2023

School of EE Lab Introductions

Device

KAIST EE

〈Professor Sanghyeon Kim's Lab.〉

3D integrated opto-electronic device Laboratory	■ Contact information		
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	Lab.	**Email: mmb07@kaist.ac.kr**	**Tel: 7552**
	Website	**https://www.3doedl.com/**	

■ Current state of the Lab. (in 2023 Fall Semester)

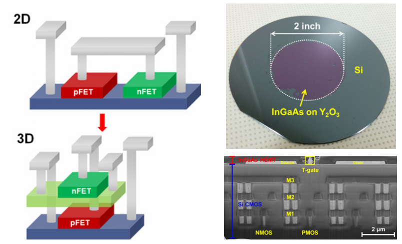
Postdoctoral Fellows : 0 PhD Students: 11 Master's Student: 10

■ Research Areas

: 3D integrated opto-electronic semiconductor devices (mainly using III-V compound semiconductor and Ge.), which is one of the most promising device research areas toward future 3D integrated systems

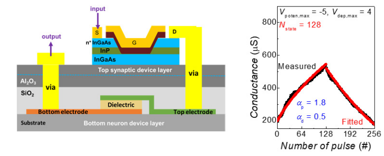
▶ Monolithic 3D integration

Monolithic 3D (M3D) integration provides increased bandwidth, smaller power consumption, smaller footprint, and increased functionality. We are exploring layer stacking and device technology to realize stackable 3D devices.



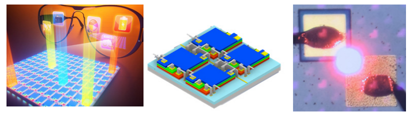
▶ Next generation computing

To reduce computing power, we are developing next-generation CMOS devices using III-V, Ge. Not only beyond conventional CMOS under Von-Neumann architecture, we initiated the research on semiconductor devices for artificial neural network / neuromorphic computing. To realize the ultra-low computing, we are developing 3D stackable neuronal and synaptic devices, which would be ultimate device structure minimizing the power consumption in the interconnect as well as the power consumption for computing.



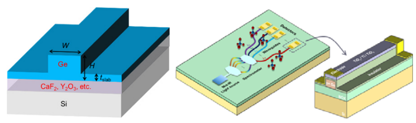
▶ MicroLED display

For ultra-small, but ultra-high resolution display, we are developing 3D stacked inorganic MicroLED display using wafer bonding and sequential device fabrication process.



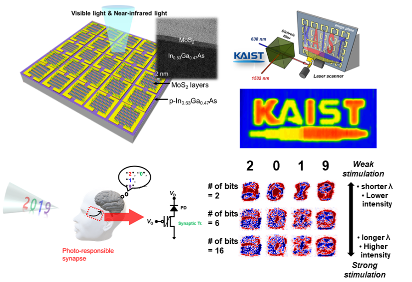
▶ Mid-IR photonics

For very compact on-chip gas sensor, we are developing Mid-IR integrated photonics platform using Ge-on-insulator structure.



▶ Thin film imager

Ultimate goal of the semiconductor-based hardware system would be a full imitation of the human's function such as feeling emotions, learning, and thinking, etc. To do that with semiconductor-based hardware, sensing the information will be an inevitable functionality. Sensing the visual information is one of the most important features to enable lots of tasks such as pattern recognition, real-time image processing, self-adaptive detecting, etc. Therefore, we are exploring the thin film imager using M3D integration technology.



■ Recommended courses & Career after graduation

Any courses about semiconductor devices and solid-state physics, semiconductor integration, photonics are recommended. Career path will include academia, major industries in semiconductor and display, etc.

■ Introduction to other activities besides research

We are encouraging students to participate in international and domestic conferences and also internship programs for their experiences. We are also planning to have enjoyable dinner and outer activities regularly.

■ Introduction to the Lab.

Prof. Kim opened the lab in KAIST on Feb. 2019. We are doing multi-disciplinary researches on various semiconductor electron and photonic devices with an emphasis on monolithic 3D integration (M3D). To contribute to future M3D semiconductor devices, we are fully supporting students' research and helping to broaden their research scope with world-class infrastructure.

■ Recent research achievements (2020-2023)

39 journal papers (some of them were featured as a cover article), 44 conference papers including flagship conferences (IEDM, VLSI, IMID, etc.)

<Professor Yong-Hoon Kim's Lab.>

Atomic-Scale Devices Simulation Lab

■ Contact information

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Lab. : dndhdrnl@kaist.ac.kr TEL : 042-350-7523 / 7623

Website : http://nanocore.kaist.ac.kr

■ Current state of the Lab. (in 2023 Fall Semester)

Postdoctoral Fellows: 3 PhD Students: 5 Master's Students: 3 Secretary: 1

■ Research Areas

1. Theory & Computation

- physics of non-equilibrium open quantum systems
- novel 1st-principles & TCAD theory/methods for quantum transport & optical excitation processes
- artificial intelligence & high-performance computing technology for 1st-principles & TCAD simulations

⇓

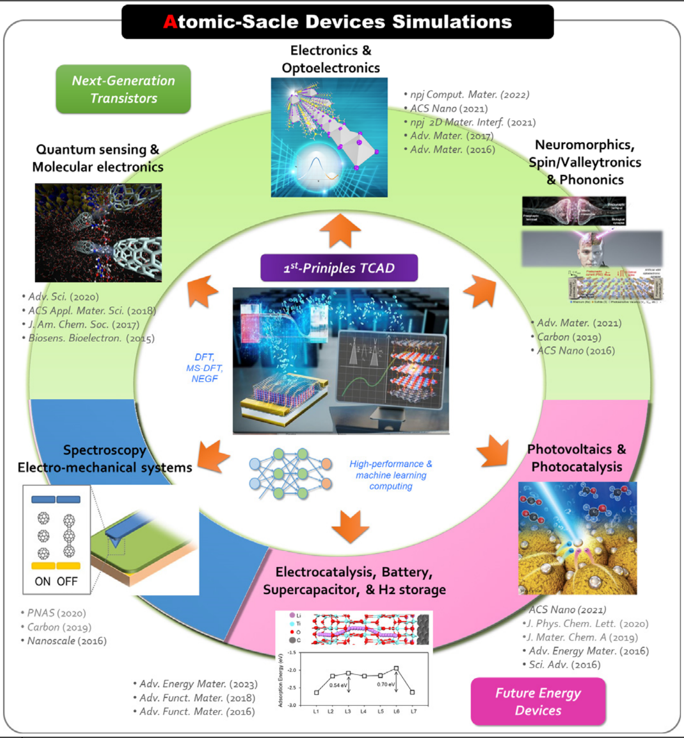
2. Functional Nano-Materials

- graphene, 2D vdW materials, & heterostructures
- semiconductor & oxide quantum dots, wires, & wells
- hybrid halide perovskites & bio/organic materials

⇓

3. More (than) Moore Nano-Devices

- "more Moore & more than Moore" devices (multi-value logic, neuromorphic computing, quantum computing)
- energy conversion & storage devices (solar cells, LED, electro/photocatalysis, supercapacitor)
- bio & electrochemical interfaces (chem-bio sensors)



■ Recommended courses & Career after graduation

- Lab members are expected to have strong interest in (1) advanced semiconductor device physics, (2) high-performance/AI computing, & TCAD
- In the past 5 years, 2 alumni were appointed as an assistant professor; 1 alumnus became permanent staff members in a National Lab; 2 alumni were hired at Samsung as research staff members

■ Introduction to other activities besides research

Daedunsan

Jeju island

Barcelona, Spain

- Annual winter schools at ski resorts, Annual summer schools at Jeju, Annual hiking trips, Weekly stroll+lunch
- Regular attendances to International conferences

■ Introduction to the Lab.

- According to *Nature* (http://nature.com/top100), among the top 100 most cited papers of all time in all fields, 12 of them are on density functional theory (DFT).
- Our group is leading the development of novel 1st-principles DFT, multiscale & AI nanodevice simulation formalism and softwares that can deal with quantum transport & optical excitations.
- This will have far-reaching implications for the understanding of the physics of non-equilibrium open quantum systems and the development of next-generation electronic/energy/bio-nanodevices.

■ Recent research achievements ('21~'23)

- *"Localized coherent phonon generation in monolayer MoSe2 from ultrafast exciton trapping …"*, Nanoscale Horiz. 8, 1282 (2023)
- *"Quantum hybridization negative differential resistance from non-toxic halide perovskite …"*, Nano Converg. **9**, 25 (2022)
- *"Gate-versus defect-induced voltage drop and negative differential resistance in vertical …"*, Npj Comput. Mater. **8**, 50 (2022)
- *"An optogenetics-inspired flexible van der Waals optoelectronic synapse and its application …"*, Adv. Mater. **33**, 2102980 (2021)
- *"Origins of genuine Ohmic van der Waals contact between indium and MoS_2"*, NPJ 2D Mater. Appl. **5**, 9 (2021)

(17 papers of impact factor > 5 SCI journals in '21-'23; See http://nanocore.kaist.ac.kr for the full publication list)

- Samsung Next Generation ICT Project (2020-2023, http://samsungstf.org) & many other awards on group members.

〈Professor Mincheol Shin’s Lab.〉

Computational Nanoelectronics Laboratory
http://cnl.kaist.ac.kr

■ **Contact information**

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LAb.	Email: cnl.kaist.lab@gmail.com	Tel: 042-350-7618
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■ Current state of the Lab. (in 2023 Fall Semester)

PhD Students: 5 Master’s Student: 5

■ Research Areas

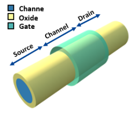
As the feature size of conventional planar metal-oxide-semiconductor field-effect transistors (FETs) shrinks into the nanometer regime, novel devices such as nanowire and tunnel FET have emerged as the next generation devices. The classical or semi-classical approach is no longer valid for the nano-sized devices so quantum-mechanical, atom-level treatment is required.

In our laboratory, we have been developing **simulators for advanced nano scaled logic devices** based on the quantum mechanical principles. Si-based as well as non-Si devices such as 2D materials and III-V compounds are being considered. To treat the devices in the atomistic level, density functional theory and the non-equilibrium Green’s function method are employed to calculate the quantum charge transport.

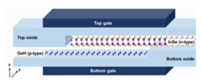
We have also studied **the next generation memory devices**, such as ferroelectric FET (FeFET) and magnetic random access memory (MRAM). For **FeFET**, we use in-house Phase-field-based simulator.

For an optimization of nanoscale devices, we have developed **machine learning(ML)-based device optimization framework** where TCAD simulator and Bayesian optimization algorithm are combined.

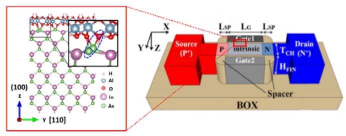
We are currently developing advanced transport models through **physics-informed neural networks** and more. Through this approach, we aim to construct advanced transport models and explore solutions to complex real-world problems by enhancing predictions and modeling.



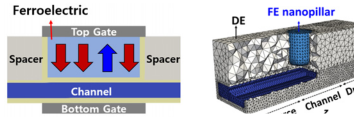
Nanowire FET



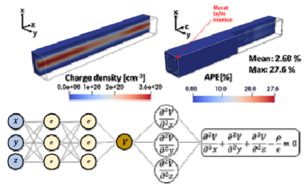
2D FET



III-V compound tunnel FET with defects



Fe-FET



ML-based device simulation/optimization

■ Recommended courses & Career after graduation

Prospective students should have good background knowledge on semiconductor physics and devices. Basic/advanced courses on the quantum mechanics, solid-state physics, and C language are also recommended to take. After graduation, they may continue their research career in universities or research institutes or work in semiconductor companies in Korea and overseas.

■ Introduction to other activities besides research

It is strongly encouraged that students set aside time for regular physical exercises. Besides research, it is emphasized that students acquire ability to develop and express their idea, thinking, opinions through reading, writing and presentation (scientific or non-scientific).

■ Introduction to the Lab.

Computational science/engineering is a new, a third way of doing research, besides the traditional way of doing research which is theory or experiment. Remarkable progress in the computer power and increasing needs for computation has led to the era of computational science/engineering. To meet the needs of the times, CNL provides its members with environments and experiences, which help them become the experts in semiconductor device physics and computational electronics. At the time of graduation, they are expected to be capable of handling all the semiconductor-device related issues that become more and more complex and ready to work both in industry and academia.

■ Recent research achievements (2021-2023)

[1] "Ferroelectric nanopillar field-effect transistors: Quantum transport simulations based on a three-dimensional phase-field", Hyeongu Lee, Yoon-suk Kim, and Mincheol Shin, Physical Review Applied, vol. 19, p. 054061, May. 2023

[2] "Efficient device simulations using density functional theory Hamiltonian and non-equilibrium Green’s function: heterostructure mode space method and core charge approximation," Seonghyeok Jeon and Mincheol Shin, Journal of Computational Electronics, May 2023.

[3] "First-Principles-based Quantum Transport Simulations of Interfacial Point Defect Effects on InAs Nanowire Tunnel Field-Effect Transistors", H. Lee, et al., IEEE Transctions on Electron Devices, vol. 68, no. 11, pp. 5901 - 5907, Nov. 2021.

[4] "Bayesian Optimization of MOSFET Devices Using Effective Stopping Condition", B. Kim and M. Shin, IEEE Access, vol. 9, 108480-108494, Aug. 2021.

〈Professor Kyounghoon Yang's Lab (양경훈 교수 연구실)〉

HIGH SPEED NANOELECTRONICS LAB HSNL High Speed Nano Electronics Laboratory	■ Contact information		
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	Lab.	E3-2, 1227	Tel: 042-350-5471
	Website	http://hsnl.kaist.ac.kr	

■ **Current state of the Lab. (in 2024 Spring Semester)**

PhD Student: 1 & Master's Students: Openings now available for Spring semester 2024.

■ **Research Areas**

● Quantum-effect High-speed Nanodevices/Integrated Circuits

A **resonant tunneling diode (RTD),** which is a semiconductor nonlinear diode with a double-barrier quantum-well structure for electrons to resonantly tunnel through, has been regarded as one of the most mature quantum-effect devices for practical low-power integration circuit (IC) applications. The resonant tunneling diode (RTD) which is the fastest electronic device has inherent negative differential resistance (NDR), nonlinearity, and multifunctional/bistable characteristics, so it has been actively researched in signal sources, detectors, and mixed-signal circuits in THz monolithic integrated circuits (TMICs) for next-generation mmW and THz cutting-edge applications.

● Wide-bandgap High-power Semiconductor Devices

For power electronics applications, the wide-bandgap semiconductors such as gallium nitride (GaN) and silicon carbide (SiC) have benefits of high breakdown voltage, lower on-resistance, and higher current. In particular, **GaN-based HEMTs are ideal for the next generation of high-frequency, high-power power electronics applications** because the GaN HEMTs generate a high concentration of two-dimensional electron gas (2-DEG) owing to the strong polarization difference and high conduction band offset at the interface and have on-resistance lower than SiC devices. Our current focus is on **enhancement-mode (E-mode) GaN HEMTs grown on Si substrate with Vds,max>150 V and Ids>25 A.** The enhanced GaN HEMT is safer and more energy efficient because the device is in the off state at zero bias, essential for recent rapidly growing high-power electronics markets.

● Nano-CMOS / III-V HEMT RF Device Modeling & mm-Wave IC Design

Mm-wave wireless T/R Front-end phased-array ICs have been developed at the frequencies ranging from 28GHz, 60GHz up to W-band (77GHz, 94GHz). With the increase of frequencies, the resolution of beam-forming and the capacity for signal data rates enhance, which is a major research focus for the next-generation wireless system development. **The research on D-band (110-170GHz) RF-ICs** is in progress and **sub-THz bands (170-300GHz)** will be also pursued towards 5G+/6G systems.

■ **Recommended courses**

► Basic Physical Electronics, Semiconductor Devices, Electronic Circuits, Microwave Engineering, etc.

■ **Career after graduation**

► Samsung Electronics/SK Hynix/ETRI/KIST/ADD/NNFC/KANC/Academia

■ **Introduction to other activities besides research**

► Laboratory workshop & picnic / Casual group meetings in open atmosphere

■ **Introduction to the Lab.**

► HSNL is currently getting into the 2nd-phase of lab research activities, moving towards ***more diversified & bigger-scale co-research with other laboratories to develop mmW/THz Devices & Wireless Comm-Radar Core & Future Quantum System IC/Modules*** from high-speed/high-frequency nano/quantum devices to Full-scale IC/Systems based on enhanced mutual-lab collaborations, which will ***provide new joining students with more in-depth & broader research opportunities from device to circuit & system levels.***

■ **Recent research achievements (2020-2023)**

[1] X. Yang et al., "Systematic characterization for RF small-signal parameter extraction of 28 nm FDSOI MOSFETs up to 110 GHz," Microelectronics Journal, 2023.

[2] K. Yang, "Status and Perspective of Resonant Tunneling Diode Technology for Future mm-Wave and Terahertz (THz) Electronics," Keynote Invited Speech, CSW2023, 2023.

[3] M. Park et al., "200 mm Si CMOS Process-compatible Integrated Passive Device Stack for Millimeter-wave Monolithic 3-D Integration," IEEE TED, 2023.

[4] X. Yang et al., "RF Characterization and Small Signal Extraction of 28nm FDSOI MOSFETs up to 110GHz," IEEE APMC, 2022.

[5] J. Lee et al., "Area-Efficient Series-Connected Resonant Tunneling Diode Pair as Binary Neuron in Cellular Neural Network", IEEE EDL, 2020.

<Professor Seunghyup Yoo's Lab>

IOEL
Integrated Organic Electronics Lab

■ Contact information

Professor	**Email: syoo_ee@kaist.ac.kr**	**Tel: 042-350-3483**
Lab.	**Email: pirds@kaist.ac.kr**	**Tel: 042-350-3483**
Website	**https://ioel.kaist.ac.kr/**	

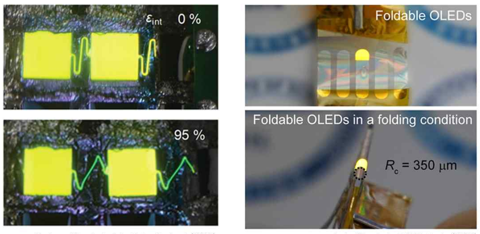
■ Current state of the Lab. (in 2023 Fall Semester)

PhD Students: 12 Integrated MS/PhD Students: 2 Master's Students: 6

■ Research Areas

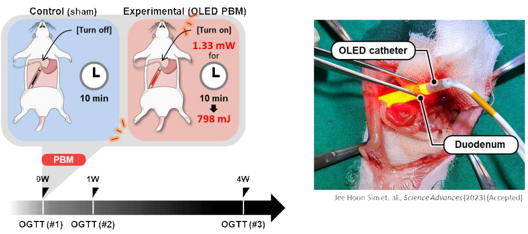
Organic Light-Emitting Diodes (OLED)
As future display panels and other applications, OLEDs are promising due to their advantages such as high color purity, applicability on versatile designs including flexible and transparent devices, and low power consumption.

- Highly efficient flexible and stretchable OLEDs



Taehyun Kim et.al., *Adv. Mater. Technol.* (2020) Junho Kim et.al., *ACS Photonics* (2023)

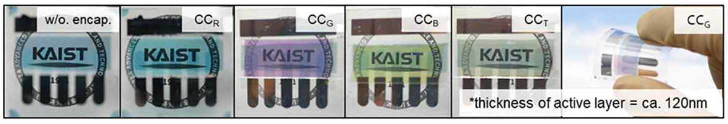
- OLEDs for phototherapy



Jee Hoon Sim et. al., *Science Advances* (2023) (Accepted)

Organic photovoltaics (OPV)
Significant advances are being made in the commercialization of solar cells for building-integrated and vehicle-integrated photovoltaics by developing flexible and semi-transparent characteristics of solar cells.

- Semitransparent and flexible OPVs

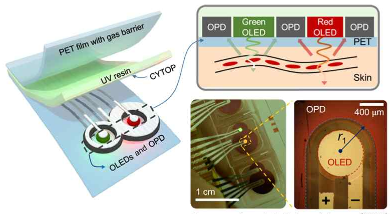


Hyunwoo Lee et.al., *Advanced Energy & Sustainability Research* (2020)

Organic electronic devices
State-of-the-art applications for future electronics including wearable/patched devices require not only various functions but also diverse form factors.

- Organic thin-film transistors
- Wearable sensors

Hanul Moon et.al., *Advanced Materials* (2014)



Hyeonwoo Lee et.al., *Science Advances* (2020)

■ Recommended courses

- Introduction to Physical Electronics (EE211)
- Semiconductor Devices (EE362)
- Organic Electronics (EE568)
- Display Engineering (EE563)

■ Career after graduation

- Research and development field in electronics (national institute or private company)
- Academic fields

■ Introduction to the Lab.

Integrated Organic Electronics Lab (IOEL) focuses on developing novel device architectures and processes based on organic and other emerging semiconductors in the following areas: display & lighting, energy, and flexible low-cost electronics. Recent research trends no longer centralize on device performance enhancement, but focus more on the realization of various functionalities. For students with knowledge in electronics and great interest in interdisciplinary fields, we hope you will join IOEL and seize the chance to apply your electrical engineering skills to various areas.

■ Introduction to other activities besides research

- IOEL encourages good interpersonal relationship through regular lab workshops and exhilarating sports days held every semester

■ Recent research achievements (2023)

[1] Hyung Suk Kim, Hyung Jin Cheon, Donggyun Lee, Woochan Lee, Junho Kim, Yun-hi Kim, and Seunghyup Yoo, "Toward highly efficient deep-blue OLEDs: Tailoring the multiresonance-induced TADF molecules for suppressed excimer formation and near-unity horizontal dipole ratio." *Science Advances,* 2023

[2] Junho Kim, Eungjun Kim, Jaehyeok Park, Jinouk Song, Subon Kim, Hanul Moon, and Seunghyup Yoo, "Toward Near-Foldable Surface Light Sources with Ultimate Efficiency: Ultrathin Substrates Embedded with Micron-Scale Inverted Lens Arrays", *ACS Photonics,* 2023

[3] Palanisamy Rajakannu, Woochan Lee, Sanghoon Park, Hyung Suk Kim, Hanif Mubarok, Min Hyung Lee, Seunghyup Yoo, "Molecular Engineering for Shortening the Pt···Pt Distances in Pt(II) Dinuclear Complexes and Enhancing the Efficiencies of these Complexes for Application in Deep-Red and Near-IR OLEDs", *Advanced Functional Materials,* 2023

[4] Hyeonwook Chae, Yongjin Park, Yehhyun Jo, Yongmin Jeon, Hyunjoo Jenny Lee, Seunghyup Yoo, and Kyung Cheol Choi, "Blue Transparent OLEDs with High Stability and Transmittance for Modulating Sleep Disorders." *Advanced Materials Interfaces,* 2023

[5] Ji Hun Choi, Chan Woo Park, Bock Soon Na, Jong-Heon Yang, Jeho Na, Jae-Eun Pi, Hee-Ok Kim, Chi-Sun Hwang, Seunghyup Yoo, "Highly stable Mo/Al bilayer electrode for stretchable electronics", *Journal of Information Display,* 2023

<Professor Jun-Bo Yoon's Lab.>

3D Micro-Nano Structures Laboratory

■ **Contact information**

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Lab.: Nanofab Center 523 (E19) TEL :042-350-5476

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■ Current state of the Lab. (in 2023 Fall Semester)

Postdoctoral Fellows : 1 PhD Students: 6 Master's Student: 3

■ Research Areas

▷We focus on the **high-performance 3-dimensional micro/nano-electro-mechanical systems (M/NEMS)**.

▷We research on **unique device-design, fabrication, and demonstration** technologies.

▷Based on our superior abilities in overall device-technology, we have developed the **world-best electrical devices, such as nano/micro-mechanical switches (DC/RF), nano-sensor devices and optical components.**

▷We have also **widen the research-field** into bio-sensor, health-care monitoring, energy harvesting devices and so on, **with lab members having various undergraduate majors (EE, ME, MSE, Chemistry, etc.)**

■ Nano/micro-switch for DC & RF applications ---

Utilizing micro/nano-mechanical switches, we achieve zero leakage current and infinite sub-threshold swing. We're advancing high-performance switches to address CMOS transistor limitations, aiming to enhance autonomous driving and space industry memory, advanced back end of line (BEOL) interconnects, circulator for quantum computing, and DC & RF applications

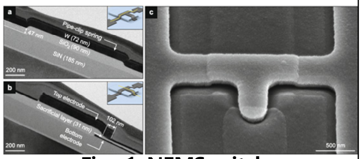

Fig. 1 NEMS witch

■ Commercial-Grade Reliable High-Performance Nano Devices ----------------------------------

Utilizing our advanced large-area, high-resolution nano-fabrication techniques, we uncover groundbreaking phenomena, leading to the creation of high-performance gas(chemical) sensors, pressure, strain and temperature (physical) sensors, as well as bolometer (optical), pivotal for Industry 4.0

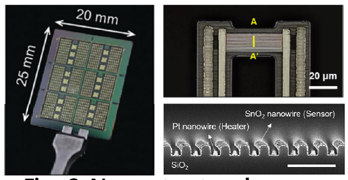

Fig. 2 Nano-structured sensor

■ Soft Electronics for Next-Generation Devices (Health Care, Human-Machine Interaction) ----

Leveraging the advantages of nanostructures, we develop high-performance and highly reliable physical sensors, including pressure, strain and temperature sensors. By integrating circuitry, communication, and AI technologies, we design systems for applications in health monitoring and human-machine interaction.

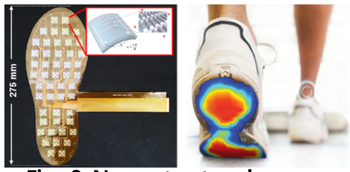

Fig. 3 Nano-structured sensor

■ Recommended courses & Career after graduation

Semiconductor devices, integrated circuit devices, and MEMS in EE perspective are recommended.

So far, 25 PhDs and 47 MS degrees have been conferred. Many of our graduates have pursued careers in global industry leaders such as **Samsung, SAIT, Broadcom, SK Hynix, and LG**. Additionally, some have gone on to conduct postdoctoral research at esteemed institutions like **Northwestern, MIT, Purdue Johns Hopkins, and NIH**, and later secured positions at national research institutes (**KIST, ADD, KIMM, NIH**) and as professors (**Hanyang, Pusan national**).

■ Introduction to other activities besides research

2023 Summer workshop

2023 Homecoming day @ Japan

Quarterly workshop :

- Summer: Pension
- Winter: Ski Resort
- Research Direction sharing

Annual Homecoming Day :

- Last homecoming day @ Japan ski resort

Leisure Activity :

- Enjoy sports regularly (Soccer, Bowling, running)

■ Recent research achievements ('21~'23)

– In total, 110 international journals, 108 international conference, 38 international and 102 domestic patents.

(Journals : Nature Nanotechnology, Nature Communications, Advanced Materials, ACS Nano, Small etc.)

– Awarded for our researches from IEEE, Samsung Electronics, Society of Micro and Nano Systems, and KAIST.

– Professor Jun-Bo Yoon won 2023 KAIST Educator Award (윤준보 교수님 '2023 KAIST 교육자상' 수상).

– Selected as a 'Healthy Laboratory' by the Ministry of Science and ICT in 2021 (2021 건강한 연구실 선정)

<Professor Kayoung Lee's Lab>

Low-dimensional Electron Systems Lab.

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Website	**https://lesl.kaist.ac.kr/**

■ Current state of the Lab. (in 2023 Fall Semester)

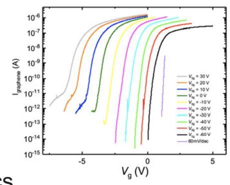
Postdoctoral Fellows : 0 PhD Students: 4 Master's Student: 5

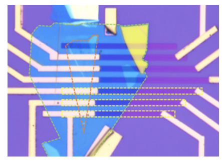
■ Research Areas

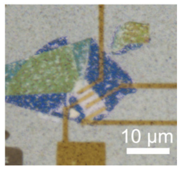
Electrical Characterization of High-mobility Emerging Semiconductors:
- Transport spectroscopy; measurements of band structure information
- Electron transport and quantum phenomena in semiconductor nanostructures

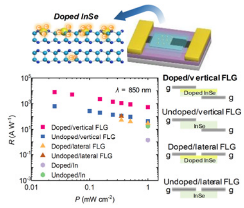
Nanostructure Electronic/Optoelectronic Device Applications:
- High mobility transistors, steep-slope transistors, low-power tunneling electronics, multi-valued logics, electronic sensors, contact property optimization etc.

Vertical Electron Transport in Heterostructures Based on van der Waals Materials:
- Dynamic modulation of band alignment and tunneling properties
- Ballistic transport along the vertical direction in van der Waals materials
- Band modulation by Morie-induced superlattices









■ Recommended courses & Career after graduation

- Introduction to Physical Electronics, Semiconductor Devices, Semiconductor Nanostructures, Semiconductor IC Technology
- Academia: National research institutes and universities
- Industry: Semiconductor-related companies such as Samsung, SK Hynix, LG, LX Semicon, Intel, Apple, Micron, etc.

■ Introduction to other activities besides research

There are few group activities, however individual freedom and hobbies are respected. In addition, there is a good relationship between the members of the laboratory and the atmosphere in the laboratory is friendly.

■ Introduction to the Lab.

We perform vigorous research for highly functional electronics enabled by physical uniqueness in low-dimensional electron systems! Our major research goals are (1) to understand fundamental electronic properties of emerging low-dimensional materials and their novel heterostructures, and (2) to realize unprecedented high-performance nanoscale device applications based on such basic study. Using advanced transport measurement techniques, we explore how electrons transport and interact each other in nanostructured electron systems, and aim to broaden our fundamental understanding of emerging materials and physics. Our biggest motivation is curiosity, but we also have the ambition to bring unprecedented future computing with high speed and low power nanoelectronics!

■ Recent research achievements (2020-2023)

- Hanbyeol Jang, Yumin Song, Yongwook Seok, Heungsoon Im, Tae Hyung Kim, Joo-Hyoung Lee, Yong-Hoon Kim, and Kayoung Lee*, "Zero power infrared sensing in 2D/3D-assembled heterogeneous graphene/In/InSe/Au," *Nanoscale* (**2022**).
- Sang-Hoo Cho, Hanbyeol Jang, Heungsoon Im, Donghyeon Lee, Je-Ho Lee, Kenji Watanabe, Takashi Taniguchi, Maeng-Je Seong, Byoung Hun Lee, and Kayoung Lee*, "Bias-controlled multi-functional transport properties of InSe/BP van der Waals heterostructures," *Scientific Reports* (**2021**).
- Sanghyun Kim, Donghyeon Lee, Binbin Wang, Shangjie Yu, Kenji Watanabe, Takashi Taniguchi, Jonathan A. Fan, Jiamin Xue, and Kayoung Lee*, "Raman spectroscopic study of artificially twisted and non-twisted trilayer graphene," *Applied Physics Letters* (**2021**).
- Hanbyeol Jang, Yongwook Seok, YiTaek Choi, Sang-Hoo Cho, Kenji Watanabe, Takashi Taniguchi, and Kayoung Lee*, "High performance near-infrared photodetectors based on surface-doped InSe," *Advanced Functional Materials* (**2021**).
  ** Highlighted in Hot Topic: Surfaces and Interfaces*
- YiTaek Choi, Yongwook Seok, Hanbyeol Jang, Arvind Kumar, Kenji Watanabe, Takashi Taniguchi, Xuan Gao, and Kayoung Lee*, "Multiterminal transport measurements of multilayer InSe encapsulated by hBN," *ACS Applied Electronic Materials* (**2021**)
- Sang-Soo Chee, Won-June Lee, Yong-Ryun Jo, Min Kyung Cho, DongWon Chun, Hionsuck Baik, Bong-Joong Kim, Myung-Han Yoon*, Kayoung Lee*, and Moon-Ho Ham*, "Atomic vacancy control and elemental substitution in a monolayer molybdenum disulfide for high performance optoelectronic device arrays," *Advanced Functional Materials* (**2020**).
  ** Highlighted on the cover*
- Sang-Soo Chee, Joo-Hyoung Lee*, Kayoung Lee*, and Moon-Ho Ham*, "Defect-assisted contact property enhancement in a molybdenum disulfide monolayer," *ACS Applied Materials and Interfaces* (**2020**).

<Professor Jung-Yong Lee's Lab.>

Advanced devices for Energy Conversion Lab (ADEC)

■ **Contact information**

Professor : jungyong.lee@kaist.ac.kr TEL : 010-9341-1834

Lab. : lmh063@kiast.ac.kr TEL : 010-3086-2804

Website : http://adec.dsso.kr

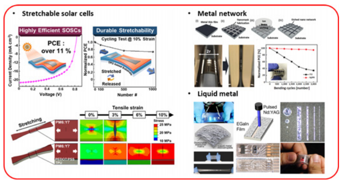
■ **Current state of the Lab. (in 2023 Fall Semester)**

Postdoctoral Fellows : 4 PhD Students: 10 Master's Student: 8

■ **Research Areas**

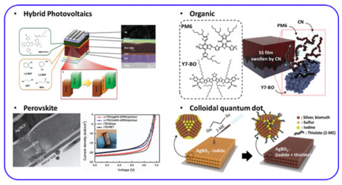
1. Stretchable optoelectronic devices

For realizing wearable devices, outstanding performance in stretchable optoelectronic devices is required. We investigate novel stretchable and transparent electrodes including silver nanonetwork, InGa-based liquid metal and hybrid electrodes. Furthermore, we perform the structural engineering for efficient stretchable optoelectronic devices.



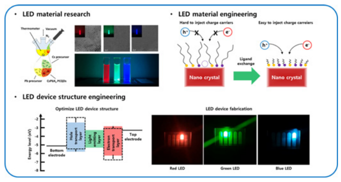
2. Highly efficient emerging optoelectronic devices

Although emerging optoelectronic materials including organic molecules, quantum dots and perovskite are beneficial to optoelectronic devices including solar cell, LED and photodetector, more efforts are required for commercialization. We study structural engineering for achieving high performance of the emerging optoelectronics devices.



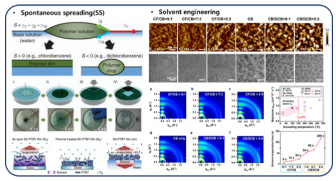
3. Next-generation light-emitting diodes and displays

Electronic devices are essential equipment for people today and provide a lot of useful information for their lives. An efficient way to convey tons of information from electronic devices is through displays. Therefore, for a clearer and more efficient display, advanced light-emitting diodes are needed. In our group, we research on synthesis and modification of materials, and optimization of device structures for advanced next-generation LEDs.



4. Novel device fabrication techniques

We develop novel thin film device fabrication techniques such as spontaneous spreading (SS), water floating, and solvent engineering. These methodologies open up new routes to new types of devices and scientific origins for efficient device performance.



■ **Recommended courses & Career after graduation**

Recommended courses : Introduction to Physical Electronics (EE211), Introduction to Organic Electronics (EE568), Solid State Physics (EE661), Advanced Electromagnetic Theory I (PH507)

Career after graduation : Professors, postdoctoral researcher, researchers of national research labs, company (SAMSUNG, LG electronics)

■ **Introduction to other activities besides research**

Exercise activity : Football, Basketball, Badmintonm, Weight training

Group teamwork : Team meating (once every two weeks), dining together (more than twice a year)

■ **Introduction to the Lab.**

Advanced devices for energy conversion (ADEC) lab has been studying on the emerging optoelectronic devices since 2010. We will support your researches whatever your interests are and help you to set up an experimental environments. Also, we are happy to discuss research issues and other problems. If possible, we can create synergistic effect on our results as we collaborate together.

■ **Recent research achievements ('21~'23)**

[1] S. Han et al., "Stretchable Electrodes Based on Over-Layered Liquid Metal Networks," Advanced Materials. 35, 2210112, (2023)

Journal articles (Total: 21) : 2021(6), 2022(6), 2023(10)

<Professor Hyunjoo. J. Lee's Lab.>

Brain/Bio Medical Microsystems Lab

■ **Contact information**

Professor : hyunjoo.lee@kaist.ac.kr TEL : 7436

Lab. : Electronics Building (E3-2) TEL : 7536

Website : https://bmm.kaist.ac.kr

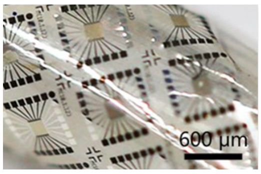
■ **Current state of the Lab. (in 2023 Fall Semester)**

Postdoctoral Fellows : 0 PhD Students: 13 Master's Student: 5

■ **Research Areas**

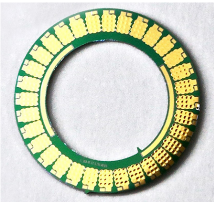
Our lab aims to develop novel systems for biomedical applications such as early detection of disease, therapeutics, and investigation of underlying mechanism of brain diseases. In specific, we focus on 1) developing Neural interface 2) developing Capacitive micromachined ultrasound transducer (CMUTs) for ultrasound neuromodulation, and 3) brain stimulation for neural circuits

Neural Interface



In order to provide chronic applications that offer long-term stability and precise measurements, flexible materials, such as those based on various polymers, are increasingly being integrated into the fabrication of microtechnologies. Multi-electrode arrays, also known as microelectrode arrays (MEAs), are one such field where flexible substrates are becoming critical components.

Ultrasound Neuromodulation



Capacitive micromachined ultrasound transducers (CMUTs) utilize traditional silicon-based microfabrication technologies to achieve highly configurable designs in a miniaturized package compatible with integrated circuits. A thin silicon membrane acts as the diaphragm for each micro-cell and a AC/DC voltage is applied across the vacuum cavity to deliver ultrasound pulses. Compared to conventional ultrasound transducers, CMUTs present numerous advantages such as easy fabrication of large arrays, large bandwidth, high sensitivity, and integration with various circuitry. In addition, CMUT arrays with various geometries and dimensions have been widely applied for biomedical ultrasound applications

Brain stimulation for neural circuits

We are exploring low intensity focused ultrasound as a new stimulation modality for treatment of brain/neurological diseases. A method currently used to treat degenerative brain diseases such as Parkinson's disease is to directly apply electrical, chemical, or light to the brain. Among them, ultrasound stimulation offers competitive advantages such as non-invasiveness, higher spatial resolution, and larger penetration depth. We are developing miniaturized flexible ultrasound transducers for small animal experiments as well as for clinical applications.

■ **Recommended courses & Career after graduation**

Recommended courses include fabrication, nano/bio electronics, and MEMS. Careers in semiconductor and medical industries as well as academia are possible.

■ **Introduction to other activities besides research**

Spring walk, Strawberry party, National teacher's day, Graduation party, and other many extra activities to accommodate friendship.

■ **Introduction to the Lab.**

Due to the interdisciplinary research field, our lab consists of a diverse group of students from different backgrounds such as electrical engineering, materials science, and chemistry.

■ **Recent research achievements ('21~'23)**

1. S. Kim†, Y. Jo†, G. H. Im, C. Lee, C. Oh, G. K, S.-G. Kim*, and H. J. Lee* (2023). Miniaturized MR-Compatible Ultrasound System for Real-Time Monitoring of Acoustic Effects in Mice using High-Resolution MRI. NeuroImage, 276.
2. Y. Kim†, E. Jang†, Y. Lee, C. Oh, K. Kim, G. Kook, M. K. Kim, M.-O. Lee, and H. J. Lee* (2023). Miniature Transparent Dopamine Sensor based on Nanosphere Lithography. Advanced Materials Technologies, 2300006.
3. G. Kook, Y. Jo, C. Oh, X. Liang, J. Kim, S.-M. Lee, S. Kim, J.-W. Choi, and H. J. Lee* (2023). Multifocal Skull-Compensated Transcranial Focused Ultrasound System for Neuromodulation Applications based on Acoustic Holography. Microsystems & Nanoengineering, 9 (45).
4. H. Chae, Y. Park, Y. Jo, Y. Jeon, H. J. Lee, S. Yoo, and K. C. Choi* (2023). Blue Transparent OLEDs with High Stability and Transmittance for Modulating Sleep Disorders. Advanced Materials Interfaces, 2202443.
5. Y. Jo, S-M. Lee, T. Jung, G. Park, C. Lee, G.H. Im, S. Lee, J.S. Park, C. Oh, G. K, H. Kim, S. Kim, B.C. Lee, G.S.B. Suh, S-G. Kim, J. Kim*, H.J. Lee* (2022). General-Purpose Ultrasound Neuromodulation System for Chronic, Closed-loop Preclinical Studies in Freely Behaving Rodents. Advanced Science, 9 (34).
6. M. K. Kim†, J. C. Leong†, Y. Jo†, G. Kook, and H. J. Lee* (2022). Multimodal Neural Probes with Small Form Factor based on Dual-Side Fabrication. Advanced Materials Technologies, 8 (2), 2200692.

⟨Professor Sanghun Jeon's Lab.⟩

■ Contact information

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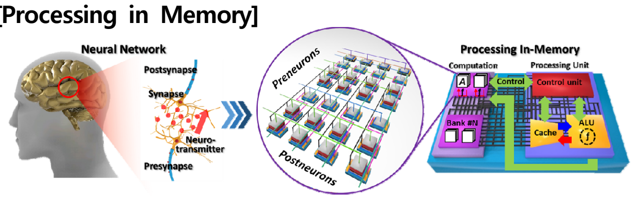
Lab.	**Email: mutual_lee@kaist.ac.kr**	**Tel: 010-3566-2497**
Website	**https://antonis.kaist.ac.kr**	

■ Current state of the Lab. (in 2023 Fall Semester)

PhD Students: 9 Master's Student: 11

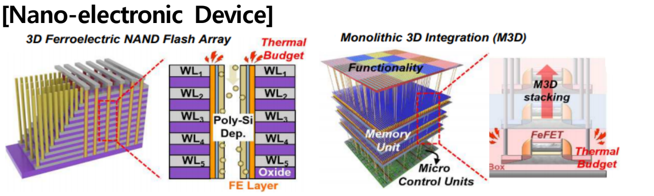
■ Research Areas

[Processing in Memory]



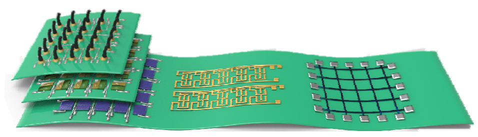
Processing in memory is a next-generation computing architecture beyond the conventional von Neumann computing architecture, and FeFET has been widely studied as a promising computational memory device based on their fast operation speed, high reliability and C-MOS compatibility. Antonis lab is actively conducting various research to develop an optimal FeFET for performing multiply and accumulation (MAC) operations, which is the most primary calculations in machine learning. In detail, we are introducing key approaches covering material and device architecture to overcome current technological issues. Moreover, using various computing logic, we are demonstrating the FeFET-PIM array with a high energy efficiency, which is evaluated by the system-level simulation.

[Nano-electronic Device]



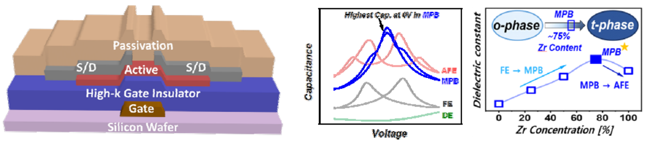
Recently, in the semiconductor industry, device structures that enable vertical stacking of transistor layers are considered as promising solution of device scaling-down limitations. In particular, 3D NAND Flash memory is the most representative memory application, as of now, aiming for 1000 layers of stacking. As the vertical dimension of the NAND flash is increaseing, the following increased burden on circuit design and channel resistance become the major hurdle. Antonis LAB is actively conducting various researches using the ferroelectric material replacing the conventional charge trap layer, or combining the existing charge trapping mechanism with the ferroelectric switching for next generation high-performance 3D NAND flash memory application.

[Bio-inspired E-skin for artificial nerve system with M3D]



We are currently working on a ferroelectric Hf-Zr-O (HZO) based artificial nerve system. Ferroelectric is well-known material with an interesting behavior that can retain its electrical dipole characteristics even after removing the external field. Also, all ferroelectric material has pyroelectric and piezoelectric properties that respond to heat and pressure respectively. In comparison with lead-zirconium-titanium-oxide (PZT) which is widely used conventional ferroelectric material, HZO has no lead component and was able to use at nm scale. We hope that the approaches in our laboratory can be widely adopted in various industrial fields such as electronic skin for humanoid robots, health-care monitoring systems, and advanced prosthetic devices.

[High-k gate insulator for oxide TFT for display]



In recent years, high-performance TFT for high speed operation has been required to realize large-area, and high-resolution displays. In this regard, high-k gate insulator with relatively high thickness (~100 nm) is required for display backplane. But there are some bottleneck for realized formation of thick, high-k dielectrics with ALD process, which is long time process, and limitation of dielectric constants below ε_r~35. Therefore, a new approach is required for the formation of thick, high-k dielectrics. In our lab, we are conducting research on improving leakage current and on current (I_{ON}) by using HfO2-based ferroelectric as the gate insulator of oxide TFTs. In addition, research on integrateing FeTFT devices is being conducted with various TFT characteristics measurements.

■ Recommended courses & Career after graduation

◇ Recommended courses : Introduction to Physical Electronics,Semiconductor Devices, Semiconductor IC Technology
◇ Career : Semiconductor Industries and Institutes (Samsung, SK hynix, Qualcomm, NVIDIA, ETRI, etc.)

■ Introduction to other activities besides research

◇ Great Work Place (GWP) event : Wine seminar, LAB field trips
◇ Regular group meal
◇ Coffee time with LAB members
◇ Cultural activities : Bowling, laser tag, book club

■ Introduction to the Lab.

Our lab focuses on the research and development of functional oxide electronics ranging from materials, process and devices for nano-electronics, intelligent semiconductor, IOT sensor and display applications. Our research in materials science aspect is mainly focused on ferroelectrics and oxide semiconductor. Based on this, we are currently developing various semiconductor devices such as DRAM, NAND Flash and X-point memory. Also with this, we are also exploring futuristic semiconductor device including processing-in-memory, logic-in-memory and neuromorphic device to turn them into reality.

■ Recent research achievements (2022-2023)

[1] Kim, Giuk, et al. "Design Guidelines of Thermally Stable Hafnia Ferroelectrics for the Fabrication of 3D Memory Devices." IEDM, 2022.

[2] Hwang, Junghyeon, et al. "Ultra-high Tunneling Electroresistance Ratio & Endurance in Oxide Semiconductor-Hafnia Self-rectifying Ferroelectric Tunnel Junction." VLSI, 2023.

<Professor Jae-Woong Jeong's Lab.>

Bio-Integrated Electronics and Systems Laboratory

■ **Contact information**

Professor : Nanofab center (E19), Room 516

Lab. : Nanofab center (E19), Room 522

Website : http://jeongresearch.org

■ **Current state of the Lab. (in 2023 Fall Semester)**

Postdoctoral Fellows : 0 PhD Students: 8 Master's Student: 7

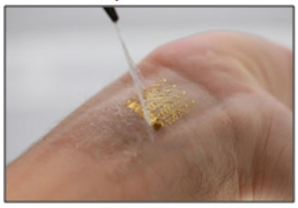
■ **Research Areas**

Our mission is to invent the future generation "soft" bioelectronics and biomedical systems for advancing healthcare and biomedical research. Research areas in our group include design and fabrication of flexible/stretchable electronics, photonic microsystems, and microfluidic devices for various applications such as health/wellness monitoring, disease diagnosis and therapy, human-machine interfaces, and neuroscience.

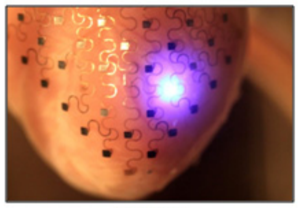
"Wearable" Skin-like Electronics

Conventional biomedical devices mounted on our body are rigid, bulky, and its mechanical properties do not match with the property of the human tissue. Based on flexible/stretchable electronics technologies, our group develops soft, flexible, and stretchable devices with diagnostic and therapeutic capabilities, which can be conformally wrapped on curvilinear-shaped skin. We are broadly interested in stretchy bio-integrated electronics that integrate multiple modalities (e.g. electronics, photonics, and microfluidics)

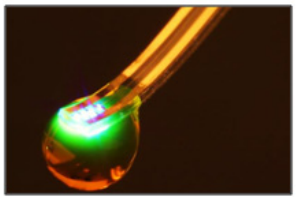
Epidermal



Cardiac



Neural



"Implantable" Soft Electronics

Implantable devices have been drawing significant attentions in biomedical research for continuous monitoring of force, pressure, temperature, and electrophysiological signals inside living subjects. Implantable electronic systems must be small in size, compatible with biological tissue, and sturdy enough to withstand the physical forces within the body. Our research focus is to develop soft, stretchable sensors and actuators that enable high spatiotemporal resolution recording and control; and that conform to the micro-geometry of 3-D tissue without creating damaging local stresses. Our particular interests are in implantable cardiac devices and wireless multifunctional neural probes for the brain.

■ **Recommended courses & Career after graduation**

Recommended courses: MEMS, micro/nanofabrication, circuit design, embedded systems, etc.

Potential career path:

Industry: Electronics, Semiconductor, Medical, etc.

Academia: Univ. Professors, Researchers at National Labs

■ **Introduction to other activities besides research**

We hold annual group party and workshop. In addition, we attend various international conferences including Transducers, MEMS, EMBC, MRS, BMES, etc.

■ **Introduction to the Lab.**

Our group works on multidisciplinary research, crossing the areas of EE, ME, BME, materials, and physics. We are actively collaborating with Washington Univ. School of Medicine, Georgia Tech, Yonsei University Medical School, etc.

■ **Recent research achievements ('21~'23)**

- ***Nature Communications, Advanced Materials*** (2021). ***Nature Biomedical Engineering, Nature Communications, Advanced Materials*** (2022). ***Nature Protocols, Nature Communications, Science Advances*** (2023).

[1] "Soft subdermal implant capable of wireless battery charging and programmable controls for applications in optogenetics." ***Nat Commun*** 12, 535 (2021).

[2] "Scalable and modular wireless-network infrastructure for large-scale behavioural neuroscience." ***Nat. Biomed. Eng*** 6, 771–786 (2022).

[3] "Rapid meniscus-guided printing of stable semi-solid-state liquid metal microgranular-particle for soft electronics" ***Nat Commun*** 13, 2643 (2022).

[4] "Customizable, wireless and implantable neural probe design and fabrication via 3D printing" ***Nat Protoc*** 12, 219-237 (2023).

<Professor Byung Jin Cho's Lab.>

NAND
Nanoelectronic And Neuromorphic Device Lab

■ **Contact information**

Professor : Cho, Byung Jin TEL : 042-350-3485

Lab. : pyk0808@kaist.ac.kr TEL : 042-350-5485

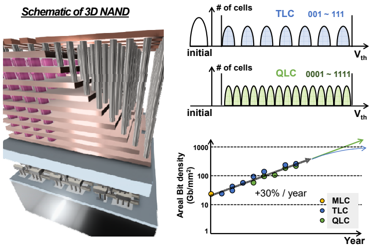
Website : https://nand.kaist.ac.kr/

■ **Current state of the Lab. (in 2023 Fall Semester)**

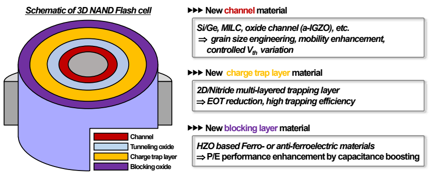
Postdoctoral Fellows : 0 PhD Students: 6 Master's Student: 9

■ **Research Areas**

3D NAND Flash

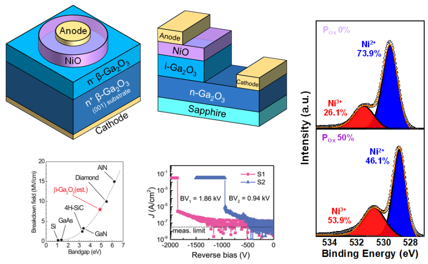


The rapid evolution of high-tech industry, including artificial intelligence, big data, autonomous driving, and cloud computing, is anticipated to drive a consistent demand for memory semiconductors, especially for **3D NAND technology**.



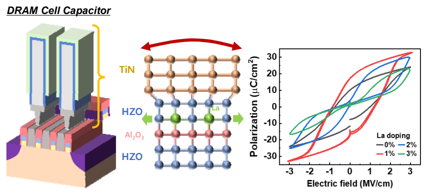
To maintain a leading position in the ever-competitive arena of 3D NAND technology, our laboratory actively has been researching for the next-generation **charge trap flash (CTF) technology**. This research area includes high-mobility channel materials, low-k interlayer dielectric (ILD), novel charge trap layer (CTL), new blocking layer and innovative cell structure.

Oxide semiconductor based device (Thyristor, Photodetectors)

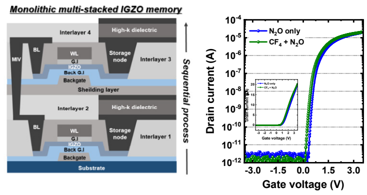


As Si-based devices has been facing various limitations, oxide semiconductors which can change the game of the semiconductor industry are emerging. Nickel oxide and Gallium oxide, which are type of oxide semiconductors featuring wide bandgap (WBG) characteristics, are getting attention as advanced channel materials for power devices, specifically **thyristor,** due to their capability of withstanding ultra-high voltage/current. In addition, oxide semiconductors can be used as optical devices (**photodetectors**) for detecting UV light with excellent photo-responsivity. Our laboratory are actively working on fabricating and developing power devices (thyristors) and photodetectors based on NiO, Ga_2O_3.

DRAM



Performance improvement of **DRAM cell capacitor** with conventional materials has reached its limit and people are seeking for new materials with high-k value and better leakage characteristic. Our research group is studying various methods to achieve the better performances utilizing ALD-$Hf_xZr_{1-x}O_2$ dielectrics for superior DRAM cell capacitor.



At the same time, to lead the low-power and high density 3D DRAM, we are researching the possibility of **Monolithic multi stacked 3D DRAM** with oxide semiconductor (e.g. IGZO) for the new channel material.

■ **Recommended courses & Career after graduation**

Our lab strongly recommends freshmen to take following courses: [EE211] Introduction to Physical Electronics, [EE362] Semiconductor Devices, [EE463] Semiconductor IC Technology, and so on. After graduation, graduates start their careers in domestic or foreign semiconductor companies (Samsung Electronics, SK Hynix, Lam Research, etc), research institutes, universities, and so on.

■ **Introduction to other activities besides research**

As COVID-19 calms down, outdoor sports (soccer and basketball) are held once a week to improve physical strength. Also, we are harmonizing the lab by holding a regular activities (spring picnic or winter MT) every year.

■ **Introduction to the Lab.**

Our lab has world-class experience and various know-hows on traditional memory devices **(NAND and DRAM)** and advanced semiconductor devices **(Monolithic 3D and Oxide semiconductor based devices)**. Currently we are running 8 main projects funded by Samsung, SK hynix, and government agencies. Our research group published **293 journals** and presented in **354 conferences**. Professor thoroughly guides our research with his deep understanding on CMOS technology. Our lab has open and friendly atmosphere that students make interactive discussion about their research.

■ **Recent research achievements ('21~'23)**

Major International Conference (one IEDM 2021, one VLSI 2023)

24 SCI papers, 16 conference presentations, 12 patents

〈Professor Kyung Cheol Choi〉

Advanced Display and Nano Convergence Laboratory	■ Contact information		
	Professor	Email: kyungcc@kaist.ac.k	Tel: 042-350-3482
	Lab.	Device Innovation Facility (E3-3)	Tel: 042-350-5482
	Website	http://adnc.kaist.ac.kr	

■ Current state of the Lab. (in 2023 Fall Semester)

Postdoctoral Fellows : 2 PhD Students: 13 Master's Student: 7

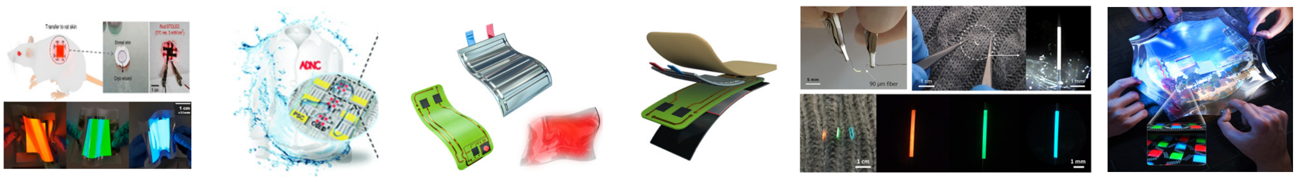
■ Research Areas

▶ **Transparent and Flexible display** – Fundamental researches on encapsulation, electrodes, and out-coupling enhancement methods applicable to transparent and flexible OLED displays.

▶ **Wearable and Stretchable display** – Various researches on display devices fabricated on textiles, such as fabric and fiber, used for truly wearable (wearing) and stretchable OLEDs are going on in the ADNC lab. Wearing textile displays are clothing-like wearable devices that can be used for fashion displays, IoT devices, and photo-therapeutic patches. Stretchable displays are beyond the curved and foldable displays and a strong candidate for future displays.

▶ **Bio and Medical applications (Photo-therapeutic by using display devices)** - Research on photo-therapeutic and cell & animal experiments (in-vitro & in-vivo) by using display devices used for medical tools, health-care is going on

▶ **Nanotechnology and nano-covergence** – New innovative technologies such as active metaphotonic color-imaging devices, oxide TFTs are also going on in ADNC Lab.



■ Recommended courses & Career after graduation

The lecture titled 'Display engineering' is recommended. A total of 54 people (as Ph.D. 35, M.S. 19) graduated from ADNC Lab. are working in university, corporations, and national institutes as professors and research engineers.

■ Introduction to other activities besides research

ADNC lab emphasizes team-work through various sports activities such as footsal, basketball, hiking and etc.

■ Introduction to the Lab.

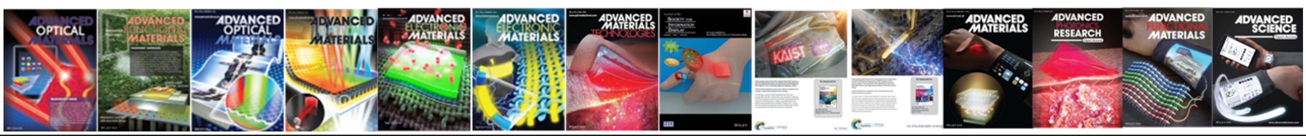
The ADNC lab conducts research on future technology of display devices. Until now, we have published 204 SCI papers, delivered 236 presentations in conferences, and filed 119 patents. ADNC lab had led the Center for Advanced Flexible Display Convergence (CAFDC), an 'Advanced Research Center Program' of the National Research Foundation of Korea (NRF) from 2007 to 2016. Since 2017, Our lab has been in charge of the important part in "Attachable Photo Therapeutics Center for e-Healthcare", a new Engineering Research Center (ERC) of NRF, which is funded until 2024. Professor Kyung Cheol Choi has been in charge of the LG Display-KAIST cooperation center from 2010 until now, and our laboratory hence has many opportunities for industry-academia cooperation with LG Display. From previous research on the world's most efficient PDP to current research on textile-based washable optoelectronic modules, we have reported numerous excellent results and have attracted attention from worldwide industries and various media. Students interested in future technologies should take note of our lab.

■ Recent research achievements (2021-2023)

21 SCI papers, 32 presentations in conference, 24 patents applied for or registered.

[Representative Journal papers]

- **[Front Cover]** Highly Air-stable, Flexible, and Water-resistive 2D Titanium Carbide MXene-based RGB Organic Light Emitting Diode Displays for Transparent Free-form Electronics (ACS nano IF: 18.027, 2023)
- **[Frontispiece]** Wearable Photomedicine for Neonatal Jaundice Treatment using Blue Organic Light-Emitting Diodes (OLEDs): Toward Textile-based Wearable Phototherapeutics (*Advanced Science* IF: 17.52, 2022)
- **[Inside Front Cover]** High-Performance and Reliable White Organic Light-Emitting Fibers for Truly Wearable Textile Displays (*Advanced Science* IF: 17.52, 2022)
- **[Front Cover]** Bright-Multicolor, Highly Efficient, and Addressable Phosphorescent Organic Light-Emitting Fibers: Toward W□earable Textile Information Displays, (*Advanced Functional Materials* IF: 19.98, 2021)



⟨Professor Sung-Yool Choi's Lab.⟩

QMDL
QUANTUM MATERIALS & DEVICES LAB

■ Contact information

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Website	qmdl.kaist.ac.kr	

■ Current state of the Lab. (in 2023 Fall Semester)

Research Professor: 1 Postdoctoral Fellows : 0 PhD Students: 7 Master's Student: 12

■ Research Areas

▸ Synthesis of 2D Material and Process Development

- Our lab possesses various skills for the synthesis of metallic graphene, semiconducting TMDs (transition metal dichalcogenides) such as MoS_2, and insulating hexagonal boron nitride
- Besides conventional CVD processes, novel synthetic approaches such as MOCVD (metal organic chemical vapor deposition), and ALD (atomic layer deposition) have been studied to overcome the existing process limitations.
- Development of novel 2D material process techniques such as doping, defect healing and transfer
- Additionally, various materials synthesis and engineering methods using IPL (intense pulsed light) are being developed.

▸ 2D Materials Applications

- Research on applications based on materials growth, processes, and device fabrications of 2D materials
- Graphene based electrodes for transparent electrodes and doping techniques for luminance efficiency improvement using atomically thin and high electron mobility of graphene
- Utilization of 2D semiconducting materials for TFT array channels in backplane for displays
- Development of low-power integrated circuits based on 2D materials
- Optical devices using various bandgap 2D materials for sensor applications

▸ Neuromorphic and Memristor Devices

- Study of novel memristor devices for memory and logic applications
- Research on next generation computing enabling in-memory-computing
- Development of memristor-based synaptic devices for neuromorphic computing
- Materials and structural engineering to improve the performance of memristors as artificial synapses
- With various memristors, device-to-system simulation performed for artificial neural network

■ Recommended courses & Career after graduation

We encourage you to take following courses.

- Introduction to Physical Electronics (EE211)
- Semiconductor Devices (EE362)
- Semiconductor IC Technology (EE463)

QMDL alumni are studying abroad, working for a research institute or semiconductor companies such as Samsung Electronics and SK Hynix.

■ Introduction of other activities besides research

We take a coffee break after lunch in a daily routine, and play team sports such as futsal and basketball once in a week. Also, once a semester, we invited alumni to introduce their research and conduct workshops. Besides, a lot of chances are provided to attend domestic and international conferences. As annual events, we have a strawberry party in April and year-end party in December.

■ Introduction of the Lab.

Quantum Materials and Devices Lab (QMDL) is focusing on the molecular-scale materials and devices for the next-generation IT-ET-BT convergence technology, spanning the electronics and photonics applications. Our vision of research is "**creative researches to change the world**". All research members can choose creative research topics based on the above-mentioned topics considering students' opinions. Freedom of time management is guaranteed for self-regulating and creative researches. Especially, **QMDL is mainly supervising GRC (Graphene/2D Materials Research Center), CAMD³ (Center for Advanced Materials Discovery towards 3D Display), and KAIST-Hansol Center for Advanced Materials and Devices.** Individual member can have opportunities to perform in-depth study by cooperating with other members to achieve outstanding performance.

KAIST GRC 그래핀/2D소재 연구센터
GRC (Since 2012)

KAIST CAMD³ 디스플레이 미래소재 연구센터
CAMD³ (Since 2016)

KAIST-Hansol Center (Since 2022)

■ Recent research achievements ('20~'23)

2D Material Synthesis & Process Development

1. Adv. Mater. Interfaces. 10, 2300135 (2023)
2. ACS Appl. Nano. Mater. 6, 8981 (2023)
3. ACS Appl. Mater. Interfaces. 14, 43907 (2022)
4. Chem 8, 1014 (2022) [Front Cover]
5. ACS Appl. Mater. Interfaces 13, 50497 (2021)
6. Adv. Mater. 1907166 (2020)
7. Adv. Sci. 7, 1903318 (2020) [Inside Back Cover]

Electronic & Optoelectronic Devices based on 2D Materials

1. Small. Online Published (2023)
2. ACS Photonics. Online Published (2023)
3. ACS Nano. 17, 9262 (2023)
4. Adv. Electron. Mater. 8, 2101325 (2022)
5. Adv. Mater. Technol. 2100494 (2021)
6. Adv. Mater. Interfaces. 8, 2100599 (2021)
7. Nano Res. 14, 1305 (2021)
8. Adv. Mat. 32, 1907166 (2020)

Neuromorphic and Memristor Devices

1. Small. 19, 2300223 (2023)
2. Mater. Horiz. 10, 2035-2046 (2023)
3. Adv. Mat. 35, 2300023 (2023) [Inside Front Cover]
4. Adv. Intell. Syst. 4, 2200177 (2022)
5. Adv. Intell. Syst. 4, 2200018 (2022) [Front Cover]
6. Sci. Adv. 7(32), eabg8836 (2021)
7. Nanoscale 12, 14301 (2020) [Inside Front Cover]

<Professor Shinhyun Choi's Lab.>

ENTIS (Emerging Nano Technology and Integrated Systems) Lab.

ENTIS

■ Contact information

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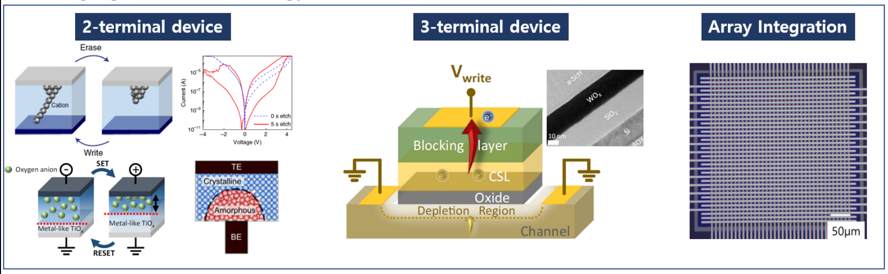
■ Current state of the Lab. (in 2023 Fall Semester)

Postdoctoral Fellows : 0 PhD Students: 7 Master's Student: 8

■ Research Areas

<Emerging Nano Technology Device>

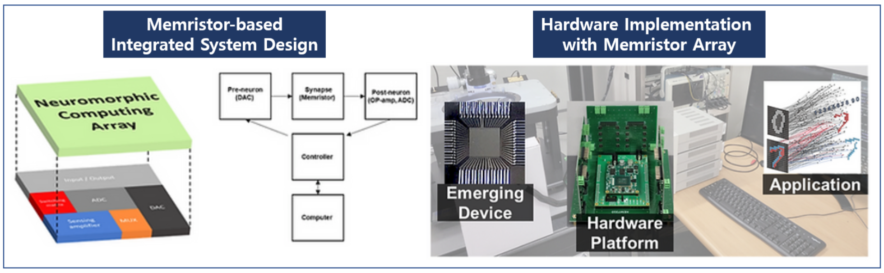


Research team designs, fabricates and evaluates emerging nanoelectronic devices such as

1) **2-terminal devices (RRAM, PCRAM, etc)**
2) **3-terminal field-effect transistor (FET)**
3) **Array Integration of emerging device.**

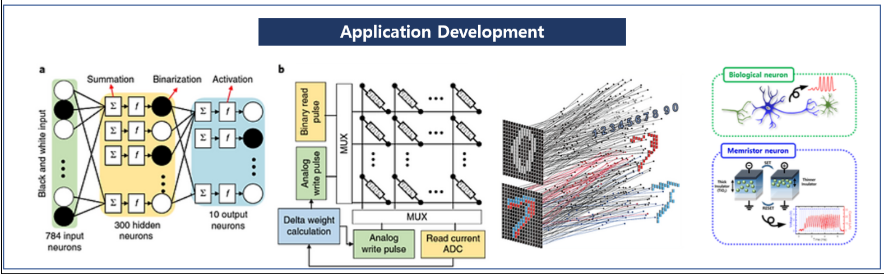
Our devices have garnered attention as possible candidates for various applications, such as neuromorphic computing, new memory technologies and logic devices.

<Integrated Systems Development>



By utilizing emerging device-based computing systems, **our team is working on demonstration of fully integrated systems from artificial neurons to artificial synapses.** Furthermore, we are also working on emerging device-based hardware such as digital/analog peripheral circuits controllers and software development for AI.

<Application Development>



Our team is focusing on **how to accurately implement AI inference and learning with low energy consumption using emerging devices.** Another focus of our team is how to use applications that can be efficient by utilizing our devices about images, sequence data, security, medical diagnosis and etc.

■ Recommended courses & Career after graduation

Major pre-requisites are Semiconductor device physics, Fabrication, and Neural networks. Other students majoring CS and circuit are also welcome. The students can become key members of academia and industry globally.

■ Introduction to other activities besides research

The lab holds annual group parties and joint-workshops for perspective collaboration. We also attend international conferences including MRS, IEDM, Memrisys etc. We also plan to have regular outdoor activities, such as soccer, basketball, hiking and so on (not mandatory).

■ Introduction to the Lab.

The group works on multi-disciplinary research areas including material sciences, device physics, circuits and neural network algorithms. Therefore, our group is able to give students a chance to participate in various fields besides device area. We will have lots of collaboration from Universities and Industries.

■ Recent research achievements ('21~'23)

S. Seo*, B. Kim*, D. Kim*, S. Park*, T. R. Kim, J. Park, H. Jeong, S. Park, T. Park, H. Shin, M. Kim, Y. Choi, and S. Choi, The gate injection-based field-effect synapse transistor with linear conductance update for online training, ***Nature Communications,*** 13, 6431 (2022)

S. Park*, H. Jeong*, J. Park*, J. Bae, and S. Choi, Experimental demonstration of highly reliable dynamic memristor for artificial neuron and neuromorphic computing, ***Nature Communications,*** 13, 2888 (2022).

S. Choi*, S. Park*, S. Seo, and S. Choi, Reliable multilevel memristive neuromorphic devices based on amorphous matrix via quasi-1D filament confinement and buffer layer, ***Science Advances,*** 8, 3 (2022)

J. Park, Y. Lee, H. Jeong, and S. Choi, Neural Network Physically Unclonable Function: A Trainable Physically Unclonable Function System with Unassailability against Deep Learning Attacks Using Memristor Array, ***Advanced Intelligent Systems,*** 3 (11) , 210011 (2021)

〈Professor Yang-Kyu Choi 〉

Nano-Oriented Bio-Electronics Lab	■ Contact information		
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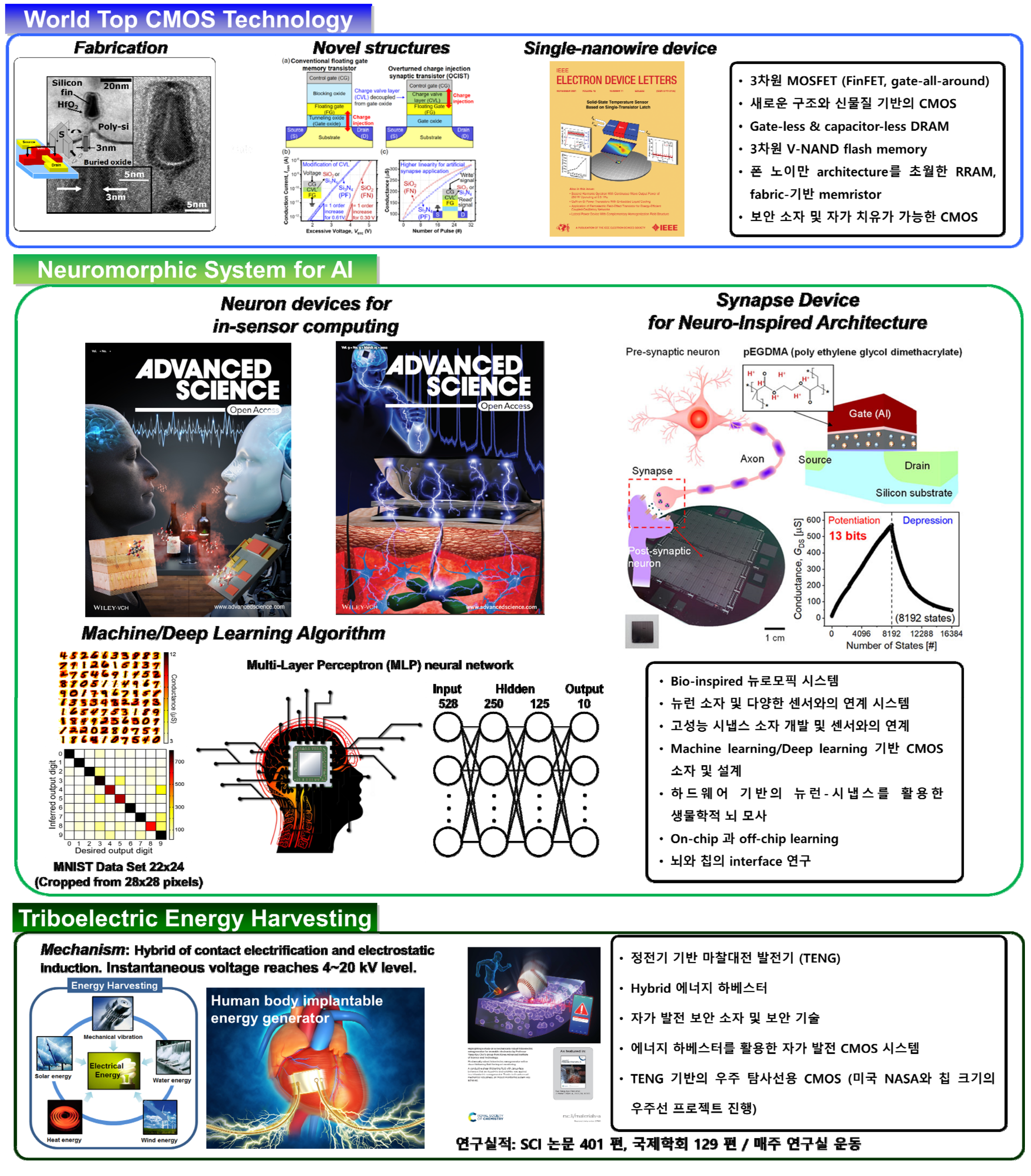
	Website	https://sites.google.com/view/nobelab/home	

■ **Current state of the Lab. (in 2023 Fall Semester)** - PhD Students: 9 Master's Student: 9



■ **Recommended courses & Career after graduation**

NASA (3), SK Hynix (14), Samsung electronics (29), Professor (11), KIST (1), Intel (2), ETC.

■ **Introduction to the Lab.** Our laboratory have friendly atmosphere with high-quality research facilities and know-hows. Students have various research field, and we try to think more creatively with deep, enthusiastic discussions.

■ **Recent research achievements (2021-2023)**

Four cover images, 60 SCI papers including high-impact journals (Science advances, etc.)

Our research were frequently highlighted in YTN Science, KBS, Etc.