission.

Contents

CZTSSe solar cells were fabricated by controlling the doping concentration of NaF in this research. NaF was evaporated by an e-beam evaporator. Performances of the samples with various NaF doing were shown in Figure 1. Every basic parameter is improved when Na doping was optimized and the performances of solar cells were best in NaF 25 nm (PCE: 8.7%, FF: 62.63%). This measurement also showed that excessive doping could have negative effects on the absorber layer. Figure 2 showed the location of doped Na in the absorber layer by Atomic probe tomography (APT). Most of doped Na ions was located on the GB and this result could explain the potential difference between IG and GB measured by Kelvin Probe Force Microscopy (KPFM). We proposed a model about the mechanism of determining carrier transport path by these results. The model explained that electrons were transported in GB and holes in IG. The model also explains that appropriate Na doping can reduce series resistance and harmful recombinations of the carriers.

Research Outcomes

[Paper] • W. Jeong, K. Kim, J. Kim, H. Park, J. Min, J. Lee, S. Mun, S. Kim, J. Jang, W. Jo and D. Lee, "Impact of Na doping on the Carrier Transport Path in Polycrystalline Flexible $Cu_2ZnSn(S,Se)_4$ Solar Cells", Adv. Sci. 1903085 (2020)

[Press release] • "Good charging efficiency and long lifespan... Resolving the disadvantages of existing solar electricity ", etnews, (2020)

[Others] • K. Kim, W. Jeong, and D. Lee, "Optimization of Sodium and Zinc Composition of a Flexible CZTSSe on Molybdenum Foil for High Photoconversion Efficiency", 38th EU PVSEC (2019)

Research Funding

• This work was supported by the GIST Research Institute (GRI), the Korea Institute of Energy Technology Evaluation and Planning (KETEP), the Ministry of Trade, Industry and Energy (MOTIE) of the Republic of Korea (No. 20183010014310) in 2020.

• This work was supported byBasic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (NRF-2018R1A6A1A03025340) in 2020.

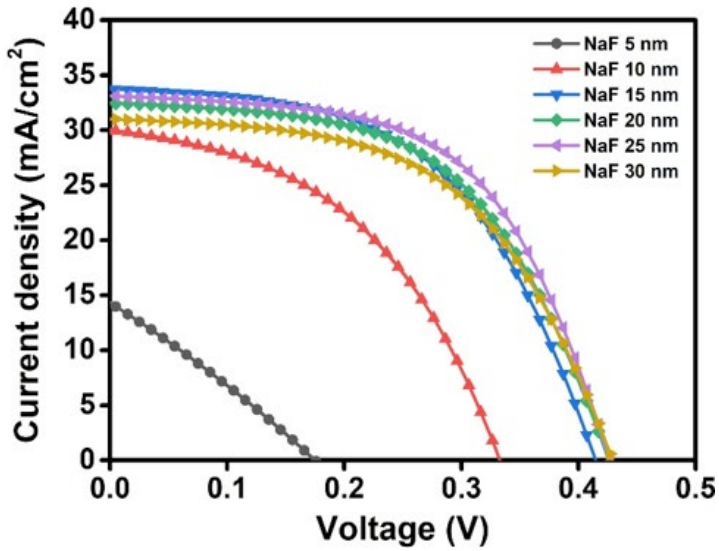


Fig. 1

Current density-voltage curve of flexible CZTSSe solar cells]

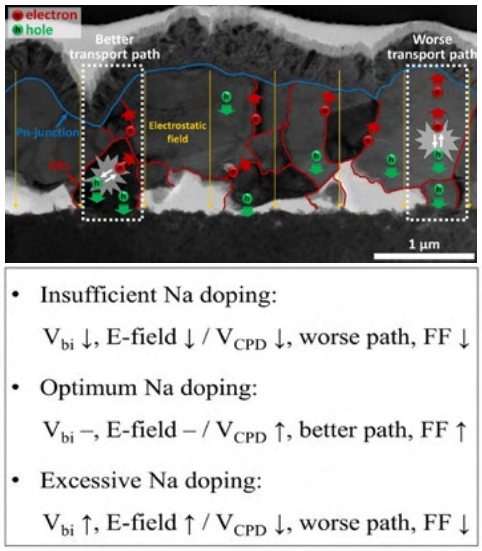


Fig. 3

Schematic representation of the effect Na doping on the electron-hole transport path illustrated on a cross-sectional TEM image of the CZTSSe solar cell sample with a 30 nm thick NaF layer

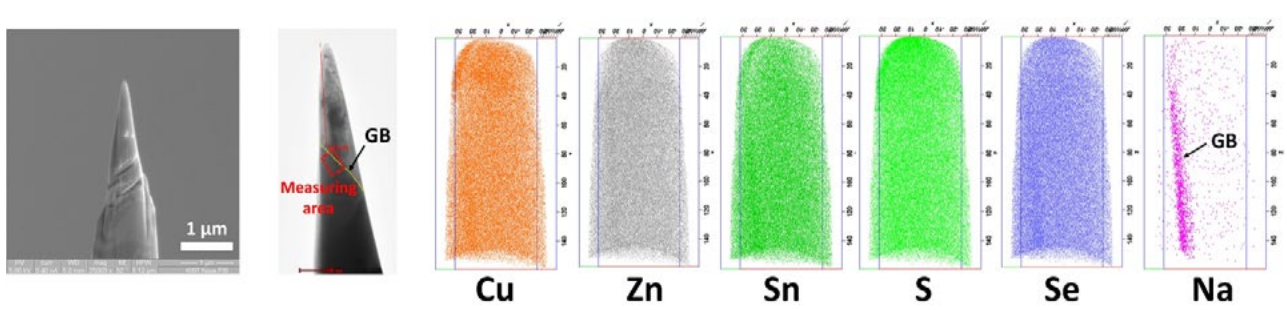


Fig. 2

Transsmision electron microscopy(TEM) image and APT 3D atomic maps of various elements]

School of Materials Science and Engineering
Electrocatalysis & Materials Laboratory

Chang Hyuck Choi

www.emlgist.com

Identification of Single-Atom Ni Site Active toward Electrochemical CO_2 Conversion to CO

To identify an active site toward electrochemical CO_2 conversion to CO, two different structures, *i.e.*, symmetric and distorted structures, are synthesized. Employing electrochemical and advanced spectrometric approaches, the structure of broken symmetry shows efficient CO_2 conversion than that of symmetry structure. Computational study reveals that broken symmetry is the key to reduce energy cost for intermediate formation, which results in superior activity. Thus, the broken symmetry at the atomic level is the key to an efficient CO_2 conversion.

Contents

CO_2 conversion is a promising strategy to produce value-added chemicals from CO_2 and water. Developing efficient catalysts is the key to its commercialization and achievement of carbon-neutral government policy.

Transition metal catalysts engineered at the atomic level exhibit high activity toward the CO_2 conversion, but inequivalent species render the identification of active sites highly vague. Identification of active site is a key for the rational design of high-performance catalysts to accomplish its real application.

To identify the active sites, two different structures, *i.e.* symmetric and distorted structures, are synthesized. Employing electrochemical and advanced spectrometric approaches, the structure of broken symmetry shows efficient CO_2 conversion. Computational study reveals that broken symmetry is the key to reduce energy cost for intermediate formation, which results in the enhanced activity.

In this study, the broken symmetry in the atomic level is the key to an efficient CO_2 conversion and rational catalyst design.

Research Outcomes

[Paper] • Identification of Single-Atom Ni Site Active toward Electrochemical CO_2 Conversion to CO (Journal of the American Chemical Society 143 (2021) 925)

Research Funding

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (No. NRF-2017M3D1A1039378 and 2020R1A2C4002233)

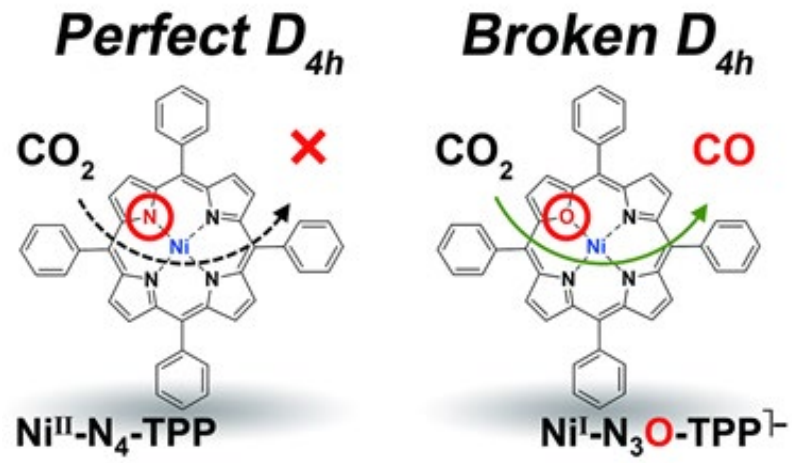


Fig. 1

Schematic image of the CO_2 conversion on the two different structures (symmetric structure: perfect D_{4h}, distorted structure: broken D_{4h}).

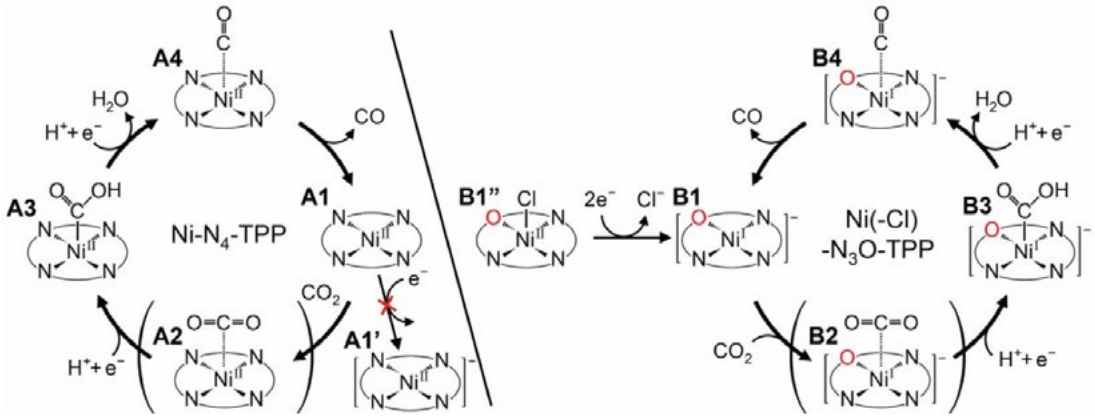


Fig. 2 Suggested CO_2 conversion cycle of two different structures.

School of mechanical engineering
E-mobility Design Optimization Laboratory

Jaewook Lee

https://sites.google.com/view/e-mobility-design-opt-lab/

Structural optimization of anisotropic composite with spatially-varying fiber layout

To achieve a carbon-neutral society, it is essential to improve the energy efficiency of mobilities such as vehicles, aircraft, ships, and robots. For this, the weight reduction of the mobility structure is one of the key technologies that is required to be developed. In this study, a structural design optimization technique for composite materials such as carbon fiber reinforced plastic (CFRP) was developed with the aim of achieving lightweight mobility structure. The developed design optimization technology can optimize the spatially-varying distribution and orientation of composite fiber structures. Through this work, it was confirmed that spatially-varying layout of the fiber reinforcement structure can improve the stiffness per unit mass from 10 to 30%, compared to a composite with uniform fiber layout and isotropic multi-material structure.

Contents

In this research, structural optimization methodology is developed for the simultaneous design of structural topology, fiber layout and orientation in anisotropic composites with spatially-varying fiber distribution. A composite structure consisted with spatially-varying fiber distribution is expected to have better stiffness than a composite structure with uniform fiber distribution or isotropic multi-material structure. In this research, an structural optimization methodology is developed based on homogenization design methods. To restore the composite microstructure acquired by homogenization design methods, a de-homogenization method based on mapping functions is developed. Here, the mapping function is obtained by solving partial differential equations derived from the optimized fiber orientation field. The developed design methodology is validated through various numerical examples. Figure 1 shows the Cantilever design optimization results. Figure 1(b) represents the design optimization results of composite materials consisting of spatially-varying fiber layout It is observed that this structure have 19.5% and 17.2% higher stiffness per unit weight, respectively, compared to composite structures with uniform distribution in Fig. 2(c) and isotropic multi-material structures in Fig. 2(d). In Figure 2, the design result of simply supported beam is demonstrated. It is predicted that the design result of composite structure with spatially-varying fiber layout is 22.4% and 11.2% stiffer than the composite structures with uniform distribution in Fig. 2(c) and isotropic multi-material structures in Fig. 2(d).

Research Outcomes

[Paper] • D. Kim, J. Lee*, T. Nomura, E.M. Dede, J. Yoo, S. Min, "Topology optimization of functionally graded anisotropic composite structures using homogenization design method", Comput. Methods Appl. Mech. Engrg. 369, 113220 (2020)

Research Funding

This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (NRF-2019R1A2C1002808).

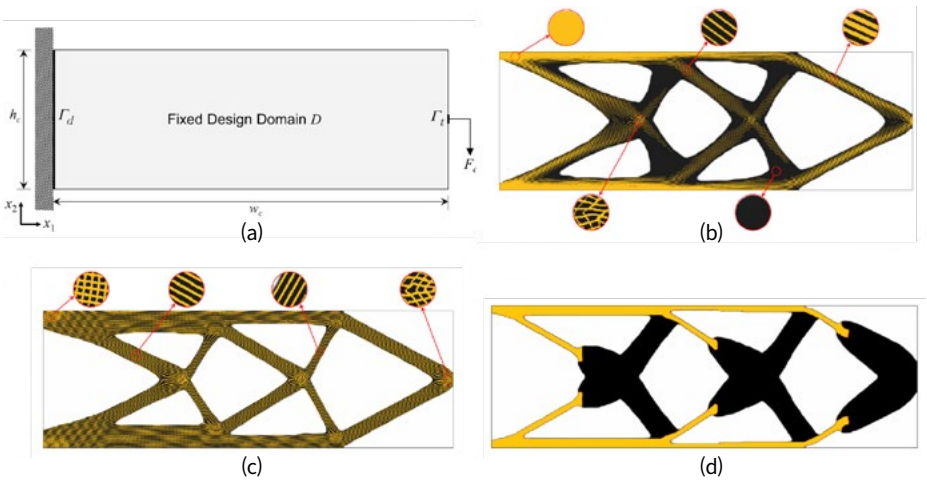


Fig. 1

Design result of Cantilever: (a) Design domain with boundary and loading conditions, (b) Design result of composite structure with spatially-varying fiber layout, (c) Design result of composite structure with uniform fiber layout, (d) Design result of isotropic multi-material structure.

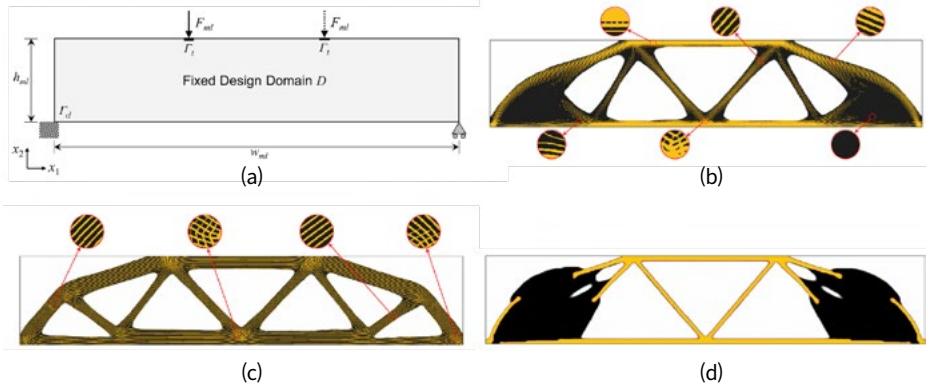


Fig. 2

Design result of simply supported beam: (a) Design domain with boundary and loading conditions, (b) Design result of composite structure with spatially-varying fiber layout, (c) Design result of composite structure with uniform fiber layout, (d) Design result of isotropic multi-material structure.

School of Earth Science and Environmental Engineering
Climate Analysis & Modeling

Jin-Ho Yoon

https://env1.gist.ac.kr/camlab/index.do

Intensification of the East Asian summer monsoon lifecycle based on observation and CMIP6

This study diagnoses extreme precipitation over East Asian in summer monsoon period. In late may 2018, intense monsoon rains more than 1000mm for around 10 days(6/28~7/8) hit the Japan, making people reeling from flooding and landslides. Right after, they faced extreme heat. This study identified successive flood-heatwave is likely to happen more frequently. Based on the observational dataset and state-or-art climate model, Coupled Model Intercomparison Project Phase 6(CMIP6), this study figured out climate change has enhanced the lifecycle of East Asian summer monsoon(EASM), bringing shorter and stronger rainy periods, followed by longer dry spells. If rain is falling harder, but for a shorter time, it might seem that the net effect is balanced-but this is not a trivial trade-off. This research suggests that these changes may drive life-altering and life-threatening weather events.

Contents

In 2018, Japan experienced heavy rainfall from late May to early June, and immediately followed by heatwave. These consecutive extremes may attribute to variability to the EASM lifecycle, so this study aims to find out long-term variability of EASM lifecycle based on observational dataset and CMIP6. Summer rainfall in northeast Asia is mainly driven by EASM lifecycle, which includes active, break, and revival phases. The lifecycle is characterized by northward propagation of the rainband and both active and break phases tend to be intensified. This intensification is derived from westward expansion of the Western North Pacific subtropical high (WNPSH) inducing early migration of the southerlies to the north and supplying water vapor in active. How well CMIP6 represents the characteristics of EASM lifecycle is examined. The models realistically reproducing average precipitation for active and break phases tend to simulate northward propagation of rainband similar with observation. Most models reproduce underestimated monsoon precipitation and the performance of CMIP6 models to simulate intensified EASM lifecycle varies. Nevertheless, some models are outstanding to simulate intensification of EASM lifecycle as well as climatological propagation of the rainband.

Research Outcomes

[Paper] • Park, J., Kim, H., Wang, S. Y. S., Jeong, J. H., Lim, K. S., LaPlante, M., &Yoon, J. H. (2020). Intensification of the East Asian summer monsoon lifecycle based on observation and CMIP6. Environmental Research Letters , 15 (9), 0940b9.

[Press release] • More than 20 articles are released

Research Funding

This research is funded by the Korean Meteorological Agency under the grant KMI2018-07010 and GIST Research Institute (GRI) grant funded by the GIST in 2020.

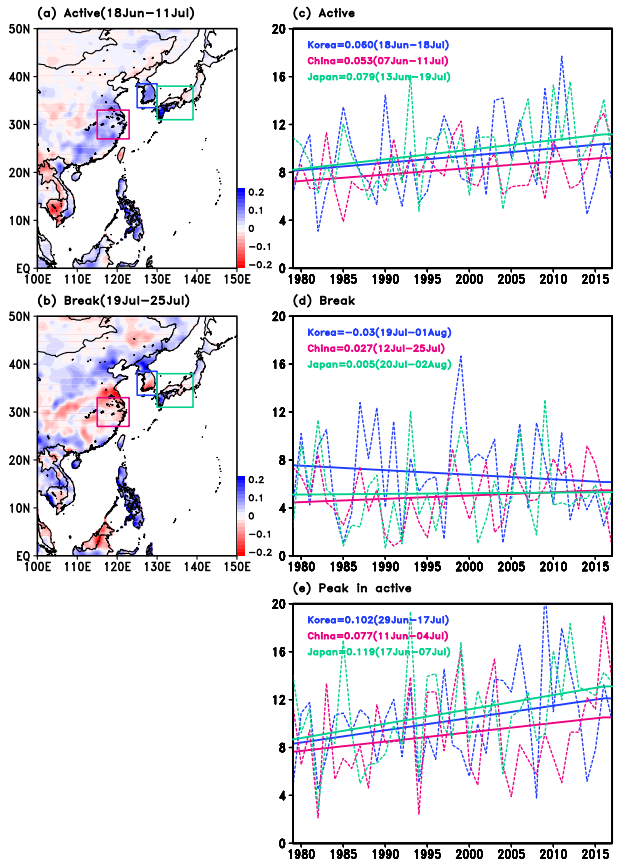


Fig. 1

Linear trend of precipitation[mm/day/yr] for (a) overlapped active period among three regions. (b) overlapped break period among three regions, and linear trend of precipitation in (c) active, (d) break, and (e) peak in active

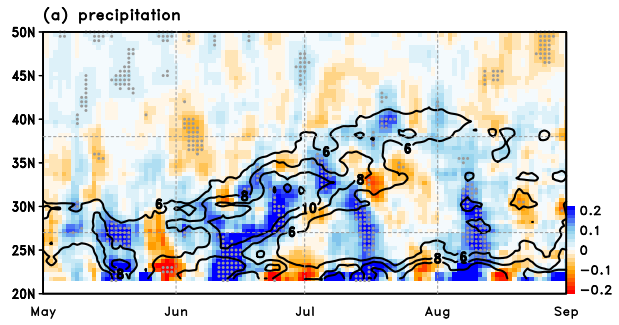


Fig. 2

Hovmöller diagram for time (x) - latitude (y) of five day running mean of rainfall[mm/day]. Contour is climatology[mm/day] and the trend is shaded ranging from –0.2mm/day/yr to 0.2mm/day/yr

School Of Life Science
Cell & Virus Logistics
Research Laboratory

Youngsoo Jun

https://life.gist.ac.kr/clar/index.do

Quaternary structures of Vac8 differentially regulate the Cvt and PMN pathways

(Functional & Structural Characterization of Autophagy, a Cellular Process for Trash Clearance)

Armadillo (ARM) repeat proteins constitute a large protein family with diverse and fundamental functions in all organisms, and armadillo repeat domains share high structural similarity. However, exactly how these structurally similar proteins can mediate diverse functions remains a long-standing question. Vac8 (vacuole related 8) is a multifunctional protein that plays pivotal roles in various autophagic pathways, including piecemeal microautophagy of the nucleus (PMN) and cytoplasm-to-vacuole targeting (Cvt) pathways in the budding yeast Saccharomyces cerevisiae. Vac8 comprises an H1 helix at the N terminus, followed by 12 armadillo repeats. Herein, we report the crystal structure of Vac8 bound to Atg13, a key component of autophagic machinery. The 70-Å extended loop of Atg13 binds to the ARM domain of Vac8 in an antiparallel manner. Structural, biochemical, and in vivo experiments demonstrated that the H1 helix of Vac8 intramolecularly associates with the first ARM and regulates its self-association, which is crucial for Cvt and PMN pathways. The structure of H1 helix-deleted Vac8 complexed with Atg13 reveals that Vac8[Δ19-33]-Atg13 forms a heterotetramer and adopts an extended superhelical structure exclusively employed in the Cvt pathway. Most importantly, comparison of Vac8-Nvj1 and Vac8-Atg13 provides a molecular understanding of how a single ARM domain protein adopts different quaternary structures depending on its associated proteins to differentially regulate 2 closely related but distinct cellular pathways.

Contents

In this research, the budding yeast Saccharomyces cerevisiae, a unicellular eukaryotic organism, was used for an experimental model. We revealed the X-ray structures of Vac8-Atg13 protein complexes that mediate Cvt pathway. Unlike the arch-like structure of Vac8-Nvj1 that we determined in a previous study, we now showed that Vac8-Atg13 complexes assume a long helical structure. Based on these results, we propose a molecular mechanism by which Vac8 interacts with different proteins to mediate different cellular processes as distinct quaternary structures. These results further suggest that a protein interacts with various proteins for specific functions as different complex structures. This research is the very first one in which protein complexes involved in autophagy assume distinct quaternary structures for various cellular processes.

Research Outcomes

[Paper] • Autophagy (the top journal in the autophagy research field; IF=11.1)

Research Funding

This research was supported by the Cell Logistics Research Center funded by the National Research Foundation of Korea. This research was also supported by the GIST Research Institute (GRI) at GIST.

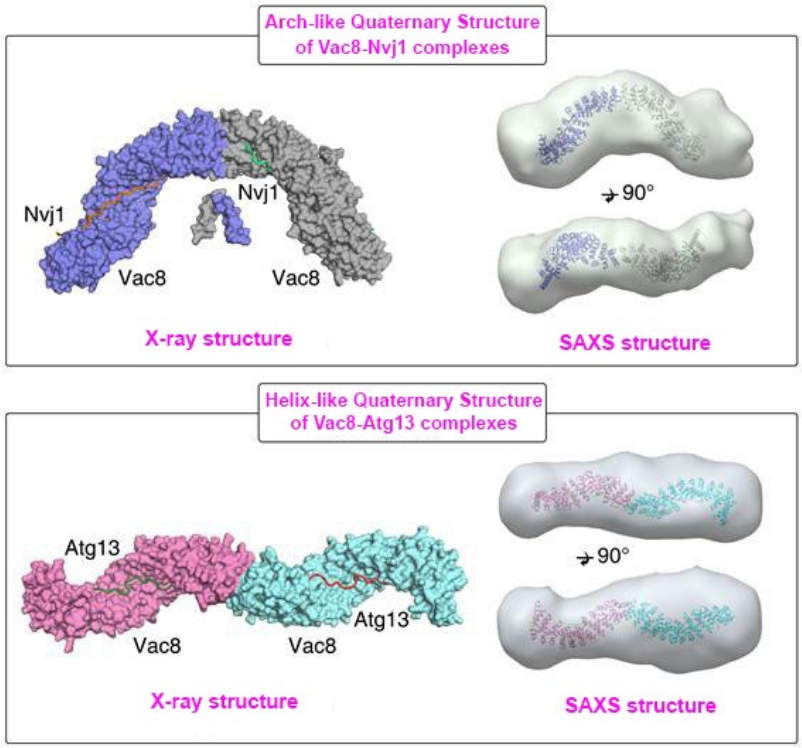


Fig. 1

Changes in the Vac8 quaternary structure by its interacting protein

X-ray crystallography provides the 3D structure of Vac8-Nvj1 complexes, and this arch-like structure is similar to one that was obtained by Small-angle X-ray scattering (SAXS). The structure of Vac8-Atg13 complexes that mediate Cvt pathway was also determined by X-ray crystallography and SAXS. This long-helix structure is clearly different from the Vac8-Nvj1 structure.

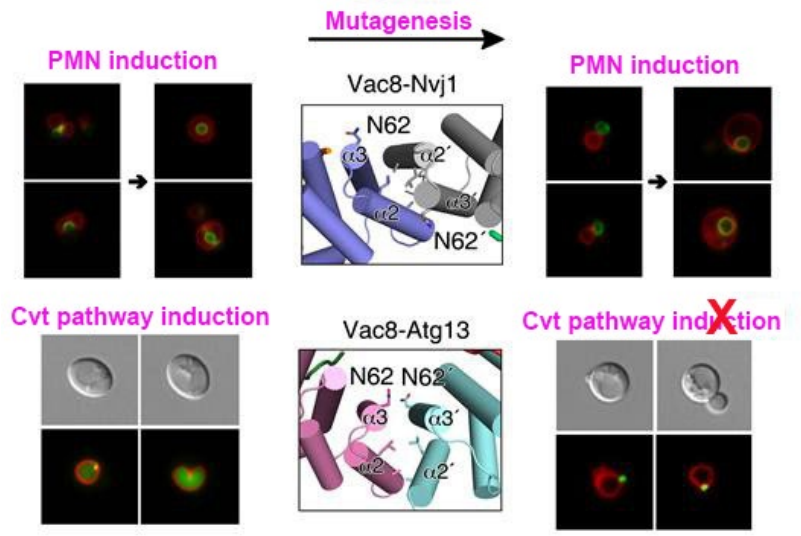


Fig. 2

Distinct quaternary structures of Vac8 complexes determine the mode of selective autophagic pathways

In cells that express wild-type Vac8, PMN and Cvt pathways are well induced upon nutrient starvation, yet in cells that express the mutant Vac8 that fails to form helix-like quaternary structure, PMN, but not Cvt pathway, normally occurs.

School of Integrated Technology
Robot AI Reinforcement learning Lab

Jeha Ryu

https://hr.gist.ac.kr/hr/

Calibration and Evaluation for Visuo-haptic Collocation in Haptic Augmented Virtuality Systems



A simple yet accurate calibration method is proposed for relating the VR world with the real world in an augmented haptic virtuality system. In the proposed method and procedure, simple yet accurate motions of the end- effector of a robot were made within the measurement volume of a commercial IR camera system. Results of the proposed method were found to be comparable with those of an existing calibration method that require a large number of data to achieve acceptable accuracy. The proposed method and procedure can be used for current VR systems with trackers. A more comprehensive evaluation of the benefits of the calibration results is scheduled for later investigation.

Contents

Haptic augmented virtuality systems can provide users with a highly immersive haptic experience by visuo-haptic collocation of physical objects with their corresponding virtual objects. The collocation can be accom- plished by an encounter-type haptic display system where a robotic device provides a physical prop that represents a whole or partial virtual object in real-time and in the space occupied by the virtual object in the virtual environment. For efficient and accurate visuo-haptic collocation, this paper proposes a novel yet simple, efficient and accurate calibration method. The method employs a high-accuracy position device such as an industrial robot that can place physical objects quickly and accurately. The transformation between the reference frames of the real (robot) and virtual worlds is obtained by the simple motion of the robot's end-effector equipped with a real object that is in turn tracked by a VR tracker system such as the HTC VIVE tracker. An evaluation of the proposed method indicates that it is possible to achieve acceptable accuracy with a few data points as compared to existing calibration methods that require a large number of data points.

Research Outcomes

[Paper] • Bae, Y., Cha, B., & Ryu, J. (2020). Calibration and Evaluation for Visuo-haptic Collocation in Haptic Augmented Virtuality Systems. International Journal of Control, Automation and Systems, 18(5), 1335-1342.

Research Funding

This work was supported by a grant (14IFIP-B085984-02) from the Plant Research Program funded by the Ministry of Land, Infrastructure and Transport (MOLIT) of the Korea government and Korea Agency for Infrastructure Technology Advancement (KAIA). First and second authors contributed equally

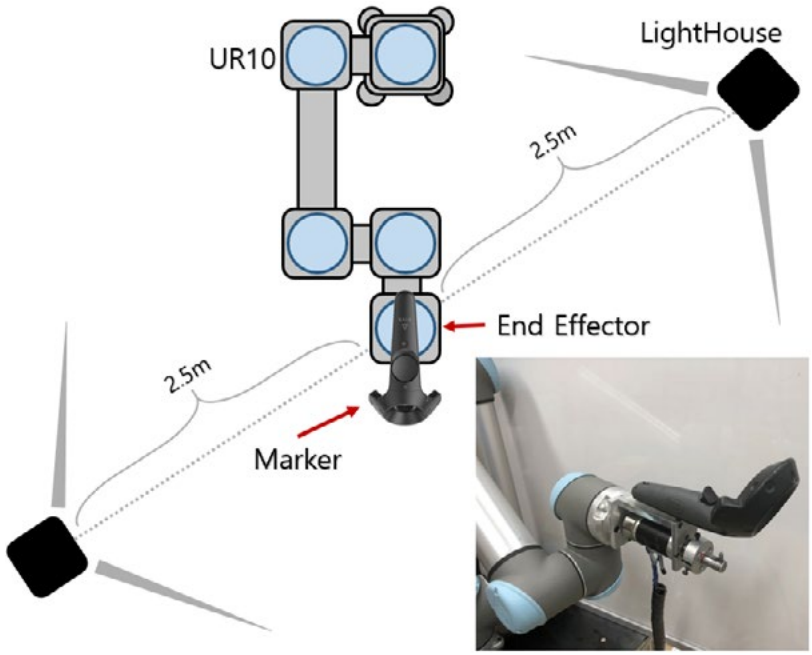


Fig. 1
Measurement system configuration.

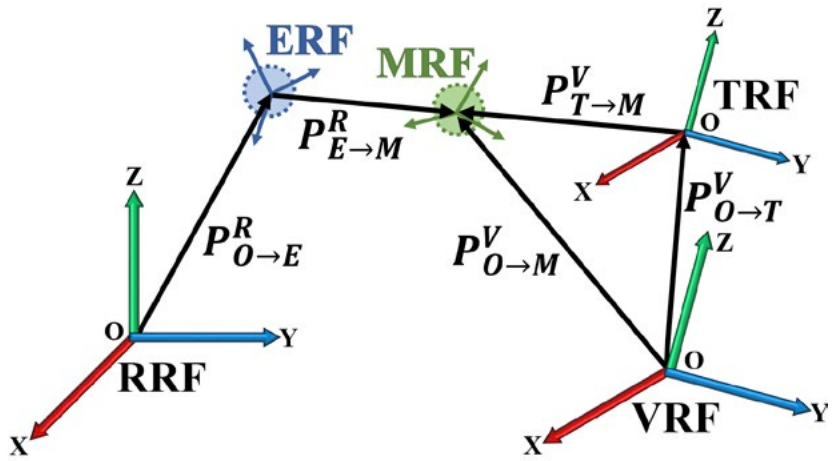


Fig. 2
Reference frames for calibration using VR (VIVE) and Robot (UR10) systems.

Graduate School of Energy Convergence
Energy storage material and device laboratory
Energy catalysis and device laboratory

Hyeong-Jin Kim
Chanho Pak

Prof. Hyeong-Jin Kim
https://esmd.gist.ac.kr/esmd/

Prof. Chanho Pak
https://iit.gist.ac.kr/catalyst/index.do

Advanced ordered mesoporous carbon with fast Li-ion diffusion for lithium-selenium sulfide batteries in a carbonate-based electrolyte

Lithium-selenium sulfide (Li-SeS_2) batteries are promising next-generation batteries due to their high energy density (1,124 mAh g^{-1} and 3,372 mAh cm^{-3}). In a carbonate-based electrolyte, Li-SeS_2 batteries show excellent cycle life but low discharge voltage. This low discharge voltage is affected by the SeS_2 content in the composite. To increase the energy density, both the discharge voltage and SeS_2 content should be elevated simultaneously. Herein, various structures of ordered mesoporous carbons (OMCs) are investigated to overcome the low discharge voltage while containing a high SeS_2 content. By tuning the OMC structure with a large pore volume and effective morphology, Li-ion diffusion is improved, thus leading to decreased ohmic resistance and charge-transfer resistance. Even at a high SeS_2 content of 75 wt.%, a platelet-type OMC (POMC2.0) with a pore volume of 2.0 cm3 g1 enables operation at 2.0 V in a carbonate-based electrolyte. The Li-SeS_2 batteries show excellent cycle performance with an average capacity of 552 mAh g^{-1} for 1,600 cycles in a carbonate-based electrolyte.

Contents

Various OMC structures were applied to Li-SeS_2 batteries, and their electrochemical performance was studied in a carbonate-based electrolyte. An effective morphology and large pore volume helped facilitate Li-ion diffusion, thus leading to decreased ohmic resistance and charge-transfer resistance. Even when containing a high content of SeS_2 up to 75 wt.%, POMC2.0, an advanced carbon structure that had a large pore volume and effective morphology, was able to work at a high discharge voltage (2.0 V) and showed excellent cycle performance with an average capacity of 552 mAh g^{-1} for 1,600 cycles. Therefore, a high-energy-density and long cycle life for Li-SeS_2 batteries are expected when applying an advanced carbon structure. In particular, the carbon design affected the electrochemical performance and properties of the Li-SeS2 batteries, such as the discharge voltage, SeS_2 content, and Li-ion diffusivity, in carbonate-based electrolytes. Reliable results can be obtained by controlling many carbon parameters. The discovery of the relationship between the carbon structure and Li-SeS_2 battery performance can help guide the preparation of advanced chalcogenide batteries in carbonate-based electrolytes that are able to fulfill the requirements of future devices.

Research Outcomes

[Paper] • W. Kim[1], J. Lee[1], S. Lee, K. Eom, C. Pak*, H-J. Kim*, Carbon 170 (2020) 236-244

Research Funding

This work was supported by GIST Research Institute (GRI) grant funded by the Gwangju Institute of Science Technology in 2020.

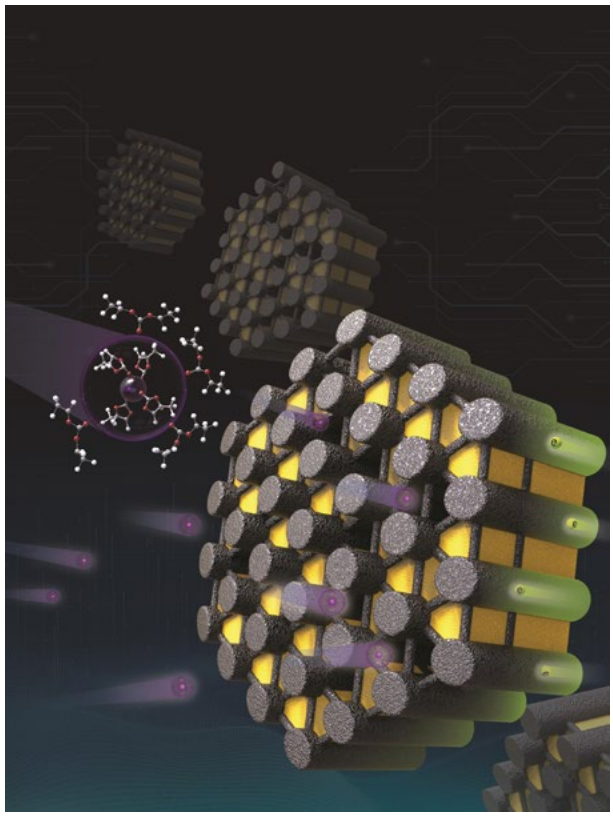


Fig. 1
Schematic image of Li-SeS2/POMC2.0-75 wt.% batteries with carbonate-based electrolyte

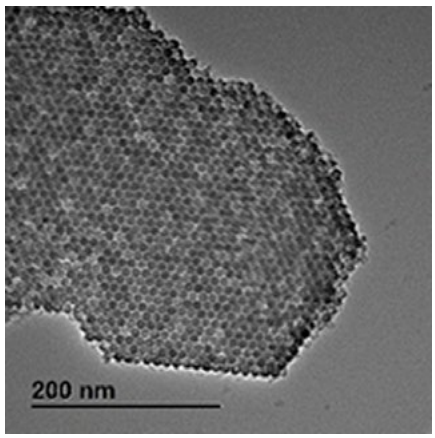


Fig. 2 TEM image of SeS2/POMC2.0-75 wt.%

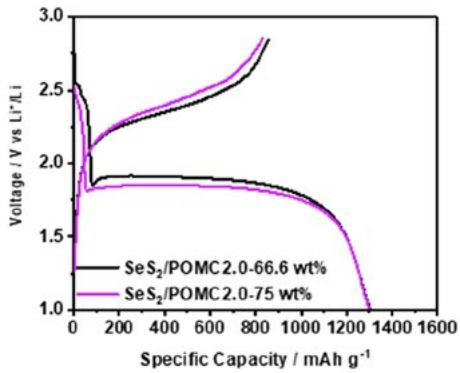
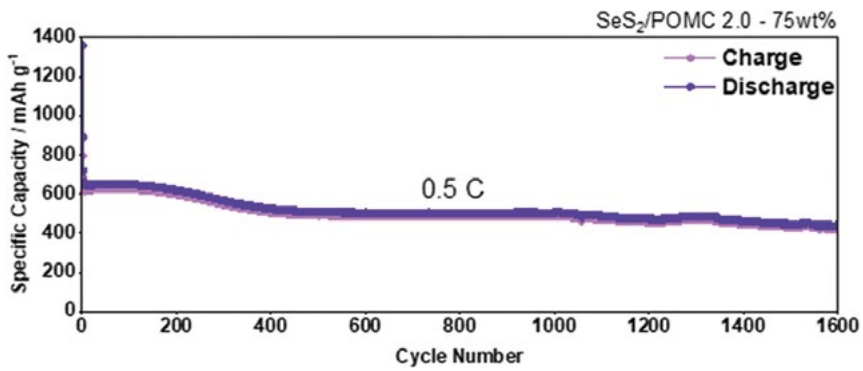


Fig. 3 The charge-discharge curve of Li-SeS2/POMC2.0-75 wt.%

Fig. 4
The cycle performance graph of Li-SeS2/POMC2.0-75 wt.% during 1,600 cycles

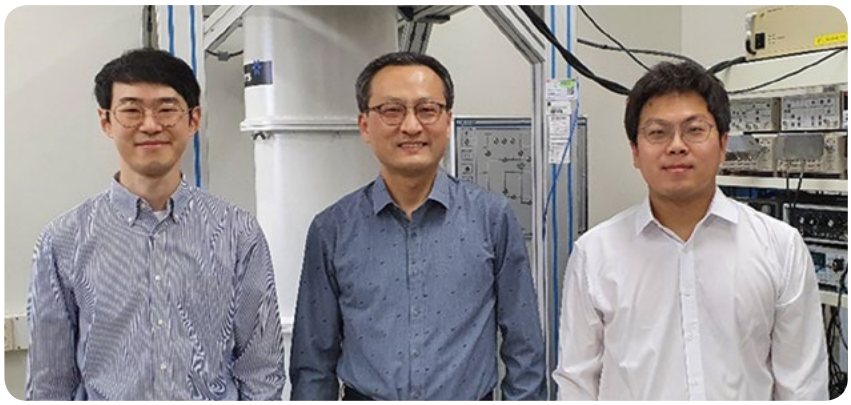


Department Of Physics And Photon Science
Quantum Devices Lab.

Yong -Joo Doh

https://qdev.gist.ac.kr

Adjustable Quantum Interference Oscillations in Sb-Doped Bi_2Se_3 Topological Insulator Nanoribbons



Topological insulator (TI) nanoribbons (NRs) provide a platform for investigating quantum interference oscillations combined with topological surface states. One dimensional subbands formed along the perimeter of a TI NR can be modulated by an axial magnetic field, exhibiting Aharonov—Bohm (AB) and Altshuler—Aronov—Spivak (AAS) oscillations of magnetoconductance (MC). Using Sb-doped Bi2Se3 TI NRs, we found that the relative amplitudes of the two quantum oscillations can be tuned by varying the channel length, exhibiting crossover from quasi-ballistic to diffusive transport regimes. The AB and AAS oscillations were discernible even for a 70 μm long channel, while only the AB oscillations were observed for a short channel. Analyses based on ensemble-averaged fast Fourier transform of MC curves revealed exponential temperature dependences of the AB and AAS oscillations, from which the circumferential phase-coherence length and thermal length were obtained. Our observations indicate that the channel length in a TI NR can be a useful control knob for tailored quantum interference oscillations, especially for developing topological hybrid quantum devices.

Contents

Herein, we present an extensive experimental study of AB and AAS oscillations obtained from Sb-doped Bi2Se3 TI NRs with various channel lengths (Lch) on the same NR. Their axial MC oscillations were measured as a function of gate voltage (Vg) and temperature (T), whereas their oscillation amplitudes were analyzed using the ensemble-averaged fast Fourier transform (FFT) method to avoid sample-specific features. We observed the crossover behavior between the AB and AAS oscillations and discovered that their respective oscillation amplitudes were adjustable depending on the channel length of the TI NR. The AAS oscillations were absent for channel lengths shorter than the perimeter length (Lp), and their length dependence was consistent with theoretical expectations based on WAL corrections11 along the perimeter of TI NR. The ABOs were discernible even for the 70 μm long channel; furthermore, the Vg-dependent alternations of 0- and π-ABOs, a characteristic feature of topological ABOs,20 were evident in all segments with Lch = 1—70 μm. Our observations suggest that the Lch of the TI NR can be a control knob to alter the quantum electronic transport from quasi-ballistic to diffusive

regimes, which would be advantageous for investigating quantum interference effects associated with topological surface states.

Research Outcomes

[Paper] • "Adjustable Quantum Interference Oscillations in Sb-Doped Bi_2Se_3 Topological Insulator Nanoribbons", ACS Nano 14, 14118 (2020)

[Press release] • ETNews (2020. 10. 20)

Research Funding

This study was supported by the NRF of Korea through the Basic Science Research Program (2018R1A3B1052827, Leader Project) and the SRC Center for Quantum Coherence in Condensed Matter (2016R1A5A1008184) and by the "GIST-Caltech Research Collaboration" grant funded by GIST

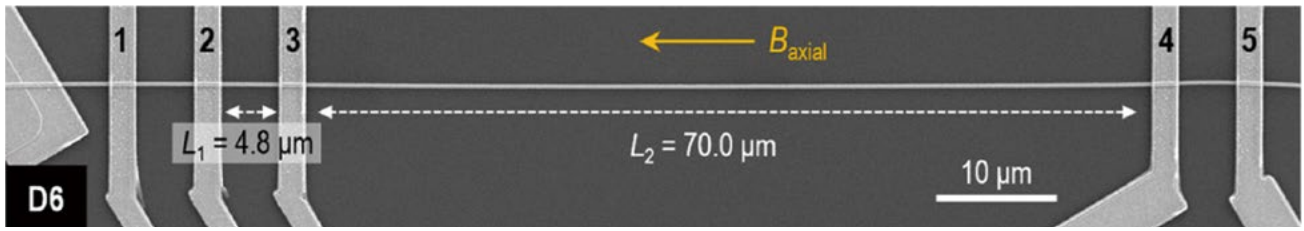
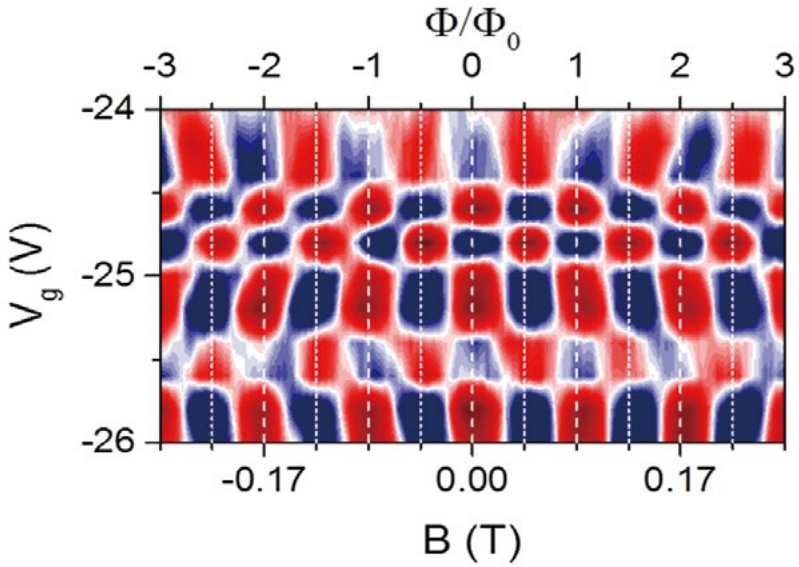


Fig. 1 Scanning electron microscopy image of the topological insulator nanoribbon devices used in this work.

Fig. 2

Interference patterns of magnetoconductance due to topological Aharonov-Bohm effect in topolgical insulato nanoribbon



Department Of Chemistry
Functional Organic Molecules Synthesis Laboratory (FOSLAB)

Sukwon Hong

https://fos.gist.ac.kr/fos/index.do

Enantioselective Alkynylation of Trifluoromethyl Ketones Catalyzed by Cation-Binding Salen Nickel Complexes

Cation-binding salen nickel catalysts were developed for the enantioselective alkynylation of trifluoromethyl ketones in high yield (up to 99%) and high enantioselectivity (up to 97% ee). The reaction proceeds with substoichiometric quantities of base (10–20 mol% KOt-Bu) and open to air. In the case of trifluoromethyl vinyl ketones, excellent chemoselectivity was observed, generating 1,2-addition products exclusively over 1,4-addition products. UV-vis analysis revealed the pendant oligo-ether group of the catalyst strongly binds to the potassium cation (K+) with 1:1 binding stoichiometry.

Contents

Fluorinated organic compounds have proven to be exceptionally useful in many areas of organic chemistry, including materials, agrochemicals, and pharmaceuticals. In particular, chiral trifluoromethyl substituted tertiary alcohols and related derivatives are important structural motifs present in a number of bioactive compounds. In an effort to develop a more sustainable method for the enantioselective alkynylation of trifluoromethyl ketones, we turned our attention to the development of a cooperative catalyst involving a Lewis acid and Brønsted base. We envisioned that the use of the salen ligand framework with a pendant crown ether which can interact with an alkali metal cation would facilitate this form of cooperative catalysis, as the Lewis acid and Brønsted base could be held in close proximity by a very rigid and specific structure.With the strategy, we have developed cation-binding salen Ni catalysts for enantioselective alkynylation of trifluoromethyl ketones. The cation-binding Ni(II)/K+ heterobimetallic catalyst plays a key role in promoting the alkynylation with substoichiometric base and open to air, resulting in high enantioselectivity (up to 97% ee) and yield (up to 99%).

Research Outcomes

[Paper] • Park, D.; Jette, C. I.; Kim, J.; Jung, W.-O.; Lee, Y.; Park, J.; Kang, S.; Han, M. S.; Stoltz, B. M.; Hong, S. "Enantioselective Alkynylation of Trifluoromethyl Ketones Catalyzed by Cation-Binding Salen Nickel Complexes", *Angew. Chem. Int. Ed.* 2020, *59, 775 –779*

[Press release] • Yunhap news, 'GIST-Caltech Research Collaboration, Development of AIDS treatment synthesis catalyst', Reporter Park Chul-hong , 2019.12.02

Research Funding

This work was supported by the "GIST-Caltech Research Collaboration" grant funded by the GIST in 2017, and by the National Research Foundation of Korea grant funded by the Korean Government (NRF-2012R1A1A2044550, NRF-2017M1A2A2049102). The NIH-NIGMS (R01GM080269) and Caltech are also thanked for support of our research program.

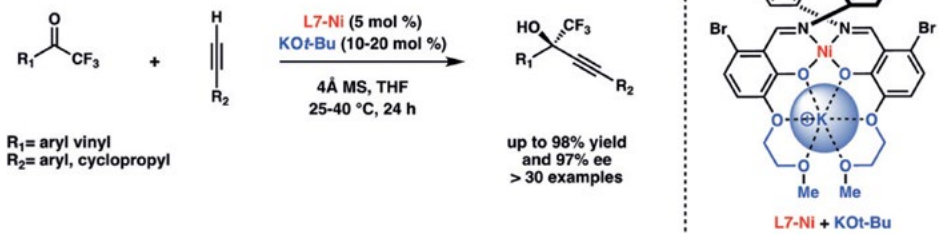


Fig. 1
Enantioselectiveaddition of terminal alkynes to trifluoromethyl ketones.

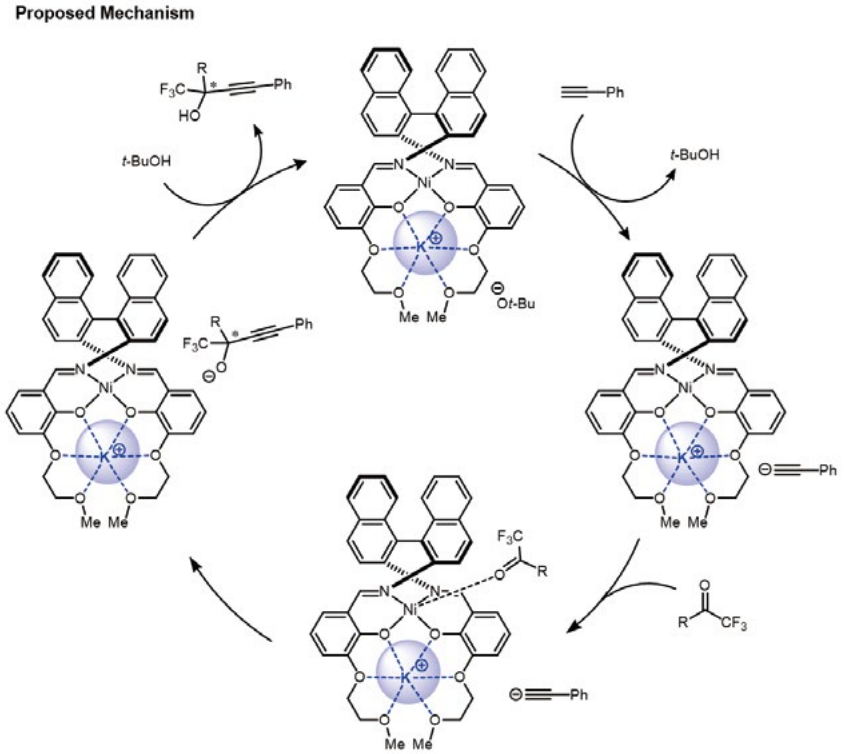


Fig. 2
Proposed reaction mechanism.

Department of Biomedical Science and Engineering
Peroxisomes and Lipid metabolism Laboratory

Raekil Park

https://bmse.gist.ac.kr/peroxisomes/index.do

TMEM135 regulates primary ciliogenesis through modulation of intracellular cholesterol distribution

Primary ciliogenesis was composed with the various steps to produce cilia such as a decapping of CP110, a transition zone formation, and a ciliary vesicle (CV) elongation. Disturbing one of those steps impaired the ciliogenesis. Our group demonstrated that the number of primary cilia was reduced in the absence of Transmembrane protein 135 (TMEM135) accompanied by the cholesterol accumulation in lysosomes. In the depletion of TMEM135, the elongation of ciliogenesis through the Rab8 trafficking to CV was impaired in spite of the Primary ciliogenesis was composed with the various steps to produce cilia such as a decapping of CP110, a transition zone formation, and a ciliary vesicle (CV) elongation. Disturbing one of those steps impaired the ciliogenesis. Our group demonstrated that the number of primary cilia was reduced in the absence of Transmembrane protein 135 (TMEM135) accompanied by the cholesterol accumulation in lysosomes. In the depletion of TMEM135, the elongation of ciliogenesis through the Rab8 trafficking to CV was impaired in spite of the trafficking and reduce the number of primary cilia.

Contents

Our group demonstrated that the cholesterol accumulation was enriched in lysosomes compartments in cell fractionation (Fig1, right panel) accompanied with the reduction of Lysosomes-Peroxisomes membrane contact in TMEM135 depletion (Fig1, Left panel).

To analyze the mechanism of impaired ciliogenesis during TMEM135 depletion, various ciliogenesis related proteins were immunofluorescence stained (not shown). Among those proteins, we observed that Rab8 and IFT20 were not localized on the centriole for ciliogenesis.

The treatment of mβCD rescued the localization of Rab8 in the absence of TMEM135 accompanied with rescued IFT20 localization on the centriole (Fig 3). The result proved that the impaired distribution of cholesterol by TMEM135 depletion disrupted the Rab8 trafficking for ciliary vesicle elongation and IFT20 vesicular transportation to the centriole.

Research Outcomes

[Paper] • Maharjan Y, Lee JN, Kwak SA, Dutta RK, Park C, Choe SK, Park R. TMEM135 regulates primary ciliogenesis through modulation of intracellular cholesterol distribution. EMBO Rep. 2020 May 6;21(5):e48901.

Research Funding

This work was supported by the National Research Foundation of Korea (NRF) under grants funded by the Korean government (Grant Nos. 2018R1A5A1024340 and 2019R1A2C2086080)

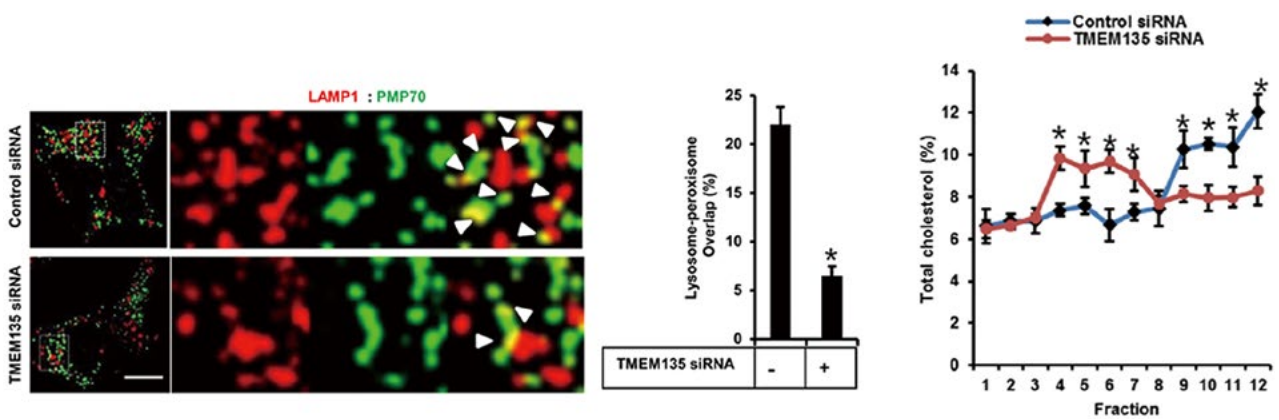


Fig. 1 Depletion of TMEM135 results in reduced lysosomes-peroxisomes membrane contact (left and middle panel) and cholesterol accumulation in lysosomes (right panel).

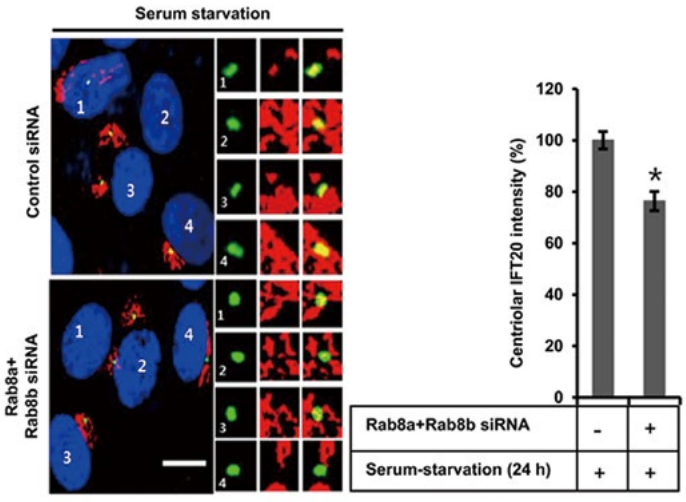


Fig. 2

Cholesterol–MβCD complex rescues impaired Rab8 trafficking to the centriole, augments Rab8‑GTP binding, and increases IFT20 intensity at the centriole in TMEM135‑depleted cells

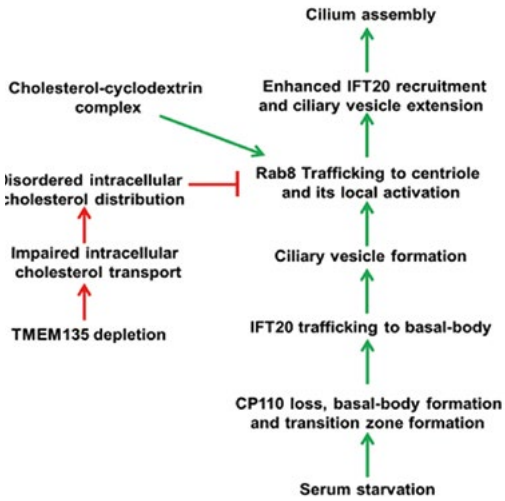


Fig. 3

Diagram of pathway: TMEM135 depletion involved in the impaired ciliogensis through the uneven cholesterol distribution.

AI Graduate School
Meta-Evolutionary
Machine Intelligence Laboratory

Ahn, Chang Wook

https://sites.google.com/view
/gist-memi/

AI-generated auto-composition technology through human interaction

We studied a method of composing customizable music by receiving user's emotions and reflecting one's needs in real time with a high degree of completeness.

- A new model for creative musicality developed with a meta-evolution algorithm, along with emotion recognition and sound source evaluation technology developed through an artificial neural network technology.
- A creativity model that avoided the use of the traditional data (learning) model, applied to music composition to create a new outcome not inferable by the learnt data.
- Transfer of the technology and know-how related to auto-composition of emotional piano songs and pop-songs to industry
- A human singer debuted with a song composed by artificial intelligence, developed by our research team, for the first time in the world

-Release of K-POP albums and managing a Youtube channel using the researched AI composition engine

Contents

So far, AI-generated musics are still in a limited usage.

- Among the existing AI music composition services, the overall feelings of the created songs are generally similar, and the absence of emergence has not been solved.
- In addition, they focus on auto-composition with only little regards to interaction with the user.

To solve the above problems, we study the expert system to generate AI music solutions at the same level of human composition with professional training. They use AI techniques such as deep learning, evolutionary computation, ensemble learning, and clustering, all combined together.

- Research on the AI-generated sound sources that do not require post-processing
- A study on creating melody and code by optimizing the process involved with music theoretical completeness, creativity, and avoidance of redundancy through computer algorithms
- A study on assisting music writing and learning to help experience the principles of music composition through a Try & Error approach with a real-time feedback based on a visual interface

Research Outcomes

[Paper] • Kim, M. J., Kim, J. S., Kim, S. J., Kim, M. J., & Ahn, C. W. (2020). Genetic state-grouping algorithm for deep reinforcement learning. Expert Systems with Applications, 161, 113695.

[Patent] • Method and apparatus for generating and evaluating music(Patent No. 10-2138247, registered on July 21, 2020)

[Press release] • The Korean singer debut by AI-generated music (Chosun Ilbo, 2020.10.09)

[Technology Transfer] • Transfer of technology and know-how related to AI-based auto-composition (2020.04.20)

[Other] • AAI composition engine EvoM's K-POP album released (2020.05.08)

Research Funding

IITP grant funded by the Korea government (MIST) (No. 2019-0-01842, Artificial Intelligence Gradate School Program (GIST))

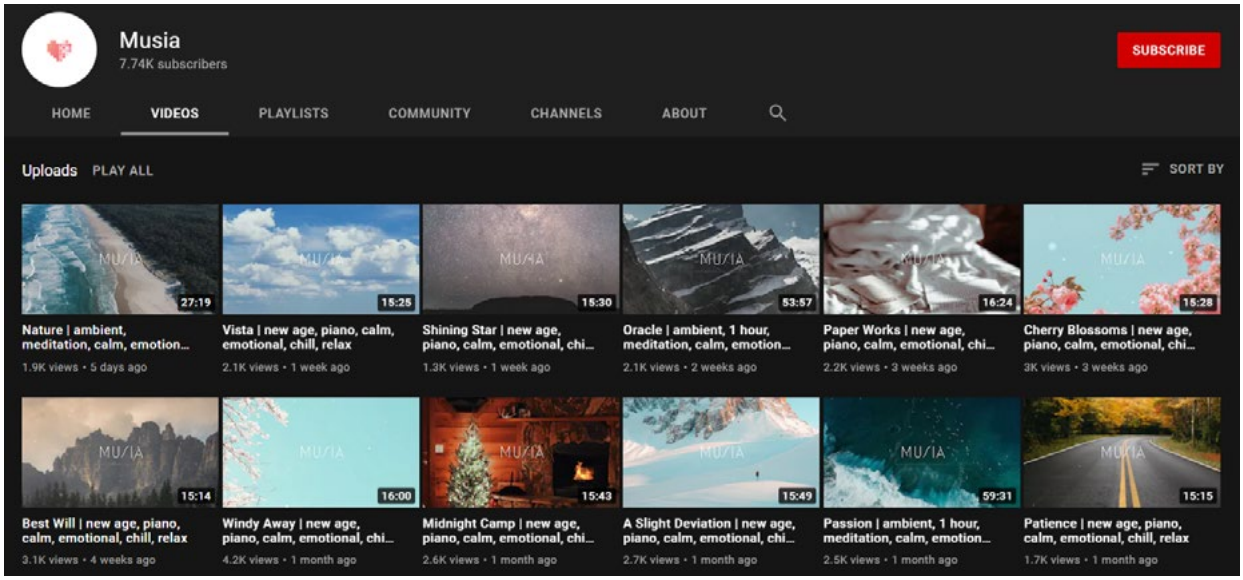


Fig. 1 Youtube channel with music clips generated by the AI composition engine

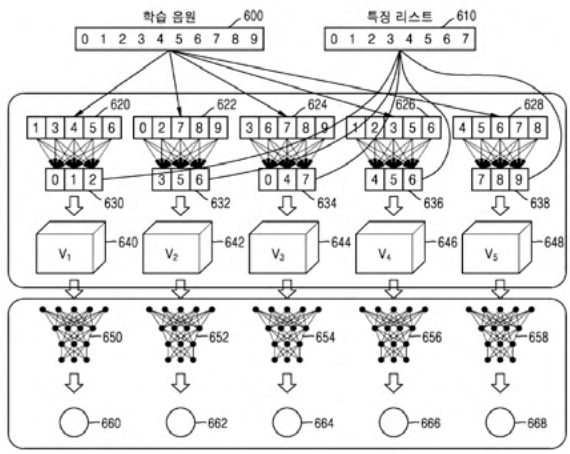


Fig. 2

Patent: Method and apparatus for generating and evaluating music

Research Institute for Solar and Sustainable Energies
Research Group of Photovoltaics

Eunji Lee

https://eunjilee99.wixsite.com/so-mat

Influence of 3D Morphology on the Performance of All-Polymer Solar Cells Processed Using Environmentally Benign Nonhalogenated Solvents

We introduce a new solvent/processing additive system that can enhance photovoltaic performance of all-polymer solar cells greatly and demonstrate, for the first time, 3D polymer blend morphology using a state-of-the-art technique of transmission electron microscopy tomography (TEMT). All polymer solar cells (APSCs) processed from environmentally benign non-halogenated solvents with appropriate additives (DMF, DMAc, and NMP) can outperform APSCs processed from toxic harmful halogenated solvents by affording favorable blend morphology and 3D TEM imaging is a powerful and essential tool to reveal the true morphology of photoactive layers.

Contents

Here, we investigated the photovoltaic properties of PTB7-Th:PNDI2OD-T2-based APSCs using various halogenated and nonhalogenated solvents. Electrical measurements of the APSCs revealed that, interestingly, the APSCs processed using toluene (TOL) and xylene (XY) performed better than those processed using chlorinated solvent systems. Moreover, the device performance was remarkably improved when XY was used in conjunction with solvent additives such as N,N-dimethylformamide (DMF), N,N-dimethylacetamide (DMAc), and N-methylpyrrolidone (NMP). The PTB7-Th:PNDI2OD-T2 blend films using various solvent systems were characterized using various techniques: ultraviolet–visible (UV–Vis) absorption spectroscopy, atomic force microscopy (AFM), photoluminescence (PL) spectroscopy, and GIWAXS, which revealed the relative degree of miscibility between p-type and n-type polymers. In particular, 3D TEMT imaging clearly revealed the important role of the good interconnection of nanoscopic domains of PTB7-Th and PNDI2OD-T2 polymers in a 3D manner in the high-performance blend films; it showed that solvent additives, especially DMAc, greatly improve the interconnection of n-type polymer domains while keeping the narrower fibril structures. Carrier mobility measurements consistently indicated that the controlled nanoscale domains of polymers and their connections for an optimal bulk heterojunction active layer improves the mobilities of holes and electrons, which contributes to the enhancement of the photovoltaic performance of APSCs. Molecular dynamics simulations revealed the origin of the performance improvement with aid of solvent additives. As a result, the PNDI2OD-T2 polymers developed nanoscopic fibril structures. Conclusively, we here demonstrate that the photovoltaic properties of the APSCs are strongly dependent on the formation of nanoscopic phase-separated domains and on the interconnectivity of the p-type and n-type polymers in the photoactive blend films.

Research Outcomes

[Paper] • Hyeseung Jung, A-Ra Jung, Seon-Mi Jin, Seah Kim, Hyojung Heo, Hoai Van T. Nguyen, Min Je Kim, Myung Hwa Kim, Youngu Lee, Kyung-Koo Lee, Jeong Ho Cho, Eunji Lee*, and BongSoo Kim*, "Influence of 3D Morphology on the Performance of All-Polymer Solar Cells Processed Using Environmentally Benign Nonhalogenated Solvents", Nano Energy, 77, 105106 (2020)

Research Funding

This work was supported by the National Research Foundation of Korea (NRF-2018R1A5A1025594, 2015M1A2A2056218, 2019R1A2B5B01070463, 2020R1A2C2014151) of the Ministry of Science and ICT. This work also supported by Ulsan National Institute of Science and Technology and Gwangju Institute of Science and Technology Research Institute (GRI) Grant.

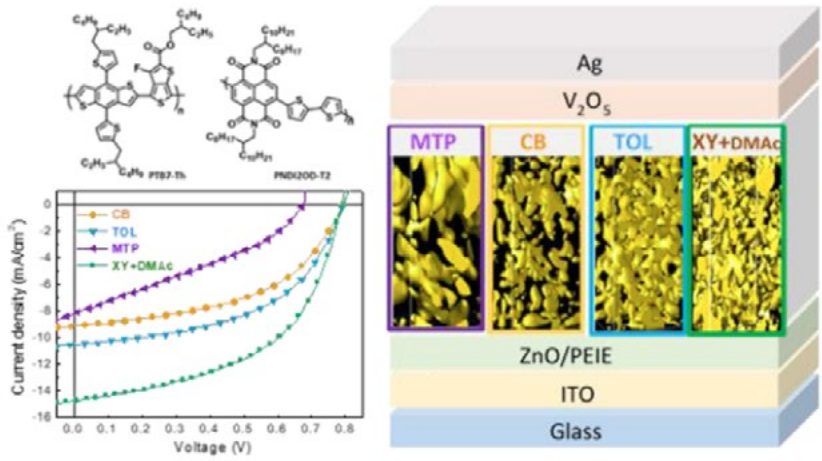


Fig. 1

Solution-processable all polymer solar cells: PCEs correlated with vertical morphology of active layers processed by halogenated and non-halogenated solvents.

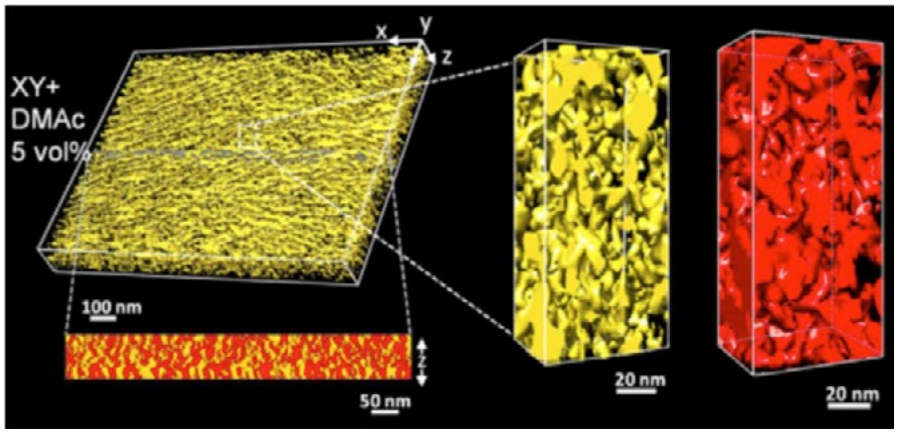


Fig. 2

All polymer solar cell-active layer morphology with optimized PCEs intepretated by 3D transmission electron microscopy.

Korea Culture Technology Institute

Taewook Kim

www.kct.re.kr

Development of Intelligent Exhibition Commentary Platforms for Deaf - Korean Sign Language/Word Translation Systems

At cultural institutions such as in art and history museums, for deaf visitors, instructions and information are needed to be presented in written texts or in sign language. In this study, we collected sign language data for the words often used in commenting about historical artifacts and built a prototype for viewing the data. The accuracy of our text to sign language translation is 94.5%, and a satisfaction score of our prototype is 76.4%. These results are well-above our initial goals, and we plan to show-case this prototype in an exhibition at the Gwangju National Museum.

Contents

The Article 8 of the Act on Welfare of Persons with Disabilities states that no one shall discriminate people with disabilities in all areas of political, economic, social, and cultural contexts. Currently, there is a need for services for the deaf visiting cultural institutions such as art and historical museums. In order to address the need, we have carried out a sequence of research and development phases: 1) constructing a sign language DB, 2) developing a virtual character, 3) developing a voice recognition system, and 4) developing and demonstrating a real-time interactive system.

- Segmentations of describing domestic historical artifacts were collected. 1,300 scripts were translated into sign language, which are processed and stored in a DB.
- Body and finger motion data of performing sign language were captured and mapped to animating a virtual human character. The quality of the character animations was confirmed by professional sign language interpreters.
- Based on the scripts and its sign language animations, an interactive mobile system is developed to provide text-to-sign language translation on interested historical artifacts.

Research Outcomes

[Paper] • The study of AI-based techinques for translating Korean texts to sign language, Korea Information and Communications Society, 2020

• The study of comparing words used in describing Korean cultural heritage and in sign language, Korea Information and Communications Society, 2020

[Press release] • The user evaluation of a prototype for supporting cultural life for the deaf (AI Times)

Research Funding

Supported by the Ministry of Culture, Sports and Tourism's R&D Policy Designation Task (Development of Intelligent Exhibition Commentary Platforms for Deaf - Korean Sign Language/Word Translation Systems)

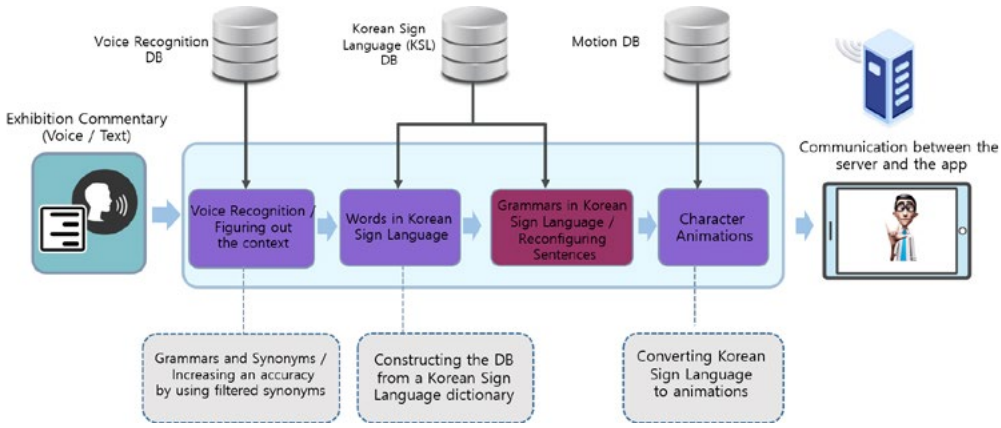


Fig. 1
a system diagram of the sign language translation platform

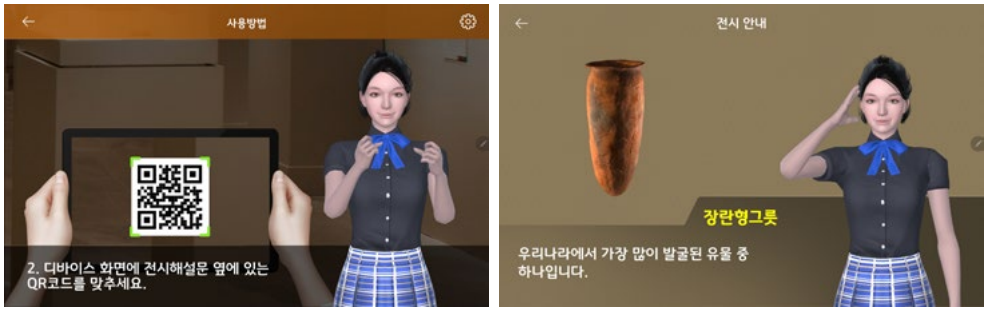


Fig. 2
example shots of tutorial and commentary sessions

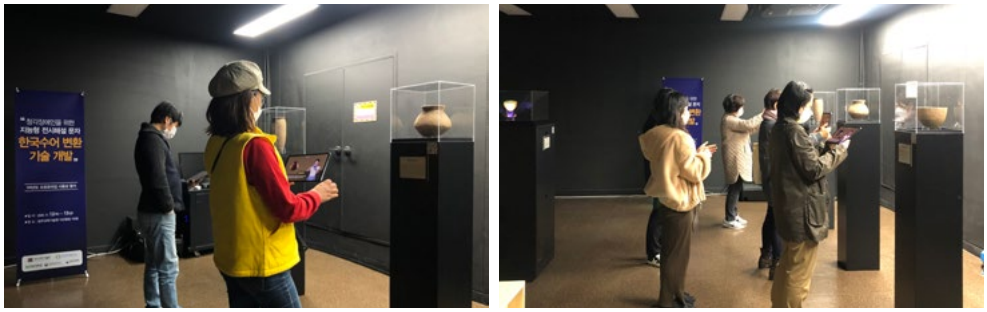


Fig. 3
deaf users testing out the commentary prototype

Intergrated Institute of Biomedical Research
RNA Genomics and Epigenetics Laboratory

Haihong Shen

https://life.gist.ac.kr/gistrna/index.do

Opposite Roles of Tra2β and SRSF9 in the v10 Exon Splicing of CD44

CD44 is a transmembrane glycoprotein involved in cell–cell and cell–matrix interactions. Several CD44 protein isoforms are generated in human through alternative splicing regulation of nine variable exons encoding for the extracellular juxta-membrane region. While the CD44 splicing variants have been described to be involved in cancer progression and development, the regulatory mechanism(s) underlying their production remain unclear. Here, we identify Tra2β and SRSF9 as proteins with opposite roles in regulating CD44 exon v10 splicing. While Tra2β promotes v10 inclusion, SRSF9 inhibits its inclusion. Mechanistically, we found that both proteins are able to target v10 exon, with GAAGAAG sequence being the binding site for Tra2β and AAGAC that for SRSF9. Collectively, our data add a novel layer of complexity to the sequential series of events involved in the regulation of CD44 splicing.

Contents

Since CD44 has nine variable exons, variable isoforms are generated through a complicated alternative splicing mechanism. In order to elucidate the regulatory mechanism of CD44 exon v10, we constructed a mini-gene including only exon v10 among 9 variable exons. When we transfected exon v10 mini-gene to HEK293T(Human embryonic kidney cells) and HCT116(Human colorectal carcinoma cells), it confirmed that the isoform containing exon v10 (inclusion) was much more than the isoform that did not contain exon v10(skipping). Using bioinformatic tools, we analyzed the sequence of exon v10 and found that potential binding sequences of Tra2β and SRSF9 existed. Based on this, when we transfected exon v10 mini-gene and Tra2β or SRSF9 together to HEK293T and HCT116, Tra2β promoted inclusion of exon v10 and SRSF9 inhibited inclusion of exon v10. In addition, in order to find out whether potential binding sequences from bioinformatic analysis actually affects the CD44 exon v10 splicing, we made substitution mutant which the GAAGAAG sequence was replaced with GGAGUAG. As a result of the same experiment using this mutant, we found that the function of Tra2β promoting exon v10 inclusion was abolished and we also confirmed Tra2β bound to the GAAGAAG sequence through RNA pull down assay. When we deleted AAGAC, a potential binding sequence of SRSF9, it revealed that the function of SRSF9 promoting exon v10 skipping disappeared and SRSF9 actually interacted with AAGAC sequence. From this research, we concluded that Tra2β binds to GAAGAAG sequence to promote exon v10 inclusion whereas SRSF9 binds to AAGAC sequence to promote exon v10 skipping.

Research Outcomes

[Paper] • Oh J, Liu Y, Choi N, Ha J, Pradella D, Ghigna C, Zheng X, Shen H. Opposite Roles of Tra2β and SRSF9 in the v10 Exon Splicing of CD44. Cancers (Basel). 12(11), 3195 (2020)

Research Funding

This work was supported by grants NRF-2020R1A2C2004682 to Haihong Shen, NRF-2019R1I1A1A01057372 to Xuexiu Zheng, a grant 2016R1A5A1007318 of Cell Logistics Research Center funded by the Ministry of Education and the National Research Foundation of Korea and grant from the Associazione Italiana per la Ricerca sul Cancro (AIRC; IG 2018 Id.21966). Davide Pradella was supported by an AIRC fellowship for Italy. This work was also supported by "GIST Research Institute (GRI) IIBR" grant funded by the GIST in 2020 and Fondazione Adriano Buzzati-Traverso.

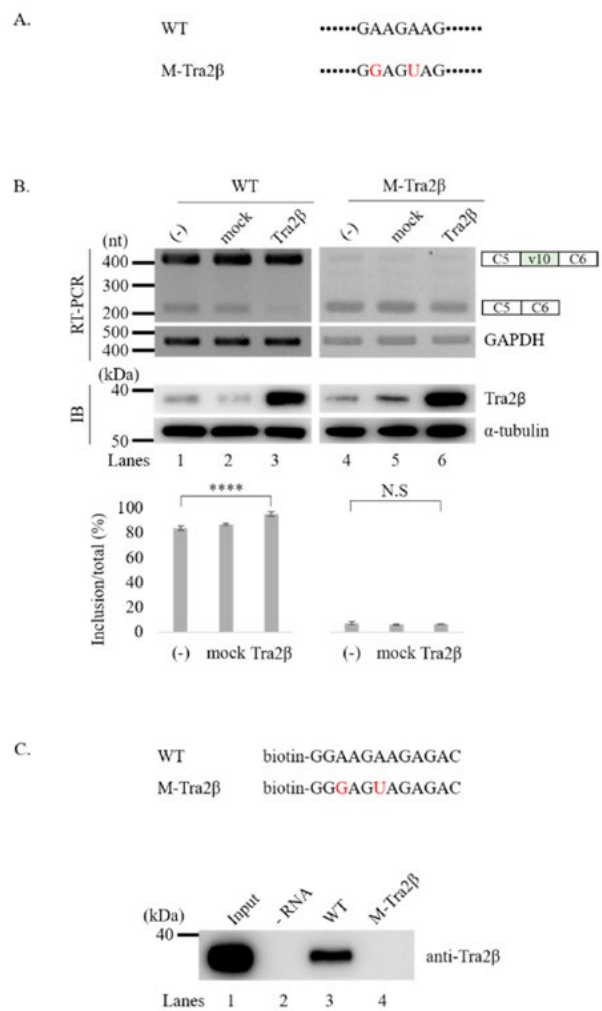


Fig. 1

Tra2β functionally targets GAAGAAG sequence in CD44 v10 exon to regulate its inclusion.

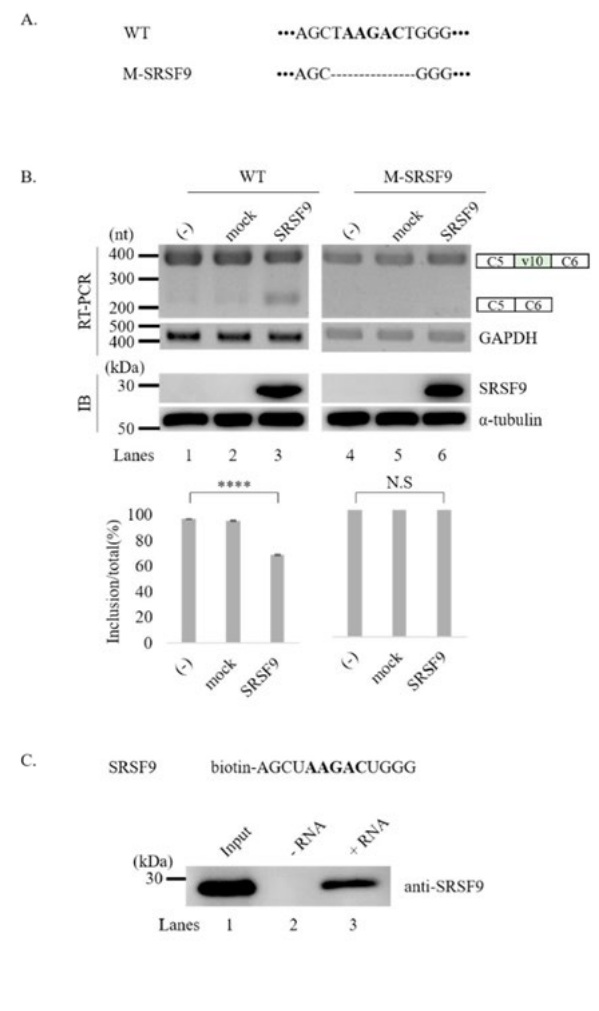


Fig. 2

SRSF9 targets AAGAC sequence in v10 exon to inhibit its inclusion.

International Environmental Research Institute

Kyoung-Woong Kim

https://ieri.gist.ac.kr/ieri/

CTCN pro bono Technical Assistance project: Application of the gravity-driven membrane (GDM) technology for supplying sustainable drinking water to rural communities in Cambodia

GIST, the 200th member of the Climate Technology Center & Network (CTCN) which is a technology development and transfer organization under the UN Convention on Climate Change (UNFCCC), was selected for the CTCN Pro bono TA project. These kinds of pro bono TA projects are undertaking without charge when CTCN network members propose the transfer of climate technologies as a trigger and provide high-quality technical assistance quickly to corresponding developing countries.

Cambodia has limited access to high water quality and hygiene. Although there has been an improvement in urban areas, most rural areas still have difficulties in water and sanitation access. A sufficient supply of safe water (including drink water) is crucial for rural people and would enable them to adapt to climate change, particularly in the prolonged drought situation that has occurred in Cambodia.

International Environmental Research Institute in GIST aims to provide safe drinking water by installing GDM water filtration systems in rural villages in Cambodia, which will bring in reducing greenhouse gas emissions and contributing to the healthy lives of residents. At the same time, it will strengthen the capacity of Cambodian central and local government officials to measure and manage water quality, and raise awareness of the importance of climate change and safe drinking water, as well as the capacity of villagers to operate and manage GDM water filtration systems.

To date, 1) its detailed implementation plan has been established, 2) all experts to participate have been selected, 3) an MOU for the implementation has been signed, and 4) a kickoff meeting of this project has been held. In addition, a village-scale GDM module (450 people) and 30 household-scale GDM modules (150 people) were shipped to Cambodia and will be distributed.

Contents

Project targeting area
Two rural villages in need of safe drinking water supply and climate change adaptation selected through consultations with Cambodian water-related ministries

Beneficiary
Village residents (450 people) with a village-scale GDM water filtration system and 30 households with 30 household-scale GDM water filtration systems (150 people)

Contents
1. Completion of detailed project implementation plans and preparation work processes
- Planning a detailed schedule for 11 months
- Selecting 3 professionals: one locally in the installation of GDM water filtration system, conducting the water quality analyses and the health surveys, one in cost-benefit analyses, and one in gender mainstreaming
- Delivering Amogreentech's GDM modules to Cambodia (Figure 1)

- Signing an MOU to implement the pro bono TA project (Figure 2, Figure 3)
- Holding a kickoff meeting on April 7, 2021, and having monthly maintenance meetings

2. Selection of target regions and villages through consulting with relevant ministries and experts
- Requesting available data from the Cambodian ministries related to water resources and water quality and choosing possible target candidates with data-driven decision making to install GDM water filtration systems
- Finalizing target villages among the candidates through conducting water quality analyses and household surveys

3. Installation of GDM water filtration systems and conducting water quality analyses/health surveys after installing
- Installing a village-scale GDM water filtration system and 30 household-scale GDM water filtration systems
- Conducting water quality analyses for 3 months periodically
- Monitoring any change in the health status of village residents over 3 months

4. Providing technical training workshops regarding of operation and management of GDM water filtration systems for sustainability
- Enlightening stakeholders including village residents and local public officials with operation and management of the systems for long term use
- Raising awareness of the importance of climate change and safe drinking water

5. Submission of the final report for CTCN review/evaluation progress

Research Outcomes

[Press release]
- GIST International Environmental Research Institute (IERI) selected as a pro bono technical assistance project for supplying GDM water filtration systems in Cambodia (etnews, pressed on December 08, 2020)
- GIST donates GDM water filtration systems to Cambodia (Fig 2.) (Yonhap News Agency, pressed on April 06, 2020)

Research Funding

120 million Korean won financial support as pro bono

Fig. 1 Amogreentech GDM modules for the village-scale and the household-scale sent to Cambodia

Fig. 2 MoU signing for the CTCN pro bono project

Fig. 3
MoU contents for the CTCN pro bono project

GIST Institute for Artificial Intelligence

Heungno Lee

https://giai.gist.ac.kr

GIST Institute for Artificial Intelligence(GIAI)'s AI+X revitalization of industry-academia joint researches and R&D cooperation for AI industry convergence complex development project, strengthening domestic and international networking

- 10 MoU agreements signed for R&D cooperation in the AI+X industry-academia joint research promotion and AI industry convergence complex development project → Strengthen domestic and overseas AI networking
- A key role in creating an artificial intelligence hub city
  - Linked to practical research by participating in AI manpower training projects with CJ Olive Networks and LG Electronics and promoting industry-university cooperation research
  - After signing a MoU with the Pyeongdong Industrial Complex Council, it is linked to the establishment of a Smart Factory Support Center
- Reinforcement of AI+X research capabilities centered on research centers by winning orders for national R&D projects
- Promoting the independence of GIAI through industry-academia joint research and build an AI industry-academia research hub
- Contributing to the creation of excellent research results and institutional development through the development of GIAI

Contents

Promotion background

- The Ministry of Science and ICT announced the 2020 Project for New Support for Industrial Convergence AI Research and Development (R&D) for Artificial Intelligence-Centered Industrial Convergence Complex. (March, 2020).
- In order to grow into a global AI research institute, GIAI aims to promote AI+X industry-academic joint research (Gwangju Metropolitan City's three major industries - mobility, healthcare, and energy) and strengthen networking of domestic and foreign artificial intelligence research institutes.
- Targeting the signing of business agreements for industry-academia R&D cooperation for the artificial intelligence-centered industrial convergence complex development project by research field

Research field	MoU target organization
Energy	Hyundai Solar Tec, Lyze, LG Electronics, Inko-Eo, Hyundai Motor Company, SH Corp., K water, Ninewatt, etc.
Mobility	Ettifos, SOS Lab, Drimaes, Frontis, Aliababcloud, Autoa2z, etc.
Healthcare	Neurophet, Intel Korea, etc.

Research Outcomes

[MoU signing status: A total of 10 signings]

- Autoa2z, Finemotors(2020.4.3.)
- LG Electronics(2020.7.30.)
- Ettifos & Tenegysoft(2020.9.15.)
- CJ Olivenetworks(2020.10.6.)
- Dkmtech(2020.10.8.)
- Lablup(2020.9.22.)
- AWS Korea(2020.10.20.)
- Dreamoceans Korea(2020.11.4.)
- NVIDIA(2020.11.10.)
  * Active cooperation activities such as NVAITC (GIST-NVIDIA Joint Cooperation Center) under the MoU for the second year.
- Intel Korea(2020.11.11.)

[Press release]

- 2020.7.30. AI Times, NEWSIS etc., “LG Electronics-GIST, AI Business Agreement”
- 2020.12.20. Seoul Economic Daily, "GIST will become a mecca for fostering AI convergence talent."
- 2020.10.6. IT Biz News, etc., "MoU signed with GIST for industry-academic cooperation in AI"
- 2020.11.12. Financial News, News 1, etc., "GIST and Intel Korea will work together in artificial intelligence field"

Fig. 1

GIST-DLI Workshop, 2020.6.7

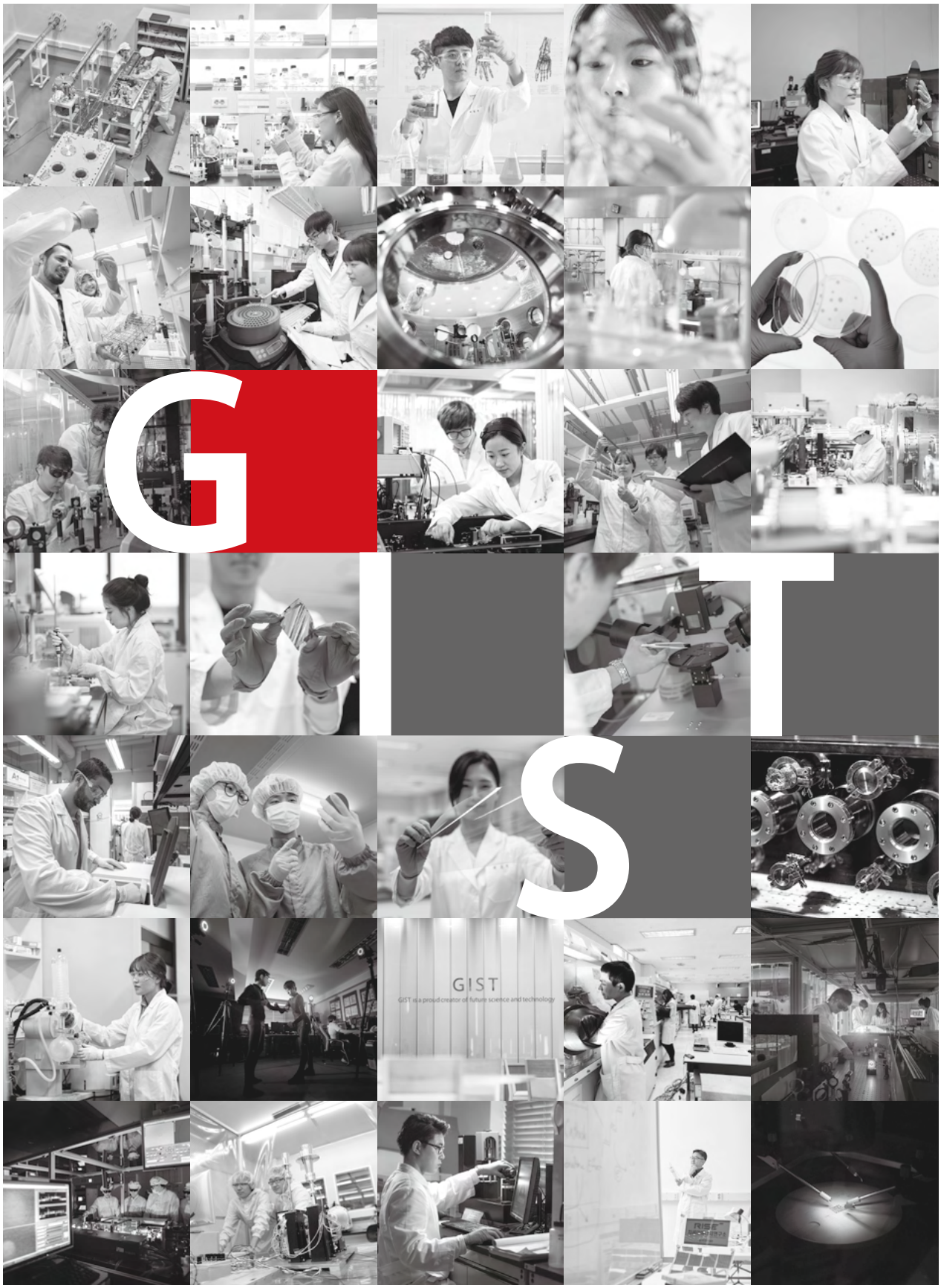
DLI Workshop is held annually under the MoU signed with NVIDIA.

Fig. 2

MoU signing ceremony with AWS, 2020.10.20

Main Research Achievements of 2020

GIST's Research Highlights of 2020


G
I
S
T
GIST
GIST is a proud creator of future science and technology

Gwangju Institute of Science and Technology

2021 ANNUAL R&D REPORT

Gwangju Institute of Science and Technology
123 Cheomdangwagi-ro, Buk-gu, Gwangju, 61005, Korea **Tel.** 062)715-2114 **Fax.** 062)715-2300 **www.gist.ac.kr**