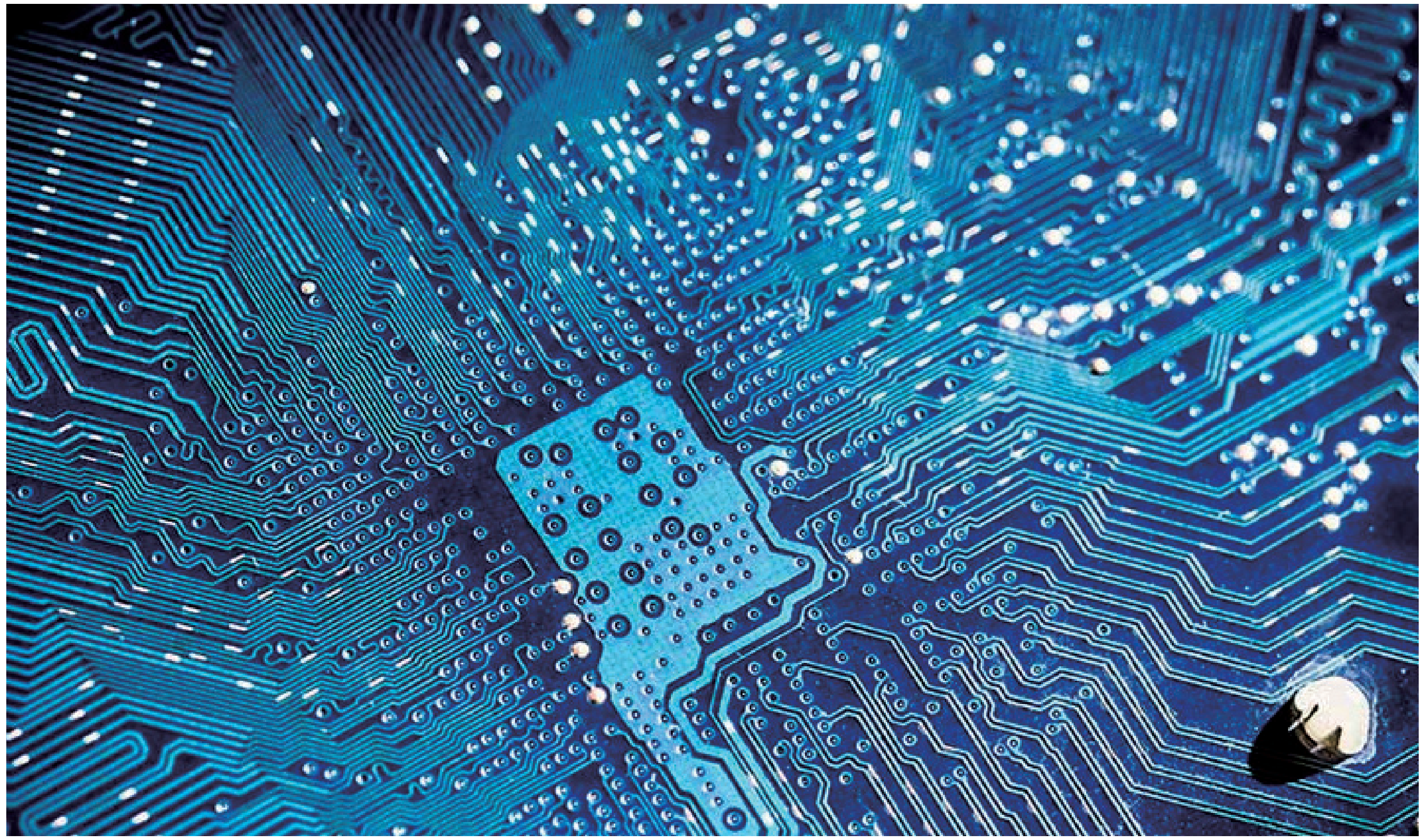
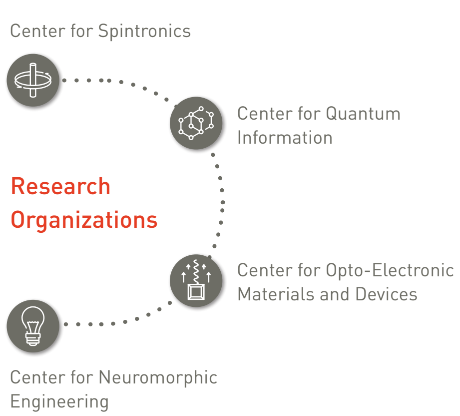


Driving technology development in the Fourth Industrial Revolution through new semiconductor materials & devices

Post-Silicon Semiconductor Institute



Since the onset of the Fourth Industrial Revolution, the need for a paradigm shift in intelligent semiconductor technology has become all the more apparent. As part of Korea's efforts to establish an industry that promotes the enhancement of our national infrastructure, the Post-Silicon Semiconductor Institute is now looking beyond the era of research aimed at miniaturizing semiconductor devices and seeks to develop new, intelligent semiconductors for computing purposes. From high-performance neuromorphic chips, brain-based artificial neural networks, massive quantum computing, and crypto-communication to spintronics technology and high-speed photoelectric devices, our institute will continue to play a central role among industry members, academia, and researchers in the Korean semiconductor R&D ecosystem and lead the creation of fundamental semiconductor technologies.

KIST Korea Institute of Science and Technology

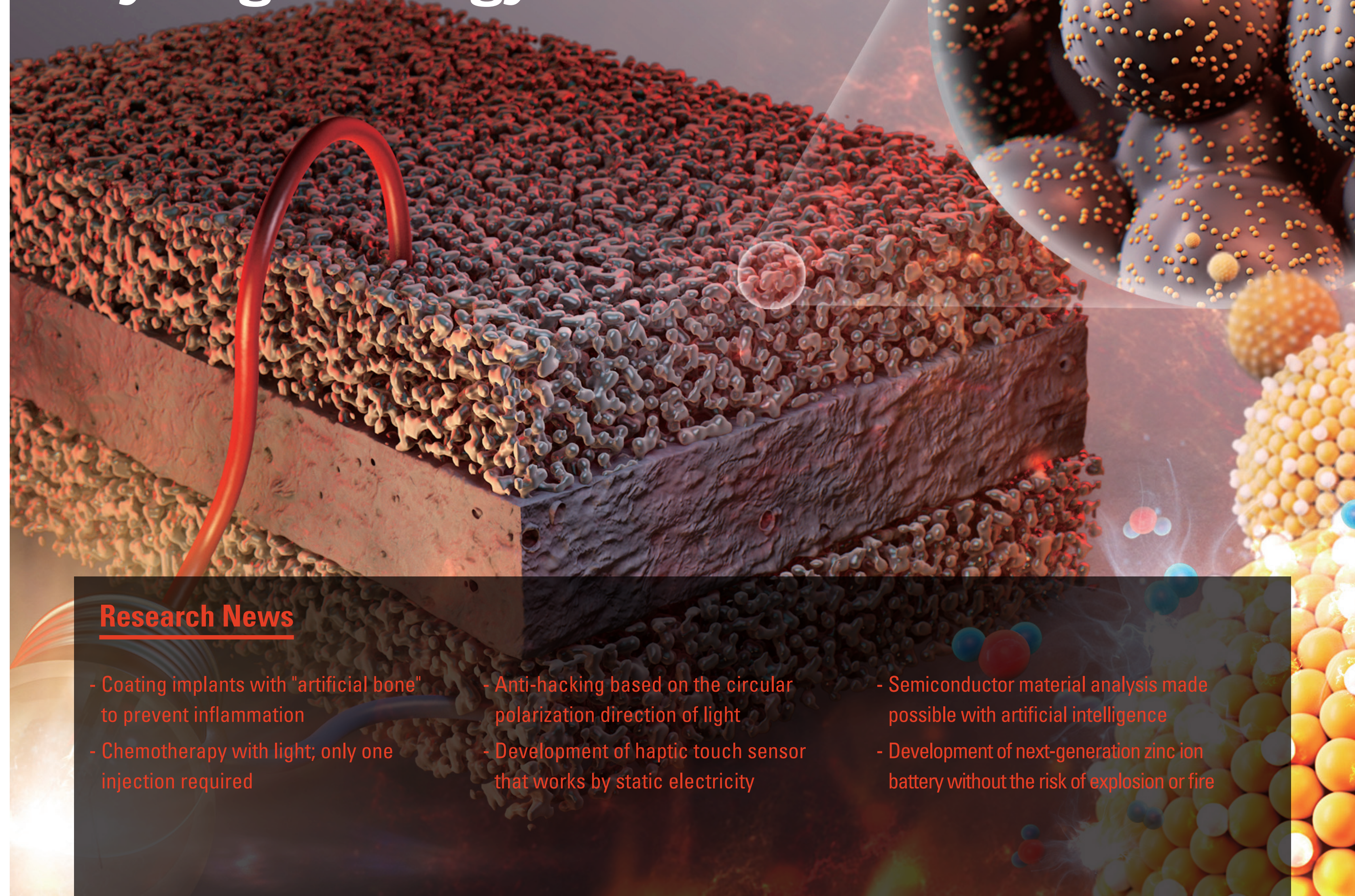
JUN 2021
ISSN 2005-9043
vol. 14

KIST

Leading to Tomorrow

KISToday

High-Performance Atom Catalysts - A Green Light for the Simultaneous Production of Electric and Hydrogen Energy



Research News

- Coating implants with "artificial bone" to prevent inflammation
- Chemotherapy with light; only one injection required
- Anti-hacking based on the circular polarization direction of light
- Development of haptic touch sensor that works by static electricity
- Semiconductor material analysis made possible with artificial intelligence
- Development of next-generation zinc ion battery without the risk of explosion or fire

June. 2021 – vol.14

KISToday

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Korea Institute of Science and Technology

ISSN 2005-9043

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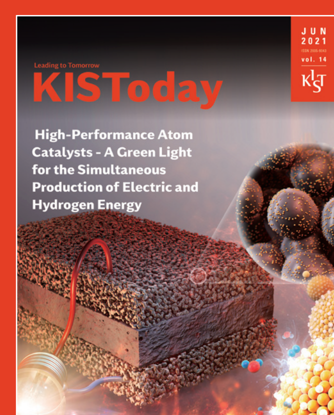
Cover Story



KIST's Center for Energy Materials Research Develops High-Performance Atom Catalysts

KIST's Efforts to Overcome COVID-19

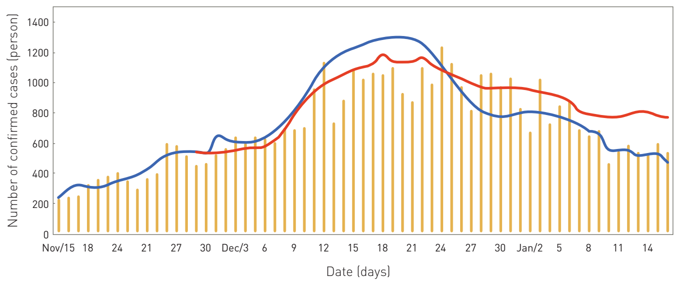
Contactless temperature check kiosk installed for Republic of Korea Joint Chiefs of Staff, developed by KIST Director-General Dr. Ig-Jae Kim's AI and Robotics Institute team

The ongoing distribution of the COVID-19 vaccines is giving us hope that the COVID-19 pandemic that shook the world last year will finally be a thing of the past, and pre-pandemic life will return. The human efforts to conquer the virus, like the hard work and dedication of our healthcare workers, is largely made possible due to science and technology. In addition to the development of vaccines, such as Pfizer, Moderna, and AstraZeneca, other technologies, such as contactless thermometers, QR-code check-ins, anti-fogging goggles, and anti-droplet masks, have protected us in our daily lives.

What Has KIST Done to Overcome COVID-19?

Since the early days of COVID-19, KIST has been working to form a scientific basis for national preventive measures via simulations using supercomputers. It has also developed an autonomous mobile robot that uses disinfectants and ultraviolet rays, as well as anti-fogging goggles and anti-droplet masks for medical staff, and is currently conducting clinical trials (Phases 1 and 2) for the development of a domestic vaccine.

What Has KIST Done to Overcome COVID-19



Spread Simulations
Red: No gatherings of more than 5 people; large-scale preemptive inspections
Blue: No gatherings of more than 5 people; no diagnostic tests
Yellow: Actual data

COVID-19 Spread Simulations to Form Scientific Basis for Preventive Measures

Chansoo Kim, a senior researcher at KIST's Computational Science Research Center, has used KIST's individual-based simulation toolkit for virus transmission – a modeling tool developed in 2013 to see how individuals' movements can influence the spread of an infection, and Abinit – KIST's supercomputer – to examine the patterns of COVID-19 spread since the virus entered South Korea. He simulated the process through which an individual is exposed to a COVID-19 patient, gets infected, and spreads the virus to others. His research found that South Korea could have become the second Italy had social distancing not been put into effect last March. He also analyzed the results of the effects of online classes and strict self-isolation among those who had entered South Korea in April.

Now, Chansoo Kim has analyzed the effects of a ban on gatherings on curbing the spread of COVID-19, and compared it with the effects of social distancing. He reported that, since Level 3 social distancing – which imposes even stricter social distancing and prohibits gatherings of more than five people – was implemented last November, the number of confirmed cases had been reduced to 300-400 per day. Meanwhile, loosening the restrictions by allowing gatherings of up to nine people was found to have the same effect as Level 2 social distancing. The number of confirmed cases in this scenario jumped to 1,000 per day, and continued to increase afterward. In effect, prohibiting gatherings of five or more people was found to be more effective than the Level 2.5 social distancing measures.

He added that, to achieve the same effect as Level 3 social distancing, the number of people at gatherings should be restricted to 2.7. In other words, rather than allowing gatherings of up to four people, stricter measures were required to reduce the number of confirmed cases, which has not been decreasing recently. He found that allowing up to 10 people at gatherings had the same effect as Level 2 social distancing. These computer simulations have once again demonstrated that the greater the number of individuals allowed at gatherings, the more difficult it becomes to stop COVID-19 from spreading.

Preventing COVID-19 Using AI Robots

Dr. KangGeon Kim from the Artificial Intelligence and Robotics Institute developed the "AIDBOT," an artificial intelligence (AI)-based disinfection robot, using available KIST technologies. The AIDBOT is able to move around inside a building which is contaminated with pathogens dangerous to humans and disinfect the building, entirely on its own. Unlike other disinfection robots, it simultaneously uses disinfectants and ultraviolet (UV) rays and can move autonomously.

A key feature of the AIDBOT is that it disinfects by emitting UV rays from its trunk and spraying disinfectants from its upper section, and does not require humans to track and manually control it. One can simply monitor it from a control center and check that it is functioning properly. The robot uses AI to create a three-dimensional map of a building's interior and disinfects the building on its own. It also intensively disinfects objects that humans frequently come into contact with, such as doorknobs. The depth camera and LiDAR sensor allow it to sense human movements and disinfect without bumping into obstacles. Since direct exposure to UV rays at a close distance is harmful to humans, the robot stops performing UV disinfection when it senses an approaching person.

AIDBOT : Artificial Intelligence Disinfection roBOT

As its name suggests, the AIDBOT is an AI-based robot that aids humans with disinfection tasks. While disinfection may be faster if done by humans, the AIDBOT eliminates the need for human labor, reduces the risk of exposure to infections, and can be continuously used. It can even perform disinfection tasks in place of humans in multi-purpose facilities, such as hospitals, public facilities, and schools, thereby protecting the health and livelihood of our citizens.

EuCorVac-19, a COVID-19 Vaccine Developed Using KIST Technologies

EuCorVac-19, which is being developed by EuBiologics Inc., is a COVID-19 vaccine candidate based on a key adjuvant (EcML) platform, EulMT. The EcML technology was developed by Dr. Hak Suk Chung from KIST's Theragnosis Research Center, and subsequently transferred to EuBiologics. EuCorVac-19 has been designed to rapidly induce antibody responses, as well as high levels of neutralizing antibodies and cellular immune responses, and has shown excellent efficacy against viral attacks in animal models.

Phase 1 trials for the vaccine were conducted at the Catholic University of Korea's Eunpyeong St. Mary's Hospital in Seoul, among 50 healthy adults aged 19-50 years, and assessed the vaccine's safety, tolerance, and immunogenicity. Phase 2 trials will be conducted among 230 adults aged 19-75 years at five hospitals in the capital area, and will assess the vaccine's dosage and immunogenicity.

EuCorVac-19 is a safe recombinant protein vaccine with an adjuvant, developed in a similar manner as other commercialized vaccines. It comes in the form of a stable liquid injection that can be stored and distributed in a refrigerated state, and can thus be conveniently distributed using common biological distribution systems.

EuBiologics is planning to conduct Phase 3 trials with the Ministry of Food and Drug Safety based on the interim results of Phase 1 and 2 trials, which will be out as early as the third quarter of this year, and will strive to receive a product license at the earliest opportunity.

EuCorVac-19

Solutions to Carbon Neutrality

Byoung Koun Min
Director-General
National Agenda Research Division

Many countries have recently announced plans to increase the renewable energy share of total energy consumption in their country to over 80%, starting in 2050. South Korea has also announced plans to go carbon neutrality by 2050.

Since the first industrial revolution began some 200 years ago, fossil fuels have been our most common source of energy. Last December, a study published in *Nature*, an international journal, reported that human-made mass had exceeded the global biomass for the first time, meaning that mankind is placing a huge burden on the Earth's environment.

Many countries have recently announced plans to increase the share of renewable energy out of their total energy consumption to over 80%, starting in 2050. South Korea has also announced plans to go carbon neutral by 2050.

The problem is how to reach these goals. Coal-fired power, which currently accounts for over 40% of all energy sources, should be replaced with renewable energy. Theoretically, as it is surrounded by sea on three sides, ocean energy is the most abundant energy source in South Korea. However, solar energy has higher potential, considering the technological limitations of ocean energy. 120,000 TW of solar energy reaches the Earth every year. Harvesting that solar energy for just one hour can satisfy all of the world's energy needs for an entire year. In the book *Clean Disruption of Energy and Transportation*, Professor Tony Seba from Stanford University predicted that solar energy will account for 100% of all energy used by the globe in 2030. Thus, solar energy is the most important key to reaching worldwide carbon neutrality.

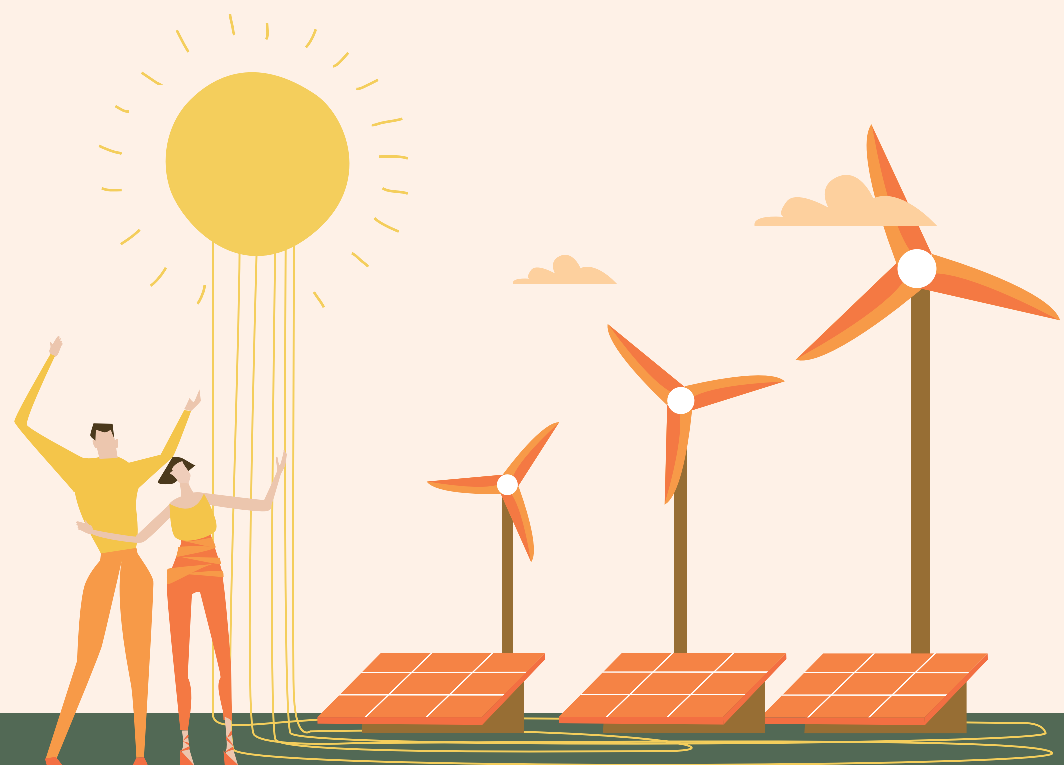
Solar cells are a relatively well-known application of solar energy. In the first and fourth quarters of this past year, solar cells capable of producing 1 GW of energy were installed in South Korea. Yet, while solar cells are a common sight in our daily life, their distribution is not ideal. Solar cells are often installed in mountainous areas, where their carbon neutrality may be reduced in the event of forest fires and other damaging events, since the batteries are susceptible to natural disasters.

To overcome this issue, it is necessary to install solar cells that can be integrated into buildings in cities. Therefore, solar cells must be developed and installed in the form of building materials, such as curtain walls, windows, and tiles, instead of just being placed on apartment balconies. Technologies are needed to develop solar cells that are flexible, permeable, and can be painted onto a surface, unlike silicone-based batteries, which currently hold a leading share of the solar battery market.

Another key solar power technology is storing energy in chemical forms. "e-Chemical," also known as artificial photosynthesis, uses solar energy to convert water, air, and carbon dioxide into chemical materials of high economic value, such as carbon monoxide, ethylene, and alcohol. This highly influential technology was introduced as "a new technology that could change the world" at the World Economic Forum in early 2017. While some e-Chemical technologies have made it to the pilot-level research phase, continued R&D is needed to improve catalyst efficiency, resolve stability issues, and achieve high system efficiency.

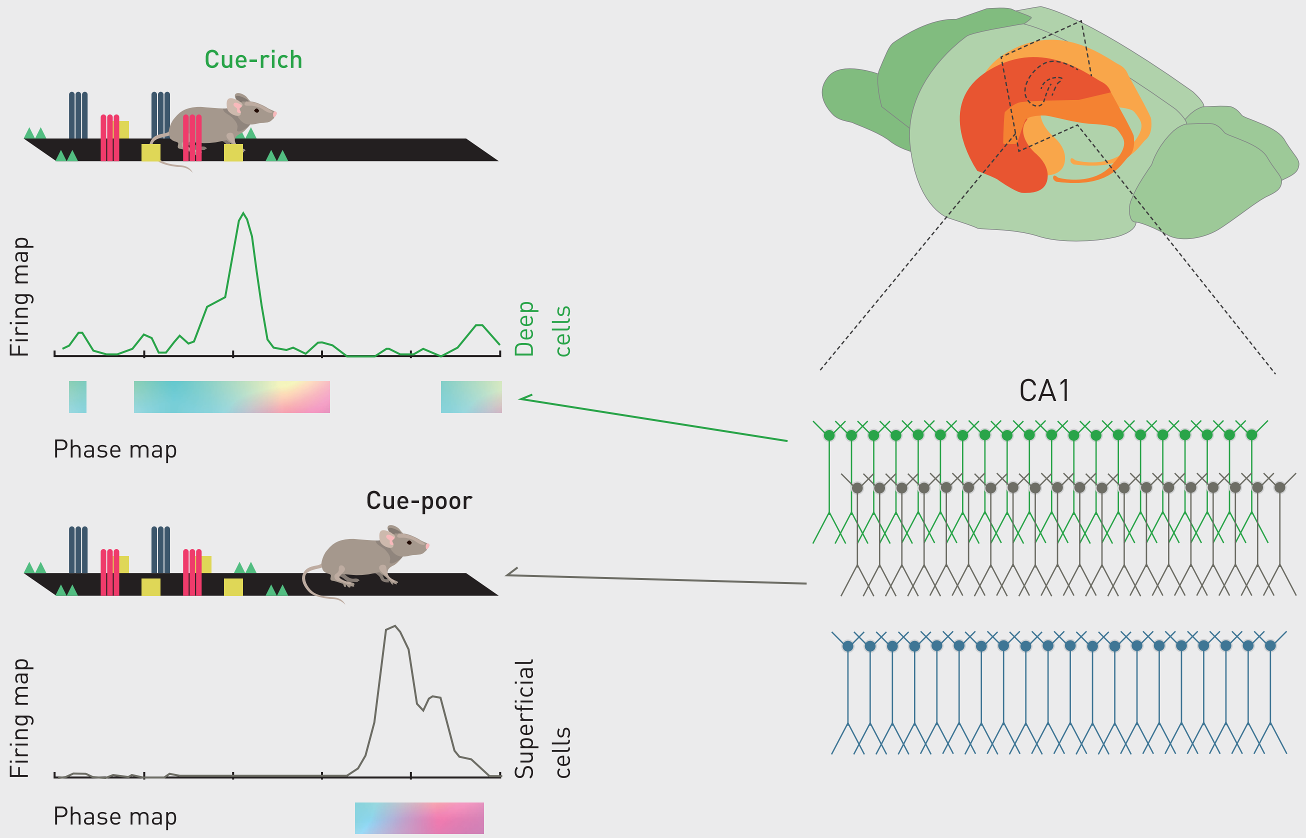
R&D on solar energy-based technologies is being competitively conducted worldwide to secure technology ownership and open up new industries. South Korea quickly jumped into funding solar energy research, the outcomes of which include solution-processed organic/inorganic solar cells and e-Chemical-related technologies. The competitive value of these technologies is acknowledged around the globe. South Korea's announcement to go carbon neutral by 2050 signals an energy paradigm shift that will bring about the country's transition into a zero-carbon society. Long-term and detailed R&D plans and strategies must be devised, based on the mutually-perceived need for changes.

Long-term and detailed R&D plans and strategies must be devised, based on the mutually-perceived need for changes.



Mechanisms to Remember Locations and Space

Sébastien Royer
Principal Researcher
Brain Science Institute

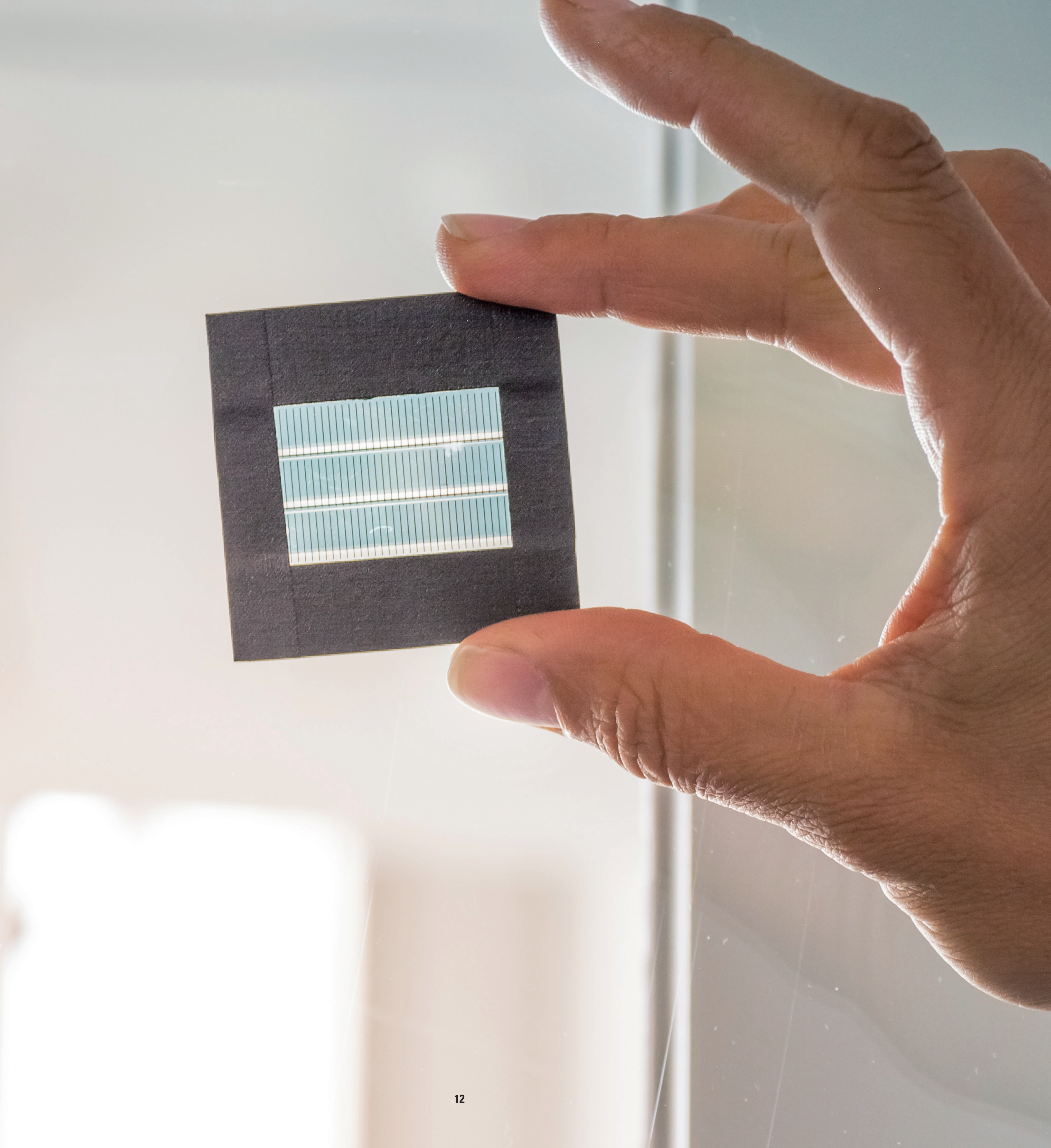


In a new city, everything seems unfamiliar. One needs to check nearby buildings and signs so as not to get lost. However, as one becomes more familiar with the environment, one no longer has to check every single sign to find one's way. The hippocampus is an important brain structure that provides information about one's environment and location, as well as helps one to learn and remember new information. It is the first structure to be damaged by the development of brain diseases such as Alzheimer's. Ever since the discovery of place cells, which recognize locations based on the cell's activities, the mechanism by which the brain stores information about locations has become clearer, and numerous studies have been published on spatial exploration and memory. However, it is not yet clear how place cells, which familiarize themselves with locations and thereby remember them, are produced or modified. Dr. Sébastian Royer from the Brain Science Institute at KIST reveals the mechanism through which spatial memory forms via learning.

See more details at
https://doi.org/10.1016/j.neuron.2020.10.034

"Subcircuits of Deep and Superficial CA1 Place Cells Support Efficient Spatial Coding across Heterogeneous Environments"

Neuron, 109, 1–14(Sharif et al)



Making Earth Sustainable with KIST's Carbon Neutrality Technology

To realize carbon neutrality that has emerged as a national issue, KIST will take the lead in responding to climate change.

The cover story looks at an international issue, carbon neutrality, which refers to achieving net-zero carbon emissions by balancing the emission of greenhouse gases – among which carbon dioxide is a prominent contributor – with their absorption. It also charts KIST's efforts to lead climate change adaptation by using technologies to achieve carbon neutrality.

Even before the government declared its vision for carbon neutrality, KIST has strived to develop anti-climate change technologies, such as high-value solar cells and hydrogen fuel cells to grow the hydrogen economy, next-generation batteries, and the production of useful chemicals through the direct use of carbon dioxide. It has published many world-class technologies, including protonic ceramic fuel cell and battery technologies, which are poised to replace existing hydrogen fuel cells due to their two-fold increase in capacity over lithium-ion cells and ability to be commercialized. And KIST continues to conduct world-renowned, high-quality research.

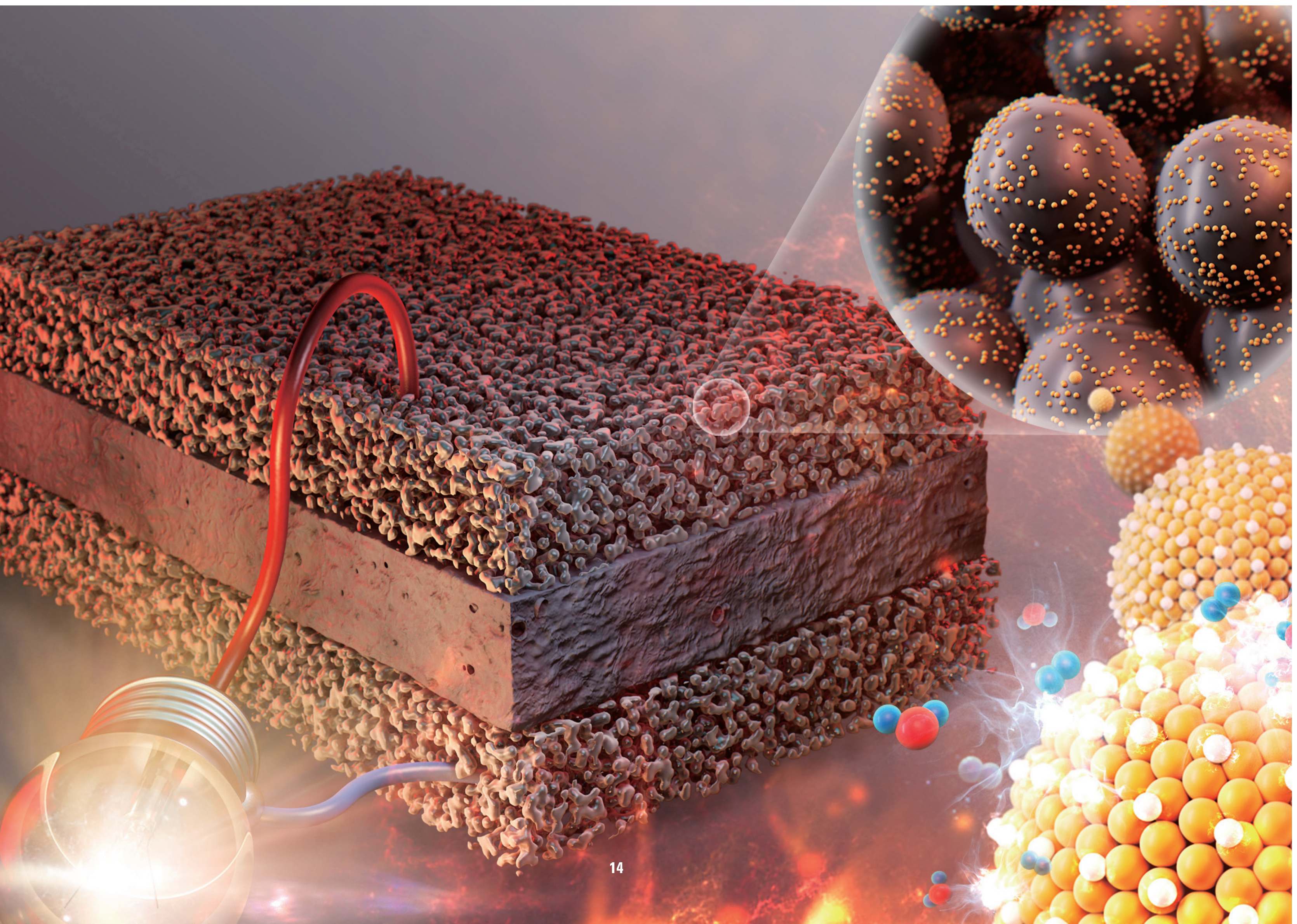
Furthermore, KIST has developed and published several technologies for the future. These include technologies to: accelerate the commercialization of perovskite solar and quantum dot next-generation solar cells; improve the performance and reduce the price of hydrogen fuel and secondary cells for hydrogen and electric cars; prevent lithium-ion battery fire incidents; and electrochemically convert carbon dioxide into carbon monoxide or ethylene.

Recently, KIST has started to look beyond performing laboratory experiments. It is focusing on researching and developing technologies that the public can directly experience for themselves, and commercializing and transferring these technologies to companies. Thus far, it has transferred to companies technologies related to hydrogen fuel cells (POSCO, 2021; Kumyang, 2021; WONIK Materials, 2020, etc.), technologies that degrade and recycle carbon-fiber-reinforced plastic (CFRP) in an environmentally friendly manner (CatackH, 2017), and technologies to thermochemically convert carbon dioxide into formic acids (Patek, 2020), and is collaborating with these companies in their research efforts.

The Development of High-Performance Atom Catalysts - A Green Light for the Simultaneous Production of Electric and Hydrogen Energy

Simply mix and inject - dispelling the assumption that platinum catalysts cannot be used at high temperatures. With stable operation at 700℃, these catalysts are expected to accelerate the commercialization of next-generation combined cycle fuel cells.

See more details at
https://doi.org/10.1039/D0EE01680B
"Highly Active and Thermally Stable Single-atom Catalysts for High-temperature Electrochemical Devices,"
Energy Environ. Sci., 2020



Kyung Joong Yoon
Principal Researcher
Center for Energy
Materials Research

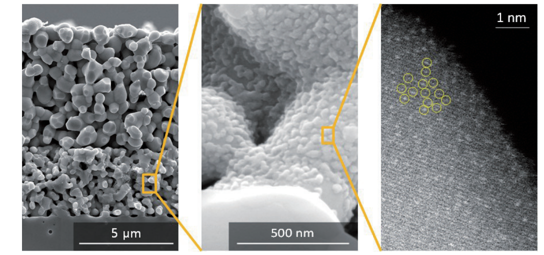
"Serendipity" refers to an unexpectedly or unintentionally obtained positive experience or result. X-rays, through which human bones can be examined without the need for cutting into the body; pencils and sticky notes, essential school stationery; and microwaves, a common appliance found in homes: these are all examples of serendipity. Serendipity is a source of happiness for scientists, since such discoveries are only possible as a result of their hard work and perseverance.

The high-performance atom catalyst discovered by Kyung Joong Yoon and Jisoo Shin's research team at KIST's Center for Energy Materials Research was also a case of serendipity. Unintentionally, they were able to create a high-performance single-atom catalyst – the likes of which had never been reported before – by developing a simple and effective catalyst processing technique in which a solution mixture is added to a fuel cell to operate it.

The catalyst developed by the research team was able to stably operate at high temperatures of over 700℃, which was previously unheard of for platinum catalysts. The new catalyst, which increased electrode reaction speed by over 10-fold and performance by 3- to 4-fold, could have various applications across a wide range of next-generation energy technologies, such as high-temperature electrolysis devices and proton-conducting ceramic fuel cells.

Cerium oxide nanoparticles, which allow oxygen molecules to move freely, create an opportunity to develop platinum catalysts

"It has been demonstrated for the first time that only a pinch of platinum is needed to produce platinum catalysts that operate stably at high temperatures. It took us a long time to understand exactly how this reaction occurred, but we are very excited about our new findings."



(Left) Solid oxide fuel cell electrode
(Center) Single-atom catalyst formed on the surface inside the electrode
(Right) Platinum atoms dispersed on the catalyst surface
(Highlighted areas: platinum atoms)

Fuel cells – an environmentally friendly electric power generating system – generate electricity through the chemical reaction between hydrogen and oxygen. Solid oxide fuel cells, which use ceramics as electrolytes, are currently the most actively studied fuel cells. The cells that operate at temperatures above 700℃ boast the highest efficiency among fuel cells, and can be used as an energy source to counteract climate change, since they regenerate hydrogen molecules used for clean energy via steam cracking.

However, these solid oxide fuel cells have a drawback: they cannot be used with platinum catalysts, which are known to have superior efficiency compared to other materials. "Smaller catalysts perform better, but platinum atoms tend to aggregate at high temperatures, resulting in reduced efficiency. This is why platinum catalysts have only been used in low temperature fuel cells, such as hydrogen fuel cells for electric vehicles," explained Dr. Yoon.

Since platinum catalysts cannot be used, researchers have been using nickel, a cheaper alternative. However, to accelerate the commercialization of solid oxide fuel cells, they felt the need to develop catalysts that could outperform nickel.

KIST's research team conducted a study aimed at evenly fixing platinum atoms to prevent their aggregation, which drew their attention to cerium oxide nanoparticles. Since fuel cells generate electricity via the chemical reaction between hydrogen and oxygen, it is necessary to create an environment in which oxygen molecules can freely move. Cerium oxide was deemed a suitable candidate, since it allows for the free movement of oxygen molecules.

Then, the research team simply mixed a solution of melted platinum and cerium ions, and injected it into the electrode of a fuel cell. Catalysts were synthesized while the fuel cell operated at high temperatures. The result was the platinum atoms being evenly fixed on the surface of the cerium oxide molecules at 1-nm intervals. In effect, the atoms were able to be stably scattered without aggregation at 700 .

According to the research team, this catalyst can stably operate at above 700 for over 500 hours. Furthermore, it achieved a 3- to 4-fold increase in electricity and hydrogen generation compared to nickel catalysts.

"The catalyst can be easily mixed and injected into an electrode without special equipment, or dispensed using a pipette. Since it is simple and easy to use, the processing costs involved are low," explained Dr. Yoon. "Another KIST research team that is working on catalysts is interested in using our catalyst in thermochemical reactions, and is studying its potential applications."

Prioritizing research over graduation! Finding a solution from an unexpected challenge

Dr. Yoon's research was initially aimed at creating platinum atoms and cerium oxide nanoparticle catalysts outside of a fuel cell, and then placing them inside. However, contrary to his expectations, the catalyst did not enter the sponge-like electrode through its pores and evenly distribute out, so this approach failed.

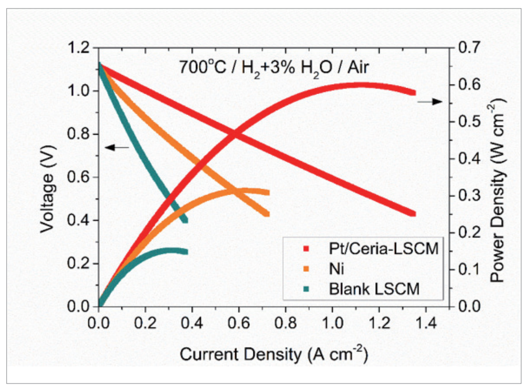
As further experiments continued to fail, Dr. Yoon felt concerned for fellow researcher Jisoo Shin and the KIST students involved, who were approaching graduation. However, in lieu of starting a different project, Shin was determined to take a completely different approach, and suggested that instead of making the nanoparticles outside the electrode, they would place the necessary ingredients inside an electrode. The idea resulted in a serendipitous discovery, as the research team was able to produce the high-performance atom catalyst.

"It took longer to understand how these results were obtained, as they were obtained unintentionally. It took an especially long time to examine the distribution of the catalysts, which cannot be seen with the naked eye, at the atomic level," said Shin. "It ended up being a meaningful experience, since the process was necessary to achieve commercializable solid oxide fuel cells."

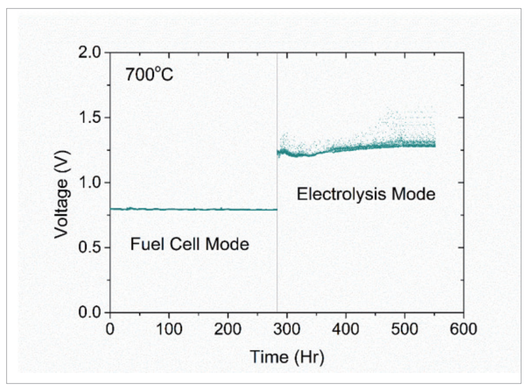
There are still several steps to be taken to apply the catalyst to solid oxide fuel cells. Processing techniques to evenly form single-atom catalysts on cells with a large area, as well as a technique to synthesize a large quantity of single-atom catalysts, are needed.

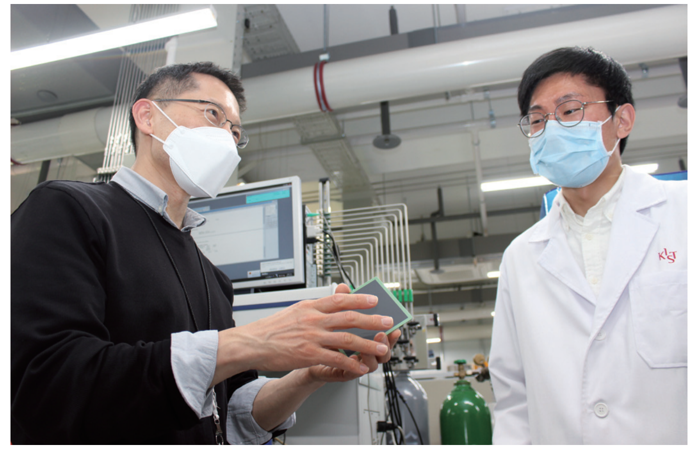
These steps will be taken through joint research with KIST's researchers. "An increasing number of high-temperature fuel cells for power plants are being installed in South Korea. Since not many countries have high-temperature fuel cells, these cells have a competitive value," said Dr. Yoon. "We will continue our research on high-temperature fuel cells, so that they can be widely used in the development of next-generation, environmentally friendly power generators and energy storage systems."

Solid oxide fuel cell performance evaluation results

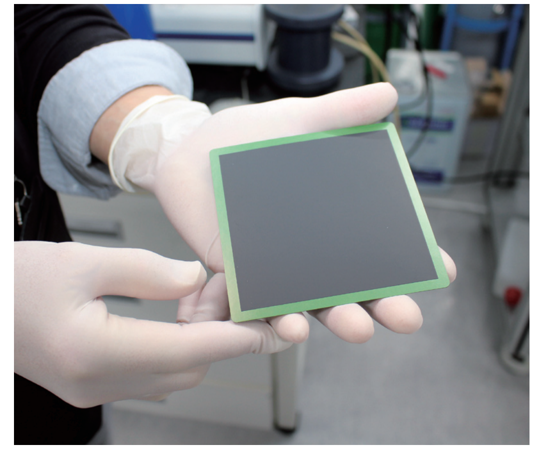


Results of stability assessment of solid oxide fuel cells with platinum single-atom catalyst



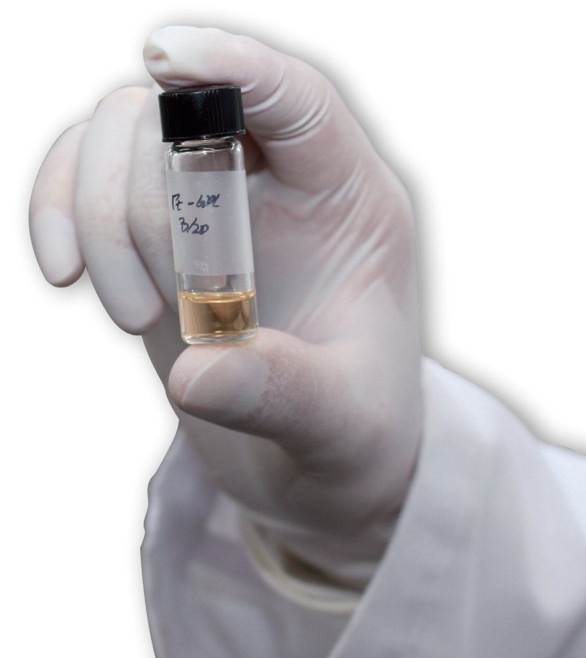


Jisoo Shin (right) are testing a solid



Solid oxide fuel cell developed by Dr. Yoon

High-performance atom catalyst developed by Dr. Yoon



Does planet Earth have "planet B"?

It is the year 2031. Humans have sprayed CW-7, an artificial coolant, into the stratosphere to stop global warming, and are instead greeted with an ice age. Survivors continue to live inside a train that travels 438,000 km every year, as it circumnavigates the planet from Africa to the tundra of the polar regions. The white landscape outside the window is far from romantic. Being outside for just 20 seconds will cause one's body to solidify, as if frozen by liquid nitrogen, and even the slightest impact can shatter it. There is no way to increase the atmospheric temperature to what it used to be. Inside the train is an isolated world with a hierarchical society. The Earth portrayed by Director Joonho Bong in his 2013 work, "Snowpiercer," is quite horrific.

During the 2015 United Nations Framework Convention on Climate Change, held in Paris, France, 197 countries gathered to discuss global efforts to stop climate change, but struggled to come to an agreement due to dissatisfaction with the prospect of shrinking industries. Subsequent to the statement by the Secretary-General of the United Nations that "there is no Plan B, because we do not have a Planet B," the Paris Agreement was signed, in which the participating countries agreed to strive to limit global warming to below 1.5℃.

Those countries now have a responsibility to achieve carbon neutrality (net-zero) by 2050. In other words, they should achieve a balance between the emission and absorption of carbon dioxide. To achieve this goal, the efforts of governments and research institutes are needed. How technological advances will prevent the future of the Earth as portrayed in "Snowpiercer" from becoming our reality is something worth keeping an eye on.

Replicating Skin and Other Organs with Artificial Tissue

01

Youngmee Jung
Principal Researcher
Biomaterials Research Center

See more details at
https://doi.org/10.1002/adfm.202008172
"Use of Elastic, Porous, and Ultrathin Co-Culture Membranes to Control the Endothelial Barrier Function via Cell Alignment,"
Advanced Func. Mat., 2021

Earlier this year, a petition was posted to the Blue House website denouncing horrific animal experiments, which included researchers implanting artificial eyes in beagles after extracting their completely healthy eyes, and then euthanizing them. Although the research team explained that there were no ethical concerns with the experiment since it was conducted only after acknowledging its necessity, the public remained unconvinced. There is now a social consensus to reduce animal deaths in animal experiments, and a growing number of people have begun to believe that unethical and irrational research practices should be discontinued.

All of the cosmetics and medications that we safely ingest, use, and apply to our skin have required the sacrifices of many animals. And while awareness about animal cruelty in research has been changing compared to what it was many years ago, it is still difficult to completely eliminate animal experimentation from research.

To resolve this issue, Dr. Youngmee Jung research team from KIST's Center for Biomaterials developed a platform that can easily produce artificial tissues similar to human tissues, which can be used to make artificial organs and skin. By efficiently culturing cells, this platform increases the stem cell differentiation rate 2.5-fold, and produces artificial organs that could be useful in novel drug development pre-clinical trials, which previously used animals.

> Cosmetic products and medications that we safely ingest, use, and apply to our skin have all required the sacrifices of many animals.

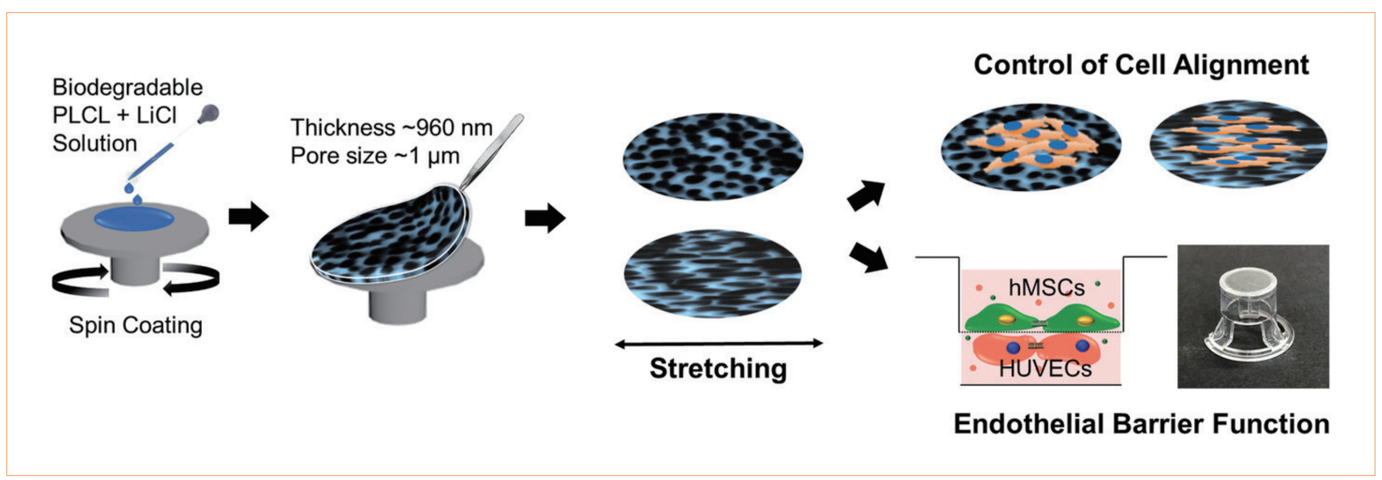
The discovery of stretching the co-culture membrane from dissolvable threads

Models of bone, skin, nervous system, nose, and finger tissue are displayed in the laboratory of Dr. Jung, who joined KIST in 2003, and show the fruits of her research.

This laboratory can create anything, from cancer cells to organs of the body. Dr. Jung successfully developed a multi-porous membrane-based cell co-culture platform that can easily and quickly produce tissues similar to our own biological tissues.

According to her, cell co-cultures, in which different cells are cultured together to produce an artificial organ, have been used to replace pre-clinical trials using animals. Since our body consists of various kinds of cells, cell co-cultures are essential for growing a variety of cells, and are used in almost all research to produce tissues that mimic real human tissues.

Overall schematic illustration of the fabrication of EPUM using PLCL through a VIPS process during spin-coating



Cell co-culture platform developed by Dr. Jung

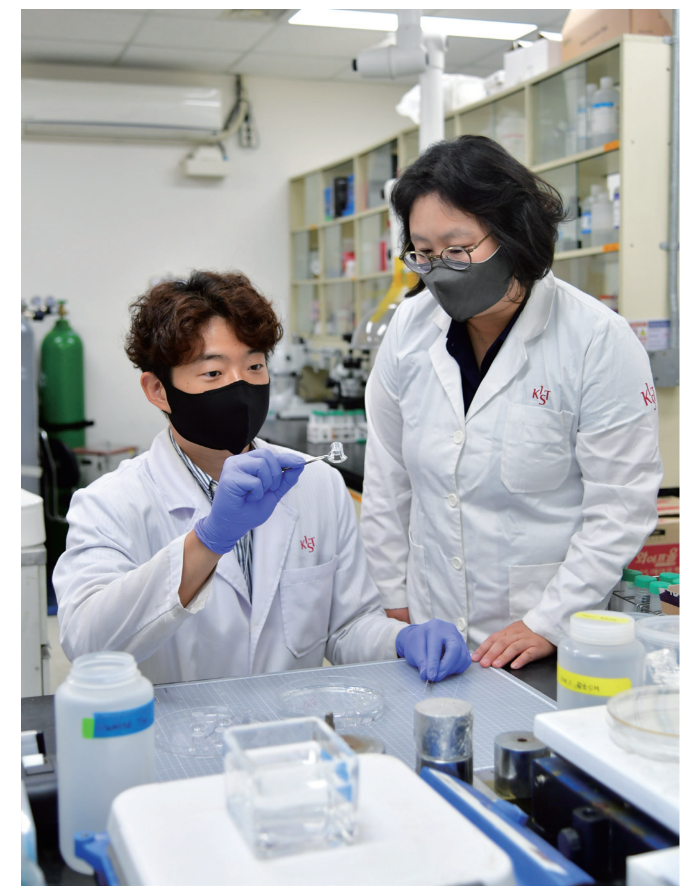
However, simply growing different cells in the same culture can cause cells with a faster growth rate to encroach on other cells, interfering with their normal growth. Various cell culture platforms have been developed to overcome this limitation, but they have failed to induce active intercellular interactions due to their membranes being relatively thick and having low pore density. These platforms required additional treatments to compensate for the differences in the culture environment and in vivo environment, in which cells grow.

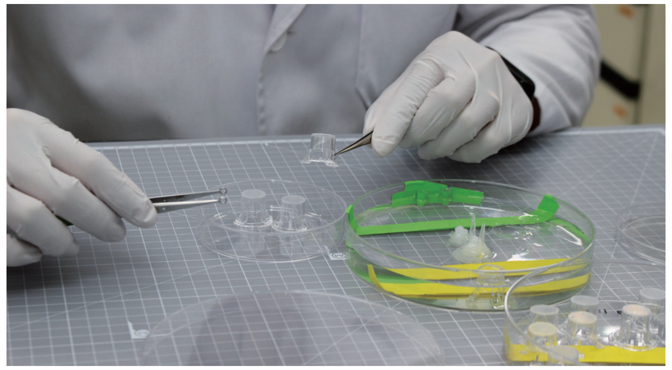
Dr. Jung's research team's attention was drawn to polylactide co-caprolactone (PLCL) polymers, which share similar properties with the dissolvable threads used in surgery. By using PLCL polymers, they managed to create a membrane 10 times thinner than the previous membrane, and provide cells with an environment resembling the in vivo environment by adjusting membrane elasticity.

According to Dr. Jung, while the materials used to produce dissolvable threads have high strength and are suitable for regenerating solid tissues, such as bone, they are unsuitable for soft tissues, such as the skin, which is elastic. The research team mixed the original materials for dissolvable threads to produce elastic, biocompatible polymers via copolymerization. They then dissolved these polymers in a solvent – tetrahydrofuran – and spin-coated the resulting solution in water (steam), which is a non-solvent, thereby inducing phase separation and adding elasticity. Eventually, they managed to produce a thin, multi-porous membrane.

The membrane had such excellent elasticity that the shape of its pores changed as it was stretched. Dr. Jung explained that "stretching the membrane rearranges the pores on it, forming nano-patterns on the membrane surface," and that "since this pore arrangement varies between stem cells, it is possible to create a structure with an optimal pore arrangement."

Dr. Jung and a member of her team discuss the research results





A researcher on Dr. Jung's team tests a co-culture platform

Excellent elasticity meant that a thin membrane that allowed for active intercellular interactions could be produced. Dr. Jung's research team observed that, after adjusting the nano-pattern's arrangement, mesenchymal stem cells effectively differentiated into cells of the vessel wall. The vascular wall formed by these cells successfully mimicked a real vessel wall.

Using the platform, the research team co-cultured stem cells that could differentiate into vascular endothelial cells forming the inner layer of the vessel wall, as well as the cells forming the outer vessel wall, and found that approximately 2.5 times more stem cells differentiated into vessel wall cells in their platform than in a commercialized platform.

This platform could also be used to recreate the skin's barrier. Dr. Jung explained that "there are unmet medical needs for skin diseases, such as atopic dermatitis and keloids, for which the only available treatment is topical or oral steroids," and that "if we can produce skin tissues of different types for different skin diseases using our platform, it may become possible to develop medications without sacrificing animals."

Is artificial tissue research undesirable? Changing the stereotype about artificial tissue research

Ever since Dr. Jung joined the world of research, she had dreamed of studying biological tissues for therapeutic applications. She wanted to produce biological tissues that could replace worn-out cartilage and narrowed blood vessels. However, since her research involved human subjects, she soon faced many hurdles, such as obtaining approvals for clinical trials and other administrative processes. There was a high hurdle to overcome before an artificially created human tissue that has been implanted in animals could finally be implanted in humans.

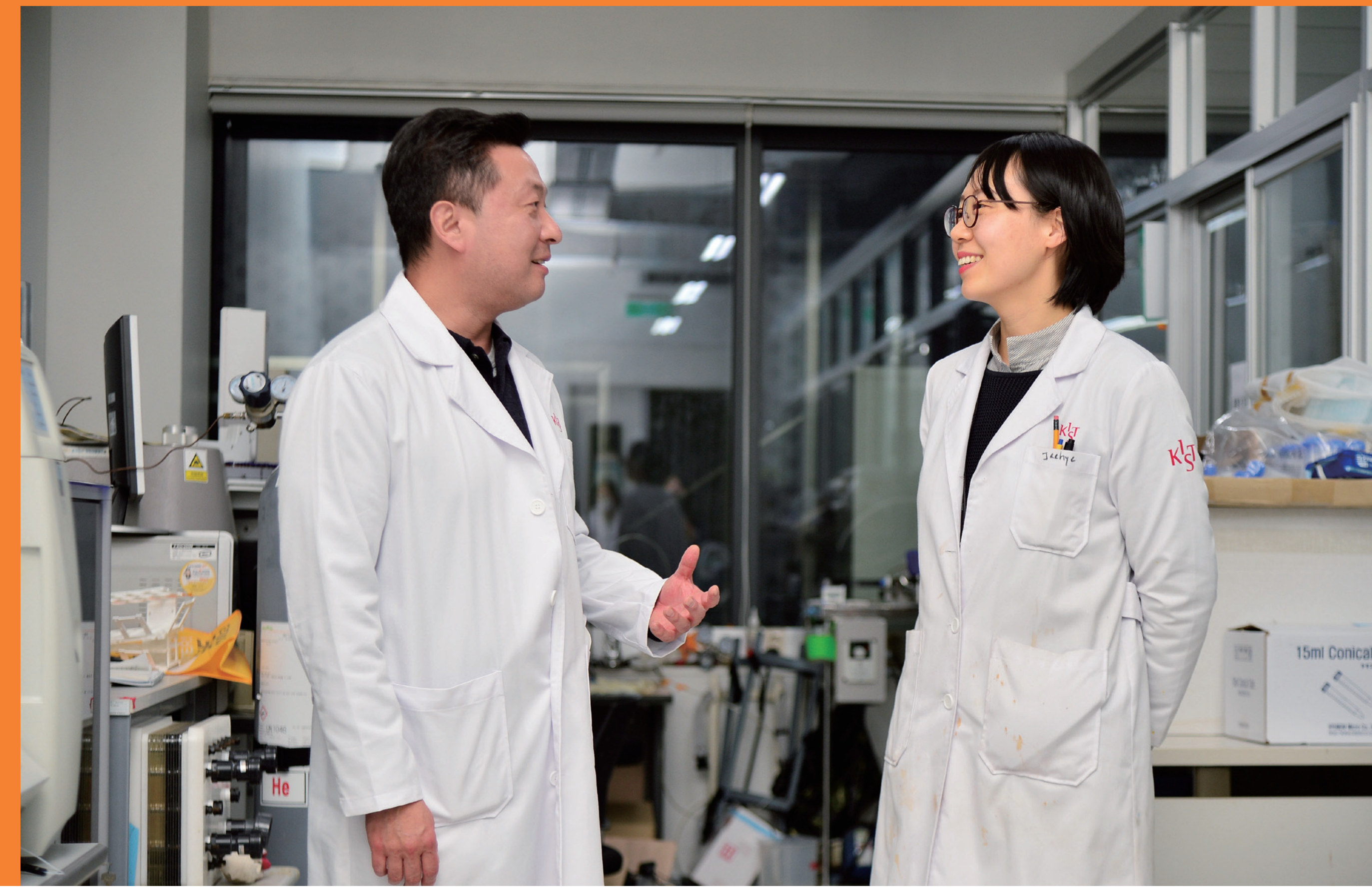
Around the time Dr. Jung began her research, there was growing opposition against animal experiments. Many researchers studying medical devices began to develop platforms that could replace animal experiments.

Once she began her research, she looked outside the box, and developed a membrane support that could form human skin layers for use in clinical trials, and felt that with additional research, it would be possible to use this platform for therapeutic purposes.

She hopes that such techniques will allow researchers to easily produce body organs which can replace animal experimentation in various contexts that require biological assessment, such as pharmaceutical companies and hospitals.

"Not all novel or cosmetic drugs tested in animals turn out to be effective in humans, due to the biological differences between humans and animals. The effects seen in animals may not appear in humans," said Dr. Jung. "I will continue studying artificial tissues to create a world where animals are not unnecessarily sacrificed."

> If we can produce skin tissues of different types for different skin diseases using our platform, it may become possible to develop medications without sacrificing animals.



Development of Water Treatment Membranes that Can Regenerate with Sunlight

02

See more details at
https://doi.org/10.1016/j.apcatb.2020.119587
"Hydrophilic Photocatalytic Membrane via Grafting Conjugated Polyelectrolyte for Visible-light-driven Biofouling Control,"
Applied Catalysis B: Environmental 2021


Seok Won Hong
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Researchers specializing in water treatment and photocatalysts have cooperatively developed a membrane that can be cleaned only using sunlight.

Researchers specializing in water treatment and photocatalysts have cooperatively developed a membrane that can be cleaned only using sunlight. Unlike existing water treatment membranes, which were prone to microbial accumulation after a week and had to constantly be cleaned to maintain performance, this new membrane could be maintained in a smart, environmentally friendly way.

Dr. Jee Hye Byun and Dr. Seok Won Hong from KIST's Water Cycle Research Center led the research. "We believed that combining the techniques developed by Dr. Byun – material synthesis and photocatalysis – with existing techniques would produce interesting results, and hence began our cooperative research," Dr. Hong said. "Our membrane could be used not only in South Korea, but also by developing countries suffering from drinking water contamination."

Dr. Seok Won Hong explains the research methodology and the objectives

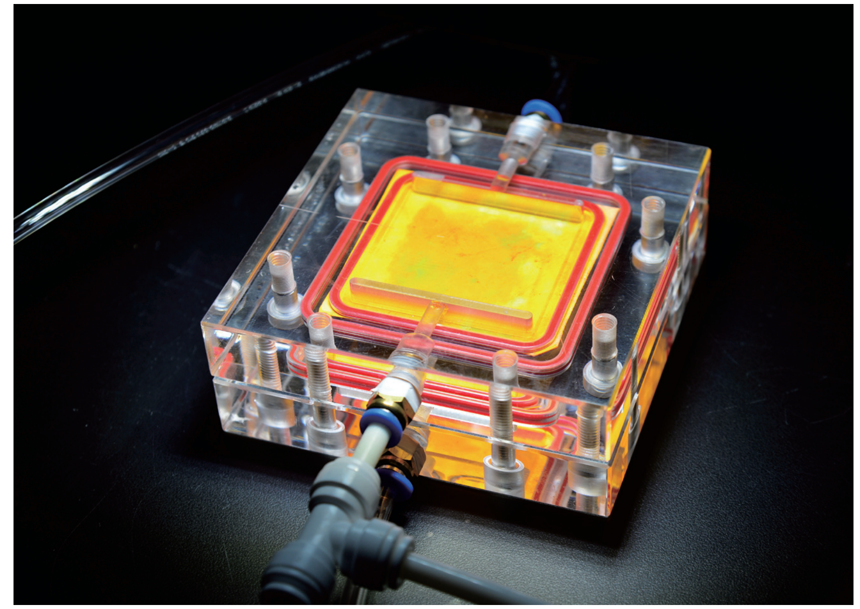
Clean membranes in just 10 minutes – a 20-year water treatment research veteran listens to the voices of sewage treatment workers

According to Dr. Hong, water treatment membranes were classified as high-end products until the 2000s. After water quality regulations were enforced, the need for water treatment membranes that could effectively filter pollutants grew. As supply met demand, the price of water treatment membranes fell. Water treatment membranes are now used for seawater desalination, water reuse, sewage treatment, and ultrapure water filtration in semiconductor industries. However, these membranes become contaminated with microbes and inorganic substances that grow and stick to their surfaces after long-term use.

Dr. Hong, a 20-year veteran of water treatment research, visited sewage treatment plants and spoke with the workers, who were having a difficult time with water treatment membranes at the sites.

"I heard that the wastewater maintenance technician spends the whole day cleaning the water treatment membranes. It takes forever to clean all the membranes, since there are so many of them to handle the large amounts of water. I sincerely feel the need for membranes that have self-cleaning capabilities."

According to the worker, chemical agents are currently used to clean water treatment membranes once a week, and the cleaning takes six hours. "Chemical cleaning process can damage water treatment membranes. Moreover, washing the membranes with sulfuric acids or chloride-based agents can release toxic wastes. Thus, there is a need to improve current water treatment membranes."



The self-cleaning membrane under visible light irradiation

The research team reported that by exposing a membrane with a rough surface to visible light, they were able to completely degrade surface pollutants and easily clean the membrane.

Dr. Byun and Dr. Hong agreed to develop a self-cleaning membrane using photocatalysts that absorb light and activate surrounding oxygen molecules to produce reactive oxygen species. The photocatalysts are known to have excellent antimicrobial and pollutant degradation capabilities, and are also used in air cleaners.

Sunlight is composed of ultraviolet light, infrared light, and visible light, with ultraviolet light accounting for the lowest energy portion of sunlight, while visible light accounts for the highest. The research team, therefore, focused on developing a water treatment membrane that responds to visible light. Since photocatalysts are most active under ultraviolet light, to maximize their cleaning performance, the research team induced them to be most active under visible light, and then firmly fixed them onto the surface of a water treatment membrane.

The research team reported that by exposing a membrane with a rough surface to visible light, they were able to completely degrade surface pollutants and easily clean the membrane. Just 10 minutes of exposure to light cleaned the membrane to the point where it could be reused. And one hour of exposure eliminated 99.9% of highly concentrated bacteria and bacteriophages, such as *Escherichia coli* and *Staphylococcus aureus*, from the membrane's surface.

Not only microbes, but also organic pollutants, such as dyes and heavy metals, could be removed from the membrane, with consistent performance being shown across 10 repeated tests.

Moreover, visible light can also be produced from fluorescent light. Therefore, in South Korea, where rainy days are common, fluorescent light can be used instead of sunlight to sterilize the membranes.

According to Dr. Byun, the major achievement of this research is that photocatalysts were able to be chemically fixed to the surface of a water treatment membrane. "Previously, photocatalysts were glued to water treatment membranes, since it was difficult to firmly fix them in place. Over time, the photocatalysts would fall off the membrane, clogging its pores and reducing its performance, and would finally have to be filtered out," explained Dr. Byun. "By


Experimental setup for making polymer photocatalysts

By chemically binding photocatalysts to membranes, we have managed to prevent photocatalysts from clogging and falling off the membranes, thereby reducing the membrane treatment process, by one step.


The membrane is on testing for biofouling removal under an LED lamp

chemically binding the photocatalysts to membranes, we have managed to prevent them from clogging and falling off the membranes, thereby reducing the membrane treatment process by one step."

No more ripped or burst membranes: how trial and error, and know-how, led to success

"After conducting fundamental research on photocatalysts, I have moved on to doing research more closely related to commercialization. I will continue my research with a clear sense of direction, and strive for my techniques to be used to easily reuse water treatment membranes and develop membrane materials," said Dr. Byun.

Dr. Byun, who has dedicated herself to basic science on photocatalysts, had her first opportunity to marry photocatalysts with water treatment membranes. Since she has recently joined KIST, this is the first time she is conducting research closely linked to commercialization.

After ripping and bursting countless membranes to test their performance, using a highly concentrated microbial solution, Dr. Byun came up with her own technique, and optimized her experiment. As a result, her membranes can effectively clean themselves under sunlight even after being exposed to an environment with a microbial concentration higher than that of wastewater.

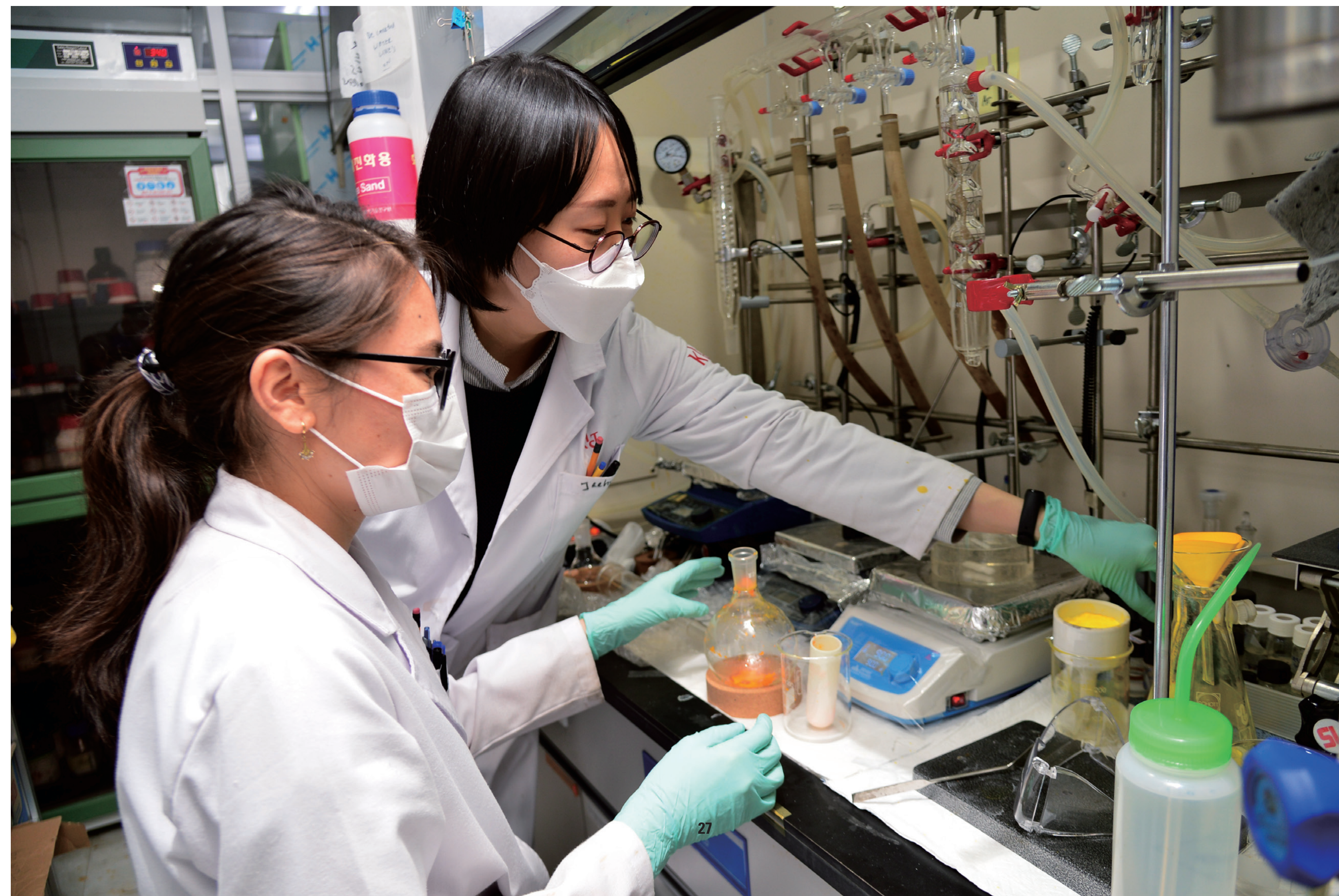
Dr. Byun's technique can eliminate contamination with only a small amount of energy, and can thus be used not only in South Korea, but also in developing countries that struggle with water hygiene maintenance. "Follow-up research and research scale-ups are needed to optimize the performance of membranes with a larger area, and ultimately, commercialize them," said Dr. Hong. "We are planning to assess the durability and long-term performance of our membranes using wastewater from real sites so that the membranes can be used on-site."

"Depending on who is doing the analyzing, there can be large errors in microbial experiments. Thanks to the thorough analysis of the experiment results by our student researchers, which was a time-consuming process, we were able to obtain successful results," added Dr. Hong, expressing his gratitude toward his colleagues.

Dr. Hong's research team plans to conduct further research on various water-related topics.

"They say water is the origin of life. This might be why many researchers pick water supply and sewage systems as technologies that have extended human lifespans. Water continuously circulates, and failures in circulation systems lead to droughts and heavy rainfall. While water-cleaning technologies are important, it is also time to turn our attention to how water cycle research is interconnected with climate change. We, the KIST Water Cycle Research Team, will do our best in our research efforts," said Dr. Hong.

Dr. Byun and her team are testing the polymer for membrane fabrication



Progress and Future Prospects of VKIST's Establishment

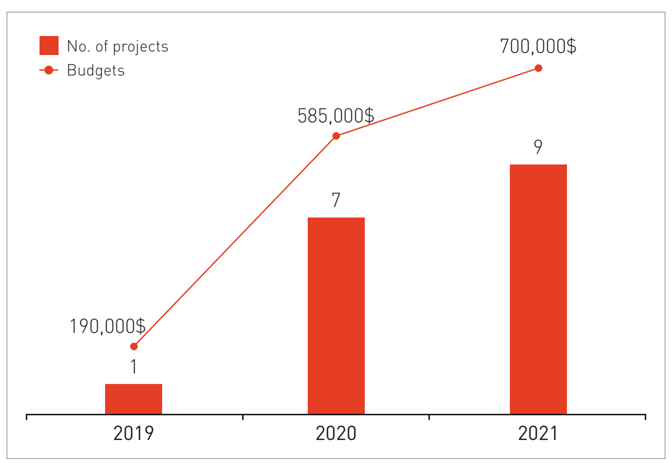
Vietnam is the largest trade and collaborative partner to Korea among countries in the South East Region both in fact and in name. Exchange between two countries is expanding to various areas including science and technology sector. An ODA project supporting the establishment of the Vietnam-Korea Institute of Science and Technology (VKIST) is a representative example in the area. This project is to build a new public R&D agency under the Ministry of Science and Technology (MOST) in Vietnam. Major mission includes promotion of applied R&D, which is urgently needed for speeding industrialization according to the Socio-economic Development Strategies of Vietnam. VKIST differs from existing public R&D agencies in Vietnam that it is based on the concept of a contract R&D institute in the public sector. VKIST is assigned to build a new paradigm through benchmarking the early model of the Korea Institute of Science and Technology (KIST) developing industrial technology urgently needed for economic development.

Following the Presidential Agreement (2013), both parties made a long-term master plan of VKIST, and has been implementing the first phase ODA project since 2014. Korea The International Cooperation Agency (KOICA) is responsible for building construction. KIST is carrying out all software-related matters necessary to establish a new R&D laboratory, which are similar to what Battelle Memorial Institute (BMI) had done to KIST 50 years ago. Job covers industry survey, consultation, training for capacity building, procurement of basic R&D equipment and managing pilot joint R&D projects with KIST.

This ODA project holds special meaning for KIST as it represents a full-scale sharing of her knowledge and experiences on laying down a research basis of science and technology and promoting industrial technology in a least developed country (Korea). KIST is the first Sister-ship MOU partner to VKIST, has assigned its Vice President as the principal investigator (PI) of the ODA project, and has been operating a special team (VKIST-supporting Center). In line with the ODA duty, the VKIST-supporting Center has been promoting research collaboration between KIST and VKIST. As this ODA project is nearing completion, it may be timely to share its activities between them.

VKIST campus at Hoa Lac High Tech Park, Hanoi

R&D collaboration trend between KIST-VKIST (2019–2021)



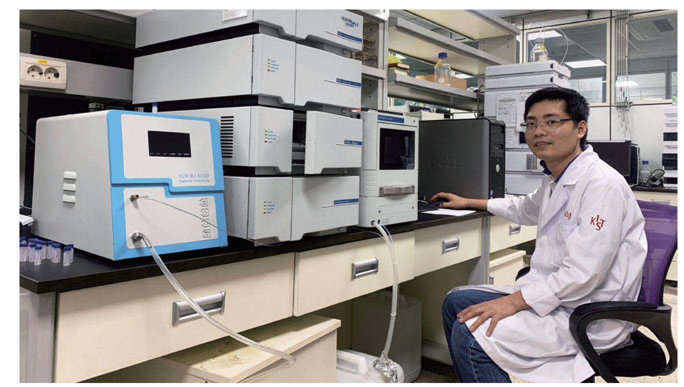
Category	Research Topic	Project Period
Pilot Joint Project (ODA)	Electric motors, bio sensors for avian influenza(AI) detection	Aug 2020 –June 2021
International Cooperation Project (MSIT & MOST)	Developing products from 'polyscias', optical fibers	3 years per project
Global Knowledge Platform project (KIST)	Face recognition, omni-directional robots, desalination, developing products from 'gac'	1 year per project

Areas of R&D collaboration between KIST and VKIST

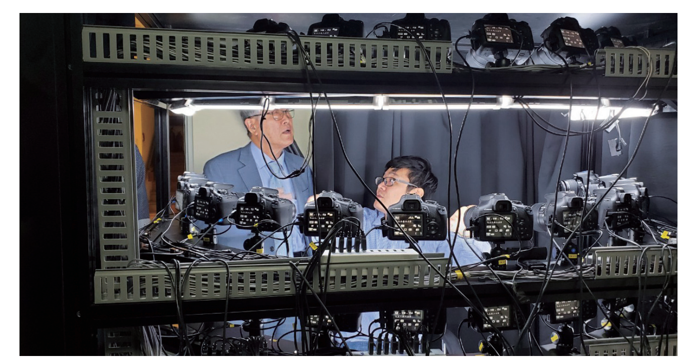
The R&D collaboration has started in September, 2019. Currently, there are three types of projects in the VKIST priority area which refer to funding sources. One is the "Pilot Joint Project": this was planned as a part of the ODA tasks and two projects are running. The aim is to share the KIST-way of laboratory practice on application research and development. The second one is "International Cooperation Project" between Korea and Vietnam jointly supported by the Ministry of Science and ICT (MSIT) and the Ministry of Science and Technology (MOST). The purpose is to support VKIST for the early initiation of research activity. Currently two projects are running and two more are on planning stage. The third type is sub-projects from KIST through the Global Knowledge Platform program. The aim is double sided: one is to support VKIST with enhancing its R&D capacity in priority area and the other is to develop a sustainable R&D partnership between KIST and VKIST.

The VKIST has mainly focused on BT and IT fields, based on its mission. In the BT field, VKIST selected the medicinal plants as one of its R&D priorities, and this topic is well aligned with the mission of the Gangneung Institute, at KIST. In order to foster closer cooperation, VKIST opened an "On-site Laboratory" at the Gangneung Institute for its BT research. And in the IT sector, R&D collaboration started from the topic of "Poliface" and extended to sensors and electric motor design. The Poliface is a platform of facial recognition technologies developed by ARI (AI & Robot Institute), and KIST and VKIST have built an Audio/Video studio in Hanoi, and VKIST is operating the system to collect face images. Through close collaboration of both parties, it expects to make achievements in the near future.

Over the long run, KIST aims to further explore ways to create a mutually beneficial relationship, and to lay down a strong bridgehead through which the two nations become vital partners in the science and technology sector. The late Dr. Choi Hyung Sup insightfully named his one memoir, which summarizes his diplomatic experiences in the science and technology sector, "Science and Technology Have No Frontiers". It is hoped that the ODA project supporting the establishment of VKIST could testify to Dr. Choi's insight and show that KIST is living up to his expectation.



(Korea) Conducting an analysis at the VKIST onsite lab



(Vietnam) Installing facial recognition equipment

Research News. 01

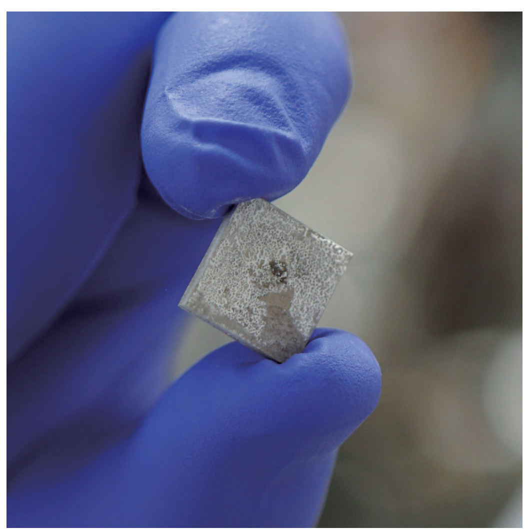
Bio/Medical

Coating implants with “artificial bone” to prevent inflammation

See more details at
https://doi.org/10.1002/adfm.202005233
“Robust hydroxyapatite coating by laser-induced hydrothermal synthesis”
Advanced Functional Materials 2020

Hojeong Jeon
Biomaterials Research Center

A piece of titanium coated with artificial bone developed by Dr. Jeon



Bone disease is becoming increasingly prevalence in modern society due to population aging among other factors, and the use of dental and orthopedic implants to treat bone disease has been on the rise. However, there are still a number of issues associated with implant procedures such as a loose implant resulting from slow integration into the bone tissue or an inflammation necessitating a secondary surgical procedure.

To mitigate these issues, there has been an attempt to coat the implant material with “artificial bone” that has the same composition as the actual human bone. Conventional coating methods, however, require a synthesis process to manufacture the artificial bone material and a separate coating process, which takes a long time. Plus, the binding between the substrate and the artificial bone coating layer tends to be weak, resulting in damage or even drop-off, and strong coating methods that could be applied to actual patients in a clinical setting were rare.

Under these circumstances, Dr. Hojeong Jeon's research team from the KIST Center for Biomaterials have developed a ceramic artificial bone coating with triple the adhesion strength compared to conventional coating materials.

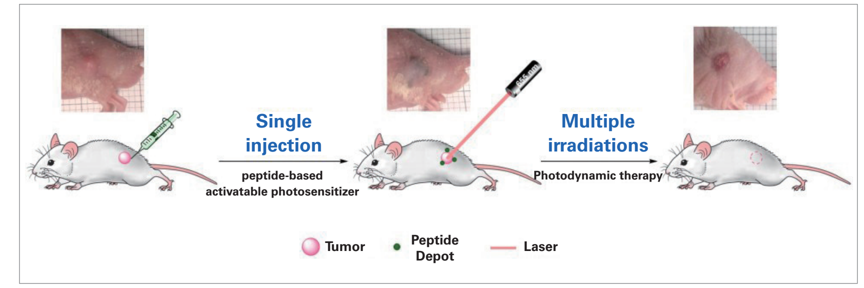
The research team developed a technology to induce artificial bone coating, which had taken at least a day and required dozens of steps, in just one hour using a single process. By using the technique, there is no need to synthesize the raw material for artificial bone coating in a separate process, and it is possible to create the coating with a nanosecond laser without any expensive equipment or heat treatment process.

Not only that, it is possible to form a coating layer with a stronger binding power than the few artificial bone coating techniques applied clinically today. Also, in case of using this process, it results in robust coating not only on metal surfaces but even on the surfaces of polymer materials such as orthopedic plastic implants, which has not been possible with conventional processes.

In order to reduce the number of steps involved in the process as well as the duration and at the same time ensure robust coating, Dr. Jeon's team positioned the material to be coated in a solution containing calcium and phosphorous, the main components of the bone, and irradiated it with laser. The temperature was raised in a localized manner at the target site of the laser, causing a reaction involving the calcium and phosphorous to produce ceramic artificial bone (hydroxyapatite) and the formation of a coating layer.

Unlike the conventional coating methods, the synthesis of the artificial bone component is induced by laser and, at the same time, the surface of the substrate is heated above the melting point for the artificial bone material to get adsorbed on the melted surface and get hardened as is, which maximizes the binding strength.

Researchers in Center for Theragnosis have developed a phototherapy technology that can significantly increase efficiency while reducing the pain of chemotherapy and minimizing side effects after treatment. Dr. Sehoon Kim's research team has developed a cancer-targeted phototherapeutic agent that promises complete elimination of cancer cells without side effects. It involves only one injection and repeated phototherapy. This development was made through joint research with Professor Dong June Ahn of Korea University and Professor Yoon-Sik Lee of Seoul National University.



Cancer being treated with a single supermolecular peptide phototherapy injection and repeated phototherapy

Phototherapy technology, a cancer treatment modality that uses light, injects a photosensitizer that destroys cancer cells in response to a laser, which accumulates in only cancerous tissues. Further, it shoots light to selectively destroy the cancer cells. It has far fewer side effects than radiation therapy or general chemotherapy (that inevitably damage the tissues surrounding the cancer cells), allowing repeated treatment.

Since the effect of the conventional photosensitizers only lasts for one session, photosensitizers have to be administered each time the treatment procedure is repeated. Moreover, the residual photosensitizer after treatment accumulates in the skin or eyes causing side effects due to light; thus, it is recommended to isolate the patient from sunlight and indoor lighting for some time after treatment. Overall, the patients receiving phototreatment have had to suffer from the pain of the repeated injection and the inconvenience of isolation in the dark each time. Recently, photosensitizers with phototherapeutic effects that get activated only in cancer tissues have been developed; however, they are still toxic and have to be injected for every repeated session of treatment.

Dr. Sehoon Kim and his team used peptides that selectively target cancer tissues and assemble themselves in a specific order to resolve the problems associated with the phototherapy technology. The research team developed a peptide-based photosensitizer that activates phototherapeutic effects only in cancer tissues by using the internalizing RGD peptide (iRGD) that can selectively penetrate and target cancer tissues, and by proper design for the modulation of its reaction to light.

When this newly developed photosensitizer is injected into a living body, it is activated by the body temperature and aggregates into a supramolecular arrangement designed by the research team, to be stored around the tumor. The subsequent phototherapy can destroy only cancer cells without affecting surrounding normal cells.

Sehoon Kim
Center for Theragnosis

Research News. 02

Bio/Medical

Chemotherapy with light; only one injection required

See more details at
https://doi.org/10.1021/acsnano.0c06881
“Injectable Single-Component Peptide Depot: Autonomously Rechargeable Tumor Photosensitization for Repeated Photodynamic Therapy”
ACS Nano, 2020

Research News. 03

Material/Systems

Anti-hacking based on the circular polarization direction of light

See more details at
https://doi.org/10.1002/adfm.202006236
"High-Performance Circularly Polarized Light-Sensing Near-Infrared Organic Phototransistors for Optoelectronic Cryptographic Primitives"
Advanced Functional Materials 2020

Jung Ah Lim
Principal Researcher
Center for Opto-Electronic Materials and Devices

The Internet of Things (IoT) allowing smart phones, home appliances, drones and self-driving vehicles to exchange digital information in real time requires a powerful security solution, as it can have a direct impact on user safety and assets. A solution for IoT security that has been is a physical unclonable function (PUF) that can supplement software-based key security vulnerable to various attack or physical attack.

Hardware-based PUF semiconductor chips, for example, each has a unique physical code, are similar to the human iris and fingerprints. Because the variations in the microstructure derived from manufacturing process act as a key value, the security keys generated via PUFs are random and unique, making it impossible to duplicate. However, there were limitations in that the hardware structure had to be changed in order to increase the number of combinations of keys to enhance cryptographic characteristics.

Under these circumstances, a team led by Jung-Ah Lim and Hyunsu Ju from the KIST Center for Opto-Electronic Materials and Devices have successfully developed an encryption device that can greatly strengthen the cryptographic characteristics of PUFs selectively detecting circular polarization, without modifying the hardware structure, through collaboration with a team headed by Suk-Kyun Ahn, Professor of Polymer Science and Engineering at Pusan National University.

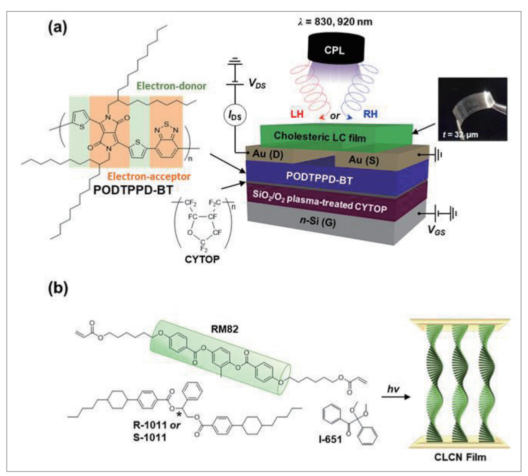
Light, which behaves as both a particle and a wave, can travel in a straight line, while rotating in the form of a spiral, as circularly polarized light.

The core technology applied to the encryption device developed by the KIST and PNU research team is a phototransistor that can detect the circular polarization of light rotating in a clockwise or counterclockwise direction.

The main strategy used in the newly developed phototransistor is a combination of cholesteric liquid crystal and low bandgap π-conjugated polymer with excellent near-infrared light absorption and charge transport properties. The cholesteric liquid crystal film has a strong tendency to selectively reflect near-infrared circularly polarized light, as the amount of light reaching the device is controlled according to the rotational direction of the light. In the study, the device exhibited excellent dissymmetry factor for photocurrent with high sensitivity in detecting circularly polarized light.

The research team succeeded in fabricating a PUF device that could serve as a fundamental solution against hacking, wiretapping, etc., by increasing the number of combinations in generating encryption keys using a simple solution process, without changing the physical size of the array.

(a) Development of NIR circularly polarized light-sensing thin-film organic phototransistors
(b) Schematic showing the formation of cholesteric liquid crystal network (CLCN) films by photopolymerization



Super-micro, low-power sensors and devices that can send and receive signals and information anytime, anywhere will become an integral part of people's lives in a hyper-connected world driven by the Internet of Things (IoT). The question is how to continually supply electricity to the countless electronic devices connected to the system.

What is believed to provide a fundamental solution to this problem is the triboelectric generator. It generates energy in a semi-permanent manner by inducing triboelectricity from contact between different materials, just as how static electricity is produced in everyday life.

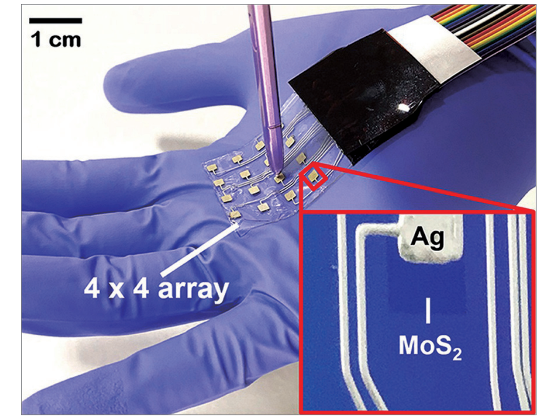
Dr. Seoung-Ki Lee from the KIST Center for Functional Composite Material Research developed a touch sensor that enhances the triboelectrification efficiency by more than 40% by forming crumple structured molybdenum disulfide through a joint study with Chang-Kyu Jeong, Professor of Advanced Materials Engineering at JeonBuk National University.

General triboelectric generators could not be applied to wearable electronic devices since they would become excessively large and heavy if their capacity was raised to generate sufficient electricity. To find a solution, there are studies being carried out that involve applying a two-dimensional semiconductor material that is atomically thin and has excellent physical properties as an active layer in generating triboelectricity.

The intensity of the triboelectricity generated varies according to the type of two materials coming in contact. When it came to the two-dimensional materials used in the past, the transfer of electric charges with the insulating material did not occur smoothly, thus substantially lowering the output of energy produced from triboelectricity.

The joint research team formed by KIST and Jeonbuk National University adjusted the properties of molybdenum disulfide (MoS_2), a two-dimensional semiconductor, and changed its structure to boost the triboelectricity generation efficiency. The material was crumpled during a strong heat treatment process that is applied in a semiconductor manufacturing process, and this resulted in a material with wrinkles to which internal stress has been applied. Due to the wrinkles, which help increase the contact area per unit area, the surface-crumpled MoS_2 device can generate around 40% more power than a flat counterpart. Not only that, the triboelectricity output was maintained at steady levels in a cyclic experiment even after 10,000 repetitions.

By applying the crumpled two-dimensional material developed as above to a touch sensor that can be used in a touchpad or touchscreen display, the joint research team came up with a lightweight and flexible self-powered touch sensor that can be operated without a battery.



Photograph of laser-directed patterned MoS_2-based flexible triboelectric haptic sensor array on a human hand

Seoung-Ki Lee
Senior Researcher
Center for Functional Composite Material Research

Research News. 04

Material/Systems

Development of haptic touch sensor that works by static electricity

See more details at
https://doi.org/10.1016/j.nanoen.2020.105266
"Laser-directed synthesis of strain-induced crumpled MoS_2 structure for enhanced triboelectrification toward haptic sensors"
Nano Energy 2020

Research News. 05

Material/Systems

Semiconductor material analysis made possible with artificial intelligence

See more details at
DOI: 10.1126/sciadv.abb0872
"Magnetic Hamiltonian parameter estimation using deep learning techniques"
Science Advances 2020

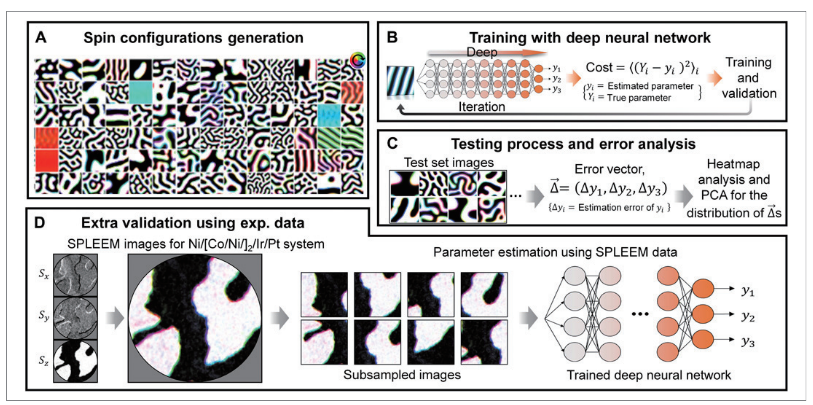
Heeyong Kwon
Post-Doc
Center for Spintronics

Studies on spintronics, which deal with the intrinsic spin of electrons and the field of electronic engineering, are actively conducted to address the limitation of integration level of silicon semiconductors currently in use and to develop ultra-low-power and high-performance next-generation semiconductors. Magnetic materials are one of the most commonly used materials to develop spintronics devices such as magneto-resistive random-access memory (MRAM). Therefore, it is essential to accurately identify various properties of the magnetic materials, such as thermal stability, dynamic behaviors, and the ground state configuration, through the analysis of the magnetic Hamiltonian and its parameters.

Previously, the magnetic Hamiltonian parameters were directly measured through various experiments in order to acquire more accurate and deeper understanding of the properties of magnetic materials, and such processes required extensive amount of time and resources.

To overcome these limitations, researchers in South Korea have developed an artificial intelligence (AI) system that can analyze magnetic systems in an instant. The collaborative research team led by Dr. Heeyong Kwon from the KIST Center for Spintronics and Professor Changyeon Won from Kyung Hee University developed a technique for estimating magnetic Hamiltonian parameters from spin structure images using AI techniques.

They constructed a deep neural network structure and trained it with machine learning algorithms and existing magnetic domain images. As a result, the magnetic Hamiltonian parameters could be estimated in real-time by inputting spin structure images obtained from electron microscope. Further, when compared with the experimentally investigated parameter values, the estimation errors of the AI system were less than 1%, indicating high estimation accuracy. According to the team, the developed AI system is capable of completing material parameter estimation process that previously took up to tens of hours in an instant by using deep learning techniques.



(A) Data generation process showing the sampled spin configurations generated through the simulated annealing process. The color wheel indicates the in-plane magnetization directions, and the grayscale indicates the out-of-plane magnetization directions.
(B and C) The training and testing processes used in this study.
(D) The additional validation process with experimentally observed magnetic domain images.

Dr. Joong Kee Lee of the KIST Center for Energy Storage Research had developed a next-generation secondary battery that uses zinc metal as an electrode without any risk of explosion or fire. This battery is safe enough to be worn on the body and can be manufactured in the form of fiber shape, which means it may potentially be applied as a power source for wearable devices in the future.

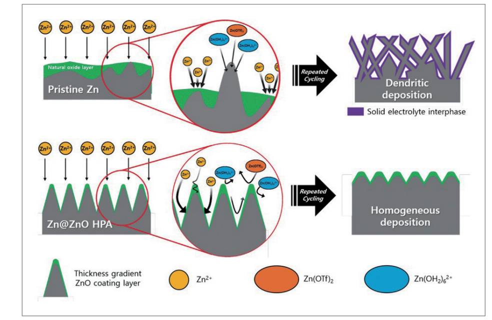
Recently, the demand for safe batteries has been rising dramatically, mainly due to fires occurring in various electronic devices using lithium-ion batteries. The primary cause of such fires is the highly flammable electrolytes, but since Zn-ion secondary batteries use water-based electrolytes, there is no risk of explosion. This is why they are considered one of the more promising candidates to replace Li-ion batteries.

However, zinc anodes, which are the core material of existing Zn-ion batteries, present an inherent problem in that they undergo continuous corrosion in water-based electrolytes. Not only that, when zinc ions are stored on a metal surface, they accumulate as crystals in the form of branches (dendrites) and trigger a short circuit between electrodes, resulting in a sharp decline in efficiency. Various studies have been carried out to come up with a solution to this problem through the means of a zinc metal complex, surface coating, and shape change, for example, but there have been major limitations in relation to processing cost and time.

The team developed a periodic anodizing method, which involves repeatedly permitting and blocking a flow of current on the surface of the metal electrode, thereby successfully controlling the surface coating morphologies and shape pattern array of the zinc oxide film simultaneously.

Using this method, the research team inhibited the generation of dendrites during the electrochemical reaction by forming a functionalized shape in which hexagonal pyramids were arranged on the surface of zinc metal. According to the periodic anodizing method, the zinc oxide covering the upper part of the hexagonal pyramid is thick, whereas it is thin on the sides. The variation in thickness induces the zinc metal to accumulate on the side with a relatively thinner layer of zinc oxide. Dendrites are a problem as they accumulate vertically on the metal surface, but the newly developed technology in question induces the zinc metal film to grow in a horizontal direction on the electrode surface, and it was able to effectively suppress the generation of dendrite. As the zinc oxide film formed on the surface, direct contact with electrolytes was blocked, thereby preventing corrosion and side reaction at the same time.

The Zn-ion secondary battery developed through this study maintained nearly 100% of its capacity over 1,000 cycles, even though it was repeatedly charged and discharged under extreme conditions, attributed to its structural and electrochemical stability.



Schematic illustration of Zn ion deposition behavior on a pristine Zn anode and the Zn@ZnO HPA anode in an aqueous electrolyte

Joong Kee Lee
Principal Researcher
Center for Energy Storage Research

Research News. 06

Energy/Environment

Development of next-generation zinc ion battery without the risk of explosion or fire

See more details at
https://doi.org/10.1002/adfm.202004210
"Functionalized Zn@ZnO Hexagonal Pyramid Array for Dendrite-Free andUltrastable Zinc Metal Anodes"
Advanced Functional Materials 2020

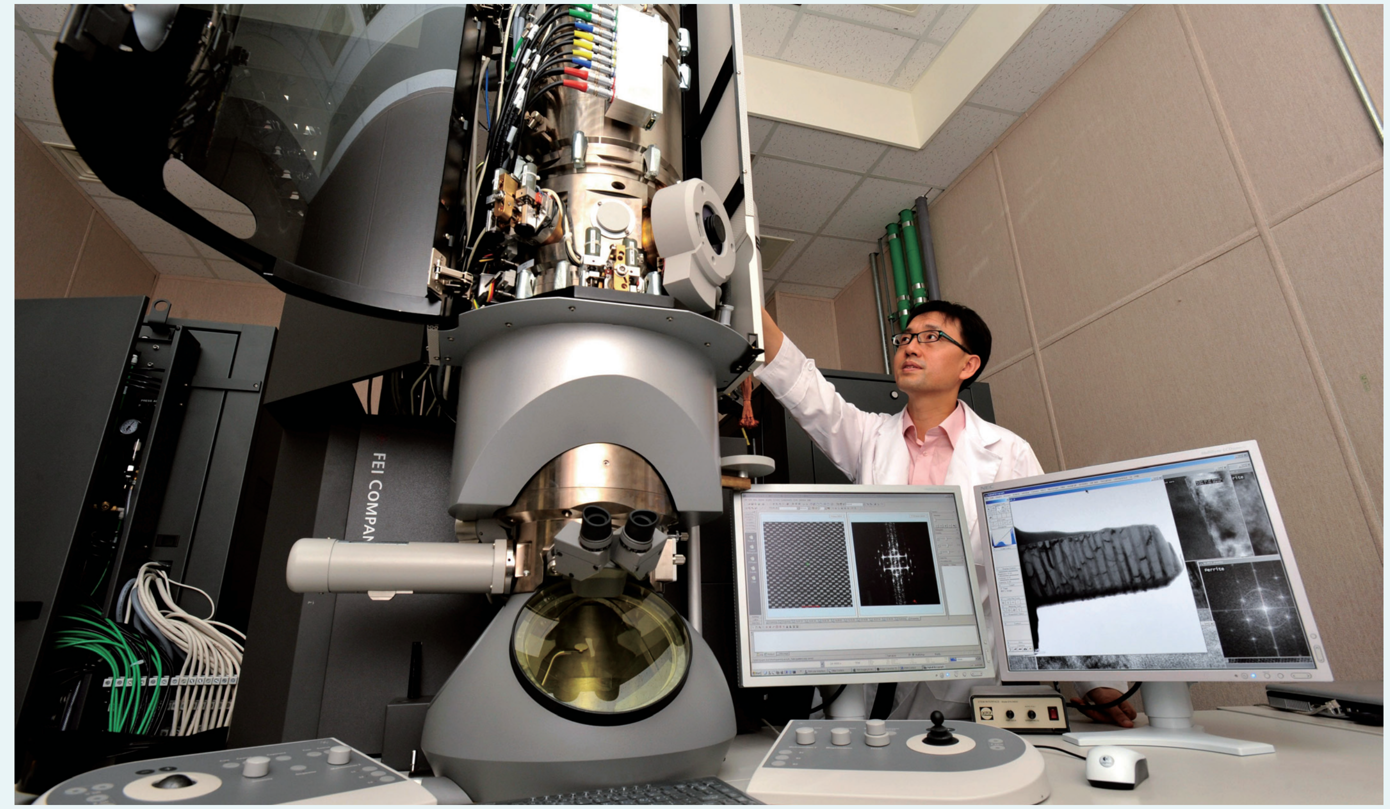
From Professionalism and Connectivity to Creative Support

Dr. Jae-Pyoung Ahn, the long-time Head of the Advanced Analysis Center, was recently appointed Director of the newly founded Research Resources Division, which consists of five centers: the Doping Control Center, Advanced Analysis Center, Technology Support Center, Research Animal Resources Center, and Micro Nano Fab Center. Together, they are responsible for managing KIST's research resources and providing broad support across its 30 centers.

Future Direction of KIST's New Research Resources and Data Support Centers

To synergize the centers which were combined as a result of the organizational restructuring, professionalism must first be established. The centers can synergistically function only when it is comprised of individuals who specialize in their given roles. Thus, maximizing the professionalism of the various experts within the centers should be the highest priority. Next, we must look for a model that maximizes the connectivity between the centers within the division. We will examine how each of these centers are interconnected in handling tasks, and develop successful cases into a representative model. Once professionalism and connectivity are established within and between the centers, the Research Resources and Data Support Centers should ultimately work toward providing "creative support." The process through which a researcher requests an analysis at the centers is analogous to how photographers take pictures. If photographers are asked to simply take pictures, they may do so using expensive cameras and assistive equipment. However, if they are requested to take pictures as artists, they may constantly suggest different poses and use their talents to take more expressive pictures. Like flexible photographers, the Research Resources and Data Support centers must actively make suggestions to researchers. Similar to how clients are unfamiliar with photographic techniques and equipment, researchers, too, do not fully understand how to improve their analyses. If those in charge of analyses do not come up with creative ideas and deliver them, researchers cannot realize their ideas. Ultimately, KIST must provide tailored technical and resource support to its researchers. It has been some time now since R&D began to utilize computers, and this has led to rapid advances in simulations and AI. Now, with enough data, AI makes predictions and interpretations at speeds humans can no longer keep up with. Data-based R&D needs the following. First, a platform that can store research data produced at KIST, along with their structured metadata. Therefore, developing a system to collect data in a structured format that can be utilized by researchers within KIST will be the first step toward data-dirven R&D. We are introducing a system that can convert unstructured R&D data into structured R&D data by upgrading the already developed KiRI note. The second step is an AI model that can discover new concepts within the data. For humans, the more the available data, the longer it takes to understand the data, but this is not true for AI models. It is only a matter of time before AI replaces humans in data analysis. But to develop such models, AI and data experts, as well as researchers, must be deeply involved in designing algorithms.

Dr. Jae Pyoung Ahn, Director of KIST's Research Resources Division



To KIST's Researchers

My wish for the researchers at KIST's Research Resources and Data Support Centers is that every one should become the best in their own fields. Since our centers play a crucial role in KIST becoming a world-renowned research institute, I would like all of you to maintain the professionalism needed to achieve the best performance. I would also like you all to not forget that the Research Resources and Data Support centers boasts the best competencies and technologies within South Korea, and is internationally competitive as well. Many researchers fail to fully utilize the various resources provided by our centers because they are busy, in a hurry, or are unfamiliar with them. While I understand that research cultures are something that cannot change immediately, smoother communication between researchers and resource providers will rapidly increase research productivity. I hope that all of you can engage in greater communication and cooperation in the future.

Once professionalism and connectivity are established within and between the centers, the Research Resources Division should ultimately work toward providing "creative support."

I would like all of you to maintain the professionalism needed to achieve the best performance.

Future Direction for Public Technology Commercialization

Chi Ho Choi
Director-General
HongReung Innotown
Operation Division

The Diffusion of Innovation Theory proposes that the rate of innovation is important in order to have or maintain a competitive advantage in a drastically changing environment. The theory suggests that only innovation leaders who achieve commercialization and efficiency in R&D can lead and survive in the global market. Futurists Alvin and Heidi Toffler explained that accelerating innovations convert an economy of size into an economy of speed in the "New Normal" world. The United Nations has been promoting research and innovative activities to respond to this kind of innovative environment, where only the fastest survive. By forming partnerships with research institutes and industries, the United Nations is attempting to improve the quality of research and innovation in public facilities. China has been steadily promoting important national projects and the growth of new market-oriented R&D facilities for technological development and commercialization via a strategy called "rapid commercialization."

South Korea's technological innovations fail to fully meet the demands of consumers, and have been limited to heavily quantitative assessments, such as papers, patents, and research results that remain within laboratories. What direction must we take to commercialize public technologies?

First, the innovation gap between research communities and industries must be minimized so that newly developed technologies can proceed to the commercialization stage. Currently, approximately 92% of public technologies are transferred to small- and medium-sized companies, which often lack business value or absorptive capacity. Innovative growth through collaboration between industries, universities, and research institutes is reaching its ceiling, demonstrating the limitations of the current linear model of innovation. Instead of pursuing innovation through a relay between industries, universities, and research institutes, an innovation process model should be adopted in which innovation leaders run alongside each other from the early phases of R&D through to commercialization. The three/four helix model accomplishes exactly this. The Organization for Economic Co-operation and Development (OECD) has also proposed the co-creation model, in which innovation leaders cooperate to produce and utilize knowledge to overcome the limitations of existing innovation systems. In its Science and Technology Basic Plan (2020-2050), Japan proposed a policy direction in which the collaboration between academia and industries is shifted to the basic research phase.

Second, to establish an ecosystem for technological commercialization, more incentives should be given to industries utilizing technologies from external sources, rather than those developing their own technologies. The closed corporate culture – resulting in a greater rate of technological development within a corporation than the rate of using technologies from external sources – as well as the reduced funds for industry-academia collaborative research provided to universities and public research institutes, only promotes closed innovation. South Korea's tax policies,

Also, with the current assessment system centered around papers and patents, it is not easy to validate and demonstrate technologies.

which favor industries that develop their own technologies rather than those that use technologies from external sources, are also contributing to this closed innovation. It is necessary to drastically expand the tax benefits for industries using technologies from external sources, and expand the range of special taxation cases to include all industries.

Also, with the current assessment system centered around papers and patents, it is not easy to validate and demonstrate technologies. Policies that grant additional weightage and royalties to technological validation and demonstration should be implemented.

Tuula Teeri, the President of Finnish Aalto University, visited South Korea in 2016, and said, "We must move beyond the idea of transferring technologies and knowledge, which are the results of R&D, to industries, and seek ways for scientists and industries to learn and obtain knowledge alongside each other," suggesting a clear shift in direction toward public R&D commercialization, which remains an unresolved issue today.

KIST & Jeonbuk National University Sign Agreement on Academia-Research Institute Teaching System

KIST announced on November 30th that it has signed an agreement with Jeonbuk National University (President: Dr. Dong-Won Kim) to "operate the KIST-Jeonbuk National University academia-research institute teaching system and to cooperate on research convergence." This agreement is the first case in which a government-funded research institute and national university have agreed to share professors and teaching systems. In attendance for the opening ceremony were Dr. Seok-Jin Yoon, President of KIST, Dr. Jin-Sang Kim, Director General of the KIST Jeonbuk Institute of Advanced Composite Materials, and Dr. Dong-Won Kim, President of Jeonbuk National University.

Under the Promotion of Industrial Education and Industry-Academic Cooperation Act, the system was designed to promote joint research and education between government-funded research institutes and universities. The renowned professors and researchers who were selected to serve as academic professors will carry out convergence research and nurture future researchers under the governance of both institutes.

According to the agreement, KIST and Jeonbuk National University will grant authority as both researcher and professor to principal research personnel in fields where they mutually specialize. Students taking part in this program will have the opportunity to take both university lectures and educational courses at research institutes, while also receiving scholarship benefits. Furthermore, KIST is planning to carry out joint research focusing on the field of 'complex materials' under the direction of the KIST Jeonbuk Institute of Advanced Composite Materials.

Research personnel participating in the teaching system will conduct national research projects in the complex materials field while offer guidance to student research personnel. Excellent researchers trained through this system will have the chance to take up roles in the carbon fusion and materials industry, the main industry of the Jeonbuk area in Korea, which will have a virtuous circle effect on the region.

Start-Ups Launching with Government-Funded Research Institutes' Original Technologies

KIST announced that it has established three technology investment companies: Txinno BioScience (CEO: Mr. Chan Sun Park), Biosonics (CEO: Mr. Kyung-sik Shin), and Medicaretec (CEO: Mr. Eun-yong Jeon) as a result of the Ministry of Science and ICT's "Biostar Project," a national research project created to encourage the launch of start-ups. It is meaningful that these three preliminary start-up teams, established with assistance from private investment institutions, have been able to create steadily evolving start-up technologies and other items, owing to the support of the public, prospective entrepreneurs, and private experts.

To achieve such results, KIST hired outside experts familiar with the bio industry as researchers during the business phase of the Ministry of Science and ICT's Biostar Project's implementation, and established an infrastructure to focus on start-up activities. In terms of R&D, researcher matching and spaces for conducting research as well as offices and research facilities were provided. Regarding the provision of equipment and commercialization, the companies received two-track support for patent portfolio establishment, start-up team building, business and investment planning, marketing strategies, and trademark application and registration.

CEO of Txinno, Mr. Chan Sun Park, who had been selected as an outside expert for the project, has developed anti-cancer drugs with Dr. Seojung Han of the Chemical Kinomics Research Center at KIST. Dr. Ji-Yoon Kang of Biosonix developed an early diagnosis kit for Alzheimer's with Dr. Chun-woo Kim of KIST's Center for Healthcare Robotics. At the same time, as a result of support for commercialization activities which includes putting together a portfolio of start-ups, building start-up teams, and organizing business plans and investment attraction strategies, the three start-ups were able to successfully acquire a KRW 33 billion investment from the Hongneung Innopolis Fund, the first fund to specialize in S&T start-ups. Operated by K-Ground Ventures, the fund is a joint venture by KIST, universities in the Hongneung area, SMEs, and the local government.

In addition, KIST has set several other goals, including improving the system, fostering direct commercialization through cooperation with private experts, and increasing performance from a long-term perspective. ImagoWorks, established on November 19, attracted KRW 3.6 billion in Series A investments from top-tier domestic investment institutions. This attempt at direct commercialization can be seen as a shift in paradigms from the existing technology transfer method (one-off, supplier-centered) to one in which contributors, start-ups, and private investment institutions together share the responsibility for corporate growth.

KIST is also pushing to establish an ecosystem for start-ups. Plans include internships for start-up education and audition-style start-up competition screenings by investment institutions, mentor matching for preliminary start-up teams to prepare for the launch of a start-up academy, which will support investment in start-up companies, marketing activities, and start-up support projects.

KIST Celebrates Its 55th Anniversary

The Korea Institute of Science and Technology (KIST) held its 55th anniversary ceremony at its headquarters in Seongbuk-gu, Seoul, at 11 a.m. on February 9, 2021 (Tuesday).

The President of KIST, Dr. Seok Jin Yoon, stated that "now is the time, when the world is changing, that the role of Science and Technology in preparing for the future of Korea is needed more than ever." He also mentioned that "I hope everyone will join us in pursuing challenging research goals that can change the world, innovating research methods, and making KIST into a research institute that will bring the future to today."

For this year's anniversary, Dr. Kiyoung Choi, the Minister of the Korean Ministry of Science and ICT, said in a congratulatory video message that "we will strengthen our basic capabilities to overcome national challenges and prepare for an uncertain future." Dr. Hyesook Lim, the newly appointed chair of the National Research Council of Science and Technology (NST) stated in a congratulatory speech that "we will create a better environment for KIST to be able to conduct challenging and innovative research."

In addition, Mr. Seounglae Jo, member of the National Assembly from the Democratic Party of Korea, Mr. Sungjoong Park from the People Power Party, Mr. Robert Rapson, Charg? d'Affaires ad interim of the U.S. Embassy & Consulate in the Republic of Korea, H.E. Nguyen Vu Tung, Ambassador of the Embassy of the Socialist Republic of Vietnam in the Republic of Korea, and Dr. Ho Gun Park, Chair of the KIST Yeonwoo Membership, via congratulatory video message, encouraged S&T researchers to strive to fulfill their expectations and roles in the face of the difficulties brought on by COVID-19.

Prior to the ceremony, the "Declaration of the Charter of Ethics" and "GRaND KIST Golden Bell" events were held. For the "Declaration of the Charter of Ethics", KIST researchers and administrative staff made five pledges to be implemented as part of efforts to recognize KIST's legitimacy as a national research institute which is trusted by the public that prioritizes ethical management and national and social responsibility. "GRaND KIST Golden Bell" was a quiz contest where 55 KIST members competed to celebrate the Institute's 55th anniversary and share KIST's history and vision.

Since its establishment in 1966, KIST has pursued research for the development of the nation's science and technology fields, and has strived to adapt itself to be a think tank for national industrialization, a follower of advanced technologies, and a pioneer of original technologies.

In compliance with the COVID-19 quarantine rules, the anniversary event was held via video conference and live online broadcast.

Protecting Civilians' Safety with Science and Technology

Korean science and technology research institutes and the Korean National Police Agency have come together to cooperate on creating a safer society. The Korea Institute of Science and Technology established the Science and Security Promotion Center as a non-profit foundation under the Korean National Police Agency (Mr. Chang Yong Kim, Commissioner General) and held a signboard-hanging ceremony at KIST's headquarters in Seongbuk-gu, Seoul.

The signboard ceremony is an important event formalizing the launch of the Science and Security Promotion Center (hereinafter referred to as the 'Center'), which will serve as the hub for scientific security promotion and innovation of the security industry. Today's ceremony symbolizes the Center's efforts to begin full-fledged work to revitalize scientific security with the vision of establishing a nationally safe society and creating an innovative, global role model for scientific security.

In November 2020, the Korean National Police Agency accelerated the establishment of the Center by signing a memorandum of understanding (MOU) with KIST to "advance science-based public security services and strengthen security capabilities." Since that time, KIST, which is well-known for being Korea's first comprehensive research institute, has been continuing to pursue cooperation with the agency through a security-focused research and development team (hereinafter referred to as the "Police Lab"). KIST has been actively involved in the establishment of the Center to provide support for the operation of national strategies and the establishment of an ecosystem for the scientific security industry.

Under the direction of its founding President, Dr. Kuiwon Choi, the Center is focused on strengthening global security competitiveness through playing a role as a think-tank in the scientific security field by offering S&T support at the security site; planning security-specific R&D projects; creating a safety industry ecosystem for improving global security competitiveness; and organizing a scientific security cooperative network that can operate at all times. Later, the Center plans to support the establishment of scientific security strategies and the operation of "Police Lab 2.0," jointly promoted by the Ministry of Trade, Industry and Energy, the Ministry of Science and ICT, the Ministry of Land, Infrastructure and Transport, and the Korean National Police Agency.

The founding President, Dr. Kuiwon Choi, made an announcement regarding the progress of the establishment of the Center and the operation plan, which states that the Center will especially focus on actively pursuing R&D in the field of scientific security to deal with crimes that have become more diversified and sophisticated. It the announcement, he also stated that the Center will focus on supporting businesses specializing in the rapidly growing security-based R&D sector and promoting the spread of its successful performance. Lastly, the announcement mentions that efforts will be put in all directions toward developing mid- and long-term scientific security strategies for preemptively responding to society's needs in the future.

Hongneung Innopolis, an Initiation into an Innovative Cluster

The Hongneung area was designated as "Hongneung Innopolis" in July 2020. As Seoul's first special R&D zone, various projects with the goal of developing the area into a global start-up cluster have been organized. Among them, the Korea Institute of Science and Technology and 11 investors gathered to hold an investment agreement ceremony on April 19 for the launch of GRAND-K, a start-up school.

The 11 institutions taking part in the agreement are The Wells Investment, Samho Green Investment, SEMA Investment, SparkLabs, ID Ventures, Aju IB Investment, The Yozma Group Korea, Infobank, K-Ground Ventures, K-Ground Partners, Plan.H Ventures. The Hongneung Innopolis Business Center and Korea Techno-Venture Foundation will also provide support.

The start-up school aims to boost the capabilities of the start-up teams at Hongneung Innopolis by providing common start-up education programs to prospective and early start-ups (those launched within the first three years) in the zone.

The audition-style start-up competition is a competitive program with a total of four rounds, with venture capitals (VC) and accelerators (AC) which will be investing in start-ups for the zone participating as judges to conduct consulting on each round's topics. The start-up team that wins the final round will be connected with investment ventures will serve as mentors. In addition, the winning team will receive other benefits, such as the opportunity to move into the Innopolis, access to Innopolis projects and marketing activities, and the opportunity to establish research labs.

Dr. Seok-Jin Yoon, President of KIST, said, "KIST, Kyung Hee University and Korea University, the key technology institutions involved in Hongneung Innopolis, will cooperate to create qualified jobs and develop themselves as role models for the nation's future industries."

Furthermore, Hongneung Innopolis is preparing to move forward with becoming a global start-up cluster along the lines of London Tech City and the clusters in Boston and San Francisco, by establishing a university-research institute convergence ecosystem for start-ups. The announcement for participation in the start-up school can be found on the websites for KIST, Kyung Hee University, and Korea University. Partners for the R&D zone hope to see many promising start-up teams pass the requirements to participate and actively take part in the competition.

Introducing KIST's New Members

Hyejeong Seong
Creative Research Center for Brain Science

Major
Chemical Engineering

Research Interests
Polymers, Nanostructure Fabrication, Bioelectronics

Life Sentence
Connecting the dots brings the big picture.

Deok-Hwang Kwon
Center for Energy Materials Research

Major
Materials Science

Research Interests
Rechargeable Batteries, Oxide Electronics, and Fuel Cells

Life Sentence
We can build a bright future together!

Hyeonjun Baek
Center for Quantum Information

Major
Condensed matter physics

Research Interests
2D Material, Quantum Light Source, Quantum Simulator

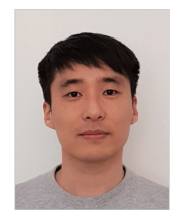
Life Sentence
I judge, decide, and take responsibility.

Seungwoo Jeon
Center for Quantum Information

Major
Electrical Engineering

Research Interests
Nanostructure Fabrication, Quantum Computing Hardware, Applications for Diamonds

Life Sentence
Seeing is believing.



Yisoo Lee
Center for Intelligent & Interactive Robotics

Major
Robotics

Research Interests
Robot Control, Humanoid Robots, Robot Dynamics

Life Sentence
Let's make robots for a better tomorrow!

Juyoun Park
Artificial Intelligence and Robotics Institute

Major
Electrical Engineering

Research Interests
Artificial Intelligence for Robots, Machine Learning, Visual Intelligence

Life Sentence
Engineers create the world that never has been.

Hyungjoo Jung
Artificial Intelligence and Robotics Institute

Major
Electrical & Electronic Engineering

Research Interests
Image Processing, Computer Vision, Machine Learning

Life Sentence
By doubting we come at the truth.

Soomin Kim
Artificial Intelligence and Robotics Institute

Major
Computer Vision

Research Interests
Image Restoration, Image Enhancement, Deep Learning

Life Sentence
If you never push yourself beyond your comfort zone, you will never improve.

Hojun Kim
Biomaterials
Research Center

Major
Materials Science and Engineering

Research Interests
Exosome Transport, Transdermal Delivery, Lipid Self-Assembly

Life Sentence
Live the life you love.

Ji-Hoon Kim
Molecular Recognition
Research Centerrrr

Major
Biology

Research Interests
Stem Cells, Aging, Organoids, Genetics

Life Sentence
I am not afraid of tomorrow, for I have seen yesterday and I love today! Welcome, the tomorrow's KIST.

Seungwon Jung
Molecular Recognition
Research Center

Major
Mechanical Engineering

Research Interests
Microfluidics, Molecular Diagnostics, Single Cell Sequencing

Life Sentence
Luck is what happens when preparation meets opportunity.

Yeonjin Ko
Chemical Kinomics
Research Center

Major
Chemistry

Research Interests
Drug Development, Protein-Protein Interaction, Chemical Biology

Life Sentence
Be a positive influence.

Gun-hee Moon
Extreme Materials
Research Center

Major
Energy & Environmental Catalysis

Research Interests
Photocatalysis, Electrocatalysis, Carbon Materials

Life Sentence
Today, which was proved to be fruitless. is the day that the dead in the past was longing for.

Juyoung Ham
Strategic Planning Team

Major
Materials Science and Engineering

Research Interests
S&T Policy, R&D Management, Energy

Life Sentence
Advancing Science and Technology, Serving Society.E

Sang Kyu Park
Functional Composite
Materials Research Center

Major
Materials Science and Engineering

Research Interests
Flexible Organic Electronics, Printing Electronics, Martensitic Transitions

Life Sentence
Sweet after bitter.

Hyungbum Park
Functional Composite
Materials Research Center

Major
Mechanical Engineering

Research Interests
Multiscale Simulations, Computational Mechanics, Data-Driven Mechanics

Life Sentence
Seize the day, keep trying.

Looking Forward to Working Together

Recruitment

KIST is looking to recruit creative and passionate research talent both in Korea and from abroad to continue our journey to preeminence in global research.

- **How to Apply**
  Please refer to the details at the below websites
  http://www.kist.re.kr
  http://onest-kist.saramin.co.kr

Institutes and Research Areas

Brain Science Institute

- Examining brain functions and causes of disease; utilizing mapping of functional-structural connections in neural circuits
- Computational neuroscience
- Neural stem cell applications
- Microsensors, MEMS, Brain Engineering and Microsystems
- Brain Disease/Neurochemical Imaging and Therapeutics

Clean Energy Institute

- Materials and systems technology for hydride/fuel cells
- Hydrogen storage material and module technology
- Solid state electrochemical thin film process and engineering technology
- Synthesis of advanced secondary cell liquid electrolytes, separators, battery engineering and production, electrode material technology

Post-Silicon Semiconductor Institute

- Quantum Computing, Quantum Communication, Quantum Information Theory
- High speed electronic devices/nonlinear photoelectric devices, optical data control/analysis/design
- Spin device using nano spin dynamics and spin trajectory
- Neuromorphic semiconducting material/devices/system

Artificial Intelligence and Robotics Institute

- Technology and system technology for intelligent robots (control/recognition/human robot interaction, etc.)
- Atmospheric environmental science related to fine dust
- Medical robot system technology
- 2D/3D video and media technology
- AI core technology

Bio & Medical Research Division

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

Advanced Materials Research Division

- Photonics materials and devices for optical control
- Biomarker detection technology based on omics and antibody engineering
- Cancer immunotherapy and medicinal chemistry
- Materials with extreme physical properties and for extreme environments(energy, environment, structure)
- Multiscale organic-inorganic hybrid catalyst active materials

National Agenda Research Division

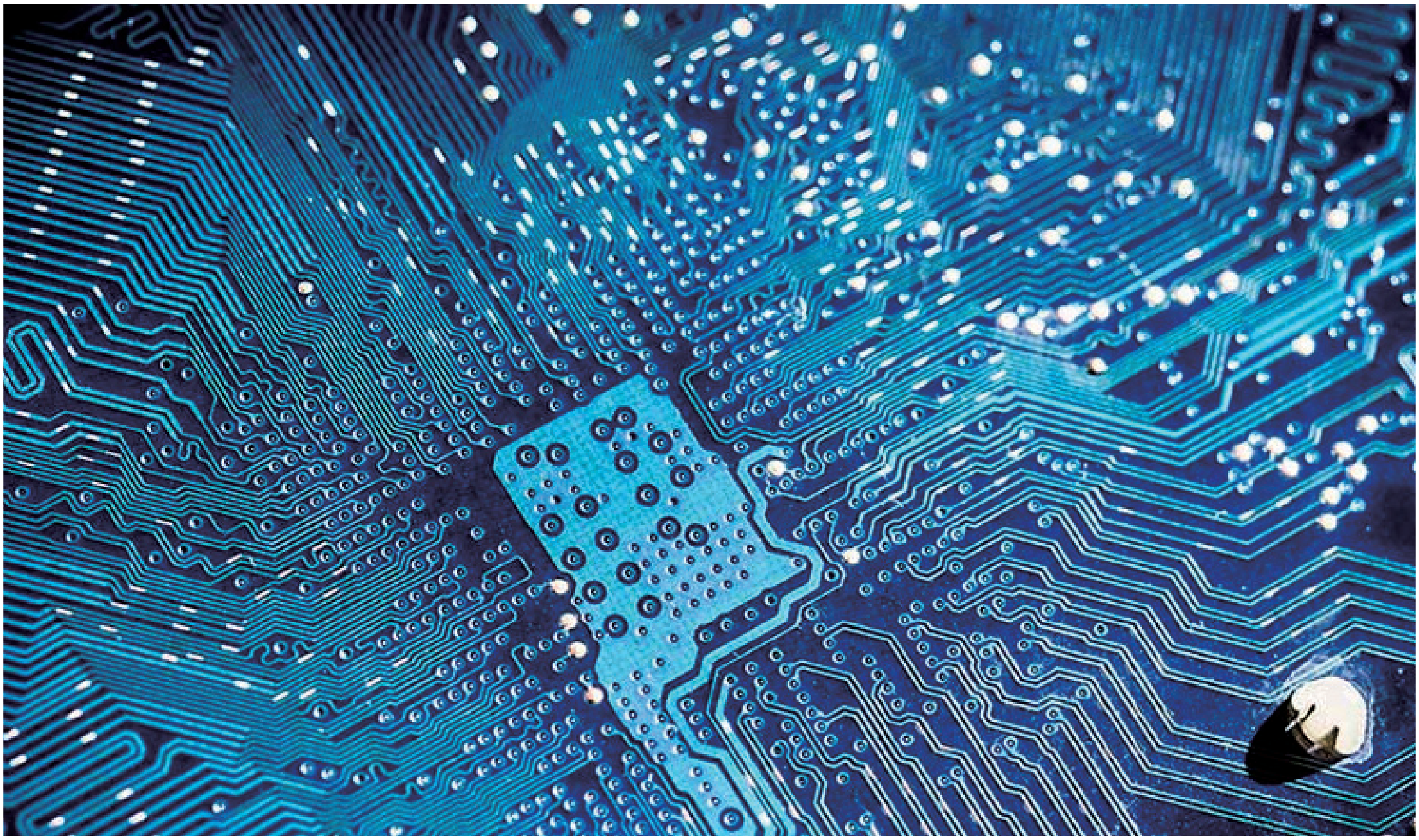
- Water resource management
- Organic/inorganic solar cells, flexible thermoelectrics, wearable energy conversion/storage materials
- Optical & electrical sensing platform technologies
- CO2 conversion using solar energy, biomass conversion, natural gas conversion
- Detection and control of hazardous environmental pollutants

KIST Gangneung* (*Must be able to work in Gangneung)

- Identifying and verifying the efficacy and mechanism of natural substances based on omics data
- Bioinformatics for the application of precision medicine to natural materials
- Analysis of changes in the signal transduction system in vivo induced by natural products (mRNA/protein)
- Smart Farm AI Control and Modeling

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

- High temperature carbon composite material manufacturing technology
- Synthesis and mechanical molding/physical analysis of thermoplastic/thermosetting polymer resins
- Polymer synthesis and analysis
- Multi-scale modeling of structural composite materials



Driving technology development in the Fourth Industrial Revolution through new semiconductor materials & devices

Post-Silicon Semiconductor Institute

Research Organizations

- Center for Spintronics
- Center for Quantum Information
- Center for Opto-Electronic Materials and Devices
- Center for Neuromorphic Engineering

Since the onset of the Fourth Industrial Revolution, the need for a paradigm shift in intelligent semiconductor technology has become all the more apparent. As part of Korea's efforts to establish an industry that promotes the enhancement of our national infrastructure, the Post-Silicon Semiconductor Institute is now looking beyond the era of research aimed at miniaturizing semiconductor devices and seeks to develop new, intelligent semiconductors for computing purposes. From high-performance neuromorphic chips, brain-based artificial neural networks, massive quantum computing, and crypto-communication to spintronics technology and high-speed photoelectric devices, our institute will continue to play a central role among industry members, academia, and researchers in the Korean semiconductor R&D ecosystem and lead the creation of fundamental semiconductor technologies.

KIST
Korea Institute of Science and Technology