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Washable E-Textiles Make Possible an Era of Smart Apparel

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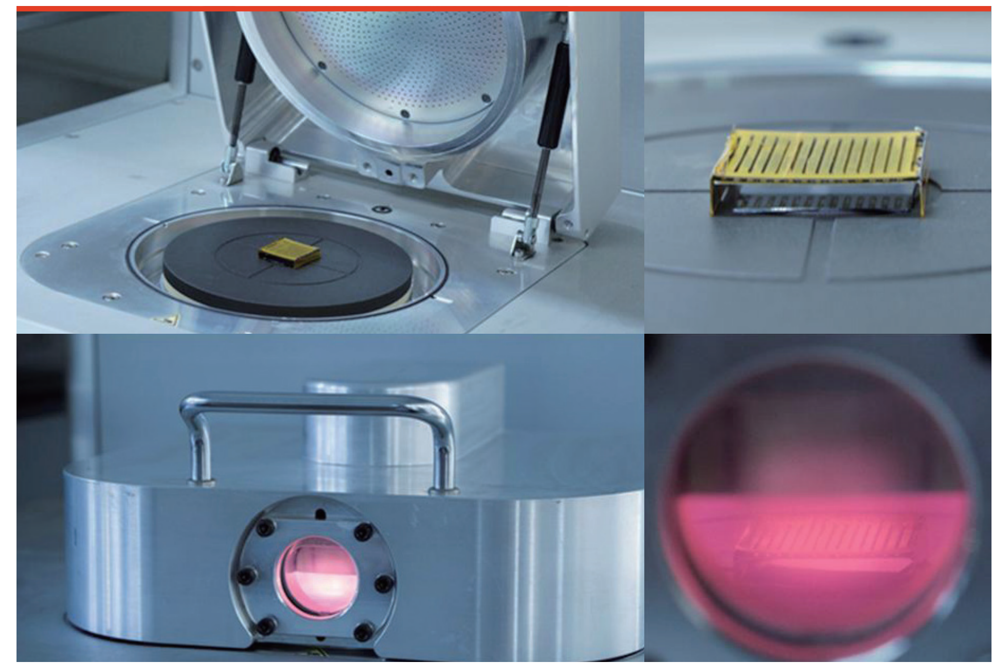
Cover Story

Dr. Jung Ah Lim (KIST, Center for Opto-Electronic Materials and Devices) has succeeded in developing a conductive fibrous transistor

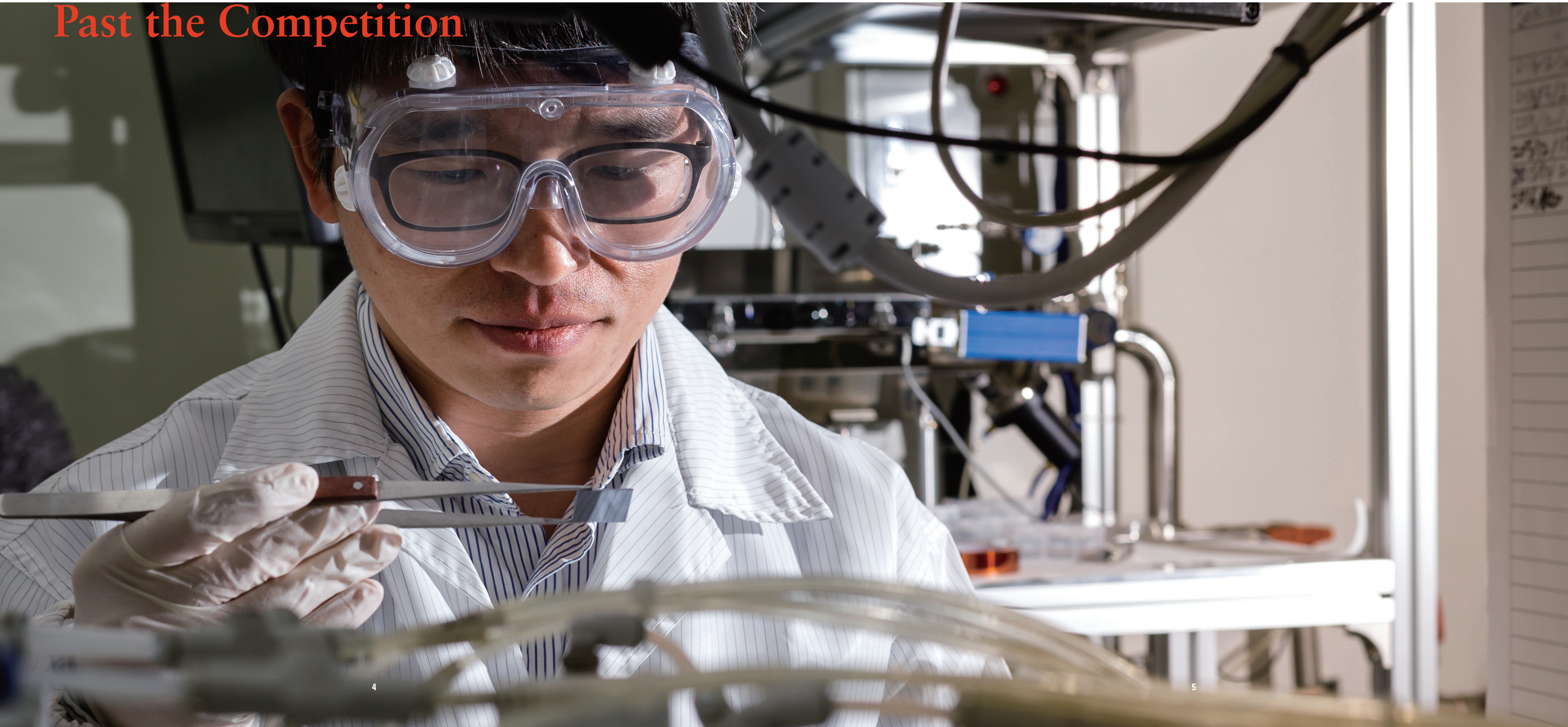
Universal Perpendicular Orientation of Block Copolymer Microdomains Using a Filtered Plasma



Here, we introduce a generalized method for creating perpendicular orientations by filtered plasma treatment of the BCP films. By cross-linking the surface of disordered BCP films using only physical collisions of neutral species without ion bombardment or UV irradiation, neutral layers consistent with the BCP volume fraction are produced that promote the perpendicular orientations. This method works with BCPs of various types, volume fractions, and molecular weights individually at the top and bottom interfaces, so it was applied to orientation-controlled 3D multilayer structures and DSA processes for sub-10 nm line-spacing patterns.

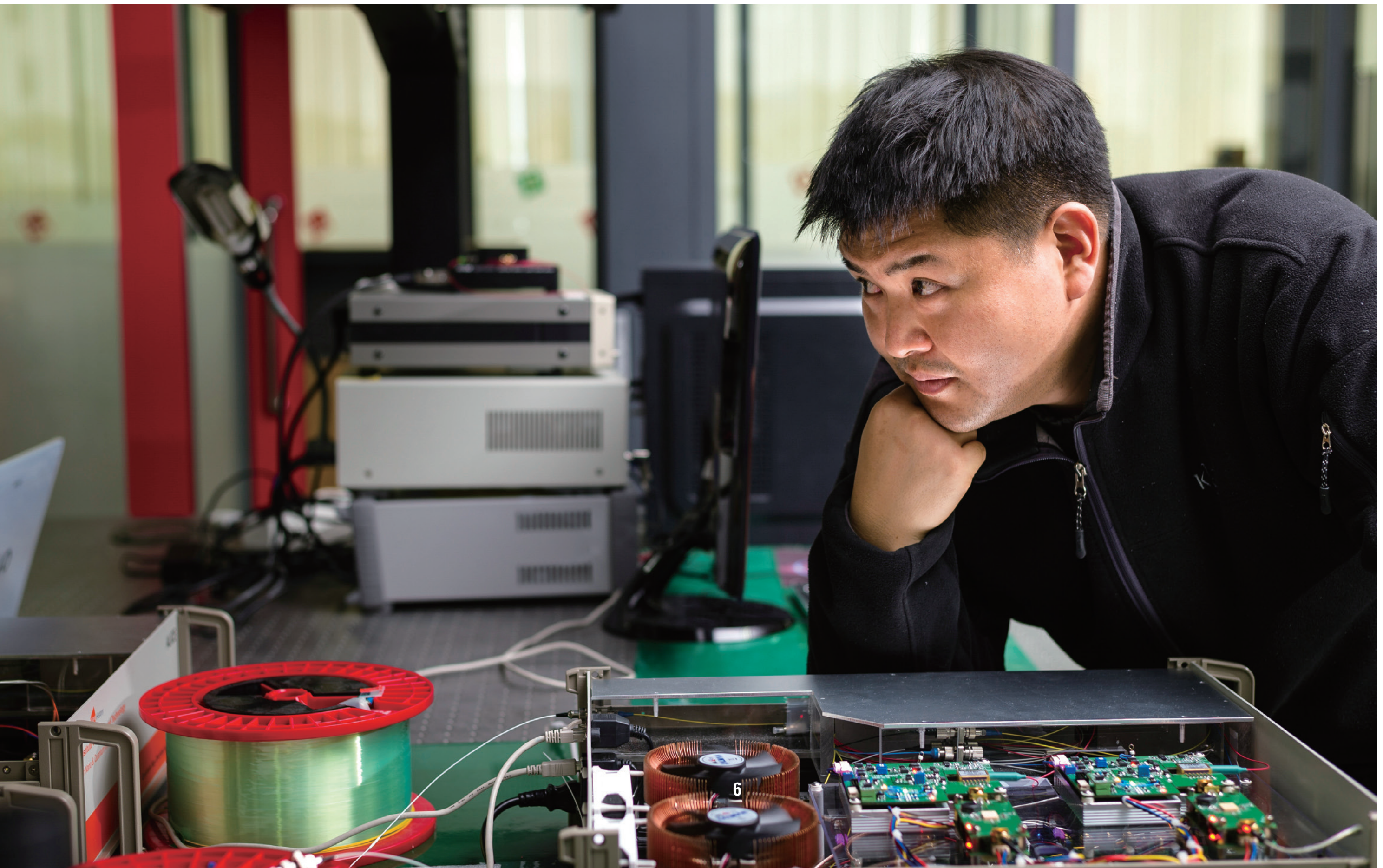
See more details on
https://doi.org/10.1038/s41467-019-10907-5

KIST's Post-Silicon Semiconductor Institute is Poised to Lead South Korea Past the Competition



Technological developments in the semiconductor industry spearheaded the advancement of smart devices.
New semiconductor technologies must now be developed to further improve performance.

The Korean semiconductor industry is a business sector of such great interest and promise that the fourth Thursday of every October has been designated "Semiconductor Day" in commemoration of October 1994 when Korea's semiconductor exports first broke the USD 10 billion mark. Korea first began exporting semiconductors to the United States in 1970. Since then, growth of these exports has been exponential, reaching USD 50 billion in 2010. As a result of the strategic promotion of the Korean semiconductor industry, semiconductors became the number one export item in terms of volume for the first time in 1990 and comprised 10.9% of total exports in 2014. In 2003 the industry was designated a next-generation growth engine forecasted to bring about GDP growth of USD 20,000 per capita. Thanks to outstanding technical skill and commitment, the country has now captured roughly 60 percent of the global memory market, clearly fulfilling the promise of making the industry a cutting-edge national growth engine.

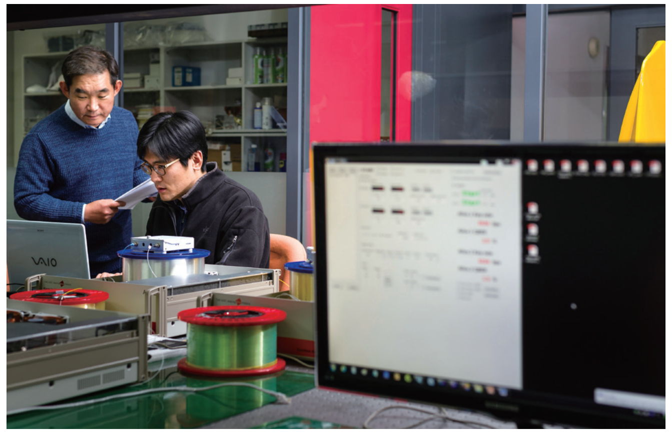


The smart devices built with this technology have now become an integral part of our daily lives. The development of IoT, smart grids, and smart cities has been made possible largely by the increased level of density and efficiency of semiconductors. Technological developments in the semiconductor industry spearheaded the advancement of smart devices, which in turn, required increased density and performance of semiconductors. However, it seems that further performance advancements related to increased density of semiconductor devices will not be feasible because a fundamental size limitation in the production of silicon-based transistors (already at around 10 nanometers) will soon be reached.

Countries around the world have started devising new methods for developing semiconductors to overcome this limitation. The U.S. holds over half the market share for the global semiconductor industry and continues to strengthen its presence through targeted investment and technical improvements while raising barriers to market entry with patented technology. Despite being a latecomer to the market, China has also continued its push to find ways to make technological improvements, backed by heavy government R&D support.

The Korean government needs to follow suit and establish an R&D strategy aimed at maintaining the country's global competitiveness in the semiconductor industry by fueling continuous investment in R&D and promoting joint research among businesses and research institutions for the development of innovative technology. KIST, a government-funded institute, established a mid-to-long term strategy for next-generation semiconductor development and commenced research in the early 2000s, publishing world-class research on semiconductor spintronics – a particularly promising field – since the late 2000s.

So far, KIST has successfully developed future-oriented semiconductor materials that allow for information exchange via light, a promising key device for optical computers. The institute is also devoted to developing "spin transistors" that run without magnetic materials, "skyrmion" technology that will be the basis for ultra-low electricity spin memory, and much more, in an effort to make a breakthrough and open up a completely new chapter for the semiconductor industry.



Semiconductor R&D geared towards innovation will ultimately be the key to the mid-to-long term rebound of the semiconductor industry and will help strengthen Korea's foothold in the international market. That is why strategic mid-to-long term technological development plans and consistent R&D investment to undergird these plans are required if we are to overcome the challenges faced by Korea's semiconductor industry.

A “glacier funeral” was held in September to commemorate the disappearance of the Pizol glaciers along the Alps. Even as late as 2000, Iceland was home to over 300 glaciers, but over 50 of those glaciers have since melted away.

Tackling Climate Change is Our Responsibility

Dr. Young Sook Yoo. Molecular Recognition Research Center, KIST

The rapid retreat of glaciers gives us a lot to think about. Clearly, the Earth is heating up.

According to the World Meteorological Organization, the highest average temperature years occurred during the most recently recorded four-year period: 2015 through 2018. Temperatures for 2019 will be released in mid-January of 2020. Given that the Earth’s monthly average temperature reached a 140-year high in July of this year, it doesn’t seem likely that 2019 will rank below the top four hottest years.

Global temperature rise has a significant impact not only on the world’s flora and fauna, but also humanity as well. Experts project that 30% of the world’s plant and animal populations will go extinct if global temperature rises two degrees above pre-industrial levels. Low-lying areas in the Arctic are disappearing under water as glaciers retreat and increasing desertification is expected to reduce the area of livable land. Rising sea levels are likely to trigger tsunamis caused by typhoons. We do not feel the immediate effects of climate change. Greenhouse gases are odorless and intangible, but when accumulated, may bring irreversible and catastrophic impacts upon humanity on a scale to rival nuclear bombs.

South Korea is the world’s seventh largest greenhouse gas emitter. Given that it is among the top 20 economic powerhouses of the world, its greenhouse gas emissions are excessive. Greenhouse gas emission levels in South Korea have increased by approximately 10% each year from 1990 to 2010. Although this is a testament to the country’s rapid economic growth, the economy can’t always come first. It’s time to take stock of the environmental sacrifices we are making.

Fortunately, South Korea has been making efforts to voluntarily curb greenhouse gas emissions and in 2008 announced a national “Low Carbon Green Growth” policy. The government declared to cut GHG emissions voluntarily even though it was not a mandatory reduction country under the Kyoto Protocol. South Korea has been spearheading low-carbon activities by chairing the OECD ministerial meeting on the environment that is convened every 3-5 years.

The three pillars underpinning South Korea’s low-carbon policy are GTC (Green Technology Center), GGGI (Global Green Growth Institute), and GCF (Green Climate Fund). These pillars form the so called “green triangle” that powers low-carbon policy efforts.

GTC, established and operated by KIST since 2011, conducts research on policies encouraging the establishment of green technology and promotes collaboration on technology transfer between countries. GGGI supports environmentally sustainable economic development on a global scale and GCF is a fund created to support the efforts of developing countries to reduce greenhouse gas emissions and spur climate action. All three are pivotal for low-carbon policies.

Remarkable progress has been made by the international community as evidenced by the Paris Agreement adopted in 2015 at the UN Climate meeting. Unlike the Kyoto Protocol which limited greenhouse gas reduction obligations to developed countries, the Paris Climate Agreement set a goal to reduce greenhouse gas emissions requiring contributions from all 196 signatories based on each country’s unique situation. Numerous countries, including North Korea, submitted their respective reduction targets with the aim of applying their initiatives after 2020. South Korea plans to reduce its greenhouse gas emission levels by 37%

The next decade or two is our last chance to take meaningful steps for change. If we miss this window of opportunity, we may reach a point of no return.

Responsibility

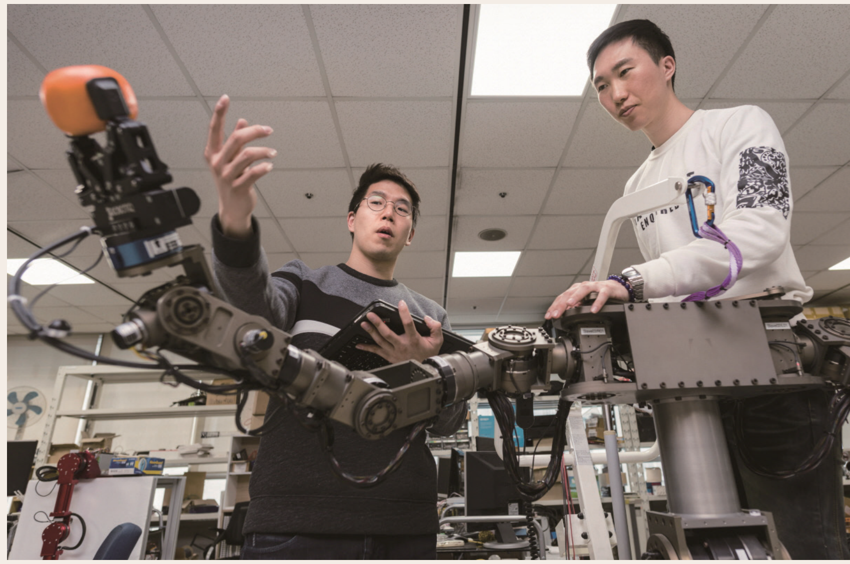
Climate Change

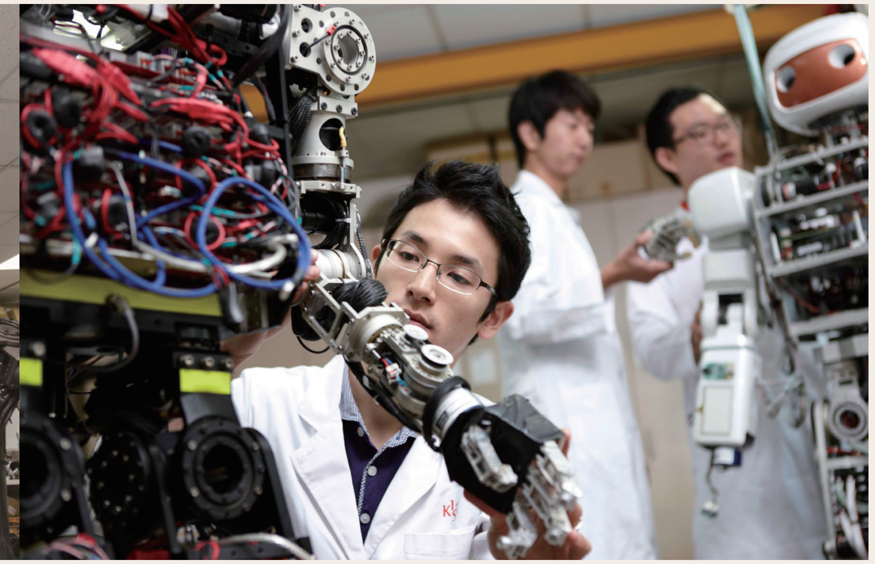
(315 million tons) compared to “business-as-usual” (BAU). Back when the Paris Agreement was adopted, President Obama declared that it would be “the most significant turning point in the history of mankind” and the mood was celebratory. However, the subsequent withdrawal of the U.S. and changing domestic energy policies, among other developments, have made things difficult.

Although it might be an uphill battle, we need to implement our own climate response policies. In that sense, it is high time we fully utilize and supply bio fuels in an effort to curb greenhouse gas emissions. Among the different types of bio fuel currently available, bio-heavy oil used to generate electricity is made from disposed raw materials such as used cooking oil, animal and plant fat and oil, by-products from bio-diesel processes, etc. Approximately 350,000 liters of water are needed to purify just one liter of used cooking oil. This means that we can conserve enough water to fill up 23 Soyang Dams if we use used cooking oil as a bio-heavy oil for fuel. This technology is suitable for Korea, a small country with four distinct seasons. Against this backdrop, I am honored to have been named president of the Bio Fuel Forum that officially launched in June and look forward to working with others on intiatives in this important area.

The next decade or two is our last chance to take meaningful steps for change. If we miss this window of opportunity, we may reach a point of no return. We need to devote all our resources to tackle climate change, keeping in mind that it is our responsibility to preserve planet Earth and build a brighter future for the generations to come.

Timeline of Innovative Robots



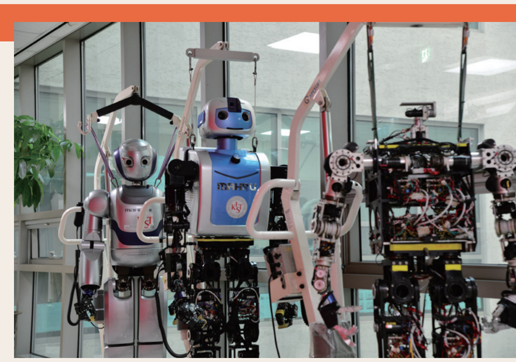


2004 ROBHAZ

Hazardous duty robot for disaster response and military applications

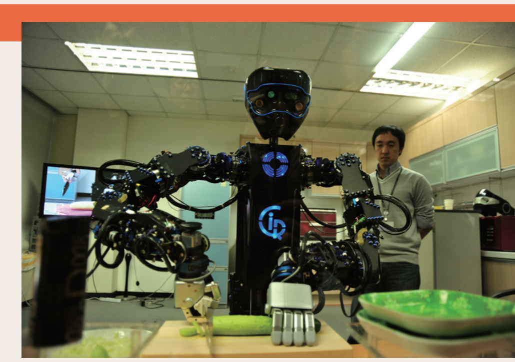
2005 MAHRU&AHRA

World's first network-based biped humanoid robots



2012 CIROS

Cooking robot



2013 Silbot

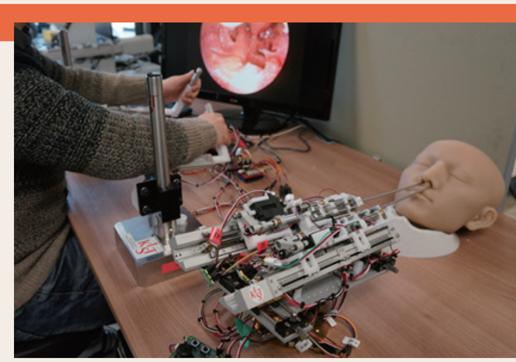
Robot for helping the elderly

2013 KIBO

Humanoid robot

2014

Micro Surgical Robot



2015

Korean Lunar Rover POC (proof of Concept) model

2017

2017 MyBom (A robot care assistant for people with dementia)

Robotic video catheter (3mm diameter) for epidural neuroplasty

Future Wearable Computers to Rely on E-Textiles

Many experts predict that computers will become even more tightly interwoven into our daily lives. In fact, future computing is likely to evolve to the point where devices can be used anytime, anywhere

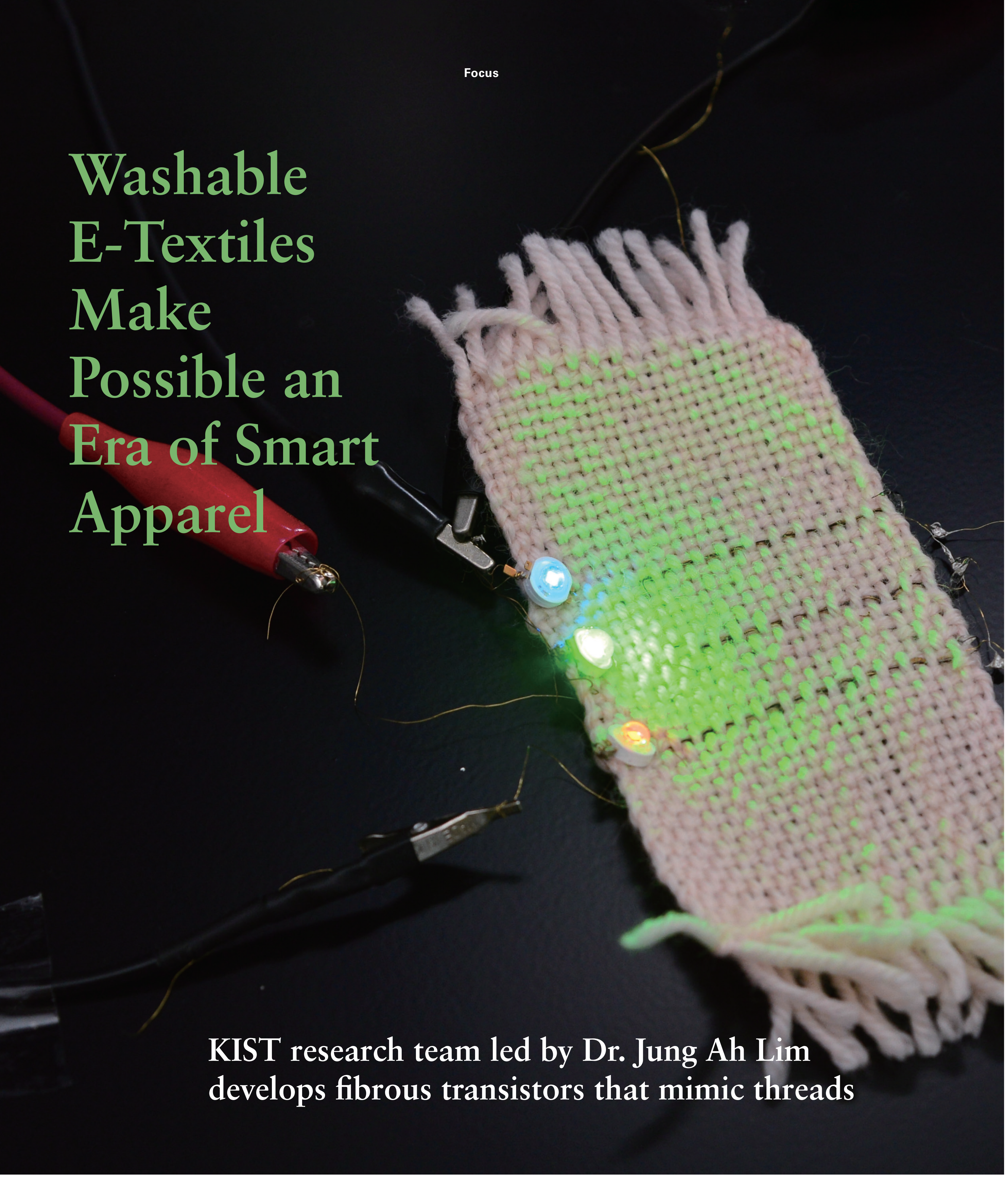
Many experts predict that computers will become even more tightly interwoven into our daily lives. In fact, future computing is likely to evolve to the point where devices can be used anytime, anywhere. One of the ways that electronic devices can take on a greater role in our lives is in the form of wearable devices which can either be attached to the skin or worn on the body. They are expected to gain huge popularity, especially in the healthcare and fitness industries.

Research in e-textiles is vital for the commercialization of wearable devices. E-textiles are conductive fabrics embedded with a digital component such as a battery, LED, or small computer. When sensors are placed inside, e-textiles can recognize the wearer's biometric information, enabling real time monitoring of his or her body. The information gathered, such as heart rate, breathing rate, and body temperature, can be utilized for personalized healthcare.

It is also very likely that these e-textiles will serve military or rescue purposes. In fact, the Ministry of National Defense recently provided soldiers with new combat uniforms that transform the wearer almost into a Darth Vader from Star Wars, complete with a personal protection device, portable computer network, and military power equipment. Artificial muscles and nanotechnology are planned to be integrated to further maximize the uniform's performance.

Also currently being developed are e-textiles that can interact with a body to change color or shape. The idea is to develop a material that changes to fit the wearer via fabric interaction after weaving multiple layers of thin, high-polymer textile. The material will store the wearer's body energy and use the energy to change its visual properties. These self-changing "chameleon" e-textiles will be useful in areas such as creating camouflage military uniforms.

Developing e-textiles requires further research in batteries and energy options for powering these electronic devices. Power-supplying batteries must always be charged for the devices to work when we need them to. Once this challenge is cleared, the field of e-textiles will surely take off, bringing innovative technology advancement and commercialization within our reach.



Washable E-Textiles Make Possible an Era of Smart Apparel

KIST research team led by Dr. Jung Ah Lim develops fibrous transistors that mimic threads

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

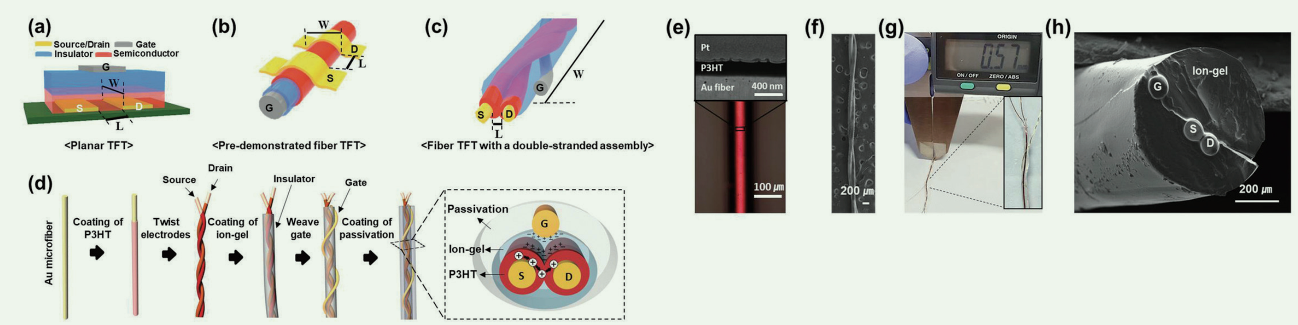
Functional textiles are highly sought-after. These synthetic textiles combine various textures with functionality, changing their fit and unique properties based on the clothing material. In the summer months, people look for functional textiles that absorb sweat and dry quickly, while in the winter season, clothes with thermal insulation are popular. Amid an outpouring of various functional textiles, a KIST research team led by Dr. Jung Ah Lim has succeeded in developing a conductive fibrous transistor that maintains its performance even after being bent over 1,000 times and washed. Its attributes include stretchability and comfort. It is expected to further lead the development of smart garments such as next-generation wearable computers and biosignal monitoring.

"A Japanese firm called after hearing the news about our technology. Businesses, textile researchers and fashion schools seem to show great interest." (Dr. Lim)

Previously, e-textile technology involved the attaching of electronic devices onto a garment. Apparel industry people suggested that while such clothing can be highly functional, it's often uncomfortable and unattractive. Dr. Lim's team's newly developed technology presents an answer to these concerns and reflects a breakthrough in the textile industry.

"We imitated threads just as they were..even controlled the level of electric current."

"I searched a lot for related articles when studying textiles. Yarn itself doesn't stretch, but knitted yarn can stretch diagonally and change into various forms depending on its structure, which I thought was interesting."



↓ Schematic illustration of structures of thin film transistors. a) Planar TFT on a flat substrate, b) pre-demonstrated fibriform TFT based on a conductive fiber, and c) fibrous TFT based on twisted electrode microfibers. d) Schematic illustration of fabrication process of DSA-fiber TFT. e) Cross-sectional SEM image (top) and optical microscopy image (bottom) of P3HT film coated on Au microfiber. f) Top-view SEM image of twisted microfibers with coated P3HT film. g) Photograph of DSA-fiber TFT with a diameter of 0.57 mm. h) Cross-sectional SEM image of the proposed DSA-fiber TFT.

Dr. Lim's team continues to work on various textile-related research. The team collaborated with other research teams and developed a fibrous pressure sensor to create posture correcting cushions and also developed washable and conductive polymer ink that doesn't penetrate into fabric for electrode patterns. In 2016, the team succeeded in developing a fibrous transistor. However, the electric current was too low and the transistor was not washable, which made practical application of the technology difficult.

The team went back to the beginning and decided to develop the device on the basis of a thread shape. Just as a thread consists of several thinner threads twisted into a bundle, the team coated two source and drain electrodes with organic semiconductors and twisted them - just like a thread.

The semiconductors' widths are adjustable depending on how tightly or loosely electrodes are twisted. The width functions as a "road" along which electrons travel. Controlling the width of the road meant that researchers were able to control the number of electron transfers – in other words, electric current - and thus control the brightness of LED. The research team controlled the thread's length and semiconductor's thickness and succeeded in producing electric current 1,000 times higher than that of existing transistors at a low voltage of below –1.3V.

To make the transistor washable, the team went through the process of wrapping and coating the twisted electrodes' surfaces with passivation polymer. The researchers washed the thread with soap and water and folded it up to a size of 7mm after wrapping it with a transistor. Despite this rigorous process, performance was maintained at above 80%.

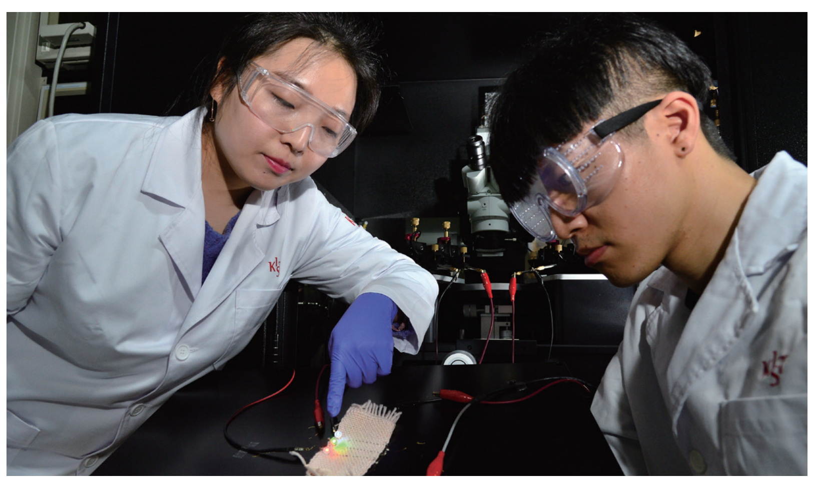
When knit, the newly developed e-textiles were woven naturally with real fabric and showed no problems when twisted. The e-textiles were coated with a transparent color to show how well they were woven into the fabric, but once they are commercialized, the colors can be coated to match the fabric.

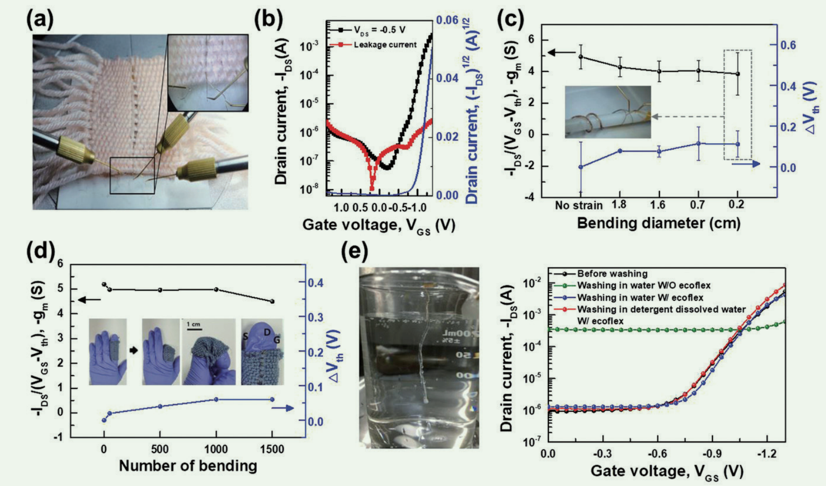
According to Dr. Lim, "Today's success wouldn't have been possible without our 2016 research outcome." She added, "We needed technology that thinly coats organic semiconductors at nanometer thickness. We had developed such technology back in 2016 and were able to proceed with coating as we controlled the thickness of semiconductors on electrodes."

Organic semiconductors and instant coffee have much in common

"Organic semiconductors are like putting in instant coffee mix. You just need to mix organic semiconductor powder with a solvent to create a solution and then apply it. I want to find answers to various possibilities for utilizing organic semiconductors."

↓ Researchers are conducting an experiment to drive LEDs using fiber-type transistors attached to clothes





→ a) Photograph of DSA-fiber TFT based on P3HT-NR film embedded in the textile. b) Transfer (I_{DS}–V_{GS}) characteristics of the textile-embedded device. c) Change in transconductance (left) and the difference in threshold voltage (right) at each bending diameter. Inset shows the photograph of bent DSA-fiber TFT with 0.2 cm diameter. d) Change in transconductance (left) and the difference in threshold voltage (right) versus number of bending cycles at a bending diameter of 7 mm. e) Comparison of transfer (I_{DS}–V_{GS}) characteristics of the DSA-fiber TFT in various conditions: before washing in water with a passivation layer (black), after washing in water without a passivation layer (green), after washing in water (blue) and detergent dissolved in water (red) with a passivation layer.

"Thinly coated electrodes kept tearing when twisted. Because on-off switching is impossible when electrodes come in contact, we focused our attention on improving hardness of the semiconductor thin films." explained Dr. Lim.

In addition, Dr. Lim succeeded in a new challenge of amplifying and measuring ECG signals. She explained, "This was a very interesting experiment. Confirming the capability of amplifying and measuring signals took us a step closer to the application of the technology as a biosignal monitoring device."

OLED is the only example of a commercialized organic semiconductor. The next likely candidate is an organic solar cell, which is currently a heavily researched topic and likely to be commercialized in the not-too-distant future. When asked why she doesn't join the organic solar cell challenge, she answered, "Many researchers are already bringing outstanding results. I believe it will be more rewarding if I find applications for other areas."

According to Dr. Lim, organic semiconductors can be made at a low cost and are thus ripe for commercialization. She recently decided to take on the challenge of solving the static issue, which is one of the hurdles organic semiconductors must overcome to be used in e-textiles.

"The weakest point of electronic devices is static," says Dr. Lim. "Cell phones, laptops, and various other electronic devices have electrostatic discharge (ESD) protection circuits, but relevant research in textiles is close to zero. When it comes to commercialization, a textile's durability is just as important as function. I plan to study ways to improve static durability and take us a step closer to e-textiles."

This research was conducted as an independent research project at KIST and supported by the Mid-Career Research Program from the National Research Foundation of Korea. Research results were published in the latest online edition of *Advanced Materials* (IF: 21.950, JCR top 1.020%), a prestigious international journal for materials research.

Science Fiction to Science Reality: Superhero Suits

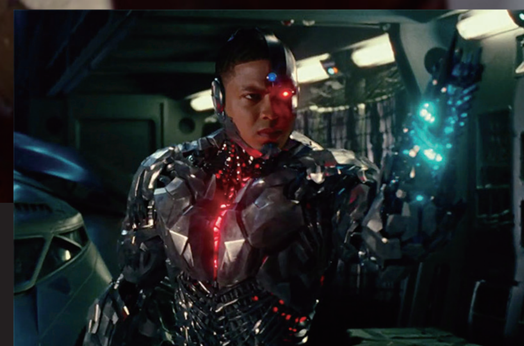


Image Sources
Fox promo materials 20th Century Fox

Protagonists in movies like Iron Man and Batman wear custom suits to fight villains. In Iron Man, Tony Stark wears a metal suit built to withstand extreme impact and fire. Batman also wears a cutting-edge suit equipped with mobility enhancement devices (exoskeleton robotics), hologram HUD (heads-up display), augmented reality, motion recognition, voice recognition, and various sensors and medical devices that monitor biometric data and have healing properties. These superhero suits we see in science fiction movies will soon be available in real life with the development of wearable device technologies.

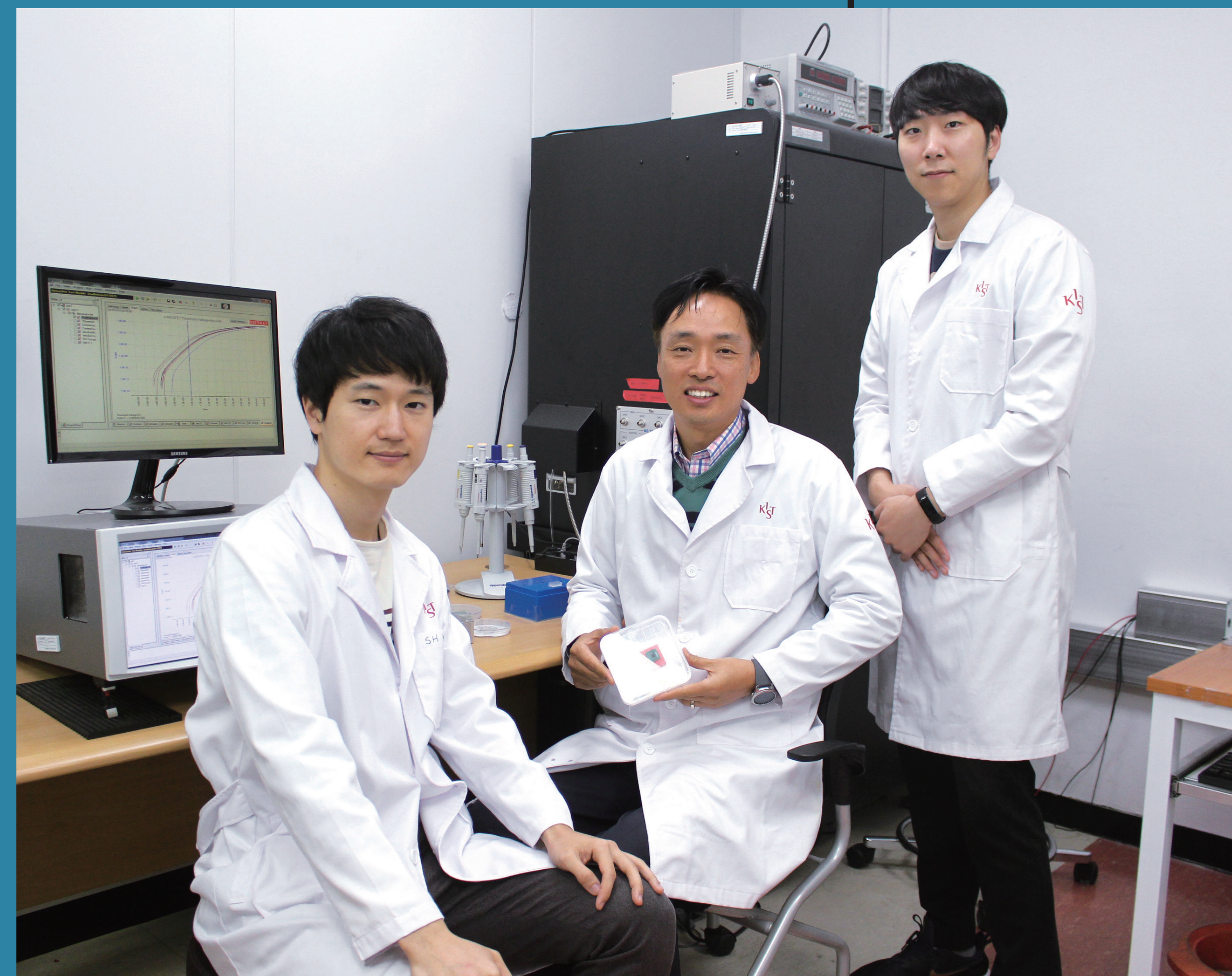
Wearable devices literally refer to electronic devices that can be worn or attached to the body. The smartphones and laptops we carry around with us today will become accessories that we wear like clothing. However, they aren't simply wearable versions of the same technologies; they are next-generation electronics that constantly read and collect information from the changing environment and the human body to provide the user with information and certain skills. These devices can be used for various purposes related to fitness and health, healthcare and medicine, defense, and business.

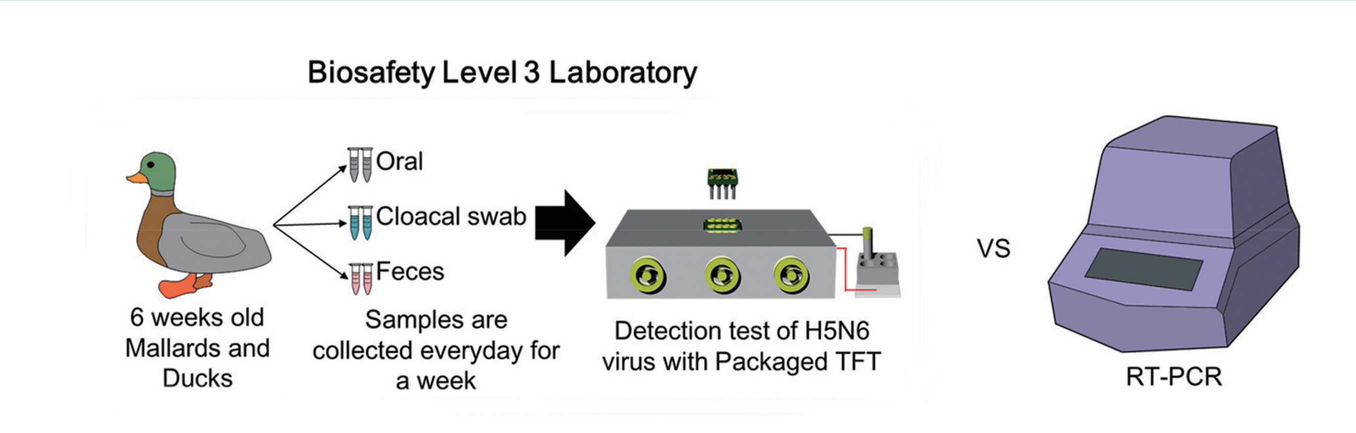
01

Dr. Kwan Hyi Lee and his research team develop a rapid, highly sensitive method to detect avian influenza on-site

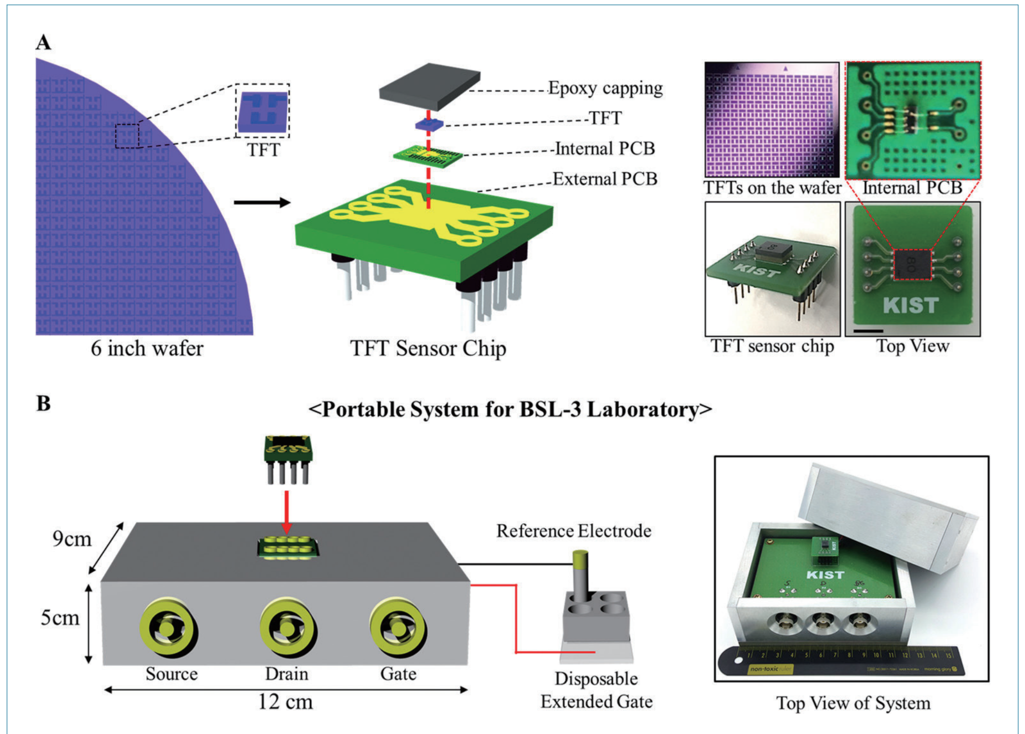
Dr. Kwan Hyi Lee
Principal Researcher
Center for Biomaterials

See more details on
https://doi.org/10.1021/acsnano.8b08298

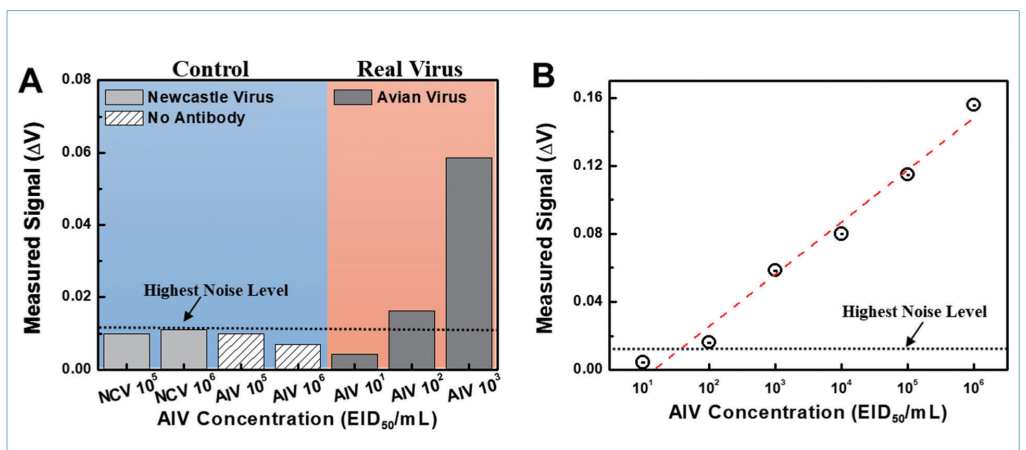




Variety of samples were prepared for measurement within the BSL-3 laboratory. Two main species, mallards and ducks, were grown to 6 weeks of age. They were then injected with the H5N6 avian influenza virus. The virus was incubated within their respective hosts and were collected through oral swabs and cloacal swabs from ducks, oral swab samples from mallards, and feces samples from ducks. The samples were initially analyzed through RT-PCR, and the samples which showed substantial results were selected to be taken and compared by the packaged biosensor.

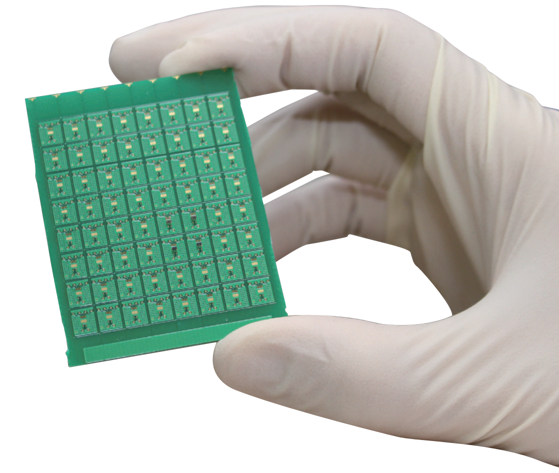


Overall schematic of the packaged biosensor. (A) Packaging and wiring process of the packaged biosensor; the semiconductor portion was extracted from a semiconductor wafer and placed onto a circuited internal PCB layer, where it was subsequently wired using gold wires. The wired semiconductor was then packaged into an external PCB for eventual usage in its respective casing and was sealed with an epoxy layer to prevent degradation of the semiconductor. (B) Minimal pieces required for the packaged biosensor sensor (image is not scaled).



Control experiments for the study. (A) When AIV similar to the Newcastle virus reacts with the HPAIV antibodies and is then washed away, a miniscule shift in voltage can be seen. The striped white boxes indicate a voltage shift recorded when no antibodies were attached to the well surface. (B) Concentration of the HPAIV increases by a factor of 10, and a nearly linear voltage shift increase can be detected. The LoD is 10^2 EID_{50}/mL.

When we spoke to him, Dr. Kwan Hyi Lee from the Center for Biomaterials at KIST had just returned from a one-year paid leave in the United States. He looked tired and jet lagged, but his eyes lit up at the mention of the avian influenza virus diagnostics platform currently being studied. The tool was improved with newly acquired artificial intelligence technology from the United States, raising its accuracy to 94 percent from its previous range of 70 to 80 percent. Commercialization efforts are underway for leveraging this technology.



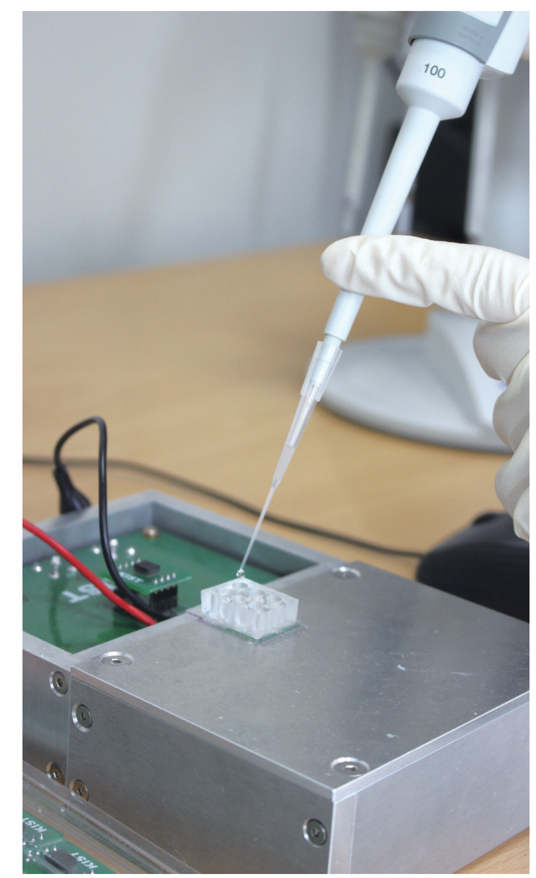
A semiconductor bio-sensor system that can detect AI virus in the field quickly and with high sensitivity.

Early detection of the avian influenza virus will be possible with this diagnostic platform as it is highly sensitive at detecting the virus and easily portable. High-risk avian influenza is known to be contagious to humans. Diagnosing the influenza early on in the field will allow for swift prevention of an epidemic.

The virus accurately identified within 20 minutes

Avian influenza diagnostic kits are nothing new. Rapid test kits that use Au nanoparticles and display easily visible test results, much like pregnancy tests, have been in use for some time. However, the low sensitivity of these kits has made it difficult to conduct tests outdoors at farms and docks. Dr. Lee explains it this way, “The existence/nonexistence of the virus was displayed with a faint lien because the test kit’s sensitivity was low, and the swab samples for persons suspected of having been infected in the first round of testing in the field were brought to labs for a second round of testing using DNA PCR amplifiers.”

To address these shortcomings, Dr. Lee’s team developed a sensor 1,000 times more sensitive using semiconductors and successfully packaged it to be portable. The high sensitivity of the sensor allows for early virus detection. This sensor uses substances that react with the virus. When the substance reacts to the infected sample, a signal is transmitted through the semiconductors, informing the tester of the results.



The greatest advantage of the sensor is that it can measure the common antigen for avian influenza no matter how high- or low-risk the virus is. This is particularly useful in the case of high-risk viruses which, according to

Dr. Lee, have typically needed to be tested in BSL-3 (Bio Safety Level-3) facilities with negative pressure rooms. Unfortunately, the downside to this testing process is that large equipment like PCR amplifiers cannot be kept inside negative pressure rooms.

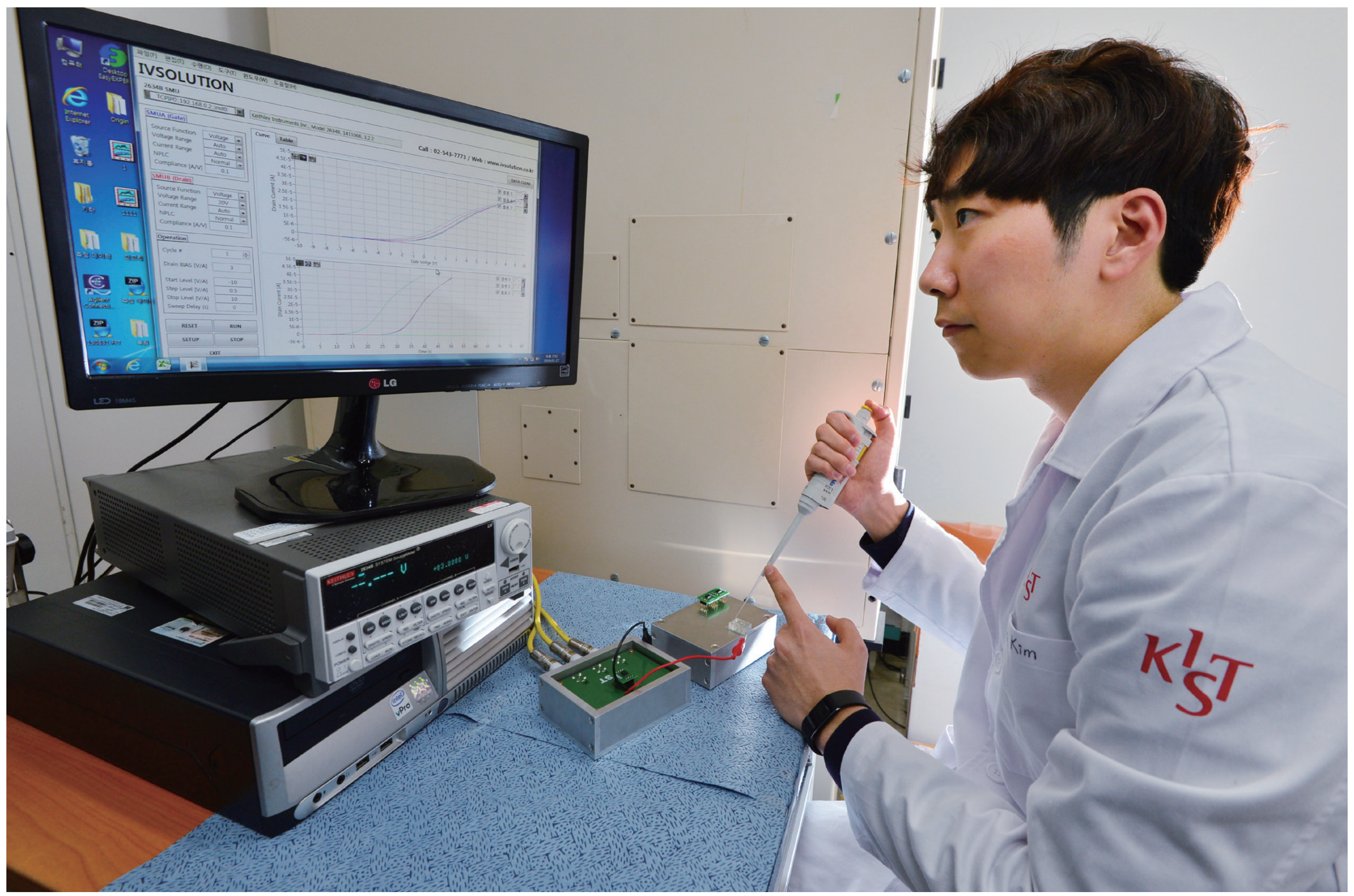
It is important to note that viruses mutate over time. Several types of avian influenza viruses may develop concurrently. Therefore, it is useful to check for the common antigen when trying to stop the virus from spreading.

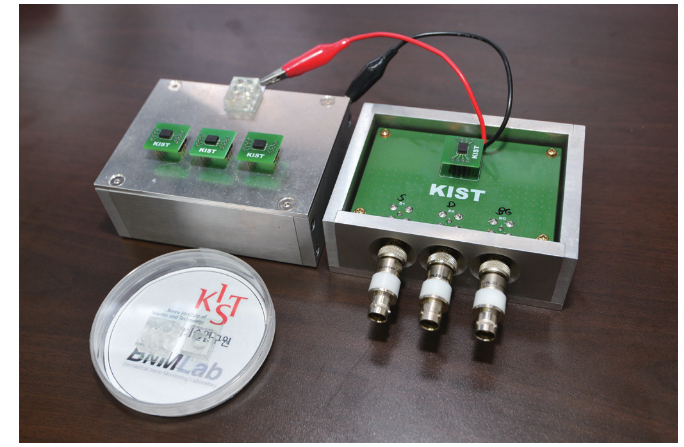
The research team also proved that the tool can distinguish between similar viruses, like the Newcastle virus, a capacity that can prevent misdiagnosis. Testing used to take at least half a day, but now requires only 20 minutes and is more accurate, even when compared to PCR testing.

Dr. Lee's future plans include the development of a tool that can test four samples at once. Research will also continue into the commercialization of the sensor so that it will be readily available for quick and convenient use.

The team made it happen

Dr. Lee conducted joint research with a team led by Professor Changsun Song at the Department of Veterinary Medicine at Konkuk University and received training on a variety of different topics such as animal testing and safe handling of high-risk contagious viruses. The team got a lot of help from the quarantine officers working in the field to test for the virus. According to Dr. Lee, "Luck is important when conducting research. The study was made possible by the outstanding people we met and put together as a team, despite the difficulties that arose because we are not bird experts."



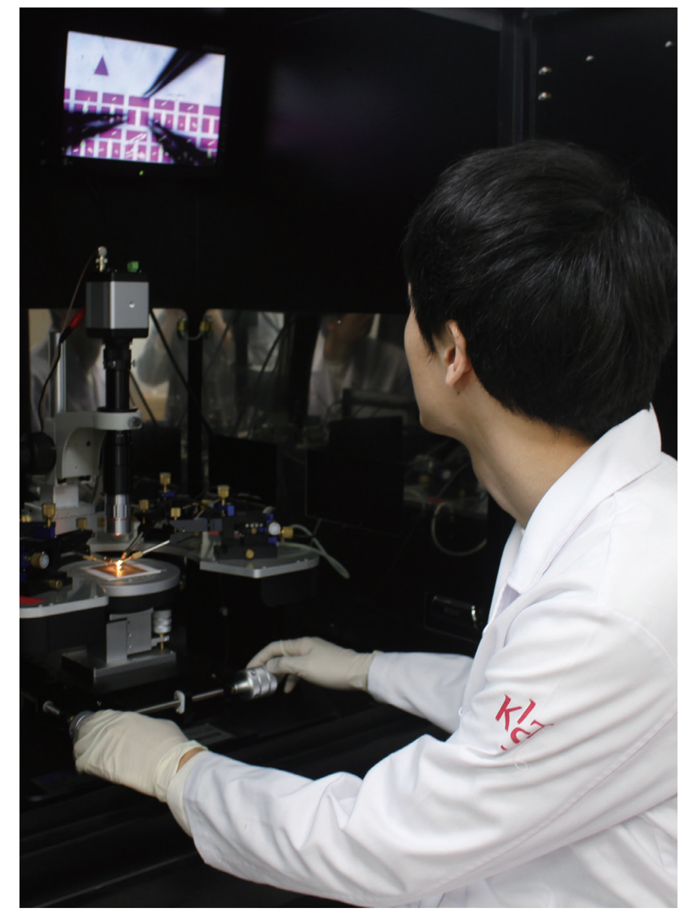


↑ The highly sensitive AI virus detection diagnostic platform, allows for immediate analysis of samples taken from the field.

Future plans aimed at public benefits

Dr. Lee feels strongly that his research efforts should be geared to solving social problems. This commitment inspired his journey to develop the avian influenza virus sensor as well as his successful results in developing a urine tester for prostate cancer, an illness which results in the highest number of fatalities internationally and continues to take the lives of more and more patients in Korea as well. He intends to build on the lessons learned from his sensor research to help prevent other viral epidemics which can have such a negative effect on public health and the economy.

> "We have developed an on-site diagnostics tool for avian influenza virus with improved accuracy thanks to artificial intelligence. This tool is currently gearing up for commercialization. Our goal is to make this easy to use for farmers."

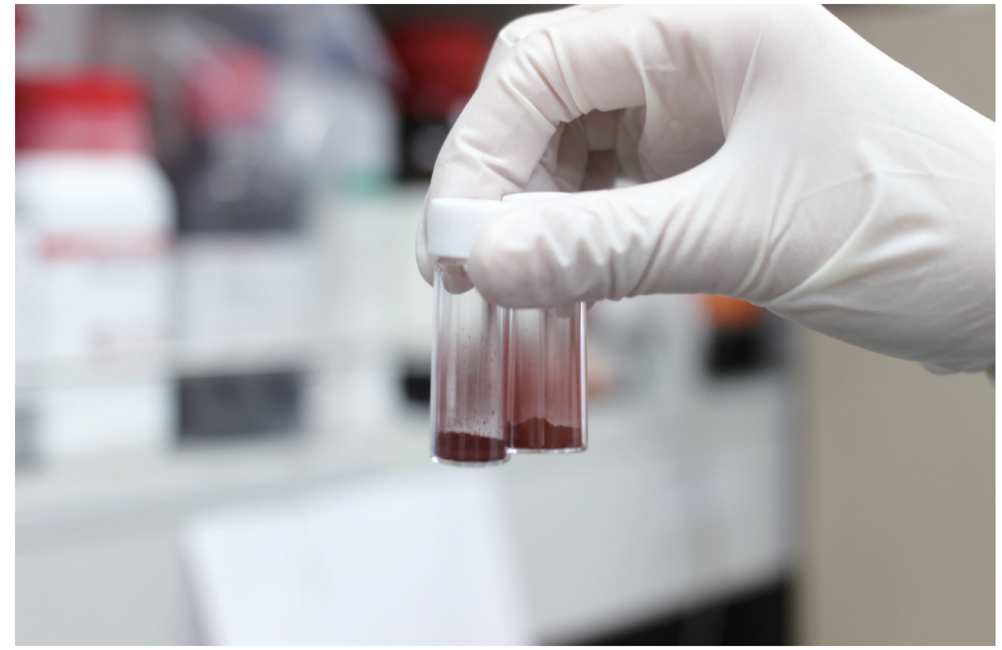


Dr. Jongsik Kim and his team develop a contaminant-removing catalyst and low-voltage process for wastewater treatment”

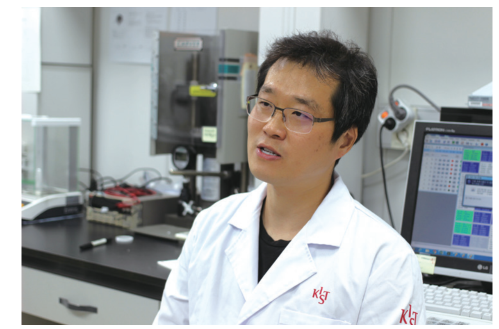
02

Dr. Jongsik Kim
Senior Researcher
Materials Architecturing
Research Center

See more details on
https://doi.org/10.1016/j.apcatb.2019.04.015

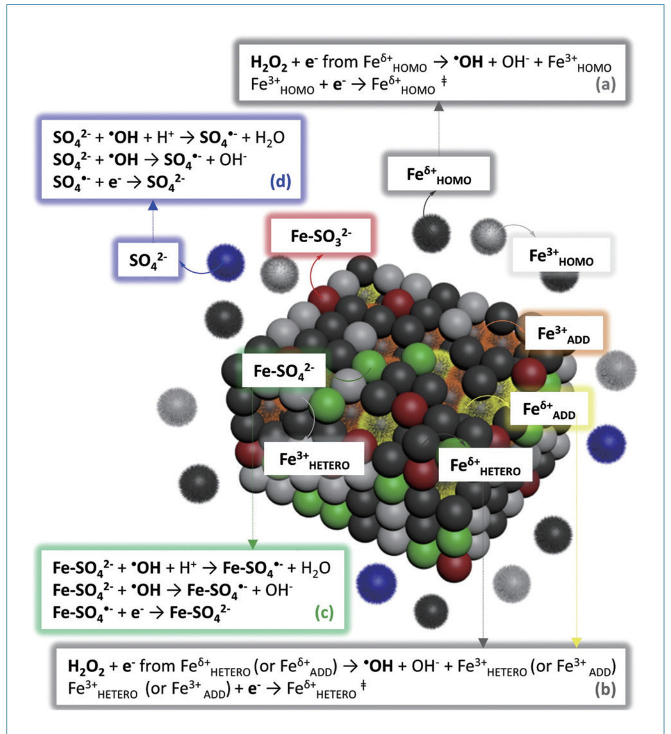


“Applying the research on ultra-fine dust removal to the one on wastewater treatment resulted in outstanding performance. We found a novel method of treating wastewater with oxidized iron, one of the most ubiquitous elements on Earth. We are also conducting joint research with corporations and look forward to commercializing this technology as soon as possible.”



Jongsik Kim, Ph.D., from the Materials Architecturing Research Center at KIST has successfully developed a catalyst and process for a new method of wastewater treatment that uses only water and electricity to remove pollutants. Dr. Kim verified the efficiency of the method by applying low voltage while still removing at least twice the amount of pollutants compared to existing methods. There are high hopes riding on this process because the simplicity and semi-permanent nature of the discovered method is anticipated to make it highly attractive to businesses.

The study didn’t start off with wastewater treatment as its main goal. The researchers stumbled onto outstanding results after discovering a catalyst for the elimination of precursors used to form ultra-fine dust (NOX reduction) and putting that catalyst in contaminated water. It was like killing two birds with one stone through a chance encounter. This turned into Dr. Kim’s initial study associated with wastewater treatment.



↑ Illustration of SO_4^{2-}-functionalized iron oxide active to produce ${}^{\bullet}OH$ or $SO_4^{\bullet-}$ via different pathways. Generation of ${}^{\bullet}OH$ on (a) leached $Fe^{\delta+}$ ($\delta \leq 2$) via homogeneous catalysis ($Fe^{\delta+}_{HOMO}$) or on (b) supported $Fe^{\delta+}$ via heterogeneous catalysis ($Fe^{\delta+}_{HETERO}$ or $Fe^{\delta+}_{ADD}$). Generation of $SO_4^{\bullet-}$ on (c) supported $Fe\text{-}SO_4^{2-}$ or on (d) leached SO_4^{2-}. O atoms and elementary steps to describe $SO_4^{\bullet-}$ generation on leached $Fe\text{-}SO_4^{2-}$ are omitted for simplicity. e- denotes electron, whereas $Fe^{\delta+}_{ADD}$ and Fe^{3+}_{ADD} denote Fe species exposed to H_2O_2 post surface Fe leaching. $Fe\text{-}SO_3^{2-}$ and Fe^{3+} present on or near the surface are also exhibited (i.e., Fe^{3+}_{HETERO} and Fe^{3+}_{HOMO}).

“Establishing the response mechanism was not easy given that there were no precedents,” says Dr. Kim, but he believes that the technology will be commercialized within the next year or two.”

Relevant for energy conservation and environmental protection

Existing commercial sewage treatment facilities mostly rely on the use of “radicals” to treat wastewater. A radical is an oxidizing agent that breaks apart contaminants that dissolve in water. However, because the catalyst involved in the process lasts for only one round of treatment and is not recyclable, there needs to be an endless supply of precursors utilized to produce the radicals necessary to remove aqueous pollutants.

Furthermore, the oxidized steel (iron) used to treat water is not dissolvable yet, is converted into iron hydroxide, which is difficult to remove. The iron hydroxide is precipitated and isolated, and therefore should be incinerated in a heating furnace. Getting rid of a few grams of iron hydroxide wouldn’t be a problem, but the amount that needs to be removed reaches tons in volume. This means that energy consumption and environmental pollution caused by carbon dioxide emissions need to be considered.

Given all these factors, Dr. Kim’s team tailored the surface of the catalyst to maximize its durability and lifespan. This led to the creation of a radical-producing catalyst that makes consistent water treatment possible without the additional supply of radical precursors. The original catalyst functioned solely as a producer of radicals, but the catalyst newly developed herein has the additional benefit of fixing the radicals immobilized on the surface of the catalyst. In this way, the once disposable radicals can now be used at least 10 times.

In addition, Dr. Kim’s team, in conjunction with another research team led by Professor Geunhong Chung at the Korea Military Academy, proved that applying low voltage would anchor the surface radicals semi-permanently. Since additional equipment is required to apply this low voltage, we asked Dr. Kim whether this wouldn’t be a cost burden on corporations. He answered that “the economics are there because our catalysts can be used at least 10 times more than existing ones.”

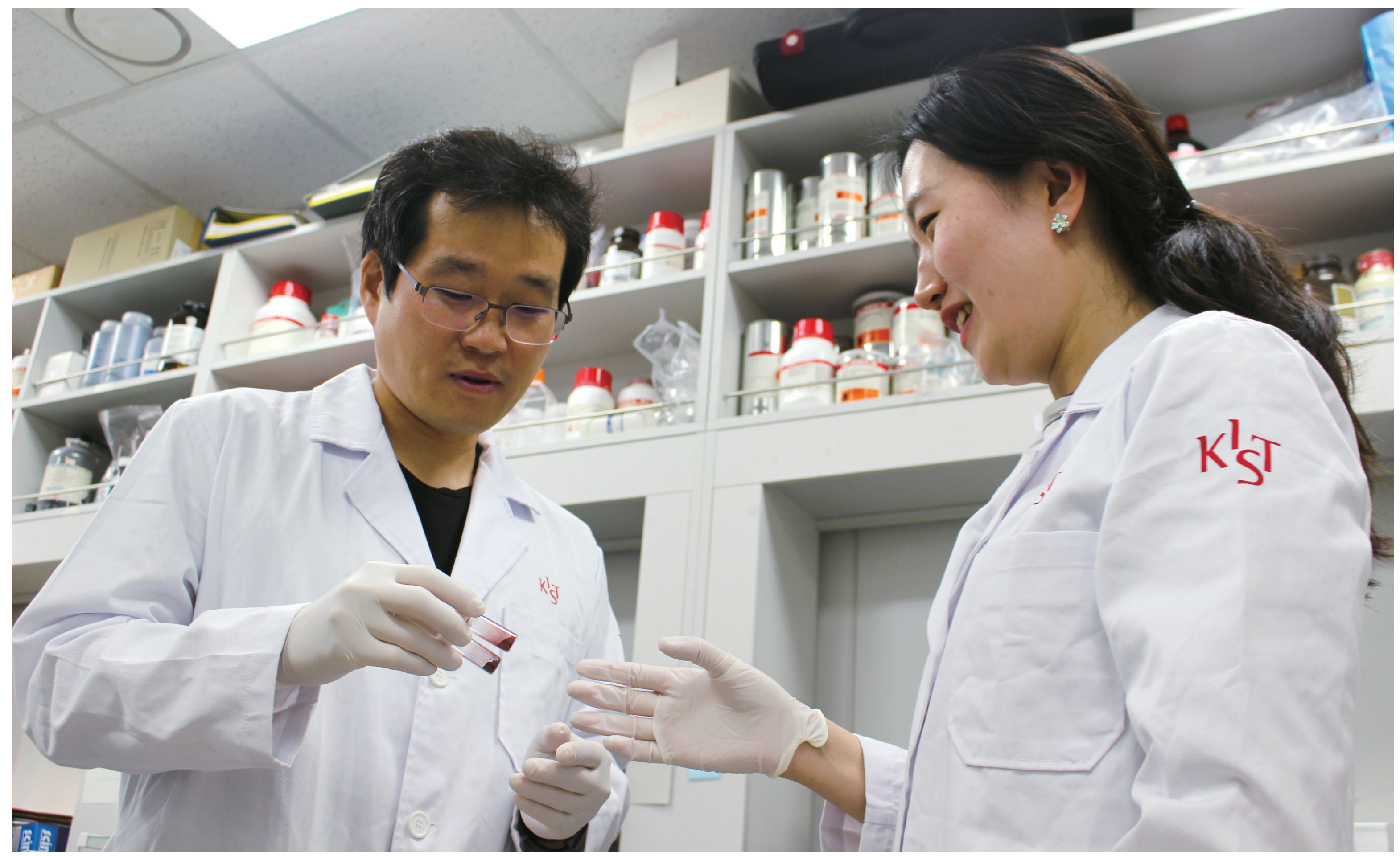
Tons of this catalyst, rather than the small gram units used in the lab, are required if commercialization is to be feasible. In response, Dr. Kim is getting ready to scale up the catalyst by soliciting help from Dr. Heon Phil Ha, an expert who has commercialized a highly efficient catalyst deployable to NOX removal industry for years.

Corporations already supporting efforts for rapid commercialization

The catalyst invented by Dr. Kim follows such a unique radical evolution mechanism that has not been reported previously, to the best of our knowledge. Hence, the verification of such a mechanism was not easy. There were numerous stumbling blocks along the way, including five rounds of article revisions in the process of publishing the results of the study in a science journal. However, research leading up to commercialization is now underway at full speed, with water treatment companies reaching out to Dr. Kim about his research following the publication of his research article. Dr. Kim’s research has been sponsored by companies for the past three months and his latest efforts involve designing a reactor used for wastewater treatment.

“Establishing the response mechanism was not easy given that there were no precedents,” says Dr. Kim, but he believes that the technology will be commercialized within the next year or two.” Collaborative research on experiments and calculations as well as research on ways to optimize the process is underway. This will help reduce the cost of purifying factory and agricultural waste water.

The results of this study have been published online in *Applied Catalysis B: Environmental*, a leading science journal.



KIST Collaborates with Dana-Farber Cancer Institute to Develop Cancer Therapeutics

Dana-Farber Cancer Institute

The Korea Institute of Science and Technology (KIST) and Dana-Farber Cancer Institute (DFCI) are collaborating to develop cancer therapeutics. The two institutions signed a memorandum of understanding in 2013 with the aim of collaborative research in the field of cancer treatment in addition to setting a foundation for KIST-DFCI on-site lab. As a result, active scientific communications and engagements over the years allowed for establishing the KIST-DFCI on-site lab in 2016 for continuous research collaboration.

Founded in 1947, the DFCI is a world-leading multidisciplinary research institute for cancer whose mission is to disseminate innovative therapies and scientific findings for patients around the world. DFCI is one of 51 comprehensive cancer centers designated by the National Cancer Institute and has more than 580 physicians and scientists specialized in medical oncology, cancer biology, immunology, virology, and other fields ranging from basic to clinical research. The institute has brought breakthroughs in clinical treatment for cancer patients through its empirical efforts from the bench-side. The DFCI's intrinsic nature of research collaboration and clinical translation is continuously discovering new treatments for cancer patients. The cancer biology department, especially, focuses on uncovering molecular principles in cancer progression and resistance and testing novel therapeutic approaches in genetically modified preclinical models.

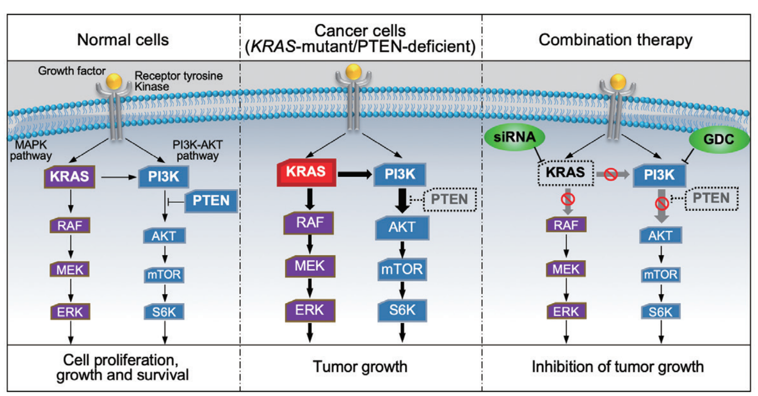
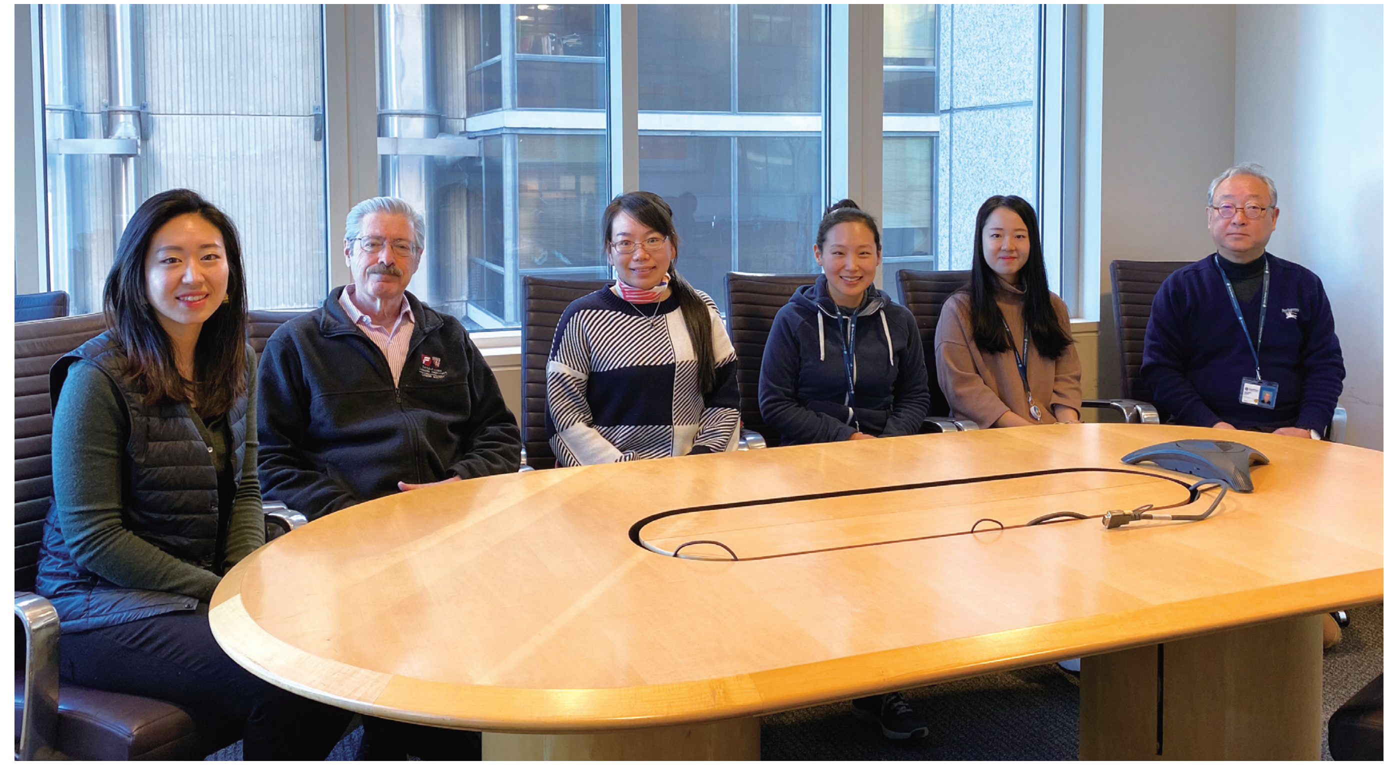
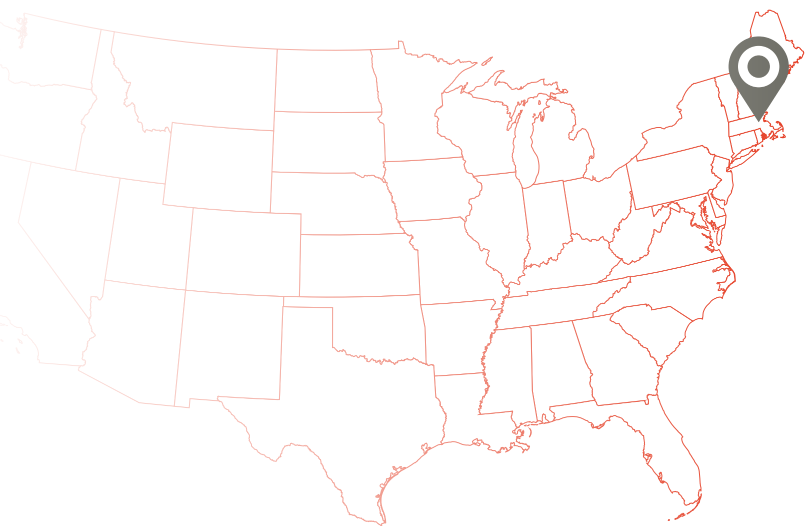


Fig 1. Signaling cascade of PI3K and RAS. Schematic illustration of the KRAS and PI3K pathways in presence of siRNA targeting KRAS, siKRAS, and a PI3K inhibitor, GDC-0941. Normal cells display well modulated signaling on MAPK and PI3K signaling pathways, whereas cancer cells with KRAS and PTEN mutation display constitutive activation of MAPK and PI3K pathways resulting in tumor growth. Combination therapy targeting KRAS and PI3K additively inhibits both signaling cascades, thus blocking a critical feedback loop, and inhibits tumor growth.





KIST's Center for Theragonosis expects to benefit in important ways from this collaboration with DFCI. The center has focused on developing drug delivery systems and molecular imaging techniques. Its research in drug delivery systems encompassing various modalities and drugs, such as poly-siRNA therapeutics, protease-responsive contrast agent, tumor-targeted nanomedicine, lymph node-targeted therapeutics, and exosomes, have demonstrated therapeutic potential in challenging diseases. Nevertheless, the encouraging results in preclinical experiments often fail to translate to the clinical outcome because of lack of therapeutically relevant molecular targets and clinically reliable disease models. For this reason, we are in collaboration with DFCI to conduct research on clinically reliable models and therapeutically relevant molecular targets for translational medicine.

The first phase of the KIST-DFCI on-site lab from 2016 to 2018 was conducted by Dr. Ju Hee Ryu with the aim of developing clinically applicable drug delivery systems. Since the launch of the second phase in 2019, collaboration between KIST and DFCI has expanded under the leadership of Dr. Ick Chan Kwon. Furthermore, the KIST-DFCI lab is now looking at ways to commercialize KIST-developed technologies in Boston, a city with extensive networks and resources. With support from the Harvard Catalyst Program, Dr. Kwon and his on-site partner, Dr. Thomas Roberts, are working on establishing a CD47 immunotherapy-based.

Research News. 01

Bio/Medical

A New Technology for Identifying High-Performing Targeted Drug Delivery Vehicles

See more details on
https://doi.org/10.1016/j.biomaterials.2018.12.026

- A new approach to identifying and selecting simple yet high-performing anticancer drug carriers
- Building a nanoparticle library that provides drug carriers with enhanced tumor-targeted delivery of anticancer agents

Dr. Dae-Ro Ahn
Principal Researcher,
KIST Center for Theragnosis

Effective cancer treatment requires targeted delivery of anticancer agents specifically to cancer tissues to minimize the side effects caused by undesired delivery to healthy organs. Despite the vast amount of research on this subject, on average only 0.7% of injected nanoparticles used as drug carriers actually reach the cancer tissue.

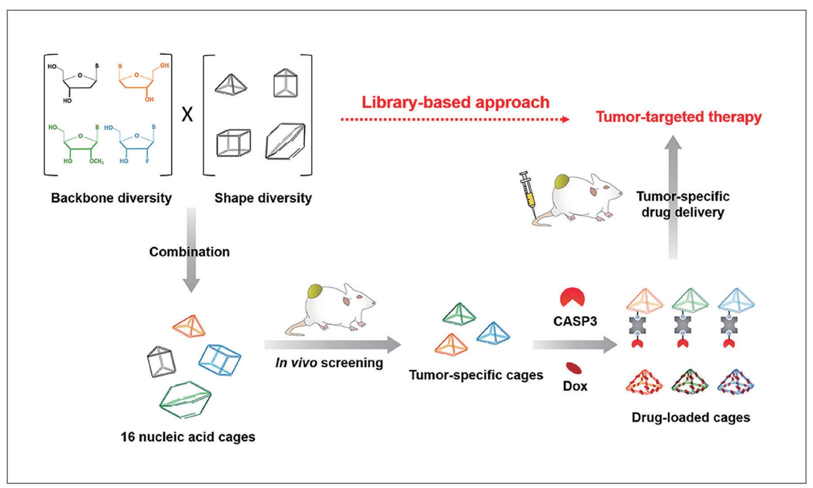
Developing nanoparticles for targeted delivery of anticancer drug is no easy feat. Even if a delivery vehicle is painstakingly and successfully designed with a significant investment of time and money, performance often fails to meet expectations due to the complexity of the human body and various unpredictable factors that come into play. This suggests a need to build a nanoparticle library by designing and producing a wide array of different nanoparticles from which we can pick and choose the ones that best fit the situation.

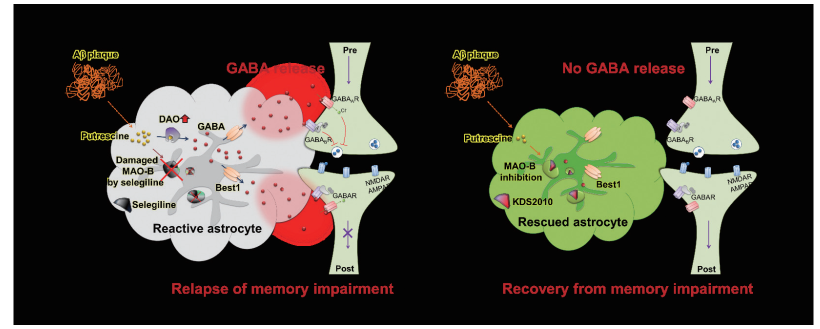
According to Dr. Ahn, "This DNA nanoparticle library-based technology to screen drug carriers can expedite development of target tissue-specific drug carriers," adding that "this will help us to easily and expediently identify selective and efficient carriers that can deliver anticancer drugs to target cells and tissues, including tricky brain structures."

The results of this study have been published online in the latest edition of *Biomaterials* (IF: 10.273, top 1.562% in JCR).

↓ kinds of DNA nanoparticle library

↓ Schematic presentation of the work-flow for the development of a tumor-specific drug carrier based on library of nucleic acid cages.





← Model diagrams of long-term treatment of AD with either irreversible or reversible MAO-B inhibitors. Aβ: amyloid-beta, MAO-B: monoamine oxidase-B, DAO: diamine oxidase, Best1: bestrophin 1, Pre: pr-esynaptic terminal, Post: posts-ynapse, NMDAR: N-methy-Das-partate receptor, AMPAR: α-amino-3-hydroxy-5-methyl-4-isoxazole propionate receptor

Dr. Ki Duk Park's research team at KIST's Convergence Research Center for DTC of Dementia and Dr. C. Justin Lee's research team at the Cognitive Glioscience Group of KIST cooperated in a joint research project that resulted in the introduction of a new paradigm capable of overcoming the limitations of existing Alzheimer's disease treatments.

The research team found that existing medications were able to reduce the quantity of Gamma-aminobutyric acid (GABA) secreted, but only in the early stages of treatment. However, with long-term administration, the compensatory mechanism in the body was activated and resulted in the recurrence of increased GABA levels and cognitive impairment.

In contrast, the drug candidate developed by the KIST research team was confirmed to consistently improve cognitive functions by avoiding the activation of the therapeutic mechanism even with long-term administration. Cognitive skills were not just restored, but significantly improved, as confirmed through diverse behavioral experiments conducted on Alzheimer's mice treated with periodic administration of the drug candidate over a prolonged period of time.

Interestingly, through screening (ADME/Tox), it was revealed that the drug candidate was conveyed to the brain extremely effectively with minimal nervous system side-effects. The results of this research project effectively expose the shortcomings of existing medications and identify the limitations of the previous paradigm.

Dr. Ki Duk Park stated, "The drug candidate was able to alleviate dementia-related cognitive impairment consistently over a prolonged period of time. The drug candidate is not only effective, but also shows high levels of brain permeation with no deleterious effects on the human body."

The outcome of this research project was recently published in *Science Advances* (IF: 12.8, top 5.07% in JCR), and the drug candidate and the technology involved was transferred to Medical Experiential Green Agricultural Bio (advance fee: KRW 550 million, fixed royalty: KRW 6 billion, running royalty: 3%). The candidate drug is currently in preclinical trials and slated to be approved for clinical trials in 2020.

Dr. Ki Duk Park
Principal Researcher,
KIST Convergence Research Center for Diagnosis, Treatment and Care System of Dementia

- A drug with longer-term benefits than other anti-dementia drugs
- Work of research team pinpoints source of existing drug failure and offers new solution

Research News. 02

Bio/Medical

A Breakthrough Anti-Dementia Drug Developed Through Convergence Research

See more details on
https://doi.org/10.1126/sciadv.aav0316

Solving the Mysteries of Quantum Measurement Brings Us a Step Closer to Quantum Computing

See more details on
https://doi.org/10.1038/s41567-019-0482-z

- KIST research team establishes relationship between "geometric phase" and "quantum measurement back-action"
- South Korea further demonstrates its expertise in quantum information

Quantum computers–future computer technology that leverages quantum physics–can solve certain complex problems that existing digital computers never solve. For example, a mathematically hard problem, which a super computer would take 150 years to solve, is expected to be solved in a matter of minutes with quantum computers. This unprecedented data processing speed is projected to bring about a sea change in industries such as energy, health, and finance.

Dr. Young-Wook Cho's team at the KIST Center for Quantum Information recently conducted joint research with Professor Yoon-Ho Kim's research team at POSTECH to prove the occurrence of a quantum geometric phase when measuring the status of Qubits, the basic unit used with quantum computers.

According to quantum mechanics, the quantum measurements always disturb the measured system. This inevitable back-action is known as "quantum measurement back-action".

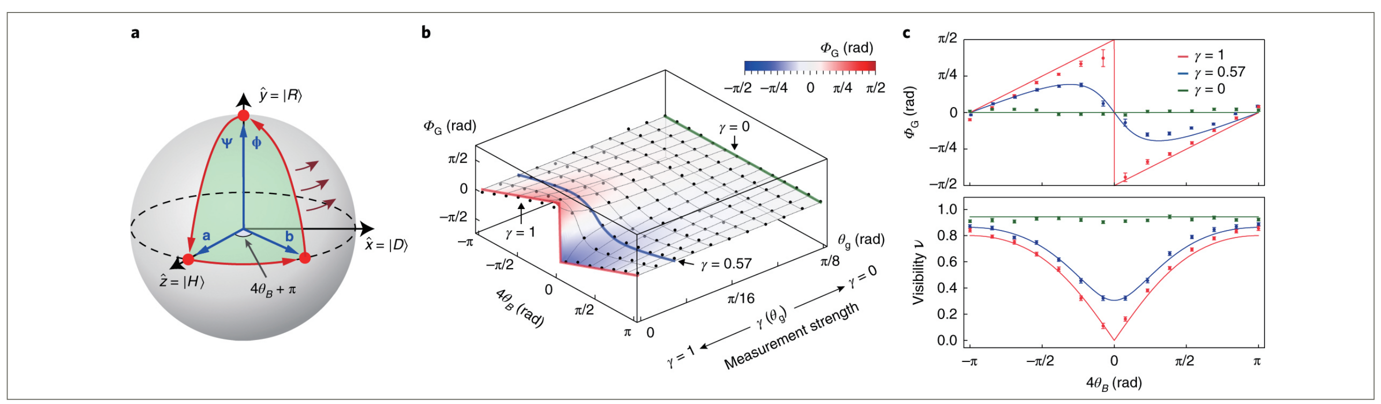
The KIST/POSTECH research team became the world's first to establish a close relationship between "geometric phase" and "measurement back-action"–two important concepts required to understand quantum physics. This study used Qubit-based quantum circuits and has been lauded as the next big step in measurement technology.

According to Dr. Cho, "The results of this research will be used directly in verifying quantum states and processes in quantum circuits." He further suggests, "This study will contribute to quantum information processing research in quantum computing and other fields, given that geometric phase is known to help Qubits maintain their quantum nature."

The results of this study have been published in the latest edition of *Nature Physics* (IF:22.61, top 1.92% in JCR), the world's most prominent physics journal.

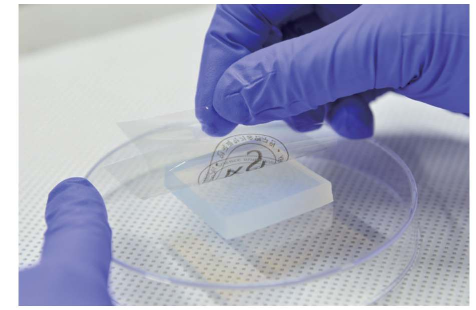
Dr. Young-Wook Cho
Senior Researcher,
KIST Center for Quantum Information

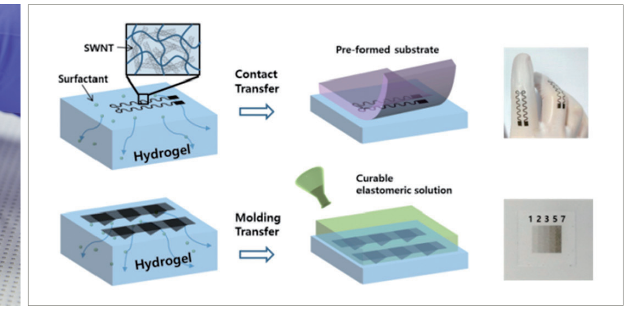
↓ Emergence of the geometric phase from quantum measurement back-action.
a The quantum state trajectory based on the geodesic hypothesis due to sequential projective quantum measurements.
b The measurement-induced geometric phase as a function of the measurement direction and the measurement strength. This results suggest that the quantum measurement back-action is the origin of the geometric phase in the measurement process.
c A sudden phase jump has been observed. This singular behaviour can be understood by the geodesic hypothesis.



→ Electrodes on top of hydrogel are transferred to PET film

→ Procedures for the hydrogel-templated transfer-printing of conductive nanonetworks





Dr. Hyunjung Yi
Principal Researcher,
KIST Center for Spintronics

- High-performance sensors built on different flexible substrates critical for next-generation wearable devices
- Simple process developed for improved transfer-printing technology

Uneven and Rough Surfaces Pose No Problem for Flexible Sensors Made with New Technology

See more details on
https://doi.org/10.1021/acs.nanolett.9b00764

Dr. Hyunjung Yi's research team at the KIST Center for Spintronics has developed a transfer-printing technology that can be used to build high-performance sensors out of hydrogel and nano-ink materials on flexible substrates with different shapes and structures.

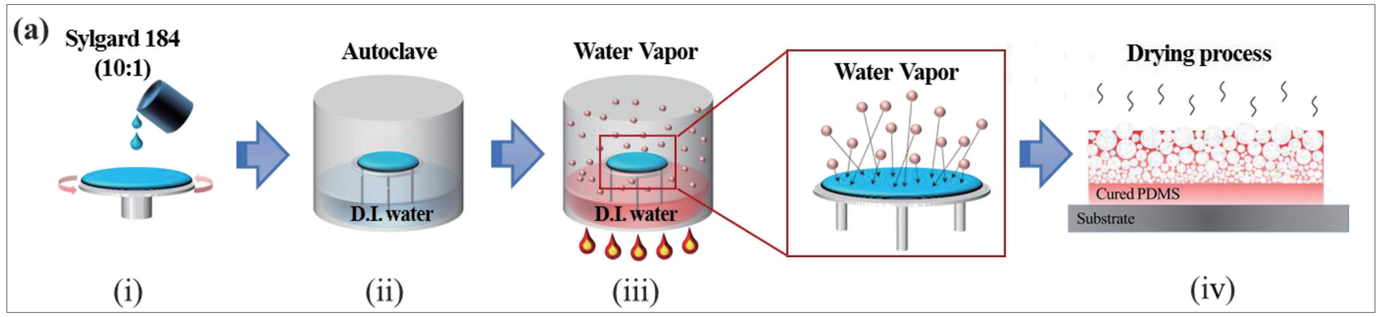
Dr. Yi's team developed a simple and easy transfer-printing technology for building high-performance flexible sensors on flexible substrates with different surface roughness and characteristics. Utilizing the porous and hydrophilic properties of hydrogel, the research team was able to use a water-based nano-material ink to print on a hardened hydrogel's surface. The surfactant and water in the ink quickly passed through the pores in the hydrogel, while nano-materials with hydrophobic properties and a size larger than the pores remained, creating the desired electrode pattern.

Because only a small amount of nano-ink is printed, the rapid formation of electrodes helps create a consistent structure and high level of purity, which produces high electrical electrical properties. In addition, the hydrophobic properties of the nano-materials keep interaction with the hydrogel to a minimum so that the electrodes are easily transferred to various substrates.

As part of the study, the team developed a nano-electrode transfer technology by curing moldable elastomeric solutions on the hydrogel so that flexible electrodes could be created easily on flexible yet rough substrate surfaces. The nano-electrodes were transferred directly to lab gloves to build a strain sensor that gauges movement and creates a high-performing flexible pressure sensor for pulsometers.

Dr. Yi expressed her hope that "the new method of building flexible high-performance sensors on substrates with different properties and structure with ease will be applied in fields that need to build integrated high-performance elements on flexible or non-conventional substrates, such as the digital health care industry, smart human-machine interfaces, medical engineering, and next-generation electronic devices."

The results of this study have been published in the latest edition of *Nano Letters* (IF: 12.080, top 5.822% in JCR), an international nanotechnology journal.



↑ (a) Fabrication process of the double dielectric layer composed of the porous and dense PDMS films via vapor encapsulation casting. (i) Spin-coating of uncured PDMS solution. (ii) Sealing the sample with D.I. water in the autoclave. (iii) Heating the autoclave to produce water vapor. Magnified image shows that water vapor penetrates into the uncured PDMS film. (iv) Curing of the double dielectric layer.

Research News. 05

Energy/Environment

Charging and Powering Electronic Devices with Everyday Static

See more details on
https://doi.org/10.1016/j.nanoen.2019.04.097

- KIST team develops an easy-to-build highly durable high-energy sponge-type nanogenerator
- Countless applications possible for this renewable energy source

Static is an inconvenience in daily life and a nuisance that produces faulty semiconductor chips during the manufacturing process. What if you could collect the wasted energy from static, vibration, light, and other sources around us to create electric energy? The spotlight has turned to energy harvesting as the international community moves toward a greater emphasis on renewables.

A research team led by Drs. Hyeoncheol Song and Jongyun Kang at the KIST Center for Electronic Materials has developed a highly durable high-energy sponge-type nanogenerator that uses harvesting technology to generate electricity out of static to produce energy for powering electronic devices.

The research team developed a fast and easy method of making a silicon sponge with fine porosity out of just water, silicon (PDMS, Polydimethylsiloxane), and vapor capsulation casting. The micropores strengthen electrostatic capacity along the entire surface so that much more static is generated, thus providing the basis for a highly durable high-energy electrostatic nanogenerator.

Dr. Song, who led this research, says, “This study carries significant meaning in that we created a porous structure using easy and simple processes, which means that this technology has the potential to undergird innovative products with price/performance/durability competitiveness compared to other energy harvesting generators.” According to Principal Researcher Kang, “A slew of energy harvesting technologies are being developed, and this study could play a key role in independently powering sensor networks in different environments.”

The results of this study conducted jointly with Professor Deokhyeon Choi (Kyunghee University) have been published in the latest edition of *Nano Energy* (IF: 13.12, top 4.452% in JCR), an international energy journal.

Dr. Chong-Yun Kang
Principal Researcher and Head of the KIST Center for Electronic Materials

Dr. Hyun-Cheol Song
Senior Researcher
KIST Center for Electronic Materials

Research News. 06

Energy/Environment

Rediscovering Lignin, an Eco-Friendly Solvent for closed-loop Biofuel Production

See more details on
https://doi.org/10.1073/pnas.1904636116

- Lignin, a plentiful component of biomass, used to develop a renewable solvent for producing biofuel
- Sustainable biofuel production technology that can help mitigate climate change

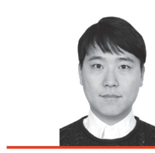
While working at KIST's satellite laboratory at the University of British Columbia (KIST-UBC) in Vancouver, Canada, Dr. Kwangho Kim from KIST's Clean Energy Research Center has developed a new type of solvent (deep eutectic solvent) required for biofuel production using the lignin found in biomass.

In general, a proper solvent is required to remove lignin from biomass in order to produce biofuel. The organic solvent that is used today is produced from petrochemicals and can significantly drive up unit production costs of biofuel if the solvent is not properly recovered and recycled. This is why sustainable and economic production of biofuel hinges on the use of eco-friendly and renewable solvents.

Recently, numerous studies have been conducted on new types of green solvents that can be substituted for organic solvents in the process of producing biofuels, such as bioethanol. The research team at KIST developed a solvent using lignin, a by-product that is generally disposed of as waste. This eco-friendly and renewable solvent can substitute for organic solvents to produce biofuel. This study has garnered attention because it allows for closed-loop biofuel production as the materials needed are procured from the production process.

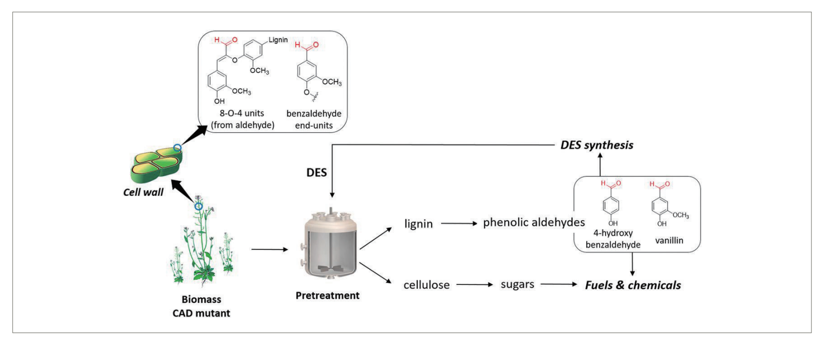
As Dr. Kim explains, “This technology directly produces the solvents needed to generate biofuel using lignin, which is a by-product of biomass and will serve as an important stepping stone in biofuel and bio-compound production.” Dr. Kim also provided details about his future plans to “work on collaborative studies with the U.S. Department of Energy Bioenergy Research Centers to advance biofuel research in Korea and develop sustainable biofuel production technologies of the future that can help mitigate climate change and global warming.”

The results of this study, conducted jointly with the U.S. DoE Joint Bioenergy Institute and Center for Bioenergy Innovation, State University of New York, and the Korea Military Academy have been published in the latest edition of *Proceedings of the National Academy of Sciences of the USA* (IF 9.504, top 7.031% in JCR), the official journal of the National Academy of Sciences.

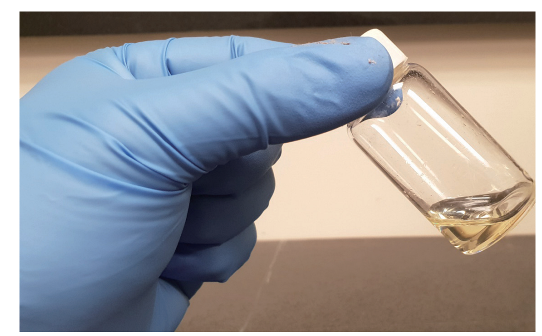


Dr. Kwangho Kim
Senior Researcher,
KIST Clean Energy Research Center

↓ A closed-loop biorefinery that can be achieved by integration of renewable deep eutectic solvent (DES) from lignin-derived phenolic aldehydes with engineered biomass.



↓ Lignin-derived deep eutectic solvent



Five Foreign Students at KIST School Share Their Stories

Eda Ates
Molecular Recognition Research Center
Materials and Life Science Research Division

Cininta Anisa Savitri
Center for Biomaterials
National Agenda Research Division

Tran Huyen Dang
Clean Energy Research Center
National Agenda Research Division

"KIST has outstanding researchers and research equipment.
I hope to become a scientist of many skills through various projects."
Student Researcher, Laura Bilbao Broch

These are just several of the comments expressed by foreign students conducting research at KIST where there are currently about 200 international students acquiring R&D skills in science and technology by participating in national joint research projects. The students have come to Korea to join KIST School, which was established jointly by KIST and UST (University of Science and Technology) in 2017.

KIST School has approximately 500 alumni around the world (as of 2018). Graduates continue their research careers at prestigious universities and government-funded institutions equipped with real research experience and strong adaptability.

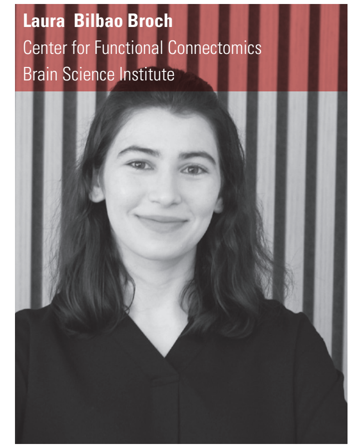
"My dream is to become a researcher of many talents"

Meet Laura Bilbao Broch. A member of the KIST Center for Functional Connectomics, she has an unusual background by having lived in six countries over the past seven years. "I wanted to experience life in Asia. That is one of the reasons why I thought of working and living in Korea" she explains.

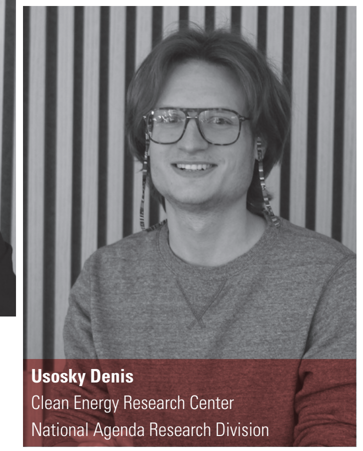
She is currently working at KIST on developing GEVIs(Genetically Encoded Voltage Indicators). Bilbao Broch explains a GEVI is a protein that can sense membrane potential in a cell and relates the change in voltage to a fluorescent output. is a protein that can sense membrane potential in a cell and is involved in the change in voltage to a fluorescent output. Using GEVIs, you can report neuronal voltage from dozens of neurons in a single field of view. She says, "GEVI is a new research field that I encountered for the first time at KIST. As I came with hopes of acquiring new knowledge, I am enjoying participating in the project."

It's been several months since she came to Korea. "I feel comfortable living here now, as you can see from how I use chopsticks with ease," she jokes. "KIST has a full array of research facilities and equipment necessary for projects, and researchers here are top experts in their fields," she adds, factors which contribute to her satisfaction with life at KIST.

With a goal to become an "well-rounded scientist," she believes, "It's natural to become an expert if you spend most of your time in one area. But I am interested in learning theories and skills from a wide range of fields." She adds, "I would like to become an well-rounded scientist by participating in diverse projects."



Laura Bilbao Broch
Center for Functional Connectomics
Brain Science Institute



Usosky Denis
Clean Energy Research Center
National Agenda Research Division

"Korea quickly advanced its science and technology and achieved exceptional growth. Coming to KIST has given me so much training in creative research. Living and studying in Korea is a huge opportunity for me."

"I wanted to live as a researcher in the country of Taekwondo"

Cininta Savitri from Indonesia is a student researcher at KIST's Center for Biomaterials. She is studying ways to develop biomaterials by synthesizing naturally-obtained CDMs into artificial material such as polymer.

"I fell in love with Korea while taking Taekwondo classes as a child," Savitri says. She found out about the KIST School program when she was considering a doctoral degree. She applied in order to grab the opportunity to experience "living in the country of Taekwondo."

As she explains, "The programs supported by KIST School were very interesting. They are research-centered and give you the chance to actually conduct research and become an author of a paper." She adds, "High pay and a full scholarship are benefits that came to me and that you can't find anywhere else in the world."

"KIST encourages and leads researchers to come up with creative ideas through programs such as the Idea Contest," Savitri states. "From facilities to experiments and so forth, KIST has a well-provided environment."

She adds, "Although I am doing research in Korea, I am able to expand to the global stage through collaborative studies with researchers in various institutions around the world, which I am happy about. Our lab is conducting joint research with labs in China and the U.S. It's a great advantage to have the opportunity to work with talents and resources there."

"Through R&D, I wish to provide a solution to my country's energy problem"

Tran Huyen Dang is a student researcher from Vietnam. Taking a doctoral program as a member of the Clean Energy Research Center, she is working on metal catalyst research, conducting experiments on the oxidation of methane and optimizing all conditions for reaction in order to find industrial applications for renewable energy.

Her interest in renewable energy comes from her desire to make a positive impact on Vietnam's environmental and energy issues. This is also why she chose Korea for doing research. Korea's history of development played a role in her decision. "Korea quickly advanced its science and technology and achieved exceptional growth. Coming to KIST has given me so much training in creative research. Living and studying in Korea is a huge opportunity for me."

After graduating from KIST School, she plans to join a postdoctoral program to gain additional research knowledge and skills and study research trends.

"Korea's R&D policy to solve global issues impressed me"

Denis, a student researcher at the Clean Energy Research Center, is now in his second year living in Korea. He is working on research related to the conversion of CO_2 to formic acid, which is known to be a more stable and adequate material for hydrogen storage and transport compared to hydrogen, gas, or liquids.

Having come to Korea through a program administered jointly by Belarus Science Academy and KIST, Denis says, "I was curious about meeting new people and their research culture. I applied without hesitation and started my internship."

He thoroughly concurs that KIST is an excellent place for R&D. Talking about the Korean government's S&T support, he explains, "Korea has S&T policies to solve global issues. These aren't easy issues for countries to try to solve, so I was impressed by Korea's long-term investment."

He hopes to continue his research career in the field of chemical catalysts and engineering. As he explains, "I plan to keep taking on new challenges, keep growing, and obtain various knowledge."

To researchers abroad who wish to come to Korea he gives the following advice, "It is difficult to stop what you are doing and come. But you need to learn to let go if you want to adjust to a new environment. There is fascination in getting to know a new world and learning unpredictable things. In these aspects, Korea can be the best starting point."

"Faced with the ever-increasing incidence of cancer, I wish to study the topic of prognosis"

At KIST's Molecular Recognition Research Center, you will find student researcher Eda Ates working on field studies necessary to develop a new biomarker.

Ates found out about KIST School by chance on the internet. She applied with hopes of conducting a wide range of research with talented colleagues and world-class facilities and says she is happy with her life at KIST.

Above all, she is attracted by joint global research projects where you can collaborate with many talented researchers. She says, "KIST has highly educated students from around the world. Because they come from such a diverse cultural background, the school provides an environment where you can understand and learn from different cultures." She adds, "I am particularly satisfied with the facilities where you can effectively conduct experiments and the fact that you can exchange opinions about science topics and strengthen creativity."

Her future challenge is to do R&D on biomarkers related to cancer. Reflecting on her future, Ates muses, "I don't have any specific plans about the future yet. But I am interested in acquiring various knowledge in biology and finding a new biomarker for cancer." She continues by saying, "Many suffer from cancer, which is increasing each year. I will start an experiment under the topic of finding biomarkers necessary in the process of cancer prognosis and treatment."

A World Where Data Dictates the Development of New Materials

Dr. Dong Su Lee
Principal Researcher
Functional
Composite Materials
Research Center

I've only been using this phone a month, but the imbedded artificial intelligence already has a good understanding of my everyday habits – what genre of music I like, what apps I most frequently use, when I come home, and much more.

I recently switched out my outdated smartphone for a new one. I ask the personal assistant program that came with my phone about the weather every morning and request playlist recommendations. I've only been using this phone a month, but the imbedded artificial intelligence already has a good understanding of my everyday habits – what genre of music I like, what apps I most frequently use, when I come home, and much more.

However, this doesn't cover the extent of the capabilities of artificial intelligence. When grand master Go player, Lee Sedol, was defeated by Google DeepMind's AlphaGo three years ago, people were shocked not just because a machine beat a person, but because human arithmetic skills were already no match for that of machines.

What was even more astounding was that machines could be good at "creative thinking," something that was considered the essence of human brain activity. This was shown when AlphaGo found moves that were more advantageous by studying (machine learning) prior information (data) created by humans. AlphaGo has since retired from the game of Go, but DeepMind has developed a new program called AlphaFold and commenced research on the protein structure of living organisms, with the grand vision of curing incurable diseases.

Efforts have been made across the board to generate creative results with machine learning algorithms. From a material scientist's point of view, artificial intelligence can potentially develop cutting-edge new materials. Let's say that material researchers across the world pool knowledge to create a database required for AI machine learning. Like the goose that laid a golden egg, AI may give birth to new materials, one after another.

Nonetheless, data related to new materials development is still lacking in both quantity and quality. Much like how people gain insights from experience, AI comes up with better options by studying large amounts of data. This is why quality data is required. Quality big data is easily generated in healthcare, marketing, and other industries, thus making the application of machine learning in these areas particularly useful and efficient. Yet so far, the same quality and quantity of information is not available to developers of new materials.

The difficulty in accumulating information about different substances makes data accumulation in the materials field challenging. Using machine learning with data sets about different materials is meaningless. Data needs to be clustered for each specific material to produce solutions.

We need to apply big data categorized for each different material to AI. However, there are only a few researchers that study specific substances, which means that acquiring big data in a short timeframe would be challenging even if we were to pool all the information that is out there. We need to go a step beyond research data acquisition and accumulation and strive to artificially generate the data that is needed.

Conditions such as synthesis temperature, substance, composition ratio, and other independent variables used to manufacture different materials are required as input values to generate relevant data. Electricity and heat conductivity, solidity, and other values become the output. Each individual researcher has different purposes in mind, which is why the input value is adjusted and controlled in different ways. Ample data would produce statistically meaningful results even if the study were to be randomized. If there isn't sufficient data, a top-down approach can be used, where variables are controlled for specific purposes, and each individual researcher provides specific input values to accumulate controlled data.

A measurement and analysis platform catered to the nature of materials should be created to make data accumulation more efficient and increase the reliability of output values. Currently data is generated in Korea using numerous analysis tools. Data hasn't been accumulated because each individual researcher requests measurements, and analysis is also provided on an individual basis.

Even if researchers agree to accumulate analyzed data, the data will be useless if we fail to collect and manage information about what analytic sample and independent variables were used to generate that data. A measurement and analysis platform built on the basis of features of specific materials through which material analysis data is processed would make it possible to efficiently manage data clusters.

Data could be generated for materials where the underlying technology has reached a sophisticated level of maturity. This could also enhance the effectiveness of machine learning. It would be wise to build a measurement and analysis platform and data clusters for promising materials that meet these conditions. A dedicated commitment to gather the necessary data will facilitate the development of new materials with the assistance of artificial intelligence.

President Moon Visited KIST to Encourage Domestic Materials and Parts Production

On September 10, President Moon paid a visit to the materials parts research facility at KIST and declared his commitment to accelerate the timeline for domestically producing materials and parts. The president arrived in his newly acquired hydrogen car, the Hyundai Nexo. In August, the Blue House added the car to the fleet of the president's personal vehicles. After the interior and exterior of the car were revamped with bullet proofing and other features, it was announced that the Nexo would be used for the president's commute and daily Blue House affairs.

The newly appointed Minister of Science and ICT, Gi-yeong Choi, President Byung Gwon Lee of KIST and Director-General Jun-yeon Chang of the Post-Silicon Semiconductor Institute accompanied the president on his visit to KIST. Director-General Chang briefed President Moon on current issues regarding Japan's export restrictions as well as KIST research results and also discussed the transistor, the key component in semiconductors. He emphasized the commitment of KIST to develop next-generation semiconductor technologies that will help retain Korea's status as a semiconductor powerhouse.

In response, President Moon joked that he "wouldn't dare pose questions about the technology here [at KIST]," but on a more serious note, he stressed that "talented experts for the mass production of next-generation semiconductors should be trained and positioned at the right place and time so that we can leverage next-generation semiconductors as our next growth engine."

Afterwards, President Moon went to the MBE (Molecular Beam Epitaxy) lab for a briefing and shook hands and offered words of encouragement to the researchers. MBE investigates nano-semiconductors by synthesizing atom-level semiconductors in an ultra-vacuum state. The lab's goal is to develop semiconductors with superior performance. President Moon expressed high hopes for MBE, reminding the researchers that their efforts would benefit future generations. His entry in the autograph album at the lab reads, "From follower to leader through the power of science and technology." After these site visits, he traveled to a cabinet meeting in his Nexo.

Designation as a Special R&D Zone Considered Critical to Hongreung's Future

The 13th Hongreung Forum was held on May 29 on the 12th floor of the Techno Cube Building at the Seoul National University of Science and Technology in Nowon-gu, Seoul.

During the forum, discussion focused on the "five pillars" needed to achieve regional development: industry, academia, research institutes, civil society, and nature. It was agreed that the government has a critical role to play in bringing these five pillars together in Hongreung. It should designate Hongreung a special R&D zone that can take advantage of the specific assets found in Seoul. In the words of President Myeong-ja Kim of the Korean Federation of Science and Technology Societies, this zone would become "a new social model, not just for economic development, but also for social development and innovative growth."

The establishment of a special R&D zone is important for promoting new technological developments and achieving economies of scale. These benefits are already apparent in one of the most well-known special R&D zones in Korea, Daedeok Innopolis, located in Yuseong-gu, Daejeon Metropolitan City. Designation as a special R&D zone would allow for comprehensive legislation covering the entire region and infrastructure grants that could be distributed all at once rather than for piecemeal projects. Seventeen research, education, public organizations in Hongreung, including Korea University, University of Seoul, KIST, and the Soorim Cultural Foundation are participating in the Hongreung Forum in order to facilitate this process.

Director-General Seok Jin Yoon a member of the Hongreung Clustering Executive Group at KIST, is very much in favor of designating Hongreung a special R&D zone because "Hongreung has ample capabilities and infrastructure, including world-class universities and research institutes, and the Seoul Metropolitan Government is also taking the initiative to build a bio cluster in Hongreung." He pointed to the example of Boston, which became a successful bio innovation cluster due to its concentration of world-renowned universities, such as Harvard and MIT, drug complanies like Novartis and Pfizer, and the state government's full support. He believes that "Hongreung can follow in Boston's footsteps."

The government is reviewing ways to develop Hongreung into a special research and development zone of international renown. Director-General for Science and Technology Employment Policy at the Ministry of Science and ICT, Chang-yoon Lee, was impressed by Hongreung's level of preparation when it applied for special zone status last year. He lists Hongreung's merits as the supportive policy of the Seoul Metropolitan Government, the outstanding talent and technology already present in the area, and a location well-suited to attracting businesses. He believes that "Hongreung has good potential to link with city regeneration projects as well if it becomes a designated special R&D zone."

Ethiopian Prime Minister Shows Strong Interest in KIST's Development Model

On the morning of August 26, the Ethiopian prime minister, Abiy Ahmed Ali, visited KIST to discuss initiatives for bilateral cooperation in science and technology. This was the prime minister's first visit since becoming the head of the government. He had visited KIST five years earlier, in 2014, after being appointed the chairman of Ethiopia's Science and Technology Information Center (STIC). The prime minister toured the cutting-edge facilities at KIST, including the Post-Silicon Semiconductor Institute and emphasized the importance of the role of R&D at institutions like KIST in spurring national economic development.

After KIST signed an MOU with Ethiopia's Ministry of Science and Higher Education in 2018 to promote bilateral exchange of science and technology talent and information, the two parties have been engaging in close cooperation in research and education fields.

During the visit, President Byung Gwon Lee of KIST said, "As Ethiopia is one of KIST's major cooperating partners, Prime Minister Abiy Ahmed Ali's visit reaffirms the science and technology partnership between KIST and Ethiopia and will serve as an important milestone in increasing substantive cooperation." For his part, Prime Minister Abiy Ahmed Ali stated that he is "deeply interested in KIST's development model that was critical in Korea's economic development," adding that he is "dedicated to expanding the bilateral science and technology partnership with KIST for Ethiopia's development."

Highly Efficient Dehumidification Technology Provides Relief During Sweltering Weather

Dr. Dae-yeong Lee's team at KIST's National Agenda Research Division has developed a dehumidification technology that is at least 160% more energy efficient than existing dehumidifiers. It uses revolutionary principles to remove humidity without affecting room temperature.

Researchers at KIST recently developed "HumiCon," a dehumidifier that uses highly efficient desiccant technology by adding a humidity filter with "desiccant rotors" to electric dehumidifiers. The air that is cooled with the heat pump's evaporator passes through the desiccant rotor and is dehumidified. Afterwards, the desiccant rotor is activated by the condenser sequence in the heat pump. The circular usage of energy provides highly energy-efficient dehumidification properties.

The proprietary large-molecule dehumidifying material used for the filter provides dehumidifying properties that are five times better than silica gel. It also acts as an excellent deodorizing, antibacterial and antifungal agent. HumiCon not only dehumidifies, but also ventilates and cleans the air all year round. Dr. Dae-yeong Lee established a start-up company known as Hu Master to commercialize HumiCon. Product development is now complete and full-fledged commercialization efforts are underway.

As Dr. Lee explains, "This highly efficient dehumidification technology will rid us of tropical nights and help us get through summer without sweat, stickiness, power outages, and outrageous electricity cost," adding that "this technology is geared not only for Korea which has a tropical, warm and humid climate, but can also be used effectively in other countries across the world, such as Japan, China, Southeast Asian countries, India, and northern Latin American countries."

Scientists Donate CFRP Crutches

On May 22, the KIST Jeonbuk Institute of Advanced Composite Materials hosted an Elbow Crutch Donation event at the Jeonbuk community welfare center for the disabled located in Wansan-gu, Jeonju-si. The purpose of the event was to utilize research done at the KIST Jeonbuk Institute to help the local community. Researchers at KIST Jeonbuk built 15 crutches out of CFRP (carbon fiber reinforced polymer). By reinforcing polymer with carbon fiber, a material that is extremely solid and elastic yet weighs less than plastic, CFRP is a light-weight material of choice for automobiles, aerospace businesses, construction, and sports equipment.

The crutches built by KIST Jeonbuk are ultra-light-weight at only 275g, but as strong and durable as metal. They are at least half the weight of wooden or aluminum crutches, yet extremely durable. Furthermore, the elbow support that comes in direct contact with the skin is made with 3D printers and and extremely comfortable for the user. The donated crutches will be distributed by the community welfare center to seniors and disabled persons who have difficulty walking.

Director-General Jae-min Hong stated, "It's a pleasure to be of help during the family month of May." He went on to say, "It's extremely meaningful that we can leverage the developments made by our researchers to help out local residents. We will continue to contribute to the local community in a variety of ways."

KIST Jeonbuk is developing original technologies for high-performance and advanced composite materials. To make the most of its highly trained research staff, it operates a science visit program for students and plans to establish an experience-based composite material center for the purpose of offering more science and technology educational and experiential opportunities to local residents.

Using Failure as a Stepping Stone, "Pursuit of Innovation with Next-generation Battery Research"

Dr. Minah Lee, recently awarded the Wiley Young Researcher Award, plans to continue work on organic batteries

Research entails one failure after another. Repeated failure does sometimes make myself question if I am not fit to be a scientist."

Dr. Minah Lee experienced failure and frustration for an entire year after beginning her project with lithium-ion battery anode materials during her second year into her master's course.

She had fulfilled her dream of becoming a scientist after graduating from a science high school and studying at KAIST and Stanford University, but her initial struggles to produce results were disheartening. She briefly regretted her career choice, but ultimately realized that her experiences and perseverance had made her a better researcher.

Secondary battery research using organic matter

"I was always interested in developing technology that could curb environmental pollution and promote clean energy usage."

Dr. Lee began is research on secondary batteries during her early years as a Ph.D. student while studying artificial photosynthesis through naturally-inspired engineering. Back then, lithium-ion batteries were thought to be the most appropriate solution for energy storage in eco-friendly EVs. Having studied artificial photosynthesis for her master's degree, this is what sparked Doctor Lee's idea of using organic matter for secondary batteries.

Doctor Lee states that "the idea bio-inspired energy storage by applying artificial photosynthesis came naturally", adding that he thought about "using organic compounds with active redox properties to build eco-friendly and high-performance batteries."

Recipient of the Wiley Young Researcher Award, "Fueled to Work Harder"

Since publishing her first dissertation, Doctor Lee now has a total of 27 papers about battery research under his belt, including 11 papers as the main author published in journals such as, Angewandte Chemie, Nature Energy, Nature Communications, and Advanced Materials. Her work has been cited at least roughly 1,400 times and she is known as a young trailblazer in this field.

Doctor Lee was selected as one of the three finalists for the Wiley Young Researcher Award, announced by Wiley, a global academic publisher based in the United States. She was chosen for her research in the field of material engineering to develop next-generation energy storage technology that can boost effectiveness of renewables, which could have a significant impact on social development and environmental protection. Doctor Lee states that "since this is just the first step as an individual researcher, I feel grateful and on the other hand immense pressure", adding that she would "take this as encouragement to work harder and do good research."

Doctor Lee plans to continue her research on secondary batteries using integrated research. Her dream is to create a clean society using effective eco-friendly energy.

Recruitment

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

- **Job openings: Ph.D ○○ openings**
  *Applicant may apply for only one job opening
- **When & How to Apply**
  January 8 (Wed) - January 23 (Thu)
  http://www.kist.re.kr
  http://onest-kist.saramin.co.kr

Categories and Specific Areas of Research

Brain Science

- Examine brain function and cause of disease; utilize mapping of functional-structural connection in neural circuits
- Computational neuroscience
- Neural stem cell application
- Microsensors, MEMS, Brain Engineering and Microsystems
- Brain Disease/Neurochemical Imaging and Therapeutics

Robotics and Media

- Technology and system technology for intelligent robots (control/recognition/human robot interaction, etc.)
- Medical robot system technology
- 2D/3D video and media technology
- AI core technology

Biomedical Engineering

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

Materials and Life Science

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

National Agenda Research

- Atmospheric environmental science related to fine dust
- Signal processing and data learning technology for intelligent sensor information processing
- Biodegradable plastic manufacturing and waste plastic resource recycling technology

Clean Energy

- Material and system technology for hydride/fuel cell
- 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 Semi-Conductors

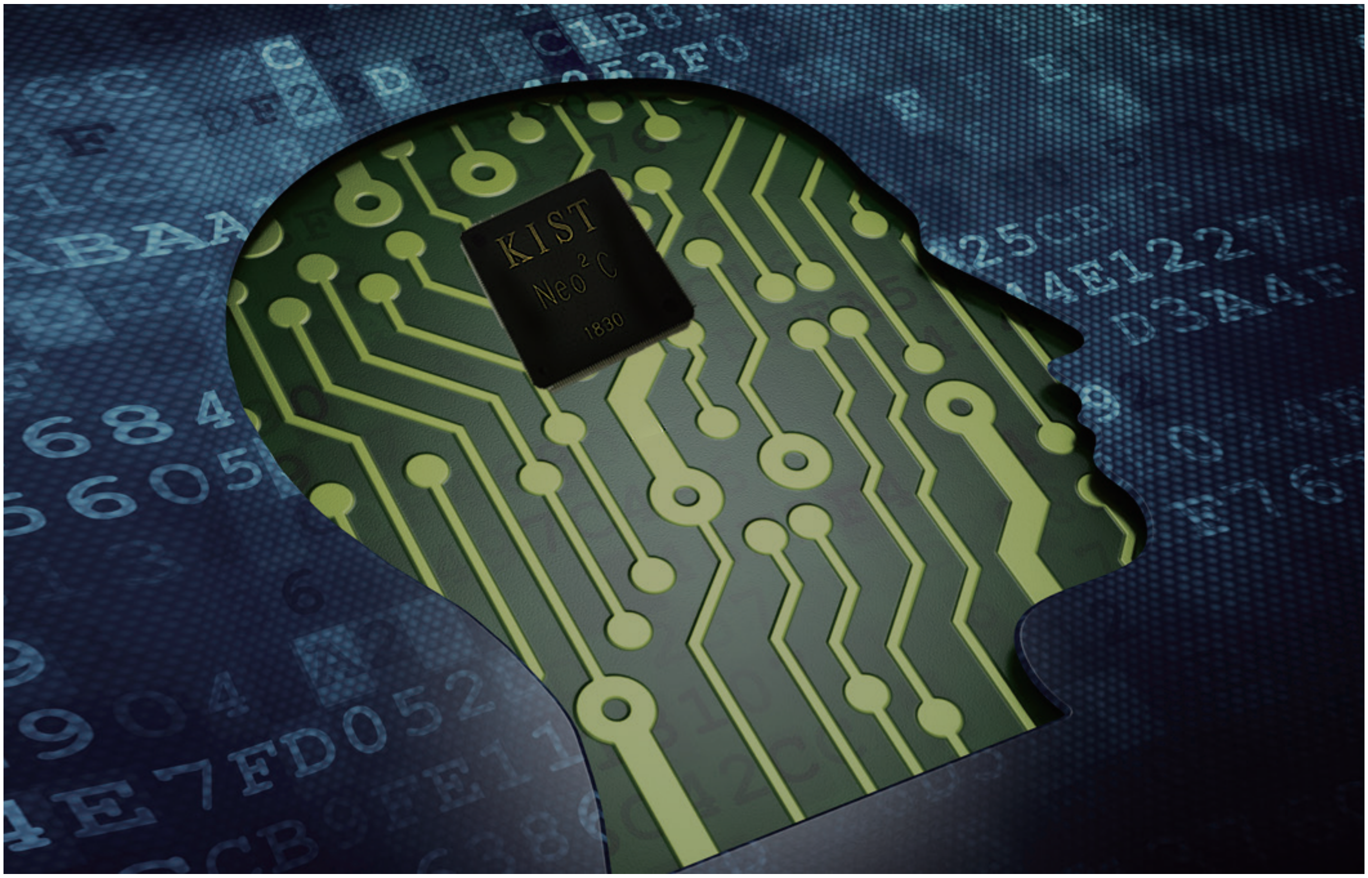
- Neuromorphic semiconducting material/devices/system
- Spin device using nano spin dynamics and spin trajectory
- High speed electronic device/nonlinear photoelectric device, optical data control/analysis/design
- Quantum Computing, Quantum Communication, Quantum Information Theory

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

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

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

- Identify and verify 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



Post-Silicon Semiconductor Institute

Leading the new generation of semiconductors

Center for Electronic Materials

Center for Spintronics

Center for Quantum Information

Center for Opto-Electronic Materials & Devices

Post-Silicon Semiconductor Institute

Current silicon-based technology is rapidly reaching its limits in terms of decreased size and increased speed. This is why KIST's Post-Silicon Semiconductor Institute is using new materials to develop advanced semiconductors that are superior to their silicon-based counterparts. The goal is to produce semiconductors that are 10x faster but consume 1/10th the power. Our research mostly focuses on oxide semiconductors, spin electronics, opto-electronic convergence, and attachable electronic devices for health monitoring.

KIST
Korea Institute of Science and Technology