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KIST

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KISToday

A New Single-Crystal 2D Material Presents Exciting Opportunities for Future Technologies

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KISToday

Leading to tomorrow

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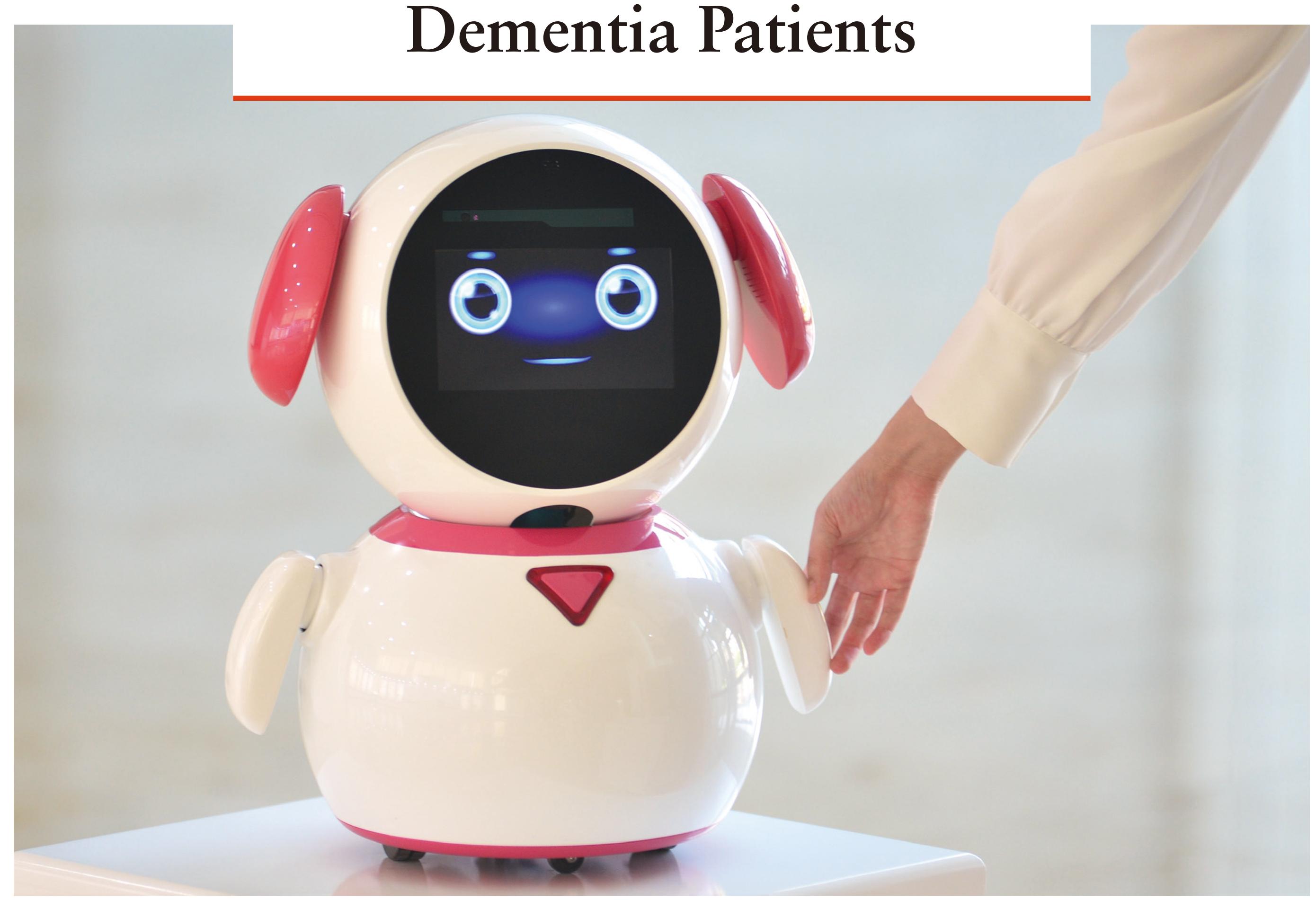
Cover Story

Joo song LEE (left) and Dr Soo Min KIM (right) from KIST are holding a wafer-scale SC-hBN film on a SiO_2-Si wafer

MyBom, Nurse Robot for Dementia Patients

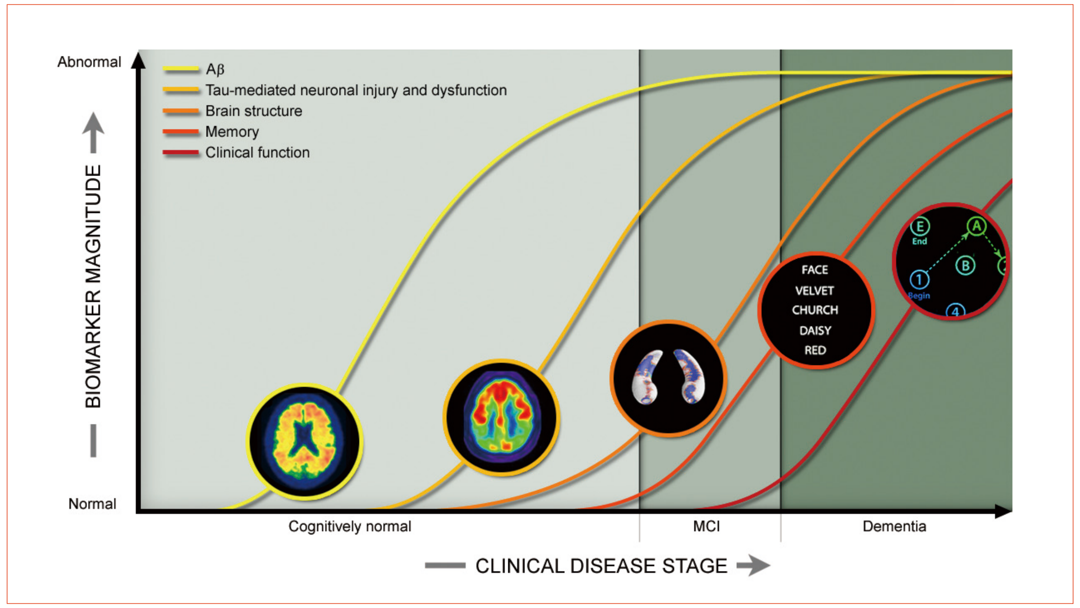


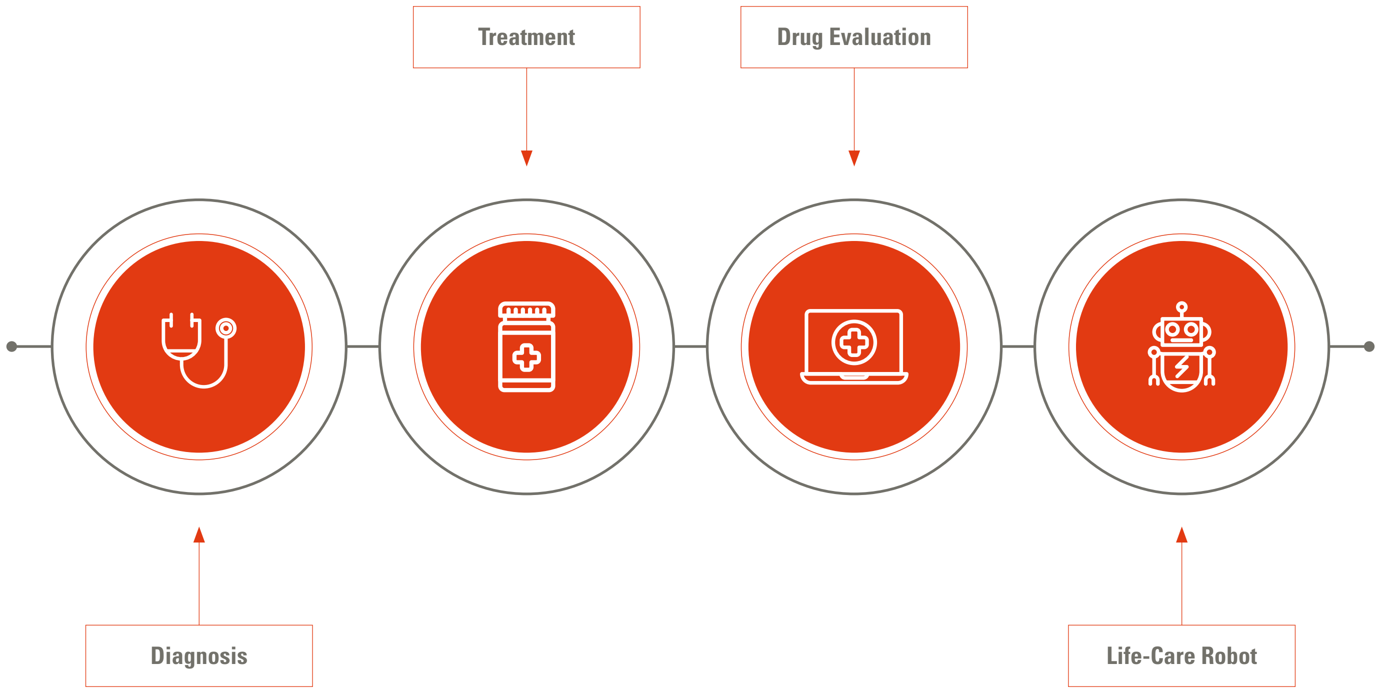
This therapeutic robot is being developed to help dementia patients cope with many aspects of daily life that have become challenging, such as remembering scheduled events and making social connections. Its intelligent systems are being designed to perform specific tasks, recognize situations requiring intervention and manage the information necessary to help the patient. It has both behavioral and service interfaces.

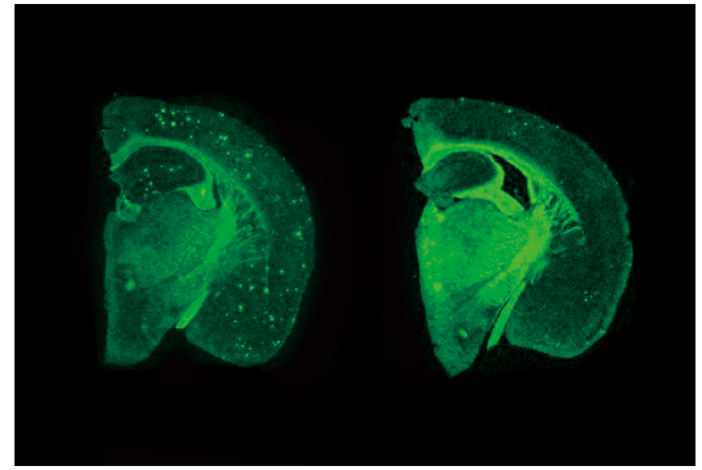
Addressing Dementia at the National Level

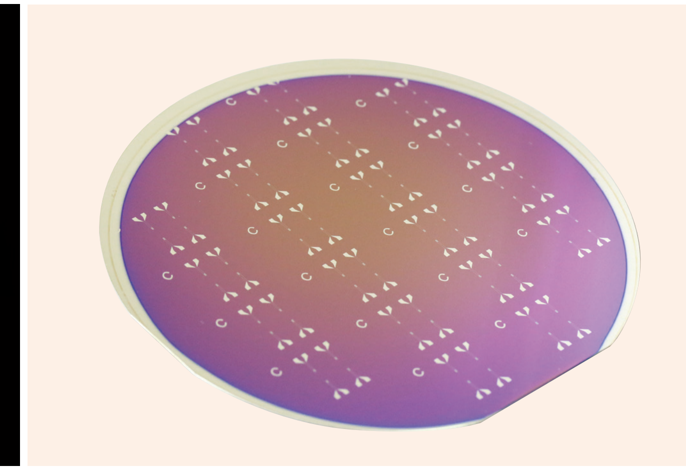
The aging of populations is a worldwide trend. The UN defines an aging society as one where older persons account for more than 14% of the entire population. By this definition, Korea became an aging society in 2017 when its over-65 population reached 14%. It is expected that Korea will represent a "super-aged" society in six years, when seniors are forecasted to account for more than 20% of the population. This trend highlights the need to make the necessary preparations to establish adequate social measures to support the elderly.

Progression of Alzheimer's Disease (Source : http://adni.loni.usc.edu/study-design/#background-container)









← Nec-1(anti-necroptotic molecule) reduces insoluble Aβ plaques in the brains of APP/PS1 mice
Related article : https://doi.org/10.15252/emmm.201606566

↑ Wafer-scale fabricated rGO biosensors, which can detect Aβ peptides with ultra-high sensitivity
Related article : https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4978995/

One area of particular concern is the increased number of dementia patients as the population ages. Dementia is a disease involving the brain and is difficult not only for patients but also for their family members, which is why it should be given serious attention.

One area of particular concern is the increased number of dementia patients as the population ages. Dementia is a disease involving the brain and is difficult not only for patients but also for their family members, which is why it should be given serious attention. In fact, dementia can cause mental illness, such as depression, in both patient and caregiver, even leading to suicide in severe cases. Given the extent of dementia-related health issues, the government is expected to spend 38.9 trillion won on medical expenses in 2030 when the number of dementia patients is expected to reach approximately 1.2 million.

Comprehensive national-level measures are thus urgently needed for the people living with dementia. Other advanced nations, including the U.S., U.K., and Japan, have already declared war against dementia and are putting institutional measures in place, such as an Alzheimer's Responsibility Law. These countries are taking other steps as well, such as research into dementia-related diagnosis, treatment and prevention, and making improvements in the quality and efficiency of patient care services.

As part of its own efforts to address dementia, Korea recently founded the Convergence Research Center for Diagnosis, Treatment and Care System of Dementia which brings together specialized researchers throughout the country to work collaboratively on the early prediction and treatment of dementia and develop relevant patient care.

Dementia is a degenerative brain disease marked by symptoms which begin with subjective cognitive disorder and progress into a weak level of cognitive disorder, eventually resulting in severe dementia. Most patients are diagnosed when they reach a weak level of cognitive disorder and survive for an average of 9.3 years after diagnosis. If patients can be diagnosed at an early stage, there is a better chance they will be able to maintain their cognitive function and delay the disease's progression, thus improving their own quality of life as well as that of their families.

In addition to early diagnosis, identifying appropriate treatment plans is very important. Unfortunately, currently available treatments are limited at this time to the mitigation of symptoms. A more advanced treatment option involves removing a protein called beta amyloid that is suspected of being a cause of dementia, but so far, drugs targeting beta amyloid have shown poor clinical results. Recently, based on a study which suggests that tau protein oligomers play an important role in degenerative brain disease and neurotoxicity, researchers have been trying to develop a mechanism that deters tau protein cohesion and have been looking for a preclinical/clinical candidate substance that targets non-neuronal cells. Research is currently being conducted to develop early prediction technologies, for example, by using wearable devices to analyze neural degeneration through related biosignals such as patient brainwaves, gaze, and posture, and developing prediction models based on big data and machine learning. An early prediction system is expected to be commercialized by 2021 after patient application and verification.

In addition, ongoing research on life-care robots are expected to improve the quality and efficiency of patient care by informing caregivers of any emergencies via 24-hour monitoring and conducting cognitive rehabilitation training.

For further information,
https://bsi.kist.re.kr/our-research/diagnosis-treatment-and-care-system-of-dementia/

Changes by the Fourth Industrial Revolution;

Making a Living in the Future Economy

Dr.Yeongoo CHOI, Director General, Division for Cooperation in Science Culture, KOFAC(Korea Foundation for the Advancement of Science&Creativity)

In its reports *"The Future of Jobs reports 2016"*, the World Economic Forum forecasted that as many as 7.1 million jobs will be lost with the coming of the Fourth Industrial Revolution, although this will be partially offset by the creation of 2 million new jobs.

This claim by an organization that first introduced the concept of the Fourth Industrial Revolution unsettled many. According to one popular scenario, as mechanization and automation accelerate with the development of artificial intelligence (AI) and robotics, more aspects of life will depend on AI and machines. Disappearing jobs will lead to an unemployment crisis and bring about total chaos in our societies. In this point of view, our future seems quite dismal.

Will science, technology and the Fourth Industrial Revolution really take away our jobs?

While many industrial experts and futurists predict that jobs will be lost to computerization and automation, it is too early to conclude that advances in science and technology will lead to job reduction. While technological development does indeed affect the job market, the job market itself is affected by many complex factors.

According to a report by the Korea Employment Information Service, there are eight factors behind changes in employment conditions. They include: changes in demographics and the working age population; changes in industry characteristics or structure; development of science and technology; climate change and energy shortages; changes in people's life values and styles; changes in global and domestic economic conditions; changes in business management strategies; and finally, changes in government policies and the legal framework. Clearly, developments in science and technology are just one of many reasons that lead to job growth or reduction. Even if these developments do indeed eliminate jobs, reductions can be offset by changes in other areas, such as economic conditions.

Obviously, employment is a key social issue. It has been at the top of the public agenda in Korea in recent years, as evidenced by all the discussions on employment policy and job creation and the spotlight directed on the Senior Secretary to the President for Job Creation and the governmental job committee. But we need to stop and think if it's right to keep our focus on jobs only. Is it true that one has to have a job in order to work? Not necessarily. There are types of work that do not actually involve formal employment.

Normally the two terms are used interchangeably, but in the strictest sense, they are different. A "job" involves employment, while "work" is something that you do in return for compensation. The Korean word for "occupation (jig-eop)" is a combination of

There is a difference between what we call "jobs" and "work." It is important to distinguish between the two.

Chinese characters that stand for "job (jig)" and "work (eop)." Creating new work does not necessarily mean creating a new job, and creating a new job does not necessarily mean there's more work. Creating work and creating jobs are different activities. Comparing the two, "work" is the more fundamental concept.

A recent trend in the job market is the concept of the "gig economy." Gigs originally referred to impromptu performances at American jazz concerts during the early 1920s. A gig economy is centered more on work than on a job. The widespread digitalization of society has propelled the development of the sharing economy as a new economic system, with online platform-based services such as Uber and Airbnb being some of the prime examples. New forms of micro-employment are emerging in the global job market in which small-scale demand is met with small-scale supply. Freelancing is also becoming commonplace, with more people opting to work independently under temporary contracts with employers. The gig economy is based on these forms of work. Gigs may become the dominant form of employment, and few, if any, conventional jobs may exist in the future. Independent work based on individual expertise is likely to make up most of the employment, with more and more people moving away from the stability of a job.

The World Future Society claimed in its report on the future that one day the concept of salaries and wages will disappear, to be replaced by a system in which skills are compensated individually. Assignments will be determined between workers and workees, and levels of compensation will vary.

While we can expect to see a continuous drop of long-term, stable jobs going forward, that does not mean there will be less work. Unskilled workers will continue to seek stable, secure jobs, while specialists, skilled and other highly educated workers will look for ways to create their own opportunities in innovative ways, preferring to commit to several different assignments at once to generate more income. It is important to remember, however, that while state-of-the-art technology is what drives the Fourth Industrial Revolution, human beings should be in charge, not technology. People come first, and developing creative talent should always be at the forefront of our priorities. At the end of the day, it is people who create the technology.

work

job

Seoul mayor Won Soon PARK recently quoted a book written by Professor Richard Florida on urban issues. The book defines three elements, referred to as 3T, that make up a creative city: technology, tolerance and talent. These elements are found in any thriving city around the world, without exception. These cities attract creative talent with easy access to cutting-edge technology within a social culture that is tolerant and accepting. Professor Florida refers to these people as the "creative class" and claims that they will be the pioneers of the 21st century just as the bourgeoisie were instrumental to the growth of the industrial age.

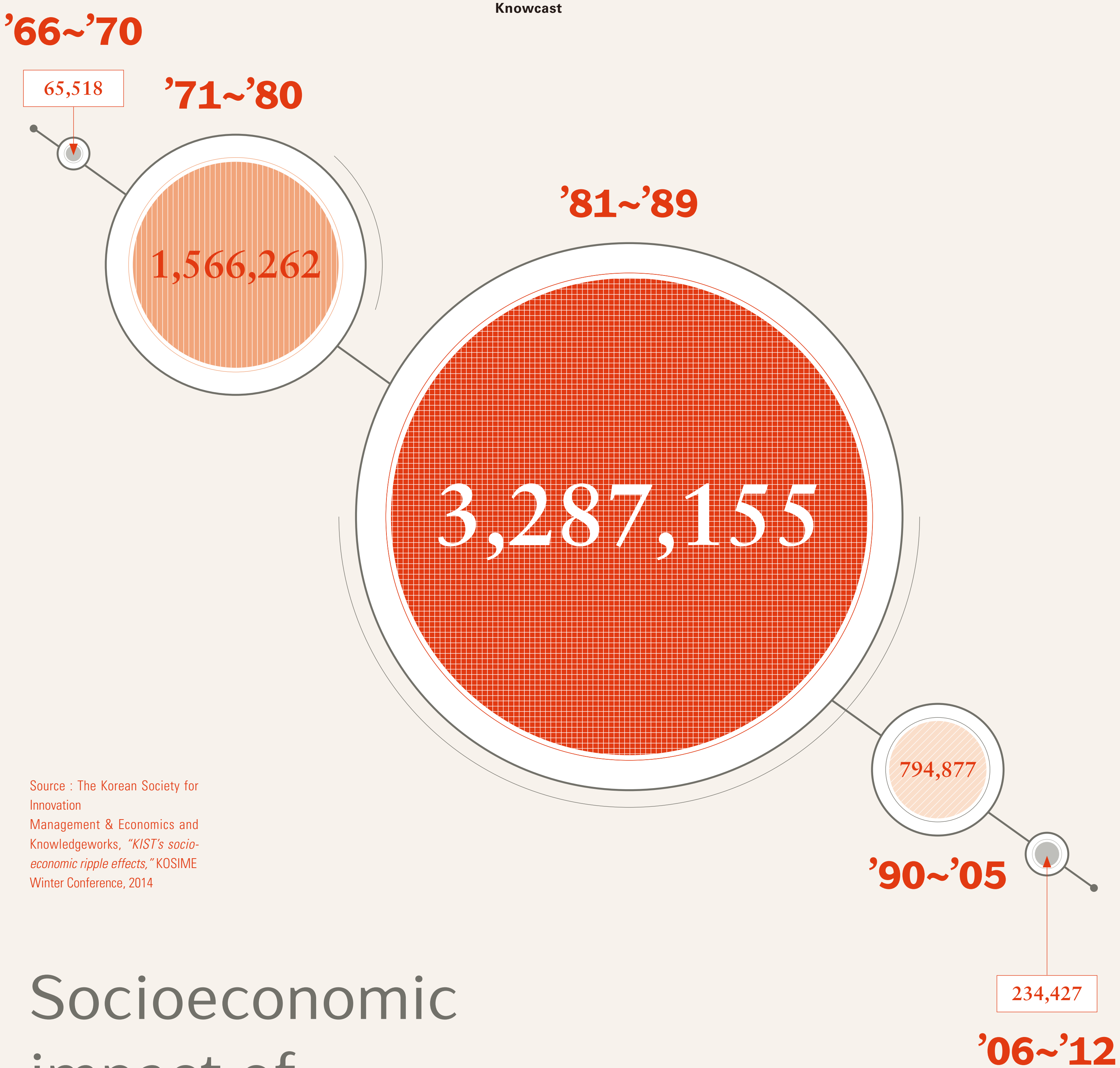
Professor Florida expects the creative class to take up professions in computing, mathematics, construction and engineering, life science, physics, social science, education and training, art, design, entertainment, recreation, sports, and media. These largely coincide with the professions that futurists believe have the most promise, despite ongoing mechanization and automation. For most of these professions, work, rather than jobs, will make up the larger share of opportunities. In this way, the creative class concept fits in nicely with the gig economy. Forcing job creation when there is no real work is not sustainable.

The job market should be stimulated by creating more opportunities for work, rather than jobs, particularly in areas that require expertise and creativity.

With current developments in technology, having a defined physical space for work is becoming increasingly meaningless. People can study without going to school, work without going to work, and can even receive medical treatment or participate in video conferences at home. Indeed, advances in 5G, IoT, and other communications technology can lead to job reduction; however, a job is a limited concept that relies on physical space. Commuting to work and sitting at a designated desk to carry out assignments is associated with the industrial age. By contrast, the Fourth Industrial Revolution will eliminate borders between time and space. People will be able to make a living without having a formal job, as long as there is work to do. It is time to stop fussing over jobs and turn our attention to work that is not confined by space or conventional concepts of employment that no longer fit economic realities.

For more detailed information on jobs and job policies, refer to *"Job and Work Policies of the Fourth Industrial Revolution"* by Yeongoo CHOI, Kistep InI (Vol. 26), 2018.

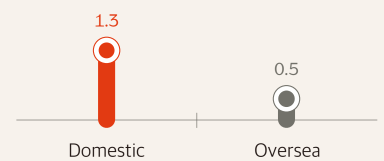
The Role of KIST in the Economic Development of Korea over the Past 50 years and New Challenges in the Coming 50 years



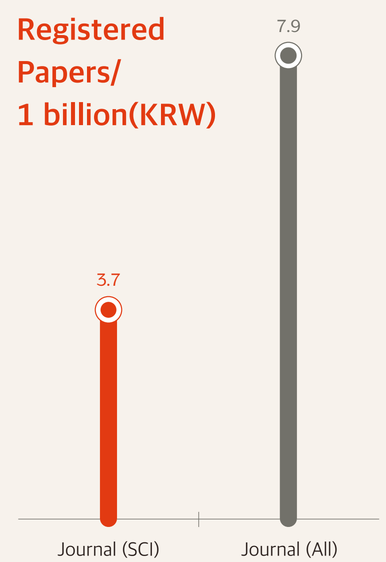
Source : The Korean Society for Innovation Management & Economics and Knowledgeworks, *"KIST's socio-economic ripple effects,"* KOSIME Winter Conference, 2014

Socioeconomic impact of KIST over the past 47 years 595 trillion KRW (as of 2013)

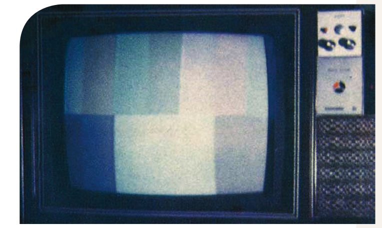
Registered Patents/ 1 billion(KRW)



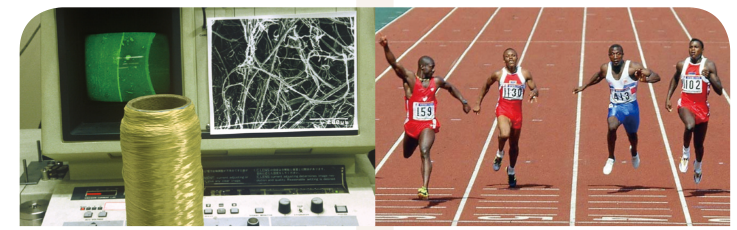
Registered Papers/ 1 billion(KRW)



1970
- Color TV screen



1980
- High intensity aramid fiber technology
- Doping Control Technology



2000
- Lithium-ion battery core technology
- Capsule type endoscope maze
- High efficiency solar cell technology
- Dementia medicine technology
- Robot for Hazardous Application
- Microsurgical robot

The term 'Ancient Futures', well known as the title of Helena Norberg-Hodge's book, shows us how we can find hope for the future in things that have been with us for ages.

Byung Gwon LEE
President of KIST

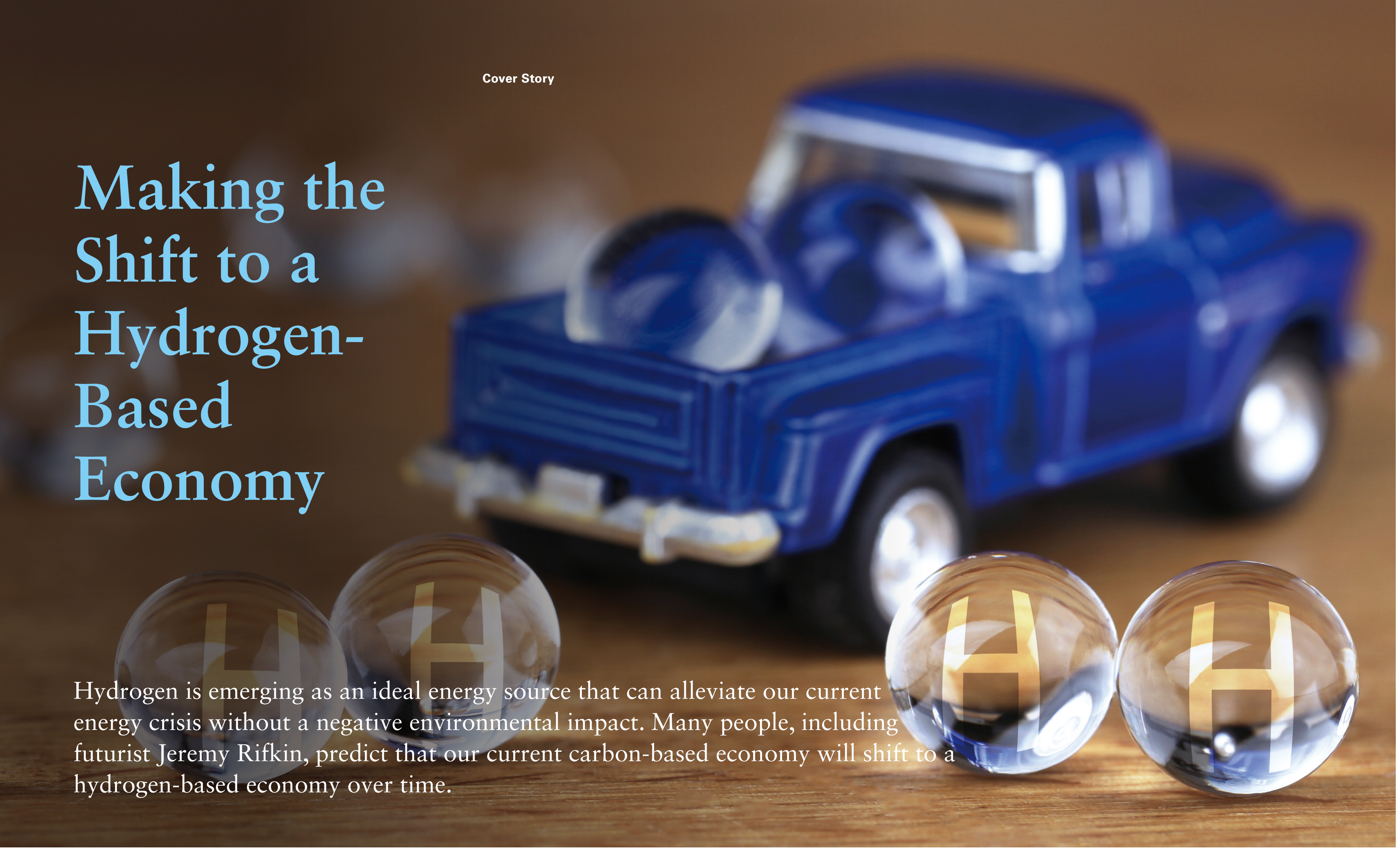
Take hydrogen, for example. This is the very first chemical element to be created in the universe and is a prime example of an ancient future.

Hydrogen technology started receiving attention as people began looking for ways to store nature's irregular energy. It took a long time, however, for hydrogen to become closer to our industrial and daily life.

Talks over hydrogen economy have recently expanded outside expert groups to the general public, providing evidence that while nationwide investment is being made in hydrogen production and distribution, it is raising concerns as well.

It is therefore necessary to consider the intricate web of industries and technologies that exist today as we draw a blueprint for hydrogen-based economy it can develop in harmony with today's industrial competition and network.

Hydrogen, the first chemical element in the universe, was first used for mankind's challenge toward the universe. This brings us to think how realizing a hydrogen society can be understood as yet another journey of challenge to turn an ancient future into reality.



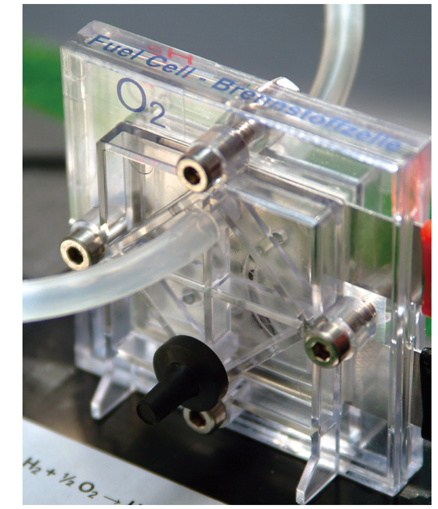
Making the Shift to a Hydrogen-Based Economy

Hydrogen is emerging as an ideal energy source that can alleviate our current energy crisis without a negative environmental impact. Many people, including futurist Jeremy Rifkin, predict that our current carbon-based economy will shift to a hydrogen-based economy over time.

Hydrogen is viewed as a new energy that will replace oil and other fossil fuels thanks to its many advantages. First, it is a secondary energy generated from other sources, just like electricity, but can be obtained from water, one of the most abundant resources on Earth, thus making it free from resource restraints or regional bias. It can also be obtained from sources other than water, such as natural gas, biogas, oil, or diesel. Another advantage is that hydrogen has a short energy cycle compared to fossil fuels because hydrogen energy created from water can be turned back into water. It is also a clean fuel as water is its only byproduct.

Fuel cells represent a key to the future development of a hydrogen economy because they comprise a well-established system for the production, storage, transport, and use of hydrogen.

A fuel cell converts a fuel's chemical energy into electricity. It has a high level of convergence efficiency because of its direct generation method and can drastically reduce CO_2 emissions. Fuel cells used for power generation average over 47% in energy efficiency while household fuel cells are over 35% efficient. Energy efficiency of over 40%



is usually obtained by GW-class combined-cycle power plants, but with fuel cells, this efficiency is possible with hundreds of kW-MW.

Many experts agree that fuel cells are competitive in terms of efficiency and eco-friendliness, and wider penetration through highly efficient devices would increase their price competitiveness as well. In addition, whereas power plants face complex construction and maintenance issues, fuel cells require only one or two containers to generate hundreds of kW, making them a favorable means of distributed generation.

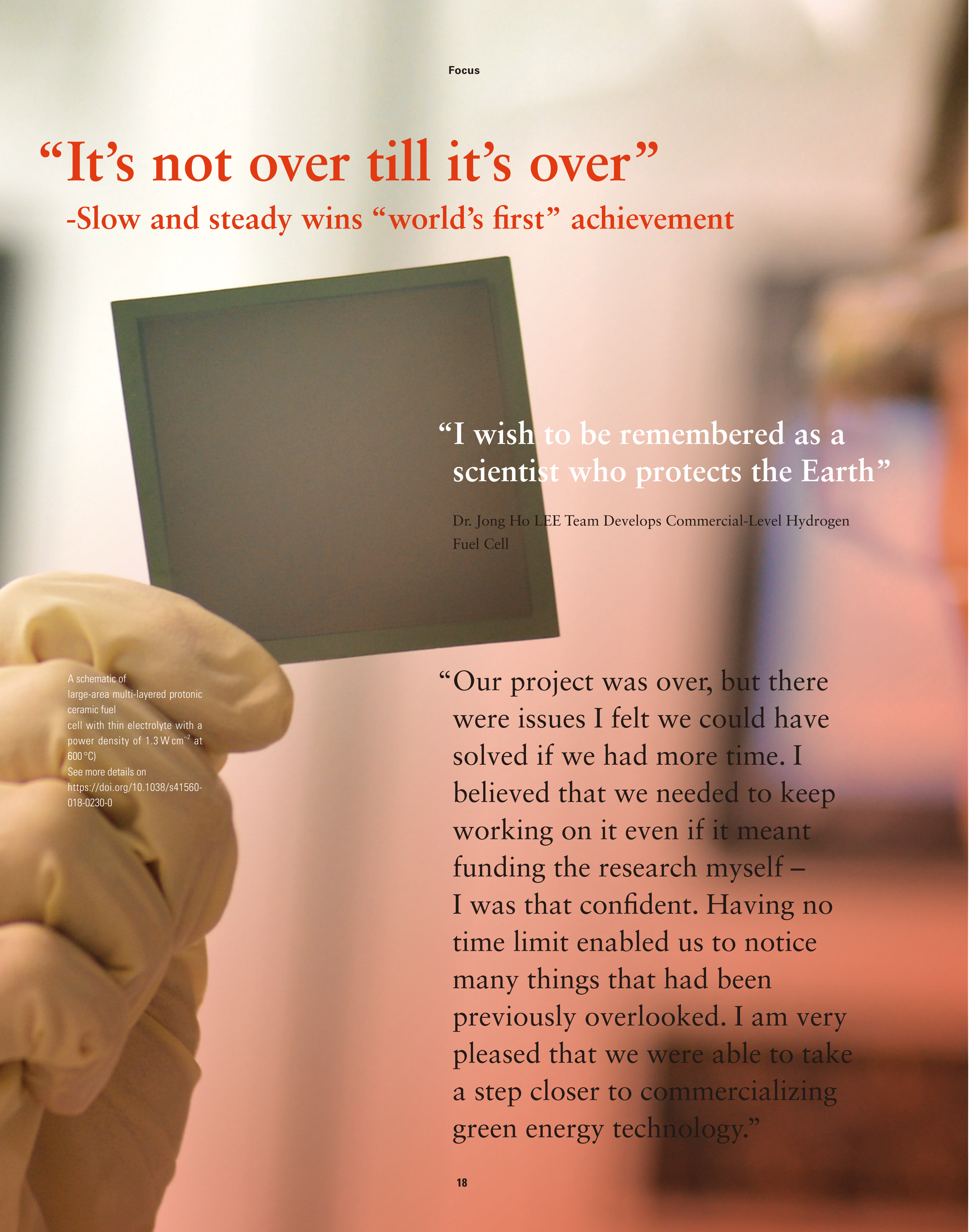
Economic and social changes are expected as the world shifts to a future hydrogen economy. Countries around the globe are actively planning for these changes by focusing on developing and distributing hydrogen and fuel cell technologies while establishing new policies and developing plans for their implementation.

To promote international cooperation in hydrogen/fuel cell R&D as well as its demonstration and deployment, the International Partnership for Hydrogen Fuel Cells in the Economy (IPHE) was established and its steering committee meets each year. Established in 2003, the IPHE currently has 17 partner states, including Korea, the U.S., Canada, France, Germany, China, and Japan.

Much work remains to be done, but the future looks bright for a cleaner, cheaper and more sustainable source for power generation.

"It's not over till it's over"

-Slow and steady wins "world's first" achievement



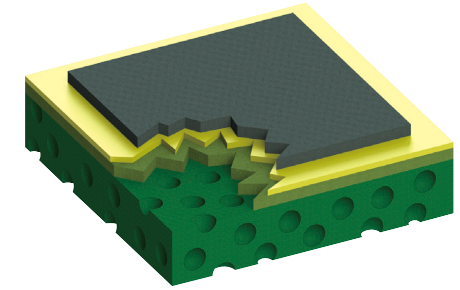
A schematic of large-area multi-layered protonic ceramic fuel cell with thin electrolyte with a power density of 1.3 W cm^{-2} at 600 °C)
See more details on https://doi.org/10.1038/s41560-018-0230-0

"I wish to be remembered as a scientist who protects the Earth"

Dr. Jong Ho LEE Team Develops Commercial-Level Hydrogen Fuel Cell

"Our project was over, but there were issues I felt we could have solved if we had more time. I believed that we needed to keep working on it even if it meant funding the research myself – I was that confident. Having no time limit enabled us to notice many things that had been previously overlooked. I am very pleased that we were able to take a step closer to commercializing green energy technology."

"I believe fuel cells are a powerful alternative to solar and wind-centered renewable energies, which are limited in growth potential, and thermal power, which emits pollution."



↑ A schematic of large-area multi-layered protonic ceramic fuel cell with thin electrolyte

Jong Ho LEE
Center for Eneegy Material Research
Principal Researcher

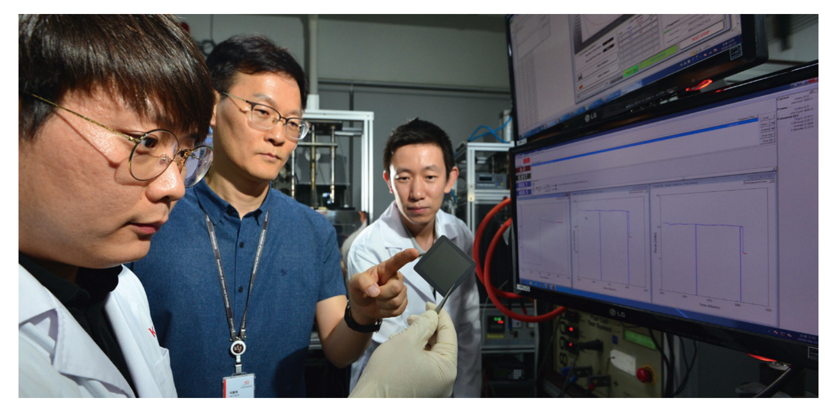
Ho Il JI
Center for Eneegy Material Research
Senior Researcher

Dr. Jong Ho LEE of the Center for Energy Materials Research (KIST) has devoted himself to ceramic fuel cell research for 20 years. He hopes to be remembered as a scientist whose concern for the planet formed the basis of his work. "I believe fuel cells are a powerful alternative to solar and wind-centered renewable energy, which are limited in growth potential, and thermal power, which emits pollution," suggests Dr. Lee. He added, "At a time when fine dust is affecting people's lives, I am worried about its effect on our growing children, particularly as a scientist and a father. I hope our R&D can provide some practical improvements to people's lives."

Fuel cells are regarded as clean energy due to their ability to convert chemical energy directly into electrical energy without emitting any pollution and for their high generation efficiency. Ceramic fuel cells are attracting worldwide attention based on this relatively high generation efficiency as well as their compatibility with various fuels, even without the use of costly precious metal catalysts.

This research is taking Dr. Lee one step closer to his dream of becoming an Earth-saving scientist. It represents the first time that protonic ceramic fuel cells have demonstrated the potential to be commercially viable. In theory, electrolytes of protonic ceramic fuel cells have conductivity over 100 times higher than that of conventional ceramic fuel cells operating in mid to low temperatures. As a result, protonic ceramic fuel cells are regarded as a next-generation fuel cell.

As Dr. Lee explained, "This is applicable to various areas other than power generation, such as fuel production and storage. It is also



← Dr. Lee and researchers are testing a large-size (5x5cm^2) protonic ceramic fuel cell composed of 5μm-thick electrolyte expected to dramatically increase the use of variable renewable energy."

The performance of protonic ceramic fuel cells in labs was excellent but faced many challenges when it came to commercialization. According to Dr. Lee, these fuel cells had been regarded as having a low chance of commercialization because of the extreme difficulty in creating joint electrolyte-electrode structure film and in the decline of their material properties when heated during high-temperature processing. Even scientists thought of protonic ceramic fuel cells as material for research purposes only.

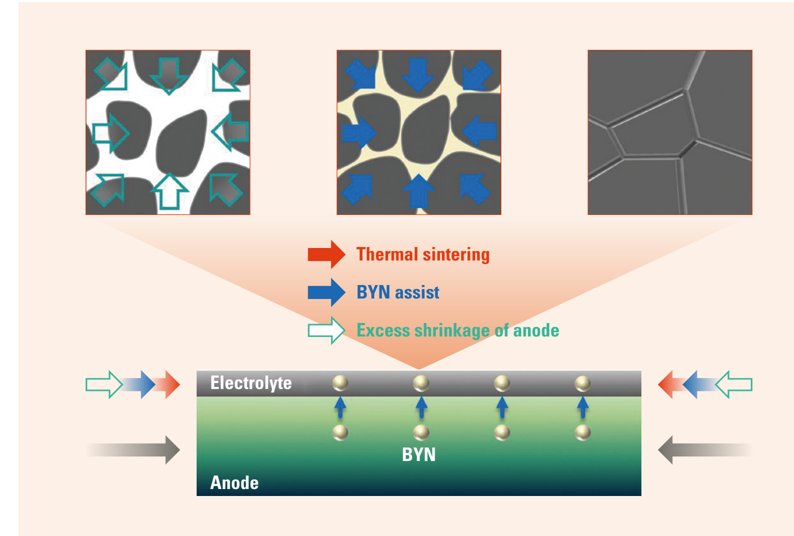
But Dr. Lee's team persevered. In order to overcome existing challenges, they continued their research through regular projects as well as cooperation with other research institutions. The truly interesting outcome, however, came long after these projects ended.

"The project was over, but I believed we were on the right track and that we should work on it even if I had to fund it myself. I thought the failure to realize protonic ceramic's unique properties was an engineering problem that could be solved if we had enough time. Looking at the project steadily and calmly down to the basics enabled us to get the desired results."

Dr. Lee went back to review many research details whose significance might not have been recognized in the team's haste to produce results. Once he did this, clues to solving the biggest challenges started to appear. Last year, in joint research with Hanyang University, his team succeeded in systematizing the principle of increasing electrolyte density when joint electrolyte-electrode structures are heated. Moreover, the team not only succeeded in radically lowering processing temperature and minimizing the thickness of electrolytes, but they were also able to enlarge the fuel cell to a size appropriate for commercial applications.

Furthermore, they confirmed the economic feasibility of producing the new fuel cell by applying a large-scale screen-printing process, used in other forms of mass production, as well as a microwave process capable of rapid, low-temperature heat treatment.

The team also succeeded in creating a battery that shows potential for commercialization. Dr. Lee explained that a battery must be at least 5x5cm^2 at the R&D stage to have the potential for mass production, as commercial ceramic cells are over 10x10cm^2. Building on previous research, Dr. Lee's team created a protonic ceramic fuel cell measuring 5x5cm^2.



↑ Schematic illustration of the electrolyte sintering process on an anode support driven by thermal sintering of the electrolyte itself (pink arrow), excess shrinkage of the anode (green arrow) and the assistance of BYN supplied from the anode (blue arrow).

"Did you know that the Terminator has two hearts? The hearts - the source of the Terminator's power – are fuel cells. And in Star Wars, there's a scene where a fuel cell power plant is under attack. Fuel cells can be used not only in futuristic cars, drones and motorcycles, but anywhere that requires light and powerful batteries."

Dr. Lee has a positive view of a future with commercialized fuel cells. For example, fuel cells allow large amounts of surplus energy from various renewable energy sources to be stored in a chemical energy form, such as hydrogen. Also, unlike batteries that have limited capacity, fuel cells can actually increase the amount of matter that generates energy just like ink cartridges, making them applicable for use in batteries that require light and high levels of energy. Their potential is endless, according to Dr. Lee.

He highlights the importance of continuous research in fuel cell technology, especially now that the government is actively putting in place measures to respond to climate change. In addition, a growing fuel cell market is seen as critical to Korea's future economic growth.

"1st and 2nd generation fuel cell technologies were brought in from abroad, but what we are researching now are future-generation fuel cells. With taxpayers' money contributing to the growth of our domestic market, I believe it is important to acquire the relevant technology so that it can strengthen our power generation market."

Going forward, Dr. Lee's research goal is to realize a conductivity increase of 100 times, a purely theoretical concept at the moment. "We have succeeded in improving the performance of protonic ceramic fuel cells, but not by 100-fold. We have selected a few candidate electrode materials that are compatible with electrolytes and may bring out their hidden potential. My goal is to find better materials and perfect our research so that it helps people's daily lives."

Energy and Food Security Explored in The Martian

Image Sources
Fox promo materials
20th Century Fox

Can mankind survive on a planet other than Earth? The 2015 movie The Martian presents a realistic answer to this question that has been asked ever since people began space exploration.

The movie depicts how Watney, an astronaut left behind on Mars after an expedition, survives. With his background as a botanist, Watney supplements his dwindling food supplies by growing potatoes.

Water is what Watney needs the most to grow potatoes. To obtain it, he separates hydrogen and nitrogen by reacting the rocket ship's hydrazine with iridium. He gets oxygen from CO_2 on Mars using the exploratory base's oxygen equipment. Using the extracted hydrogen and oxygen, Watney produces water and successfully grows potatoes.

Even after Watney has solved his food problem, he has to tackle yet another challenge in order to find his way back to Earth: either figure out how to efficiently store solar energy or search for a different energy source.

The issues Watney deals with in this movie, such as efficiency in energy storage and various ways to develop fuel cells, are based on actual research trends in science and technology. It is reflective of our search to find the best possible way to utilize and store limited energy and is critical to the survival of Earth's future generations.

A New Single-Crystal 2D Material Presents Exciting Opportunities for Future Technologies

Stronger than steel, harder than diamond. Light, transparent, flexible, and capable of transferring electricity or heat quickly. Can be used as the main material in wearable computers and electric garments as well as ultra-high-speed semiconductors and high-efficient solar cells. Sound too good to be true? Say hello to graphene.

The research was published on Science (16 Nov 2018 "wafer-scale single-crystal hexagonal boron nitride film via self-collimated grain formation").
See more details on
https://doi.org/10.1126/science.aau2132

Developing a new material can significantly influence future technology since it is at the heart of the industrial process. This is why competition is intense among researchers trying to develop new materials, despite a low success rate. Nevertheless, a team of Korean researchers has defied the odds by successfully developing a new method of synthesizing materials having properties considered crucial for running future electronic devices.

Dr. Soo Min KIM of Functional Composite Materials Research Center(KIST), Director Young Hee LEE of Dongguk University collaborated to create a technology synthesizing hexagonal boron nitride (hBN), a 2D material composed of nitrogen and boron, into a single-crystal material. Since publication of their work in the November 2018 issue of Science, requests for samples of the material have been streaming in from around the world.

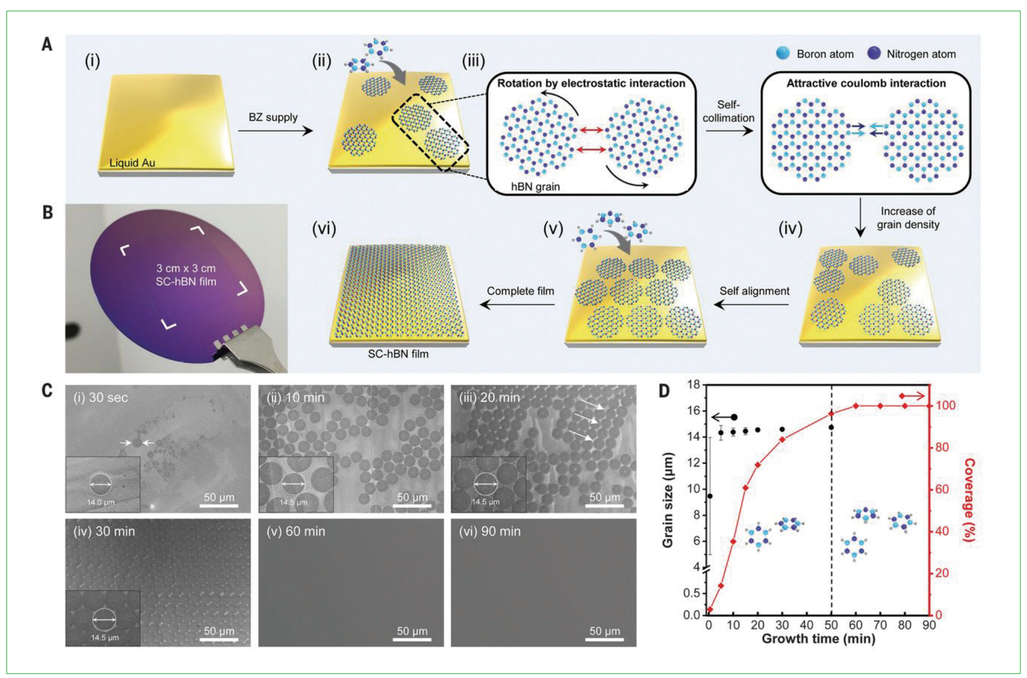
Hexagonal boron nitride (hBN) is a flat-surface material whose insulating properties make it useful for transparent and flexible electronic devices.

To maintain these strong insulating properties, the team focused on synthesizing it into a single-crystal form where the entire crystal is formed around a constant crystallographic axis. The team confirmed their theory through repeated experiments. This rigorous testing was important since this type of synthetization process had been considered impossible using existing technology.

As Dr. Kim explains, "hBN is the only material with insulating properties among 2D materials, but due to difficulties handling the precursor, there hadn't been many studies done on synthesis. This research is meaningful in that it succeeded in synthesizing hBN, a heterojunction 2D material, into a monocrystal."

The team designed a method of synthesizing hBN film on a surface of liquid gold. On a gold surface, nitrogen and boron atoms interact electrically and maintain a certain distance from each other, so this characteristic was used to achieve synthesis.

Dr. Kim explained further by saying, "We used the synthesized hBN film as a template for synthesis of other 2D materials such as graphene, molybdenum disulfide (MoS_2), and tungsten disulfide (WS_2) into single-crystal forms. We are receiving many sample requests, but we can't fill all the requests because the synthesis process is very difficult and takes a long time."



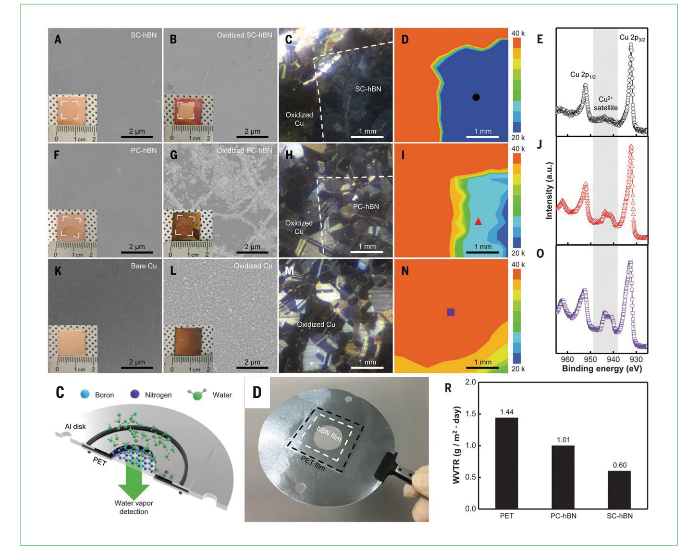
→ (A) Schematic illustration for the growth of SC-hBN film by means of self-collimated circular hBN grains with a rotation invoked by the attractive Coulomb interaction of B and N edges between grains (i to vi). BZ, borazine. (B) Photograph of a wafer-scale SC-hBN film on a SiO_2-Si wafer. (C) Growth evolution of SEM images of hBN film. Single-headed arrows indicate linear alignment of hBN grains.
(D) Time evolution of hBN grain size and coverage. Full coverage of monolayer hBN film is achieved at 60-min growth time. Error bars indicate the size deviation of hBN grains.

This achievement was made possible by collaboration. Experts from several different institutions worked together to produce the results over a three-year period. In theory, the research result was achievable, but confirming it through experiments was difficult. Dr. Kim points to collaboration as the key factor behind this astonishing success. Director Lee had actually been her academic advisor and she had been already working with Prof. Ki Kang KIM team for several years.

As Dr. Kim explained, "We were able to produce results because we had been sharing the same ideas and had worked together for years. Research is difficult to do alone. We went through synthesis, measurement, and discussions for alternative methods together."

Collaboration is particularly important in 2D-material research, according to Dr. Kim. She explained that because there are so few people doing research on 2D material in Korea, everyone has to combine their efforts in order to be competitive on a world scale.

Unique research challenges were also overcome through collaboration. For example, high humidity in the summer interfered with the synthesis process and the slightest change in lab conditions altered results, confounding the researchers.



↑ Protecting layer against Cu oxidation and water vapor barrier applications of wafer-scale SC-hBN film. SEM images of SC-hBN–, PC-hBN–covered, and bare Cu foils before (A, F, and K) and after (B, G, and L) oxidation in air at 300°C for 1 hour. Optical (C, H, and M) and corresponding XPS (D, I, and N) mapping images of SC-hBN, PC-hBN, and bare Cu samples after oxidation. (E, J, and O) Representative Cu 2p core level spectra from the circle, triangle, and square symbols from (D), (I), and (N).The peaks near 952.2 and 932.3 eV in the spectra are assigned to Cu $2p_{1/2}$ and Cu $2p_{3/2}$, respectively. (P and Q) Schematic and photograph for the WVTR measurement. (R) WVTR values of PET, PC-hBN, and SC-hBN samples.

"The first two years were a period of continuous failure. We were constantly repeating the cycle of experimenting, measuring, and confirming. It was difficult to achieve a uniform single-crystal structure throughout the entire area. The team constantly discussed why we had failed and looked for solutions, which is how we ultimately achieved success."

Joo Song LEE was a doctoral student at Chonbuk National University(CNU) working on the team. Performing experiment after experiment without complaint, he had the honor of being named lead author on the paper presenting the results, which went on to be published in the prestigious journal Science. This marked the first time that CNU had a paper published in Science since the university established its Department of Bio-Info-Nano (BIN) Fusion Technology.

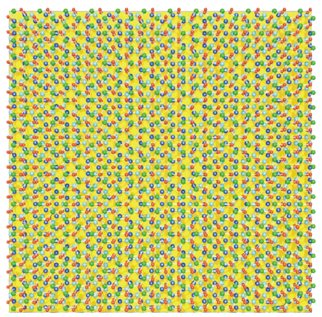
Dr. Kim appreciated Lee's persistence, "It's not easy for a doctoral student to be an author of a paper published in a journal like Science. I am glad the research worked out, but the process must have been difficult for Lee. His colleagues had generally published multiple papers already, but this was his first."

Thanks to this research, Dr. Kim received the KIST Person of the Month award in December 2018. She is praised as having achieved the seemingly impossible synthesis of heterogeneous 2D materials and having presented a new research paradigm for various 2D materials. Based on their recent research, the team is planning to investigate the large-area single-crystal synthesis of 2D semiconducting materials such as MoS_2 and WS_2, establish synthesis mechanisms and pioneer their application.

Dr. Kim stressed, “Corporations are aware of the need for heterojunction materials, which are critical to electronic devices. But commercialization requires the materials to be larger and thus cheaper. This is difficult to achieve on an individual level. The private sector must participate.”

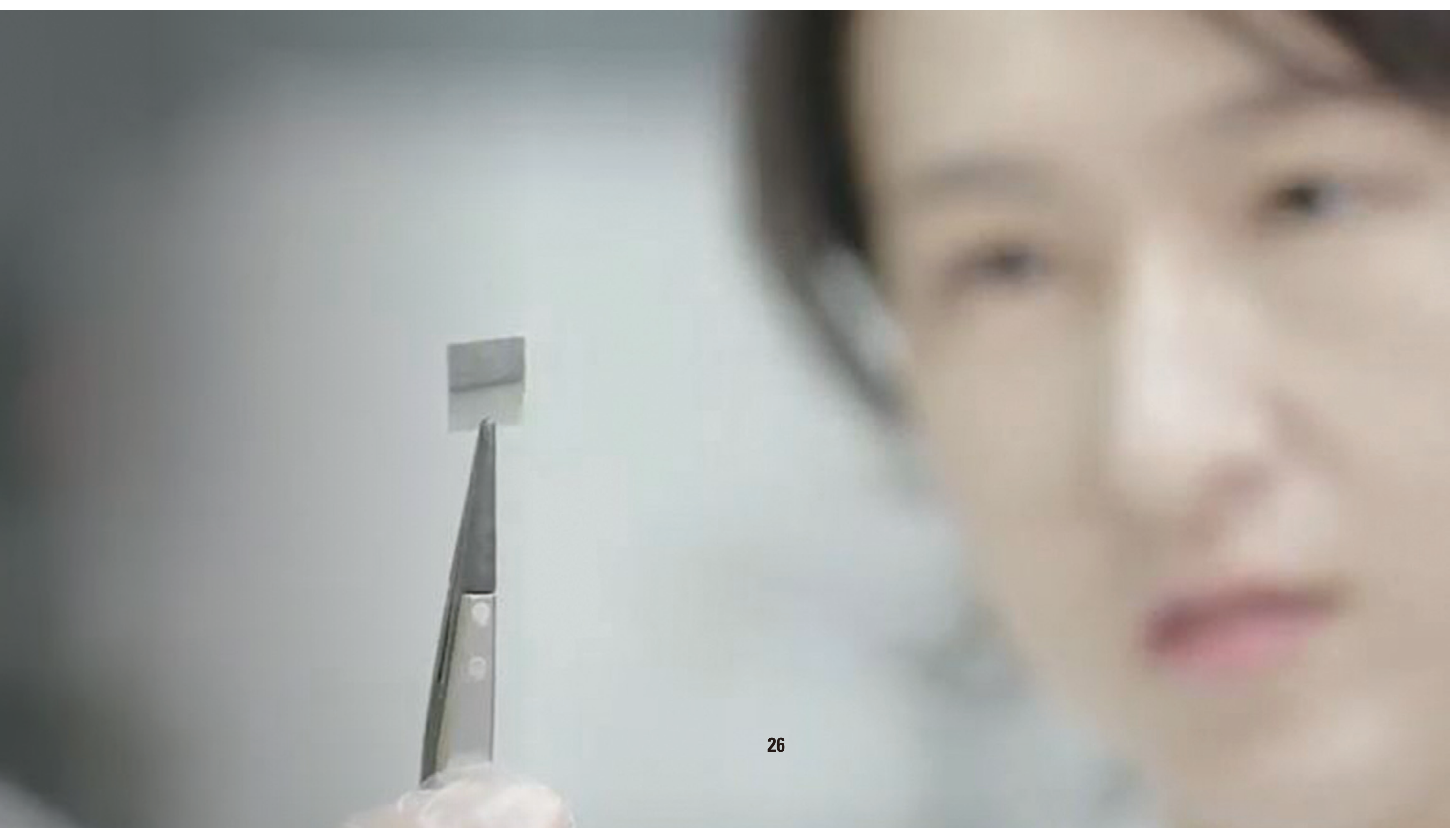
She continued by saying,

“This research is only a beginning. We plan to continue our work on establishing a synthesis mechanism and applying the technology to other 2D materials.”



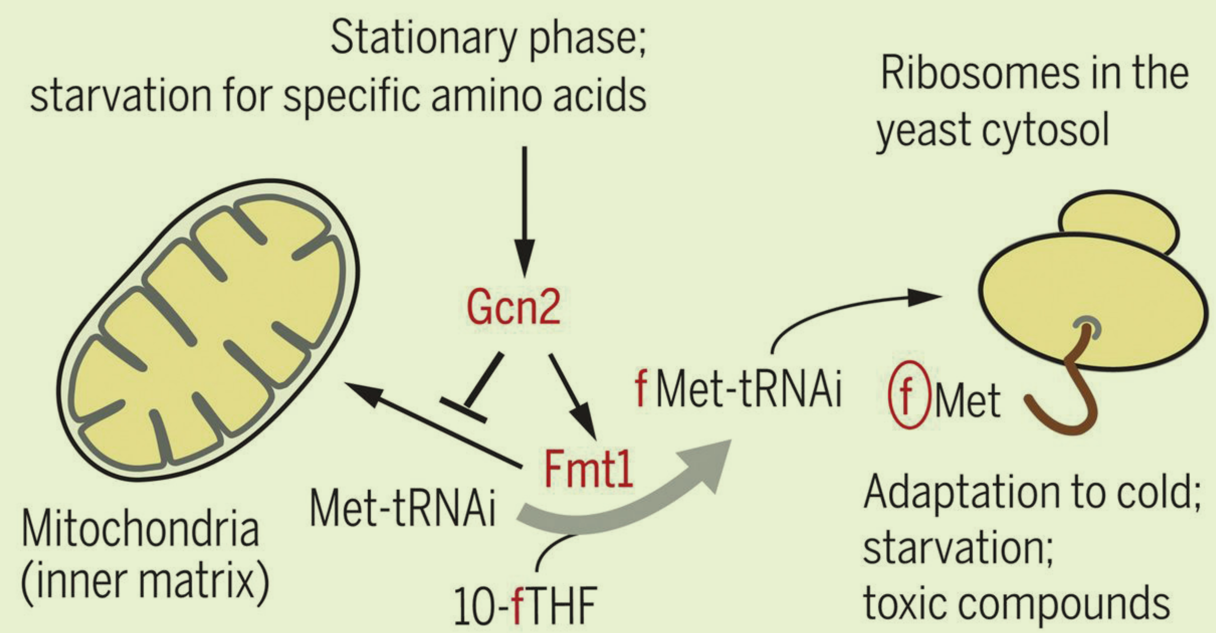
↑ SIngle Crystal WS_2 on hBN

Toward the end of the interview, Dr. Kim expressed hope for more support in material research. “We have to take a long-term view of material research. Source research, which serves as the root for other research, has to be strongly established to develop competitive applied technology. Material can be used continuously if backed by solid research. The U.S. has long been supporting this field, and China is growing fast as well. We must also keep going if we are not to fall behind.”



How do life forms survive in extreme hunger and cold?

↓ Under undernutrition conditions, the Gcn2 kinase augments the cytosolic localization of the Fmt1 formyltransferase, and possibly also its enzymatic activity. Consequently, Fmt1 up-regulates the cytosolic fMet–tRNAi (initiator transfer RNA), and thereby increases the levels of cytosolic Nt-formylated proteins, which are required for the adaptation of cells to specific stressors.



The research was published on Science (30 Nov 2018 “Formyl-methionine as an N-degron of a eukaryotic N-end rule pathway”)
See more details on https://doi.org/10.1126/science.aat0174

Dr. Cheolju LEE of Center for Theragnosis (KIST) and Prof. Cheol Sang HWANG of POSTECH led the team that made this discovery. Their joint research team isolated a mechanism that enables formylmethionyl-transferase (FMT), an enzyme necessary for protein synthesis, to help eukaryotes survive in extreme conditions. They also found that this enzyme is involved in protein decomposition, which determines a protein's lifespan.

The process that led to the discovery is a prime example of the benefits of convergence research. Dr. Lee's team are experts in proteomics while Prof. Hwang's team specialize in molecular biology. Prof. Hwang's research hypothesis was somewhat outside mainstream theory, but received support, nonetheless, from KIST's proteome researchers. As a result of this support, Prof. Hwang's team was able to create a certain antibody and discover a new biological phenomenon.

We met with Dr. Cheolju LEE and Mr. Shin Young JU, one of his graduate students to hear about the significance of this research, specific challenges of the project, and future research plans.

Dr. Lee's research focus is the development of proteomic core technologies, the identification of disease biomarkers, and protein analysis. He obtains information through precision analysis of proteomes and studies their correlation with disease. His team uses various mass spectrometry-based research methods such as N-terminal proteomic tool. This methodology can find a desired protein even in a small sample. The team uses a technology he developed to analyze only the very front part of a protein, even among countless proteins within a cell.

> "All parts of a protein are important, but particularly the head section because it contains a certain signal that enables us to analyze a protein's lifespan or pathway,"

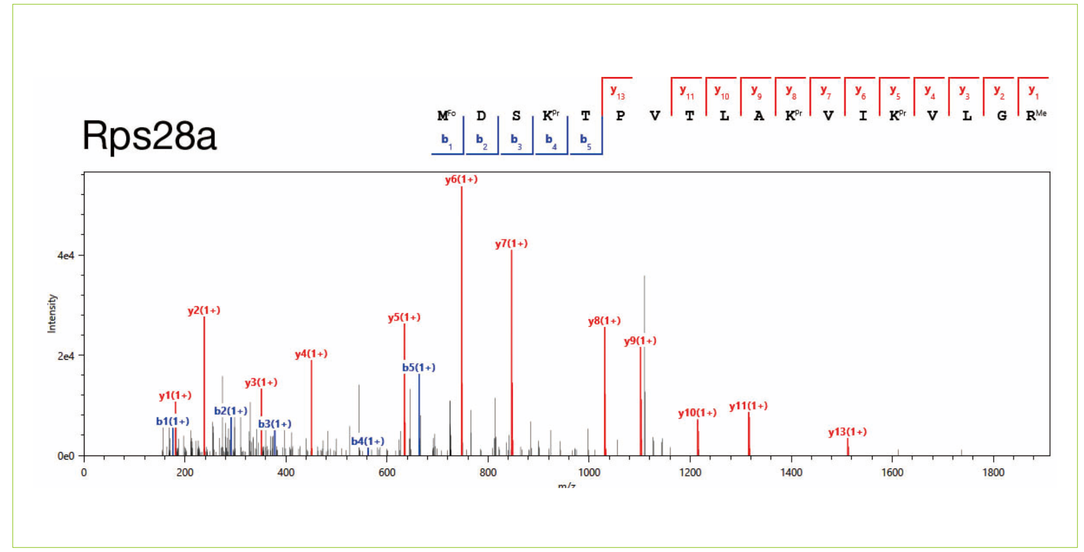
explained by Dr. Lee. He added, "Analytic equipment is designed to work on a quantity basis. It first analyzes protein that is most abundant, which is why technology that separates a desired area's protein is important."

The research team is also diversifying their research in N-terminal peptides. Examples include developing a kit that conducts a biochemical analysis of N-terminus in a small sample within 24 hours, research for finding cut-off proteins, and studying the relationship between antibodies and the N-terminus. Small sample analysis is expected to be used to study patients' proteins and develop a better understanding of why certain proteins are cut off. This should ultimately provide a clue to the interrelationships between certain diseases and proteins. Investigating the relationship between antibodies and the N-terminus can contribute to developing new drugs.

According to Mr. Ju, "Most new drugs take the form of an antibody, and one's response to an antibody changes dramatically depending on the type of N-terminus. We are expecting to see, through changes in the N-terminus, whether a new drug is effective or not. We are continuing our research on nanogram-level analysis so the technology can be commercialized."

Using these advanced technologies, the KIST research team was the first to discover a hidden biological phenomenon in formylmethionine (FM) which provides a clue to the secret of survival of eukaryotes in extreme environments. Organisms invisible to the eye, such as bacteria, are prokaryotes, while visible multicellular organisms such as humans are called eukaryotes. Whereas eukaryotes form protein from methionine, prokaryotes create protein from FM, a variant form of methionine. In the case of mitochondria, which produce energy within a eukaryotic cell, protein is formed from FM, which is why scientists believe mitochondria originated in coevolution with prokaryotic species. Coevolution refers to a phenomenon where one species' evolution leads to the evolution of another species. An example of coevolution is the relationship between host and parasites.

Interestingly, the enzyme that creates FM - FMT - is synthesized within the cytoplasm and immediately moves to the mitochondria to form protein from FM. In order to



→ Mass spectrometric analyses of Nt-formylated proteins (Rps28a, a ribosomal protein) from wild-type (lacking EcFMT) S. cerevisiae.

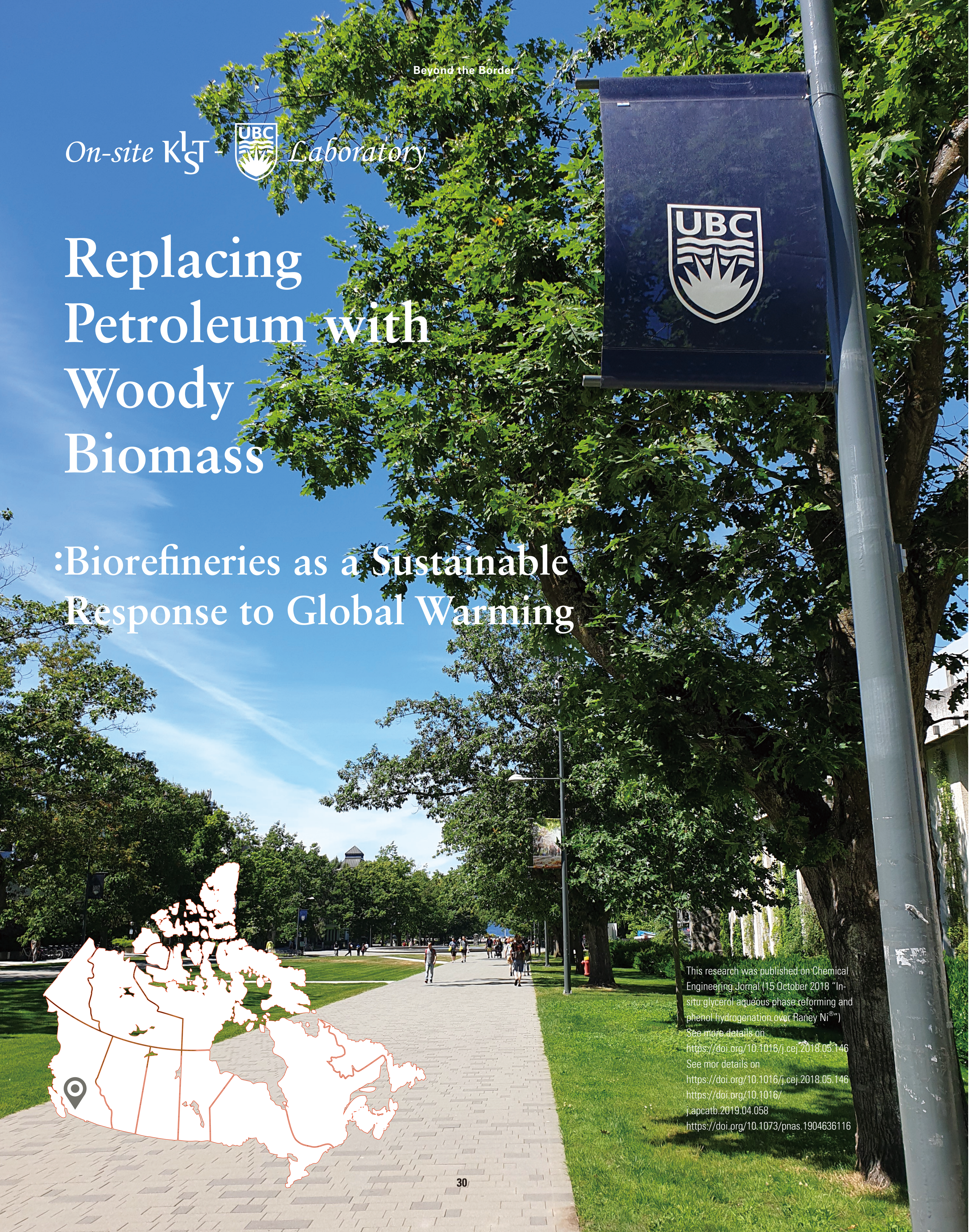
determine the biological significance of this process, Prof. Hwang's team began a verification process using various biochemical and molecular biological experiment methods. By using yeasts a eukaryotic microorganism which is easy to genetically modify, the team found that during periods of prolonged low temperature or malnutrition, FMT does not move to the mitochondria, but instead, remains in the cytoplasm to synthesize protein using FM. Contrary to existing theory, the process of protein synthesis from FM within eukaryotic cytoplasm imitates that of prokaryotes, which the team demonstrated was necessary for a cell to adapt to extreme conditions and increase resistance. In addition, the research team found a new decomposition pathway that directly recognizes and removes formyl peptide synthesized in eukaryotic cytoplasm.

Dr. Lee worked for ten years researching N-terminal peptides using mass spectrometry. This experience was vital for locating peptides that contain FM, which only exists in trace amounts and for a very short time. "I think no research can be accomplished in a short period," said Dr. Lee. "We were able to achieve the results we did thanks to the depth of each person's research experience built over the last decade."

The joint research team shared their progress over the phone since they were at different physical locations either in Seoul or Pohang. Their five years of work can be found in their phone records. "I talked over the phone countless times with a POSTECH researcher. He told me that the total hours of phone conversations he had with me were probably longer than what he had had with his wife," Mr. Ju laughingly recalled.

The positive experience of their recent research together has prompted the team to continue joint research efforts, this time involving a certain gene expression caused by a rare phenomenon and signal changes of the N-terminus. The KIST team is also conducting research with Seoul National University and another project with a research team abroad. Dr. Lee and his team are planning to study the correlation between certain diseases and proteins. As Dr. Lee explains,

> "Because our research focuses on proteins, we will be doing many studies on diseases such as cancer. We will emphasize research in N-terminus mutation and signal delivery in cells and defining their correlation."



On-site KIST - UBC Laboratory

Replacing Petroleum with Woody Biomass

:Biorefineries as a Sustainable Response to Global Warming

This research was published on Chemical Engineering Jornal (15 October 2018 "In-situ glycerol aqueous phase reforming and phenol hydrogenation over Raney Ni®")
See more details on
https://doi.org/10.1016/j.cej.2018.05.146
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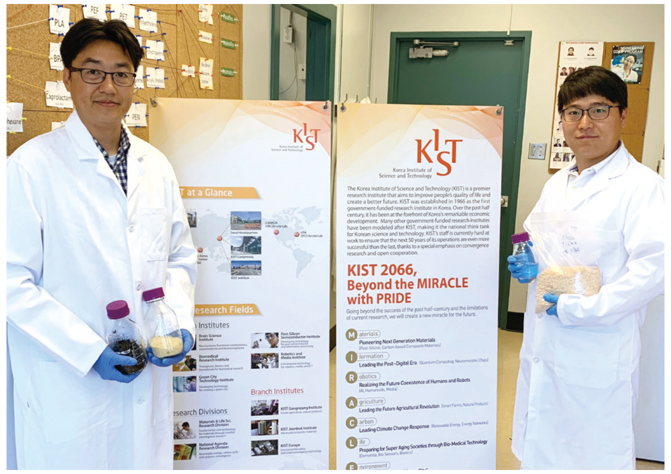
https://doi.org/10.1016/j.apcatb.2019.04.058
https://doi.org/10.1073/pnas.1904636116

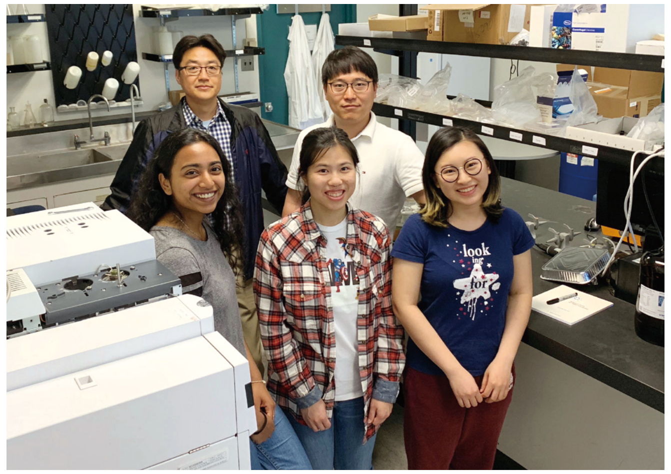
KIST conducts cooperative research in various fields through branches, specialized centers and labs around the world. One such lab is the KIST-UBC biorefinery on-site lab, established in 2013 in partnership with the University of British Columbia in Canada. This lab is dedicated to a new initiative involving the replacement of traditional petroleum refineries with biorefineries, a technological development that would benefit both participating countries.

Researchers around the world have been conducting studies in lignocellulosic biomass, such as woody biomass and other non-edible biomass sources. Lignocellulosic biomass is the only alter-native resource replacing petroleum and its deri-vatives at the same time even without causing climate change.

However, greener fuels derived from this resource have been forced to rely on subsidies and the social consciousness of consumers for their use because they are expensive to produce. The intrinsic features of lignocellulosic biomass, known as lignin-carbohydrate complex, account for the high cost and difficulties in processing where only carbohydrates are utilized to produce the greener fuels.

However, added value from lignin and lignin-derived compounds can offset high cost from carbohydrate targeted process. Lignin, a phenolic biopolymer accounting for ~30% of biomass, has the great potential as a renewable source of aromatic compounds and carbon materials.





In fact, a research team led by Dr. Chang Soo KIM at the KIST-UBC biorefinery on-site lab is developing a new technology to utilize both lignin and carbohydrates. The principle research themes of the team include: 1) fractionation of lignocellulose components; 2) upgrading of lignin derivatives into biofuels and specialty chemicals; and 3) the production of carbon materials from lignin. Dr. Kim's team works not only with the UBC but also with the JBEI (Joint Bio Energy Institute, USA) on developing an integrated process for the production of biofuel,; other researchers at KIST's headquarters on the production of biocrude for upgrading to bioethanol and jet fuels; and KIST's Jeonbuk branch on carbon materials applicable to carbon fibers, battery electrodes, and 3D printing materials.

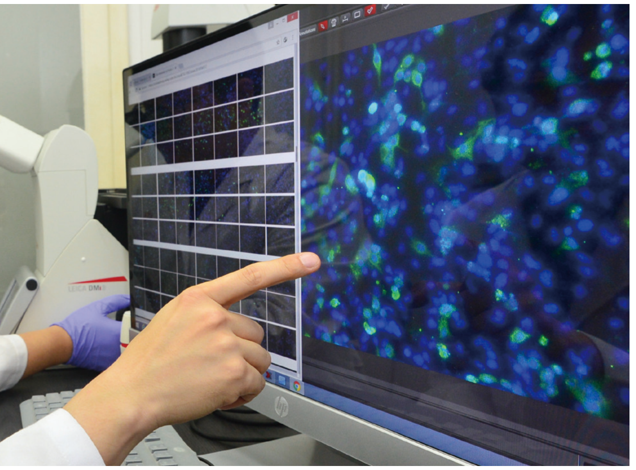
The major significance of the KIST-UBC biorefinery on-site laboratory program is the cooperative nature of its research in which several institutes work together to benefit future generations. This scheme of collaborative research has led to break-throughs in current biorefinery technology, such as value-added pro-cess development of lignin and crude glycerol as byproducts from the forestry and biodiesel industries, catalytic microwave application in biofuel production, and integrated lignin fractionation with novel solvents. International collaboration and cooperative research within KIST will continue as the KIST-UBC biorefinery on-site laboratory develops solutions for replacing petroleum with woody biomass.

Research News. 01

Bio/Medical

KIST Develops Technology Detecting Avian Influenza Using Virus Fingerprinting

The research was published on Sensors and Angewantde chemie international edition (22 June 2018 "Discrimination of Avian Influenza Virus Subtypes using Host-Cell Infection Fingerprinting by a Sulfinate-based Fluorescence Superoxide Probe")
See more details on
https://doi.org/10.1002/anie.201804412



AI virus-infected cells show flurescent pattern

Jun Seok LEE
Molecular Recognition Research Center
Senior Researcher

Avian influenza (AI) occurs routinely each year, causing considerable economic hardship and health hazards. It is potentially damaging to neighboring countries as well, which is why early detection and prevention of its spread are critical. This requires developing technology that can detect and differentiate AI viruses (AIV) from a large number of samples at an early stage of an outbreak. KIST has developed a new method of identifying infection and also discriminating between subtypes based on fluorescence-emitting materials in AIV-infected cells.

A KIST team led by Dr. Jun Seok LEE of the Molecular Recognition Research Center, together with a research team led by Prof. Chang Seon SONG of Konkuk University's College of Veterinary Medicine, used superoxide-inductive fluorescent dye to treat cell lines infected with AIV and analyzed the appearing fluorescent pattern to differentiate infected cells and subtypes.

The current method of in ovo injection and genetic sequencing tests require a minimum of three to seven days to obtain results. These methods also require specialized facilities for egg incubation and use methods such as immunoblotting and polymerase chain reaction (PCR), which also require additional equipment and time for analysis.

To overcome these limitations, Dr. Lee's team based its research on the fact that cells display different sensitivities to infection and that infected cells release active oxygen. Consequently, researchers applied superoxide fluorescent probes to detect AIV. The team first took 23 types of cell lines from mammals and measured their level of infection from three types of AIV. Researchers then calculated how the cells' fluorescent patterns changed with infection.

As a result, three AIV subtypes were successfully differentiated. In light of these findings, Dr. Lee would like to see the rapid application of the detection system, "We will distribute the cost-efficient primary screening technology that uses the AIV fingerprinting developed in our research. We expect the technology will quickly prevent the spread of AIV upon outbreak and minimize economic damage."

Research News. 02

Bio/Medical

Stent Prevents Restenosis for Frequently Returning Esophageal Cancer

The research was published on ACS Nano (7 June 2018 "On-Demand Drug Release from Gold Nanoturf for a Thermo- and Chemotherapeutic Esophageal Stent")
See more details on
https://doi.org/10.1021/acsnano.8b01921

Esophageal cancer, which causes esophageal stricture, narrows the esophagus and makes it difficult to swallow food. In many cases, dysphagea (difficulty in swallowing) signals that cancer has already reached an advanced stage and is spreading to other parts of the body, which is why esophageal cancer has a low survival rate. Stents have been developed to reduce dysphagia and enhance quality of life, but are associated with high recurrence rates of disease due to restenosis caused by malign esophagus cancer cells.

It is thus welcome news that a joint research team recently developed a new stent that minimizes cancer cell restenosis while working in concert with conventional anticancer therapies, such as radiotherapy. The research team, led by Dr. Young Mee JUNG of Center for Biomaterials (KIST) and Prof. Tae Il KIM of Sungkyunkwan University, developed a new esophageal cancer stent that can deliver drug treatment. The team announced that it effectively formed a nanostructure made of nitinol on the surface of the stent which allowed control of drug release speed, thereby treating the cancer and minimizing restenosis. Using biocompatible polymers on an existing stent's surface, the team formed tens to hundreds of small Nano pores, allowing the anticancer drug to be delivered evenly. The team also covered the drug with a thin gold film, which effectively converts light into heat, thus enabling thermotherapy that kills cancer cells by using infrared rays absorbed from a catheter.

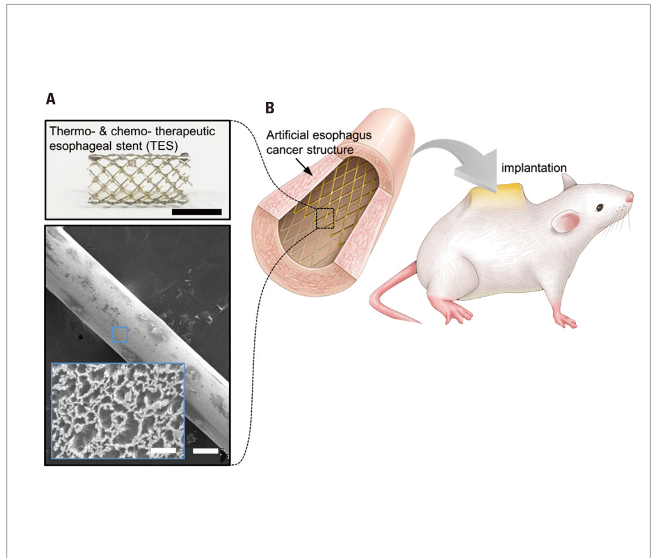
Research experiments confirmed that it is possible to slowly release drugs that have been loaded from heat and found that the surface nanostructure minimizes restenosis. This signified that the structure can be effective in not only treatment but also minimizing cancer recurrence.

The team also created a collagen tube inside an animal body that included human esophageal cancer cells, mimicking in vivo esophageal cancer. This mimicking platform was then integrated within the animal body and proved that drug delivery and effective treatment of human cancer cells are both possible, thereby opening a path to future clinical use.

Experimental mice with collagen tube developed by the researchers

Young Mee JUNG
Center for Biomaterials
Principal researcher

Ji Yeon LEE
Chemical Kinomics Research Center
Senior Researcher



(A) Photographic (top) and SEM image (bottom) of a curvilinear nitinol wire stent with pristine nanoturf structures are shown. Inset: Enlarged SEM image of the nanoturf structures on the stent surface. Scale bars are 1 cm (top), 1 mm (bottom), and 1 μm (inset) (B) Schematics of the multifunctional esophageal stent covered with an esophagus-mimicking organoid tube and its subdermal implantation into a mouse for in vivo study.

Research News. 03

Bio/Medical

Ultrasound Stimulus Accelerates Post-Stroke Cerebral Nerve Recovery

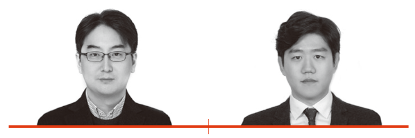
The American Society of Neurorehabilitation has reported 1.5 million cases of stroke per year worldwide, causing death in one out of three cases and leaving another one out of three patients permanently impaired. Because post-stroke symptoms can have such a deleterious effect on patients, early rehabilitative treatment is critical to a patient's quality of life. Drug treatment is not a particularly viable option for stroke patients because the blood-brain barrier (BBB) limits drug access to brain tissue. This is a major reason why researchers around the world are focusing their research on finding rehabilitative effects from different cerebral stimulation sites.

A KIST Center for Bionics research team, led by Dr. Hyung Min KIM, used a low-intensity focused ultrasound (LIFU) brain stimulation technique to control the neural activity of a specific cerebellar region and found that this could compensate for cerebral nerve damage from stroke as well as treat motor disorder caused by hemiplegia, thereby brightening the outlook for post-stroke rehabilitative treatment.

The team based its research on prior studies that observed secondary hypostasis and hypometabolism in the cerebellum, which is functionally connected to lesion sites although spatially set apart. The team delivered noninvasive cerebellar stimulations using LIFU, which aided functional recovery from brain atrophy, and moreover, activated neural pathways connected to infarction areas.

Without using intrusive deep brain stimulation, this research demonstrated the effectiveness of treatment for motor damage caused by hemiplegia and is expected to lead to further applied research in treatment techniques for cerebral nerve recovery.

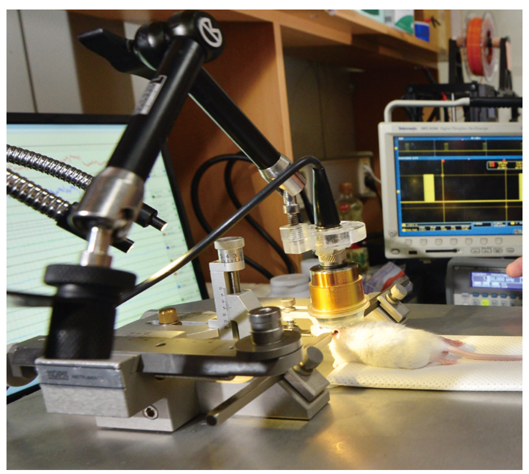
The research was published on Neurorehabilitation and Neural Repair (29 August 2018 "Modulation of Cerebellar Cortical Plasticity Using Low-Intensity Focused Ultrasound for Poststroke Sensorimotor Function Recovery")
See more details on
https://doi.org/10.1177/1545968318790022



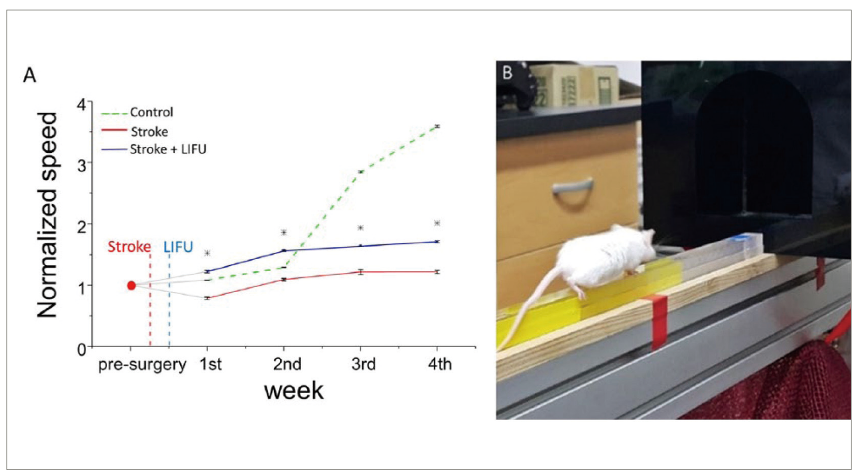
Hyung Min KIM
Center for Bionics
Principal Researcher

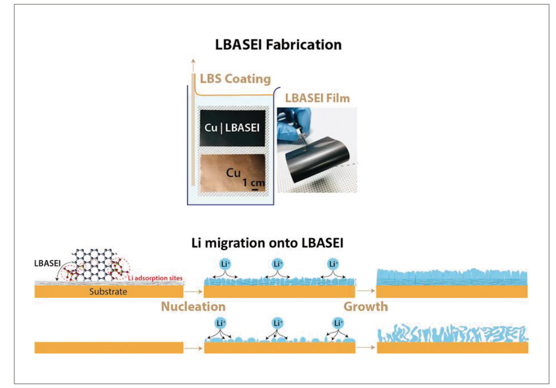
Ki Joo PAHK
Center for Bionics
Postdoc Researcher

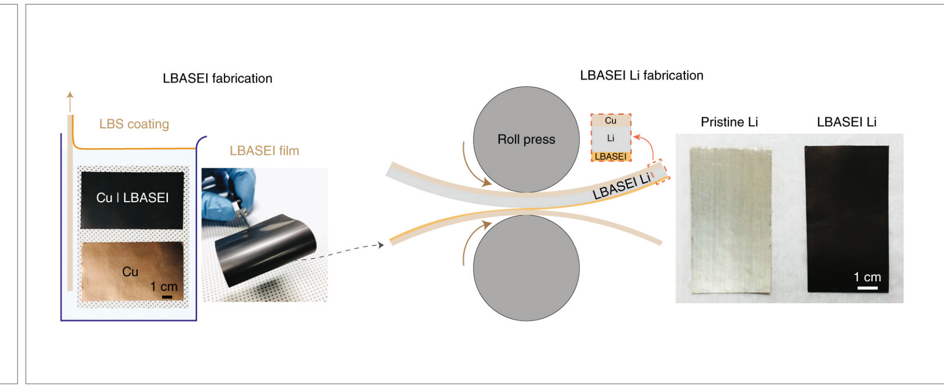
↓ Researchers are doing ultrasound stimulation tests on stroke mice model



↓ (A) Experimentally measured walking speed using the balance beam test. Control group shows a sharp increase from the second week. In our study, at least 2 weeks was needed for mice to start learning the complex coordinated movement on the balance beam. (B) An example showing a mouse crossing the beam toward a dark box.

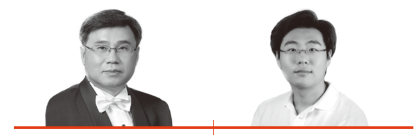






↑ LBASEI designs and fabrication processes for the LBASEI Li electrode

↑ KIST researcher Moon Sek KIM (left) and Dr. Won Il CHO (right) are testing their Lithium Metal Ion Battery using a drone and LEDs



Won Il CHO
Center for Energy Storage Research
Principal Researcher

Mun Sek KIM
Center for Energy Storage Research
Researcher

Research News. 04

Energy/Environment

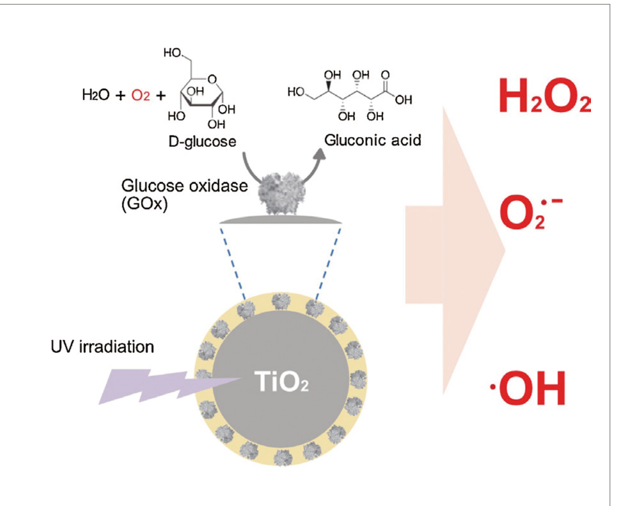
New Lithium Metal Ion Battery Promises Greater Capacity and Stability

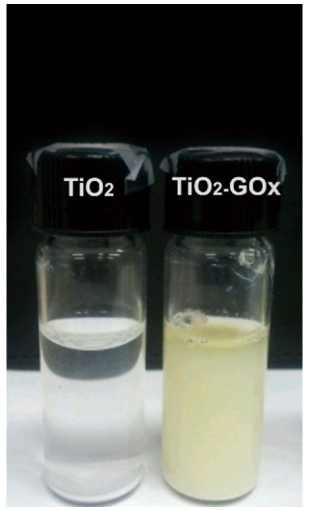
Lithium metal ion batteries have, in theory, an energy capacity 10 times higher than lithium ion batteries because they use lithium metal rather than graphite for the anode. However, a high chemical reactivity creates dendrite on the metal surface, potentially causing the battery to explode or shortening its life. To address this problem, a team from KIST's Center for Energy Storage Research, led by Dr. Won Il CHO, has developed a lithium metal ion battery that more than doubles the energy density found in today's smartphones and laptops while maintaining a large portion of its initial performance even after extensive charging and discharging. The team improved battery performance and stability by coating the lithium metal surface with an artificial protective layer.

The process used by the research team was to evenly coat the surface of lithium metal with a graphene nanomaterial to prevent dendrite and develop an optimum electrolyte mix by using an artificial protective layer called "Langmuir-Blodgett artificial solid-electrolyte interphases." A quantum mechanics calculation was then applied. The study found that the artificial protective layer and electrolyte mix enabled the battery to maintain 80% of its initial performance even after being charged and discharged 1,200 times. Despite scaling down the lithium metal quantity to commercial lithium ion battery levels, it was still able to charge/discharge over 200 times.

This research proved it is possible to produce high-capacity and durable cells that overcome the energy storage limitations of lithium ion batteries. The team's findings suggest great opportunities for the next-generation battery industry associated with lithium metal ion batteries as well as lithium–sulfur and lithium air batteries. These more advanced batteries can potentially be applied in various products, including drones, autonomous cars, unmanned submarines, and other unmanned vehicles.

The research was published on Nature Energy (24 September 2018 "Langmuir–Blodgett artificial solid-electrolyte interphases for practical lithium metal batteries")
See more details on
https://doi.org/10.1038/s41560-018-0237-6





Schematic of the production of reactive oxygen species by TiO_2-GOx particles

The pictures of pristine TiO_2 (left) and TiO_2-GOx (right)

Byoung Chan KIM
Environment, Health and Welfare Research Center
Principal Researcher

Seok Won HONG
Water Cycle Research Center
Principal Researcher

Research News. 05

Energy/Environment

New Environmentally-Friendly Antibacterial Composite Fights Aquatic Bacteria

Ever since toxic substances in sterilizers were determined to be the cause of death and lung disease in newborns and their mothers, there has been increasing interest in and a need for harmless yet effective antibacterial materials. Dr. Byoung Chan KIM (Environment, Health and Welfare Research Center) and Seok Won HONG (Water Cycle Research Center) recently conducted a study using organic glucose in which a natural antibacterial material capable of safely and effectively blocking aquatic bacteria was developed and confirmed to be effective.

The research team developed an antibacterial composite by combining the organic biocatalyst glucose oxidase with inorganic photocatalyst TiO_2 and examined the principal of the composite's antibacterial activity. They observed a drastic decline in TiO_2's catalyst effect in a glucose-rich aquatic environment. Glucose, an essential carbon source for humans, is also necessary for bacterial growth, and a high concentration of glucose enables bacteria to thrive. Glucose oxidase (GOx) generates H_2O_2 in the process of breaking down glucose, and H_2O_2, a reactive oxygen species, can by itself be used to remove bacteria.

Experiments also showed that whereas TiO_2's antibacterial performance dropped dramatically as glucose concentration rose in a UV environment, the TiO_2-GOx composite's antibacterial performance showed quantitatively measured improvement.

This research is significant in that it developed an excellent antibacterial material out of a naturally abundant resource, in this case glucose, so once the technology is patented, it can be used to create safe and environmentally-friendly antibacterial products.

The research was published on Applied Catalysis B: Environmental (March 2019 "Bio-organic–inorganic hybrid photocatalyst, TiO_2 and glucose oxidase composite for enhancing antibacterial performance in aqueous environments")
See more details on
https://doi.org/10.1016/j.apcatb.2018.09.102

Research News. 06

Material/Systems

Thin Film Battery for Smart Contact Lens

Hats, glasses, belts, watches, and clothes are a few examples of widely applied and studied wearable electronic devices that can constantly monitor a wearer's health. Nowadays, the scope of wearable device research ranges from simple tasks such as tracking walking pace or heart rate to conducting professional-level diagnosis via biosignal analysis. The most advanced form of a wearable device to date is a smart lens, and corporations worldwide are competing to develop this technology, which includes augmented reality (AR), displays and diabetes monitoring devices.

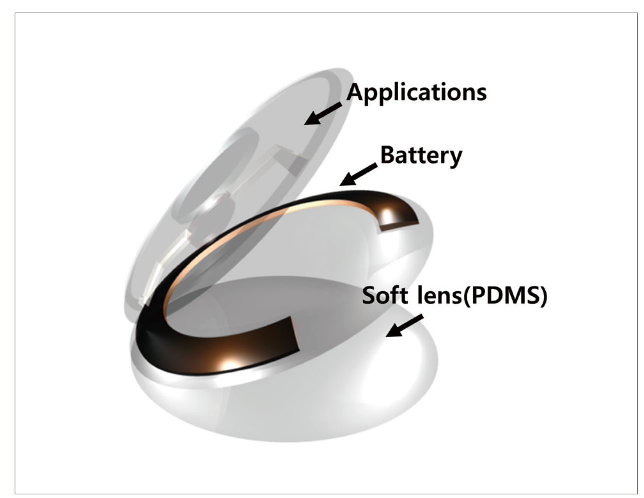
A KIST Center for Electronic Materials research team, led by Dr. Ji Won CHOI, has been successful in deveoping a very thin form of secondary battery for use in a smart lens. Existing smart lenses are powered externally, but this new thin film secondary battery can be directly installed on smart lenses to provide an internal power supply. Another advantage is that the battery is rechargeable. Unlike conventional batteries, it is an ultra-thin type and has properties which enable it to be fabricated on the curved surface of contact lenses. Its flexibility allows application under bent and wet conditions.

The highest level of safety is required for a device worn on the human eye, which has added to the challenge of developing smart lenses. There has been little research on batteries for powering these lenses. However, the thin film battery developed by KIST is made entirely of flexible components and does not use liquid electrolytes, as do solid film forms, thus making it extremely safe and free of risk from explosion. In the words of Dr. Choi, "This thin film secondary battery is the first battery to be applied to contact lenses and will be a core part of future smart lenses. Its flexibility has the potential to power other wearable devices as well.

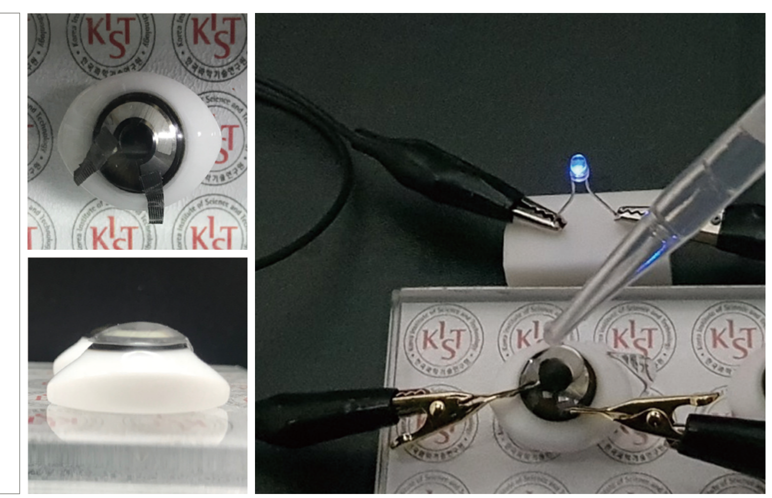
The research was published on Nano Energy (November 2018 "Scalable fabrication of flexible thin-film batteries for smart lens applications")
See more details on
https://doi.org/10.1016/j.nanoen.2018.08.054

Ji Won CHOI
Center for Electronic Materials
Principal Researcher

The schematic of the battery-embedded smart lenses



top view, side-view and operation of the fabricated battery lighting an LED while wet



Research News. 07

Material/Systems

A Flexible Platform that Stretches Like Skin

The research was published on Advanced Materials (21 August 2018 "Artificial Soft Elastic Media with Periodic Hard Inclusions for Tailoring Strain-Sensitive Thin-Film Responses")
See more details on
https://doi.org/10.1002/adma.201802190

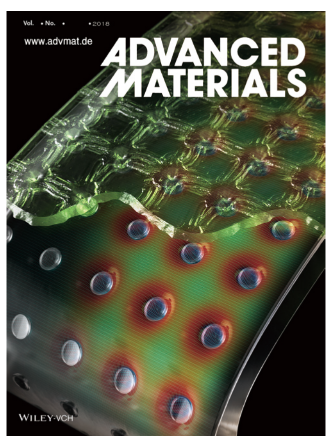
Seung Jun CHUNG
Center for Opto-Electronic Materials and Devices
Senior Researcher

Recent advances in technologies which extend internet connectivity to a range of devices and objects, known as the Internet of Things (IoT), is sparking interest in electronic devices that are flexible and can attach to the body. However, existing semiconducting devices have limitations in that their electrical performance declines under mechanical stress which occurs when stretched and affects the interaction between the stretchable board and functional film. Therefore, more research needs to be conducted on optimizing stretchable electrical media and platforms in order to achieve operational stability in wearable electronic devices.

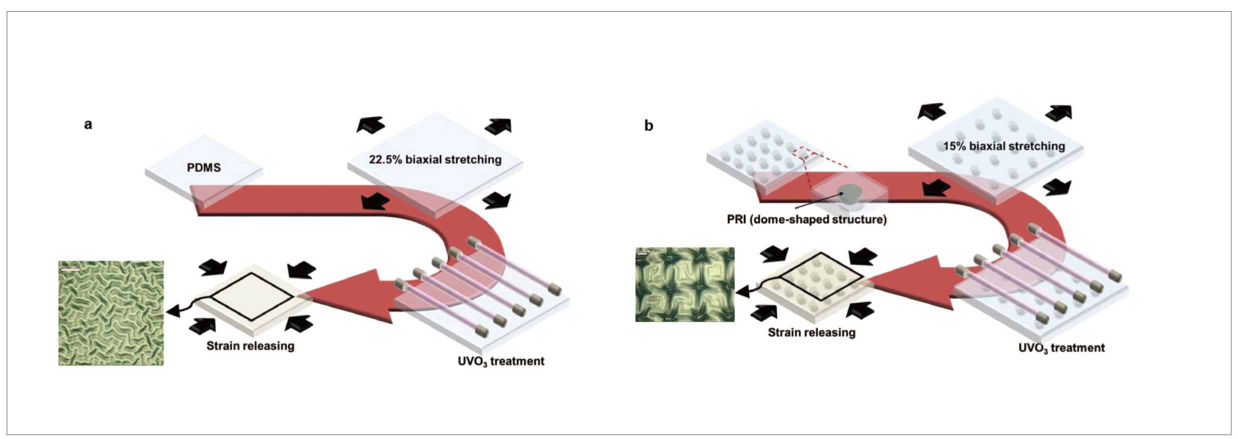
In response to this challenge, Dr. Seung Jun CHUNG of Center for Opto-Electronic Materials and Devices (KIST) succeeded in developing a skin-like elastic platform that can freely manipulate various electrical, mechanical, and surface morphological properties of thin-film materials. Working with another research team, led by Prof. Yong Taek HONG at Seoul National University, joint researchers inserted a translucent structural compound with high mechanical intensity inside a flexible platform and announced that they had found a way to control mechanical stress. Based on intensity, size, and array, the research team reported that it was not only possible to control the level of mechanical stress received by thin-film materials when compressed, but it was also possible to focus or disperse mechanical stress to a desired area. This research is particularly significant in that researchers found through experiments and simulations that they can freely control the electrical, mechanical, and surface morphological properties of metal, oxidized, and organic thin films.

By showing it is possible to manipulate thin films' changing properties when subjected to mechanical stress during stretching, this research is expected to enhance the reliability of electronic devices, such as stress-sensitive wearable displays and sensors.

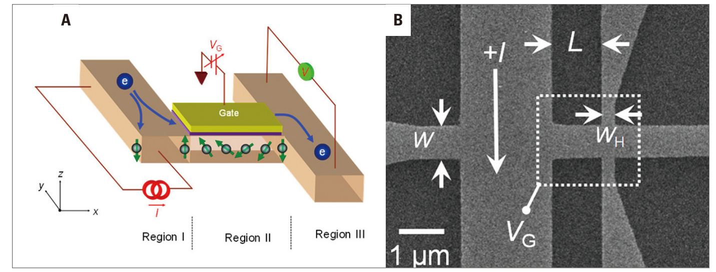
The results of the study were selected as back cover 'Advanced Materials' (Oct. 2018)

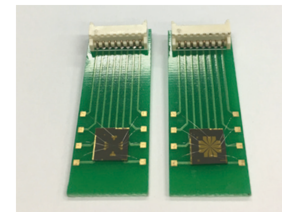


A process flow for biaxial prestrain-induced spontaneous wrinkle formation



(A) Schematic diagram of device
(B) Scanning electron micrograph of device before forming gate electrode





A picture of Ferro magnet-free all-electric spin hall transistors

Hyun Cheol KOO
Center for Spintronics
Principal Researcher

Research News. 08

Material/Systems

Spin Transistors Free of Magnetic Substance

The research was published on Nano Letters (18 November 2018 "Ferromagnet-Free All-Electric Spin Hall Transistors")
See more details on
https://doi.org/10.1021/acs.nanolett.8b03998

A transistor is a key component in semiconducting devices, functioning as a "switch" that amplifies, blocks, or delivers electric signals. A computer's processing capability is determined by the number of transistors, and what had first been 2,300 per computer has increased to billions today. However, integrating more transistors onto a fingernail-sized processor has now reached its physical limit, making transistor technology unable to keep up with the exploding amount of data.

A new solution to this conundrum is a "spin transistor," which uses a semiconductor's electron spin, a quantum-mechanical state of electrons similar to a spin involving the electrons' magnetic direction. This highly advanced transistor represents the next-generation transistor.

Under the direction of Dr. Hyun Cheol KOO, a research team from KIST's Center for Spintronics became the world's first to overcome the biggest obstacle to commercialization of spin transistors: spin injection from ferromagnetic electrodes. Their findings are the subject of intense interest by the global semiconductor industry.

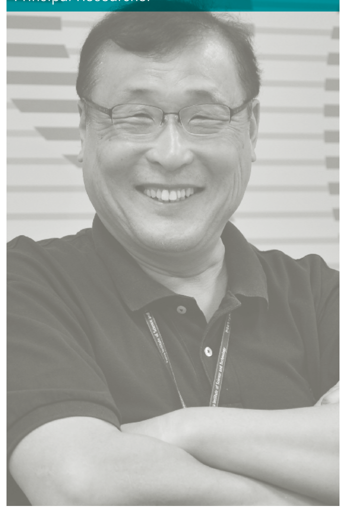
During the course of their investigation, researchers eliminated magnetic field and magnetic substance, both of which are essential for existing spin transistors, and using only ultra-high speed semiconducting channels, created a new spin transistor that can form, control, and detect spins. A spin transistor can differentiate digital signals based on the direction of electron spin, thereby radically increasing the speed of information processing. Also, its ability to run on low power makes it superior to a silicon semiconductor. Despite its high potential, however, it has faced commercialization difficulties due to the fact that a spin transistor requires a magnetic field and magnetic substance to induce electron movement and existing transistors lose most signals where a ferromagnetic substance and the semiconductor meet.

By eliminating any magnetic field and ferromagnetic substance, researchers developed a spin transistor composed only of a semiconducting channel, eliminating any magnetic substance-induced spin injection into the semiconductor. The semiconductor produced its spin information and controlled its direction via gate voltage and was then made to electrically read information. This enabled the researchers to improve spin transistors' greatest weak point - signal transmission – by over 100-fold.

This research result has significant implications for the future of spin transistors, as these electronic materials using ultra-high speed III-V semiconductors can have many applications throughout the semiconductor industry.

Five Scientists Who Embrace Convergence Research

Young Jin KO
Center for Electronic Materials
Postdoc



Wook Seong LEE
Center for Electronic Materials
Principal Researcher

Jae Woo CHOI
Water Cycle Research Center
Principal Researcher

The research was published on Water Research (15 Nov 2018 "Strong chromate-adsorbent based on pyrrolic nitrogen structure: An experimental and theoretical study on the adsorption mechanism")
See more details on https://doi.org/10.1016/j.watres.2018.08.033

To solve social problems that are becoming increasingly diverse and complex, researchers are voluntarily teaming up to conduct convergence research. Convergence research isn't easy - working in different labs makes it challenging to schedule meetings, and researchers are already working long hours on other major projects. But the benefits of taking a lead research role and working on such significant issues make convergence research appealing.

[Idea Born During Basketball Match Scores Big]

"An idea that came up during a game with KIST basketball club members was the start of it all. Our joking comments took shape. Because we were in charge of everything from ideas to experiments, the process was fun - and that's why I think we produced good results." (Dr. Wook Seong LEE)

Dr. Lee and Dr. Choi led a team that last year succeeded in developing an adhesive material that can efficiently remove toxic $Cr6^{+}$, a heavy metal which is often discharged in high concentrations in industrial wastewater.

Researchers first came together for this interdisciplinary convergence project back in 2015. Researcher Young Jin KO, a member of the KIST basketball club, started talking about a research topic he was interested in while taking a break after a game. Ko said, "Polypyrrole is frequently used to deliver electric signals in artificial muscles. When I was doing research on polypyrrole, I was told that it is also used to remove heavy metal in water."

Ko and Dr. Lee went on to create an adhesive material using polypyrrole, which is widely used as a conductive polymer, and Dr. Choi's team then used the material to experiment with heavy metal adhesion. The KIST Computational Science Research Center also joined in and analyzed the adhesion change of $Cr6^{+}$ according to certain parameters and contributed to schematizing the experiments. As a result, the combined team was able to quantitatively define the adhesion mechanism of $Cr6^{+}$ in aquatic conditions through its oxidation and deoxidation reaction according to different pH conditions, using a certain nitrogen-carbon structure within polypyrrole.

Researchers really enjoyed conducting research which they planned on their own, but it wouldn't have been possible to achieve the results without input from experts in various fields. As Dr. Lee explained, "There was a lot of research similar to ours starting in the early 2000s, but none of it quite reached the level of in-depth analysis of related mechanisms. We approached from various fields – material, physics, and chemistry, which made the difference. I also think doing research with a good frame of mind led to good results."

[Convergence Research? It's What We Do Everyday]

"Convergence research is an everyday activity. You ask an expert if you have questions about an unfamiliar field. Doing research based on the idea created in that process is how I see convergence research." (Dr. Ki Hoon KIM)

Dr. Ki Hoon KIM and Dr. Hyo Jin LEE recently succeeded in developing a biosensor that diagnoses precocious puberty using urine. 1 mL of urine is enough to detect trace amounts of sex hormone, making this biosensor the most sensitive in the world.

This research was not the first convergence project for the two researchers. While postdoctoral researchers at the same university, they already had experience working together on confirming the denaturation of biomaterial using mass spectrometry, so it was easy to join forces once again. It made sense to Dr. Lee, "We had to analyze a specific sample – urine – for hormones. Because this is a specialized area of the KIST Doping Control Center, I suggested to Dr. Kim that we work together on this project."

To develop the biosensor, Dr. Lee assumed the role of design and synthesis while Dr. Kim worked on signal testing and analysis. A major research challenge was an insufficient amount of sex hormones in urine. To address this issue, researchers assigned a specific barcode to urine sex hormones. First, they made a biosensor composed of a magnet and gold nanoparticles, and then attached an antibody that draws sex hormones to the magnet, while the gold nanoparticles were tied with aptamer and 7 million chemical substances capable of combining with certain sex hormones. When sex hormones inside urine bind to the gold particles, the biosensor sends a strong signal, just like a barcode, to signal the existence of sex hormones.

Dr. Lee said, "I believe that asking an expert about something you don't know and accepting the challenge to move from a new idea to a result is what convergence research is about. Interacting and having casual conversations with other researchers made this project possible."

The research was published on Sensors and Actuators B: Chemical (1 March 2019 "Non-invasive molecular barcode assay for diagnosis of sex hormones correlated with precocious puberty")
See more details on https://doi.org/10.1016/j.snb.2018.11.087

Hyo Jin LEE
Center for Biomaterials
Senior Researcher

Ki Hun KIM
Doping Control Center
Senior Researcher

Encompassing five distinct neighborhoods in northeastern Seoul, the name "Hongreung" refers to a royal tomb originally located in the area. Its historical importance was thus already established when it became the center for the industrialization and scientific development of Korea starting in the 1960s.

Efforts to Make Hongreung a World Class Innovation Cluster Gain Momentum

Hyeokseong LEE
Policy Planning Team
Senior Researcher

What is Hongreung?

Hongreung is home to nine government-supported research institutes (GRIs), including KIST, and eight universities with combined student bodies of 120,000. It is known for its highly educated labor force, which includes 6,000 Ph.D's. Added to these resources is an excellent transportation infrastructure, as evidenced by eight area subway stations and two easily accessible international airports located at Incheon and Gimpo.

Despite these strengths, however, Hongreung has seen a downturn in its economic fortunes in recent years. A push by the national government to better distribute wealth, opportunities and populations within the country has resulted in the relocation of public institutions, from Hongreung to the provinces. The area's skilled labor force and its associated purchasing power have been affected by these changes, and Hongreung's economy has suffered as a result.

How to Revitalize Hongreung?

To counteract the negative economic impact of recent changes, 17 Hongreung-based institutions, including KIST, Korea University, Kyung Hee University and Seoultech, came together in 2012 to initiate a collaborative project for the revitalization of Hongreung. The group, known as the Hongreung Forum, has met regularly to discuss goals, strategies and specific projects to boost the area's future development. It became clear that the most promising path forward was to transform Hongreung into a global innovation cluster. However, progress on specific projects floundered until an executive group was formed to design and execute the projects.

Working closely with the Seoul Metropolitan Government, the executive group has taken steps for Hongreung to be the location of "InnoTown," a project officially launched in July 2018 by the national government for the establishment of a special zone to conduct accelerated R&D and associated business development activities (R&DB). It is conceived as an area in which technological core institutes are concentrated. Hongreung meets the criteria well due to its existing high R&DB capabilities. The steps being taken to demonstrate Hongreung's suitability for InnoTown are summarized below.

❶ The Seoul Metropolitan Government has built a Seoul Bio Hub where biotech startups have established operations. Here they can take advantage of opportunities for networking and global marketing supported by Johnson & Johnson Innovation, a multinational giant whose Seoul Innovation Quick-fire Challenge encourages creative business development ideas for the healthcare industry.

❷ The executive group has established an investment fund to promote the commercialization of technologies developed in Hongreung. Currently, the fund totals about 17 billion won. Such a fund represents a powerful incentive for companies considering a move to Hongreung.

❸ Hongreung's institutions are collaborating to make the best use of the area's resources to develop, test and market innovative biomedical technology. A project known as H-TRAIN (Hongreung Translational Research and Industrialization) links fundamental research on biomedical technology performed by KIST to clinical research undertaken at the hospitals of Korea University and Kyung Hee University.

❹ Developing a community identity and enhancing livability for the Hongreung region is an important goal of the executive group. An example of this effort is a contest which was held for an overall facility and space design with ten proposals selected among more than 100 submitted. The ideas contained in the winning proposals will be proposed to the Seoul Metropolitan Government as part of the new city design process.

❺ Anchor facilities for the management of resources are considered essential to a successful innovation cluster. In light of this need, KIST is making plans to build a landmark S&T Innovation Center at the current site of the North Gate parking lot.

An Exemplary Cluster: Kista Science City, Sweden

There are a number of role models for Hongreung to consider in the process of estabishing InnoTown. One of the most renowned clusters in the world is Kista Science City in Sweden. Also known as the "Silicon Valley of Northern Europe," it is a hub for ICT innovation and has been the location for ICT giants such as Ericsson, Intel and Microsoft since 1976. These large enterprises have developed frontier technologies like GSM, LTE and 5G communication in cooperation with universities, public research institutes, startups and other related organizations. This cooperative model, known as the Triple Helix model, and an innovation-friendly environment are key factors which have made Kista Science City such a resounding success.

The Triple Helix Model

One of the key factors behind Kista's successful development into an industrial city is the level of cooperation among industry, academia and government. Pioneering companies in the sector also played a critical role, including the telecom giant Ericsson. These leading companies worked together with small and medium enterprises (SMEs), venture companies, universities and major government research institutes to generate substantial innovative synergy.

Furthermore, the city of Stockholm successfully brought in top-notch research talent by having government research institutes, such as SICS and Acreo, join Kista. It also promoted the brand image of the Kista Science City by holding international ICT conferences.

Johan Ödmark, CEO of Electrum Foundation and Kista Science City AB, emphasizes that in order to ensure sustainable development using the Triple Helix model, it is important to attract companies that have fresh innovative potential. To this end, he points out, the cluster needs its own "indigenous culture." Ödmark explains that for most companies, new buildings and a new location do not matter as much as the opportunity for "match-making," or "who I can meet." This becomes a greater consideration for SMEs and venture firms, which are often not as aware of what they need to do as are large businesses.

Innovation-Friendly Environment

Kista Science City focuses on the development of new ICT technology that will lead the Fourth Industrial Revolution and other future industrial changes. It runs the "Urban ICT Arena" to support R&D and testing of cutting-edge technology such as the Internet of Things (IoT). The Arena offers a testbed and various projects to test new technology such as city drones, streaming sensor data, 5G, 6LoWPAN, and IoT platforms.

Conclusion

Kista Science City is somewhat different from Hongreung in that it is an industry cluster centered on large businesses, whereas Hongreung focuses on universities and research institutes. However, they share a common vision of nurturing SMEs and venture companies, which makes it possible for the two clusters to work with each other in the future.

Hongreung has great potential to become a global-level innovation cluster, but some policy adjustments, such as relaxation of regulation and improvement of the urban environment, are needed to ensure success. Bottom-up efforts have been made. Now is the time to bring the full weight of support, at all levels, to making an innovation cluster in Hongreung a powerful contributor to Korea's future strength.

International Experts Gather at KIST Jeonbuk to Discuss the Future of Advanced Composite Materials

KIST recently hosted a conference at its Jeonbuk campus on research trends and future development strategies in the field of advanced composite materials. It was attended by over 200 participants from government, industry and academia. Three renowned specialists accepted the invitation to give presentations on relevant topics of interest:

- Prof. Satish Kumar from the Georgia Institute of Technology, who leads a US DARPA project and is conducting joint research with Boeing, gave a presentation on carbon fiber research trends.
- Prof. Hubert Jaeger from TU Dresden, the former chief of technology and innovation at SGL Group (the world's leading manufacturer of carbon and graphite products) and currently a prominent authority on composite materials for the automobile industry, discussed the importance of fiber-reinforced composite materials.
- Dr. Park Chul from NASA gave a presentation on boron nitride nanotubes, a multifunctional material for future space vehicles and structures.

In addition to the presentations, panel discussions were held to talk about Korea's strategy for advancing the composite materials industry.

↓ KIST Jeonbuk Institute of Advanced Composite Materials

KIST Holds Symposium on Autism

Director-General Uhtaek OH of Brain Science Insitute (KIST)

KIST hosted the "KIST Autism Symposium" on November 30, 2018, at its Seoul headquarters. About 100 participants were in attendance, including brain scientists specializing in autism research.

Autism spectrum disorder (ASD) refers to a development disorder in children characterized by difficulty interacting or building emotional ties with others; autistic children are seen to be "shut inside their own world." The KIST Brain Science Institute hosted this symposium to examine the causes and symptoms of ASD from a neurological standpoint and share information on the newest reports related to treatment. The event served as an opportunity to discuss research results on ASD as well as the latest trends on stem cell treatment and present numerical analysis.

Prominent experts from around the world attended the event, including: Prof. Toru Takumi from RIKEN Japan, Prof. Zi-long Qiu from the Chinese Academy of Sciences, Prof. Rusty Gage, who leads the Salk Institute for Biological Studies and is the top authority on induced pluripotent stem cells (iPSC) and organoids, and Dr. Xin Jin, who specializes in neural circuits and is also from the Salk Institute. Korea's leading researchers in the field of brain disease, cognition, and brain engineering, including Prof. Kim Eunjoon from IBS, also presented their latest findings on autism.

Director-General Uhtaek OH, head of the Brain Science Institute stressed the need for more research, "Though more patients are being diagnosed with ASD, there is insufficient investment in organized, in-depth research. I hope this symposium provides an opportunity for researchers to actively engage in collaborative efforts to expand ASD research."

The KIST Brain Science Institute began ASD research in 2017 with the goal of defining the abnormal neural circuits and mechanism of autism and develop new medicinal treatments and technologies to control the disease's symptoms.

Dr. Hoon RYU from Boston University Joins KIST's Center for Neuroscience

KIST has announced the appointment of Dr. Hoon RYU as head of its Center for Neuroscience, part of the Brain Science Institute (BSI). Dr. Ryu is a professor at the Boston University School of Medicine and a prominent authority in brain science. A pioneer of research in neuronal gene expression and epigenetics in degenerative brain diseases, he has focused on discovering epigenetic biomarkers related to Huntington's disease and Alzheimer's as well as studying the pathogenesis, diagnosis, and treatment of these diseases though epigenetic-targeting drugs.

Dr. Ryu received his Ph.D and was an instructor at Harvard Medical School, later becoming a professor at the Boston University School of Medicine. He spent 23 years outside of Korea building a career in research. His research findings have been globally recognized, with over 120 articles published in SCI(E) journals. He has repeatedly been named by Korea's Biological Research Information Center (BRIC) as a figure who has enhanced the reputation of Korea abroad.

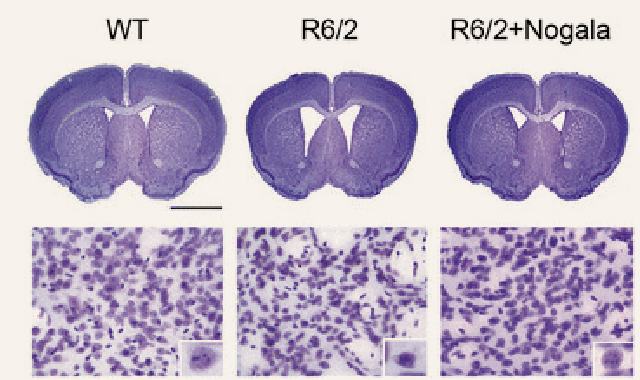
Dr. Ryu is expected to facilitate research cooperation between KIST BSI and the Boston University School of Medicine. BSI signed an agreement with Boston University in 2018 formalizing research cooperation. It is also planning to pursue joint research and exchange with Boston University's Alzheimer's Disease Center, Chronic Traumatic Encephalopathy (CTE) Center, and Harvard University.

According to Dr. Ryu, "KIST's research talent, capability, and infrastructure is world-class and I was captivated by everyone's passion for their work, which is why I joined KIST."

KIST President Lee was similarly enthusiastic, "With Dr. Ryu, we will be able to further strengthen our research capability in brain science." He added, "We expect Prof. Ryu will take research at BSI, already a leader in Korean brain research, to a new level."

Head Hoon RYU of Center for Neuroscience (KIST)

Dr. Hoon RYU recently conducted a joint research with KIST on Huntington's disease. See more details on https://doi.org/10.1007/s00401-017-1732-8

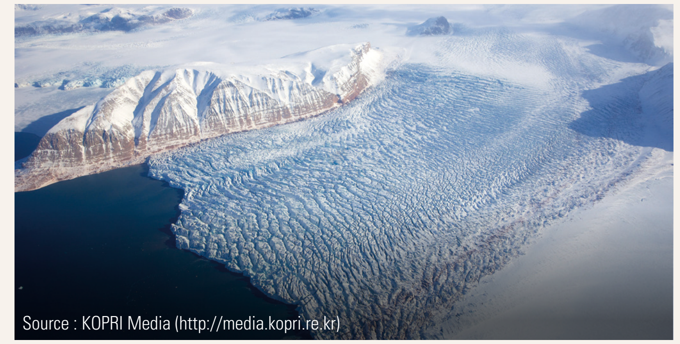


KIST Holds Festival for Future Scientist

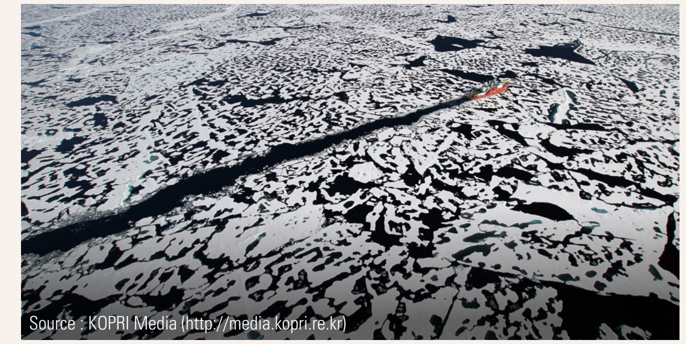
To celebrate Korea's 52nd Science Day, KIST held a "Share Scientific Imagination Festival" on April 19, 2019, for elementary school students.

The event was held at two locations. The first, at Sangwolgok subway station, highlighted climate change and the importance of alternative energy through an Antarctica photo exhibition held in collaboration with the Korea Polar Research Institute. The children also listened to stories on renewable energy and made scientific devices. The exhibition will be open until June 30, and exhibition guests will receive a postcard with an image of Antarctica and a penguin doll. KIST headquarters served as the second event venue and included science booths and imaginative painting contests to present science information in a fun way to the young scientists-to-be and stimulate their imaginations. Students who participated in the Scientific Imagination Drawing Contest, the festival's main event, each handed in a drawing under the theme "Our Future World." A total of 15 drawings will be chosen for awards, with prizes to be sent to the recipients' schools.

Marking the 9th anniversary of the KIST-sponsored Science Festival, about 100 students and their parents participated in the activities. Rather than collecting an event fee, KIST asked for donations of clothes and books from participants and delivered the items to a social welfare organization, Life Line Seoul.



Source : KOPRI Media (http://media.kopri.re.kr)



Source : KOPRI Media (http://media.kopri.re.kr)

KIST-KOPRI First-ever Joint Research Pioneers New Research Areas

Presents new model of convergence research focused on four areas including body temperature's impact on aging

Korea Institute of Science and Technology (KIST) and Korea Polar Research Institute (KOPRI) established under Korea Institute of Ocean Science & Technology (KIOST) have joined hands to overcome limitations in existing polar research and bring about a paradigm shift through joint research. The two institutions aim to apply polar research to extreme technologies to conduct creative research that benefits industries and everyday life.

This is the first time KIST, Korea's only comprehensive research center, and KOPRI are conducting extensive studies on extreme technologies. The research projects are expected to serve as a critical turning point for KOPRI to expand its capabilities beyond polar research as its Antarctic King Sejong Station and Jang Bogo Station recently celebrated their 30th and 5th anniversaries.

Four projects for joint research have been selected in January, which will be funded as institutional programs and begin next month. Research on molecular physiology and aging of polar organisms will be conducted by a research team led by Dr. Man Ho CHOI at KIST Molecular Recognition Research Center and a research team led by Senior Research Scientist Seung Hyun KANG at KOPRI Unit of Polar Genomics. Under the topic "Body Temperature's Impact on Aging and Longevity", researchers will try to define the cause of physiological changes made by body temperature and discover the principle of controlling and restraining aging.

The Antarctic sponge has an extremely slow growth rate. Some were reported to have survived for about 15,000 years in extreme low temperatures. Known to be the simplest form of multicellular organisms, Antarctic sponges are among the world's five longest-living creatures. Greenland sharks have the longest lifespan among vertebrates, living for an average of 272 years. According to a study published in the journal Science in 2006, one greenland shark was suggested to be 500 years old based on radioactive isotope analysis.

As such, polar organisms have evolved to grow extremely slowly due to their slow metabolism while having a long lifespan. Understanding their evolution and mechanism to adapt to polar environments will help research on human aging, but this requires research on molecular physiology of polar marine organisms. The joint research by KIST and KOPRI is thus expected to pave the way for convergence research that overcomes existing research limitations and also discover new ideas that can lead convergence studies in other fields.

Young Scientist Recognized by Forbes magazine for Producing Water in Arid Environments

Each year, the U.S.-based Forbes magazine announces young leaders under 30 by region, including entrepreneurs, scientists, athletes, and entertainers. 29-year old Hyun Ho KIM of Water Cycle Research Center (KIST) was chosen for demonstrating the operation of an atmospheric water-harvesting device for dry regions using solar energy. He was the first in the world to have achieved this.

Kim started this research when he was a graduate student at MIT. With a research background in thermal energy storage from his master's studies, Kim dove into this new project captivated by the single idea of harvesting water from the atmosphere using adsorbent material. Technologies that harvest water from the air have been around for a long time, as we can see from home dehumidifiers.

However, lower humidity reduces their efficiency, making it difficult to obtain water from this method in dry regions. Kim succeeded in developing a device that adsorbs enough water from the air to have practical use, by using sunlight and an adsorbent material that can naturally gather water even in dry conditions.

A metal-organic framework (MOF) structure was used to adsorb water. MOF is a class of porous material capable of adsorbing gas or water and is emerging as a core material for addressing water shortages and the effects of climate change. Kim found through simulations that the device could harvest 3 kg of water per day using 1 kg of MOF at 20% relative humidity. Research results on prototype development and simulation were published in Science in 2017, and the technology was selected as one of the World Economic Forum and Scientific American's 2017 list of top 10 technologies that will change the world.

After publishing his paper, Kim and a colleague headed to Arizona, United States in May of 2017 to see how much water could be harvested in an actual arid environment. Since he couldn't experiment in the middle of the desert, he chose the roof of a building in Arizona State University for his experiment. For over 12 hours a day for two weeks, his team experimented atmospheric water adsorption and harvesting. Although temperatures in May are relatively lower than the summer months in Arizona, Kim still had to battle the desert heat.

"The temperature would go over 40°C during the day. Since we had to document our research and turn on the computer, we covered our equipment with aluminum foil, but it was no help. Ozone alerts went off frequently as well."

Kim plans to expand the scope of his research to develop cheaper adsorbents and harvest more water. "The water harvesting device we made uses new, advanced material. To reduce costs, I will develop a device that uses cheaper commercial adsorbents by engineering and optimization of system design."

Of his future plans, he explained, "My dream is to do research people need, rather than chasing success. I was lucky to have papers published in high impact journals, but I believe the most important part is to do research that is useful to our lives and that people need. My goal is to do joint research with KIST and global researchers so that my research can be used in real world, and to ultimately become an expert in energy and water field."

Hyun Ho KIM
Water Cycle Research Center Researcher

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Category and Specific Areas of Research

Brain Science

- Examine brain function and cause of disease; utilize mapping of functional-structural connection in neural circuits
- Computational neuroscience
- Neural stem cell application
- Brain disease/neural imaging probes and therapeutic agents
- Brain engineering and microsystems including: developing system/algorithm for brain signal analysis/processing, flexible devices, in vitro models, diagnostic sensors

Robotics and Media

- AI & robotic intelligence, human-robot interaction (social/physical), humanoid design and control, AI-based robot software architecture, robotic visual and sensor convergence
- Learning-based robot control and navigation, field/service robot system design and control
- Machine learning, deep learning, data mining, computer vision and pattern recognition, distributed computing, photo math

Biomedical Engineering

- Analysis and application of medical big data
- Rehabilitation technology for overcoming disability
- Electric/optical sensor for implantable devices
- Targeted anticancer agents and cancer immunotherapy

Materials and Life Science

- Organic/inorganic hybrid ionomer reactive filter material
- Functional assessment of in vivo and vitro disorder physiology and environmental disorders
- Search for innovative new drugs

National Agenda Research

- Tract/detect/measure/analyze fine dust and environmentally harmful substances and catalytic technology for their reduction
- Nanomaterial and semiconductor-based micro/nano scale sensor devices

Green City Technology

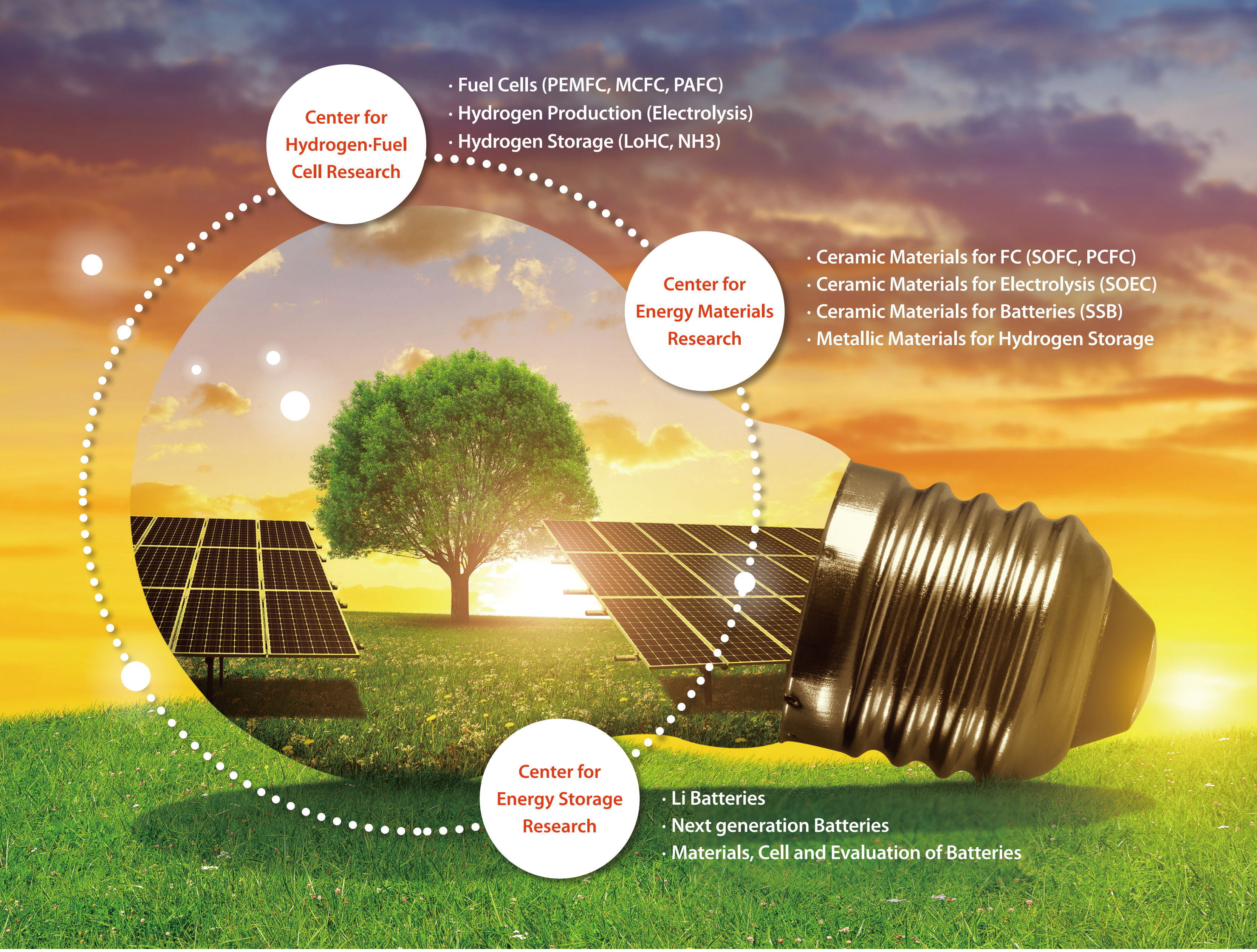
- Synthesis and analysis of electrolyte films used for fuel cell/water electrolysis
- Synthesis of advanced secondary cell liquid electrolytes, separators, battery engineering and production, electrode material technology
- Inorganic material-based electrochemical device interfacial thin film
- Solid-state hydrogen storage material and systems

Post-Silicon Semi-conductors

- Electric material, devices, and systems using AI
- Neuromorphic semiconducting material, devices, algorithms
- Spintronics material and device processes
- III-V MBE growth, ultra-high-speed electronic devices, photonics
- Quantum computing and quantum communication
- Innovative material/device source technology for post-silicon semiconductors, information processing, and storage

KIST Jeonbuk*
(*Must be able to work in Wanju)

- Organic/inorganic/metal nanostructure engineering, dimensional control and synthesis
- Property analysis of functional nanomaterial (electromagnetic wave shields, flexible optical analysis, TEM)
- Polymer physics and rheological properties
- Spinning technology
- Engineering/composition/modelling and interpretation of structural composite material
- Non-disruptive structural analysis/assessment of composite material



Clean Energy Institute

Using R&D on Energy-related Technologies to Create a New Paradigm Shift in Clean Energy

Energy and environmental problems such as climate change, micro-dust, and fossil fuel depletion are the number one issue we as a nation must face, and the only solution is to shift the energy paradigm away from fossil fuels and toward renewable/hydrogen energy- based systems.

The Clean Energy Institute (CEI) develops core energy technologies from materials, components and systems pertaining to hydrogen production/storage, fuel cells, and batteries. These technologies mainly center on zero-emission vehicles, distributed power generation, and large-capacity energy storage.

Our R&D is sure to contribute to the early realization of a clean energy society, while also growing Korean energy industries into global tech leaders.

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