BIENNIAL REPORT 2022

KAIST MECHANICAL ENGINEERING

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MECHANICAL ENGINEERING

BIENNIAL REPORT 2022

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2022

BIENNIAL·REPORT

Contents

Greetings from Department Head

Welcome to the KAIST Department of Mechanical Engineering!

Since 1971, KAIST Mechanical Engineering Department has cultivated industry and academic leaders and will further foster individuals who can solve the global problems of humanity. Our goal is to establish our department as an international hub department where young and talented people from the world will want to study and a department that provides new stimuli and challenges to students. In today's rapidly changing environment, facing mega-trend issues including the digital transformation, carbon neutrality, and aging societies, we aim to provide students with a vision for the future and the foundation to achieve such a vision. Up to now, mechanical engineering has played a key role in creating new value for human civilization. Future innovations will be in the areas of Energy, Healthcare, and Mobility. Research in our department takes on challenges to solve problems ranging from the nanoscale to large scale structures in a diverse range of areas, including functional materials, intelligent vehicles, ultra-precision measurement machinery, humanoid robots, digital fabrication engineering, eco-friendly energy, design, and biomedical engineering. Based on such research, we are collaborating with researchers worldwide to develop technologies that can produce wealth and improve the quality of life for everyone. We provide a balanced curriculum covering the fundamentals of mechanical engineering and state-of-the-art research, with additional emphasis on experiments, hands-on learning, and collaborative system design. The exchange of students is actively pursued through international joint degree programs with top mechanical engineering departments in Europe and the Americas. We respect diversity and openness and will provide an education to help students meet the most important challenges in their lives. This biennial report helps you understand our department and reach us in many ways in education and research.

Aug, 2022
Head of Department of Mechanical Engineering
Professor **Jung Kim**, Ph.D.

Vision

Vision

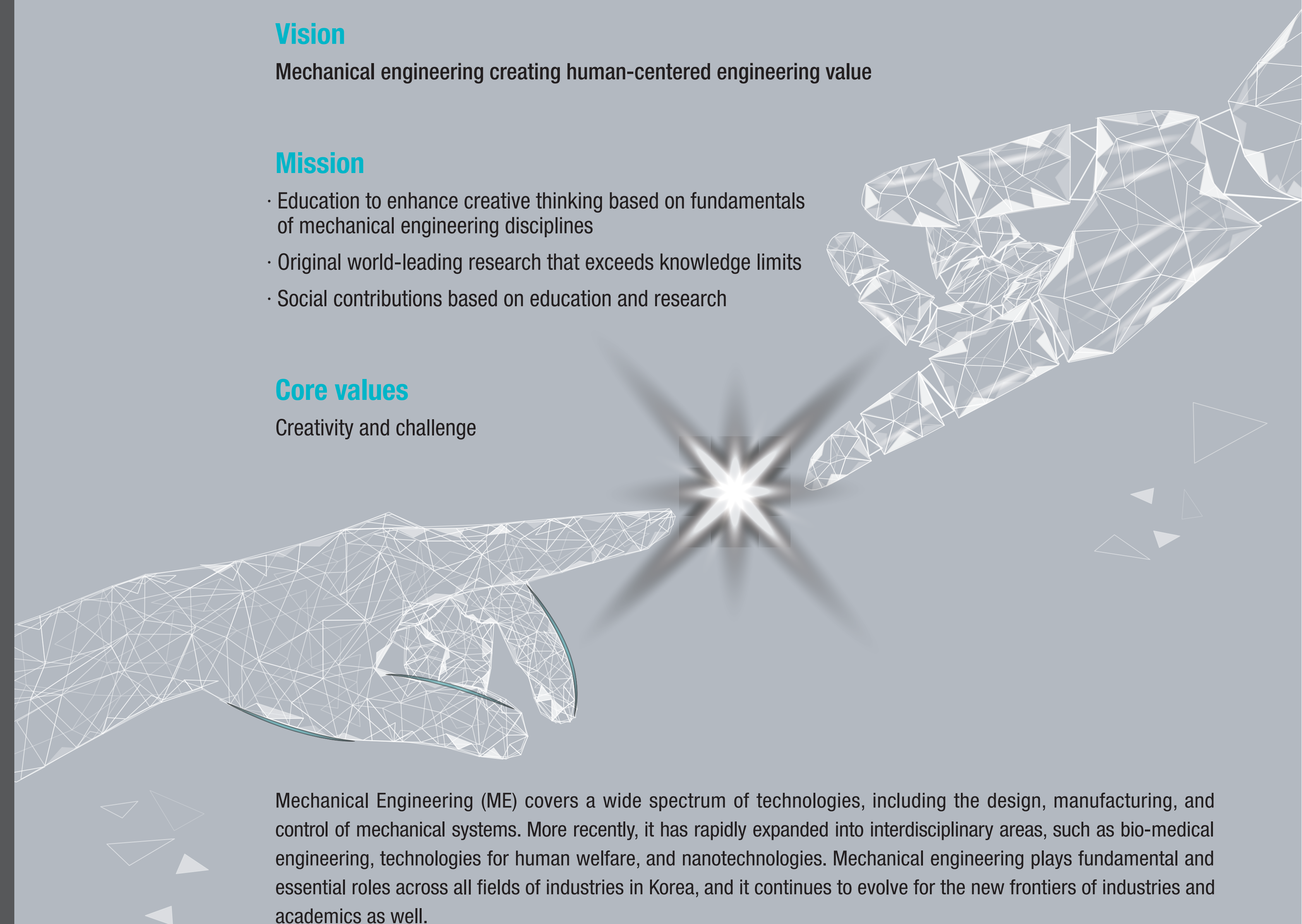
Mechanical engineering creating human-centered engineering value

Mission

- Education to enhance creative thinking based on fundamentals of mechanical engineering disciplines
- Original world-leading research that exceeds knowledge limits
- Social contributions based on education and research

Core values

Creativity and challenge

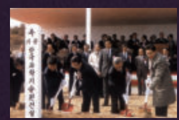


Mechanical Engineering (ME) covers a wide spectrum of technologies, including the design, manufacturing, and control of mechanical systems. More recently, it has rapidly expanded into interdisciplinary areas, such as bio-medical engineering, technologies for human welfare, and nanotechnologies. Mechanical engineering plays fundamental and essential roles across all fields of industries in Korea, and it continues to evolve for the new frontiers of industries and academics as well.

The vision of KAIST ME is to create human-centric engineering values through the unique missions of education and research with societal contributions. KAIST ME focuses on educating graduate and undergraduate students to enhance their creative and critical thinking on the basis of the strong fundamentals of mechanical engineering disciplines. We also pursue innovative and revolutionary research that exceeds current knowledge limits. In the end, the KAIST ME will contribute to the enrichment and improvement of our nation's industry and social communities as well as academia.

Brief History








1970's

1971 Establishment of Department as part of Korea Advanced Institute of Science (KAIS) in Seoul campus

1973 First admissions to the Master's program (17 students)
Prof. Bae, Soon-hoon, Prof. Lee, Choong Hong and Prof. Lee, Chung Oh joined the department

1975 First graduation from the Master's program (14 M.S.)
First admission to the Ph.D. program (3 students)

1978 First graduation from the Ph.D. program (1st Ph.D. : Dr. Yang, Dong-Yol)
Inauguration of the master of engineering of Production engineering program in the department

1980's

1981 Merger with Korea Institute of Science and Technology (KIST)
Establishment of Korea Advanced Institute of Science and Technology (KAIST)

1982 Separation of the Production engineering program from the department as Department of production engineering

1984 Establishment of Korea Institute of Technology (KIT)
Beginning of undergraduate programs

1986 First admission to the undergraduate program of KIT

1989 Separation of KIST from KAIST
Merger of KAIST with KIT
First graduation from Bachelor's program (31 B.S.)

1990's

1990 Move to Daejeon campus

1992 Change of the name of Department of production engineering to Department of precision engineering

1995 Merger with Department of precision engineering
The 25th Anniversary of the Department

1996 Joining of Department of automation and Design engineering (from Seoul campus) to the department

2000's

2008 1000th Ph.D. graduate from the Department

2010's

2013 Ranked the 19th in 2013 QS World university ranking by subject of Mechanical, Aeronautical & Manufacturing Engineering

2014 Ranked the 21st in 2014 QS World university ranking by subject of Mechanical, Aeronautical & Manufacturing Engineering

2015 Merger with Division of Ocean systems engineering

2016 Ranked the 21st in 2016 QS World university ranking by subject of Mechanical, Aeronautical & Manufacturing Engineering

2017 Mechanical Engineering Building Remodeling(Certification of Conversion of Green building-the first in Korea)
Ranked the 15th in 2017 QS World university ranking by subject of Mechanical, Aeronautical & Manufacturing Engineering

2018 Ranked the 16th in 2018 QS World university ranking by subject of Mechanical, Aeronautical & Manufacturing Engineering

2019 Ranked the 23th in 2019 QS World university ranking by subject of Mechanical, Aeronautical & Manufacturing Engineering

2020's

2020 Ranked the 22th in 2020 QS World university ranking by subject of Mechanical, Aeronautical & Manufacturing Engineering

2021 Ranked the 22th in 2021 QS World university ranking by subject of Mechanical, Aeronautical & Manufacturing Engineering

2022 Ranked the 22th in 2022 QS World university ranking by subject of Mechanical, Aeronautical & Manufacturing Engineering

Overview and Status

QS Ranking

2016	21
2017	15
2018	16
2019	23
2020	22
2021	22
2022	22

Faculty (Aug. 2022)

36 Professor Emeritus

23 Professor

22 Associate Professor

6 Assistant Professor

87 Total

Research Activities

Research Contracts (unit: 1 billion Korea won)

	Industry	Government	
2017	5.3	23.6	28.9
2018	6.9	35.2	42.1
2019	7.7	46.5	54.2
2020	4.3	47.8	52.1
2021	7.0	37.3	44.3

Academic Performances

	SCI (E)	Journal Impact Factor per Faculty member	Number of journals per faculty member
2017	292	20.6	5.5
2018	308	30.2	5.5
2019	267	26.3	4.3
2020	316	41.4	5.5
2021	342	44.2	6.0

Registered Patents

	Domestic	International
2017	76	15
2018	84	27
2019	107	16
2020	117	25
2021 ~Nov.	161	22

Student Enrollment
(Apr. 2022)

211 B.S. Students
Government Scholarship 194
KAIST Scholarship 0
General / Industry Scholarship 0
International 17

190 M.S. Students
Government Scholarship 144
KAIST Scholarship 25
General / Industry Scholarship 5
International 16

400 Ph.D. Students
Government Scholarship 200
KAIST Scholarship 117
General / Industry Scholarship 63
International 20

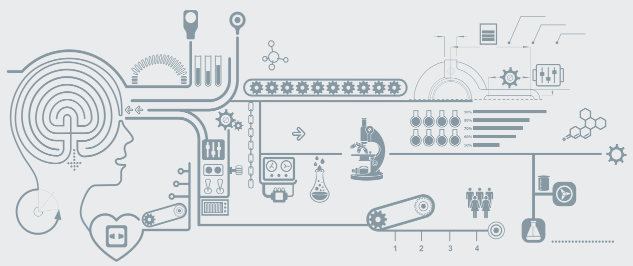
Career Status of Alumni

2,206 B.S. (Aug. 1989 ~ Aug. 2021)
High Degree 64.6%
Industry 20.2%
Research Institute 0.7%
University 0%
Government office 2.2%
etc 27.3%

3,502 M.S. (Aug. 1975 ~ Aug. 2021)
High Degree 46.%
Industry 28.3%
Research Institute 6.5%
University 1.8%
Government office 1.4%
etc 32.1%

1,761 Ph.D. (Aug. 1978 ~ Aug. 2021)
High Degree 0%
Industry 35.3%
Research Institute 27.4%
University 15.2%
Government office 2.2%
etc 40.2%

Research Centers



Human-Robot Interaction Research Center

Director: **Prof. KYUNG, Ki-Uk**
Sponsor: **Ministry of Trade, Industry and Economy**
Year established: **2004**

The HRI Research Center, sponsored by the 21C Frontier Program, aims to develop core technology for human-robot interactions for the coexistence of service robots and humans in everyday life.

Center for Future Medical Robotics

Director: **Prof. Dong-Soo Kwon**
Sponsor: **Ministry of Education**
Year established: **2008**

Center for Future Medical Robotics aims to develop medical robots that can overcome the difficulties in surgical procedures. For this purpose, a flexible endoscopic surgery robot, a laparoscopic (single port and multi port) surgery robot, and a micro surgery robot are being developed.

High Speed Mechanical Properties Data Center

Director: **Prof. YOON, Jeong Whan**
Sponsor: **Ministry of Trade, Industry and Economy**
Year established: **2010**

The goal of the center is to develop national standard reference data pertaining to high-speed material properties. Measurement and evaluation procedures are developed for accurate and reliable high-speed material properties of steels and metallic and polymeric materials. Improving the technological capabilities of industries and research institutes is promoted by managing the national standard reference database of high-speed material properties.

Center for Noise and Vibration Control (NOVIC+)

Director: **Prof. Youngjin Park**
Year established: **1993**

The objective of the center is to promote cooperation with industry to enhance education and basic and applied research in the area of noise and vibration control and newly emerging fields.

Humanoid Robot Research Center

Director: **Prof. PARK, Hae-Won**
Sponsor: **Ministry of Commerce Industry and Energy, Agency for Defense Development, National Research Foundation, Samsung Electronics, NAVER LABS**
Year established: **2005**

The ultimate goal of the research center is to enhance human welfare by providing and advancing robotics technologies that are essential for robot development and human-robot interaction.

Ultrafast Optics for Ultraprecision Technology Research Group

Director: **Prof. KIM, Young-Jin**
Year established: **2008**

- Establishing the new foundation for ultra-precision technologies enabling next-generation nano-fabrication and nano-metrology
- Development of noble coherent light sources covering the whole optical spectrum spanning from THz waves to X-ray
- Connecting ultrafast photonics to ultra-precision for IT, NT, BT and aerospace technology
- Strengthening the national capabilities for ultra-precision in distance metrology, precision manufacturing, optical communications and 6G THz technologies

Kaist Ocean Technology Center

Director: **Prof. LEE, Phill-Seung**
Year established: **2011**

Objectives
- Close links with shipbuilding, marine and related industries.
- Research and development of innovative ocean systems.
- Discovering large research projects related to ocean systems engineering.
- Laying the foundation for securing next-generation marine technologies.

Center for Functionally Antagonistic Nano-Engineering: Creative Research Initiatives (CRI)

Director: **Prof. Il-Kwon Oh**
Sponsor: **Ministry of Science, ICT and Future Planning**
Year established: **2015**

The present objective of the research center is to develop a new multiscale and multidisciplinary process that creates a strong engineering synergy between two antagonistic functions (viz., defect vs crystal, hydrophilic vs hydrophobic, conductive vs insulative, and energy dissipation and energy storage) based on multifunctional hetero nanostructures and materials.

Rehabilitation Engineering for Neurological disorders Worldwide Center (RENEW Center)

Director: **Prof. PARK, Hyung-Soon**
Year established: **2019**

Objectives
The present objective of the research center is to develop the patient-specific optimized rehabilitation method based on the profound understanding of the human motor function recovery. In this center, the human movement modeling from the neuron, neural network to the musculoskeletal system is studied, and the novel engineering approaches for effective neuro-rehabilitation are developed.

AI(Advanced and Intelligent) Platform Center for Manufacturing

Director: **Prof. YOON, Jeong Whan**
Sponsor: **Ministry of Science and ICT**
Year established: **2020**

The AI Platform Center for Manufacturing was opened to establish an education platform in the area of advanced manufacturing and to raise the next generation engineers for manufacturing innovation in the era of the 4th Industrial Revolution. Together with the establishment of an education platform in the advanced manufacturing field, the center aims to enhance the competitiveness of small and medium sized enterprises, to advance the education in the manufacturing field, and to foster competitive manpower through research, and industry-academia cooperation.

Research center for next-generation metal-supported protonic ceramic fuel cells

Director: **Prof. BAE, Joongmyeon**
Sponsor: **Ministry of Science and ICT**
Year established: **2021**

Objectives
This research center aims to develop core technologies for a world's first, novel, and next-generation hydrogen fuel cell; metal-supported protonic ceramic fuel cell. The ultimate goal of the center, based on the technologies, is vitalization and commercialization of the hydrogen industry infra-structure.

Korea Innovative Technology Startup Center

Director: **BAE, Joongmyeon**
Sponsor: **Ministry of Science and ICT**
Year established: **2016**

Objectives
Public Technology-Based Market Link Customer Discovery Support Project
To promote the commercialization of public research achievements under research by universities, the government supports Customer Discovery for start-ups in the market linkage.

KAIST-HHI Research Cooperation Center

Director: **LEE, Phill-Seung**
Year established: **2019**

Objectives
The research center focuses on strengthening industry-academic cooperation with Hyundai Heavy Industries Group and developing key technologies for next-generation manufacturing solutions.

KAIST-CERAGEM Next Generation Healthcare Research Center

Director: **Prof. PARK, Hyung-Soon**
Year established: **2021**

In KAIST-CERAGEM research center, KAIST research laboratories expertised in various healthcare science/engineering and the CERAGEM research center work together for developing future healthcare technology to prepare for the aging society worldwide.

Daedong-KAIST Research Center for Mobility

Director: **Prof. KIM, Kyung-Soo**
Year established: **2022**

Objectives
- Providing the research cooperation platform between KAIST and the Daedong, a Korean leading machinery company for agriculture.
- Developing the core technologies for autonomous agricultural machines and new mobility vehicles.
- Studies on the e-mobility systems using e-powertrains, sensors and batteries.

Faculty Startups

NANOSCOPE SYSTEMS

Founder GWEON, Dae-Gab(Emeritus Professor)

Year of establishment 2006

Web page http://www.nanoscope.co.kr

Nanoscope Systems, Inc. is a developer and manufacturer of a confocal laser scanning microscope. Established in 2006 by the engineering researchers specialized in confocal microscopy, we have successfully built up the world class confocal microscope for three-dimensional measurement and inspection in industrial applications and academic researches for the first time in Korea. As a leading developer and provider of confocal microscopic technology, we are dedicated to the realization of newer technology for three-dimensional measurement at higher speed with superior resolution. We believe that our continuous investment in research and development is the best way to increase our technical capabilities, and it is also the best way to enhance our customers' competitive position. We will strive to build customers' trust and royalty by providing reliable products and services.

RAINBOW ROBOTICS

Founder OH, Jun-Ho(Emeritus Professor)

Year of establishment 2011

Web page www.rainbow-robotics.com

Rainbow Robotics is a robot platforms company founded by a group of experienced researchers at the KAIST Humanoid Robot Research Center and HUBO Lab. From the world's best disaster response robots to cooperative robots (cobots) developed in-house and in Korea, Rainbow Robotics invests its energy and resources in commercializing robots by securing its own technology with relentless research and development, and by providing outstanding robots at reasonable prices. Using humanoid robotics technology, Rainbow Robotics researches and develops a wide variety of robots, including cobots, autonomous mobile robots, medical robots, quadruped walking robots, and astronomical mounts, and the company is always looking for new opportunities to expand into new areas of business. 'We touch the core' Moving forward, Rainbow Robotics aspires to leverage its superior technological capacities to become a leader in the global robotics field.

HnPower

Founder BAE, Joongmyeon

Year of establishment 2009

Web page http://www.hnpower.co.kr

HnPower is constantly striving to move towards a true hydrogen society. Our goals are to save Earth by creating a hydrogen society, prevent environmental pollution by reducing carbon emissions, provide animals and plants with a better life, and encourage hydrogen-related industries, which are in a rapid decline. We want to share the dream of an eco-friendly future through our products. HnPower is a leader in solving environmental issues with technology that covers the extraction and utilization of hydrogen. HnPower is the only company in the world that can extract hydrogen by reforming liquid raw materials. We can process not only light natural gas but also diesel and heavy marine oil. We can also obtain energy and produce clean oil using waste materials. We aim to solve environmental problems with technologies that extract and utilize hydrogen in various ways.

LATTICE TECHNOLOGY

Founder CHANG, Daejun

Year of establishment 2012

Web page https://lattice-technology.com

LATTICE Technology provides the LPV-based solutions of liquefied gases, especially for the energy and transport sectors. Lattice Pressure Vessel (LPV) is the world's first and unique free-shape free-size pressure vessels adaptable to any space. In this regard, it is a revolution in the area of pressure vessel technology and awarded "the ASME emerging technology award in pressure vessel in 2019". The LPV provides less CAPEX, less OPEX, more safety, more compact and better space utilization. This technology was approved by ASME, all major classification societies, and US Coastal Guard. It has been already commercialized in LNG, LPG, NH_3, CO_2, and liquid hydrogen (LH_2). LATTICE Technology is also developing an innovative vacuum insulation technology, called the V-CCS (Vacuum Cargo Containment System). The conventional vacuum insulation is based on the tank-in-tank configuration, which cannot be applicable to large-scale LH_2 storage such as cargo tanks for ships and terminals handling LH_2. Since the V-CCS is modular and limitless scalable, it is a breakthrough insulation solution for large-scale LH_2 storage.

Faculty Startups

J-micro

Founder LEE, Seung Seob

Year of establishment 2017

Web page https://www.jmicro.co.kr

Jmicro is a manufacturer of ‘transparent conductive films’ with high performance (90% transparency and 0.3 Ω /sq). Currently, we are manufacturing and developing various application products such as ‘transparent antenna film’ and ‘transparent heating film’ using ‘transparent conductive film’. We have developed ‘transparent antenna film’ with a company specializing in antennas and are promoting it in the U.S. and Europe. And we are developing 'smart glass for mobility' with Korean auto parts manufacturers.

ANGEL ROBOTICS

ROBOTICS FOR BETTER LIFE

Founder KONG, Kyoungchul

Year of establishment 2017

Web page www.angel-robotics.com

Angel robotics creates robot technologies for helping everyone enjoy everyday life. We develop robots to help people with difficulty in walking, so that they can walk by themselves and overcome their disabilities. In addition, we are developing robots that can protect people from injuries in the workplace, and help systematic health care in daily life.

ROEN SURGICAL

Founder KWON, Dong-Soo(Emeritus Professor)

Year of establishment 2018

Web page www.roensurgical.com

ROEN Surgical is a company created by a group of young researchers to develop excellent surgical robot systems to contribute to patients, doctors, and society. We strive to bring flexible robotics to the surgery room, to introduce the next generation of robotic surgery. Flexible robots enable surgeries that previously required incision, to be scarless.

A2US

Founder LEE, Seung Seob

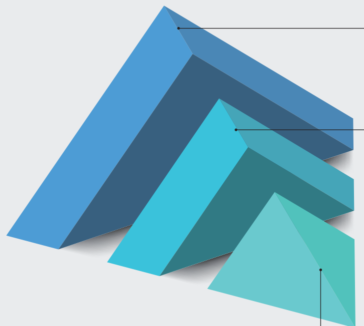
Year of establishment 2021

Web page http://a2us.co.kr

A2US is a company founded based on ‘Water Micro Electrospray’ technology. ‘Water Micro Electrospray’ of A2US is a new concept of technology that can simultaneously perform functions such as “antibacterial/antivirus,” “humidification,” “fine dust removal,” and “deodorization.” Currently, products that can be applied to various fields such as homes, public facilities, and agriculture are being developed in cooperation with various companies and research institutes.

Industry Cooperations

Industry Cooperations



Industrial Advisory Board

- Consultation and Evaluation of Department education and research activities
- IAB Annual Boards Meeting consisting of twelve industry representatives
- Systematization of Industry cooperation and Providing specialized human resources
- Direct bridge between KAIST-Industry for promoting cooperation and mutual relationship

Industry Academia Consortium

- Direct bridge between KAIST-Industry for promoting cooperation and mutual relationship
- Consulting technology problems in Industry
- Dispatch of cooperation human resources

Industry-cooperated open lecture

- 198 open lectures held since 1982
- Providing research expertise from traditional and new areas of ME

IAB (Industrial Advisory Board)

In order to reflect opinions from industries on education and research, we have established the IAB (Industrial Advisory Board) and held annual meetings of the board of directors of IAB. We systematize industry-academia cooperation and provide on-demand high-quality human resources. IAB advises and evaluates education and research activities and helps industries to understand the research achievements produced by KAIST ME. IAB serves as a direct bridge to enhance mutual understanding and cooperation between industries and KAIST ME.

Industry-Academia Consortium

An industry-academia consortium is run by the department to improve industry-academic cooperation. The consortia include Samsung Heavy Industries, LG Electronics, Hyundai Heavy Industries, Korea Institute of Machinery & Materials. The consortium carries out industry-KAIST ME research and development, consultations on industry-related technologies, and exchanges of manpower and academic information together with on-demand education using the KAIST scholarship program. A steering committee for each consortium meets twice a year on a regular basis.

Short Courses for Engineers in Industry

In order to transfer professional knowledge and new technologies to industry, more than 198 short courses have been provided since 1982. For engineers in the automotive, electronics, ocean, aeronautical, and heavy industries, where many ME alumni hold positions, we provide not only fundamental subjects but also high-quality specialized knowledge in emerging fields of mechanical engineering. Students from other universities also attend these short courses to gain an understanding of recent technologies and trends.

Industry Collaboration Programs

1999 | **SHI-KAIST** Samsung Heavy Industries · **POSCO-BK21** POSCO

2005 | **HANON-KAIST** Hanon Systems · **DHI-KAIST** Doosan Heavy Industries

2006 | **DI-KAIST** Doosan Infracore · **DSME-KAIST** Daewoo Shipbuilding and Marine Eng.

2008 | **STX-KAIST** STX Offshore and Shipbuilding

2010 | **SCP-KAIST** Samsung Corning Precision Materials · **MI-KAIST** Microinspection · **LG-KAIST** LG Electronics

2013 | **KATECH-KAIST** Korea Automotive Technology Institute

2015 | **HHI-KAIST** Hyundai Heavy Industries

2016 | **HYUNDAI-KAIST** Hyundai Motor co.

2018 | **NAVER LABS-KAIST** Naver Labs. · **KIMM-KAIST** Korea Institute of Machinery & Materials

2021 | **CERAGEM-KAIST** CERAGEM

2022 | **DAEDONG-KAIST** Daedong

ME Co-op Programs

An educational program designed for third- and fourth-year undergraduate students of the Department of Mechanical Engineering at KAIST to gain real-world research experience and gain credits by participating in a joint project between KAIST and a matched company through two months of prior learning at KAIST and six months of full-time dispatch at the participating company (1+9 credits to be completed)

Program Organization

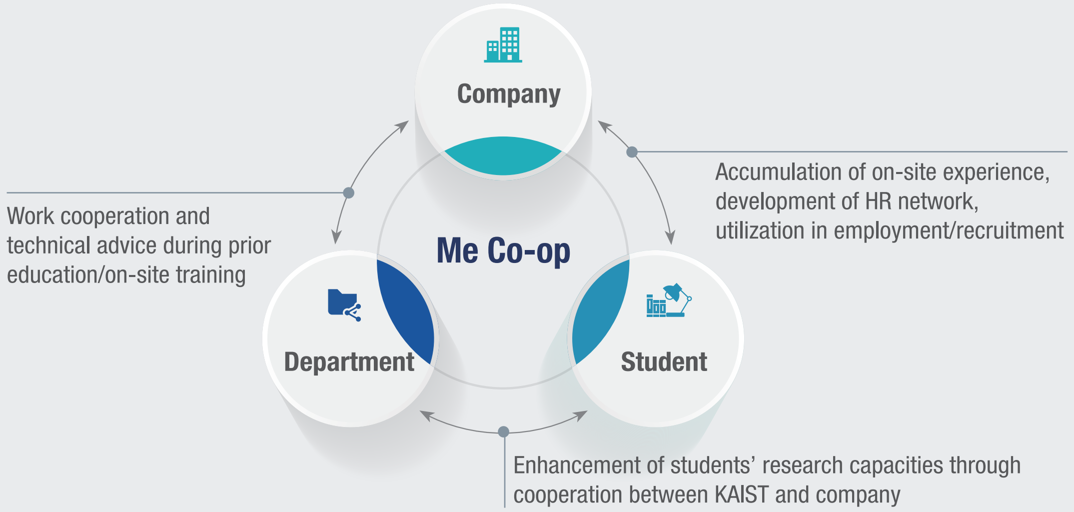
Prior Learning (2 months)

Students conduct individual research during the school break in a laboratory related to duties proposed by the company to make up for their absence from classes during on-site training and gain knowledge in their major (1 credit)

On-site Training Semester (6 months)

Students gain real-world experience by participating in a six-month customized project during the regular semester and school break (Spring semester: March–August / Fall semester: September–February, 9 credits)

Program Characteristics and Expected Outcomes



1. Students matched to companies based on company-provided work plans
2. Two-month prior education conducted to minimize companies' burden of providing job training for students
3. Students can make practical contributions by participating in actual projects during the long-term dispatch (six months)
4. KAIST ME Co-op Center conducts one mid-term assessment during the six-month program, and organizes company visits or student guidance where necessary
5. Efficient on-site training supported by continuous cooperation via the KAIST ME laboratory-business-student network
6. Support for participation in prestigious exhibitions at home and abroad (CES, etc.) based on outcomes
7. Follow-up research and startup support using outcomes

List of Participating Companies in ME Co-op Program

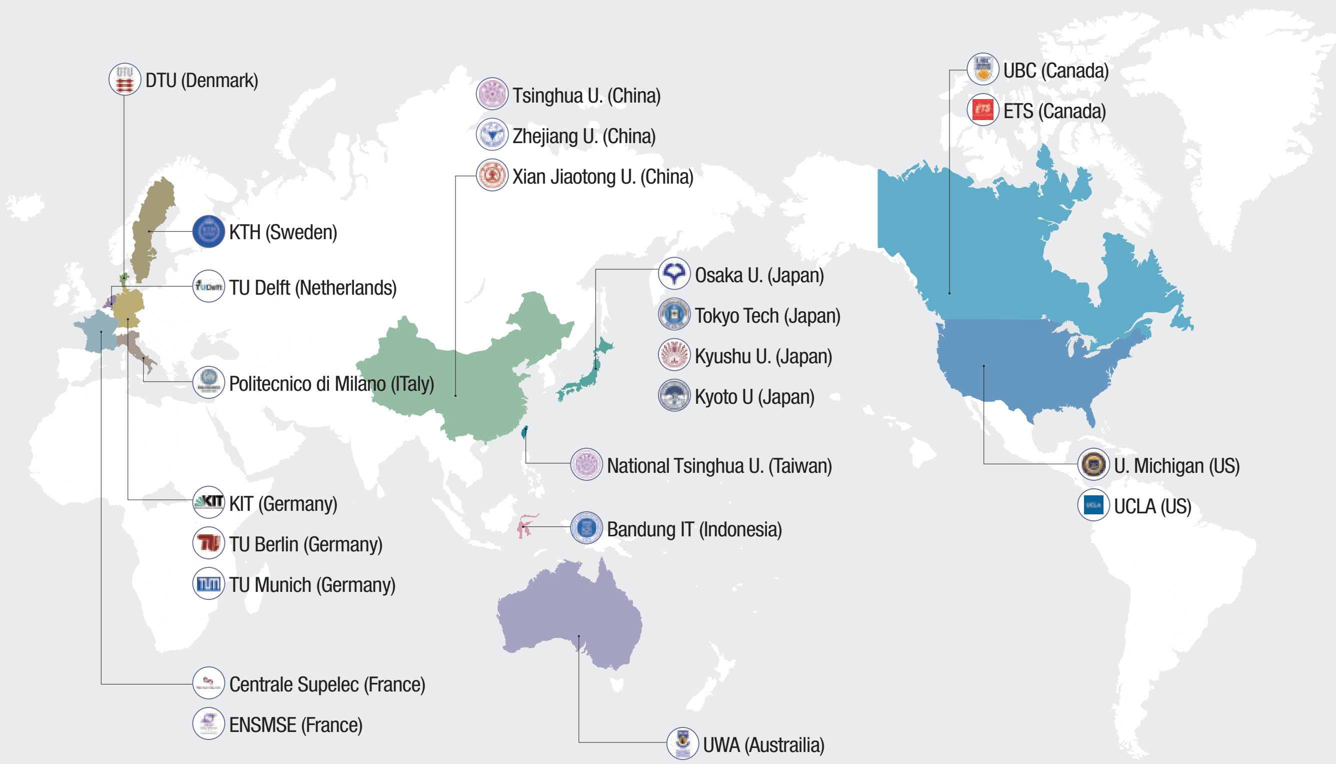
Period	Participating Companies
Fall/winter 2019	Naver Labs, Samsung Heavy Industries, InBody, Hanon Systems
Spring/summer 2020	Koh Young Technology, InBody, Hanon Systems
Fall/winter 2020	Koh Young Technology, Naver Labs, InBody, Samsung Heavy Industries, Comotomo, Korea Institute of Science and Technology
Spring/summer 2021	InBody
Fall/winter 2021	Naver Labs, Samsung Electronics, Samsung Heavy Industries, Angel Robotics, InBody, Korea Institute of Science and Technology, Hanon Systems
Spring/summer 2022	Samsung Heavy Industries, Angel Robotics, InBody, Korea Institute of Science and Technology
Fall/winter 2022	42dot, Samsung Electronics, Samsung Heavy Industries, Angel Robotics, InBody

International Collaboration(Dual Degrees/MOUs)

The goal of international collaboration is to achieve practical globalization such that students can be nurtured as global leaders. To strengthen the capability of graduate students as global leaders, we run a dual-degree program, long-term and short-term exchange programs, and international student symposiums organized by graduate students. In addition, our international collaborative research activities with overseas industries and universities are extensive. With such efforts, the numbers of graduate students and alumni going abroad and faculty visiting overseas universities are increasing continuously. In addition, the world-leading international conferences in Korea organized by ME faculty members increase the opportunities for student participation and enhance the visibility of our department.

MOU (Memorandum of Understanding)

We have MOU agreements to promote exchanges of faculty and students, for the publication of educational information, to realize international joint lectures, and to undertake joint workshops with overseas institutes. Currently, we have MOUs with 34 institutes (Asia 16, Europe 11, North America 6, Oceania 1), including the University of Michigan, UCLA, ITB, Tokyo Tech. We are in the process of reaching agreements with other renowned institutes, to be completed in the near future.

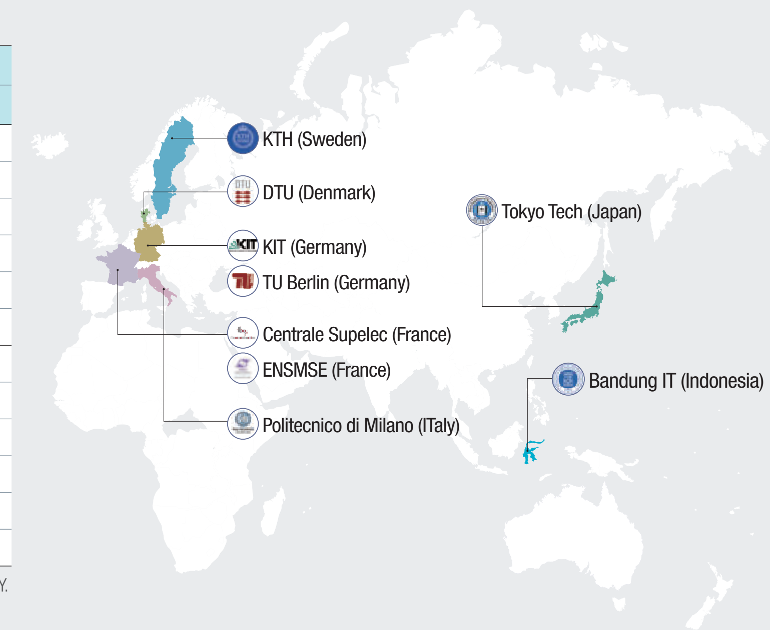


Dual-Degree Program

We have implemented a dual-degree program and produced 38 M.S. graduates from the dual-degree program thus far. The dual-degree program is an educational program that pursues the globalization of graduate students. Students are exchanged under mutually agreed-upon principles with overseas universities, where the students obtain an overseas dual degree as well as diverse international experience and a broadened viewpoint. The dual-degree program plays an important role in educating international human resources and in enhancing the department's global competitiveness. We have exchanged graduate students through the dual-degree program with KTH Royal Institute of Technology (KTH), Tokyo Institute of Technology, Karlsruhe Institute of Technology (KIT), Politecnico di Milano (PoliMi) and the Technical University of Denmark (DTU).

	University	Number of students	
		Completed	Enrolled
Inbound	TU Berlin	6	0
	KIT	17	4
	ENSMSE	1	0
	DTU	12	2
	KTH	2	1
	Politecnico di Milano	2	3
Outbound	KIT	4	0
	ENSMSE	1	0
	Tokyo Institute of Tech	1	0
	DTU	8	0
	Centrale suplec	1	0
	Politecnico di Milano	1	0

※ Due to the uncertainty of COVID-19 situation, outbound has shrunk in 2021/2022 AY.



International Collaborative Research Activities

Continuous and practical collaborative research activities play a significant role in world-class research and provide opportunities for students to participate in research activities. We are involved in international collaborative research activities with overseas universities, research institutes, and industries, such as Drexel University, the University of Arizona, HP Company, Aramco Overseas Company, the Institute for Infocomm Research, the Office of Naval Research Global, and the US National Science Foundation.

Long-term and Short-term Exchange Programs for Graduate Students

We offer long-term exchange programs to provide opportunities for students to study and conduct research at overseas universities and overseas companies. The period of the long-term exchange program is a minimum of two months and a maximum of 12 months. Funding for living expenses and round-trip airfare are provided through the BK21 program. More than ten students have visited and carried out research at overseas universities and research institutes.

A short-term exchange program lasting less than two months is offered to enhance the capabilities of graduate students in their efforts to conduct research by attending and presenting papers at international conferences and workshops. In particular, graduate students are encouraged to organize and participate in student symposiums, such as the KAIST-Kyushu university student symposium and the China-Japan-Korea student symposium.

Faculty

Professor

Professor	Laboratory	E-mail
BAE, Choongsik	Future Transport Power Laboratory	csbae@kaist.ac.kr
BAE, Joongmyeon	New Energy Conversion System Laboratory	jmbae@kaist.ac.kr
CHANG, Daejun	Innovative Energy Systems Engineering Laboratory	djchang@kaist.ac.kr
CHO, Yeunwoo	Waves & Fluid Mechanics Laboratory	ywoocho@kaist.ac.kr
CHOI, Seibum	Automotive Control Laboratory	sbchoi@kaist.ac.kr
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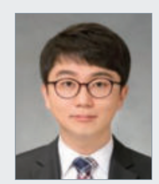

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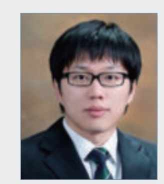

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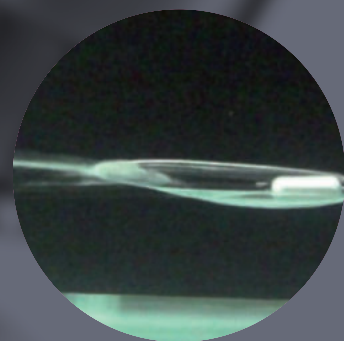
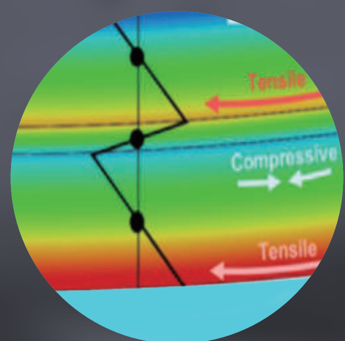
RESEARCH AREAS

Materials, Mechanics, and Manufacturing

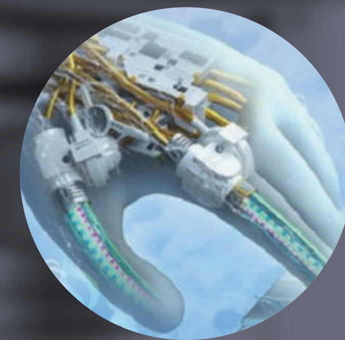
Energy, Environment and Ocean

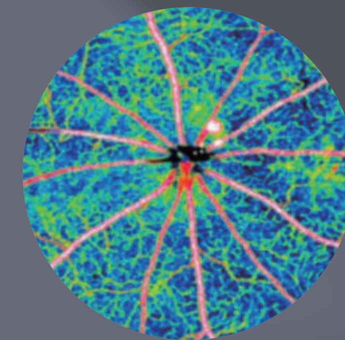


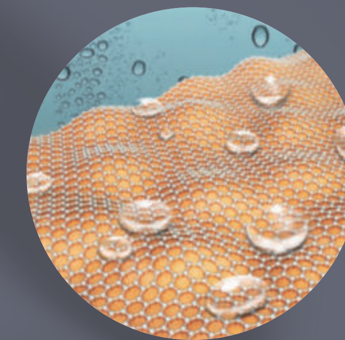
Robotics, Control and Mobility

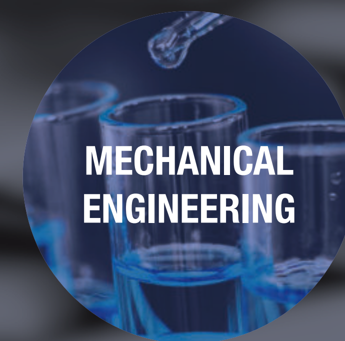


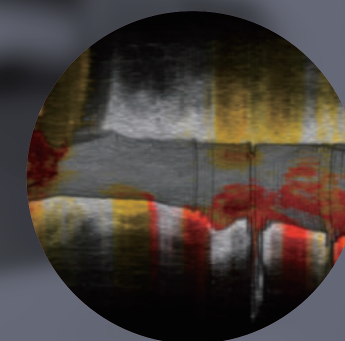
Healthcare, Nano and Optics







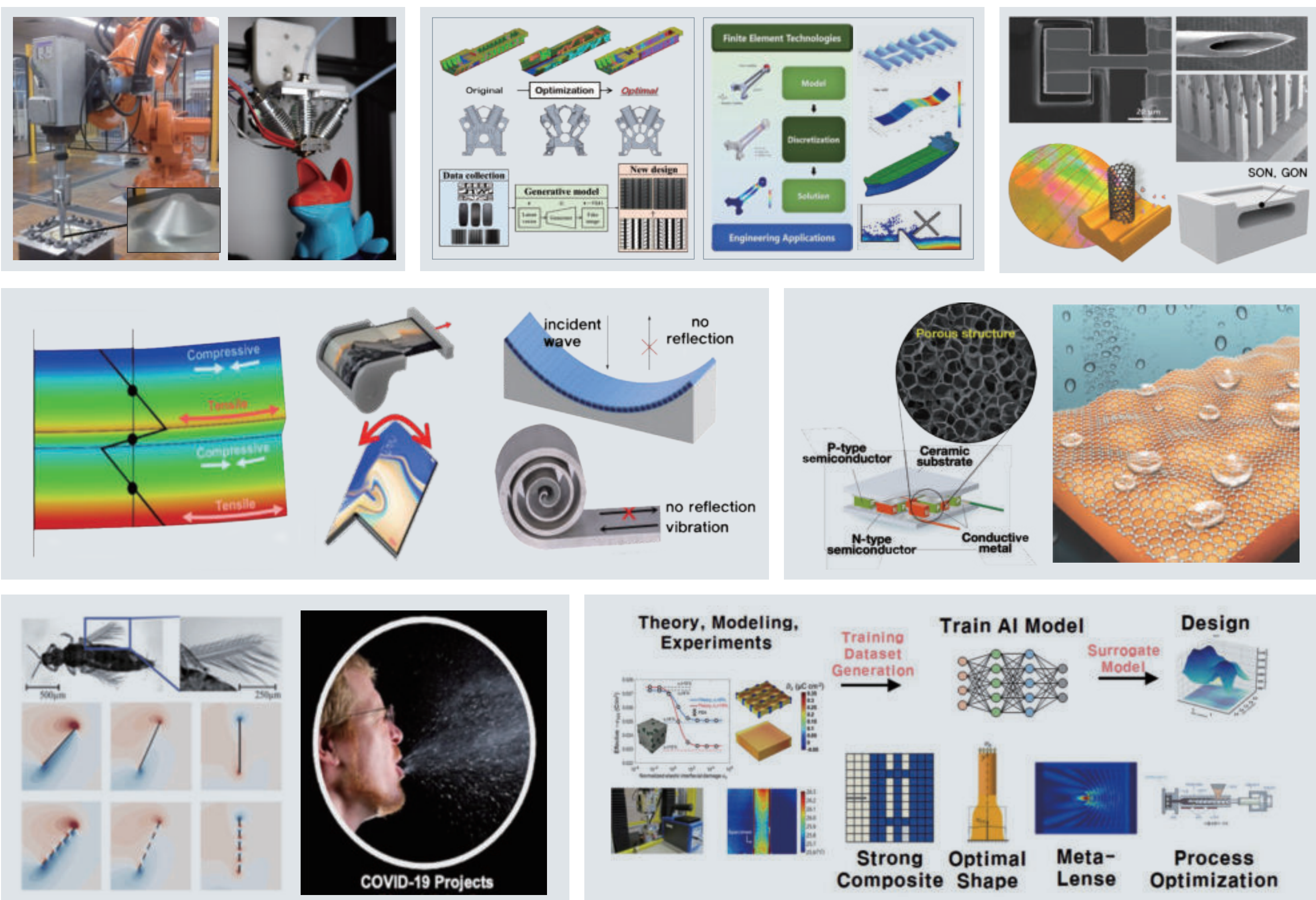




Materials, Mechanics and Manufacturing

We keep strengthening our global leadership in the field of Materials, Mechanics, and Manufacturing by establishing fundamentals in mechanics, by analyzing and applying new materials and structures, and by developing design and production strategies based on innovative theories and AI algorithms to realize high-reliability, high-precision, and intelligent system, which is essential in the key national industries, including automotive, semiconductor, aerospace, shipbuilding, electronics, and energy.

- Establish fundamentals in mechanics to quantitatively understand and effectively utilize physical phenomena that exist in a variety of ways from everyday life to industries
- Analyze thermal & mechanical characteristics of various materials, such as metals, polymers, ceramics, composites, and advanced materials, and their structures and systems
- Understand mechanics and develop analysis techniques for macroscopic systems such as automobiles, aerospace, and shipbuilding, and for microscopic systems such as semiconductors, electronic components, and secondary batteries
- Develop optimal design techniques and advanced production processes, which is essential for high value-added manufacturing industries
- Realize intelligent and autonomous material characterization and manufacturing processes for future customized flexible production system
- Utilize AI and big data in the entire manufacturing cycle, 'material development - shape design - process optimization'

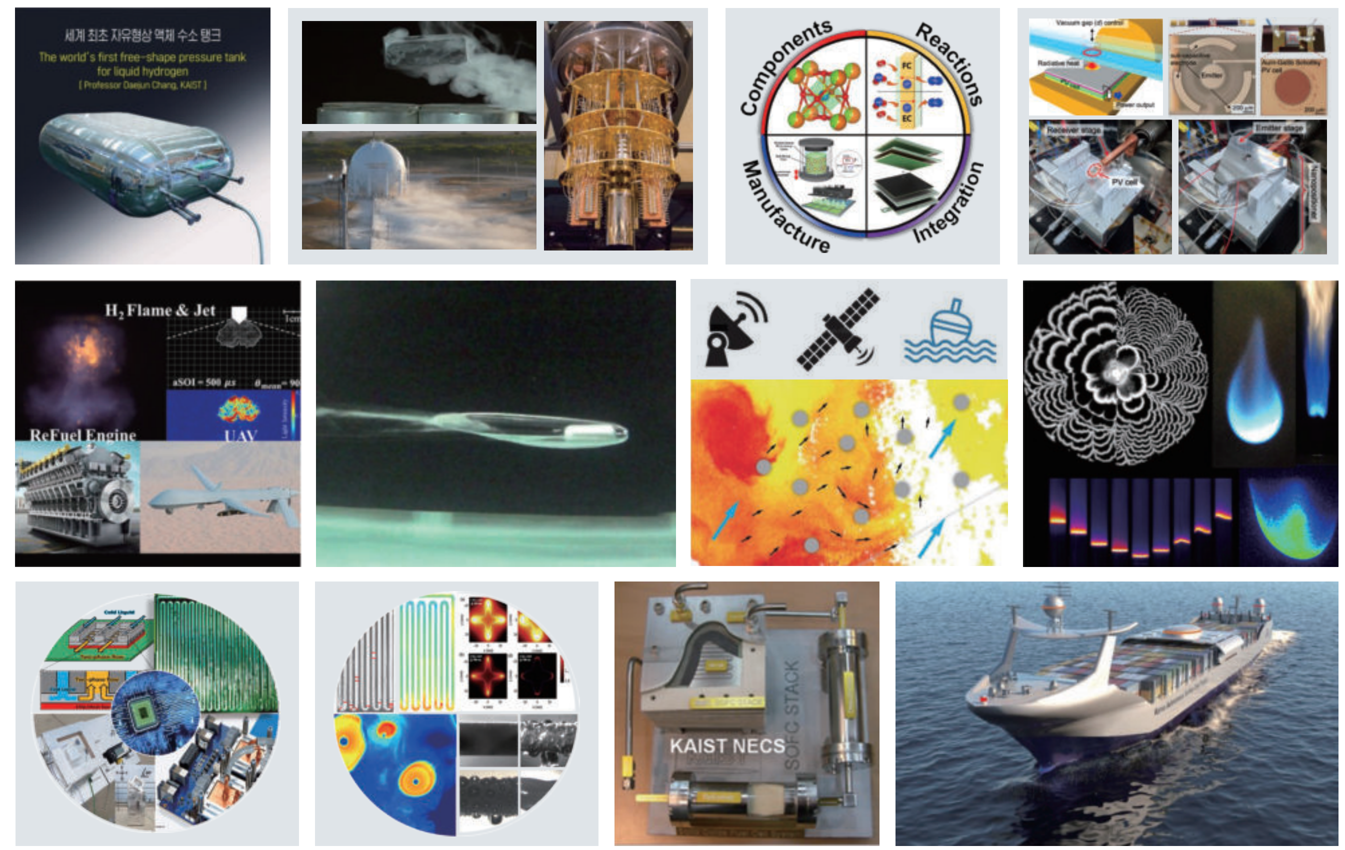


1 Customized & Personalized Manufacturing with High Process Flexibility 2 Optimized Design, Computer Modeling & Simulation, Digital Twin
3 Micro/Nano Ultra-Precision Machining & Measurement 4 Rollable/Foldable Multi-Layered Devices & Noise/Vibration Cancelling Composite Structures
5 Mechanical Design using Advanced Nano Materials 6 Fluid-Structure-Environmental Interaction 7 AI/Big-Data Infused Design & Manufacturing

Energy, Environment and Ocean

Research on state-of-the-art technologies for response to climate change and sustainability: Carbon-neutral & Eco-friendly & Higly Efficient Energy Conversion/Storage/Transfer System, Carbon-neutral Power Generation, Ocean Renewable Energy (Wind Power/Photovoltaics/Tidal Power), Large-scale Energy Storage.

- New energy conversion and storage technology for green hydrogen production and eco-friendly power generation
- Multi-scale energy system design for CO_2 capture and emission reduction technology & hybrid/hydrogen engine toward carbon-neutrality
- Free-shape liquid hydrogen storage & Cryogenic applications research & Superconducting quantum computers
- Heat transfer & fluid mechanics-based technologies including combustion system control, AI-based heat exchange design, nanoscale thermal energy transfer, and supercavitation
- Global infrastructure technology for marine data-based statistical analysis, renewable energy exploration technology and intercontinental energy transport system
- Thermal management technology for wearable & portable devices and data management center for artificial intelligence / big data / cloud computing



1 Liquid Hydrogen Storage 2 Cryogenics Cryocooler Design Applied Superconductivity 3 Fuel Cells/Electrolysis Cells 4 Energy Conversion Devices
5 Carbon-neutral Energy Technology 6 Fluid Mechanics/Supercavitation 7 Environmental Fluid Dynamics/Environmental Sensing 8 Clean Combustion Technology
9 Cooling Technology for Semiconductor 10 Heat Transfer Enhancement 11 Hydrogen Energy System 12 Autonomous Surface Ship Technology

Robotics, Control and Mobility

Our research group aims to enhance the visibility of mechanical engineering technologies required by the 4th Industrial Revolution and to support related domestic industries for global technological competitiveness. Our research areas include intelligent robots and future mobility that represent cutting-edge research in mechanical engineering and, in addition, medical and rehabilitation robotic research that can improve the quality of human life.

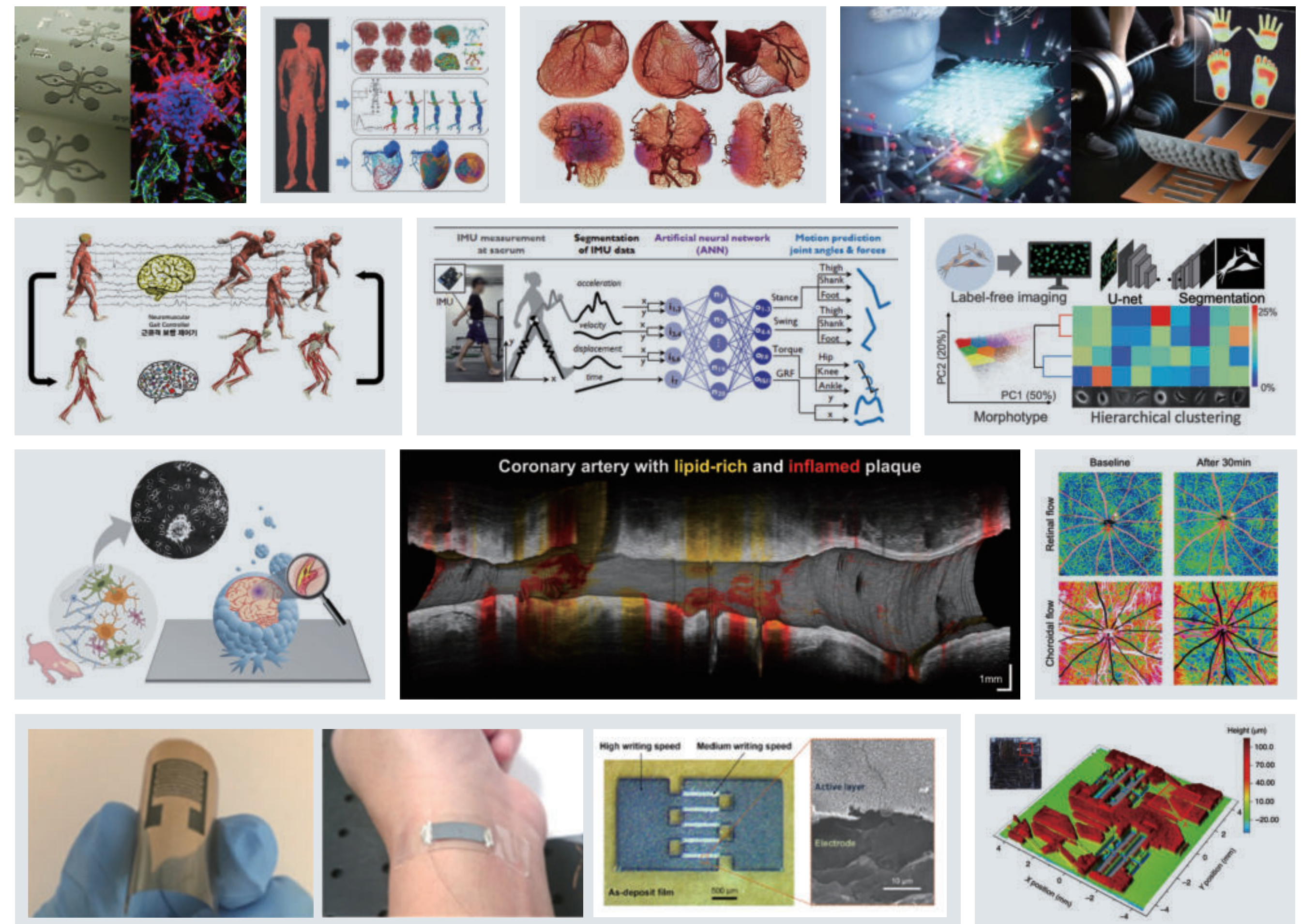
- Design and control of mechatronic systems representing intelligent advanced machines as the combination of mechanical and electronic systems
- Future mobility and mobile robot technologies that will change the paradigm of transportation and logistics
- Humanoid and multi-legged robots as new mobility platforms to overcome the limitations of existing mobile robots
- Medical, rehabilitation and wearable robots that will play a key role in improving the quality of human life in a rapidly aging society
- Development of soft robot, sensor and artificial muscle driver technology to overcome the limitations and disadvantages of existing sensors and actuators
- Emotional engineering technology that analyzes the characteristics of hearing and visual functions and actively reflects them in product design
- Maximize the usefulness of technology in real-world physical environments by incorporating software technology, machine learning and computer vision technology into machine/hardware systems

❶ ❷ ❸ ❶Humanoid and multi-legged robots ❷Medical, rehabilitation and wearable robots ❸Future mobility, transportation and mobile robots
❹ ❺ ❻ ❹Machine learning and computer vision ❺Vibration, sound, vision and emotional engineering ❻Soft robotics, sensors and actuators
❼ ❽ ❼Design and control of mechatronic systems ❽Biomechanics and machine-learning based healthcare

Healthcare, Nano and Optics

We investigate the mechanical properties of biological systems ranging from cells to tissues to the human body, and develop sensors, microfluidic chips, disease models, biomaterials, and algorithms for diagnosis and treatments. We also perform researches on the high-tech sensors, actuators, and displays based on the design and manufacturing of micro/nanoscale materials and structures. In addition, we develop novel photonic measurement, machining, patterning, and imaging technologies, and explore their application to healthcare and various industrial manufacturing processes.

- Development of organ and disease models, AI-based cell classification algorithms, and patient-specific drug screening technologies
- Understanding the dynamics and control mechanisms of the musculoskeletal and nervous systems for human movement and apply them to customized healthcare and sports training
- Development and application of computerized methods for accurate understanding of biological and industrial systems
- Development of cutting edge photonic imaging technologies and application to healthcare and industrial manufacturing processes
- Development of ultrafast laser-based ultra-precision measurement/control/manufacturing/patterning technologies
- Development of nanosensor devices and systems and application to healthcare and environment IoT



❶ ❷ ❸ ❹ ❶Lab-on-a-chip & organ-on-a-chip ❷Diagnosis of Cardiovascular Disease ❸Computational Biomechanics ❹Micro/nano-structure based environment & healthcare sensors
❺ ❻ ❼ ❺Human musculoskeletal digital twin ❻AI-based human dynamics estimation ❼AI-Based Cellular Morphotyping
❽ ❾ ❿ ❽Cell-Based Disease Model ❾Optical biomedical imaging technology ❿Photonic blood flow imaging for early disease diagnosis
⓫ ⓬ ⓫Ultra-fast laser based ultra-precision patterning ⓬Ultrahigh-speed & precision 3D photonic imaging

RESEARCH HIGHLIGHTS

Mechanically-reinforced soft gripper for lifting extremely high payloads

KYUNG, Ki-Uk

Robotic technology that enables people to walk again

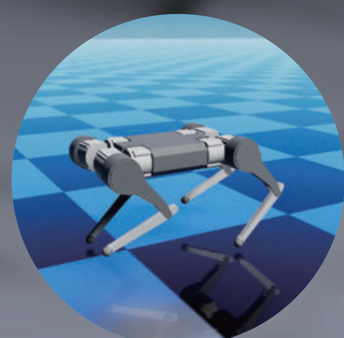
KONG, Kyoungchul

Coffee-ring-less Polygonal Quantum Dots Patterns for Display Diodes Using Self-induced Marangoni Flows

KIM, Hyoungsoo

Ultra-stable transfer of laser light over an 18 km open-air link

KIM, Seung-Woo
KIM, Young-Jin



Enabling legged robots to perform acrobatic maneuvers

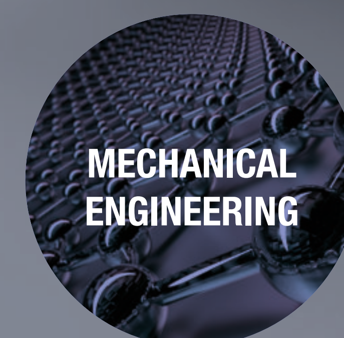
PARK, Hae-Won

Multilayer metrology

KIM, Jungwon

Synergizing optical imaging and machine learning to diagnose coronary artery disease accurately

YOO, Hongki



Microfluidic platform for tumor microenvironments through the formation of an oxygen tension gradient

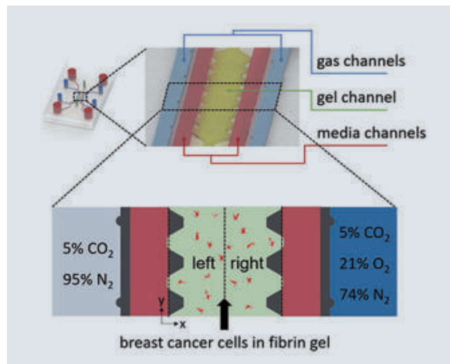
JEON, Jessie Sungyun

Microfluidic platform for tumor microenvironments through the formation of an oxygen tension gradient

Associate Professor
JEON, Jessie Sungyun

Research Interests
Microfluidics / Lab-on-a-chip / Organ-on-a-chip / Drug screening platform / *In vitro* disease microenvironment

The simplified design of a tumor microenvironment using microfluidic devices enables the investigation of cancer cell responses to varying oxygen tensions and cancer drugs in a hypoxic tumor microenvironment.



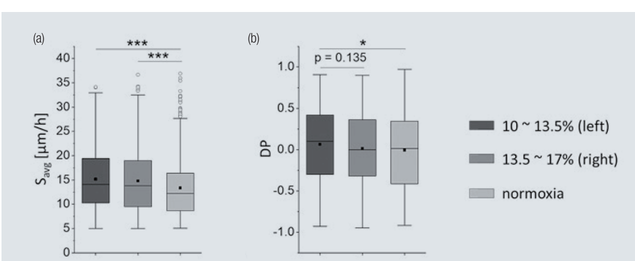
Cancer metastasis, which is prevalent in malignant tumors, is present in a variety of cases depending on the primary tumor and metastatic site. The cancer metastasis is affected by various factors that surround and constitute a tumor microenvironment. One of the several factors, oxygen tension, can affect cancer cells and induce changes in many ways, including motility, directionality, and viability.

A research team of Prof. Jessie S. Jeon in the Department of Mechanical Engineering at KAIST and Prof. Kenichi Funamoto in the Institute of Fluid Science at Tohoku University employed a microfluidic device composed of oxygen-permeable poly(dimethylsiloxane) to mimic the oxygen tension gradient in the tumor microenvironment and confirmed its feasibility through the cell response and various applications according to different oxygen levels.

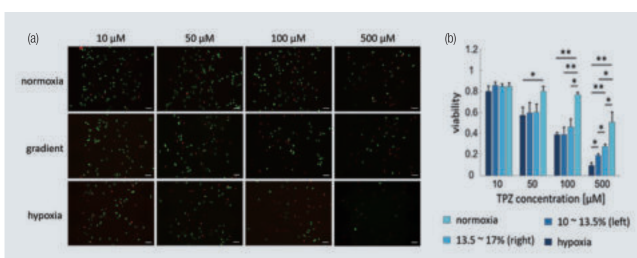
Under an oxygen tension gradient, the average speed increased with decreasing oxygen tension. Also, the directional persistence in the right gradient and left gradient increased by 2.27-fold and 9.7-fold compared to the absolute mean value of directional persistence in normoxic condition, showing a significant increase in the left gradient condition compared to normoxic condition [Figure 1]. As a result, the cancer cells tended to migrate in the direction of higher oxygen tension, which was enhanced in lower oxygen tension ranges, suggesting that oxygen plays an important role in cancer metastasis.

More importantly, when the anticancer drug was treated for 48 hours, the viability of the cancer cells varied significantly as the oxygen tension decreased. When the concentration of Tirapazamine was 500 ㎛, the viability decreased by 88.38% in hypoxia to 0.093 ∓ 0.029 compared to 10 ㎛, whereas in normoxia, the viability was 0.51 ∓ 0.097, which was 40% decrease compared to 10 ㎛ [Figure 2].

The microfluidic device, which is designed to consider the oxygen gradient in tumor microenvironment, makes it possible to more clearly observe the causal relationship between the changes in the oxygen tension and the responses of the cancer cells that were difficult to observe previously. This research was published in Biomicrofluidics under the title of "Cancer cell migration and cancer drug screening in oxygen tension gradient chip" (DOI: 10.1063/5.0011216). All figures are reproduced from [Biomicrofluidics 14 (4), 044107 (2020)], with the permission of AIP Publishing.



[Figure 1.] (a) The average speed, Savg. The cancer cells had higher Savg at lower oxygen tensions. (b) The directional displacement, DP. The lower and upper boundaries of each box represent the 1st quartile (Q1) and 3rd quartile (Q3), respectively, and the whisker ranges from minimum to maximum, where the minimum and maximum are Q1 minus 1.5 times the box's interquartile range and Q3 plus 1.5 times the interquartile range, respectively. The horizontal line and the rectangular dot in each box are the median and the mean, respectively, and the circular points outside the whisker is the outliers. *p < 0.05, **p < 0.01, and ***p < 0.001.



[Figure 2.] (a) Representative live/dead micrographs different oxygen tensions and TPZ concentrations. (b) Viability of the cancer cells for different TPZ concentration and oxygen tensions. Scale bars = 100 ㎛. Error bars represent the standard error of the mean (n = 3). *p < 0.05 and **p < 0.01.

Multilayer metrology:

Combining optical spectral measurements and machine learning

Professor
KIM, Jungwon

Research Interests
Advanced laser engineering / Sensors and imaging / Photonic signal processing / Industrial laser metrology

A joint research team of Prof. Jungwon Kim and Samsung Electronics demonstrate a non-destructive method for thickness characterization of 3D semiconductor devices. The team could characterize the thickness of each layer with an average error of 1.6 Å over >200 layers.

With the recent explosive demand for data storage, ranging from data centers to various smart and connected devices, the need for higher-capacity and more compact memory devices is constantly increasing. As a result, semiconductor devices are now moving from 2D to 3D. The 3D-NAND flash memory is the most commercially successful 3D semiconductor device today, and its demand for supporting our data-driven world is now growing exponentially.

The scaling law for 3D devices is achieved by stacking an increasing number of semiconductor layers, well above 100 layers, in a more reliable way. As each layer's thickness corresponds to the effective channel length, accurate characterization and control of layer-by-layer thickness is critical. Unfortunately, to date, in structures with hundreds of layers, accurate non-destructive measurement of each layer's thickness has not been possible, which creates a serious bottleneck in the future scaling of 3D devices.

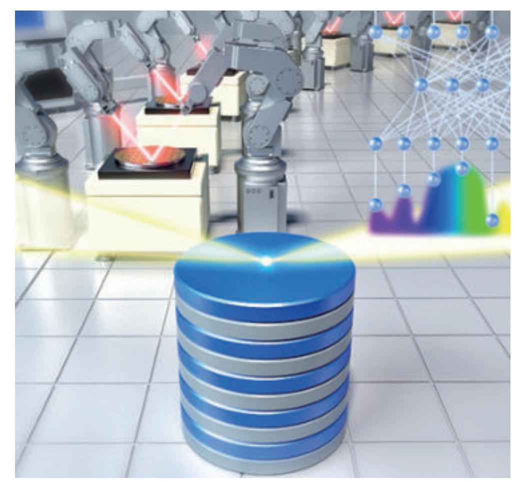
In a new paper published in Light: Advanced Manufacturing, a team of engineers from KAIST and Samsung Electronics Co. Ltd., led by Professor Jungwon Kim of KAIST has developed a non-destructive thickness characterization method by combining optical spectral measurements and machine learning. By exploiting the structural similarity between semiconductor multilayer stacks and dielectric multilayer mirrors, spectroscopic optical measurements, including ellipsometric and reflectance measurements, are employed. Machine learning is then used to extract the correlation between spectroscopic measurement data and multilayer thickness. For multilayer stacks with more than 200 layers of oxide and nitride, the thickness of each layer over the entire stack could be determined with an average of approximately 1.6 Å root-mean-square error.

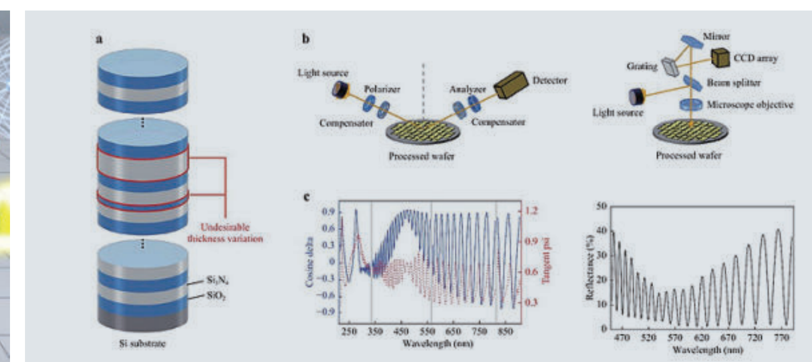
In addition to the accurate determination of the multilayer thickness under normal fabrication conditions, which is helpful for controlling etching and deposition processes, the research team developed another machine learning model that can detect outliers when layer thicknesses significantly vary from the design target. It used a large number of simulated spectral data for more effective and economical training and could successfully detect the faulty devices and the exact erroneous layer location in the devices.

"The machine learning approach is useful for eliminating measurement-related issues," said Hyunsoo Kwak, a doctoral student at KAIST and first author of the study. "By using noise-injected spectral data as input to the machine learning algorithm, we can eliminate various errors from measurement instruments and changes in material properties under different fabrication conditions," he added.

"This method can be readily applied for the total inspection of various 3D semiconductor devices," said Professor Kim, "which is exemplified by the fact that all the data used in this work were obtained in commercial 3D NAND manufacturing lines of Samsung Electronics."

This research was supported by the Industry–Academia Cooperation Program of Samsung Electronics Co., Ltd.





[Fig 2.] Principles of the proposed multilayer thickness metrology method. a. Multilayer structure with alternating silicon oxide (blue) and silicon nitride (white) layers on a Si substrate. In the layer deposition process, undesirable thickness variations can occur. b. Schematics of a typical spectroscopic ellipsometer (left) and reflectometer (right).c. Examples of ellipsometric (left) and reflectance (right) measurement data. For the ellipsometric measurement data, the solid and dashed lines denote cosine-delta and tangent-psi, respectively. The grey areas indicate the unused spectral range, where the measurement errors between the instruments are large.

Coffee-ring-less Polygonal Quantum Dots Patterns for Display Diodes Using Self-induced Marangoni Flows

Associate Professor
KIM, Hyoungsoo

Research Interests
Soft Matter / Fluid Mechanics / Complex Fluids / Experimental Hydrodynamics

Professor Hyoungsoo Kim's research team developed a novel coating technology to completely eliminate coffee-ring patterns of quantum dots, which are applicable for the next-generation display devices. Also, the research team can achieve uniform coating patterns from circular to polygonal shapes regardless of the pattern shape.

Recently, quantum dots have been spotlighted as an attractive material for next-generation displays. So, there are enormous efforts and contributions to develop its coating method for the display diode. However, there is still an efficiency issue due to limited mass productivity, resolution, and coffee-ring patterns.

The coffee-ring stains are still one of the most troublesome issues for the ink-jet printing technology, which is occurred due to the relatively non-uniform evaporation rate along the droplet surface. The research team found out that if the multiple arrays of binary mixture droplets evaporated together in a confined space, the coffee-ring was totally suppressed by the self-induced vapor-driven solutal Marangoni flows. Furthermore, they showed that it is possible to create a totally uniform dried mark regardless of the shape of the pattern by properly adjusting the component ratio of the solvent in which the quantum dots are dissolved and the size of the confined space. In fact, if the droplet shape is polygonal, the Marangoni effects become pre-dominant due to its vertex structure and the coffee-ring effect will be eventually disappeared. Using the current technique, it is able to fabricate various pattern sizes from O(100 um) to O(1 mm). Sum up, the primary advantage of the current method is that complicated physico-chemical processes can be avoided by using a simple evaporation of multiple neighboring binary mixture droplets.

The research team said, "Quantum dot patterns for QLEDs can be easily modified by manufacturing process factors, which can damage to the QLEDs diodes. If we can use inkjet-based printing technology combining with our techniques, the self-induced sequential Marangoni effects can create a coffee-ring-less QLEDs multi-arrays using a simple evaporation method." Furthermore, they developed a theoretical model providing a control parameter for Marangoni effects and uniform coating results.

The current method can be applied to the ink-jet printing process for actual display mass production in which any complex physico-chemical treatments are not required for the red, green, and blue quantum dot patterns of high-efficient next-generation quantum dot LED display. Also, due to its drop-on-demand process, this method can save expensive materials used in printed electronics accordingly and simple large-area printing can be performed effectively.

This research was carried out with support from the National Research Foundation and supported by the Individual Basic Research (NRF-2021R1A2C2007835).

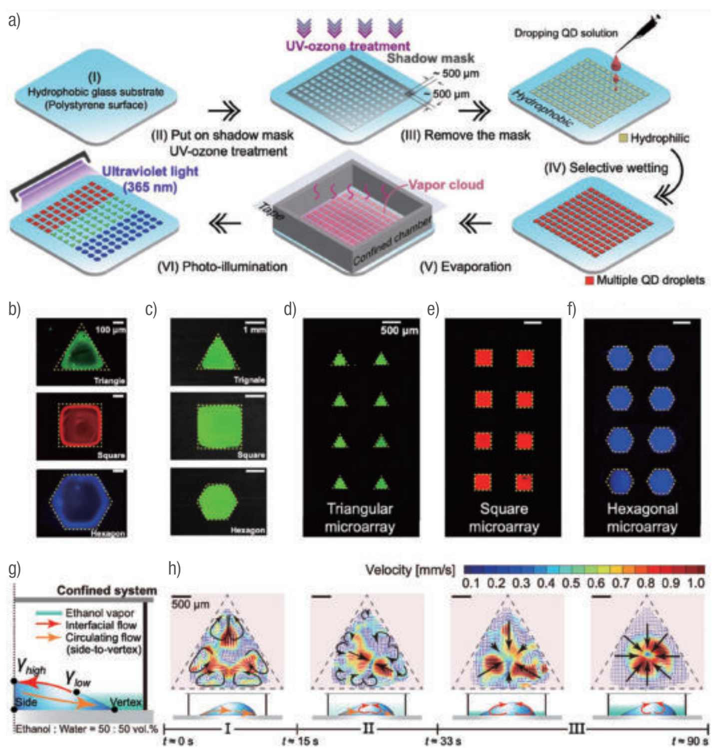


Figure 1. Multiarray uniform quantum dots patterns.
a) Fabrication processes for micro QD array.
b) QD micro-size coffee-ring polygonal patterns after QD binary mixture drops evaporate.
c) A millimeter size green QD polygonal patterns. The scale bars are 1 mm.
d-f) QD micro-size-arrays with triangular, square, and hexagonal patterns.
g) Schematics of two spontaneous and sequential solutal Marangoni effects in a confined condition. An orange and red arrow indicate a typical flow during early and mid-late evaporation, respectively.
h) Time evolution of the flow fields inside a triangular ethanol-water mixture (50:50 vol. %) drop on a substrate in a confined chamber, which is classified as follows: Regime I, controlled side-to-vertex circulating flows at all the vertices (same as an open system), Regime II, transition of the Marangoni flow structures, and Regime III, radially inward interfacial flows. A schematic of the side view is provided below each regime.

Ultra-stable transfer of laser light over an 18 km open-air link:

Multichannel high-density coherent optical & microwaves transmission for next-generation space communications

Emeritus Professor
KIM, Seung-Woo

Research Interests
Ultra-precision Optics / Ultra-fast Photonics / Optical Metrology / Precision Machine Systems Design

Associate Professor
KIM, Young-Jin

Research Interests
Ultrafast Photonics / Ultra-Precision Metrology / Ultra-Precision Manufacturing

An advanced technique of free-space optical frequency transfer has been demonstrated with the aim of realizing next-generation optical communications in space between satellites and ground stations. Optical phase noise caused by severe atmospheric turbulence on multichannel optical carriers is corrected collectively by utilizing the frequency comb of an ultrashort fiber laser as the frequency reference stabilized to the atomic clock. This technique permits high-density multichannel coherent communications using not only laser light but also extremely high band microwaves.

A research team led by Professor Seung-Woo Kim and Young-Jin Kim of the Department of Mechanical Engineering at KAIST has developed an ultra-precision multichannel optical frequency transfer technology through the atmosphere, which suppresses the phase disturbance due to open-air turbulence in real time. This technology has potential applications in areas such as next-generation space-to-ground ultra-high-speed optical communications.

Phase-coherent transfer of optical frequencies over a long distance is required for diverse photonic applications, including optical clock signal dissemination and physical constants measurement. Several demonstrations have been made successfully over fiber networks, but no such work had been done yet through the open air where atmospheric turbulence prevails. The research team has transferred multiple ultra-stable lasers, extracted directly from the frequency comb of a fiber ultrashort laser, over an 18 km free-space link constructed between the KAIST main campus and a nearby mountain in Daejeon [See Figure 1]. This free-space transfer of optical frequencies over a long haul outdoor link was performed with suppression of atmospheric phase noise to -80 dBc/Hz. The concurrent transfer of multiple comb-rooted optical carriers has also enabled the delivery microwave signals by pairing two separate carriers with inter-comb-mode phase coherence, with phase noise of -145 dBc/Hz at 1 kHz offset for a 10GHz microwave signal. Furthermore, coherent optical communication has been demonstrated with the potential of multi-Tbps data transmission by multiplexing comb-rooted carriers in free space. The proposed free-space transfer of comb-rooted optical and microwave frequencies is expected to facilitate many photonic applications such as atomic clock dissemination, fundamental constants measurements, long-baseline interferometers, and coherent communications.

The lead author Dr. Hyun Jay Kang said, "We have shown that the multi-channel narrow-linewidth lasers that propagate through the ambient air can be transferred over 18 km with the same level of coherence properties, even under atmospheric disturbance. This result shows that the laser, which has to propagate through the existing optical fiber, can be utilized beyond the limitation of space." And they said, "We expect that the distribution and synchronization of optical time/frequency standard through the ambient air will improve the performance of next-generation navigation systems and be used for space-to-ground ultra-high-speed optical communications."

This research was published online in September 30, 2019 in the journal Nature Communications under the title, "Free-space transfer of comb-rooted optical frequencies over an 18 km open-air link".

[Figure 1] Phase-coherent transfer of comb-rooted optical frequencies over an 18-km free space link.

Robotic technology that enables people to walk again

Associate Professor
KONG, Kyoungchul

Research Interests
Human assistive robotics / Human power augmentation / Design and control of wearable robots

Wearable robots can assist human muscular power and mobility. Wearable robot technology has great potential in various fields, from enhancing the muscular power of people without disability to assisting and rehabilitating people with disability in walking. Professor Kyoungchul Kong's research team has developed wearable robot technology from a sensor and actuator to integrated robot systems. The team showed a wearable robot for torch bearing of 2018 PyeongChang Paralympics. Recently, the team has also developed the world's lightest and most accurate wearable robot, which is suitable even for the rehabilitation of children. The team has developed WalkON Suit 4.0 and won a gold medal at the Cybathlon 2020.

Gold and Bronze Medalist of the CYBATHLON2020 walking with the WalkON Suit 4.0

Poor eyesight is no longer considered as a disability. However, if someone has difficulty in walking, he/she may be called a disabled person. What is the difference? It is because the vision problem can be easily overcome by wearing glasses or contact lenses, but the walking problem has no such a complete solution yet.

Many research teams are searching for a practical and reliable solution for people with difficulty in walking. As the whole population is aging globally, and Korea is one of the most rapidly aging countries in the world, the need for a solution for people with mobility problems is increasing. Several research teams have studied stem cell technology to regain the lost motor functions in the human body, but they have failed to find a practical solution so far.

To this end, wearable robots may be a good alternative. Wearable robots are legged robots developed to assist human motion. As they have two legs (since humans have two legs), the overall structure of wearable robots is similar to that of a humanoid robot. However, wearable robots must be operated according to the intention of a wearer, and their motions must be perfectly synchronized with the human motions. In addition, the number of degrees of freedom (namely, the number of joints in the robot) is limited, because the overall weight of wearable robots is restricted due to the issue of comfortability.

The Exoskeleton Laboratory (EXO Lab) of the Department of Mechanical Engineering, Korea Advanced Institute of Science and Technology (KAIST), has studied promising and reliable solutions for developing wearable robots to assist people in different applications. The first application is human power augmentation of non-disabled persons such as workers who are frequently subjected to physically demanding tasks. In this case, the control and design of a wearable robot may intelligently recognize the motion intention of the wearer. Therefore, the research goal was to learn and follow the human motion characteristics.

The second application of the EXO Lab is developing robots for complete paraplegics. Since the motor system of complete paraplegics is not functional at all, human motion could be dominated by the control system of a robot. The EXO Lab has developed WalkON Suit, which is a wearable robot specialized for complete paraplegics. Professor Kyoungchul Kong, the director of the EXO Lab, and his research team won a gold medal at the Cybathlon 2020 with the WalkON Suit by enabling a complete paraplegic wearer to walk faster than 1 meters per second, which is the world-record for a wearable robot for the complete paraplegic so far.

EXO lab is nominated as a "Leading Research Team" by NRF Korea recently and now developing the next version of WalkON Suit to be the defending champion on the CYBATHLON 2024. More degrees of freedom will be added and control system considering human motion dynamics will be included in the system.

In the era of the fourth industrial revolution, many people may be afraid of over-advanced robotics and A.I. technologies, which may replace the roles of humans. Wearable robots, however, are the robotics technology that improves the quality of human lives. Everyone would experience difficulty in movement as getting old; however, one day in the future, we may all benefit from the research of Prof. Kong's team.

Mechanically-reinforced soft gripper for lifting extremely high payloads

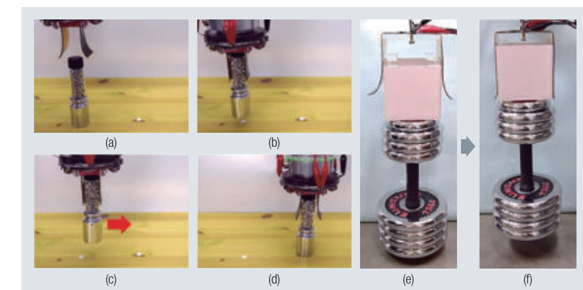
Associate Professor
KYUNG, Ki-Uk

Research Interests
Soft Robotics / Medical·Rehabilitation Robots / UI·UX: Haptics, Wearable Devices / Intelligent Human-Robot Interaction

Prof. Ki-Uk Kyung's research team developed a high-payload soft gripper which consists of a mechanically strengthened electro-adhesive skin and a multi-layered artificial muscle. The developed soft gripper can hold up 480 times heavier objects than the gripper's mass.

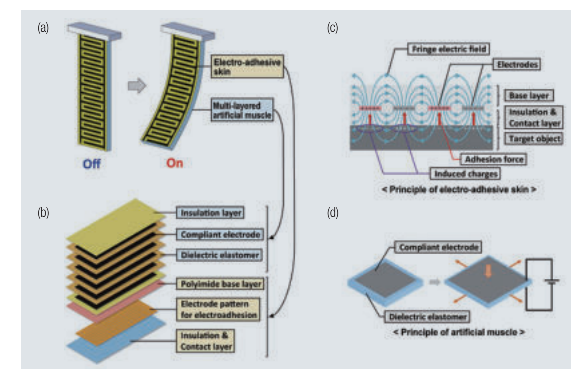
Picking up and placing various objects by a robot system is one of the most important tasks for industrial applications, such as manufacturing and logistics. However, conventional grippers with hard materials have some limitations in gentle grasping. For example, with a conventional robot gripper, it is difficult to grasp brittle or very soft objects due to its rigidity. A soft gripper has been considered as a potential solution to this issue because it enables the careful grasping of objects due to the compliance of the gripper.

Although a soft gripper adapts its shape to various objects, it lacks sufficient strength to pick up heavy objects due to the softness of the gripper material. To resolve this limitation, the research team of Prof. Ki-Uk Kyung in the Department of Mechanical Engineering developed a mechanically reinforced soft gripper for extremely high-payload capability. The soft gripper can hold up an object 480 times heavier than the gripper's mass [Figure 1].



[Figure 1] High-payload soft gripper with mechanically strengthened structure. (a-d) Picking up and placing tasks with a robot manipulator. (e-f) Picking up and holding a target object of 16.8 kg (480 times heavier than the gripper's mass).

The proposed soft gripper is composed of artificial muscle and electro-adhesive skin [Figure 2]. The artificial muscle actuates the soft gripper to make contact with target objects, and it is made up of electroactive polymers (EAPs) that can be mechanically deformed with electric fields. To enhance the grasping force, the research team applied multi-layered EAPs and optimized the performance of the actuator.

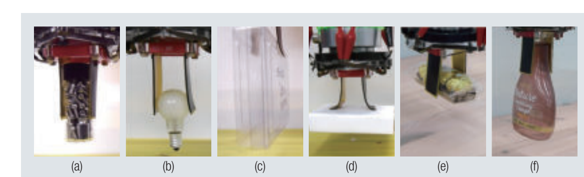


[Figure 2] Structure and working principles of the soft gripper. (a) Operation process. (b) Stacked structure with multi-layered artificial muscle and electro-adhesive skin. (c) Principle of electro-adhesive skin. (d) Principle of artificial muscle.

The electro-adhesive skin generates a strong adhesion force between the gripper and target objects. When the driving voltage is applied to electrodes of the electro-adhesive skin, the attractive force is generated between the electrodes and induces charges in target objects. The research team designed flexible electro-adhesive skin which has a high elastic modulus compared with typical soft materials. This enables the soft gripper to have a reinforced structure without compromising the flexibility of the soft mechanism.

The soft gripper with an optimized specification is able to lift and move an object weighing 625 g, even though the gripper's mass is only 6.2 g. Moreover, the soft gripper with a larger contact area, weighing just 35 g, is capable of holding up to 16.8 kg. This is 480 times heavier than the gripper's mass.

The developed soft gripper can lift various shaped objects as well, including cylinders, spheres, hexahedrons, and flat shapes [Figure 3]. This enables the gripper to perform various tasks without changing the robotic hand. In addition, the light weight of the gripper is expected to reduce a robot manipulator's workload. Therefore, the proposed soft gripper can be used in various applications, including manufacturing and distribution as well as the semiconductor and space industries, where a conventional gripper or vacuum suction is challenging to apply.



[Figure 3] Picking up various shaped objects by using the developed soft gripper. (a) Cylindrical vial bottle (120 g). (b) Spherical light bulb (7.6 g). (c) Hexahedral PET box (35.4 g). (d) Flat paper box (25.1 g). (e) Chocolate packed with PE film (43.8 g). (f) Concave-shaped PET bottle (35.8 g).

The results of this research are published in *Smart Materials and Structure and IEEE Trans. Industrial Electronics*, which is a top-tier journal paper in the instruments fields.

This research has been supported by a Korea Evaluation Institute of Industrial Technology (KEIT) grant funded by the Korea government (MOTIE), and the Alchemist Project of Ministry of Trade, Industry, and Energy.

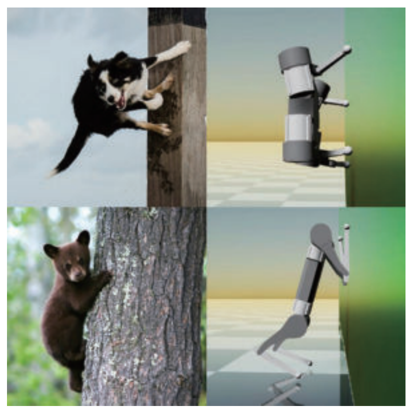
Enabling legged robots to perform acrobatic maneuvers

Associate Professor
PARK, Hae-Won

Research Interests
Control and design of dynamic robot systems / Legged locomotion robots / Bio-inspired robots

Professor Hae-Won Park's research team has designed a novel control algorithm that will enable acrobatic maneuvers by legged robots in three-dimensional (3D) space by utilizing Lie group theory. This result was published in the 2020 International Conference on Intelligent Robots and Systems (IROS) Proceedings, and the team won the RoboCup Best Paper Award.

Over the past years, recent advances in robotics have enabled legged robots to walk and run across rough terrain, climb staircases, and jump over obstacles. Extending this recent technical progress, Professor Hae-Won Park's research team in the department of mechanical engineering aims to achieve extreme mobility of animals to traverse difficult terrain. In pursuit of this aim, they designed a novel control algorithm that will enable acrobatic maneuvers of legged robots in 3D space by utilizing Lie group theory and model predictive control. Good examples of such acrobatic maneuvers in biological animals are illustrated in [Figure 1.]



[Figure 1.] Complex acrobatic maneuvers of animals and robots.

1) Acrobatic maneuvers and orientation

To achieve stable locomotion in various environments, a robot must continuously correct its orientation, namely, how much the body is tilted from the balancing pose. In control algorithms, a robot's orientation is usually represented with three numbers, which are called 'Euler angles'. This representation suffices if the robot rotates primarily one angle and small amounts on the other two rotations, which is quite common in the normal operations [Figure 2.] of legged robots including walking and running. However, when it comes to complex acrobatic maneuvers in 3D space, this representation could suffer from the so-called 'Gimbal lock' phenomenon, which can cause instability. This phenomenon can occur in vertical upright body poses of quadrupedal robots [Figure 3]. When a robot is executing acrobatic motions, the robot's pose may pass through around this problematic vertical upright pose.

[Figure 2.] Nominal Body Pose.

The research team looked for formal solution about this issue by adopting the fundamental concept of Lie group theory from mathematics, and derived equations needed for the design of control algorithm explained next.

2) Best choice for the future force

The control algorithm utilizes a model predictive control approach, one of the most promising control strategies that can control dynamic legged locomotion. The algorithm predicts how much force legs should apply to the ground to produce thrusts necessary to achieve desired movements. To do this, the algorithm foresees numerous robot behaviors into the future with multiple options of leg forces, and chooses the best leg forces to achieve the desired dynamic motions among them. To be implemented in the robot system, this calculation should be finished in less than one hundredth of a second. The research team devised an efficient optimization algorithm for this fast calculation.

[Figure 3.] Body Pose close to Gimbal Lock

The control algorithm will be implemented in real-world robots to perform various acrobatic maneuvers such as twisted jumps and wall-climbing motions.

This research was published in IEEE/RSJ IROS 2020 under the title of, "Real-Time Constrained Nonlinear Model Predictive Control on SO(3) for Dynamic Legged Locomotion", and the paper won the RoboCup best paper award. The research was supported by the Defense Challengeable Future Technology Program of Agency for Defense Development, Republic of Korea.

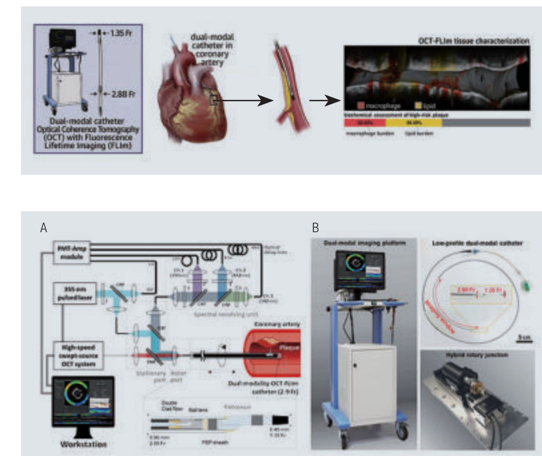
Synergizing optical imaging and machine learning to diagnose coronary artery disease accurately

Associate Professor
YOO, Hongki

Research Interests
Optical System Design / Biomedical Optics / Optical Metrology

Dual-modal optical imaging and machine learning are combined to diagnose coronary artery disease accurately via a comprehensive assessment of high-risk coronary plaque without labels. Valuable images lend insight into coronary artery disease as a promising diagnostic method toward cardiovascular therapeutics.

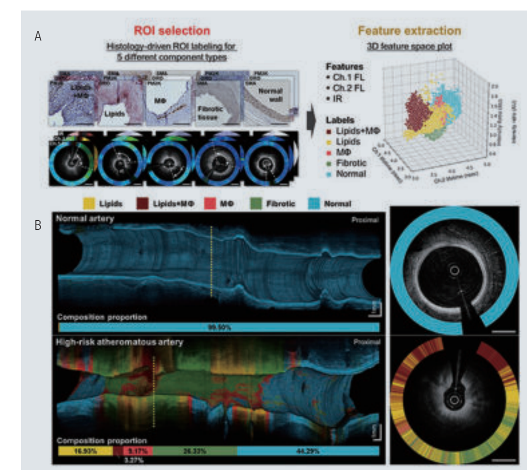
Prof. Hongki Yoo and Dr. Hyeong Soo Nam, from the Department of Mechanical Engineering, successfully developed a label-free, comprehensive intravascular imaging catheter and undertook the simultaneous microstructural and biochemical assessment of high-risk coronary plaque in vivo for a precise diagnosis of coronary artery disease. This study, in collaboration with Prof. Sunwon Kim at Korea University Ansan Hospital and Prof. Jin Won Kim at Korea University Guro Hospital, was published in JACC-Basic to Translational Science (IF 8.648) under the title "Comprehensive Assessment of High-Risk Plaques by Dual-Modal Imaging Catheter in Coronary Artery" (volume 6, issue 12, pages 948-960) in December of 2021.



[Figure 1.] Schematic diagram and images of the combination of the OCT-FLIm system and the dual-modal imaging catheter

It has been demonstrated that a lipid-rich, inflamed core and a thin overlying cap are hallmarks of high-risk plaque. Multimodal molecular imaging approaches are expected to allow better risk assessments, as they enable detailed interrogation of the plaque composition and molecular activity. However, current multimodal molecular imaging methods have limited clinical applicability as they inherently require exogenous imaging agents and thus involve potential toxicity risks.

Recently, a research team led by Prof. Hongki Yoo in the Department of Mechanical Engineering at KAIST and Prof. Jin Won Kim of the Cardiovascular Center at Korea University Guro Hospital developed a fully integrated optical coherence tomography-fluorescence lifetime imaging (OCT-FLIm) system and a low-profile dual-modal imaging catheter to provide both clinical-grade OCT images and co-registered compositional FLIm information [Figure 1]. This combined imaging system allows rapid image acquisition (100 RPS, 20 mm/s pullback) and multispectral FLIm measurements of the biochemical features of coronary arteries in a label-free manner, unlike other multimodal imaging modalities. The capability of OCT-FLIm to characterize high-risk coronary plaque features was demonstrated for the first time in beating swine hearts. By incorporating a machine-learning framework trained based on rigorous histological validations, multiple key components associated with plaque destabilization, including lipids and macrophages, can be automatically and quantitatively characterized in combined OCT-FLIm images [Figure 2]. An assessment of these key biochemical components offers quantitative measures for stratifying individual plaque risks in living patients and will thus provide new opportunities for optimal treatments. "This technique is a promising diagnostic method in the upcoming era of cardiovascular therapeutics, providing valuable image-based insight into the complex interplay between lipids and atherogenic immune responses," said Prof. Hongki Yoo. In addition to these advantages of this technology, OCT-FLIm has great potential for clinical applications, with the first in-human clinical trials scheduled to begin in the near future.



[Figure 2.] Machine-learning-based automated biochemical characterization: (A) the dataset was assembled using biochemical FLIm readouts from predetermined regions of interest with the five different class labels (normal wall, fibrotic tissues, macrophages, lipids, lipid+macrophage). (B) Cross-sections and volume-rendered images of the machine-learning-applied OCT-FLIm. This imaging approach enables intuitive visualization of the structural-biochemical characteristics of target plaque and quantitative composition analyses of five different biochemical components.

This research work was supported by a grant from the Samsung Research Funding Center of Samsung Electronics (SRFC-IT1501-51). More information can be found at the following

link: https://www.sciencedirect.com/science/article/pii/S2452302X21003119.


BIENNIAL REPORT
2022
RESEARCH
MECHANICAL
ENGINEERING

Future Transport Power Laboratory

RESEARCH OVERVIEW

FTPL research group focuses on the improvement of energy efficiency and harmful emission reduction, especially in the transportation sector. Research on alternative fuels is being conducted by a number of diagnostic methodologies such as high-speed imaging, spectroscopy, flow visualization and etc. Recently, carbon-neutral fuel (e-Fuel) research has been explored to reduce the carbon intensity from the heavy-duty applications that require the high energy density (Aviation, Marine, Commercial vehicles, etc).

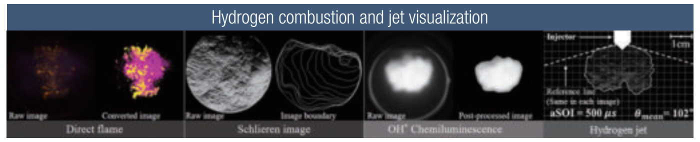
RESEARCH HIGHLIGHTS

Hydrogen Engine
Research on hydrogen direct injection engine. Fundamental hydrogen jet and combustion diagnostics in a constant volume chamber. Hydrogen stratified energy conversion research with high-pressure hydrogen injection.

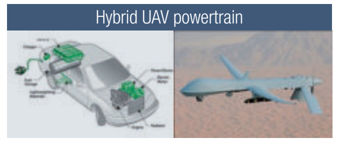
Unmanned Aerial Vehicle (UAV) powertrain
Application of intermittent engine in a UAV system. Analysis of IC engine operation under the high-altitude condition. Powertrain optimization research with simulation data for hybrid UAV powertrain.

Carbon-neutral and Alternative Fuels
Researches on the application of carbon neutral fuels, and alternative fuels such as hydrogen-based synthetic fuel, Bio-diesel, LPG, CNG, DME, Methanol, Ethanol in both compression ignition and spark ignition engines are on-going.

Hydrogen combustion and jet visualization



Hybrid UAV powertrain



Alternative fuel marine propulsion

Advanced Combustion
We are trying to realize new combustion strategies such as duel-fuel combustion, gasoline direct injection compression ignition and low temperature combustion which are regarded as clean and efficient future engine technologies.

Environmentally Friendly Powerplant
Research on particulate number (PN) emission in gasoline direct injection engines. The effect of flow characteristics on the PN generation mechanism in an optically accessible acryl engine. Optimization of fuel injector nozzle design for better fuel economy and emission characteristics.

Artificial Intelligence Diagnostics
Cylinder pressure reconstruction with machine learning. Reconstruction with vibrational signal from CNG-Diesel dual-fuel engine for marine application

SELECTED PUBLICATIONS

[1] Bae, C., & Kim, J. (2017). Alternative fuels for internal combustion engines. Proceedings of the Combustion Institute, 36(3), 3389-3413.

[2[Lee, S., Kim, G., & Bae, C. (2022). Effect of mixture formation mode on the combustion and emission characteristics in a hydrogen direct-injection engine under different load conditions. Applied Thermal Engineering, 209, 118276.

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[4] Kim, G., Park, C., Kim, W., Jeon, J., Jeon, M., & Bae, C. (2021). The Effect of Natural Gas Substitution Ratio and Diesel Injection Timing on Accuracy of In-cylinder Pressure Prediction DNN Model from Vibration Signal in a CNG-Diesel Dual-Fuel Engine. Transactions of the Korean Society of Automotive Engineers, 29(10), 909-919.

[5] Lee, S., Kim, G., & Bae, C. (2021). Behavior of hydrogen hollow-cone spray depending on the ambient pressure. International Journal of Hydrogen Energy, 46(5), 4538-4554.

Professor
BAE, Choongsik
Research Interests
Carbon-neutral Technology for Transport Power on Air, Sea and Land / Advanced Engines; Hybrid, Hydrogen Engines / Combustion Process in Engines / Laser Diagnostics and Instrumentation / Fuel Spray and Atomization / Energy Technology Perspective
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New Energy Conversion System Laboratory

RESEARCH OVERVIEW

Prof. Bae's group (New Energy Conversion System Laboratory, NECS) focuses on solid oxide fuel cells, hydrogen generation and hydrogen storage systems. Research is being conducted on the development of metal-supported SOFC cells and SOFC stacks, hydrogen generation using fuel processor, and hydrogen storage systems using metal hydride and LOHC.

RESEARCH HIGHLIGHTS

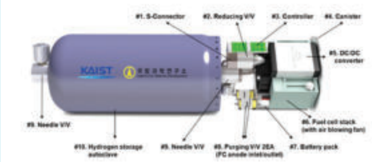
Metal-supported SOFC
A metal-supported solid oxide fuel cell (MS-SOFC) platform based on interconnect material was developed as a solution for the low thermo-mechanical strength of a conventional SOFC. By introducing a thin-film electrolyte, the MS-SOFC unit cell, which operates at a relatively low temperature and has excellent chemical and mechanical stability under thermal impacts, is being developed.

Fuel processor
A fuel processor converts hydrocarbon fuels into gases for fuel cells. In order to supply hydrogen to FCEVs, we have been developing a novel "Membrane fuel processor" to produce pure hydrogen (>99.9%) by reforming liquid HCs and selectively permeating hydrogen. We have also developed a PROX catalyst to remove carbon monoxide under 10ppm level and investigated the reaction mechanism and kinetics.

Hydrogen carrier (Metal hydride and liquid organic hydrogen carrier, LOHC)
A hydrogen energy storage system, so called water battery, was developed for portable/mobile applications. An application-oriented design and system integration strategy were newly suggested to maximize energy density while incorporating technologies for the electrolyzer, the metal hydride, and the fuel cell. We found that developed system can produce 1,200Wh of electricity, which is twice the capacity of conventional energy storage systems
LOHC is safe hydrogen storage technology in which hydrogen is stored in form of liquid organics. It is not flammable and can be used for long-term hydrogen storage on a large scale. Recently we have developed core technologies of LOHC catalysts, the nation's largest LOHC demonstration system designs, and integrated operation with PEMFC.

System rendering images

Docking process for charging the water battery



Discharging component (Water battery)

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Journals

[1] S. Lee, T. Kim, G. Han, S. Kang, Y. Yoo, S. Jeon, J. BAE*, "Comparative energetic studies on liquid organic hydrogen carrier: A net analysis", *Renewable and Sustainable Energy Review* 150, p. 111447-111460 (2021).

[2] J. Yoo, J. Lee, G. Han, A. Harale, S. Katikaneni, S. Paglieri, J. BAE*, "On-site hydrogen production using heavy naphtha by maximizing the hydrogen output of a membrane reactor system", *Journal of Power Sources* 508, pp. 230332-230345 (2021).

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Patents

[1] A fuel cell system using liquid fuel and hydrogen peroxide and a method for operating fuel cell, 2020, Korea

[2] Method for fabricating metal-supported solid oxide fuel cell using ex-situ bonding and metal-supported solid oxide fuel cell fabricated by the same, 2020, Korea

[3] Solid oxide electrolyte including thin film electrolyte layer of multiple repetitive structures, method for manufacturing the same, solid oxide fuel cell and solid oxide electrolysis cell comprising the same, 2021, Korea

[4] Module typed system for liquid organic hydrogen carrier and operation method for the same, 2021, Korea

Professor
BAE, Joongmyeon
Research Interests
Solid oxide fuel cell (SOFC) / Fuel processing / Hydrogen carrier / Numerical analysis / SOFC stack / Hydrogen production / Hydrogen storage / Energy system
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Innovative Energy Systems Engineering Laboratory

RESEARCH OVERVIEW

Liquid hydrogen (LH2) solutions	GWhr-scale ESS
- LH2 storage tanks from 0.2 m3 to 40,000 m3 - LH2 infrastructure including LH2 terminals, ships, and land transporters - LH2-based mobility including buses, trucks, and aeroplanes	- Integrated scalable molten salt energy storage system - Modelling of grid-scale electricity systems

RESEARCH HIGHLIGHTS

Tank size vs. LH2 applications: LT's solutions

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[1] J.K. Lee, Y.S. Choi, S.H. Che, M.S. Choi, D. Chang, "Integrated design evaluation of propulsion, electric power, and re-liquefaction system for large-scale liquefied hydrogen tanker", Int'l J of Hydrogen Energy, Vol. 47, pp. 4120-4135, 2022.

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[3] M.S. Choi, W.G. Jung, S.H, Lee, T.W. Joung, D. Chang, "Thermal Efficiency and Economics of a Boil-Off Hydrogen Re-Liquefaction System Considering the Energy Efficiency Design Index for Liquid Hydrogen Carriers", ENERGIES, Vol. 14, 2021.

[4] S.H. Che, J.W. Kim, D. Chang, "Liquid Air as an Energy Carrier for Liquefied Natural Gas Cold Energy Distribution in Cold Storage Systems", ENERGIES, Vol. 14, 2021.

Professor
CHANG, Daejun

Research Interests
Liquid hydrogen solutions / GWhr-scale ESS

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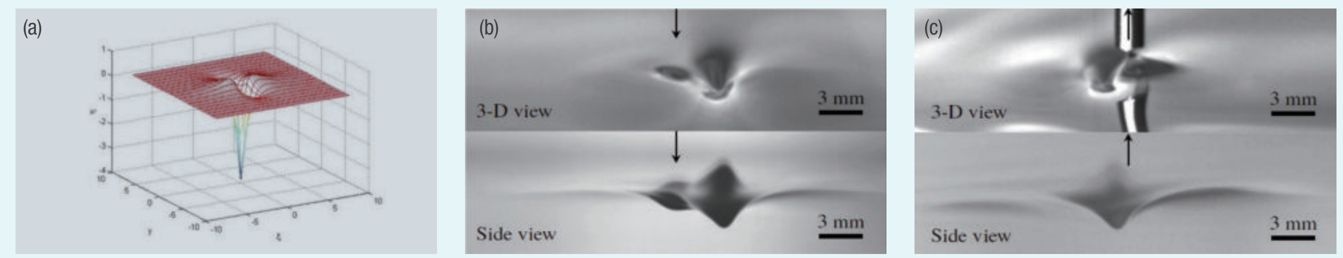
Waves & Fluid Mechanics Laboratory

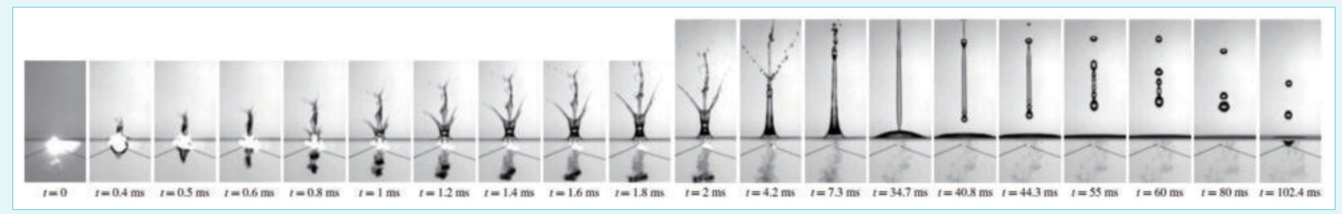
RESEARCH OVERVIEW

Cavity flows	Bubbles / Drops	Waves in Fluids and on Soft Matter	Renewable Energy systems
- Air lubrication for drag reduction - High-speed supercavitating vehicles	- Bubble Jet - Droplet control	- Surface waves - Internal waves	- Vortex-wave Interaction - Mechanically Smart Hybrid-type Wave-Current energy systems

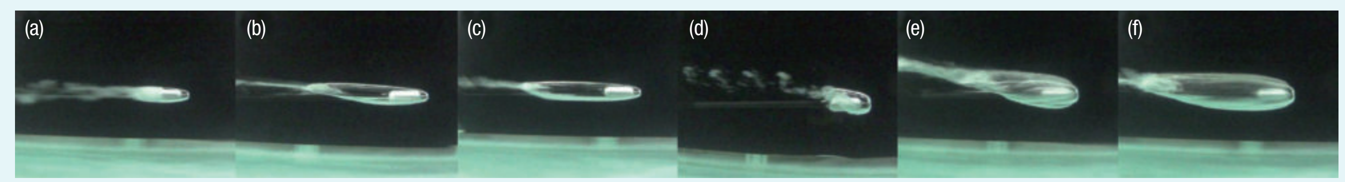
RESEARCH HIGHLIGHTS



Nonlinear gravity-capillary solitary waves (a) Theoretical / Computational result, (b) Solitary waves generated by a left-moving air-blowing, (c) Solitary waves generated by a left-moving air-suction (Park & Cho, 2020, Journal of Fluid Mechanics, 885, A20)



Squirting and Jetting phenomena generated by an underwater bubble (Kang & Cho, 2019, Journal of Fluid Mechanics, 866, 841–864.)



Supercavitation: ((a) Half supercavity with foamy cavity downstream (HSF), (b) Twin vortex supercavity (TV), (c) Reentrant-jet supercavity (RJ), (d) Half supercavity with a ring-type vortex shedding downstream (HSV), (e) RJ inside & TV outside double-layer supercavity (RJTV), (f) RJ inside & RJ outside double-layer supercavity (RJRJ)) (Chung & Cho, 2018, Journal of Fluid Mechanics, 854, 367–419)

RESEARCH AREAS

Fluid Mechanics, Wave Mechanics, Applied Mathematics

Associate Professor
CHO, Yeunwoo

Research Interests
Fluid Mechanics on Supercavitation, Waves, Bubbles and Drops

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Automotive Control Laboratory

RESEARCH OVERVIEW

Self Energizing DCT & Gear Shifting Control

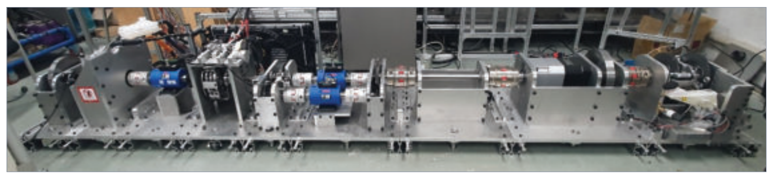
Precise control of clutches of a dual clutch transmission (DCT) during gear shifting is very important in order to improve both driver's comfort and shift efficiency. The main objective of this research is to develop a model-based integrated controller structure and proper control strategies of DCT actuated by unique self-energizing clutch actuators. Our researches are also focused on developing an clutch torque observer for the DCT that can effectively estimate both clutch torques during gear shifts without any additional sensors so that they can be used for feedback control.

Vehicle dynamics and control

The main goal of this research is enhancing the driving performance using vehicle dynamics and applying controls. The vehicle states required for vehicle motion control but unmeasurable are obtained through vehicle dynamics-based state observers. By controlling driving or braking torque appropriately, vehicle dynamic performance is maximized.

Personal Mobility

This research suggests minimum-size and ultra-light urban 3-wheeler EVs based on front-wheel-drive and rear-wheel-steering to maximize its agility in congested urban environment and fuel efficiency. With a very small turning radius obtained by independently driven front wheels and 180 degree range of rear wheel steering, parking spaces can be optimally utilized. Using smart devices, the 3-wheeler EV can also be driven remotely or controlled externally to help parking easily at a small space. We also investigate narrow 3-wheelers with a unique feature of semi-active tilting mechanism which can improve control bandwidth, efficiency as well as cost.


Self Energizing DCT & Gear Shifting Control


Vehicle dynamics and control


Personal Mobility

SELECTED PUBLICATIONS

[1] GS Park, SB Choi, "A Model Predictive Control for Path Tracking of Electronic-Four-Wheel Drive Vehicles", IEEE Transactions on Vehicular Technology, November, 2021

[2] GS Park, SB Choi, "An Integrated Observer for Real-Time Estimation of Vehicle Center of Gravity Height", IEEE Transactions on Intelligent Transportation Systems, September, 2021

[3] DS Jeong, ST Kim, JY Lee, SB Choi, MT Kim, HJ Lee, "Estimation of Tire Load and Vehicle Parameters Using Intelligent Tires Combined with Vehicle Dynamics", IEEE Transactions on Instrumentation and Measurement, January, 2021

[4] SH Jung, SB Choi, JS Kim, YH Ko, HY Lee, "Adaptive Feed-Forward Control of the Clutch Filling Phase for Wet Dual Clutch Transmission", IEEE Transactions on Vehicular Technology, September, 2020

[5] SY Kim, SB Choi, "Cooperative Control of Drive Motor and Clutch for Gear Shift of Hybrid Electric Vehicles with Dual-Clutch Transmission", IEEE-ASME Transactions on Mechatronics, June 2020

[6] J KC Jeong, SB Choi, HJ Choi, "Sensor Fault Detection and Isolation Using a Support Vector Machine for Vehicle Suspension Systems", IEEE Transactions on Vehicular Technology, April 2020

[7] DH Kim, JW Kim, SB Choi, "Design and Modeling of Energy Efficient Dual Clutch Transmission with Ball-Ramp Self-Energizing Mechanism", IEEE Transactions on Vehicular Technology, March 2020

HONORS / AWARDS

[1] Sci. & Tech. Excellence Award, Korean Federation of Sci. & Tech. Societies, 2020

[2] Technology Innovation Award, KAIST, 2021

Professor
CHOI, Seibum
Research Interests
Vehicle Dynamics and Control / Advanced Powertrain Systems / Transportation Systems / Vehicle State Observer / Sensor Applications / Intelligent Tires / Fault Diagnosis
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Robotics and Artificial Intelligence Laboratory

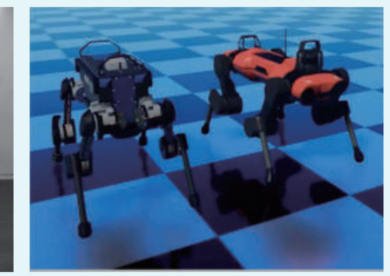
RESEARCH OVERVIEW

The goal of our research is to develop dynamic and intelligent legged robots for many industrial applications. Even though legged robotics has been advancing remarkably in the past four decades, the existing legged robots are not yet robust and reliable enough to perform many real-world tasks. Furthermore, their limited speed and efficiency make them an uneconomical option for long-range applications. We address these issues from two different angles: intelligence and design. To make legged robots more intelligent, we devise deep learning algorithms and network architectures tailored for legged robots. Our artificial neural networks not only control the robots but also estimate the state; perceive the environment; plan the trajectory for a short horizon. They replace the heuristic rules that have been used to control the robots and thereby make the systems more agile and reliable. In addition, we design high-performance and energy-efficient legged robots to embody the intelligence that we develop. Transparent transmission and low-delay actuators allow us to accurately model the hardware and consequently lead to efficient simulation-to-real transfers. They reduce energy expenditure and thus lead to longer battery life. By concurrently developing the hardware, software, and algorithms, we make highly performant legged systems for the most challenging environments.


Legged robotics


Autonomous driving


Reinforcement Learning


Dynamics / simulation

RESEARCH HIGHLIGHTS

Control of a legged robot with reinforcement learning.

We introduced a variety of ways to train control policies for a legged robot in simulation and transfer them to the real robot in various environments. Prof. Hwangbo's publication in Science Robotics in 2019 [1], which was featured as one of the top ten papers in 2019 [3] by Nature, ignited worldwide interest in reinforcement learning in the legged robotics community. His team at KAIST is continuing this line of research to improve the capabilities of legged robots.

SELECTED PUBLICATIONS

[1] Hwangbo, Jemin, Joonho Lee, Alexey Dosovitskiy, Dario Bellicoso, Vassilios Tsounis, Vladlen Koltun, and Marco Hutter. "Learning agile and dynamic motor skills for legged robots." *Science Robotics* 4, no. 26 (2019): eaau5872.

[2] Hwangbo, Jemin, Inkyu Sa, Roland Siegwart, and Marco Hutter. "Control of a quadrotor with reinforcement learning." *IEEE Robotics and Automation Letters* 2, no. 4 (2017): 2096-2103.

[3] Ji, G., Mun, J., Kim, H. and Hwangbo, J., 2022. Concurrent Training of a Control Policy and a State Estimator for Dynamic and Robust Legged Locomotion. *IEEE Robotics and Automation Letters* , 7 (2), pp.4630-4637.

[4] Kim, Yunho, Chanyoung Kim, and Jemin Hwangbo. "Learning Forward Dynamics Model and Informed Trajectory Sampler for Safe Quadruped Navigation." *Robotics: Science and Systems 2022 and arXiv preprint arXiv:2204.08647* (2022).

HONORS / AWARDS

[1] Robots, hominins and superconductors: 10 remarkable papers from 2019 by Nature

Assistant Professor
HWANGBO, Je Min
Research Interests
Reinforcement learning / Legged robots
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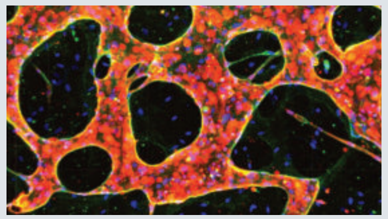
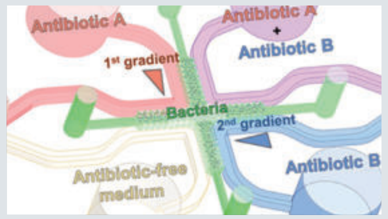
Biomicrofluidics Laboratory

RESEARCH OVERVIEW

Mimicking 3D Biological System	Design and Fabrication of Microfluidic System	Disease-on-a-chip
- Human biological systems such as bone, muscle, and microvasculature are modeled in microfluidic system. - Bacterial microenvironment and formation biofilm can be modeled.	- Different microfluidic platforms for each biological systems are designed to best mimic the targeted microenvironments. - Microfluidic systems are also developed for biosensors or drug screening platforms.	- Human diseases such as cancer metastasis and atherosclerosis are modeled in the developed microfluidics systems. - Effects of biophysical and biochemical external factors for diseases can be tested or identified in the system for therapeutic purposes.





SELECTED PUBLICATIONS

[1] S.Kim, H.Nam, B.Cha, J.Park, H.J.Sung, J.S.Jeon, Acoustofluidic stimulation of functional immune cells in a microreactor, Advanced Science, 2022, 2105809.

[1] H.Nam, H.J.Sung, J.Park, J.S.Jeon, Manipulation of cancer cells in a sessile droplet via travelling surface acoustic waves, Lab on a Chip, 2022, 22(1), 47-56.

[2] J.Kim, W.Kim, J.Ahn, Y.J.Jang, H.S.Park, J.S.Jeon, Investigation on the Effect of Cyclic Stretch and Hypoxia on Recovery of Damaged Skeletal Muscle Cells Using Microfluidic System, Advanced Materials Technologies, 2021, 6(11), 2170063.

[3] Y.Im, S.Kim, J.Park, H.J.Sung, J.S.Jeon, Antibiotic susceptibility test under a linear concentration gradient using travelling surface acoustic waves, Lab on a Chip, 2021, 21(18), 3449-3457.

[4] DH.Ryu, H.Nam, J.S.Jeon, YK.Park, Reagent- and actuator-free analysis of individual erythrocytes using three-dimensional quantitative phase imaging and capillary microfluidics, Sensors and Actuators B: Chemical, 2021, 348, 130689.

HONORS / AWARDS

[1] Young Investigator Award, The Korean BloChip Society, 2018.

Associate Professor
JEON, Jessie Sungyun

Research Interests
Microfluidics / Lab-on-a-chip / Organ-on-a-chip / Drug screening platform / *In vitro* disease microenvironment

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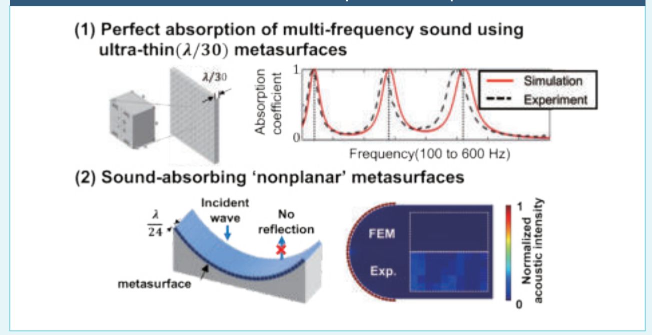
Wave Energy Control Laboratory (WAVE LAB)

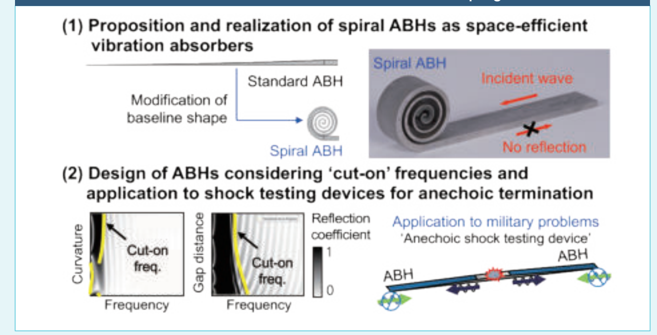
RESEARCH OVERVIEW

WAVE LAB develops new and innovative solutions for old and long-standing problems of sound and vibration occurring in various mechanical systems such as home appliances and future vehicles (e.g., autonomous electric cars and urban aerial vehicles). To overcome the limitation of existing materials or technologies for wave (sound and vibration) energy control, we proposed new concepts of meta-structures ('meta' in Greek means 'beyond' in English) including 'Spiral Acoustic Black Holes', 'Nonplanar Metasurfaces', 'Hierarchical Phononic Crystals' and 'Acoustic Metaliners' with experimental validation. Our main research interests include (but are not limited to) the followings topics:

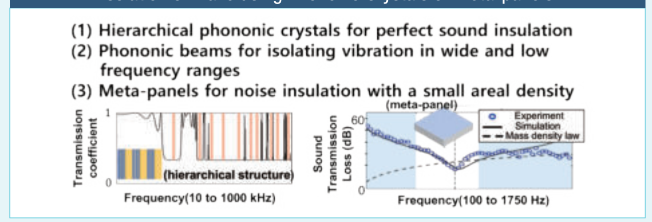
Acoustic Metasurfaces for Near-perfect Absorption of Sound



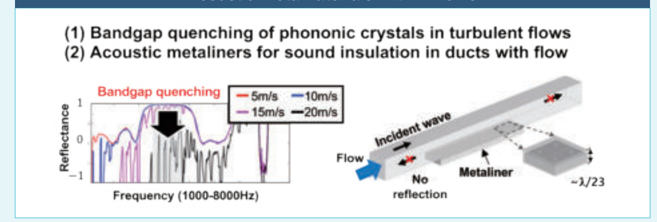
Acoustic Black Holes for Vibration Damping



Isolation of Wave using Phononic Crystals or Meta-panels



Acoustic Metamaterials within Flows



RESEARCH HIGHLIGHTS

[1] Development of nonplanar(curved) acoustic metasurfaces exhibiting near-perfect absorption of sound waves

[2] Identification of steady/unsteady flow effect on bandgap characteristics (e.g. quenching) of phononic crystals

[3] Development of metaliners that insulate noise in ducts while allowing fluid flow with little flow resistance

[4] Formulation of new mathematical theory to analyze the cut-on frequency of spiral acoustic black holes (ABHs), aiming to apply the spiral ABHs to real-world problems such as reduction of vibration in home appliances and heavy industries

SELECTED PUBLICATIONS

[1] S. Park, J. Y. Lee, and W. Jeon, Vibration damping of plates using waveguide absorbers based on spiral acoustic black holes, *Journal of Sound and Vibration*, Vol. 521, 116685 (Mar. 2022)

[2] T. S. Oh and W. Jeon, Acoustic metaliners for sound insulation in a duct with little flow resistance, *Applied Physics Letters*, Vol. 120, 044103 (Jan. 2022)

[3] S. Park and W. Jeon, Ultra-wide low-frequency band gap in a tapered phononic beam, *Journal of Sound and Vibration*, Vol. 499, 115977 (May. 2021)

[4] J. Kim and W. Jeon, Nonplanar metasurface for perfect absorption of sound waves, *The Journal of the Acoustical Society of America*, Vol. 149, 2323 (Apr. 2021)

Associate Professor
JEON, Wonju

Research Interests
Sound and Vibration / Acoustic·Elastic Metamaterial / Silent Drone and UAM / Aeroacoustics and Fan Noise

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Cryogenic Engineering Laboratory

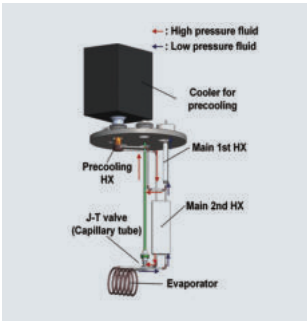
RESEARCH OVERVIEW

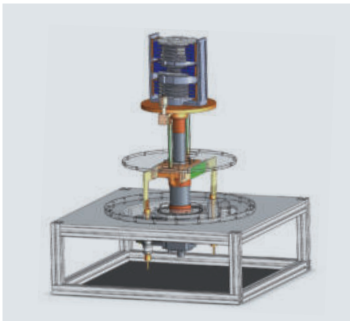
Cryogenic refrigerator and superconductivity applications

Cryogenic refrigeration is an enabling technology to create low enough temperature below -150°C for various low temperature applications including space exploration. The current research in the Cryogenic Engineering Laboratory of KAIST involves cryogenic fluid management such as liquid nitrogen, hydrogen, and oxygen, MR (Mixed Refrigerant) Joule - Thomson (JT) refrigeration, sorption refrigeration, and Magnetic refrigeration.

MR-JT research results can be applied to cryogenic refrigeration system for cryoprobe or large-scale LNG or liquid hydrogen plants. Various cryogenic heat exchanger concepts including PCHE (Printed Circuit Heat Exchanger) is also being examined to enhance the whole system performance efficiency.

Magnetic refrigeration is a new heat pumping method not only for cryogenic temperature range but also for room temperature environment. The current researches are focused on the technologies related to liquid hydrogen temperature (20 K), High Temperature Superconductor (HTS) cooling schemes, ultra-low temperature cryogenic refrigerators, and cryogenic fluid management





SELECTED PUBLICATIONS

[1] K. Kim, J. Bae, L. Jin, S. Joeng, "Experimental and numerical investigations on continuous pressure drop characteristic of tube-in-tube recuperative heat exchanger for 1.8 K cooler on continuous pressure drop characteristic of tube-in-tube recuperative heat", *Cryogenics*, Vol. 118, 103345, 2021.

[2] B. Kim, D. Kwon, S. Jeong, "Temperature distribution of long-length high temperature superconducting cable cooled by slush-nitrogen", *Cryogenics*, 103369, 2021.

[3] J. Bae, D. Kwon, S. Jeong, "Development of a switchless thin-plate type sorption compressor cell for 5 K sorption J-T refrigerator", *Cryogenics*, Vol. 109, 103112, 2020.

[4] D. Kwon, B. Kim, Y. Chu, L. Jin, S. Jeong, "Quench phenomena in a conduction-cooled fast-ramping high temperature superconducting magnet", *IEEE Transactions on Applied Superconductivity*, Vol. 30(4), pp 1-6, 2020.

[5] L. Jin, J. Lee, S. Jeong, "Investigation on heat transfer in line chill-down process with various cryogenic fluids", *International Journal of Heat and Mass Transfer*, Vol. 150, 119204, 2020.

[6] H. Cho, L. Jin, S. Jeong, "Experimental investigation on performances and characteristics of nitrogen-charged cryogenic loop heat pipe with wick-mounted condenser", *Cryogenics*, Vol. 105, 102970, 2020.

PUBLICITY(MEDIA+NEWS)

Development of high temperature superconducting motor with on-board cryocooler

KAIST 정산권 교수 연구팀, 세계최초로 극저온 냉동기를 탑재한 '초전도 모터' 개발

Professor
JEONG, Sangkwon

Research Interests
Cryogenics / Cryocooler Design / Applied Superconductivity System / Cryogenic Heat Transfer / Refrigeration

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Applied Fluid Mechanics Laboratory

RESEARCH OVERVIEW

Our research group studies multi-scale fluid-structure interactions and flow physics found in nature and technology. Mechanical applications of our researches include developments of novel sustainable energy harvesting systems for winds and water flows, bio-inspired designs of hydrodynamic and aerodynamic propulsion systems, and developments of cutting-edge flow control technology for defense and safety.

RESEARCH HIGHLIGHTS

Aerodynamics of micro-scale bristled wings [Fig.1]
Unlike the smooth wings of common insects or birds, micro-scale insects such as fairyfly have a distinctive wing geometry, comprised of a frame with several bristles. Motivated by this peculiar wing geometry, we investigate flow structure around a bristled wing with various configurations and flow conditions and elucidate the correlations of these parameters with aerodynamic performance.

Energy harvesting based on flow-induced vibration [Fig.2]
We study the mechanisms of flow-induced vibration of a structure under fluid flow and its applications to energy harvesting. A buckled elastic sheet and an elastically mounted cylinder exhibit novel features of nonlinear dynamics in regards to energy harvesting performance. Furthermore, contacts of an oscillating structure with the sidewalls installed near the structure can be utilized for energy harvesting based on triboelectrification.

Interaction of cavitating bubbles with interface [Fig.3]
The formation of cavitating bubbles near a solid interface has been major issues in naval architecture and fluid machinery because of strong damage induced by the collapse of bubbles. Furthermore, cavitating bubbles can be used in diverse industrial and medical applications such as jet printing and drug delivery. We investigate the behaviors of bubbles under diverse conditions such as a patterned surface, an elastic solid, a thin liquid film. Depending on such surrounding conditions, a bubble shows novel nonlinear responses throughout its life cycle, compared with under ambient conditions.

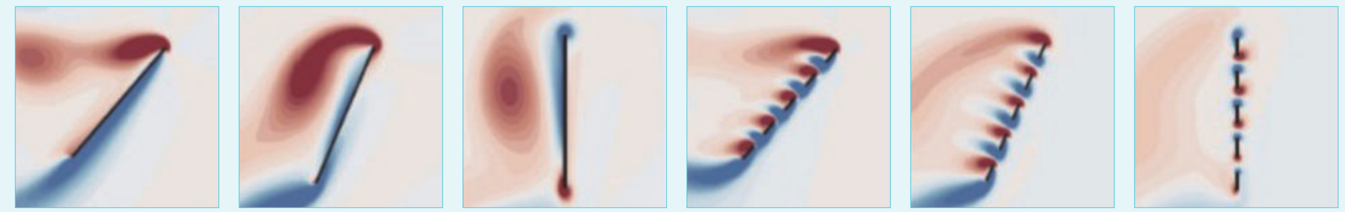

Fig.1 Comparison of flow structure between continuous wing (top) and bristled wing (bottom)

Fig.2 Periodic snap-through oscillations of elastic sheets in tandem under uniform flow

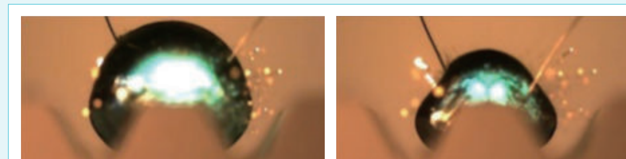

Fig.3 Collapse of a bubble on the ridge of a patterned surface

SELECTED PUBLICATIONS

[1] Junyoung Kim and Daegyoum Kim 2022 "Flow-induced vibration and impact of a cylinder between two close sidewalls", Journal of Fluid Mechanics, 937, A28

[2] Cheolgyun Jung, Minho Song, and Daegyoum Kim 2021 "Starting jet formation through eversion of elastic sheets", Journal of Fluid Mechanics, 924, A7

[3] Hyeonseong Kim, Mohsen Lahooti, Junsoo Kim, and Daegyoum Kim 2021 "Flow-induced periodic snap-through dynamics", Journal of Fluid Mechanics, 913, A52

[4] Seung Hun Lee and Daegyoum Kim 2021 "Aerodynamic response of a bristled wing in gusty flow", Journal of Fluid Mechanics, 913, A4

Associate Professor
KIM, Daegyeoum

Research Interests
Fluid-structure interaction / Biological flow / Bio-inspired design / Flow-induced vibration / Multi-phase flow

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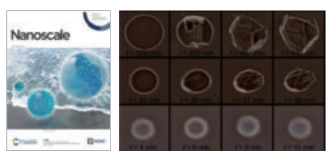
Fluid & Interface Laboratory

RESEARCH OVERVIEW

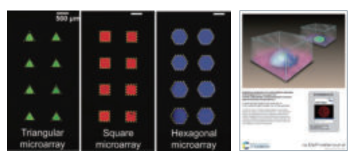
Our research areas revolve around experimental fluid mechanics with applications to physics and engineering over a wide range of scales, from the microscale to macroscale and entail collaborations with researchers from many disciplines and industries.

Particularly, we study various fluid interface problems that are basically driven and inspired by curiosity in ordinary life and industrial applications including: 1) Phase change (e.g., morphing phenomena) at the liquid-liquid interface of complex fluid, 2) Uniform coating of quantum dots and display applicable nanomaterials for display and semiconductor applications, 3) Marangoni effects for droplet microfluidics applications, 4) Vapor visualization of floral scent and toxic gas, 5) Sintering-free liquid metal nano- and microparticles for flexible devices, and 6) Development of air cleaning devices against COVID-19 pandemic. Simultaneously, advanced flow field measurement techniques will be developed and applied to investigate complex fluid and flow problems.

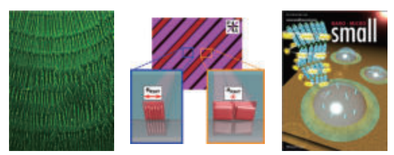
Crystal Capillary Origami[1]



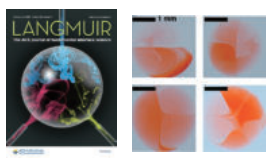
Uniform Quantum Dot Coating[2]



Pattern Control of Nanomaterials[6]



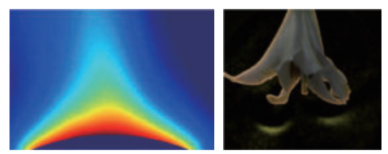
Microfludics Applications[3,4,5,7]



COVID - 19 Problems[8-11]

Negative Pressure Pumps

Flow Visualization Techniques



SELECTED PUBLICATIONS

[1] K. Park and H. Kim, "Crystal capillary origami capsule with self-assembled nanostructures", *Nanoscale* 13(35), 14656-14665 (2021) [2] J. Pyeon and H. Kim, "Controlling uniform patterns by evaporation of multi-component liquid droplets in a confined geometry", *Soft Matter* 17(13), 3578-3585 (2021) [3] J. Ryu, J. Kim, J. Park, and H. Kim, "Analysis of vapor-driven solutal Marangoni flows inside a sessile droplet", *Int. J. Heat Mass Tranf.* 164, 120499 (2021) [4] E. Um, M. Kim, H. Kim, J. H. Kang, H. A. Stone, and J. Jeong, "Phase synchronization of fluid-fluid interfaces as hydrodynamically coupled oscillators", *Nat. Comm.* 11(1), 1-11 (2020) [5] Y. J. Kim, A. Kim, J. M. Kim, D. Lim, K. H. Chae, E. N. Cho, H. J. Han, K. U. Jeon, M. Kim, G. H. Lee, G. R. Lee, H. S. Ahn, H. S. Park, H. Kim, J. Y. Kim, and Y. S. Jung, "Highly efficient oxygen evolution reaction via facile bubble transport realized by three-dimensionally stack-printed catalysts", *Nat. Comm.* 11(1), 1-11 (2020) [6] M. J. Han, J. Kim, B. Kim, S. M. Park, B. Kim, H. Kim, D. K. Yoon, "Orientation control of semiconducting polymer using micro channel molds", *ACS Nano* 14(10), 12951-12961 (2020) [7] J. Park, J. Ryu, H.J. Sung, and H. Kim, "Control of solutal Marangoni-driven vortical flows and enhancement of mixing efficiency", *J. Colloid Interface Sci.* 561, 408-415 (2020) [8] A Negative Pressure Mobile Device Using Cyclone (Patent Reg. No: 10-2339302-0000) [9] Cyclone Negative Pressure Mask (Patent Reg. No: 10-2337725-0000) [10] Portable Negative Pressure Pump Module for Negative Pressure Stretcher (Patent App. No: 10-2021-0075453) [11] Hybrid Positive-Negative Convertible Pressure Cyclone-type Personal Protection Equipment (Patent App. No: 10-2021-0153502)

HONORS / AWARDS

[1] 2022, Technology Innovation Award, KAIST
[2] 2021, Fusion Research Award, KAIST
[3] 2021, Best Teaching Award, Mechanical Engineering, KAIST
[4] 2021, Songam Future Scholar for Excellent Research, KAIST
[5] 2018, Young Engineering Award, The Korea Society of Visualization

Associate Professor
KIM, Hyoungsoo

Research Interests
Fluid Mechanics / Soft Matter / Complex Fluids / Flow visualization

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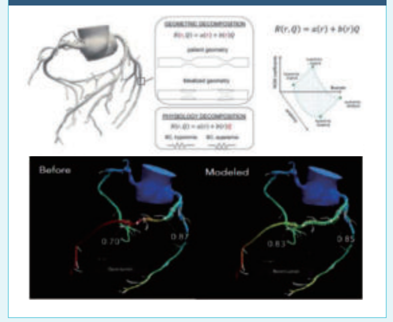
Computational Cardiovascular Biomechanics Lab

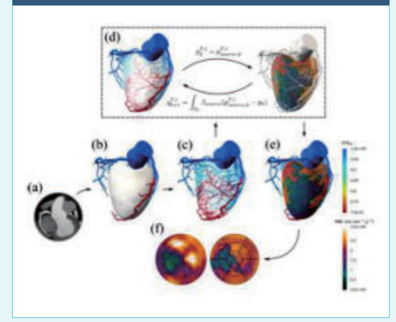
RESEARCH OVERVIEW

We are interested in developing computational methods to better understand the functions and pathophysiologic process of the cardiovascular system. We are particularly interested in understanding the physiology and pathophysiology of the blood vessels and tissues by considering the interactions between the arteries that we can segment from each patient's medical image data and the tissues these arteries supply blood to. We construct a computer model of the arteries and the tissues by segmenting the input image data and develop multiscale computational models which solve for blood flow and pressure for vessels from arteries to arterioles and eventually to the tissues through the capillaries. We have developed a simulated perfusion framework whereby the construction and the simulation of the multiscale blood flow equations are solved for both the segmented and synthetically generated vessels and the tissues. This computational framework is demonstrated to exhibit realistic flows for healthy and diseased coronary and cerebrovascular models. We are refining and optimizing this computational framework to better estimate physiological blood flows for given biological tissues, to identify the risk of ischemia with the cardiovascular disease, and to predict the risk of microvascular disease or compromise in the autoregulatory mechanisms for each patient. Using this framework, we are going to understand patient-specific functions below the medical image resolution and predict the pathological severity of the biological tissues and the blood vessels.

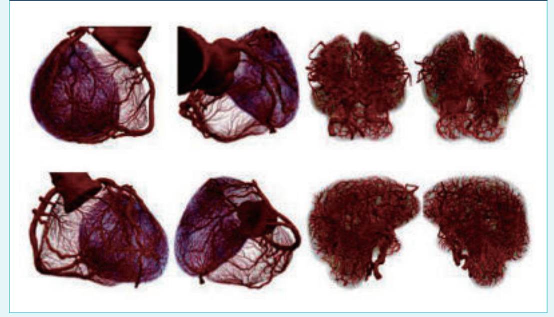
Reduced order model solver computes pressure and flow simultaneously even for updated gometries



Simulated perfusion framework



Tree generation and perfusion applied to ventricles and brain tissues



RESEARCH HIGHLIGHTS

1. Modeling of small vessels below the medical image resolution
2. Multiscale blood flow simulations
3. Reduced order models
4. Modeling interactions of the blood vessels and tissues

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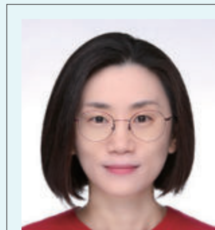
[1] L. Papamanolis et al. Myocardial Perfusion Simulation for Coronary Artery Disease: A Coupled Patient-Specific Multiscale Model. Annals of Biomedical Engineering 49, 1432–1447, 2021
[2] T. Toba et al. Wall shear stress and plaque vulnerability: Computational fluid dynamics analysis derived from CCTA and OCT. JACC: Cardiovascular Imaging 14 (1), 315-317, 2021
[3] S. Sankaran et al. Physics driven real-time blood flow simulations. Computer Methods in Applied Mechanics and Engineering 364, 112963, 2020



Associate Professor
KIM, Hyun Jin

Research Interests
Computational Biomechanics / Computational Fluid Dynamics / Medical Image Processing / Clinical Applications

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Mobile Robotics and Intelligence Laboratory

RESEARCH OVERVIEW

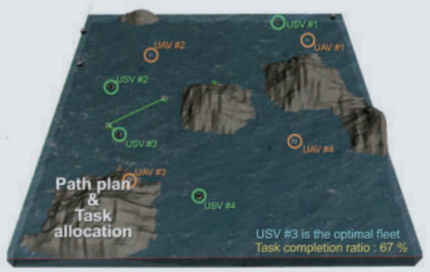
Mission Management and Planning for Cooperative Multi-Vehicle Systems

Mobile Robotics & Intelligence (MORIN) Laboratory is a research group focused on intelligent control and autonomy of vehicles and mobile robotic systems. We are conducting research on vehicle intelligence across the full range of manned and unmanned vehicle applications. We are also working on developing innovative algorithms and techniques which are applicable to all types of vehicles and mobile robotic systems.

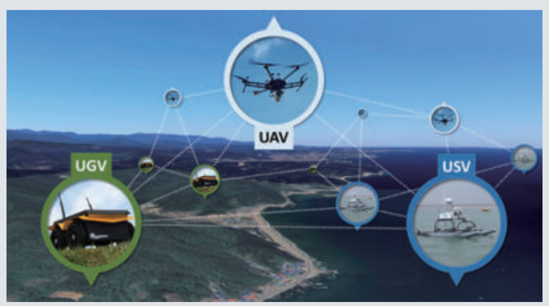
RESEARCH HIGHLIGHTS

Mission Management and Planning for Cooperative Multi-Vehicle Systems

Collaborative mission and route planning of multi-vehicle systems



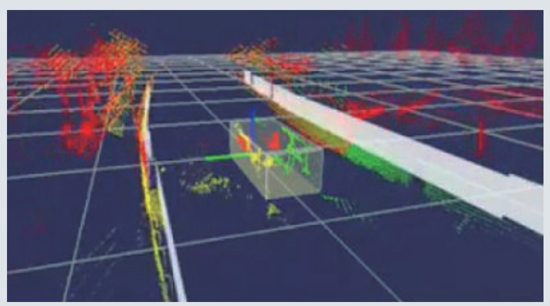
Cooperative operation between heterogeneous multiple unmanned systems



Vehicle Intelligence for Autonomous Ships and Unmanned Surface Vessels

Field experiment with an autonomous surface boat in Pohang Canal

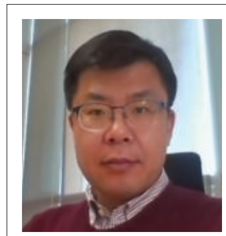
Environmental sensing and perception for collision-free navigation



SELECTED PUBLICATIONS

[1] Haggi Do, Seonghun Hong and Jinwhan Kim*, "Robust Loop Closure Method for Multi-robot Map Fusion by Integration of Consistency and Data Similarity", IEEE Robotics and Automation Letters (RA-L) (with IROS), Vol. 5, No.4, pp. 5701-5708, 2020.

[2] Keunhwan Kim, Jonghwi Kim and Jinwhan Kim*, "Robust Data Association for Multi-Object Detection in Maritime Environments Using Camera and Radar Measurements", IEEE Robotics and Automation Letters (RA-L), Vol. 6, No. 3, pp. 5865-5872, 2021.



Professor
KIM, Jinwhan

Research Interests
Mobile robotics, marine robotics / Vehicle intelligence and perception / Dynamics and control of marine vehicles and floating structures

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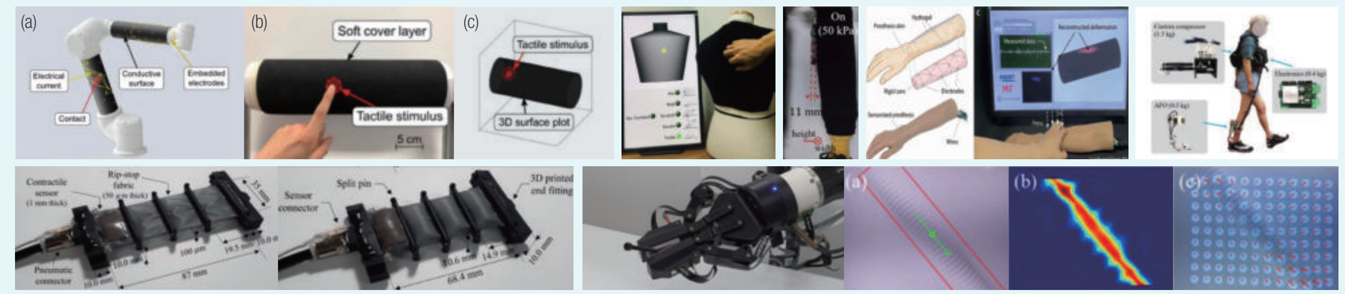
Biorobotics Laboratory

RESEARCH OVERVIEW

The goal of Biorobotics Lab is to harness features of perception, sensing, actuation, mechanics, dynamics, and control strategies to expedite the technologies of dependable physical human robot interactions (pHRI). Research in the lab ranges from fundamental understanding of human haptic and motor science to novel sensor / actuator techniques for many applications including haptic interfaces, tactile sensors, exoskeleton robot, soft robots, orthotic devices, assistive devices, whole body tactile robotic sensors and human-robot cooperation. The students are diligently performing and constantly improving our research capabilities through keeping an open mind and through in-depth discussions. Our lab has had an active collaborative networks with other research institutions and labs in the biomechanics and robotics, and published papers in international journals.



RESEARCH HIGHLIGHTS

The paper "Compact Flat Fabric Pneumatic Artificial Muscle (ffPAM) for Soft Wearable Robotic Devices" received the best paper award of service robotics in ICRA 2021, which is the premiere conference in Robotics.

BioRobotics Lab member, Kyung-seo Park, Min-jin Yang, and Jun-hui Cho won the silver prize at the 28th Samsung Human Tech Papers Awards.

The study of robot skin attracted great international attention in 2022 when it was reported in public broadcasting stations and newspapers.

SELECTED PUBLICATIONS

[1] K Park, H. Yuk, M. Yang, J Cho, H Lee, Jung Kim, "A biomimetic elastomeric robot skin using electrical impedance and acoustic tomography for tactile sensing". Science Robotics(2022)

[2] K Park, H Lee, Katherine J Kuchenbecker, Jung Kim,"Adaptive Optimal Measurement Algorithm for ERT-based Large-area Tactile Sensors" IEEE-ASME TRANSACTIONS ON MECHATRONICS (2022)

[3] H Park, K Park, S Mo Jung Kim, "Deep Neural Network Based Electrical Impedance Tomographic Sensing Methodology for Large-Area Robotic Tactile Sensing", IEEE Transactions on Robotics (2021)

[4] W Kim, H, Park, Jung Kim, "Compact Flat Fabric Pneumatic Artificial Muscle (ffPAM) for Soft Wearable Robotic Devices" IEEE ROBOTICS AND AUTOMATION LETTERS (2021)

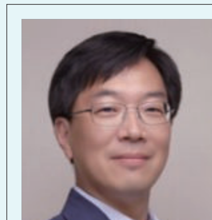
[5] H Chang, SJ Kim, J Kim, "Feedforward Motion Control With a Variable Stiffness Actuator Inspired by Muscle Cross-Bridge Kinematics", IEEE Transactions on Robotics (2019)

[6] Oh, J, Park, H, Kim, J, Park, S "Pressure Insensitive Strain Sensor with Facile Solution-Based Process for Tactile Sensing Applications", ACS NANO (2018)

[7] Y Na, J Kim, "Dynamic Elbow Flexion Force Estimation Through a Muscle Twitch Model and sEMG in a Fatigue Condition", Transactions on Neural Systems and Rehabilitation Engineering (2017)

[8] H Chang, SJ Kim, J Kim, "Development of Self-Stabilizing Manipulator Inspired by the Musculoskeletal System Using the Lyapunov Method", IEEE Transactions on Robotics (2017)

[9] H Lee, D Kwon, H Cho, I Park, J Kim, "Soft Nanocomposite Based Multi-point, Multi-directional Strain Mapping Sensor Using Anisotropic Electrical Impedance Tomography." SCIENTIFIC REPORTS (2017)



Professor
KIM, Jung

Research Interests
Medical Robotics / Physical Human Robot Interactions / Soft Robotics / Haptics

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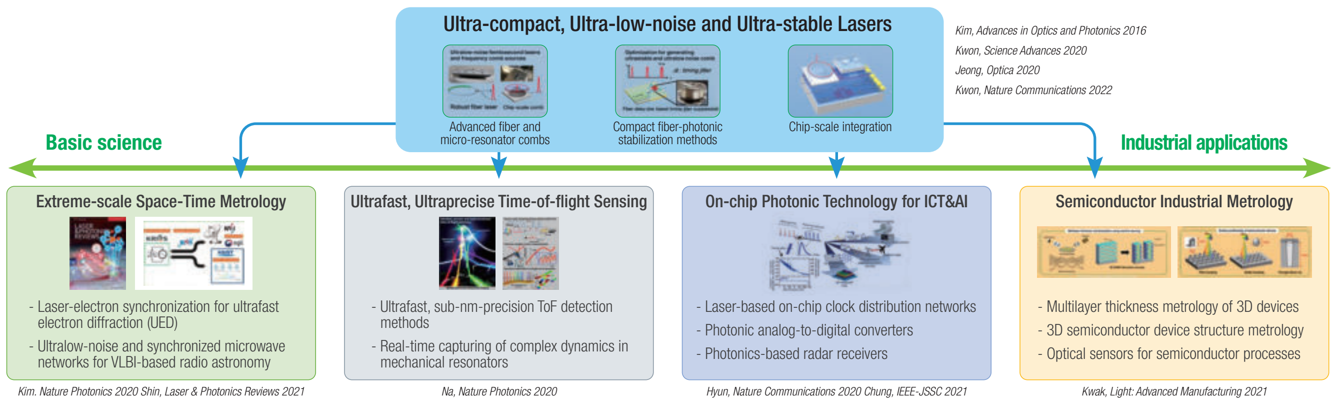
https://www.youtube.com/channel/UCgDd10qUFhI7EAHS158ze0g

Ultra-Scale Photonic Control and Measurement Group

RESEARCH OVERVIEW

Advanced ultrafast lasers and frequency combs enable us to explore ultrahigh-precision measurement and control capabilities. Our research objective is to achieve world-class performance in noise and stability of advanced lasers and microresonator-based light sources and develop new photonic technologies based on such light sources. We are also interested in developing more robust, compact, low-noise and ultra-stable laser sources, as well as expanding the range of their applications. Our recent research results have been not only published at high-impact journals, but also actively applied for high-tech industries including Quantum Technology, ICT & AI, Defense, and Semiconductor Manufacturing. Thanks to the multidisciplinary nature of our research, we also enjoy a wide range of domestic and international collaboration opportunities with academia, national labs, and industries. We believe that the rapid convergence of ultrafast and ultralow-noise lasers, precision measurement and control, and integrated photonic systems will open up interesting new paths in the coming years.



RESEARCH HIGHLIGHTS

We recently demonstrated a novel time-of-flight (TOF) detection technology that uniquely combines ultrafast measurement speed, sub-nm precision, and ambiguity range of more than several mm by integrating an optical frequency comb with ultrasensitive electro-optic sampling-based timing detection approach. We were able to demonstrate multifunctional sensors, such as 3D surface profilometry and strain sensors, utilizing our TOF detection approach. It also facilitates the study of broadband and nonlinear mechanical dynamics in micro-scale devices by allowing real-time detection of rapid and high-dynamic-range mechanical displacements. This finding was published in *Nature Photonics* in June 2020, and it's also featured in the Nature Research Collection *"Sensing at the Limit."* Prof. Kim was also selected as the *Scientist of the Month* for October 2020, awarded by the Ministry of Science and ICT of Korean Government, for his contribution to "broadening the horizon of precision engineering by developing ultrafast, ultrahigh-resolution, and multi-functional TOF sensor technology."

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[1] Kwon, D., Jeong, D., Jeon, I., Lee, H., and Kim, J., "Ultrastable microwave and soliton-pulse generation from fibre-photonic-stabilized microcombs", *Nature Communications*, vol. 13, article 381, Jan. 2022.

[2] Hyun, M., Na, Y., Chung, H., and Kim, J., "Attosecond electronic timing with rising edges of photocurrent pulses", *Nature Communications*, vol. 11, article 3667, Jul. 2020.

[3] Na, Y., Jeon, C., Ahn, C., Hyun, M., Kwon, D., Shin, J., and Kim, J., "Ultrafast, sub-nanometre-precision and multifunctional time-of-flight detection", *Nature Photonics*, vol. 14, no. 6, pp. 355-360, Jun. 2020.

[4] Kim, H., Vinokurov, N., Baek, I., Oang, K., Kim, M., Kim, Y., Jang, K., Lee, K., Park, S., Park, S., Shin, J., Kim, J., Rotermund, F., Cho, S., Feurer, T., and Jeong, Y., "Towards jitter-free ultrafast electron diffraction technology", *Nature Photonics*, vol. 14, no. 4, pp. 245-249, Apr. 2020.

[5] Kwon, D., Jeon, I., Lee, W., Heo, M., and Kim, J., "Generation of multiple ultrastable optical frequency combs from an all-fiber photonic platform", *Science Advances*, vol. 6, article eaax4457, Mar. 2020.

Professor
KIM, Jungwon

Research Interests
Advanced laser engineering / Sensors and imaging / Photonic signal processing / Industrial laser metrology

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Mechatronics, Systems & Control Laboratory

RESEARCH OVERVIEW

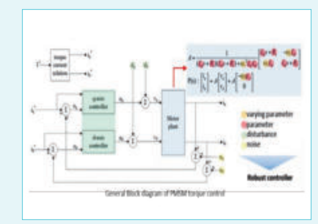
Mechatronics, Systems & Control (MSC) Lab. mainly focuses on the control systems composed of sensors, actuators, and control algorithms. MSC lab. consists of three research groups - Applied Optics Group (AOG), Control theory & Application Group (CAG), and Semi-Robot Group (SRG). AOG handles the fine measurement of the thickness of thin substances using Terahertz optics, component analysis of materials using fiber optics, etc. CAG studies on the robust control principles and their applications to the robots, automotive and industrial devices. For example, the e-Powertrain with the PMSM motor and an inverter is of special interest for EV applications. Recently, we work on autonomous vehicle technologies including vision, Lidar and Radar signal processing. In SRG, the walking robots and the bionic robot hands are the main topics. A quadruped robot equipped with cameras and detection modules is being developed for autonomous inspection of the surface of water tunnels in power plants. The bionic robot hands achieve a powerful but faster motion based on the MSC's unique driving mechanisms so-called the twisted-string actuation.

RESEARCH HIGHLIGHTS

3D Vision and image processing: Towards obtaining accurate information from vision sensors that retain performance under different deployment conditions we are focusing and working on both the front end (camera ISP) and back end (High-Level Vision tasks) to determine and demonstrate performance efficacy. ; Learning Camera ISP: Learning the transformation from RAW to RGB domain using CNNs with emphasis on obtaining DSLR quality images from a single low-cost camera sensor. Image Denoising: Noise removal (Pixel, Patch, Homogeneous, and Non-Homogeneous) using CNNs. 3D Monocular Object Detection: Using monocular cameras to determine the 3D bounding box for enclosing an object accurately. Lane Detection: Using predefined anchor points to estimate lane line characteristics, in the absence or visual degradation of lane markers.

Lidar De-noise (snow, rain, etc.): we proposed a new intensity-based filter that differs from the existing distance-based filter that causes low speed. This method shows overwhelming performance in speed and accuracy by removing only snow particles, not important environmental features. It was possible by deriving the intensity criteria for snow removal based on analyzing the properties of laser light and snow particles.

Integrated Electric Vehicle Safety Control (ABS/ESC): The Anti-lock braking system (ABS) and Electric Stability Control (ESC) guarantee the vehicle's stability while driving by applying brake pressure. Original vehicle safety control consists of each dynamic motion subsystem control. In an electric car, the power source has higher bandwidth than the international combustion engine and can make accurate torque. So we are going to suggest a general control form based on a nonlinear full car model and integrated electric vehicle safety control method.



The Prosthetic hands: Using the active dual-mode twisted string actuation (TSA) mechanism and tiny tension sensors on the tendon strings, an anthropomorphic robot hand is newly designed compactly. Thanks to the active dual-mode TSA mechanism, which is a miniaturized transmission, the proposed robot hand does have a wide range of operations in terms of grasping force and speed. It experimentally produces maximally the fingertip force of 31.3N and minimally the closing time of 0.5s on average. Also, tiny tension sensors with the dimension of 4.7(W)x4.0(H)x10.8(L)mm are newly presented and embedded at the fingertips to measure the tension on the tendon strings, which would allow the grasping force control.

MAJOR PUBLICATION

[1] Lee, Minyoung, Jung-Seok Cho, Kyung-Soo Kim, and Soohyun Kim. "Modulated Motion Blur-Based Vehicle Body Velocity and Pose Estimation Using an Optical Image Modulator." *IEEE Transactions on Vehicular Technology* 70, no. 9 (2021): 8744-8754. [2] Kim, Wooyong, Pyeong-Yeon Lee, Jonghoon Kim, and Kyung-Soo Kim. "A robust state of charge estimation approach based on nonlinear battery cell model for lithium-ion batteries in electric vehicles." *IEEE Transactions on Vehicular Technology* 70, no. 6 (2021): 5638-5647. [3] Kim, Donghyun, Yun-Pyo Hong, and Kyung-Soo Kim. "Bipedal Walking and Impact Reduction Algorithm for a Robot with Pneumatically Driven Knees." *International Journal of Control, Automation and Systems* 19, no. 12 (2021): 3937-3946. [4] Choi, Kyunghwan, Yonghun Kim, Seok-Kyoon Kim, and Kyung-Soo Kim. "Current and position sensor fault diagnosis algorithm for pmsm drives based on robust state observer." *IEEE Transactions on Industrial Electronics* 68, no. 6 (2020): 5227-5236. [5] Park, Ji-Il, Jihyuk Park, and Kyung-Soo Kim. "Fast and accurate desnowing algorithm for LiDAR point clouds." *IEEE Access* 8 (2020): 160202-160212. [6] Cho, Younggeol, Pyungkang Kim, and Kyung-Soo Kim. "Estimating simultaneous and proportional finger force intention based on sEMG using a constrained autoencoder." *IEEE Access* 8 (2020): 138264-138276.

Professor
KIM, Kyung-Soo

Research Interests
Control theories & applications / Sensors and Actuators, Robotics / Automotive technology

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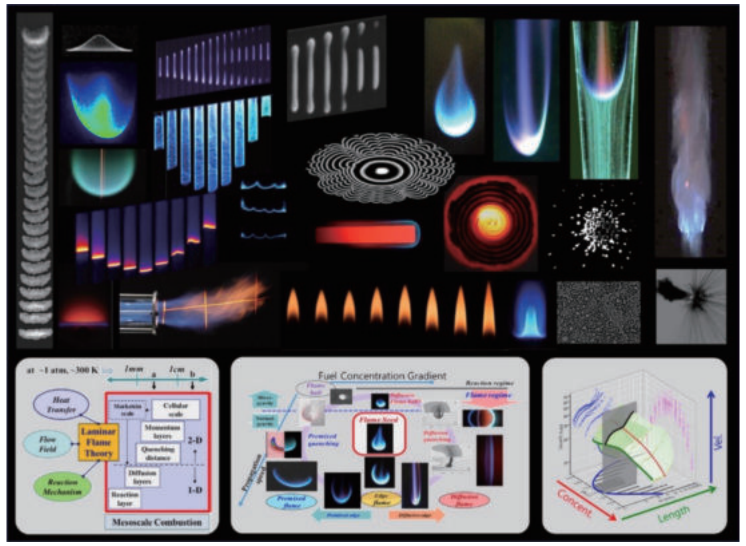
Combustion Laboratory

RESEARCH OVERVIEW

Flame Structure and Theory
Combustion studies have been developed based on flame structure theories. Flame structures and related theories are investigated at Combustion Lab in KAIST. Recently, structural transition and combustion instability affected by inherently different flame structures have been of interest to construct an advanced theory on the flame structure.

Combustion Diagnosis and Modeling
The combination phenomena and flame structures are investigated using advanced experimental techniques (MS, PIV, LIF, LII, etc.). Various combustion systems have been developed, and their performance was analyzed with theoretical and numerical methods.

Combustion New Technology
Recent new technologies related to combustion phenomena are investigated, and advanced systems for combustion applications are designed. Phenomena in small-scale or meso-scale combustion spaces could reveal hidden interactions between ordinary and heterogeneous combustion theories. Specific industrial burner systems such as gas-turbine combustors or oxy-combustor are developed.



RESEARCH HIGHLIGHTS

The stabilization characteristics of laminar and turbulent lifted flames were investigated experimentally with various characteristic configurational length scales under various conditions such as high/low pressures, oxy-combustion, and hydrogen enhancement. Such investigation and related mechanisms can provide essential knowledge for the burner design. The instability mechanism of an unsteady premixed flame propagation within a narrow combustion space was investigated with initial pressure, fuel dilution, and hydrogen concentration variation.

In addition, various practical combustion technologies have been investigated. Breakup characteristics of the water-in-oil emulsion structure were investigated, and valuable technologies that can control emulsion properties were developed. New technologies that can suppress fine dust emissions were developed based on Machine-learning. Burner design was modified for less combustion noise, and numerical analysis of a blast furnace has been investigated.

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[1] Gyu Jin Hwang, Dong Seok Jeon, Nam Il Kim, Stabilization criteria of laminar lifted flames in a non-premixed jet through pressure elevation experiments, *Fuel* 314 (2022.04) 122797.

[2] Gyu Min Jang, Nam Il Kim, Investigation on breakup characteristics of multicomponent single droplets of nanofluid and water-in-oil emulsion using a pulse laser, *Fuel* 310 (2022.02). 122300.

[3] Jiseop Lee, Gyu Jin Hwang, Jeong Ik Lee, Aqil Jamal, Nam Il Kim, Flame stabilization and soot emission of methane jet flames for CO_2 diluted oxy-combustion at elevated pressure, *Combustion and Flame* 231 (2021.09) 111490.

[4] Sang Min Lee, Hye Jin Jang, Nam Il Kim, Premixed flame propagation of CH_4 and C_3H_8 in a narrow-gap-disk-burner using constant-volume processes at elevated-pressure, Combustion and Flame 231 (2021.09) 111482.

[5] Hye Jin Jang, Sang Min Lee, Nam Il Kim, Effects of ignition disturbance on flame propagation of methane and propane in a Narrow-Gap-Disk-Burner, *Combustion and Flame* 215 (2020.05) 124-133.

Associate Professor
KIM, Nam Il

Research Interests
Flame Structure and Theory / Combustion Diagnosis and Modeling / Combustion New Technology

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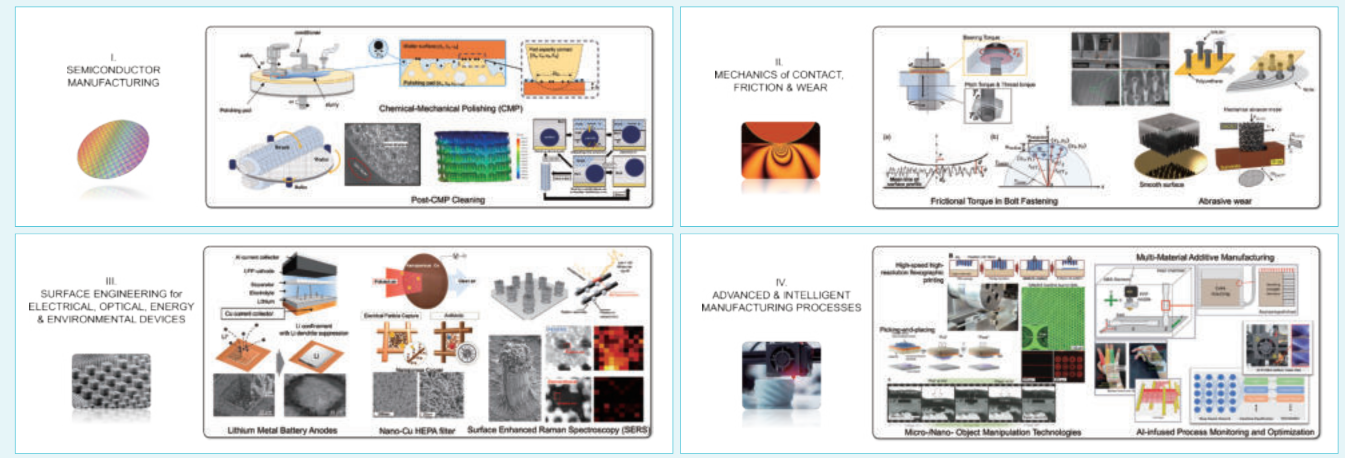
Advanced Manufacturing and Surface Engineering Laboratory

RESEARCH OVERVIEW

AMSElab@KAIST, led by Professor Sanha Kim, aims to advance and innovate manufacturing science and technologies via understanding the mechanics of solid-solid contact and engineering the involved surface phenomena, such as adhesion, friction, wear, material transfer and deformation. We also explore novel materials and processing methods to design and manufacture multi-functional engineered surfaces for multidisciplinary applications, including advanced manufacturing tools, robotics, energy storage devices, biosensors, and environmental system. Our current focus includes:
- Chemical-mechanical polishing (CMP) & post-CMP cleaning for semiconductor manufacturing
- Mechanics of contact, friction and wear.
- Surface engineering for electrical, optical, energy and environmental devices
- Advanced & intelligent manufacturing processes for mass-customization

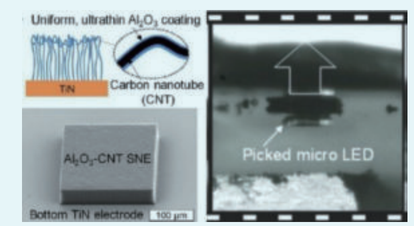


RESEARCH HIGHLIGHTS

Nanocomposite 'Electroadhesive' stamp picks up and puts down microscopic structures We introduced soft nanocomposite electroadhesives (SNEs), comprising sparse forests of dielectric-coated carbon nanotubes (CNTs), which have electrostatically switchable dry adhesion. SNEs exhibit 40-fold lower nominal dry adhesion than typical solids, yet their adhesion is increased >100-fold by applying 30 V to the CNTs. We characterized the scaling of adhesion with surface morphology, dielectric thickness, and applied voltage and demonstrated digital transfer printing of films of Ag nanowires, polymer and metal microparticles, and unpackaged light-emitting diodes

Science Advances, vol. 5, no. 10, eaax4790, 2019

* Featured at 10 news outlets including MIT News, World Economic Forum, Chemical & Engineering News.



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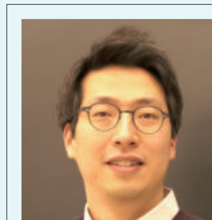
[1] Mechanical abrasion by bi-layered pad micro-asperity in chemical mechanical polishing, Hyun Jun Ryu, Dong Geun Kim, Sukkyung Kang, Ji-Hun Jeong, Sanha Kim*, *CIRP Annals – Manufacturing Technology*, vol. 70, no. 1, 273-276, 2021.

[2] Exploring SERS from complex patterns fabricated by multi-exposure laser interference lithography, Seong Jae Kim, June Sik Hwang, Jong-Eun Park, Minyang Yang, Sanha Kim*, *Nanotechnology*, vol. 32, no. 31, 315303, 2021.

[3] Tailoring the surface morphology of carbon nanotube forests by plasma etching: a parametric study, Seongju Seo, Sanha Kim*, Shun Yamamoto, kehang Cui, Junichiro Shiomi, Taiki Inoue, Shigeo Maruyama*, A. John Hart*, *Carbon*, vol. 180, 204-214, 2021.



Associate Professor
KIM, Sanha

Research Interests
Manufacturing / Contact Mechanics / Surface Engineering / Carbon Nanotubes / 2D·3D Printing

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Mechanical Design Lab. with Advanced Materials

RESEARCH OVERVIEW

Our group is actively researching on the fundamental behavior, analysis, design, manufacturing, and testing of composite materials. Static and dynamic behaviors of fiber reinforced composites are studied through the use of appropriate mathematical models and computational simulation analysis. We are also interested in the application of composites in high-tech areas such as energy storage systems, automobiles, and aerospace engineering. The focus of the research efforts can be broken into the following categories:

Manufacturing technology for composite materials [Fig.1]
- Development of the optimization method for composite manufacturing processes reflecting the various mechanical imperfection.
- Modeling of representative volume element (RVE) for composites to reduce the time and cost effectively.

Composite structural analysis and design [Fig.2]
- Mechanical design of shape memory polymer composite actuators for the space deployable systems.
- Development of composite based machine components for various applications in the field of automobile, aerospace, shipbuilding, and robotics.

Energy conversion and storage systems [Fig.3]
- Development of vanadium redox flow battery (VRFB) based energy storage system (ESS).
- Development of the structural battery for high specific energy properties.

Smart materials [Fig.4]
- Fabrication and optimization of the functional composite materials for various application such as sensors, thermoelectric, piezoelectric, and sound absorbing.
- Simulation of the materials to analyze the interaction of the constituents.

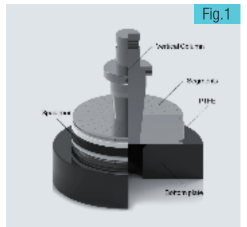
Fig.1

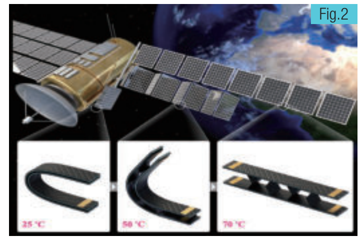
Fig.2

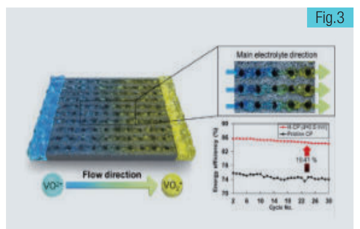

Fig.3

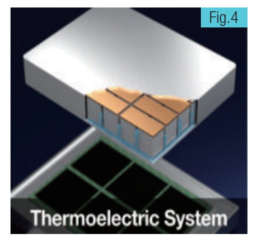

Fig.4

SELECTED PUBLICATIONS

[1] SY. Park, SS. Kim*, et al. "Effects of process-induced residual stress and geometric characteristics on pressure-resisting capability of corrugation in primary barriers of liquefied natural gas carriers." Ocean Engineering 237 (2021): 109613. [2] JM. Jeong, SS. Kim*, et al. "Stacked carbon paper electrodes with pseudo-channel effect to improve flow characteristics of electrolyte in vanadium redox flow batteries." Applied Materials Today 24 (2021): 101139. [3] SM. Baek, SS. Kim*, et al. "Design of an equivalent dielectric film using periodic patterned screen printing and prediction of dielectric constants based on equivalent circuit method" Composites Structures 271 (2021): 114151. [4] SH. Lim, SS. Kim*, et al. "Resin impregnation and interfacial adhesion behaviors in carbon fiber/ epoxy composites: Effects of polymer slip and normalized surface free energy with respect to the sizing agents", Composites Part A 146 (2021): 106424. [5] HS. Hong, SS. Kim*, et al. "Phase transformation of poly (vinylidene fluoride)/TiO2 nanocomposite film prepared by microwave-assisted solvent evaporation: An experimental and molecular dynamics study", Composites Science and Technology 199 (2020): 108375. [6] WT. Kim, SS. Kim*. "Design of a segment-type ring burst test device to evaluate the pressure resistance performance of composite pressure vessels", Composite Structures 242 (2020): 112199. [7] "Sensor-integrated foam core sandwich composite spring capable of measuring bending deformation", US Patent Pending No. 17562667, 2021. [8] "Core-shell structured fiber type strain sensor and method of manufacturing the same" China Patent Pending No. 202080000920.7, 2020.

HONORS / AWARDS

[1] Best paper award, KSCM Fall conference 2021, Hyunsoo Hong, Seong Su Kim
[2] Best paper award, KSCM Fall conference, 2020, Seongyeon Park, Suhyun Lim, Wonvin Kim, Seong Su Kim
[3] Best presentation award, 7th KAIST-SJTU-UTokyo Joint Academic Symposium, Jaemoon Jeong, Seong Su Kim

Associate Professor
KIM, Seong Su
Research Interests
Multi-scale Design and manufacturing of composites / Nano·Micro·Macro composite Materials / Energy storage system using composites / Multi-functional Materials
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Applied Heat Transfer Laboratory

RESEARCH OVERVIEW

Pulsating Heat Pipes
A pulsating heat pipe (PHP) transfers heat by the oscillating motion of the working fluid without wick structure [Fig.1]. It is easy to be fabricated due to the wickless structure and has high thermal performance compared to a conventional heat pipe. The goal is to optimize the thermal performance of a PHP and to fabricate a flexible PHP.

3D Multiporous Cooling Device
Ultra-high heat flux thermal management (> 1 kW/cm^2) is one of the main challenges for the future of electronics. 3D multiporous cooling device is a novel cooling scheme which effectively promotes the liquid supply and the vapor venting at the heated surface [Fig.2]. The device will aid in solving critical challenges in the practical use of the two-phase cooling.

CHF (Critical Heat Flux) Mechanism in Pool Boiling
Proper physics-based understanding of the mechanisms by which CHF (Critical Heat Flux) occurs is crucial to the development of high heat removal devices. The goal is to develop a new CHF model which is based on local temperature and heat flux information that has recently been acquired using an IR-based measurement technique in pool boiling [Fig. 3].

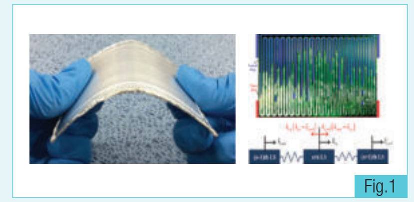
Fig.1

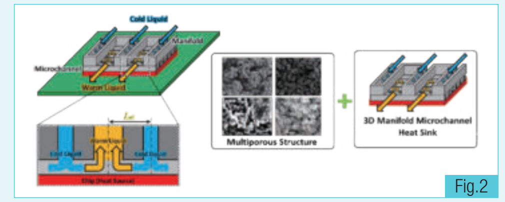

Fig.2

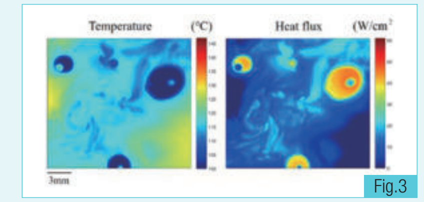

Fig.3

RESEARCH HIGHLIGHTS(2020-2021)

[1] C. Jung, S.J. Kim, Effects of oscillation amplitudes on heat transfer mechanisms of pulsating heat pipes, *International Journal of Heat and Mass Transfer* 165 (2021) 120642.
[2] J. Lim, S.J. Kim, A channel layout of a micro pulsating heat pipe for an excessively localized heating condition, *Applied Thermal Engineering* (2021) 117266.
[3] A. Yoon, S.J. Kim, A deep-learning approach for predicting oscillating motion of liquid slugs in a closed-loop pulsating heat pipe, *International Journal of Heat and Mass Transfer* (2021) 121860.
[4] Y.J. Lee, S.J. Kim, Thermal optimization of the pin-fin heat sink with variable fin density cooled by natural convection, *Applied Thermal Engineering* 190 (2021) 116692.
[5] M. Kim, S.J. Kim, A mechanistic model for nucleate pool boiling including the effect of bubble coalescence on area fractions, *International Journal of Heat and Mass Transfer* 163 (2020) 120453.
[6] M. Kim, A. Sergis, S.J. Kim, and Y. Hardalupas, Assessing the accuracy of the heat flux measurement for the study of boiling phenomena, *International Journal of Heat and Mass Transfer* 148 (2020) 119019.
[7] C. Jung, J. Lim, and S.J. Kim, Fabrication and evaluation of a high-performance flexible pulsating heat pipe hermetically sealed with metal, *International Journal of Heat and Mass Transfer* 149 (2020) 119180.
[8] W. Kim, S.J. Kim, Effect of a flow behavior on the thermal performance of closed-loop and closed-end pulsating heat pipes, *International Journal of Heat and Mass Transfer* 149 (2020) 119251.

Honors / Awards (2020-2022)

[1] KAIST Academic Excellence Award: Grand Prize (2022).
[2] LINKGENESIS Best-Teacher Award: Grand Prize (2020).

KEPCO Endowed Chair Professor
KIM, Sung Jin
Research Interests
Cooling Technology for Electronic Packages / Microscale Heat Transfer and Fluid Flow / Optimum Design of Heat Exchangers, Heat Pipes, and Heat Sinks / Convection Heat Transfer in Porous Media / Critical Heat Flux Mechanism in Pool Boiling
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Environmental Fluid Mechanics Laboratory

RESEARCH OVERVIEW

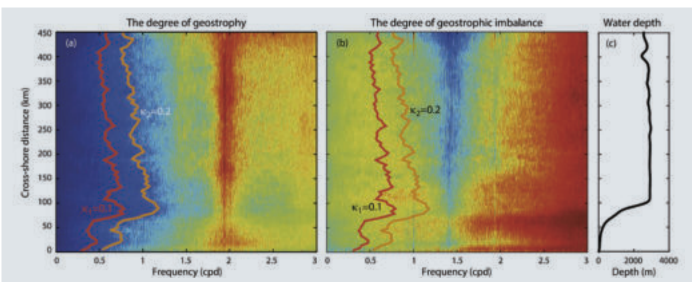
We study various environmental fluids in nature using observations, theories, and numerical simulations. The environmental fluids are observed using acoustic and electromagnetic sensors such as satellites, coastal radars, underwater gliders, moving platforms, and stationary buoys (see a figure on the right below). The observed environmental fluids are understood with statistical and dynamical data analysis (e.g., signal processing, big data analysis, and machine learning) and theoretical frameworks (e.g., momentum equations and advection-diffusion equations). The interpreted environmental fluids are applied to practical and engineering problems. We can list examples here: tracking of water-borne materials (e.g., pollutants, search and rescue missions, and larvae transport), renewable energy using tides and winds, energy cascade via geophysical turbulent mixing, long-term climate changes, sensor fabrication, and spatial and temporal sampling designs.

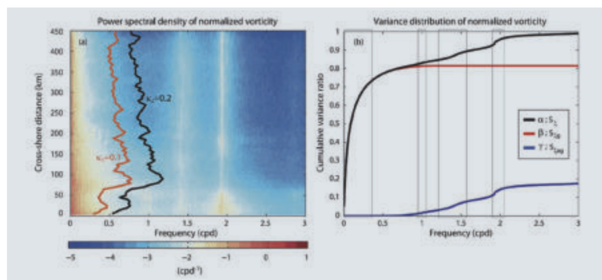
As the boundary layer flows in the air-sea-land interface and a rotating frame, you can easily find the environmental fluids around you, such as coffee in a mug, water in a bathtub, rivers, lakes, atmosphere, ocean, etc. Our primary research foci are the environmental and geophysical fluids at the mesoscale [O(100 to 10000) km] and sub-mesoscale [O(1 to 100) km] and the waves and turbulent mixing below the O(1) km scale.

RESEARCH HIGHLIGHTS

Derivation from surface currents from high-resolution sea surface heights

- Feasibility test to extract submesoscale surface currents from sea surface heights obtained from upcoming satellite missions (e.g., SWOT, COMPIRA, SKIM, WaCM).
- Evaluation of contribution of geostrophy and ageostrophy in coastal ocean currents.
- Regional submesoscale ageostrophic currents account for up to 50% of the total variance and are primarily associated with near-inertial currents and internal tide.





PUBLICITY

[1] 'Ocean and A Cup of Coffee' was won on the double of two significant awards: (1) one of the Top 50 Best Science Books of the Year 2020 from the Ministry of Science and Information and Communication Technology and the Korea Foundation for the Advancement of Science and Creativity, and (2) one of the scholarly books of the year, Sejong Book, from the Publication Industry Promotion Agency of Korea. Professor Kim has published this book as a series of 'Descriptions of Science and Technology by Renowned Scholars,' funded by the Korea Academy of Science and Technology in 2019 (2020. 07. 27; 2020. 11. 06).

[2] Professor Kim received the excellent paper award in Physical Oceanography at the Korean Oceanographic Society Fall meeting held in Gyeongju Hwabaek International Convention Center on November 5, 2020. (2020. 11. 05).

[3] Professor Kim contributed to the United Nations Second World Ocean Assessment (WOA II), the primary output of the second cycle of the Regular Process for Global Reporting and Assessment of the States of the Marine Environment, including Socioeconomic Aspects. The WOA II is the newest outcome of the only integrated assessment of the world's ocean globally, covering environmental, economic, and social aspects (2021. 04. 22).

[4] Professor Kim was invited as the primary speaker in the first meeting of the Book Debate regarding 'Climate Change and Carbon Neutrality' hosted by the Korea Foundation for the Advancement of Science and Creativity (2021. 05. 20).

[5] Professor Kim was recommended and elected as Associated Editor and Editorial Board Member of the international journal, Frontiers in Marine Science (FMS), which aims to bring the existing ocean science together with topics in various fields. As a forward-looking journal that publishes research results of grafted convergence science, Professor Sung Yong Kim was selected for the first time among domestic oceanographers to recognize his domestic and foreign expertise in Coastal Ocean Processes (2021. 08. 26).

Assistant Professor
KIM, Sung Yong
Research Interests
Environmental fluid dynamics / Boundary layer flows / Air-sea and air-sea-land interactions / Environmental BIG DATA / Submesoscale processes / Geophysical turbulent flows / Environmental sensing / Arctic science and engineering
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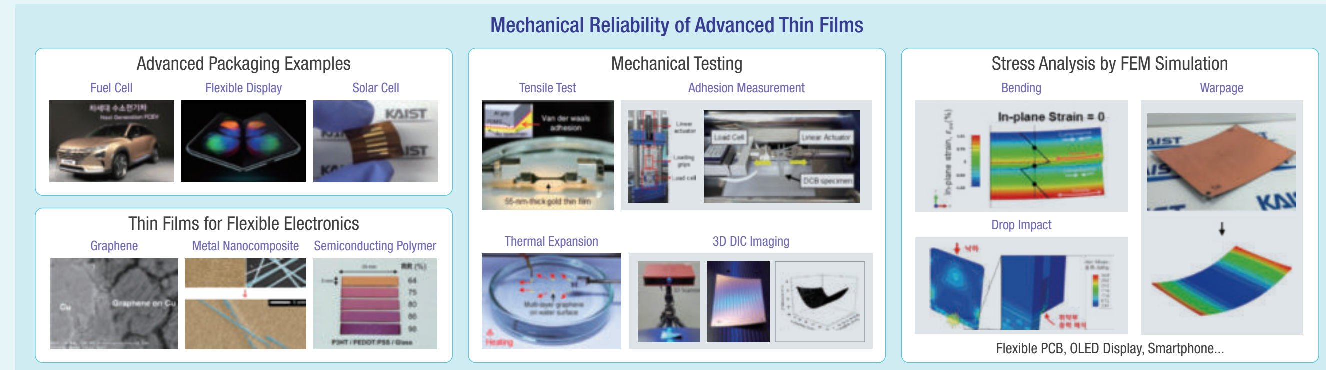
Advanced Packaging and Thin Film Laboratory

RESEARCH OVERVIEW

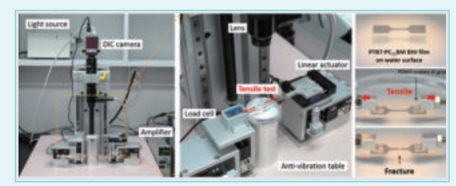
Our main research interests center around the mechanics-related subjects of advanced packaging and thin films for emerging flexible display, fuel cell, solar cell, battery, and microelectronics technologies. We especially focus on experimental mechanics for the study of adhesion, deformation, fracture, fatigue, reliability, and stress/strain induced multiphysics phenomena.

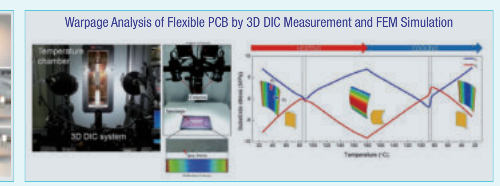


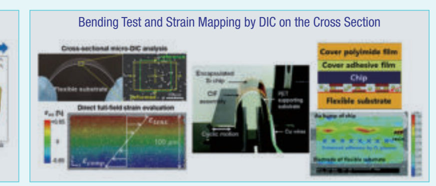
RESEARCH HIGHLIGHTS

The mechanical properties of thin films such as Young's modulus, yield strength, tensile strength, and ductility have been of paramount importance to many thin film applications including microelectronic, biological technologies and energy conversion devices. We have developed the pseudo free-standing tensile testing system and used it to investigate the mechanical properties of various thin and ultra-thin films. With this novel method, the mechanical properties of the most advanced thin and ultra-thin films, which cannot be measured by conventional methods, have been successfully measured.

Using the measured adhesion and mechanical properties of the various thin films, we are also actively working on the stress/strain analysis of flexible electronics, soft actuators, and packaging. Especially, deformation measurement by 3D digital image correlation (DIC), simulation by finite element method (FEM), and bending/folding/stretching tests are performed systematically in order to optimize fabrication processes and device structures.







HONORS/AWARDS

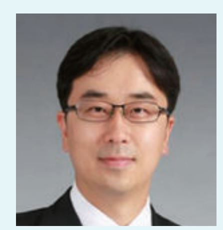
[1] Science and Technology Excellent Paper Award, the Korean Federation of Science and Technologies Societies, 2021.9.10.

[2] 2020 IEEE Transactions on Components, Packaging and Manufacturing Technology Best Paper Award, IEEE Electronic Packaging Society, 2021. 6.

[3] The 2020 Technology Innovation Award Outstanding Prize, KAIST College of Engineering, 2020.12.29.

[4] KAIST Outstanding Faculty Award for Academic Excellence, 2020.7.30.

[5] Member of the Young Korean Academy of Science and Technology, 2020.1.



Professor
KIM, Taek-Soo
Research Interests
Mechanical properties of advanced packaging and thin films
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Ultra-Precision Metrology and Manufacturing Laboratory

RESEARCH OVERVIEW

Ultrafast Photonics: Development of ultrafast lasers for next-generation precision metrology/manufacturing [Fig.1]
Ultra-Precision Metrology: Ultra-precision laser ranging, surface topography, non-destructive internal defect inspection of semiconductor and flat panel display products [Fig. 2]
Ultra-Precision Manufacturing: Direct laser pattering of flexible/stretchable green electronics/optics [Fig.3]

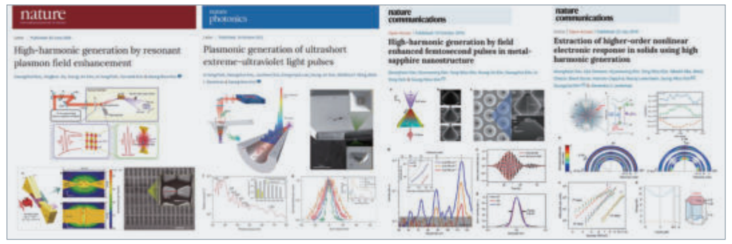


Fig.1 Development of Ultrafast Lasers and Exploration of Nonlinear Photonics

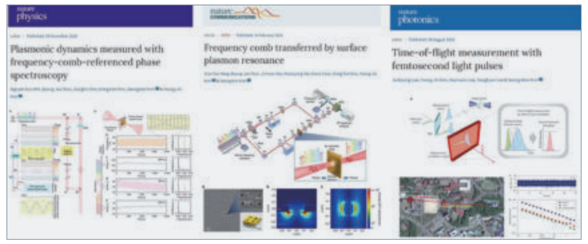


Fig.2 Multi-scale Ultra-precision Metrology: From Kilometers down to Picometers

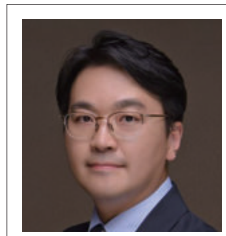
Fig.3 Ultra-Precision Manufacturing of Flexible/Stretchable Opto-Electronics

SELECTED PUBLICATIONS

[1] B.-S. Moon, T.K. Lee, W.C. Jeon, S.K. Kwak, **Young-Jin Kim* (corresponding author)** and D.-H. Kim*, "Continuous-wave upconversion lasing with a sub-10 W cm−2 threshold enabled by atomic disorder in the host matrix", Nature Communications, 12, 4437 (2021) [2] N.D. Anh, B.J. Chun, S. Choi, D.-E. Kim, S. Kim and **Young-Jin Kim* (corresponding author)**, "Plasmonic dynamics measured with frequency-comb-referenced phase spectroscopy", Nature Physics, 15, 132-137 (2019) [3] H.J. Kang, J.-W. Yang, B.J. Chun, H. Jang, B. Kim, **Young-Jin Kim* (corresponding author)** and S.-W. Kim, "Free-space transfer of comb-rooted optical frequencies over an 18 km free-space link", Nature Communications, 10, 4438 (2019) [4] J.S. Hwang, S. Arthanari, J.-E. Park, M. Yang, S. Kim, S.-W. Kim, H. Lee, and **Young-Jin Kim,* (corresponding author)**, "One-step Template-free Laser Patterning of Metal Microhoneycomb Structures", Small Methods, 2022, 2200150 (2022) [5] T.-S.D. Le, Yeong A. Lee, Han Ku Nam, Kyu Yeon Jang, Dongwook Yang, Byunggi Kim, Kanghoon Yim, Seung-Woo Kim, Hana Yoon, and **Young-Jin Kim* (corresponding author)**, "Green flexible graphene-inorganic-hybrid micro-supercapacitors made of fallen leaves enabled by ultrafast laser pulses", Advanced Functional Materials, 2021, 2107768 (2021) [6] C. Yu, J. An, Q. Chen, J. Zhou, W. Huang, Y.-J. Kim* (corresponding author) and Gengzhi Sun, "Recent advances in design of flexible electrodes for miniaturized supercapacitors", Small Methods, 1900824 (2020) [7] T.-S.D. Le, S. Park, J. An, P.S. Lee and **Young-Jin Kim,* (corresponding author)**, "Ultrafast laser pulses enable one-step graphene patterning on woods and leaves for green electronics", Advanced Functional Materials, 2019, 2902771 (2019) [8] T.-S.D. Le, J. An, Y. Huang, Q. Vo, J. Boonruangkan, T. Tran, S.-W. Kim, G. Sun, and **Young-Jin Kim,* (corresponding author)**, "Untrasensitive anti-interference voice recognition by bio-inspired ski-attachable self-cleaning acoustic sensors", ACS Nano, 13, 13293-13303 (2019)

HONORS/AWARDS

[1] Young Scientist Award, Korean President, 2021. [2] Optical Technology Innovation Award, Optical Society of Korea, 2021. [3] IJPEM-Green Technology Highly Commended Paper Award, The Korean Society of Precision Engineering 2019. [4] Outstanding Presenter Award, International Symposium on Precision Engineering and Sustainable Manufacturing (PRESM) 2020. [5] Outstanding Presenter Award, International Symposium on Precision Engineering and Sustainable Manufacturing (PRESM) 2019. [6] Young Researcher Award, International Symposium on Precision Engineering and Sustainable Manufacturing (PRESM) 2018. [7] Singapore National Research Foundation (NRF) Fellowship, 3.0 million SGD, 2015-2020 (funded by the National Research Foundation of Singapore). [8] Editorial Director of Korean Society of Mechanical Engineers (KSME). [9] Editorial Director of Korean Society of Precision Engineering (KSPE).



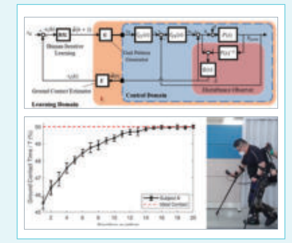
Associate Professor
KIM, Young-Jin
Research Interests
Ultrafast Photonics / Ultra-Precision Metrology / Ultra-Precision Manufacturing
Ph.D., KAIST [2008] +82-42-350-3017 yj.kim@kaist.ac.kr http://upm2.kaist.ac.kr

Exoskeleton Laboratory

RESEARCH OVERVIEW

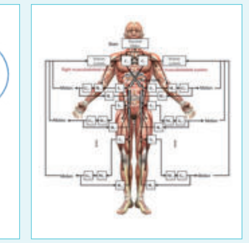
Wearable robots can assist human muscular power and mobility and have great potential in various fields from assisting and rehabilitating people with walking disabilities to enhancing the muscular power of people without disability, e.g., workers or soldiers.

The researchers of the Exoskeleton Laboratory (EXO Lab) are studying promising and reliable solutions for wearable robots in various applications with their exceptional ability based on 1) Digital System Control Theory, 2) Robot Hardware and Sensor Design, and 3) Human Motion Control Theory and Deep Learning.



Control Theory

Wearable Robot Hardware and Sensor Design



Human Motion Control Theory

RESEARCH HIGHLIGHTS

1. The Exo Lab has developed WalkON Suit, a wearable robot specialized for complete paraplegics. which have won gold and bronze medals at the Cybathlon 2020.
2. Soft Angel-Suit, a soft wearable robot specialized for stroke patients, has been developed. The robot is obtaining a medical device certification and in clinical trials.
3. Exo-booster, an exoskeleton for sprinting augmentation, has been developed. We verified that the robot exceeds the wearer's sprinting ability.
4. Angel-Suit, a wearable robot for people with partial impairments, was revealed at the Wearable Robotics Association Conference 2019 (WearRAcon19). A child with spina-bifida demonstrated walking and other various motions while wearing Angel-Suit.

WalkON Suit

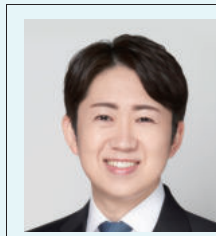
Soft Angel-Suit

Exo-booster

Angel-Suit

HONORS/AWARDS

[1] Nominated as a Leader Researcher of Engineering School, 2022, National Research Foundation of Korea [2] Commendation by Minister, 2022, Ministry of Science and ICT, Korea [3] The 31^{st} Science and Technology Excellence Paper Award, 2021, 2021 Korea Science and Technology Annual Conference [4] Inclusive Award of National Information Society Agency, 2021, The 2^{nd} Social Data·Network·AI Innovation Award of Eyenews24 [5] KAIST Breakthroughs Readers' Choice Award, 2021, KAIST [6] Commendation by Minister, 2021, Ministry of Trade, Industry and Energy, Korea [7] The 16^{th} Korea Robotics Society Annual Conference, KRoC 2021, Best Paper Award [8] Commendation by Minister, 2021, Ministry of Health and Welfare, Korea [9] KAIST's Top 10 Research Achievements in 2020, KAIST [10] Gold and Bronze Medals, Powered Exoskeleton Race, Cybathlon 2020 [11] Commendation by Prime Minister, 2019, Prime Minister of Korea, recognized for the contribution of 2018 Pyeongchang Paralympic Games Held Ceremony [12] President's Award for the Best Innovation, 2017, Korea Invention Patent Exhibition [13] UAE Ai& Robotics Award for Good, 2017 [14] Journal of Mechanical Science and Technology Editor's Award, 2017, Korean Society of Mechanical Engineers [15] Young Researcher Award, 2017, Korean Society of Robotics [16] Commendation by Minister, 2017, Ministry of Commerce, Industry and Energy, Korea [17] Core Engineer for Future Technology, 2017, The National Academy of Engineering of Korea [18] Bronze Medal, Powered Exoskeleton Race, Cybathlon 2016 [19] Outstanding Academic Activity Award, 2016, Institute of Control, Robotics and Systems



Associate Professor
KONG, Kyoungchul
Research Interests
Human assistive robotics / Human power augmentation / Design and control of wearable robots
Ph.D., University of California, Berkeley [2009] 82-42-350-3012 kckong@kaist.ac.kr http://robotics.kaist.ac.kr

Musculoskeletal Biodynamics Laboratory

RESEARCH OVERVIEW

Human movement is a result of complex orchestration of neural command, muscle-tendon activation, and ligaments contained skeleton systems. Malfunction of any part of the structures can hinder normal movement. Movements and mechanical stresses in human musculoskeletal system including skeleton, muscle and connective tissues are investigated through subject testing, medical imaging and computer simulation to understand mechanical pathways of joint injuries

RESEARCH HIGHLIGHTS

DEEP LEARNING OF HUMAN WALKING : Walking is a result of complex process that involves neuronal control of muscles, musculoskeletal dynamics and interaction with environments. We investigate the neuronal controller of human walking using the deep reinforcement learning for the applications in orthopaedics, rehabilitation, and sports. Human gait study is closely related with bipedal robots and exoskeleton robots assisting walking. [Fig.1]

MUSCULOSKELETAL DYNAMICS SIMULATION : Human joints are mechanically redundant systems consisting of multiple ligaments and muscles. We have developed musculoskeletal dynamics models of the knee and foot joints and have run simulations to estimate muscle forces, ligament tensions and articular contact forces during daily activities, which helps understand the mechanism of joint injuries. [Fig.2]

SKELETAL IMAGING AND MOTION ANALYSIS : Unusual movements of the human joint can initiate a degenerative process by changing the mechanical stresses in soft tissues and bone surfaces. We have developed a dual X-ray fluoroscopic imaging system to measure the patient's accurate three-dimensional joint motion. We use this system to understand abnormal joint movements and changes due to surgical intervention. [Fig.3]

Fig.1

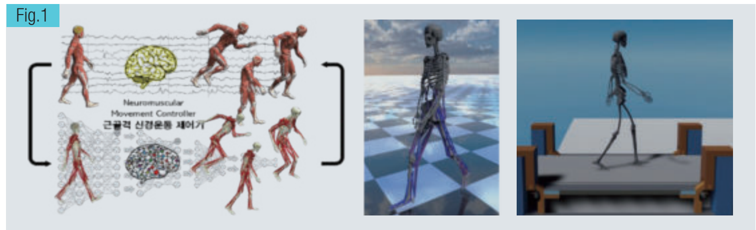
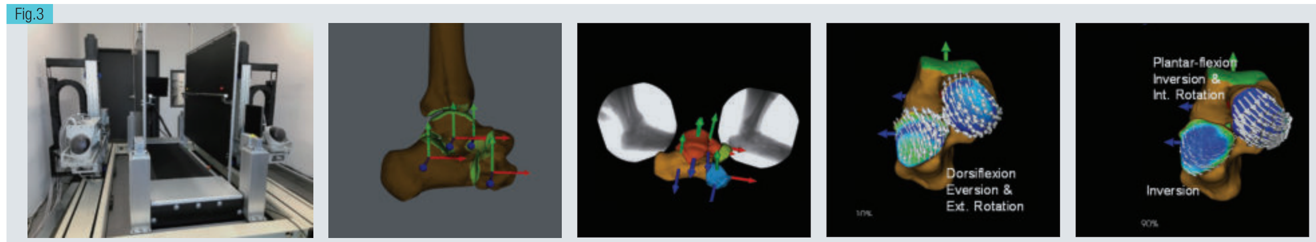


Fig.2

Fig.3



SELECTED PUBLICATIONS

[1] Park G, Lee KM, Koo S, Uniqueness of gait kinematics in a cohort study, Scientific Reports, 11: 15248, 2021.

[2] Phan CB, Lee KM, Kwon SS, Koo S, Kinematic instability in the joints of flatfoot subjects during walking: A biplanar fluoroscopic study, Journal of Biomechanics, 127:110681, 2021.

[3] Jeon S, Lee KM, Koo S, Anomalous gait feature classification from 3-D motion capture data, IEEE Journal of Biomedical and Health Informatics, 26(2):696-703, 2022.

Associate Professor

KOO, Seungbum

Research Interests

Human Joint Movement / Musculoskeletal Dynamics Simulation / Orthopaedic Medical Devices

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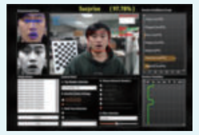
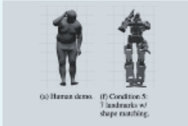
Telerobotics and Control Laboratory

RESEARCH OVERVIEW

Telerobotics and control lab studied in various fields such as HRI (Human Robot Interaction), Medical Robot and Haptic. HRI has been focusing on the field of perception, cognition, emotional interaction, and expression between human and robot. Medical robot research has been focusing on developing surgery robots, aiming to minimize invasiveness for patients, and maximize convenience for surgeons. Haptic is a research field of creating tactile sensation that has been focusing on the creation of virtual objects or texture in simulation by tactile feedback.



Facial expression recognition



Motion retargeting

RESEARCH HIGHLIGHTS

HRI (Human-Robot Interaction) research in TCL aims to develop software and hardware platforms that enable a robot to be regarded as a natural interaction partner. To this purpose, we have developed deep learning-based human facial expression recognition model and touch pattern recognition model to offer proper services and to have a natural interaction with a human. For the natural expression of robots, motion generation based on learning human surface information also proceeding. In addition, a monitoring system has been developed to prevent dangerous accidents to human.

Medical robot research in TCL aims to develop surgical robots that can expand robotic surgery beyond conventional surgical robots. To this purpose, we have developed various type of flexible surgical robot including K-FLEX, K-FLEXa1, easyColon, easyEndo, and easyUretero. Each robot is developed for natural orifice transluminal endoscopic surgery (NOTES), transoral robotic surgery (TORS), colonoscopy, endoscopy, and urology. The feasibility of each robots was validated through dry-lab test and in-vivo animal test. In addition, we have developed various rigid type surgical robots including easyMicro, easyArthro, and APOLLON2. Each robot is developed for versatile microscopic surgery, arthroscopy, and general laparoscopic surgery. Due to its high precision and adjustable workspace, each robot platforms can be applied to general surgeries with different requirements.

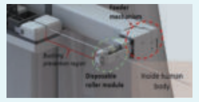
Haptic research in TCL mainly focused on the application of tactile feedback on various type of display. We researched on the rendering strategy of tactile feedback with mechanical vibration and electro-vibration for more immersive interaction with virtual objects on conventional visual display. This research will be applied to future devices that simultaneously receive visual and tactile information through a display. Recently, we developed a Braille actuator module and tactile display for visually impaired people who most need high-resolution of tactile information. This technology is expected to be applied to actual portable refreshable Braille devices and utilized as tactile displays.

In December 2021, **EasyEndo Surgical Inc.**, the entrepreneurial company that Professor Kwon, Dong-Soo founded successfully got 17th designation of innovative medical devices about easyUretero platform. Also, the company successfully obtained medical device GMP quality satisfaction with the safety, effectiveness, suitability and consistency of the production of medical devices designed, developed, produced, installed and serviced.

Safety monitoring

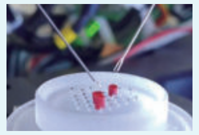
K-FLEXa 1

easyUretero

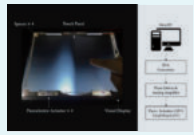


easyColon

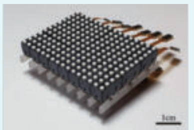
APOLLON2



easyMicro



Rendering Ractile Feedback



Braille Display

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[1] Ryu, Semin, et al. "Rendering Strategy to Counter Mutual Masking Effect in Multiple Tactile Feedback." *Applied Sciences*, vol.10, no. 14, 4990, 2020. [2] Kim, Joonyeong, et al. "Braille display for portable device using flip-latch structured electromagnetic actuator." *IEEE transactions on haptics*, vol.13, Issue 1, pp.59-65, 2020. [3] Lim, Chan-Soon, and Dong-Soo Kwon. "Body Shape-Guided Motion Retargeting to Reduce Effort on Human to Humanoid Landmark Placements." *IEEE Access*, vol. 9, pp.40996-41009, 2021. [4] Jae Min You, et al. "Design and Analysis of High-Stiffness Hyperredundant Manipulator With Sigma-Shaped Wire Path and Rolling Joints", IEEE Robotics and Automation Letters, vol. 6, no. 4, pp. 7357-7364, 2021. [5] Hansoul Kim, et al. "A Sigmoid-Colon-Straightening Soft Actuator With Peristaltic Motion for Colonoscopy Insertion Assistance: Easycolon", IEEE Robotics and Automation Letters, vol. 6, no. 2, pp. 3577-3584, 2021. [6] Dong-Ho Lee, et al. "Non-Linear Hysteresis Compensation of a Tendon-Sheath-Driven Robotic Manipulator Using Motor Current", IEEE Robotics and Automation Letters, vol. 6, no. 2, pp. 1224-1231, 2021. [7] Young-Hoon Nho, et al. "UI-GAN: Generative Adversarial Network-Based Anomaly Detection Using User Initial Information for Wearable Devices", IEEE Sensors Journal, vol. 21, no. 8, pp. 9949-9958, 2021. [8] Kyu-Seob Song, et al. "A Motion Similarity Measurement Method of Two Mobile Devices for Safety Hook Fastening State Recognition", IEEE Access, vol. 10, pp. 8804-8815, 2022.

Professor

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Research Interests

Human-Robot Interaction / Medical Robotics / Haptics

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Human-Robot Interaction Laboratory

RESEARCH OVERVIEW

1. SOFT ACTUATORS & SENSORS
   Development of Artificial Muscle, Shape Memory Alloy Actuators, Electrohydraulic Actuators, Stretchable Strain & Pressure Sensors
2. MEDICAL APPLICATIONS
   Wearable Rehabilitation Devices, 3DoF Force Sensors for Surgical Robot, Endoscopic Robot [Fig.3]
3. SOFT ROBOTICS APPLICATIONS
   Design of Soft Manipulators and Grippers, Bioinspired Robots, Artificial Creatures
4. HAPTIC APPLICATIONS
   Soft Material based User Interface, Flexible Haptics Interface, Design of Wearable Interfaces providing User Experience, Automotive Applications

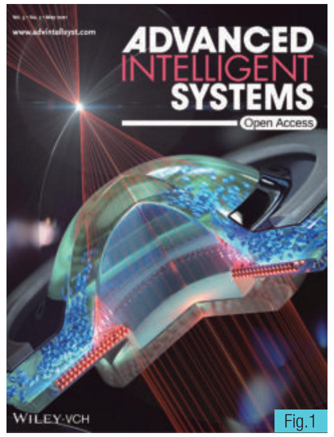

Fig.1

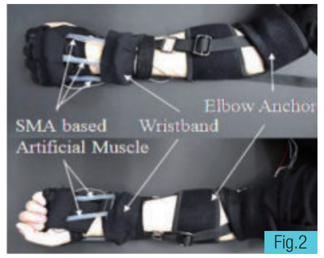

Fig.2

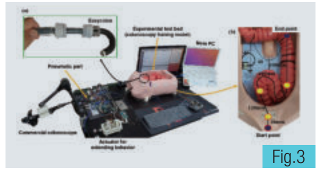
Fig.3

RESEARCH HIGHLIGHTS

1. High-Output Force Electrohydraulic Actuator Powered by Induced Interfacial Charges (2021) [Fig.1]
2. Wrist Assisting Soft Wearable Robot with Stretchable Coolant Vessel integrated SMA Muscle (2021) [Fig.2]
3. Electroadhesion based High-Payload Soft Gripper with Mechanically Strengthened Structure (2021) [Fig.4]
4. A Soft and Transparent Visuo-Haptic Interface Pursuing Wearable Devices (2020) [Fig.5]

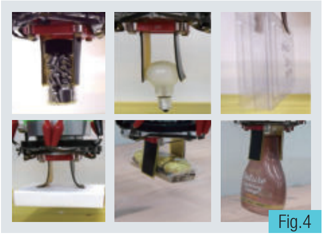
Fig.4

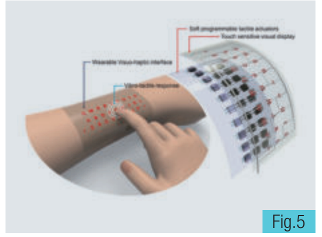
Fig.5

SELECTED PUBLICATIONS

[1] Youn, JH; Jeong, SM; Hwang, G; Kim, H; Hyeon, K; Park, J; *Kyung, KU; "Dielectric Elastomer Actuator for Soft Robotics Applications and Challenges", APPLIED SCIENCES-BASEL, vol.10, no.2, pp.640, 2020

[2] Yun, S; Park, S; Park, B; Ryu, S; Jeong, SM; *Kyung, KU; "A Soft and Transparent Visuo-Haptic Interface Pursuing Wearable Devices", IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, vol.67, no.1, pp.717~724, 2020

[3] Jeong, JY; Hyeon, KJ; Han, JW; Park, CH; Ahn, SY; Bok, SK; *Kyung, KU; "Wrist Assisting Soft Wearable Robot with Stretchable Coolant Vessel integrated SMA Muscle", IEEE/ASME TRANSACTIONS ON MECHATRONICS, 2021

[4] Park, SK; Run, S; Hwang, GW; *Kyung, KU; *Park, S; "Highly contrastive, real-time modulation of light intensity by reversible stress-whitening of spontaneously formed nanocomposites: application to wearable strain sensors", JOURNAL OF MATERIALS CHEMISTRY C, vol. 9, no. 27, pp. 8496-8505, 2021 (Front Cover Article)

[5] Kim, HW; Ma, JH; Kim, MK; Nam, JS; *Kyung, KU; "High-output Force Electrohydraulic Actuator Powered by Induced Interfacial Charge", ADVANCED INTELLIGENT SYSTEMS, vol.3, no.5, pp.2100006, 2021 (Front Cover Article)

[6] Youn, JH; Mun, H; *Kyung, KU; "A Wearable Soft Tactile Actuator with High Output Force for Fingertip Interaction", IEEE ACCESS, vol.9, pp.30206~30215, 2021

[7] Hwang, G; Park, J; Diaz Cortes, DS; Hyeon, K; *Kyung, KU; "Electroadhesion based High-Payload Soft Gripper with Mechanically Strengthened Structure", IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, vol.69, pp.642 - 651, 2021

[8] Kim, HS; Kim, JH; You, JM; Lee, SW; *Kyung, KU; *Kwon, DS; "A Sigmoid-Colon-Straightening Soft Actuator with Peristaltic Motion for Colonoscopy Insertion Assistance: Easycolon", IEEE ROBOTICS AND AUTOMATION LETTERS, vol.6, no.2, pp.1~1, 2021

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Research Interests
Soft Robotics / Medical · Rehabilitation Robots / UI · UX: Haptics, Wearable Devices / Intelligent Human-Robot Interaction

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Thermal Radiation Laboratory

RESEARCH OVERVIEW

With a clear aim of contributing to future development of the energy conversion & generation technology, the ultimate goal of Thermal Radiation (TRAD) Laboratory is to conduct the 'Application-Driven Fundamental Research' on the thermal energy transport at the nanometer scale and make significant impact on future applications of nanoscale thermal radiation for energy conversion and utilization.

RESEARCH HIGHLIGHTS

Daytime Radiative Cooling [Fig.1]
Ability to tailor the far-field radiative properties is a direct result of the interaction between electromagnetic waves and surface nano/micro structures in the near-field regime (i.e., at the length scale comparable to the characteristic wavelength). We achieved 0.99 emissivity in the wavelength of 8–13 mm using grating-patterned PDMS film.

Near-Field Thermal Radiation at Nanoscale Vacuum Gaps [Fig.2]
Near-field thermal radiation dominates radiative energy transfer between two objects that are located closer than the characteristic wavelength of thermal radiation determined by Wien's displacement law. In fact, when two objects are held at a separation distance less than the characteristic wavelength, the radiative heat transfer rate can exceed that between two blackbodies (i.e., Stefan-Boltzmann law) by several orders of magnitude. Due to difficulties in maintaining the nanoscale gap distance between the emitter and the receiver, experimental investigations of near-field radiative heat transfer are rather limited to relatively simple geometries, such as spherical or point-like emitters. We experimentally demonstrate a substantially increased near-field radiative heat transfer between asymmetric structures (i.e., doped Si and SiO2) by using a thin Ti film as a plasmonic coupler.

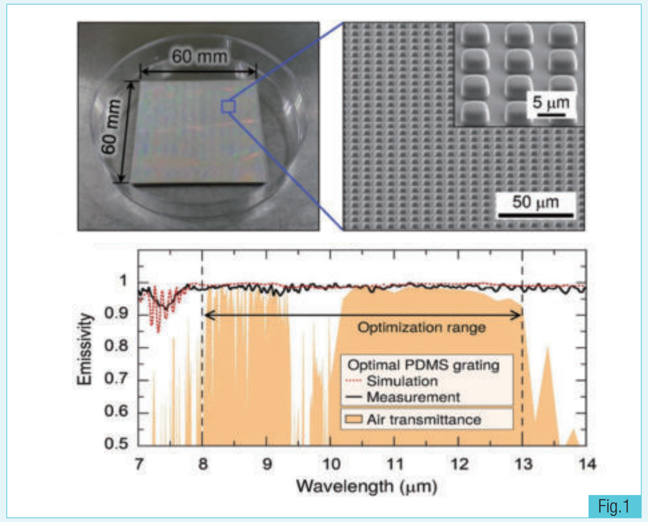

Fig.1

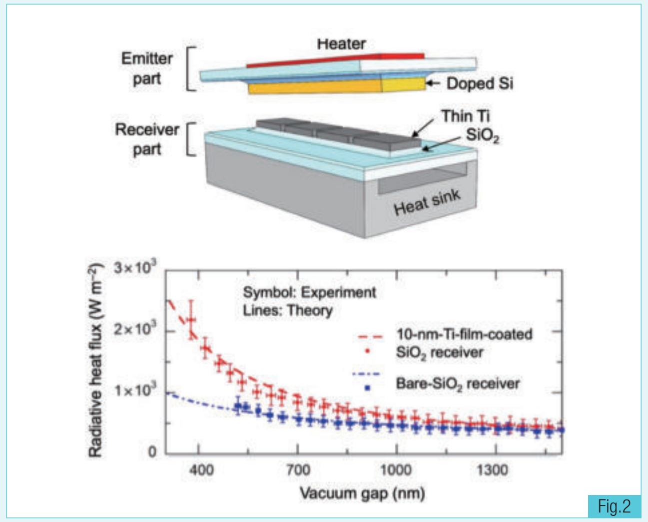

Fig.2

HONORS/AWARDS

[1] Fellow of ASME, 2021
[2] The 6th KSME-SEMES Open Innovation Challenge, Bronze Award, 2021
[3] The 5th KSME-SEMES Open Innovation Challenge, Encouragement Award, 2020
[4] KAIST Endowed Chair Professor, 2020

Professor
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Research Interests
Near-Field Thermal Radiation / Passive Daytime Radiative Cooling / Micro · Nanoscale Thermometry

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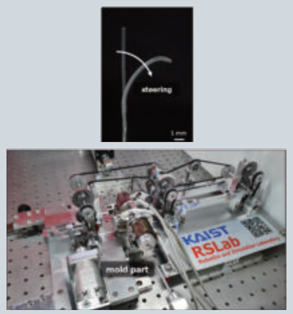
Robotics and Simulation Laboratory

RESEARCH OVERVIEW

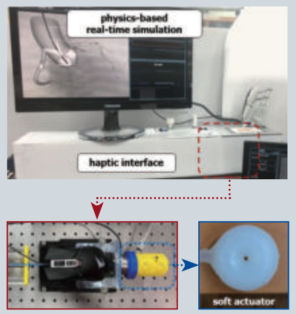
We specialize in robotics, high-fidelity simulation, and their application to healthcare. Our interests in the robotics include master-slave control systems and haptic systems for robots and devices used in the surgery and medical intervention. We investigate innovative ways to apply robotics to healthcare, for example, haptic masters for robotic catheters, and active-steering catheters for vascular intervention. Simulation is a powerful tool for planning and training of surgery, intervention, and many medical procedures. We research technology essential to the high-fidelity medical simulation. We have been developing simulations of various medical procedures including upper & lower gastrointestinal endoscopy; ERCP (Endoscopic Retrograde Cholangiopancreatography); CRIF (Closed Reduction & Internal Fixation); interventions using needles and catheters; and emergency diagnosis of thoracic and abdominal trauma.

RESEARCH HIGHLIGHTS

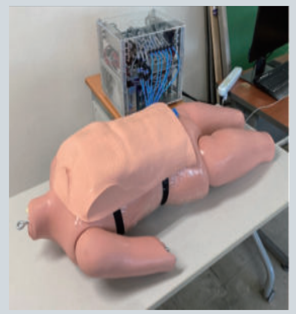
Active-steering medical guidewire and its manufacturing system



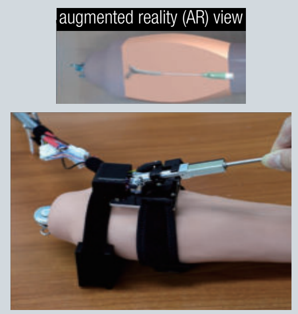
Training simulation of arterial intervention using catheters



Haptic interface for training simulation of thoracic and abdominal trauma



Haptic interface for training simulation of arterial injection



SELECTED PUBLICATIONS

[1] S. Kim and D. Y. Lee, "Control of Haptic Systems Based on Input-to-State Stability", *IEEE Access,* vol. 10, pp. 27242-27254, 2022.

[2] C. Kim and D. Y. Lee, "Adaptive Model-Mediated Teleoperation for Tasks Interacting with Uncertain Environment", *IEEE Access,* vol. 9, pp. 128188–128201, 2021.

[3] S. P. Byeon and D. Y. Lee, "Adaptive Surface Representation Based on Homogeneous Hexahedrons for Interactive Simulation of Soft Tissue Cutting", *Computer Methods and Programs in Biomedicine,* vol. 200, 105873, 2021.

[4] S. Kang and D. Y. Lee, "Hydraulically Steerable Micro Guidewire Capable of Distal Sharp Steering", *IEEE Transactions on Biomedical Engineering,* vol. 68, no. 2, pp. 728–735, 2021.

[5] H. Han and D. Y. Lee, "Deformable Objects Modeling with Iterative Updates of Local Positions", *Computer Methods and Programs in Biomedicine,* vol. 190, 105346, 2020.

[6] S. P. Byeon and D. Y. Lee, "Method for Real-Time Simulation of Haptic Interaction with Deformable Objects using GPU-Based Parallel Computing and Homogeneous Hexahedral Elements", *Computational Mechanics,* vol. 65, no. 5, pp. 1205–1218, 2020.

[7] M. Kim and D. Y. Lee, "Multirate Haptic Rendering Using Local Stiffness Matrix for Stable and Transparent Simulation Involving Interaction with Deformable Objects", *IEEE Transactions on Industrial Electronics,* vol. 67, no. 1, pp. 820–828, 2020.

Professor
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Research Interests
Medical Robotics & Haptics / Medical Simulation

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Innovative Design Optimization Laboratory

RESEARCH OVERVIEW

Simulation-Based Design under Uncertainties [Fig.1&2]
- Reliability-based design optimization
- Robust design optimization
- System reliability analysis and design optimization

Improved Topology Optimization using Grouping Variables [Fig.3]
- Reduce elapsed time to convergence in topology optimization

Improvement of Surrogate Model Generation Method [Fig.4]
- Surrogate model generation using basis screening Kriging method

Development of Efficient Statistical Model Calibration [Fig.5]
- Model calibration based on discordance between test and simulation

Optimization with Artificial Intelligent [Fig.6]
- Pattern generation with generative adversarial network

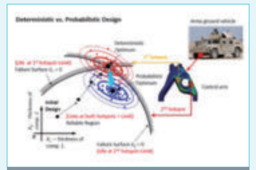


Fig.1 Design under Uncertainty

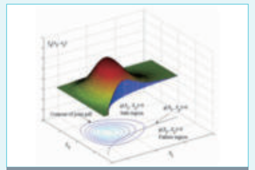


Fig.2 Reliability Analysis

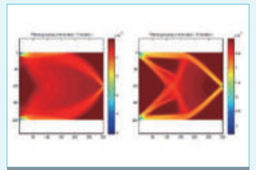


Fig3. Grouping Variables based on Density and Sensitivity

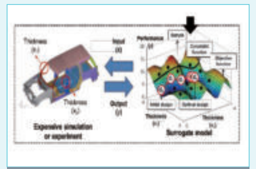


Fig. 4 Surrogate Model Generation Using Kriging Method

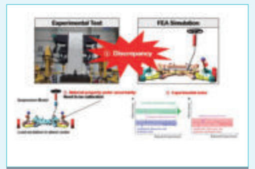


Fig. 5 Statistical Model Calibration

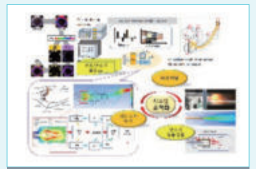
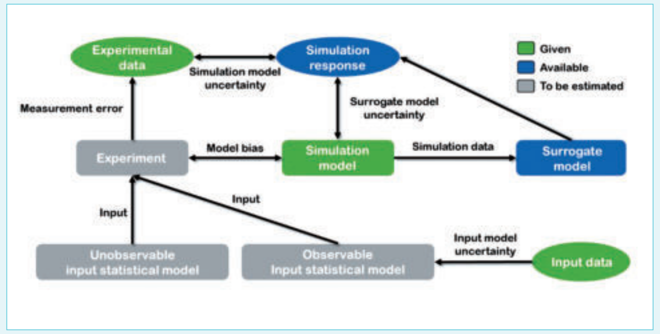
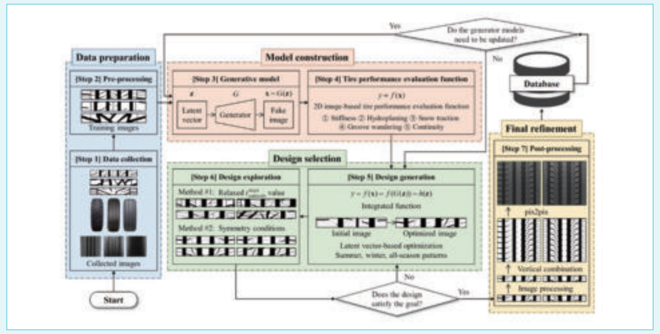


Fig. 6 Optimization with Deep Learning

RESEARCH HIGHLIGHTS



[1] Jung, Y., Kang, K., Cho, H., & Lee, I. (2021). Confidence-based design optimization for a more conservative optimum under surrogate model uncertainty caused by gaussian process. *Journal of Mechanical Design,* 143(9).



[2] Lee, M., Park, Y., Jo, H., Kim, K., Lee, S., & Lee, I. (2022). Deep generative tread pattern design framework for efficient conceptual design. *Journal of Mechanical Design,* 1-28

RESEARCH AREAS

[1] Reliability Analysis & Simulation-based Design under Uncertainty
[2] Surrogate Modeling
[3] Statistical Model Calibration
[4] Topology Optimization
[5] Optimization with Artificial Intelligence

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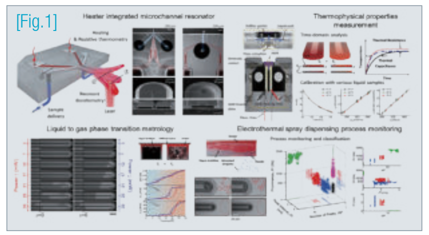
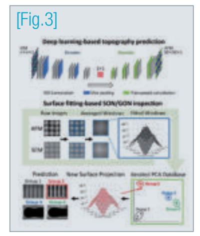
Manufacturing and Instrumentation Laboratory

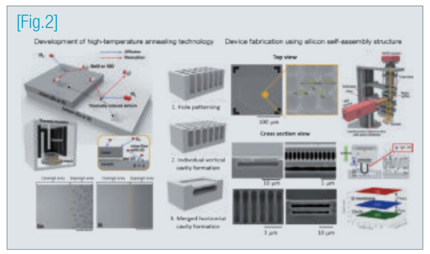
RESEARCH OVERVIEW

Remember that only limited researchers have access to high-end micro-/nanofabrication facilitates worldwide. Processes and materials we are currently relying on may not be the best out of available options. We look for better processes for conventional micro-/nanofabrication materials and better materials to realize high-performance transducers. Our current research interests include large scale batch fabrication of nanostructures based on silicon self-assembly, hydrogel based micro-/nanoelectromechanical systems, materials and processing for flexible, stretchable, and wearable devices, nanoscale 3D printing of organic and inorganic hybrids, 3D printing for biomedical applications, multifunctional atomic force microscopy, single molecule force / mass spectroscopy, high-precision laser based manufacturing and metrology, additive manufacturing, and thermophysical property measurements.

1. **High temperature annealing based micro-nano fabrication technology** [Fig.1]
   Silicon-on-nothing and germanium-on-nothing technology, Interferometry microscope for non-destructive test of SON and GON
2. **Nanomechanical sensing with heater integrated microchannel resonator** [Fig. 2]
   Multimodal sensing platform to enable fast, quantitative, and wide range temperature modulation with promising applications
3. **Machine vision-based fabrication monitoring and analysis** [Fig. 3]
   Deep learning scheme applied to predict nanoscale topography from optical microscope images
4. **MICROPIPETTE RESONATOR** [Fig.4]
   Micropipette resonator for targeted aspiration and mass measurement of single particle and cells

[Fig.1]


[Fig.3]


[Fig.2]


[Fig.4]


RESEARCH HIGHLIGHTS

1. **Bronze Award at 6th KSME-SEMES Open Innovation Challenge**
   At the "6th KSME-SEMES Open Innovation Challenge" co-organized by Korean Society of Mechanical Engineers (KSME) and SEMES, the research team composed of Prof. Jungchul Lee, Prof. Bong Jae Lee, Mun Goung Jeong, Taeyeong Kim (Ph.D. student) and Jaewoo Jeong (Master student) from Center for Extreme Thermal Physics and Manufacturing (CETPM), received the Bronze Award with their creative idea entitled "Fabrication and recognition of embedded micro-pattern-based anticounterfeiting tag".
2. **Silver prize at 28th Samsung Humantech Paper Award**
   At the "28th Samsung HumanTech Paper Awards" hosted by Samsung Electronics, Juhee Ko, a doctoral student in Professor Jungchul Lee's lab and Center for Extreme Thermal Physics and Manufacturing (CETPM), won the Silver Prize in the Mechanical Engineering section with the creative idea entitled "Heater integrated microchannel resonators: A new experimental platform for microscale heat transfer". This paper presents a new experimental platform named heater integrated microchannel resonator (HMR) to explore microscale thermal metrology and thermal manufacturing. The possibility of a newly introduced experimental platform is shown by implementing three promising applications along with the fabrication and characterization of HMR.

HONORS / AWARDS

[1] Commendation from the Minister of Science and ICT on the 53rd Science day (2020)
[2] The 5th KSME-SEMES Open Innovation Challenge, Encouragement Award (2020)
[3] The 6th KSME-SEMES Open Innovation Challenge, Bronze Award (2021)
[4] Fall Conference of the Society of Micro and Nano System, Best Poster Presentation Award (2021)
[5] Silver prize at 28th Samsung Humantech Paper Award (2022)
[6] NCC 2022 conference, Best oral presentation award and best poster presentation award (2022)

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Research Interests
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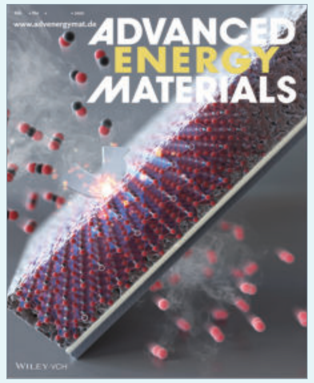
Advanced Energy Conversion and Storage Laboratory

RESEARCH OVERVIEW

Developing highly efficient energy conversion and storage technology based on solid oxide systems is the main goal of current research includes power generation, hydrogen production, and CO_2 electrolysis. The key technical issue that bottlenecking this transformative technology is its high operating temperature, resulting in higher systems costs and performance degradation. To address this issue, designing systems with reduced operating temperature has been emphasized. Therefore, the focus is on materials-to-cell design of solid oxide systems and understanding electrochemistry inside. We explore unique candidate materials with highly conductive and catalytic active properties, and develop efficient and scalable fabrication processes. Superior performance and long-term stability have been examined by integrating components to cell. Furthermore, microstructure is reconstructed by 3D nano image to seek critical structural factors for electrochemical reaction. Based on this understanding, we feedback interfacial design of the components. Overall, our research will provide highly efficient and feasible energy technology for future energy conversion and storage applications.

RESEARCH HIGHLIGHTS

For CO_2 electrolysis in solid oxide systems, the electrochemical reaction is mostly dominated by the fuel electrode reaction related to the CO / CO_2 redox couple on the electrode surface. Thus, several research groups have extensively searched for durable fuel electrode that provide high catalytic reactivity compared to the conventional Ni-based blending electrodes which is easily deactivated by re-oxidation or carbon formation. In this study, the dual composite oxide cathode including $(La_{0.75}Sr_{0.25})_{0.97}Cr_{0.5}Mn_{0.5}O_3$ and $Ce(Mn,Fe)O_2$ was developed without any metal catalyst. With the accelerated electrode reaction attributed to the enhanced active sites and surface oxygen vacancy concentration for CO_2 adsorption and the subsequent dissociation processes, high faradaic efficiency of 92% and a current density of 2.6 $A{\cdot}cm^{-2}$ were obtained for CO_2 electrolysis, indicating that the novel composite cathode is a promising oxide electrode material for CO_2 electrolysis application.



[Figure.] Schematic illustration of all-perovskite CO_2 electrolysis cells and a novel composite material.

SELECTED PUBLICATIONS

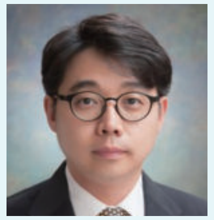
[1] S. Lee#, M. Kim#, **K. T. Lee***, John. T.S Irvine, T. H. Shin*, "Enhancing electrochemical CO_2 reduction using Ce(Mn,Fe)O_2 with La(Sr)Cr(Mn)O_3 cathode for high-temperature solid oxide electrolysis cells", *Advanced Energy Materials,* 2100339, (2021). (IF=29.368)

[2] S. Lee, H. Ha, K. T. Bae#, S. Kim, H. Choi, J. Lee, J. H. Kim, J. Seo, J. S. Choi, Y-R. Jo, B-J. Kim, Y. Yang, **K.T Lee***, H. Y. Kim*, W. Jung*, "A Measure of Active Interfaces in Supported Catalysts for High-temperature Reactions", *Chem,* 8, 1, (2022). (IF=22.804)

[3] J. Park#, K.T. Bae#, D. Kim, W. Jeong, J.-E. Nam, M.J. Lee, D. O. Shin, Y. -G. Lee, H. Lee, **K. T. Lee***, Y. M. Lee*, "Unraveling the limitations of solid oxide electrolytes for all-solid-state electrodes through 3D digital twin structural analysis", *Nano Energy,* 79, 105456, (2021). (IF=17.881)

[4] D. Kim#, I. Thaheem#, H. Yu, J. H. Park, **K. T. Lee***, "Highly Promoted Electrocatalytic Activity of Spinel $CoFe_2O_4$ by Combination with $Er_{0.4}Bi_{1.6}O_3$ as a Bifunctional Oxygen Electrode for Reversible Solid Oxide Cells", *Journal of Materials Chemistry A,* 10, 2045, (2022). (IF=12.732)

[5] D. Kim#, J. W. Park#, M. S. Chae#, I. Jeong, J. H. Park, K. J. Kim, J. J. Lee, C. Jung, C.-W Lee*, S.-T. Hong*, **K. T. Lee***, "An Efficient and Robust Lanthanum Strontium Cobalt Ferrite Catalysts as a Bifunctional Oxygen Electrode for Reversible Solid Oxide Cells", *Journal of Materials Chemistry A,* 9, 5507, (2021). (IF=12.732)



Associate Professor
Lee, Kang Taek
Research Interests
Solid Oxide Fuel Cells / Solid Oxide Electrolysis Cells / Solid-state Batteries / 3D Nano-Imaging
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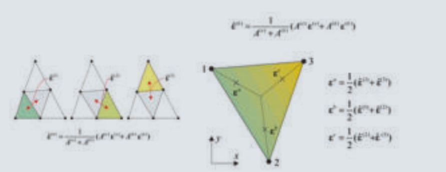
Computational Mechanics and Structural Systems

RESEARCH OVERVIEW

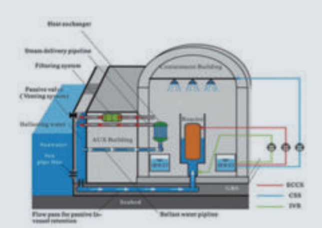
Computational Mechanics

- Finite element method, Strain-smoothed finite elements
- Smoothed particle hydrodynamics, Hydroelastic analysis
- Development of solid, beam and shell finite elements
- Model reduction techniques
- Topology optimization, Crack propagation
- Deep-learned finite elements, Self-updated FEM



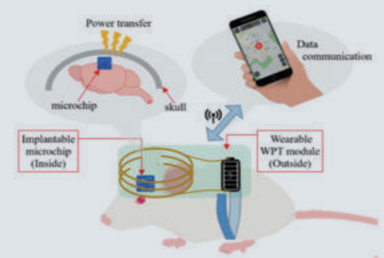
Structural Systems

- Floating wind turbines
- Underwater explosion
- Offshore nuclear power plants
- Welding deformation analysis



Experimental Biology

- Animal-robot interaction systems
- Cyborg animal systems
- Deep brain stimulations



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[1] Lee DH, Kim HJ, Lee PS. Direct calculation of interface warping functions for considering longitudinal discontinuities in beams, Structural Engineering and Mechanics, 80, 625-643, Dec 2021.
[2] Oh MH, Kim HJ, Yoon K, Lee PS. Direct evaluation of the local stability of structures using nonlinear FE solutions, Structural Engineering and Mechanics, 80, 477-490, Nov 2021.
[3] Hyun C, Lee PS. A load balancing algorithm for the parallel automated multilevel substructuring method, Computers & Structures, 257, 106649, Sep 2021.
[4] Jung J, Jun H, Lee PS. Self-updated four-node finite element using deep learning, Computational Mechanics, Aug 2021.
[5] Kim HJ, Lee DH, Yoon K, Lee PS. A multi-director continuum beam finite element for efficient analysis of multi-layer strand cables, Computers & Structures, 256, 106621, Aug 2021.
[6] Park HJ, Seo H, Lee PS. Direct imposition of the wall boundary condition for simulating free surface flows in SPH, Structural Engineering and Mechanics, 78, 497-518, May 2021.
[7] Seo H, Park HJ, Kim J, Lee PS. The particle-attached element interpolation for density correction in smoothed particle hydrodynamics, Advances in Engineering Software, 154, 102972, Jan 2021.
[8] Lee C, Kim S, Lee PS. The strain-smoothed 4-node quadrilateral finite element, Computer Methods in Applied Mechanics and Engineering, 373, 113481, Jan 2021.
[9] Jung J, Yoon K, Lee PS. Deep learned finite elements, Computer Methods in Applied Mechanics and Engineering, 372, 113401, Dec 2020.
[10] Kim HJ, Yoon K, Lee PS. Continuum mechanics based beam elements for linear and nonlinear analyses of multi-layered composite beams with interlayer slips, Composite Structures, 235, 111740, Mar 2020.
[11] Hyun C, Boo SH, Lee PS. Improving the computational efficiency of the enhanced AMLS method, Computers & Structures, 228, 106158, Feb 2020.

HONORS / AWARDS

[1] Academic Award, Computational Structural Engineering Institute of Korea, 2021.
[2] Editor, Structural Engineering and Mechanics, 2011-present.
[3] Coordinator, KAIST-DTU joint scientific seminar on energy technologies. Nov 2020.
[4] Organizer, The 6th KAIST-U.Tokyo-SJTU symposium. Oct 2020.
[5] Chair, 2020 International Conference on Ocean Systems Engineering. Aug 2020.

Professor
LEE, Phill-Seung

Research Interests
Structural Systems / Fluid-Structure Interaction / Computational Mechanics / Experimental Biology

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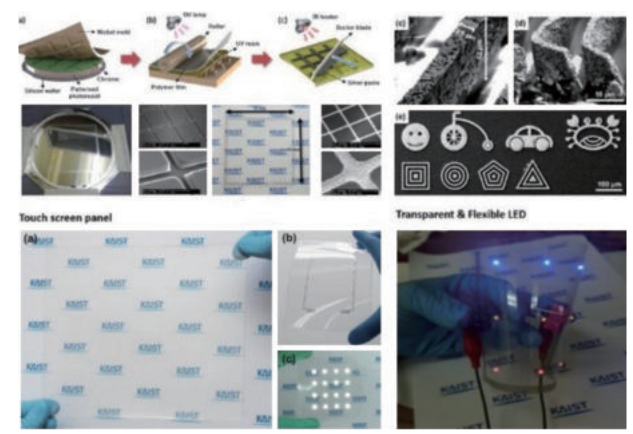
Micro Mechanical System Technology Laboratory

RESEARCH OVERVIEW

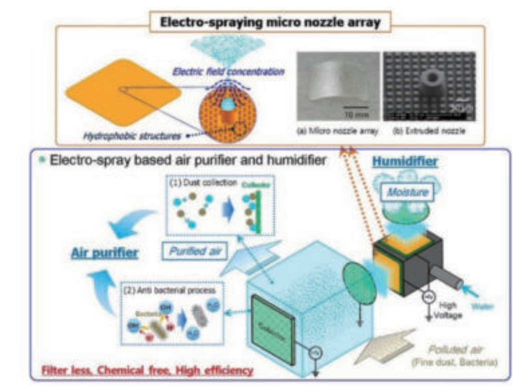
Transparent conductive film using metal mesh

Metal mesh is comprised of microscale patterns consisting of metal such as gold, silver, or copper. The design of the mesh pattern, which is expressed as the line width, pitch, and height, enables adjustments to its performance. The metal mesh is fabricated by using UV embossing and doctor blading process. These processes are relatively simple and do not require high temperature, vacuum environment, and expensive.



Micro nozzle array for electrospray air purification

Electrospray technique has been widely used due to its uniform and fine droplets generation characteristics. The electrospray also shows excellent air purification (fine dust collection and anti bacterial function) properties when the spray liquid is pure water. However, it is extremely difficult to spray water electrically due to its high electrical conductivity and surface tension. Micro nozzle array made of dielectric material is being developed to produce large amount of water nano-droplets in a stable electrospray condition. With the help of MEMS technology, high aspect ratio of micro nozzle can be fabricated uniformly and is expected to be applied in commercial air purifier and humidifier.



SELECTED PUBLICATIONS

[1] J. S. Kim, D. J. Kim, Seung. S. Lee, "Development of a doctor blade printing method for fabrication of neutron activation foil arrays", Journal of Radioanalytical and Nuclear Chemistry, 330(1), 385-394, 2021.
[2] J. Jang, J. Song, Seung S. Lee, S. Jeong, B. J. Lee, and S. Kim, "Analysis of temperature-dependent IV characteristics of the Au/n-GaSb Schottky diode", Materials Science in Semiconductor Processing, 131, 105882, 2021.
[3] J. Song, J. Jang, M. Lim, J. Lee, S. S. Lee and B. J. Lee, "Near-field electroluminescent refrigeration system consisting of two graphene Schottky diodes", Journal of Heat Transfer, 142, 072101-1, 2020.
[4] J. Jeong, H. Choi, K. Park, H. Kim, J. Choi, I. Park, and S. S. Lee, "Polymer micro-atomizer for water electrospray in the cone jet mode", Polymer, 122450, 2020.
[5] M. Jo, S. Bae, I. Oh, J. Jeong, B. Kang, S. J. Hwang, S. S. Lee, H. J. Son, B. Moon, M. J. Ko, and P. Lee, "3D Printer-Based Encapsulated Origami Electronics for Extreme System Stretchability and High Areal Coverage", ACS Nano 13, 11, pp.12500-12510, 2019.

PUBLICITY(MEDIA+NEWS)

[1] "초미세 물방울로 코로나19 바이러스 제거" (https://news.kbs.co.kr/news/view.do?ncd=5026145&ref=A, 2020)
[2] "대구시-카이스트, 물 이용한 대중이용시설 공기정화 시스템 개발" (https://news.imaeil.com/page/view/2021111115080132863, 2021)

Professor
LEE, Seung S.

Research Interests
Polymer-based MEMS / Bio-MEMS / Harsh-MEMS / Various Applications

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Multiscale Energy Laboratory

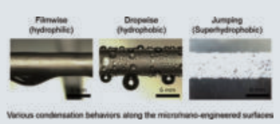
RESEARCH OVERVIEW

We aim to address thermal energy challenges facing our world. In our energy grid system, ~70% of the total energy input is wasted as heat, which causes significant environmental damages. The strong demands for the new industrial platforms along with the sharp increase in the power density of incorporated semiconductors induce unprecedented challenges in thermal management. We combine a fundamental understanding of phase change physics, novel thermal materials, intelligent vision, and state-of-the-art model & experimental techniques to address such challenges.

MULTISCALE PHASE CHANGE PHYSICS

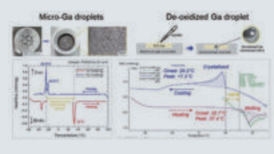
Multiscale condensation phenomena

We investigate and tailor multiscale condensation behaviors and resulting heat/mass transfer performance to enable more effective energy conversion and thermal management



Supercooling of liquid metals

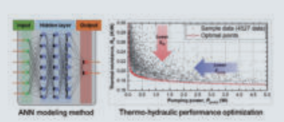
We aim to understand and suppress the supercooling phenomena of Ga-based liquid metals to enable effective thermal storage and release.



INTELLIGENT THERMAL MANAGEMENT & CONVERSION

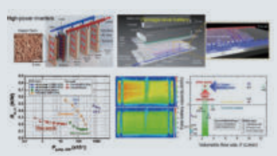
Effective optimization combined with additive manufacturing

We develop effective thermal design and manufacturing processes by combining the surrogate model-based multi-object optimization schemes and additive manufacturing.



Electric vehicle & 2.5D/3D semiconductor thermal management

We investigate single/multiphase solutions to address thermal challenges in the electric vehicles as well as 2.5D/3D high heat flux semiconductor.



RESEARCH HIGHLIGHTS

Advanced condensers for high heat flux conditions: Previous condensation heat transfer enhancement has been limited at low heat flux conditions. We introduced the condensers providing >5 times higher heat transfer coefficient compared to the conventional ones even at high (~40 W/cm^2) heat flux levels [1] with long-term stability [2], which will provide new opportunities in developing real-world high-performance energy systems

Liquid metal thermal interfacial materials: Previous thermal interfacial materials have poor thermal conductivities or limited long-term stability. We developed novel thermal interfacial materials by combining the oxide-free metal nanoparticle network within the Ga-based liquid metal alloy. The developed material provides a high thermal conductivity (~65 W/mK) with high thermal stability applicable for high heat flux semiconductors [3].

Bio-inspired EV thermal management solution: We introduced the bio-inspired thermal management solutions inspired by a human respiratory system [4], and applied them to EV inverter/battery thermal management. The developed solutions provided extremely low thermal resistance and temperature deviation by using orders of magnitude lower pumping power compared to previous solutions.

SELECTED PUBLICATIONS

[1] D. Seo, J. Shim, K. Lee, B. Moon, J. Lee, C. Lee and Y. Nam, Passive Anti-Flooding Superhydrophobic Surfaces, *ACS Applied Materials & Interfaces,* vol. 12(3), pp. 4068-4080 (2020)

[2] D. Seo, J. Shim, C. Lee and Y. Nam, Brushed Lubricant-Impregnated Surfaces (BLIS) for Long-Lasting High Condensation Heat Transfer, *Scientific Reports,* vol. 10, pp. 2959 (2020)

[3] S. Ki, J. Shim, S. Oh, E. Koh, D. Seo, S. Ryu, J. Kim and Y. Nam, Gallium-Based Liquid Metal Alloy Incorporating Oxide-Free Copper Nanoparticle Clusters for High-Performance Thermal Interface Materials, *International Journal of Heat and Mass Transfer,* Vol. 170, pp. 121012 (2021)

[4] S. Ki, J. Lee, S. Ryu, S. Bang, K. Kim and Y. Nam, A Bio-Inspired, Low Pressure Drop Liquid Cooling System for High-Power IGBT Modules for EV/HEV Applications, *International Journal of Thermal Sciences,* Vol.161, pp. 106708 (2021).

Associate Professor
NAM, Youngsuk

Research Interests
Multiscale phase change physics / Intelligent thermal management·conversion

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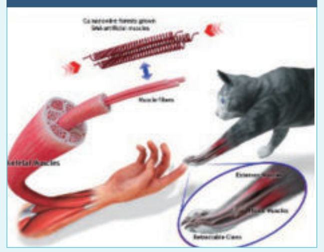
Active Materials and Dynamic Systems Laboratory

RESEARCH OVERVIEW

We develop and design advanced functional materials, which can solve engineering challenges in the field of (1) soft actuators and robotics, (2) energy harvesting and storage, (3) mechanical metamaterials, and (4) smart materials and structures.

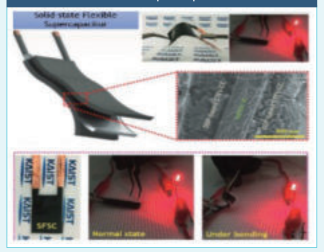
1. **Soft Actuators and Robotics** We are focusing on the development of soft actuators and artificial muscles, which can be applied to intra/extra human body robotics, haptic-feedback systems, wearable power suits, and flexible and soft electronics.
2. **Energy Harvesting and Triboelectricity** Triboelectric nanogenerator (TENG) is the energy harvester which produce electricity from mechanical kinetic energy utilizing triboelectrification and electrostatic induction effect. We are optimizing the mechanical systems and triboelectric materials to maximize the efficiency of TENGs.
3. **Energy Storage Structures** We are developing structural batteries, which can have the load bearing capability and store electricity into the structures. The structural batteries are crucial to the next-generation transportation vehicles such as UAV, UAM, and electrical vehicles. Also, we are developing advanced active materials for the future energy storage devices such as Li-S battery, Li-Metal battery, and supercapacitors.
4. **Mechanical Metamaterials** Metamaterial indicates the functional material designed to have the singular property which cannot be found in nature. Currently, we are focusing on the elastic topological insulators which show the unparalleled wave transmission and acoustic bandgap materials.

Artificial Muscles



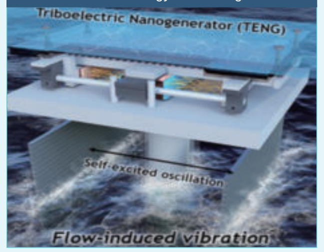
(1) Soft Robotics

Flexible Supercapacitor



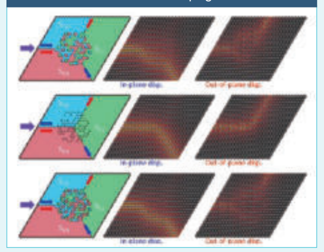
(2) Energy Storage

Ocean Energy Harvesting



(3) Energy Harvesting

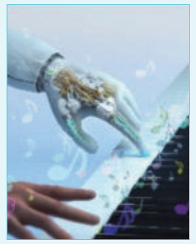
Robust Wave Propagation

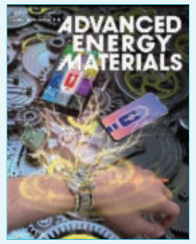


(4) Wave Control

RESEARCH HIGHLIGHTS

1. **CTF-based Soft Actuator for Playing Electronic Piano** Actuators often show a lack of high bending displacement with back relaxation and irregular response characteristics under low input voltages. In this study, we demonstrated an electro-ionic soft actuator based on a metal-free covalent triazine framework that shows controllable high bending deformation under low input voltages and plays electronic piano by soft touch operation.
2. **Long-lasting and steady triboelectric energy harvesting from low-frequency irregular motions using escapement mechanism**
Il-Kwon Oh and co-workers developed an escapement mechanism-based triboelectric nanogenerator (EM-TENG) that efficiently harvests energy from extremely low-frequency irregular motions. The EM-TENG can provide long-lasting and steady electricity to operate portable electronics.





SELECTED PUBLICATIONS (2020-2021)

[1] K.W. Han, J.N. Kim, A. Rajabi-Abhari, V.T. Bui, J.S. Kim, D. Choi, I.K. Oh, "Long-Lasting and Steady Triboelectric Energy Harvesting from Low-Frequency Irregular Motions Using Escapement Mechanism", Advanced Energy Materials, Vol. 11, Issue 4, No. 2002929, 2021

[2] M. Mahato, R. Tabassian, V.H. Nguyen, S. Oh, S. Nam, W.J. Hwang, I.K. Oh, "CTF-based soft touch actuator for playing electronic piano", Nature Communications, Vol. 11, No. 5358, 2020

[3] H. Kim, Q. Zhou, D. Kim and I.K. Oh, "Flow-induced snap-through triboelectric nanogenerator", Nano Energy, Vol. 68, No. 104379, 2020

[4] M. Mahato, R. Tabassian, V.H. Nguyen, S. Oh, S. Nam, K.J. Kim, I.K. Oh, "Sulfur- and Nitrogen-Rich Porous π-Conjugated COFs as Stable Electrode Materials for Electro-Ionic Soft Actuators", Advanced Functional Materials, Vol. 30, Issue 46, No. 2003863, 2020

Professor
OH, Il-Kwon

Research Interests
Soft Actuators and Robotics / Energy Harvesting and Storage / Mechanical Metamaterials / Smart Materials and Structures

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Photonic Imaging Laboratory

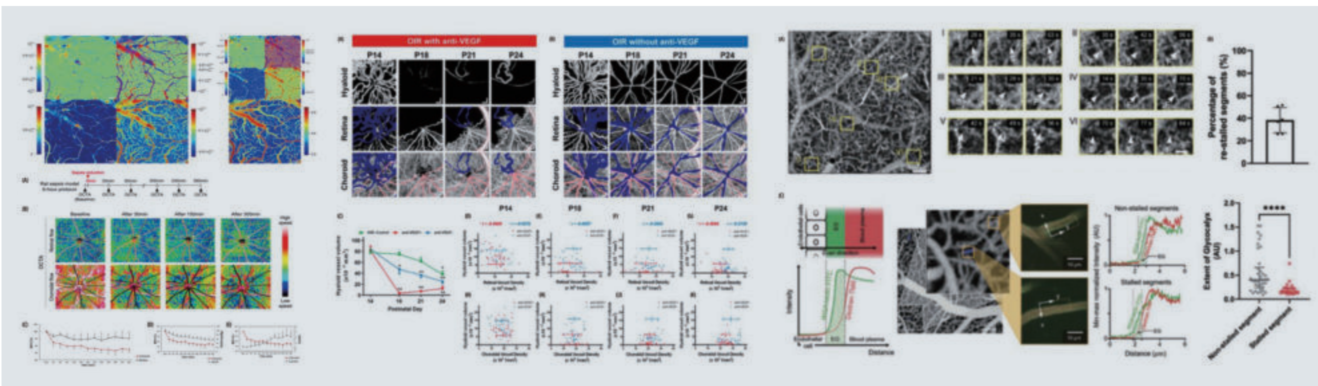
RESEARCH OVERVIEW

The main research interests of our laboratory are focused on the development of advanced optical imaging techniques for various applications, especially in clinical medicine and biological research. To address and solve important problems in medicine and biology, inter/multidisciplinary collaboration integrating our top-notch photonic imaging capability with expertise of clinicians and biologist is critical. Current research projects include development of ultrahigh-speed multifunctional optical coherence tomography (OCT) system and its application to cardiovascular imaging, ophthalmic imaging, imaging study on neurovascular coupling, and imaging study on various animal disease models and new drug development.

Active clinical collaborations are going on in major hospitals around the world including Korea University Guro Hospital, Seoul, Korea, Seoul National University Bundang Hospital, Bundang, Korea, Kyungpook National University Hospital, Daegu, Korea, and Harvard Medical School, Massachusetts General Hospital, Boston, USA.

RESEARCH HIGHLIGHTS

Recent research has focused on the development of multi-MHz ultrahigh-speed OCT light source and system, and the application of the multi-functional OCTA (OCT Angiography) to critical biomedical studies. The development of the first 10 MHz ultrahigh-speed OCT at 1300 nm and the studies on retinal, brain, and systemic diseases using multi-functional OCTA highlight recent research achievements.



SELECTED PUBLICATIONS

[1] J.R. Park, B.K. Lee, M.J. Lee, K. Kim*, and W.Y. Oh*, "Visualization of three-dimensional microcirculation of rodents' retina and choroid for studies of critical illness using optical coherence tomography angiography", Sci. Rep., vol. 11, pp. 14302.1-8 (2021).

[2] P. Shin, J.H. Yoon, Y. Jeong*, and W. Y. Oh*, "High-speed optical coherence tomography angiography for the measurement of stimulus-induced retrograde vasodilation of cerebral pial arteries in awake mice", Neurophotonics, vol. 7. pp. 030502.1-8 (2020).

[3] Y. Kim, J.R. Park, H.K. Hong, M. Han, J. Lee, P. Kim, S.J. Woo, K.H. Park*, and W.Y. Oh*, "In vivo imaging of the hyaloid vascular regression and retinal and choroidal vascular development in rat eyes using optical coherence tomography angiography", Sci. Rep., vol. 10, pp. 12901.1-11 (2020).

[4] T.S. Kim, J.Y. Joo, I. Shin, P. Shin, W.J. Kang, B.J. Vakoc*, and W.Y. Oh*, "9.4 MHz A-line rate optical coherence tomography at 1300 nm using wavelength-swept laser based on stretched-pulse active mode-locking", Sci. Rep., vol. 10, pp. 9328.1-9 (2020).

Professor
OH, Wang-Yuhl

Research Interests
Multifunctional OCT / Ultrahigh-speed OCT / Cardiovascular Optical Imaging / Ophthalmic Optical Imaging / Studies on animal disease models

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Dynamic Robot Control and Design Laboratory

RESEARCH OVERVIEW

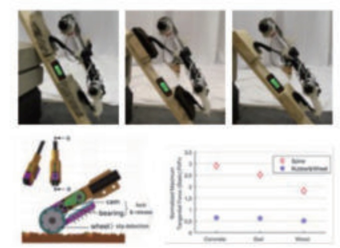
The central objective of my research is to make fundamental contributions to the understanding of legged systems to grant high efficiency, extreme agility, and remarkable versatility to robot systems. The robots with such high-performance features will possess extreme mobility capable of navigating in unstructured, dynamic, and complex environments. To enable the extreme mobility, my approach offers a vertically integrated research strategies across mechanical design, modeling, simulation, and control of legged systems. My group investigates novel hardware design and control framework for legged robot systems utilizing approaches from design optimization, geometric methods for robotics, optimal control, and reinforcement learning. We aim to propose a unified and systematic design method for control and planning algorithm and hardware systems of legged robots.

RESEARCH HIGHLIGHTS

Our lab investigated and contributed to the design of the model predictive control (MPC) algorithm as a unique and systematic control design framework for legged robot systems. Employing MPC, the research team further aims to achieve extreme mobility of animals to traverse difficult terrain. In pursuit of this aim, the candidate designed a novel MPC algorithm that will enable acrobatic complex maneuvers of legged robots in 3D space. The candidate proposed representation-free MPC (RF-MPC) algorithm by utilizing formal mathematical tools from Lie Group Theory and variational linearization. The result of this research work has been published to IEEE-TRO, the most cited journal in the field of robotics and IEEE's top robotics journal, and presented in IEEE IROS winning the RoboCup Best Paper Award. Also, the IEEE-TRO paper has been selected as a finalist of 2020 IEEE RAS TC on Model-Based Optimization for Robotics Best Paper Award.

Mechanical Design

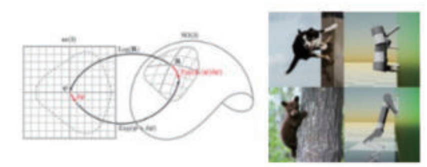
Quasi Direct Drive Design [IROS'17]
(IROS Best Student Paper Finalist)



Anti-Skid Foot Design [Ra-L'19]

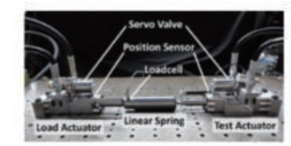
Quadrupedal Robots

Representation-free MPC [T-RO'21]
('20IEEE-RAS TC Best Paper Finalist)

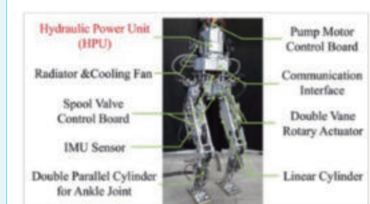


Nonlinear MPC on SO(3) [IROS/20]
(IROS Best RoboCup Paper)

Humanoid Robots



Learning-based Force Control [RA-L'21]



Hydraulic Humanoid [RA-L'21]

HONORS/AWARDS

[1] Early Career Spotlight Award, Robotics: Science and Systems (RSS), 2021
[2] IEEE Robotic Automation Society, TC Best Paper Award Finalist, Technical Committee for Model-based Optimization for Robotics, 2020
[3] RoboCup Best Paper Award, IEEE IROS, 2020
[4] Research Prize, Outstanding Faculty Awards, KAIST, 2020

Associate Professor
PARK, Hae-Won

Research Interests
Control and design of dynamic robot systems / Legged locomotion robots / Bio-inspired robots

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Neuro-Rehabilitation Engineering Laboratory

RESEARCH OVERVIEW

Our mission is to improve quality of life of those who suffer from physical impairments due to injuries. We apply engineering principles to enhance the effectiveness of rehabilitation after injuries and to improve reliability and accuracy of clinical assessments. We try to understand the mechanism of recovery to suggest optimal rehabilitation program after injuries. These research themes not only improve the quality of life of patients and disabled people but also help build better healthcare systems for our increasingly aging society.

RESEARCH HIGHLIGHTS

Soft Wearable Hand Rehabilitation Device

Hand involves more than 20 DOF; therefore, hand rehabilitation device tends to become bulky and heavy. We have developed KADEX (KAIST dexterous) glove that replicates the structure and function of the hand tendons and muscles to provide dexterous motions with a compact and light design. Repetitive training of various grasping tasks will be available by using this device.

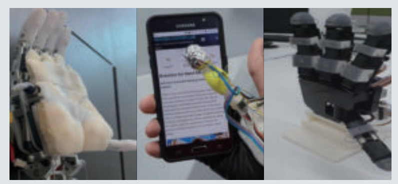
Brain-Computer Interface

For the closed-loop rehabilitation protocol, we have developed an intention recognition system with EMG and EEG signals. This system detects patients' intention of grasping in real-time by analyzing biosignals to provide an interactive rehabilitation protocol for the patients. It can classify six different grasping intentions that are frequently used in daily living. Furthermore, we analyzed the brain and muscle activation during rehabilitation training using EMG and EEG to evaluate the enhanced feedback to the patients.

Prosthetic Hand for Dexterous Motion

For the dexterous manipulation of a human-like prosthetic hand, we developed:

1. Biomimetic three-layer skin structure mimicking the unique stiffness characteristics of the human palm
2. Biomimetic carpometacarpal joint with 2 degrees of freedom to enable dexterous motions like scrolling
3. Shared autonomy system that can recognize user intention for complex grasping scenarios



SELECTED PUBLICATIONS

[1] Bhatia, Divij, Kyoung-Soub Lee, Muhammad Umer Khan Niazi, and Hyung-Soon Park. "Triboelectric nanogenerator integrated origami gravity support device for shoulder rehabilitation using exercise gaming." *Nano Energy* 97 (2022): 107179.

[2] Lee, Kun-Do, and Hyung-Soon Park. "Real-Time Motion Analysis System Using Low-Cost Web Cameras and Wearable Skin Markers." *Frontiers in Bioengineering and Biotechnology* 9 (2022): 790764.

[3] Kim, Jaesang, Wanho Kim, Jisong Ahn, Young Jin Jang, Hyung-Soon Park, and Jessie S. Jeon. "Investigation on the Effect of Cyclic Stretch and Hypoxia on Recovery of Damaged Skeletal Muscle Cells Using Microfluidic System." *Advanced Materials Technologies* 6, no. 11 (2021): 2100465. (Inside Front Cover)

[4] Mun Hyeok Chang; Dong Hyun Kim; Sang-Hun Kim; Yechan Lee; Seongyun Cho; Hyung-Soon Park; Kyu-Jin Cho. "Anthropomorphic Prosthetic Hand Inspired by Efficient Swing Mechanics for Sports Activities." *IEEE/ASME Transactions on Mechatronics* (2021).

[5] Kim, Dong Hyun, Yechan Lee, and Hyung-Soon Park. "Bioinspired High-Degrees of Freedom Soft Robotic Glove for Restoring Versatile and Comfortable Manipulation." *Soft Robotics* (2021).

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[7] Lee, Hangil, Seok Hee Kim, and Hyung-Soon Park. "A Fully Soft and Passive Assistive Device to Lower the Metabolic Cost of Sit-to-Stand." *Frontiers in bioengineering and biotechnology* 8 (2020): 966.

[8] Heo, Si-Hwan, Cheolgyu Kim, Taek-Soo Kim, and Hyung-Soon Park. "Human-Palm-Inspired Artificial Skin Material Enhances Operational Functionality of Hand Manipulation." *Advanced Functional Materials* 30, no. 25 (2020): 2002360.

Professor
PARK, Hyung-Soon

Research Interests
Rehabilitation Robotics / Brain-Machine Interface / Orthopedic Biomechanics

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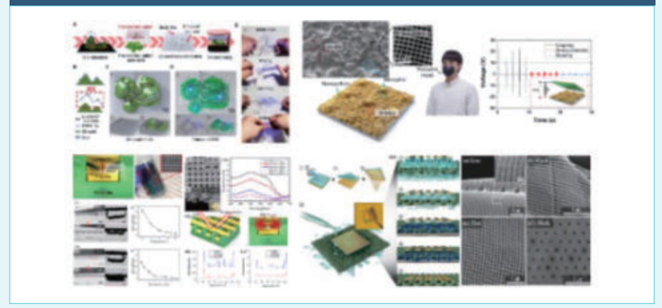
Micro and Nano Transducers (MINT) Laboratory

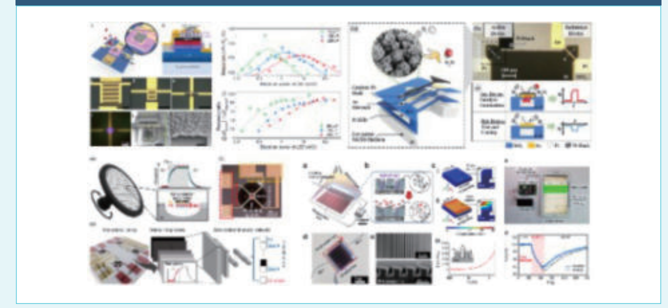
RESEARCH OVERVIEW

The needs for smart sensors are rapidly growing in the Industry 4.0 era. Novel functionalities of micro/nano-structures and devices make them promising for the smart sensors with excellent performances and unique applications. We actively research the design and fabrication of multiscale and hybrid micro/nano-structures towards advanced sensing applications in the fields of healthcare, environment, energy and real metaverse.

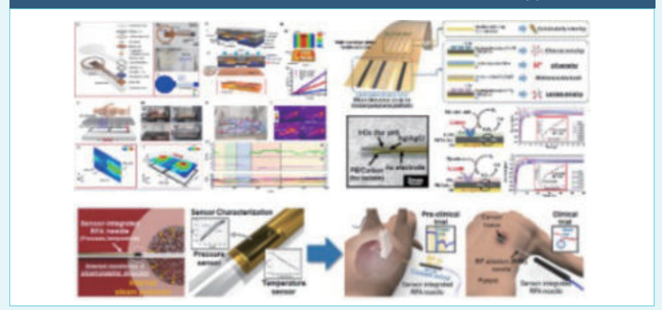
Multiscale and Hybrid Micro/Nano Manufacturing



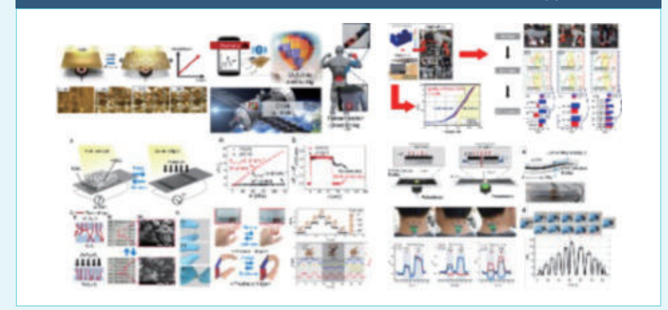
Micro/Nano Sensors for Environment & Energy Monitoring



Micro/Nano Sensors for Biomedical, Clinical & Healthcare Applications



Wearable Sensors for Human-Machine Interface & Metaverse Applications



RESEARCH HIGHLIGHTS

1. **Flexible Sensor-Integrated Needle for Smarter Medical Treatment:** A thin film sensor array integrated on a medical needle monitors temperature & pressure of tissues for smarter and safer RF ablation of tumor. (*Adv. Sci.* 8, 2100725 (2021))
2. **Battery-Free, Wireless Physical Sensor for Pressure Injury Prevention**: A battery-free, wireless sensing system continuously monitors pressure & temperature of patient's skin for prevention of pressure injury. (*Nat. Commun.* 12, 5008 (2021))

SELECTED PUBLICATIONS (* as a corresponding author)

[1] J. Gu, **I. Park***, et al., "Self-powered strain sensor based on the piezo-transmittance of a mechanical metamaterial", *Nano Energy* 89, 106447 (2021)

[2] Y.S. Oh, **I. Park***, et al., "Battery-free, wireless soft sensors for continuous multi-site measurements of pressure and temperature for patients at risk for pressure injuries", *Nat. Commun.* 12, 5008 (2021)

[3] J. Choi, **I. Park***, et al., "Customizable, conformal, and stretchable 3D electronics via pre-distorted pattern generation and thermoforming", *Sci. Adv.* 7, eabj0694 (2021)

[4] M. Seo, **I. Park***, et al., "Chemo-mechanically operating palladium-polymer nanograting film for self-powered H_2 gas sensor", *ACS Nano* 14, 16813 (2020)

Professor
PARK, INKYU

Research Interests
Micro·Nano Manufacturing / Smart Sensors for Environment & Energy / Smart Sensors for Biomedical, Clinical & Healthcare / Wearable Sensors for HMI & Metaverse

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Biomechanics Laboratory

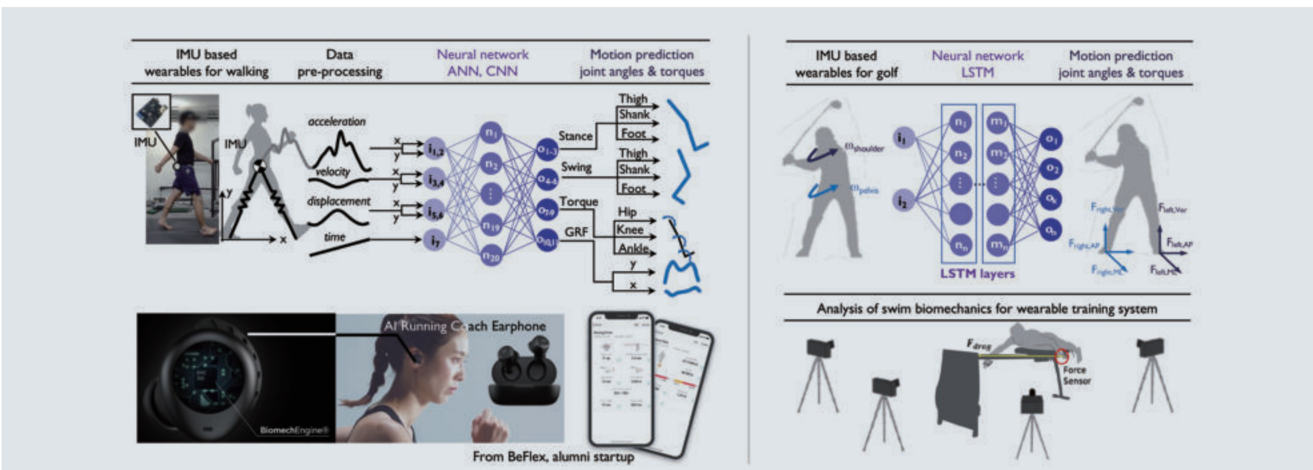
RESEARCH OVERVIEW

Biomechanics Lab aims to contribute to understand the mechanics of human movement and to develop the engineering applications of biomechanics. Recent research interests focus on the mechanics of human locomotion like walking and running, sports biomechanics like golf, jogging, and swimming. Recent research projects include the development of wearable systems for motion monitoring for customized healthcare and sports training. We applied biomechanical domain knowledge with various machine learning algorithm to improve quality and quantity of motion information measured from IMUs and vision sensors.

Human locomotion biomechanics: The dynamics of body center of mass of human during walking and running has been known to share compliant mechanics represented by a spring loaded inverted pendulum. We proposed a compliant bipedal model that reproduces the human walking and running dynamics and joint kinematics. Combining this representative gait model with various machine learning algorithm such as ANN, CNN, and LSTM could reduce the complexity of wearable systems for locomotion monitoring while improving the accuracy of the system. Unmeasured joint kinetic and kinematics data could be well estimated by the proposed machine learning algorithm even from a single IMU or RGB image measurement of body movement.

Sports monitoring using wearables: Recently, various IMU-based wearables with motion monitoring functions for healthcare and sports applications have been released. Since the types and numbers of sensors mounted in the wearables are limited, the motion information provided from them is quantitatively and qualitatively limited as well. To resolve this issue, Biomechanics Lab combines various machine learning techniques with biomechanical domain knowledge of walking, running, golf, and swimming to extracted more accurate and useful information from wearable systems for motion monitoring and sports coaching.

Alumni startup: Alumni of Biomechanics Lab built a startup company **BEFLEX** and developed a IMU imbedded microprocessor, called BiomechEngine®, which makes any head-worn device into a real-time motion analysis device and is applicable for sports wearables and healthcare devices. Recently BEFLEX launched a AI runner-coaching earphone, which measures head movement from IMU sensor imbedded microchip and provides customized running biomechanical indices for performance enhancement and injury prevention, such as maximum leg force, vertical oscillation, and postural information.



RESEARCH HIGHLIGHTS

Journals [1] Hyunho Jeong, and Sukyung Park. "Estimation of the ground reaction forces from a single video camera based on the spring-like center of mass dynamics of human walking." *Journal of Biomechanics* 113 (2020): 110074, [2] Bumjoon Kim, Hyerim Lim, and Sukyung Park. "Spring-loaded inverted pendulum modeling improves neural network estimation of ground reaction forces." *Journal of Biomechanics* 113 (2020): 110069, [3] Myunghyun Lee, and Sukyung Park. "Estimation of Three-Dimensional Lower Limb Kinetics Data during Walking Using Machine Learning from a Single IMU Attached to the Sacrum." *Sensors* 20.21 (2020): 6277, [4] Myeongsub Kim, and Sukyung Park. "Golf swing segmentation from a single IMU using machine learning." *Sensors* 20.16 (2020): 4466, [5] Hyeob Choi, and Sukyung Park. "Three dimensional upper limb joint kinetics of a golf swing with measured internal grip force." *Sensors* 20.13 (2020): 3672, [6] Hyerim Lim, Bumjoon Kim, and Sukyung Park. "Prediction of lower limb kinetics and kinematics during walking by a single IMU on the lower back using machine learning." *Sensors* 20.1 (2019): 130.

Professor
PARK, Sukyung

Research Interests
Biomechanics / Dynamics and control of human locomotion / Machine learning / Sports biomechanics / Wearable systems for motion monitoring / Human sensory integration

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Human-Machine Interaction Laboratory

RESEARCH OVERVIEW

Pursuing intelligent machines that recognize human's condition and surrounding events autonomously, my research focuses on the dynamical modeling, analysis, sensing and recognition of machine system and human body by means of vibration, acoustics and optical ways. Recent research outcomes include following breakthroughs:

- Ultra-small, high-resolution (FHD) 3D Lidar based on optical wave phase demodulation
- Environment-robust acoustic event detection and source localization based on the human auditory system knowledge and the state-of-the-art deep learning algorithms
- Vibration signal analysis and dynamical system modeling (digital twin) in combination of state-of-the-art deep learning for machine diagnosis (motor, power plant, engine)
- Non-invasive health monitoring sensor utilizing human body vibration characteristics with wearable devices detecting blood pressure, cardiovascular disease, diabetes, etc.

RESEARCH HIGHLIGHTS

3D Measurement and Recognition: Ultra-compact 3D Lidar sensor and machine learning-based recognition algorithm are developed as a set of core technology toward commercialization of autonomous vehicle and smart robots. This group's novel phase-demodulation methodology plus laser-scanning module enable Full HD-resolution, mm-level 3D measurement accuracy and environmentally robust 3D scene recognition with compact, low-cost solution. Also, vibration motion amplification is developed for non-contact, sensor-free measurement of vibrations of machines and human body. Color-depth fusion is utilized for sophisticated understanding of human characteristics and scenes based on deep learning algorithm.

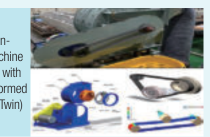
(Left) 3D Scene: (Right, Bottom) 3D Depth image indication 3D geometry

Acoustic Recognition and Source Localization: Targeting robust acoustic event recognition against harsh listening condition such as reverberation, background noises, and multiple sources, we focus on sound classification, localization, and separation incorporated with AI. We strongly rely on the acoustic domain knowledge, which can outperform other state-of-the-art acoustic recognition neural networks. As basis, in-depth functional analysis of human auditory system is carried out via time-frequency analysis. As outcomes, KAIST cough detection camera was developed and acoustic signal-based condition monitoring and machine diagnosis for engine transmission, and power plant are intensively developed based on developed AI algorithm.

KAIST Cough Detection Camera

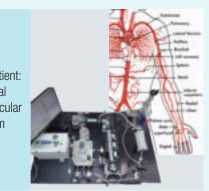
Vibration Analysis and Machine Diagnosis (High-Fidelity Digital Twin): As key building blocks, vibration system modeling, finite element-based numerical and experimental modal analysis are thoroughly studied with emphasize on high-fidelity digital twin and structural parameter identification. For the machine diagnosis, physics-informed deep learning model is constructed in conjunction with the high-fidelity digital twin in the application of the fault diagnosis of motors, air conditioner, power plants, engine and power trains. The physical model-and-data driven hybrid approach outperforms in machine diagnosis problems as well as human body health monitoring.

Vibration-based Machine Diagnosis with Physics informed AI (Digital Twin)



Non-invasive Biometric Health Sensors: Non-invasive, wearable health sensors are developed for the continuous monitoring of blood pressure, cardiovascular diseases, glucose level, fat, and skin conditions by means of human body vibration and physics-informed AI-based classification. Intensive time-frequency signal processing, coupled-field finite element method (FEM), experimental modal analysis (EMA), and biometric parameter identifications in conjunction with AI algorithms are utilized under strong interdisciplinary works. Recently, a world-first virtual patient that can simulate cardiovascular behavior of actual human body was constructed to predict cardiovascular diseases. Wearable, continuous health monitoring, biometric authentication, and cosmetology applications are expected from outcomes of this research in near future.

Virtual Patient: Artificial Cardiovascular System



SELECTED PUBLICATIONS

Journals [1] Sung-Hyun Lee, Wook-Hyeon Kwon, Yoon-Seop Lim, and Yong-Hwa Park, "Highly precise AMCW time-of-flight scanning sensor based on parallel-phase demodulation", Measurements, 2022 [2] Gyeong-Tae Lee, H. W. Nam, S. H. Kim, S. M. Choi, Y. K. Kim, Yong-Hwa Park, "Deep learning based cough detection camera using enhanced features", Expert Systems with Applications, 2022 [3] Gil-Yong Lee and Yong-Hwa Park, "A proper generalized decomposition based Padé approximant for stochastic frequency response analysis", Int J Numer Methods Eng. pp.1-17, 2021 [4] Yugang Chen, Yong-Hwa Park, "Measurement of an Analyte Concentration in Test Solution by Using Helmholtz Resonator for Biosensor Applications", Sensors, Vol.19, No.1227, 2019 [5] Yong-Hwa Park et al, "Three-dimensional imaging using fast micromachined electro-absorptive shutter", J. Micro/Nanolithography MEMS and MOEMS, Vol.12, No.2, pp.1-11, 2013

Patents (in 5 years) KP 10-2351239 (2022), KP 10-2333332, KP 10-2306969, KP 10-2287478, KP 10-2279341, KP 10-2232390 (2021), KP 10-2162019, US 10311298, KP 10-1955334, US 10212358 (2019), US 10061029, US 9998730, US 9894347, US 9904078, US 9874637 (2018), US 9787971, US 9769456, US 9749613, US 9699377, US 9671627, US 9667944 (2017)

Associate Professor
PARK, Yong-Hwa

Research Interests
3D Measurement and Recognition for Autonomous Robot and Vehicles / Acoustic Recognition and Source Localization / Vibration analysis and Machine Diagnosis (High-fidelity Digital Twin; Physics-informed AI) / Non-invasive Biometric Health Sensors

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System Dynamics and Applied Control Laboratory

RESEARCH OVERVIEW

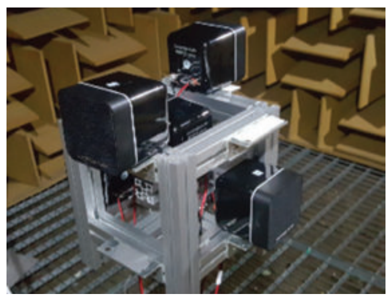
Recent research area of SDAC laboratory mainly focused on ANC (Active Noise Control). SDAC laboratory had already adopted ANC into many applications like Active Window System, MRI, dishwasher, and vehicles. Recently, integration of EANC (Engine sound Active Noise Control) and ASD (Active engine Sound Design) is developed. ANC for global area has been researched using compact speaker array. In addition, ANC using CPU-GPU architecture is newly been researched.

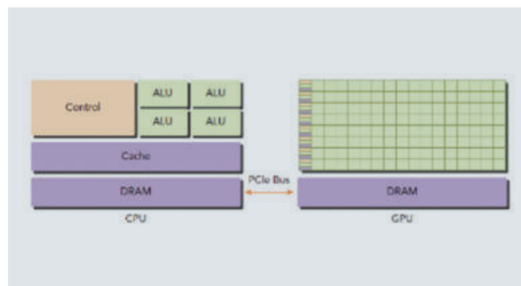
ANC technologies customized to various applications such as Hybrid sound barrier, Active Window System, MRI, dishwasher, Road noise mitigation inside the vehicle.

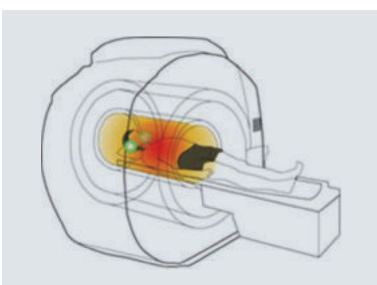
Also, Hyper-Nyquist Frequency Modal analysis based on vision sensor and novel household washing machine design for maximum loading capacity as well.

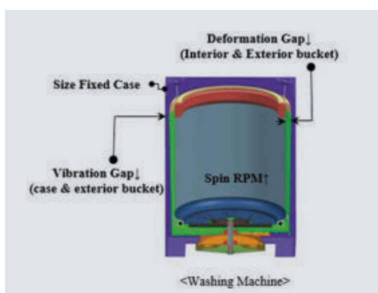
RESEARCH HIGHLIGHTS

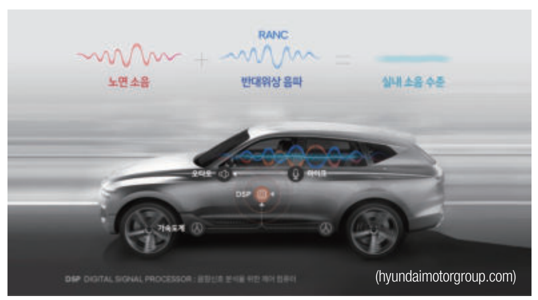
Active control of interior road noise has been investigated from late 90s in our lab. and its research outcome finally realized into the commercial product (RANC option for GV80) in 2020 by HMC through the R&D collaboration with R&D oriented companies (some headed by graduates of our lab.) and our lab.











SELECTED PUBLICATIONS

[1] Sanghyeon Lee, Youngjin Park, Compact Hybrid Noise Control System: ANC System Equipped with Circular Noise Barrier Using Theoretically Calculated Control Filter, Applied Acoustics 188 (2021)

[2] Kim, Yeongseok, and Youngjin Park. "CPU-GPU architecture for active noise control." APPLIED ACOUSTICS 153 (2019)

[3] Woo, Jung-Han, Jeong-Guon Ih, and Youngjin Park. "Comparison of two vibro-acoustic inverse methods to radiate a uniform sound field from a plate." JOURNAL OF SOUND AND VIBRATION (2019)

Professor
PARK, Youngjin

Research Interests
Active Noise Control / Vibration Analysis and Control

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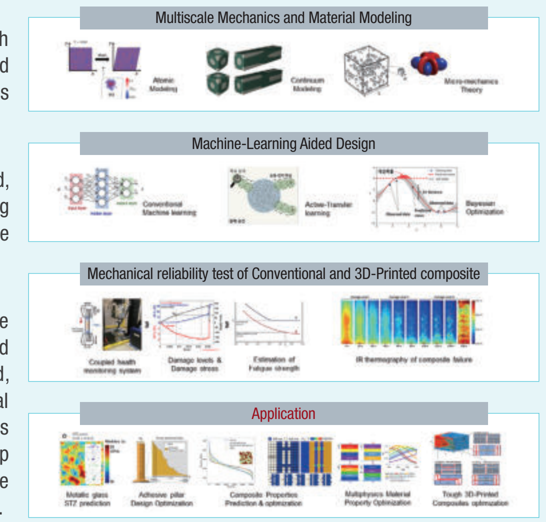
Multiscale Mechanics and Materials Modeling Laboratory

RESEARCH OVERVIEW

Application of AI to Manufacturing Processes
With the advancement of machine learning (ML) techniques, extensive efforts are underway to establish alternative data-driven design frameworks for finding the optimal microstructure, external shape, and processing condition of composite materials and structures. We establish systematic design strategies using machine learning by accounting for the size of design space, size and fidelity of the dataset.

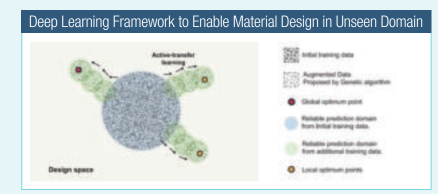
Understanding Material Properties With Multiscale Modeling and Theory
Properties of nano/micro materials and composites can be accurately predicted and optimized, provided that one has fundamental understanding of the mechanical properties. By combining multiscale simulations and theoretical modeling, we aim to fundamentally understand and characterize the mechanical properties of technologically important materials.

Composite Theory, Numerical Modeling, and Experiments
For optimized synergy between reinforcement and matrix, man-made and biological composites are assembled with different microstructures to meet specific requirements: first, particulate-reinforced composites in which particulate reinforcements are randomly dispersed in a matrix; second, composites with relatively periodic and regular microstructures that can often be found in natural composites made with self- assembly process and biomimetic composites; and third, composites with fully random microstructures. For facile design and application of composites, we aim to develop theoretical and numerical methods for three different composite configurations to predict effective composite properties in terms of shape, volume fraction, and spatial distribution of the reinforcements.



RESEARCH HIGHLIGHTS

SCHEMATIC OF DEEP LEARNING FRAMEWORK FOR MATERIAL DESIGN SPACE EXPLORATION. GRADUAL EXPANSION OF RELIABLE PREDICTION DOMAIN OF DNN WITH THE ADDITION OF DATA GENERATED FROM HEURISTIC GENETIC ALGORITHM AND ACTIVE TRANSFER LEARNING.
This study proposed a deep neural network-based forward design approach that enables an efficient search for superior materials far beyond the domain of the initial training set. This approach compensates for the weak predictive power of neural networks on an unseen domain through gradual updates of the neural network with active transfer learning and data augmentation methods. [npj Computational Materials 7, 140 (2021).]



SELECTED PUBLICATIONS

[1] "Adaptive Affine Homogenization Method for Visco-hyperelastic Composites with Interfacial Damage", Applied Mathematical Modelling 107, 72 (2022).

[2] "Designing staggered platelet composite structure with Gaussian Process Regression based Bayesian optimization", Composites Science and Technology 220, 109254 (2022)

[3] "A Study on Dislocation Mechanisms of Toughening in Cu-Graphene Nanolayered Composite", Nano Letters 22, 188 (2022).

[4] "Deep Learning Framework for Material Design Space Exploration using Active Transfer Learning and Data Augmentation", npj Computational Materials 7, 140 (2021).

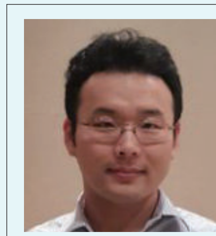
[5] "Mechanical robustness of aluminum-matrix composites rendered by graphene functionalization", Nano Letters 21, 5706 (2021).

[6] "Multiscale Modeling Framework to Predict Effective Stiffness of Crystalline-Matrix Nanocomposite", International Journal of Engineering Science 161, 103457 (2021).

[7] "How and When a Cassie-Baxter Droplet Begins to Slide on a Textured Surface", Langmuir 36, 14031 (2020).

[8] "Designing Adhesive Pillar Shape with Deep Learning-based Optimization", ACS Applied Materials & Interface 12, 24458 (2020).

[9] "Coupled Health Monitoring System for CNT-doped Self-sensing Composites", Carbon 166, 193 (2020).



Associate Professor
RYU, Seunghwa

Research Interests
AI based Design of Materials, Shape, and Process / Computational Multiscale Mechanics of Materials / Mechanical Reliability Test of Composites / Homogenization Theory

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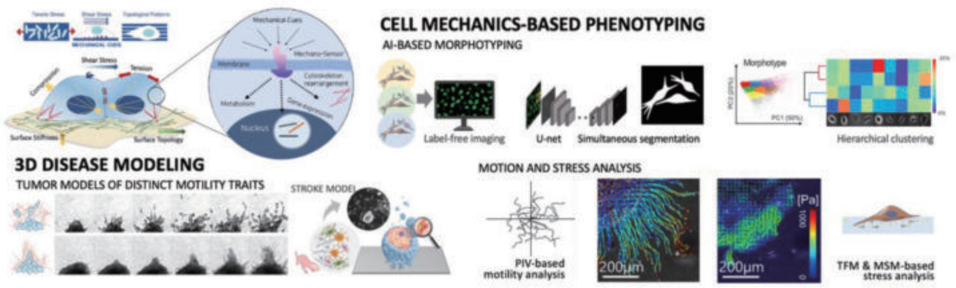
Soft Biomechanics and Biomaterials Laboratory

RESEARCH OVERVIEW

Cells in our bodies are constantly exposed to a variety of physical stimuli, and in response to these stimuli, cells regulate their physiological functions such as morphology, motility, differentiation, and death. Our objective is to decipher the physical mechanisms underlying fascinating cellular dynamics through quantitative experiments and analyses conducted under simplified conditions. The primary research interests of our lab revolve around the emerging interdisciplinary field of mechanobiology. We seek to understand the fundamental mechanism of mechanobiology by establishing links between physical stresses (tension, shear, electric field, or topography) and physiological responses. Our laboratory focuses on the following specific topics: cell mechanics, cellular mechanobiology, and AI-based cell classification in order to gain a better understanding of cellular physiology in the context of various pathological conditions for diagnostic and therapeutic applications. We begin by developing experimental platforms (including microfluidic biochips) suitable for biofunctional assays to investigate mechano-responses at the cellular level. Additionally, we develop strategies for the generation of functionally appropriate 3D spheroid-based disease models. The functional states of the cells are then quantified using gene/protein level assays and stress analyses using traction force microscopy and monolayer stress microscopy. Recently, an AI-based platform for high-dimensional big data analysis was developed and used to analyze the heterogeneity of stem cells, cancer cells, and cancer associated fibroblasts (CAFs) surrounding tumors.



SELECTED PUBLICATIONS

Cell Mechanics & Mechanobiology

- Geonhee Lee, Youngbin Cho, Eun Hye Kim, Jong Min Choi, Soo Sang Chae, Min-Goo Lee, Jonghyun Kim, Won Jin Choi, Joseph Kwon, Eun Hee Han, Seong Hwan Kim, Sungsu Park, Young-Ho Chung, Sung-Gil Chi, Byung Hwa Jung, Jennifer H Shin, Jeong-O Lee, Pillar-Based Mechanical Induction of an Aggressive Tumorigenic Lung Cancer Cell Model, ACS Applied Materials & Interfaces, Supplementary Cover Article (2021)
- Tae Yoon Kwon, Jaeseong Jeong, Eunyoung Park, Youngbin Cho, Dongyoung Lim, Ung Hyun Ko, Jennifer H. Shin, and Jinhee Choi. Physical analysis reveals distinct responses of human bronchial epithelial cells to guanidine and isothiazolinone biocides. Toxicology and Applied Pharmacology. Aug. 1;424:115589 (2021)
- Chan E. Park, Youngbin Cho, Hyunsu Jung, Byeonyeon Kim, Jennifer Shin, Sungyoung Choi, Sek-Kyu Kwon, Young Ki Hahn, Jae-Byum Chang, Super-Resolution Three-Dimensional Imaging of Actin Filaments in Cultured Cells and the Brain via Expansion Microscopy, ACS Nano, 14(11) 14999-15010 (2020)

Disease Models & Characterization

- Eunmin Ko, Mong Lung Poon, Eunyoung Park, Youngbin Cho, Jennifer H. Shin, Engineering 3D cortical spheroids for an in vitro ischemic stroke model. ACS Biomaterials Science & Engineering, 7 (8), 3845-3860. Supplementary Cover Article (2021)
- Eunyoung Park, Johnathan G Lyon, Melissa Alvarado-Velez, Martha I Betancur, Nassir Mokarram, Jennifer H Shin, Ravi V Bellamkonda, Enriching neural stem cell and anti-inflammatory glial phenotypes with electrical stimulation after traumatic brain injury in male rats. Journal of Neuroscience Research. Jul. 99(7):1864-1884 (2021)
- Youngbin Cho, Seung Jung Yu, Jiwon Kim, Ung Hyun Ko, Eun Young Park, Jin Seung Choung, Goro Choi, Daehyun Kim, Eunjung Lee, Sung Gap Im, Jennifer Shin, Remodeling of Adhesion Network within Cancer Spheroids via Cell-Polymer Interaction, ACS Biomater. Sci. Eng. 6(10), 5632-5644 (2020)

HONORS/AWARDS

[1] The Hyung-Gyu Lim LINKGENESIS Best Teacher Award, KAIST (2022)

[2] Outstanding Prize Winner, Technology Innovation Awards of College of Engineering, KAIST (2020)

Professor
SHIN, Jennifer Hyunjong

Research Interests
Cell mechanics / Cellular mechanobiology / In vitro disease models / AI-based cell classifications & phenotyping

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in-situ Characterization and Reliability Evaluation Laboratory

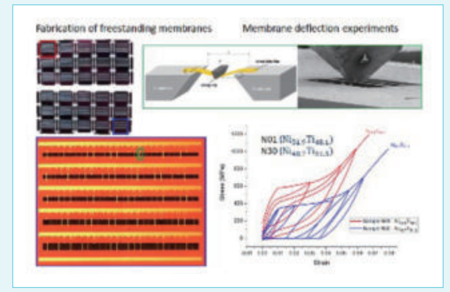
RESEARCH OVERVIEW

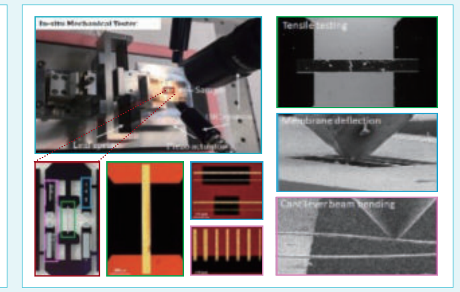
Our research interests span the areas of Mechanics and Materials. We aim to understand the mechanical behavior of materials at different length scales, environment conditions and to use the knowledge to develop materials/structures for advanced technological applications.

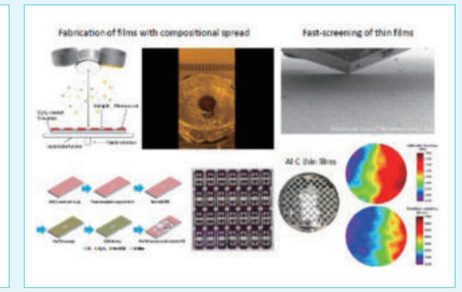
1. Instrumentation and Micro-fabrication for Testing the Mechanical Behavior of Thin Films
- High-Throughput Sample Fabrication & Characterization [Fig.1]
- Development of Micro/Nano-scale Mechanical Testing Methods [Fig.2]

2. Development of Advanced Metallic Alloys for use in Extreme Environments
- Nanotwinned Metal MEMS Films with Unprecedented Strength and Stability
- Mechanical Properties and Reliability of Al-C Thin Films in Extreme Environments
- High-Throughput Mechanical Characterization of Shape Memory Alloy Thin Films [Fig.3]

3. Multi-scale Mechanical Characterization of Additively Manufactured Metal Alloys







RESEARCH HIGHLIGHTS

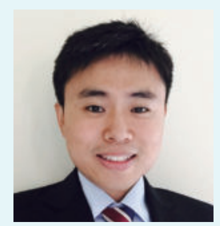
1. Experimentally measured the additional length scale parameter introduced in the couple stress theory by performing bulk-scale tensile and micro-scale cantilever bending experiments (Published in *Materials & Design*).
2. The thermo-mechanical response of micro-architectured tungsten coatings has been characterized in the temperature range of 293 to 673 K using *in-situ* micro-compression experiments inside a scanning electron microscope (Published in *Journal of the Mechanics and Physics of Solids*).
3. Developed a mixed tetrahedral element based on the Lagrange multiplier for the modified couple stress theory (Published in *Computers & Structures*).
4. Developed high-throughput mechanical characterization methods for studying advanced metallic alloys including Al-C and NiTi (Manuscripts in preparation).

HONORS/AWARDS

[1] Acta Materialia and Scripta Materialia Outstanding Reviewer Award

[2] POSCO Young Professor Science Fellowship, POSCO TJ Park Foundation (Research fellowship of 50 million KRW for 2 years)

[3] Teaching Excellence Award, KAIST (ME 533: Fracture Mechanics)



Assistant Professor
SIM, Gi-Dong

Research Interests
Mechanical Properties of Materials / Thin Film Mechanics / Fracture and Fatigue / Deformation Mechanism of Materials in Extreme Environments

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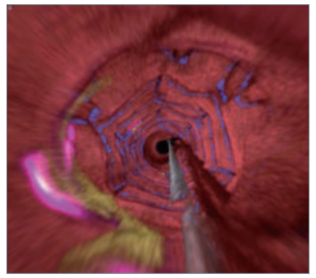
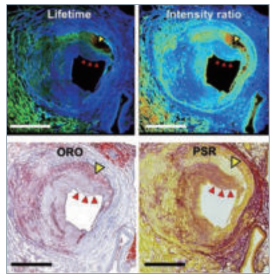
Biomedical Optics and Optical Metrology Laboratory

RESEARCH OVERVIEW

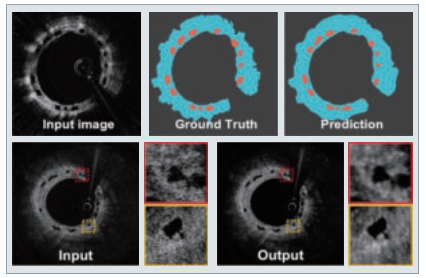
Research interests at the Biomedical Optics and Optical Metrology (BOOM) Lab. focus on the development of new optical imaging techniques and its applications to solve medical problems and industrial challenges. We strive to develop new optical instrumentations and methods based on advanced optical technology.

The Biomedical Optics team develops new optical instrumentations such as endoscopic imaging catheters and multimodal microscopes and translates these new technologies into preclinical and clinical research. This study will improve patient care by providing advanced diagnostic and therapeutic methods. The Optical Metrology team is developing optical imaging technologies, including confocal microscopy, spectroscopy and 3D microscopy, and solving industrial challenges by providing high-precision and high-speed metrology. Overall, our research objective is to focus on developing novel optical systems for medical diagnostics and precision industry applications by visualizing the previously unseen.

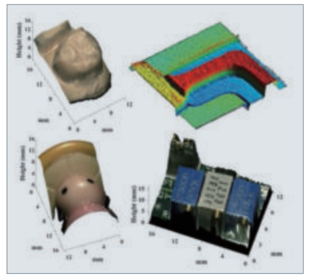

Endoscopic imaging



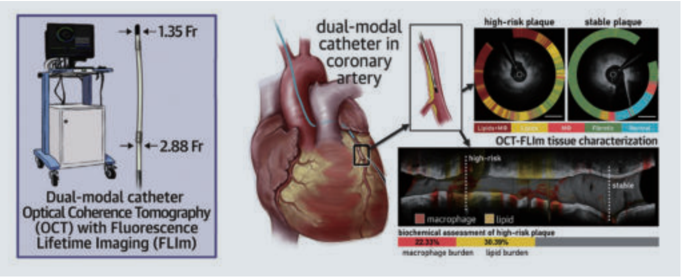
Optical biopsy



Machine learning


3D measurement

RESEARCH HIGHLIGHTS



Synergizing optical imaging and machine learning to diagnose coronary artery disease accurately, featured in KAIST Breakthroughs, Spring 2022.

Dual-modal optical imaging and machine learning are combined to diagnose coronary artery disease accurately via a comprehensive assessment of high-risk coronary plaque without labels. Valuable images lend insight into coronary artery disease as a promising diagnostic method toward cardiovascular therapeutics.

SELECTED PUBLICATIONS

[1] S. Kim, H. S. Nam, et al., "Comprehensive Assessment of High-Risk Plaques by Dual-Modal Imaging Catheter in Coronary Artery", JACC: Basic to Translational Science, 6(12): 948-960, 2021

[2] W. Lee, et al., "Robust autofocusing for scanning electron microscopy based on a dual deep learning network", Scientific reports, 11: 20933, 2021

[3] J. W. Song, H. S. Nam, J. W. Ahn, et al., "Macrophage targeted theranostic strategy for accurate detection and rapid stabilization of the inflamed high-risk plaque", Theranostics, 11(18): 8874-8893, 2021

[4] J. Kang, et al., "Label-free multimodal microscopy using a single light source and detector for biological imaging", Optics Letters, 46(4):892-895, 2021

[5] J. Kim, S. Kim, et al., "Flexible endoscopic micro-optical coherence tomography for three-dimensional imaging of the arterial microstructure", Scientific Reports, 10:9248, 2020

Associate Professor

YOO, Hongki

Research Interests

Optical System Design / Biomedical Optics / Optical Metrology

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Computer-Aided Net Shape Manufacturing

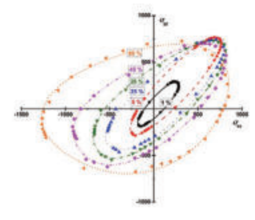
RESEARCH OVERVIEW

The theme of research at CANESM is high reliability design and manufacturing for lightweight materials and structures. Lightweight material processing including forming and joining are the main area for research. The research goal is provide the linkages between materials science and production engineering design by developing advanced material & process (multi-scale) models for the uses in aerospace, defence, automotive, and rigid-packaging applications. The research areas cover advanced manufacturing including forming, machining and 3D printing and various structural optimization based on the finite element method. Especially we have developed the pioneering areas for various constitutive and failure modeling in plasticity including non-associated flow plasticity and stress-based failure prediction. The high impact papers have been published in the areas of fundamental plasticity and new finite element method. The proposed theories have been implemented into various commercial software material and element libraries.

RESEARCH HIGHLIGHTS

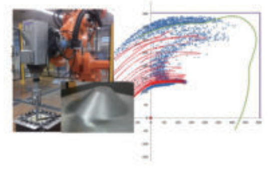
Light Weight Materials Characterization and Processing

- DIC-based materials characterization
- Multi-scale modeling of constitutive behavior and fracture criteria for the direct application to production engineering



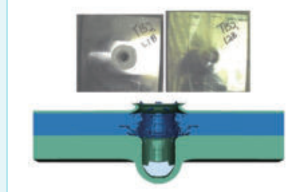
Intelligent Forming

- Forming limit and fracture considering nonlinear strain paths
- Incremental sheet formimg
- AI-based forming control
- Modeling of instability including PLC effect, wrinkling, and necking



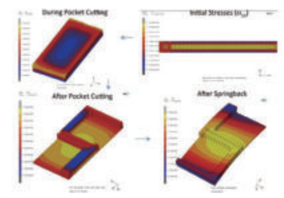
High Strain-rate Fracture

- Ballistic and blast modeling
- Architecture design for armor plate
- Development of high strain-rate fracture model



Residual Stress

- Prediction of distortion from residual stress
- Machining considering residual stress



SELECTED PUBLICATIONS

[1] D.P. Jang, P. Fazily, J.W. Yoon, "Machine learning-based constitutive model for J2-plasticity", Int. J. of Plasticity 138, 102919 (2021)

[2] Q. Hu, J.W. Yoon, N. Manopulo, P. Hora, "A coupled yield criterion for anisotropic hardening with analytical description under associated flow rule: Modeling and validation", Int. J. of Plasticity 136, 102882 (2021)

[3] Y. Kim, S. Zhang, V. Grolleau, C.C. Roth, D. Mohr, J.W. Yoon, "Robust characterization of anisotropic shear fracture strains with constant triaxiality using shape optimization of torsional twin bridge specimen", CIRP Annals 70 (1), 211-214 (2021).

[4] Y. Lou, S. Zhang, J.W. Yoon, "Strength modeling of sheet metals from shear to plane strain tension", Int. J. of Plasticity 134, 102813 (2020)

[5] N. Park, T.B. Stoughton, J.W. Yoon, "A new approach for fracture prediction considering general anisotropy of metal sheets", Int. J. of Plasticity 124,199-225 (2020)

[6] J.W. Yoon, "AEPA2018 SPECIAL ISSUE: Evolution in metal forming research", Int. J. of Plasticity 135 (2020)

Professor

YOON, Jeong Whan

Research Interests

Mechanics & Materials: Plasticity and Materials Modeling / Fracture & fatigue
Materials Processing & Characterization: Metal forming / New process development / High performance machining / Joining

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Visual Intelligence Laboratory

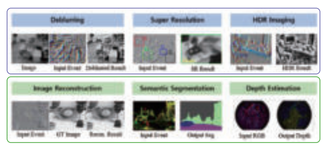
RESEARCH OVERVIEW

At Visual Intelligence Laboratory, we target a variety of issues in the field of computer vision and machine learning. Our research focuses on creating perception algorithms that can be applied to various systems and machines such as autonomous cars, drones, medical applications, and any other AI systems. Furthermore, we target various vision tasks by using various vision sensors to improve machine perception.

RESEARCH HIGHLIGHTS

1. VISION-BASED ADAS FOR VEHICLES / DRONES / ROBOTS [Fig.1]
   Driving Scene Understanding combining 3D Sensing, Object Detection and Tracking, SLAM and Visual Odometry, Road Surface Profile Estimation, Road Segmentation
2. VISUAL SLAM, VISUAL ODOMTRY, OPTICAL FLOW ESTIMATION
   Visual Odometry, Visual-Inertial Odometry, Feature-based and Direct VO, Spatio-temporal Consistent Scene Flow Estimation
3. EVENT-BASED COMPUTER VISION [Fig.2]
   Omnidirectional Event Cameras, Event-based Image Reconstruction, Event-based Super Resolution, Stereo Depth Estimation using Events, Deblurring using Events
4. WEAKLY-SUPERVISED SEMANTIC SEGMENTATION [Fig.3]
   Class Activation Maps, Weak Supervision, Semantic Segmentation, Pixel-level Annotation
5. 3D RECONSTRUCTION FROM IMAGES [Fig.4]
   Multi-view Stereo Vision, 3D Scene Flow Estimation, Visual SLAM, Structure-from-motion
6. MULTI-SENSOR FUSION
   IMU and Camera Calibration, Indoor 3D Scene Reconstruction with Color and Depth Cameras, Fusion of a Camera and In-vehicle Sensors (IMU, Wheel Speed Sensors)
7. MULTI-OBJECT DETECTION AND TRACKING [Fig.5]
   Deep-learning-based Object Detection, Object Tracking with Relative Motion Network, Appearance Learning with Deep Learning


[Fig.1]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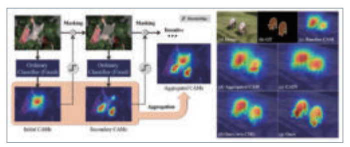
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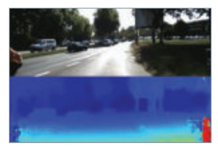
[Fig.4]


[Fig.5]

SELECTED PUBLICATIONS

[1] Lin Wang, Yujeong Chae, Sung-Hoon Yoon, Tae-Kyun Kim, and Kuk-Jin Yoon, "Evdistill: Asynchronous events to end-task learning via bidirectional reconstruction-guided cross-modal knowledge distillation." CVPR, pp. 608-619. 2021. ▶ [2] Hyeokjun Kweon, Sung-Hoon Yoon, Hyeonseong Kim, Daehee Park, and Kuk-Jin Yoon, "Unlocking the potential of ordinary classifier: Class-specific adversarial erasing framework for weakly supervised semantic segmentation," ICCV, pp. 6994-7003. 2021. ▶ [3] Lin Wang, Yujeong Chae, and Kuk-Jin Yoon, "Dual transfer learning for event-based end-task prediction via pluggable event to image translation." ICCV, pp. 2135-2145. 2021. ▶ [4] Mohammad Mostafavi, Kuk-Jin Yoon, and Jonghyun Choi, "Event-Intensity Stereo: Estimating Depth by the Best of Both Worlds." ICCV, pp. 4258-4267. 2021. ▶ [5] Mohammad Mostafavi, Lin Wang, and Kuk-Jin Yoon, "Learning to reconstruct HDR images from events, with applications to depth and flow prediction." IJCV 129, no. 4 (2021): 900-920. ▶ [6] Lin Wang, and Kuk-Jin Yoon, "PSAT-GAN: Efficient adversarial attacks against holistic scene understanding." IEEE TIP 30 (2021): 7541-7553. ▶ [7] Kwonyoung Ryu, Kang-il Lee, Jegyeong Cho, and Kuk-Jin Yoon, "Scanline Resolution-Invariant Depth Completion Using a Single Image and Sparse LiDAR Point Cloud." IEEE RA-L 6, no. 4 (2021): 6961-6968. ▶ [8] Hoonhee Cho, Jaeseok Jeong, and Kuk-Jin Yoon, "EOMVS: Event-Based Omnidirectional Multi-View Stereo." IEEE RA-L 6, no. 4 (2021): 6709-6716. ▶ [9] Lin Wang, Tae-Kyun Kim, and Kuk-Jin Yoon, "EventSR: From asynchronous events to image reconstruction, restoration, and super-resolution via end-to-end adversarial learning," CVPR, pp. 8315-8325. 2020. ▶ [10] Mohammad Mostafavi, Jonghyun Choi, and Kuk-Jin Yoon, "Learning to super resolve intensity images from events," CVPR, pp. 2768-2776. 2020. ▶ [11] Taewoo Kim, Kwonyoung Ryu, Kyeongseob Song, and Kuk-Jin Yoon, "Loop-Net: joint unsupervised disparity and optical flow estimation of stereo videos with spatiotemporal loop consistency." IEEE RA-L 5, no. 4 (2020): 5597-5604. ▶ [12] Lin Wang, Wonjune Cho, and Kuk-Jin Yoon, "Deceiving image-to-image translation networks for autonomous driving with adversarial perturbations," IEEE RA-L 5, no. 2 (2020): 1421-1428.

Associate Professor
YOON, Kuk-Jin

Research Interests
Event-Based Computer Vision / Weakly-Supervised Semantic Segmentation / Vision-based ADAS for autonomous driving of vehicles · drones · robots / Multi-Sensor Fusion / 3D reconstruction from images / Multi-object detection and tracking

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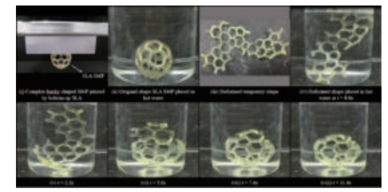
Just Do it Laboratory

RESEARCH OVERVIEW

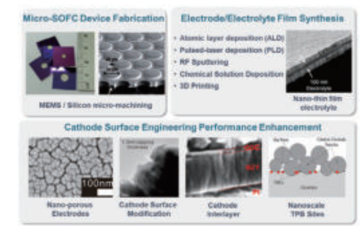
Additive Manufacturing

Design for Additive Manufacturing, Process parameter optimization of 3D Printing, 4D printed Shape memory polymer



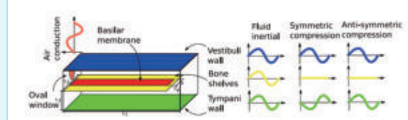
Novel Clean Energy

Semiconductor Fab Silicon Solid-oxide Fuel cell, Drone power, Military portable emergency power



Cochlea Mimicking Electro-acoustic Sensor

Physiologically-based 3-D box type electro-acoustic sensor which mimics mamallian cochlea with sensory neural hair cells

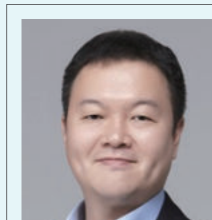


SELECTED PUBLICATIONS

*: Corresponding Author
[1] Noh, Jinhong, et al. "TiO2 nanorods and Pt nanoparticles under a UV-LED for an NO2 gas sensor at room temperature." Sensors 21.5 (2021): 1826.
[2] Loc, Ho Huu, et al. "How the saline water intrusion has reshaped the agricultural landscape of the Vietnamese Mekong Delta, a review." Science of The Total Environment 794 (2021): 148651.
[3] Kamlungsua, Kittiwat, et al. "Inkjet-printed Ag@ SDC core-shell nanoparticles as a high-performance cathode for low-temperature solid oxide fuel cells." International Journal of Hydrogen Energy 46.60 (2021): 30853-30860.
[4] Won, Wan-Sik, et al. "Hygroscopic properties of particulate matter and effects of their interactions with weather on visibility." Scientific reports 11.1 (2021): 1-12.
[5] Andreu, Alberto, et al. "4D printing materials for Vat Photopolymerization." Additive Manufacturing 44 (2021): 102024.
[6] Mishra, Abhinay, et al. "Fabrication of plasmon-active polymer-nanoparticle composites for biosensing applications." International Journal of Precision Engineering and Manufacturing-Green Technology 8.3 (2021): 945-954.
[7] Kim, Noori, et al. "A rotationally focused flow (RFF) microfluidic biosensor by density difference for early-stage detectable diagnosis." Scientific Reports 11.1 (2021): 1-12.
[8] Ho, Chee Meng Benjamin, et al. "Printing of Woodpile Scaffold Using Fresnel Lens for Tissue Engineering." International Journal of Precision Engineering and Manufacturing-Green Technology (2021): 1-16.
[9] Lee, Hyo-Ju, et al. "Optical and electrical properties of multilayer grid electrodes for highly durable transparent conductive electrodes." International Journal of Precision Engineering and Manufacturing-Green Technology 8.2 (2021): 501-508.
[10] Noh, Jinhong, Pilkee Kim, and Yong-Jin Yoon. "Load Resistance Optimization of a Magnetically Coupled Two-Degree-of-Freedom Bistable Energy Harvester Considering Third-Harmonic Distortion in Forced Oscillation." Sensors 21.8 (2021): 2668.
[11] Won, Wan-Sik, et al. "Impact of fine particulate matter on visibility at incheon international airport, South Korea." Aerosol and Air Quality Research 20.5 (2020): 1048-1061.
[12] Kim, Noori, et al. "Understanding interdependencies between mechanical velocity and electrical voltage in electromagnetic micromixers." Micromachines 11.7 (2020): 636.

PUBLICITY(MEDIA+NEWS)

[1] KAIST, 미세 유체 회전 운동 활용한 '현장 진단용 초고감도 바이오센서' 개발 (https://news.mt.co.kr/mtview.php?no=2021101811023290422)
[2] 카이스트, 대학산업기술지원단과 인간중심 디자인씽킹 글로벌 창업교육에 앞장 서 (https://www.mk.co.kr/news/society/view/2020/12/1248331/)



Associate Professor
YOON, Yong-Jin

Research Interests
Additive Manufacturing / Advanced 3DP research / Novel Clean Energy / Fuel Cell

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Emeritus Professors

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Slow Viscous Flow,
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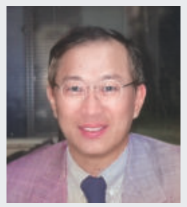

YOON, Yong-San
Professor Emeritus

NOTES Surgery Robot System,
Intelligent Tire System,
New Hybrid Vehicle Transmission

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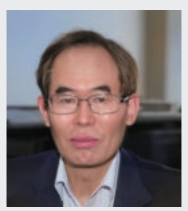

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Micromechanics,
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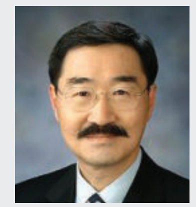

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Phase Change Heat Transfer,
Spray / Atomization Technology,
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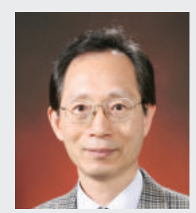

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Mechanical / Electrical Reliability in Thin Films,
Thermo-Mechanical Reliability
in Electronic Packaging

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CHOI, Sang-Min

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Thermal Power Generation Systems, Design of Industrial
Plants: Solid Processing and Process Metallurgy,
Coal Combustion and Solid Fuels

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Emeritus Professors

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HUH, Hoon

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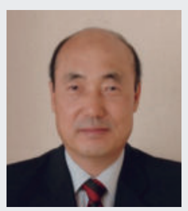

SONG, Tae-Ho

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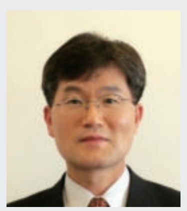

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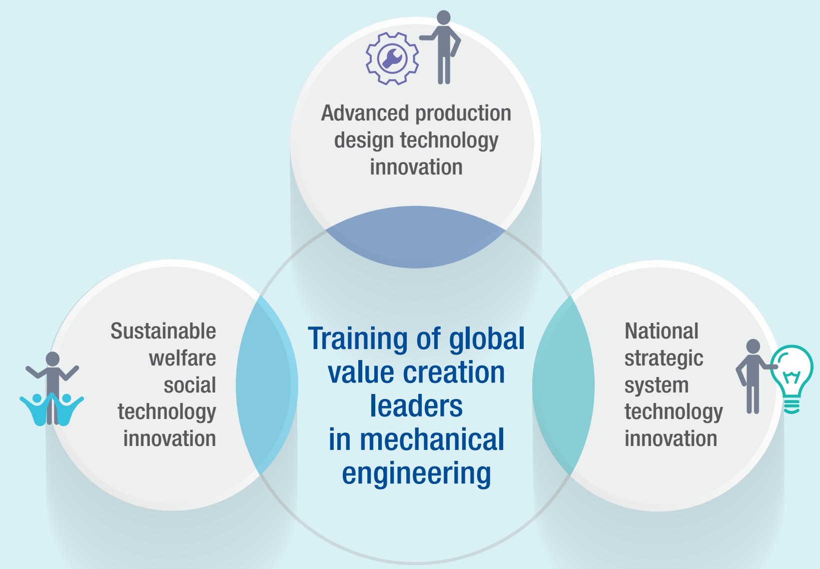
BK21 FOUR Program

KAIST Value-creative Mechanical Engineering



Professors	Graduate students	Annual budget (approximate)	Best Institute	Highest ranking
54	502	700 million won	1992 - 2012	2006 - 2012

The Brain Korea 21 (BK21) Program (FOUR) is a higher education human development program that intensively supports master's and Ph.D. student and up-and-coming research personnel(Post-doctoral researchers) for the purpose of developing world-class graduate schools and nurturing excellent research human.

The School of Mechanical, Aerospace and Systems Engineering at KAIST has been selected to host BK21 FOUR under the title the "KAIST Value-creative Mechanical Engineering" for the period of September 2020 to August 2027. Our goal is to foster elites for "value-creative" in mechanical engineering for human society and to produce experts in the fields of (1) advanced production design technology innovation, (2) sustainable welfare social technology innovation (3) national strategic system technology innovation. We are the largest mechanical engineering institute in Korea, with 54 professors and 501 graduate students. Our annual budget is roughly 700 million won, supported by the government and industries. Our department was selected as the Best Institute by the President of Korea based on our achievements during the first stage of the BK21 program [1999~2005]. During the second stage, we were commended with the highest ranking from among nine universities for three consecutive years in mechanical engineering [2008-2010] and were selected as the Best Institute in the overall evaluation [2006-2012]. We are making every effort to achieve our goal of becoming the world's best graduate school.

Undergraduate Program

Course Requirements (Mar. 2022)

1. Graduation Credits: At least 136 credits in total

- Applicable to students entering KAIST in 2016 and thereafter
- Students entering KAIST before 2016 is at least 130 credits in total
- A cumulative grade point average of 2.0 or higher out of a possible 4.3 in all coursework
- Students must apply for at least one out of Advanced major, minor, double major or individually Designed major(applicable to students entering KAIST in 2016 and thereafter)

2. General Courses: At least 28 credits and 8AU

- Applicable to students enrolled in 2018 and thereafter
- For students enrolled before 2018, refer to course completion requirements by year of admission
- Mandatory General Courses: 7 credits /Elective General courses in Humanities & Social Sciences: at least 21 credits

3. Basic Courses: At least 32 credits

- Applicable to students entering KAIST in 2012 and thereafter; for those who have entered KAIST in and before 2011, refer to the Course Completion Requirements by Year of Admission

Mandatory Basic Courses: **23 credits**

① 1 course among Fundamental Physics I (3), General Physics I (3), and Advanced Physics I (3)
② 1 course among Fundamental Physics II (3), General Physics II (3), and Advance Physics II (3)
③ 1 course of General Physics Lab I (1)
④ 1 course of Basic Biology (3) or General Biology (3)
⑤ 1 course of Calculus I (3) or Honor Calculus I (3)
⑥ 1 course of Calculus II (3) or Honor Calculus II (3)
⑦ 1 course among Basic Chemistry (3), General Chemistry I (3), and Advanced Chemistry (3)
⑧ 1 course of General Chemistry Lab I (1) or Advanced Chemistry Lab (1)
⑨ 1 course of Basic Programming (3) or Advanced Programming (3)

- Students having entered KAIST in 2007 or before : 23 credits (①~⑨)
- Students having entered KAIST between 2008 and 2011: 26 credits((①~⑨), Freshman Design Course: Introduction to Design and Communication)(3))

Elective Basic Courses: at least **9 credits**

- Take over 9 credits including at least 2 courses among Introduction to Linear Algebra, Differential Equations and Applications, and Applied Mathematical Analysis.
- Students admitted in and before 2011 should take more than 6 credits

※ Students having a double major take at least 3 credits

※ Students entering KAIST through the admission for the special talented are required to take 12 credits in the mandatory basic courses and to take the remaining credits in the elective basic courses. (applicable to students entering KAIST in 2015 and thereafter)

4. Completion of Major Courses

- Students admitted in 2015 or before: at least **59 credits**

Mandatory Major Courses

- **12 credits** (for students entering KAIST in 2014 and thereafter)
  Basic Mechanical Practice(3), Mechanical Engineering Laboratory(3), Capstone Design I(3), Engineering Design(3)
- 9 credits (Students entering KAIST in 2012 and before)
  Basic Mechanical Practice(3), Mechanical Engineering Laboratory(3), Capstone Design I(3)
- 9 credits (Students entering KAIST in 2013 and thereafter)
  Basic Mechanical Practice(3), Mechanical Engineering Laboratory(3), Capstone Design I(3)

Elective Major Courses

- At least **47 credits** (for students entering KAIST in 2014 and thereafter)
  Select at least **7 courses** from below 9 courses
  Applied Electronics(3), Dynamics(3), Fluid Mechanics(3), Heat Transfer(3), Mechanical Vibrations(3), Modeling and Control of Engineering Systems(3), Solid Mechanics(3), Thermodynamics(3), Understanding of Materials and Processing(3)
  ※ Major courses in other departments are recognized up to 10 credits as major choices in mechanical engineering including 3 credits in the elective major course (CoE code) of the College of Engineering.
- At least **40 credits** (Students entering KAIST in 2012 and before)
  Select at least **6 courses** from below 8 courses
  Applied Electronics(3), Dynamics(3), Fluid Mechanics(3), Engineering Design(3), Modeling and Control of Engineering Systems(3), Solid Mechanics(3), Thermodynamics(3), Understanding of Materials and Processing(3)
- At least 40 credit (Students entering KAIST in 2013 and thereafter)
  Select at least **6 courses** from below 8 course
  Applied Electronics(3), Dynamics(3), Fluid Mechanics(3), Engineering Design(3), Modeling and Control of Engineering Systems(3), Solid Mechanics(3), Thermodynamics(3), Understanding of Materials and Processing(3)
  ※ Students entering KAIST in 2013 and thereafter must take over 59 major course credits including 10 credits from KAIST

Minor

- At least **21 credits** (Applicable to students from other major/department)
  Must include mandatory major courses 'Basic Mechanical Practice(3), Mechanical Engineering Laboratory(3), Capstone Design I(3)' and at least 4 courses from 9 ME Basic(core) Elective major courses

Double Major

- At least **40 credits** (Applicable to students from other major/department)
  At least 40 credits including mandatory major courses
  ※ In the event that major courses and double-major/minor courses overlap, up to 9 credits can be applied to both courses of study.
  ※ Completion of minor/double major courses is subject to the requirement of admission year, minor/double-major application period, or the graduation assessment period

- Students admitted in 2016 and after: at least **48 credits**

Mandatory Major Courses: 12 credits

- Basic Mechanical Practice(3), Mechanical Engineering Laboratory(3), Capstone Design I(3), Engineering Design(3)

Elective Major Courses: At least **36 credits**

- Select at least **5 courses** from below 9 courses
  Applied Electronics(3), Dynamics(3), Fluid Mechanics(3), Heat Transfer(3), Mechanical Vibrations(3), Modeling and Control of Engineering Systems(3), Solid Mechanics(3), Thermodynamics(3), Understanding of Materials and Processing(3)
  ※ Major courses in other departments are recognized up to 10 credits as major choices in mechanical engineering including 3 credits in the elective major course (CoE code) of the College of Engineering.

★ Must choose and complete at least one of Advanced Major, Double Major, Minor and Individually Designed

Advanced Major: At least **15 credits**

- At least 15 credits from major courses excluding completed courses from general major
- Should take all 9 Basic(core) Elective major courses

Individually Designed Major: At least **12 credits**

- At least 12 credits from major courses of two or more departments except for the affiliated department

Minor: At least **21 credits** (Applicable to students from other major/department)

- At least 21 credits from major courses including over 2 mandatory major courses

※ Credits taken for minor and double major will not be counted towards ME major courses graduation requirements

Double Major: At least **40 credits** (Applicable to students from other major/department)

- At least 40 credits from major courses including 12 credits from mandatory major courses

※ Credits taken for minor and double major will not be counted towards ME major courses graduation requirements

Undergraduate Program

Course Requirements (Mar. 2022)

5. Completion of Research Courses: At least **3 credits**

- Taking at least 3 credits of Graduate Research is mandatory, but may replace with Capstone Design II(3) (Not applicable for double major students)
- Up to 4 Individual Study credits are approved as Research Course credits. Seminar credits are approved as Elective Course credits
- Up to 9 credits earned by completing the 24 week Internship program ME Co-op1(INT482, INT495) can substitute for the Graduation Research(3), Electives Major courses(3) and Elective courses(3) toward graduation credits. Up to 3 credit earned by completing the ME Co-op2(INT492, INT495) can substitute for the Elective courses(3) toward graduation credits.

6. Completion of Elective Courses: Take mandatory and elective major courses from other departments

7. English Proficiency Requirements upon Graduation

- Before entering or during studying at KAIST, students should obtain the minimum required score or higher from one of the¬¬ following: TOEFL, TOEIC, TEPS and IELTS.
- Students who have hearing impairment level 3 or above should obtain the minimum required score or higher, excluding listening.

A.Students who have submitted past scores for TOEIC (before April 2006) or TEPS (before February 28, 2007)

Students admitted in 2008 or later

Classification	iBT TOEFL	PBT TOEFL	CBT TOEFL	TOEIC	TEPS	IELTS
General qualification score	83	560	220	775	690	6.5
Qualification score for hearing impairment level 3 or above	62	372	146	387	414	4.8

Students admitted in 2007 or earlier

Classification	iBT TOEFL	PBT TOEFL	CBT TOEFL	TOEIC	TEPS	IELTS
General qualification score	83	560	220	760	670	6.5
Qualification score for hearing impairment level 3 or above	62	372	146	380	402	4.8

B.Students who have submitted NEW TOEIC score taken after May 2006 or TEPS score taken after March 1

2007

Classification	iBT TOEFL	PBT TOEFL	CBT TOEFL	TOEIC	TEPS 1)	TEPS 2)	IELTS
General qualification score	83	560	220	720	559	326	6.5
Qualification score for hearing impairment level 3 or above	62	372	146	360	359	196	4.8

1) TEPS: 2007.3.1. ~ 2018.4.7. Conducted Test / 2) New TEPS: 2018.5.12. After Conducted Test

8. Graduation requirements for international students: TOPIK (Test of Proficiency in Korean)

- Undergraduate international students are required to obtain level 2 or higher score in TOPIK before entering or during studying at KAIST.

※ Applies to students entering KAIST in 2013 and thereafter

Table of curriculum

Classification	Subject No.	Subject Name	Lecture	Lab	Credit	Semester
Elective Basic Course	ME106	Human and Machine	3.0	0.0	3.0	Fall
Mandatory Major course	ME200	Basic Mechanical Practice	2.0	3.0	3.0	Spring
	ME303	Mechanical Engineering Laboratory	2.0	3.0	3.0	Spring, Fall
	ME340	Engineering Design	2.0	3.0	3.0	Fall
	ME400	Capstone Design I	1.0	6.0	3.0	Spring
Elective Major Course (Basic Course)	ME207	Applied Electronics	2.0	3.0	3.0	Spring
	ME211	Thermodynamics	3.0	0.0	3.0	Spring
	ME221	Fluid Mechanics	3.0	0.0	3.0	Fall
	ME231	Solid Mechanics	3.0	1.0	3.0	Spring
	ME251	Dynamics	3.0	0.0	3.0	Fall
	ME311	Heat Transfer	3.0	0.0	3.0	Spring
	ME351	Mechanical Vibrations	3.0	0.0	3.0	Spring
	ME361	Modeling and Control of Engineering Systems	3.0	0.0	3.0	Spring or Fall
	ME370	Understanding of Materials and Processing	3.0	0.0	3.0	Spring
Elective Major Course (Advanced Course)	ME203	Mechatronics system design	2.0	3.0	3.0	Fall
	ME301	Numerical Analysis	3.0	0.0	3.0	Spring
	ME302	Creative Problem Solving	2.0	3.0	3.0	Spring
	ME305	Electronics Laboratory for Mechanical Engineers	2.0	3.0	3.0	Spring, Fall
	ME312	Energy and Environment	3.0	0.0	3.0	Fall
	ME313	Applied Thermodynamics	3.0	0.0	3.0	Fall
	ME320	Applied Fluid Mechanics	3.0	0.0	3.0	Spring
	ME330	Foundation of Stress Analysis	3.0	0.0	3.0	Spring
	ME341	Mechanical Component Design	3.0	0.0	3.0	Fall
	ME342	Mechanism Design	3.0	0.0	3.0	Fall
	ME371	Advanced Materials Engineering and its Application	3.0	0.0	3.0	Fall
	ME401	Capstone Design II	1.0	6.0	3.0	Fall
	ME403	Introduction to Naval Architecture and Ocean Engineering	3.0	0.0	3.0	Spring, Summer, Fall, Winter
	ME404	Introduction to Simulation of Medical Procedures	3.0	1.0	3.0	Spring
	ME405	Design Thinking and Entrepreneurship	2.0	3.0	3.0	Spring, Fall
	ME411	Energy System Design and Optimization	3.0	0.0	3.0	Fall
	ME413	Engine Technology	3.0	0.0	3.0	Spring

Undergraduate Program

Table of curriculum

Classification	Subject No.	Subject Name	Lecture	Lab	Credit	Semester
	ME414	Applied superconductivity and Thermal Engineering	3.0	0.0	3.0	Fall
	ME416	Vehicle Dynamics	3.0	0.0	3.0	Spring
	ME421	Microfluidics	3.0	0.0	3.0	Fall
	ME422	Fluids and Environment	3.0	0.0	3.0	Spring
	ME430	Introduction to Reliability in Mechanical Engineering Design	3.0	0.0	3.0	Fall
	ME431	Introduction to Continuum Mechanics	3.0	0.0	3.0	Fall
	ME432	Deformation, Fracture and Strength of Materials	3.0	0.0	3.0	Spring
	ME433	Introduction to Thin Film Mechanics	3.0	0.0	3.0	Spring
	ME440	Engineering Design via FEM	3.0	1.0	3.0	Spring
	ME452	Noise Control Engineering	3.0	0.0	3.0	Fall
	ME453	Introduction to Robotics Engineering	3.0	0.0	3.0	Fall
	ME459	Introduction to Visual Intelligence	3.0	0.0	3.0	Spring
	ME460	Automatic Control	2.0	3.0	3.0	Spring or Fall
	ME461	Introduction to Fuel Cell Systems	3.0	0.0	3.0	Spring
	ME475	Mechanical Engineering and Applied Mathematics	3.0	0.0	3.0	Fall
	ME480	Introduction to Biomedical Optics	3.0	0.0	3.0	Fall
	ME481	Introduction to Electromagnetism & Optics	3.0	1.0	3.0	Spring
	ME484	Structure & Function of Human Body	3.0	0.0	3.0	Fall
	ME487	Introduction to Cell Mechanics	3.0	0.0	3.0	Spring
	ME488	Introduction to biomedical machine technology	3.0	0.0	3.0	Fall
	ME489	Special Topics in Mechanical Engineering Practice I	2.0	3.0	3.0	Spring or Fall
	ME491	Special Topics in Mechanical Engineering	3.0	0.0	3.0	Spring, Fall
	ME492	Special Topics in Mechanical Engineering Practice	1.0	6.0	3.0	Spring, Fall
	ME493	Special Topics in Mechanical Engineering I	1.0	0.0	1.0	Summer,Winter
	ME494	Special Topics in Mechanical Engineering II	2.0	0.0	2.0	Summer,Winter
Research	ME490	Thesis Study	0.0	6.0	3.0	Spring, Fall
	ME495	Individual Study	0.0	6.0	1.0	Spring, Fall
	ME496	Seminar	1.0	0.0	1.0	Spring, Fall

* Note: 400 level courses open to both undergraduate and graduate students.

Graduate Program

Course Requirements (Mar. 2022)

1. Master's Program

Mandatory General	Mandatory Major	Elective	Research	Total
3 Credits + 1AU	-	21	12	36

① Graduation Credits: Required to complete a total of more than **36 credits**
② Mandatory General Courses : **3 credits and 1AU**
- 'CC010 Special Lecture on Leadership' (Non-credit, this applies to students entering KAIST in 2002 and thereafter; general scholarship students, international students, and Changwon-KAIST program students are excluded)
- 1AU: 'CC020 Ethics and Safety I'
- 3 credits: Choose 1 course among below

Course No.	Course Name	Course No.	Course Name
CC500	Scientific Writing	CC512	Introduction to Materials and Engineering
CC510	Introduction to Computer Application	CC522	Introduction to Instruments
CC511	Probability and Statistics	CC530	Entrepreneurship and Business Strategies

※ CC532 Collaborative System Design and Engineering credits are recognized as CC courses to only Renaissance Program students, Changwon-KAIST program students and general scholarship students.

③ Mandatory Major Courses : None
④ Elective Courses: **at least 21 credits**
- Should take more than 12 credits offered by the ME department. For dual degree students (excluding KAIST-TUB dual degree), credits approved by home universities can be transferred to Elective courses offered by ME department. (Please note that not all Elective course are available. Must seek prior approval for credit recognition)

⑤ Research Courses: **at least 12 credits (Must include 2 Seminar credits)**
- International students, Changwon-KAIST program students and general scholarship students admitted in 2009 and thereafter are exempt from seminar credits.

2. Doctoral Program

Mandatory General	Mandatory Major	Elective	Research	Total
3 Credits + 1AU	-	36	30	69

① Graduation Credits: Required to complete a total of more than **69 credits**
② Mandatory General Courses : **3 credits and 1AU**
- 1AU: 'CC020 Ethics and Safety I'
- 3 credits: Choose 1 course among below

Course No.	Course Name	Course No.	Course Name
CC500	Scientific Writing	CC512	Introduction to Materials and Engineering
CC510	Introduction to Computer Application	CC522	Introduction to Instruments
CC511	Probability and Statistics	CC530	Entrepreneurship and Business Strategies

※ CC532 Collaborative System Design and Engineering credits are recognized as CC courses to only Renaissance

③ Mandatory Major Courses : None
④ Elective Courses: **at least 36 credits**
⑤ Research Courses: **at least 30 credits**
- Course credits earned during master's course may be accumulated. (excluding research credits)
- Course requirements for Ph.D. candidates who have graduated from universities other than KAIST or other majors varies, thus must be decided by the recommendation of Academic Advisor, Curriculum Committee and the department head's approval.

3. MS-PhD Intergrated Program

- Will abide by the existing master's and Ph. D program requirements.
- Course credits and research credits earned during master's course may be accumulated.

Graduate Program

Table of curriculum

Classification	Subject No.	Subject Name	Lecture	Lab	Credit	Semester	Remark
Mandatory General Course	CC010	Special Lecture on Leadership					Required
	CC020	Ethics and Safety I					
	CC500	Scientific Writing					Choose 1
	CC510	Introduction to Computer Application					
	CC511	Probability and Statistics					
	CC512	Introduction to Materials Science and Engineering					
	CC522	Introduction to Instruments					
	CC530	Entrepreneurship and Business Strategies					
Elective Course	ME500	Mathematical Methods in Mechanical Engineering	3.0	0.0	3.0	Spring	
	ME502	Introduction to Finite Element Method	3.0	0.0	3.0	Spring	
	ME505	Measurement Instrumentation	3.0	0.0	3.0	Fall	
	ME510	Advanced Fluid Mechanics	3.0	0.0	3.0	Spring	
	ME511	Advanced Thermodynamics	3.0	0.0	3.0	Spring	
	ME512	Advanced Heat Transfer	3.0	0.0	3.0	Fall	
	ME513	Advanced Combustion	3.0	0.0	3.0	Fall	
	ME514	Multiphase Flow I	3.0	0.0	3.0	Fall	
	ME515	Cryogenic Engineering	3.0	0.0	3.0	Spring	
	ME516	Experimental Thermo-Fluid Engineering	2.0	3.0	3.0	Fall	
	ME521	Viscous Fluid Flow	3.0	0.0	3.0	Fall	
	ME526	Introduction to Nanotech Processing	3.0	0.0	3.0	Fall	
	ME530	Advanced Mechanics of Solids	3.0	0.0	3.0	Spring	
	ME533	Fracture Mechanics	3.0	0.0	3.0	Fall	
	ME534	Fatigue Fracture and Strength	3.0	0.0	3.0	Spring	
	ME536	Mechanics of Plastic Deformation	3.0	0.0	3.0	Fall	
	ME537	Optimal Design of Composite Structures	3.0	0.0	3.0	Spring	
	ME543	Optimal Design	3.0	1.0	3.0	Fall	
	ME545	Theory of Hydrodynamics Lubrication	3.0	0.0	3.0	Spring	
	ME547	Knowledge - Based Design System	3.0	1.0	3.0	Fall	
	ME549	Reliability in Microsystems Packaging	3.0	1.0	3.0	Fall	
	ME550	Advanced Dynamics	3.0	0.0	3.0	Fall	
	ME551	Linear Vibration	3.0	0.0	3.0	Spring	
	ME552	Introduction to Acoustics	3.0	0.0	3.0	Spring	
	ME553	Robot Dynamics	3.0	0.0	3.0	Spring, Fall	
	ME554	Future energy-utilization engineering	3.0	0.0	3.0	Spring, Fall	

Classification	Subject No.	Subject Name	Lecture	Lab	Credit	Semester	Remark
Elective Course	ME561	Linear System Control	3.0	0.0	3.0	Spring	
	ME562	Digital System Control	3.0	0.0	3.0	Fall	
	ME564	Artificial Neural Network: Theory and Applications	3.0	0.0	3.0	Spring	
	ME567	Introduction to Statistical Thermodynamics	3.0	0.0	3.0	Fall	
	ME570	Advanced Manufacturing Systems	3.0	0.0	3.0	Spring	
	ME572	Design and Implementation of Nano Actuation System	2.0	3.0	3.0	Spring	
	ME574	Joining Engineering	3.0	1.0	3.0	Fall	
	ME576	Vehicle Dynamics and Control	3.0	1.0	3.0	Spring	
	ME582	Introduction to Microfabrication Technology	3.0	0.0	3.0	Spring	
	ME583	MEMS Design and Experimental Microfabrication	2.0	3.0	3.0	Fall	
	ME585	Mechanics and Control of Human Movement	3.0	0.0	3.0	Spring	
	ME587	Optomechatronics	3.0	0.0	3.0	Fall	
	ME589	Applied Optics	3.0	1.0	3.0	Spring	
	ME591	Random Data: Analysis and Processing	3.0	1.0	3.0	Fall	
	ME592	Laser: Principles and Applications	3.0	0.0	3.0	Fall	
	ME600	Mechanical System Design Project 1	0.0	9.0	3.0	Spring	
	ME601	Mechanical System Design Project 2	0.0	9.0	3.0	Fall	
	ME604	Metrology	2.0	3.0	3.0	Spring	
	ME606	Creative Knowledge Creation Process and Application	3.0	0.0	3.0	Fall	
	ME607	Computational Linear Algebra	3.0	1.0	3.0	Spring	
	ME611	Convective Heat Transfer	3.0	0.0	3.0	Spring	
	ME612	Transport Phenomena	3.0	0.0	3.0	Spring	
	ME613	Computational Fluid Mechanics and Heat Transfer	3.0	0.0	3.0	Fall	
	ME615	Nanoscale Heat Transfer	3.0	0.0	3.0	Spring	
	ME616	Automobile Technology and Environment	3.0	0.0	3.0	Fall	
	ME617	Advanced Vehicle Control Design	3.0	0.0	3.0	Fall	
	ME621	Turbulence	3.0	0.0	3.0	Spring	
	ME623	Rotating Flow	3.0	0.0	3.0	Fall	
	ME632	Theory of Viscoelasticity	3.0	0.0	3.0	Fall	
	ME633	Mechanical Behavior of Polymeric and Composite Materials	3.0	0.0	3.0	Fall	
	ME635	Plastic Analysis and Design of Structures	3.0	0.0	3.0	Fall	
	ME638	Axiomatic Design of Composite Structure	3.0	0.0	3.0	Spring	
	ME639	Introduction to Elasticity and Micromechanics	3.0	0.0	3.0	Fall	
	ME642	Medical Biomechanics	3.0	0.0	3.0	Fall	

Graduate Program

Table of curriculum

Classification	Subject No.	Subject Name	Lecture	Lab	Credit	Semester	Remark
Elective Course	ME644	Tribology	3.0	0.0	3.0	Spring	
	ME647	STEP for Electronic Commerce	3.0	1.0	3.0	Spring	
	ME653	Mechanical Signature and System Analysis	3.0	1.0	3.0	Fall	
	ME654	Noise Control	3.0	0.0	3.0	Fall	
	ME655	Robotics Engineering	3.0	1.0	3.0	Fall	
	ME656	Vehicle NVH	3.0	1.0	3.0	Fall	
	ME662	Design of Precision Actuation System	3.0	0.0	3.0	Spring	
	ME674	Optical Imaging System Design	3.0	0.0	3.0	Fall	
	ME675	Ultrafast Optic Technology	3.0	0.0	3.0	Fall	
	ME683	Human Robot Interaction: Haptics	3.0	0.0	3.0	Fall	
	ME692	Wave Propagation	3.0	0.0	3.0	Spring	
	ME711	Radiation Heat Transfer	3.0	0.0	3.0	Spring	
	ME722	Computational Turbulence Modeling	3.0	0.0	3.0	Spring	
	ME731	Nonlinear Computational Mechanics of Solid	3.0	0.0	3.0	Spring	
	ME732	Reliability in Strength Design	3.0	0.0	3.0	Fall	
	ME752	Structure-borne Sound	3.0	0.0	3.0	Fall	
	ME761	Nonlinear System Control	3.0	0.0	3.0	Spring	
	ME771	Analysis and Design of Metal Forming Processes	3.0	1.0	3.0	Fall	
	ME781	Molecular Dynamics and Nanomechanics	3.0	0.0	3.0	Spring	
	ME800	Special Topics in Mechanical Engineering	3.0	0.0	3.0	Spring, Fall	
	ME801	Special topics in Mechanical Engineering I	1.0	0.0	1.0	Summer, Winter	
	ME802	Special topics in Mechanical Engineering II	2.0	0.0	2.0	Summer, Winter	
	ME810	Special Topics in Thermal & Fluid Engineering	3.0	0.0	3.0	Fall	
	ME830	Special Topics in Design Engineering	3.0	0.0	3.0	Fall	
	ME850	Special Topics in Dynamics and Control	3.0	0.0	3.0	Spring, Fall	
	ME870	Special Topics in Production Engineering	3.0	0.0	3.0	Spring, Fall	
Research	ME960	M.S. Thesis	0.0	0.0	0.0	Spring, Fall	
	ME964	Individual Research M.S.	0.0	3.0	1.0	Spring, Summer, Fall, Winter	
	ME966	Seminar (M.S. Program)	1.0	0.0	1.0	Spring, Fall	
	ME967	Individual Research M.S.	0.0	6.0	2.0	Spring, Fall	
	ME980	Ph.D. Thesis	0.0	0.0	0.0	Spring, Fall	
	ME985	Individual Research Ph.D.	0.0	3.0	1.0	Spring, Summer, Fall, Winter	
	ME986	Seminar (Ph.D.)	1.0	0.0	1.0	Spring, Fall	

* Note: 500 level courses open to both undergraduate and graduate students.

Graduate School of Ocean Systems Engineering program

Course Requirements (Mar. 2022)

1. Master's Program

Mandatory General	Mandatory Major	Elective	Research	Total
3 Credits + 1AU	-	21	9	33

① Graduation Credits: Required to complete a total of more than **33 credits**

② Mandatory General Courses : **3 credits and 1AU**

- 'CC010 Special Lecture on Leadership' (Non-credit, this applies to students entering KAIST in 2002 and thereafter; general scholarship students, international students, Changwon Univ.-KAIST students are excluded)
- 1AU: 'CC020 Ethics and Safety I'

③ Mandatory Major Courses : None

④ Elective Courses: **at least 21 credits**

- Among the 21 credits, at least 12 credits should be taken in our department's courses

⑤ Research Courses: **at least 9 credits**

- Must include 1 Seminar credit.
- International students, Changwon-KAIST program students and general scholarship students are exempt from seminar credits.

2. Doctoral Program

Mandatory General	Mandatory Major	Elective	Research	Total
3 Credits + 1AU	-	27	30	60

① Graduation Credits: Required to complete a total of more than **60 credits**

② Mandatory General Courses : **3 credits and 1AU**

- 1AU: 'CC020 Ethics and Safety I'

③ Mandatory Major Courses : None

④ Elective Courses: **at least 27 credits**

⑤ Research Courses: **at least 30 credits**

- Course credits earned during master's course may be accumulated. (excluding research credits)
- Course requirements for Ph.D. candidates who have graduated from universities other than KAIST or other majors varies, thus must be decided by the recommendation of Academic Advisor, Curriculum Committee and the department head's approval.

3. MS-PhD Intergrated Program

- Will abide by the existing master's and Ph. D program requirements.
- Integrated master's/doctoral program students should take more than 60 credits including completed courses credits from master's program and should qualify the courses requirement of doctoral degree program of the department.
- Course credits and research credits earned during master's course may be accumulated.

Graduate School of Ocean Systems Engineering program

Table of curriculum

Classification	Subject No.	Subject Name	Lecture	Lab	Credit	Semester	Remark
Mandatory General Course	CC010	Special Lecture on Leadership					Required
	CC020	Ethics and Safety I					
	CC500	Scientific Writing					Choose 1
	CC510	Introduction to Computer Application					
	CC511	Probability and Statistics					
	CC512	Introduction to Materials Science and Engineering					
	CC522	Introduction to Instruments					
	CC530	Entrepreneurship and Business Strategies					
Elective Course	ME509	Engineering Mechanics in Ocean Systems	4.0	0.0	4.0	Spring	
	ME522	Flow Instability	3.0	0.0	3.0	Fall	
	ME523	Introduction to Fluid-Structure Interactions	3.0	0.0	3.0	Fall	
	ME524	Ocean Hydrodynamics	3.0	0.0	3.0	Spring	
	ME532	Advanced analysis of solids and structures	3.0	0.0	3.0	Spring	
	ME535	Finite Element Analysis of Structures	3.0	0.0	3.0	Fall	
	ME538	Ocean Systems Design	3.0	0.0	3.0	Spring, Fall	
	ME539	Design of Energy Plants and Systems	3.0	0.0	3.0	Fall	
	ME540	Stochastic Theory of Structure System	3.0	0.0	3.0	Spring	
	ME541	Reliability and Risk Analysis for Energy Systems	3.0	0.0	3.0	Spring	
	ME548	Knowledge - Based Design System for Ocean System	3.0	1.0	3.0	Spring	
	ME555	Vibration of Offshore Structures	3.0	0.0	3.0	Fall(in an even year)	
	ME556	Underwater Acoustics	3.0	0.0	3.0	Fall	
	ME558	Dynamics of Offshore Structures	3.0	0.0	3.0	Spring, Fall	
	ME559	Dynamics and Control of Ocean Vehicles	3.0	0.0	3.0	Spring, Fall	
	ME568	Ocean VR Simulation	3.0	0.0	3.0	Fall	
	ME571	Marine Production Systems Engineering	3.0	0.0	3.0	Spring	

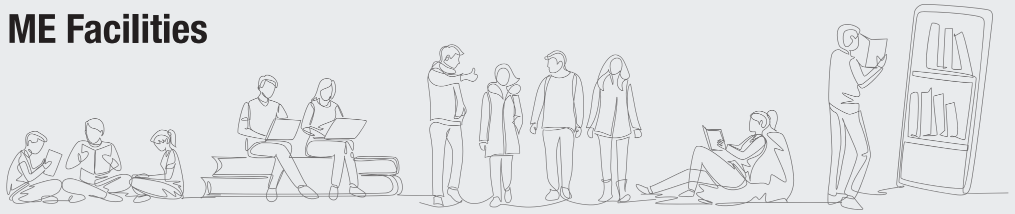
Classification	Subject No.	Subject Name	3.0	Lab	Credit	Semester	Remark
Elective Course	ME590	Ocean System Innovation	3.0	0.0	3.0	Spring, Fall	
	ME593	Harbor Engineering	3.0	0.0	3.0	Fall	
	ME594	Ocean Systems Engineering	3.0	0.0	3.0	Spring	
	ME595	Ocean Systems Management	3.0	0.0	3.0	Spring	
	ME596	Shipbuilding and Offshore Plants Management System	3.0	0.0	3.0	Spring	
	ME597	Renewable ocean energy system	3.0	0.0	3.0	Spring	
	ME598	Ocean Nuclear Power: A Challenging Pursuit for Energy Solution	3.0	0.0	3.0	Spring	
	ME620	Advanced Ocean Wave Mechanics	3.0	0.0	3.0	Spring, Fall	
	ME622	Floating Body Dynamics	3.0	0.0	3.0	Spring	
	ME624	Simulation of Ship Hydrodynamics and Waves	3.0	0.0	3.0	Spring	
	ME630	Deepsea Petroleum production Engineering	4.0	0.0	4.0	Fall	
	ME634	Functional Materials and Structures	3.0	0.0	3.0	Fall	
	ME652	Mobile Robotics	3.0	0.0	3.0	Spring	
	ME658	Engineering System Identification	3.0	0.0	3.0	Spring, Fall	
	ME670	Construction of Offshore Structures	2.0	0.0	2.0	Summer, Winter	
	ME671	Product Lifecycle Management System for Ocean System	3.0	1.0	3.0	Spring	
	ME803	Special Topics in Ocean Systems Engineering	3.0	0.0	3.0	Spring, Fall	
	ME804	Special Topics and Design Laboratory of Ocean Systems Engineering	2.0	3.0	3.0	Summer, Winter	
Research	ME960	M.S. Thesis	0.0	0.0	0.0	Spring, Fall	
	ME966	Seminar (M.S. Program)	1.0	0.0	1.0	Spring, Fall	
	ME968	Seminar of Career Planning for Ocean Engineering	1.0	0.0	1.0	Spring, Fall	
	ME980	Ph.D. Thesis	0.0	0.0	0.0	Spring, Fall	
	ME986	Seminar (Ph.D.)	1.0	0.0	1.0	Spring, Fall	

* Note: 500 level courses open to both undergraduate and graduate students.

ME Building and Facilities

ME Building

ME Facilities



Lobby

Lecrure room

ME Meeting Room

Computer room

ME Study Cafe

Shower room

Discussion room

Meeting space

Meeting room

Faculty rounge

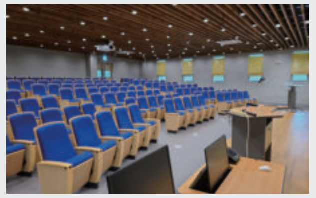
Administrative / BK21 office

Narae practice building

Manufacturing lab

Seminar room

Roof-top garden



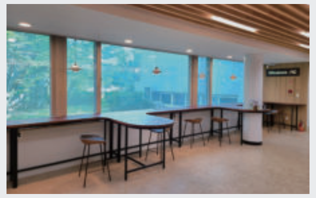
Conference Hall

HAEDONG Hall

Machining room

ME Garden

SHI-KAIST Sermina room



Windows in ME

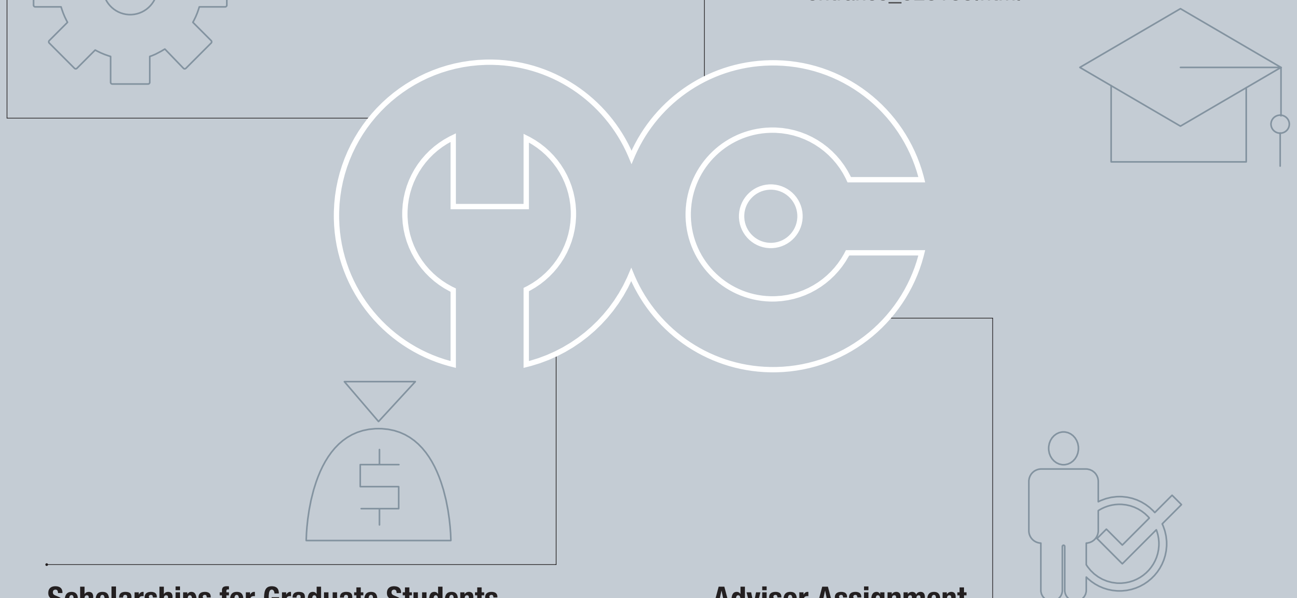
Admissions

The students who are admitted through the KAIST admission process can enter the Department of Mechanical Engineering, declaring mechanical engineering as their major at the beginning of their sophomore year.

Undergraduate Program

Graduate Program

- The admission procedure includes documented evaluations with English scores (TOEFL, TOEIC or TEPS) and an interview of qualified applicants by faculty members.
- Graduates of other majors, such as the electrical engineering, computer science and material science, may apply for the program as well.
- For more information, please visit http://admission.kaist.ac.kr and https://me.kaist.ac.kr/entrance/entrance_020100.html



Scholarships for Graduate Students

Every graduate student at KAIST is eligible for one of the following scholarships:

- Government Scholarship (sponsored by the government)
- KAIST Scholarship (sponsored by the research funds of a faculty member or by industry-funded education programs)
- General Scholarship (sponsored by outside organizations)

Advisor Assignment

- A student with a government scholarship shall be assigned a faculty member in the department.
- A student with a KAIST scholarship shall be assigned a faculty member who has in advance requested students under special education programs. The field of the student's research may have been pre-determined if the student is supported by the research funds of a faculty member.
- A student with a general scholarship shall be assigned a faculty member in the field of research specified by the sponsoring organization.

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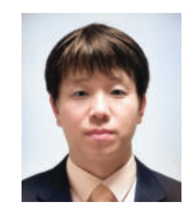

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Map

East Campus Map

- **E1** Main Gate
- **E2** Industrial Engineering & Management B/D
- **E3** Information&Electronics B/D
- **E4** KAIST Institutes B/D
- **E5** Faculty Club
- **E6** Natural Science B/D
- **E7** Biomedical Research Center
- **E8** Sejong Hall
- **E9** Academic Cultural Complex
- **E10** Storehouse
- **E11** Creative Leaarning B/D
- **E12** Energy Plant
- **E13** Satellite Technology Research Center
- **E14** Main Administration B/D
- **E15** Auditorium
- **E16** ChungMoonSoul B/D
- **E17** Stadium
- **E18** Daejeon Disease-model animal center
- **E19** National Nano Fab Center
- **E20** Kyeryong Hall
- **E21** KAIST Clinic. Pharmacy

West Campus Map

- **W2** Student Center-1
- **W3** Galilei Hall
- **W4** Yeoul Hall, Nad hall, Dasom Hall, Heemang Hall
- **W5** Married Students Housing, Startup Village, International Village A,B,C
- **W6** Mir Hall, Narae Hall
- **W7** Nanum Hall
- **W8** Educational Support B/D
- **W9** Outdoor Theater
- **W10** Wind Tunnel Laboratory
- **W11** International Faculty Apartment
- **W12** West Energy Plant
- **W16** Geotechnical Centrifuge Testing Center

North Campus Map

- **N1** Kim Beang-Ho&Kim Sam-Youl ITC B/D
- **N2** Branch Administration B/D
- **N3** Sports Complex
- **N4** School of Humanities&Social Science B/D
- **N5** Basic Experiement and Research B/D
- **N6** Faculty Hall
- **N7** Mechanical Engineering B/D
- **N7-1** Dept. of Nuclear and Quantum Engineering
- **N7-2** Dept. of Aerospace Engineering
- **N7-3,4** Dept. of Mechanical Engineering
- **N7-5** Automobile Technology Laboratory B/D
- **N9** Practice B/D
- **N10** Undergraduate Branch Library
- **N11** Cafeteria
- **N12** Student Center-2
- **N13** Tae Wul Gwan
- **N14** Sarang Hall
- **N15** Staff accommodation
- **N16** Somang Hall
- **N17** Seongsil Hall
- **N18** Jilli Hall
- **N19** Areum Hall
- **N20** Silloe Hall
- **N21** Jihye Hall
- **N22** Alumni Venture Hall
- **N23** fMRI Center
- **N24** LG Innovation Hall
- **N25** Dept. of Industrial Design B/D
- **N26** Center for High-Performance Integrated Systems
- **N27** Eureka Hall
- **N28** Energy&Environment Research Center

Please be a strong supporter for Department of Mechanical Engineering!

Commitment method

Online commitment

Visit Web-Page
https://giving.kaist.ac.kr

Postal, Telephone and Fax applications

KAIST, 291 Daehak-ro, Yuseong-gu, Daejeon 34141, Republic of Korea
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Visit

Visit KAIST Development Foundation office on the First floor of the KAIST Main Administration B/D(E14)

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Mechanical Engineering

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MECHANICAL ENGINEERING

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