Low-dimensional Electron Systems Lab.

■ Contact information

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■ Current state of the Lab. (in 2025 Spring Semester)

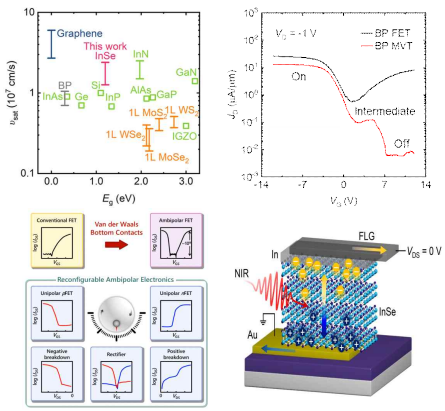
Postdoctoral Fellows : 0 PhD Students: 6 Master's Student: 7

■ 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

While not many group activities, individual freedom and hobbies are respected. Furthermore, the laboratory members have a positive relationship, fostering a friendly atmosphere.

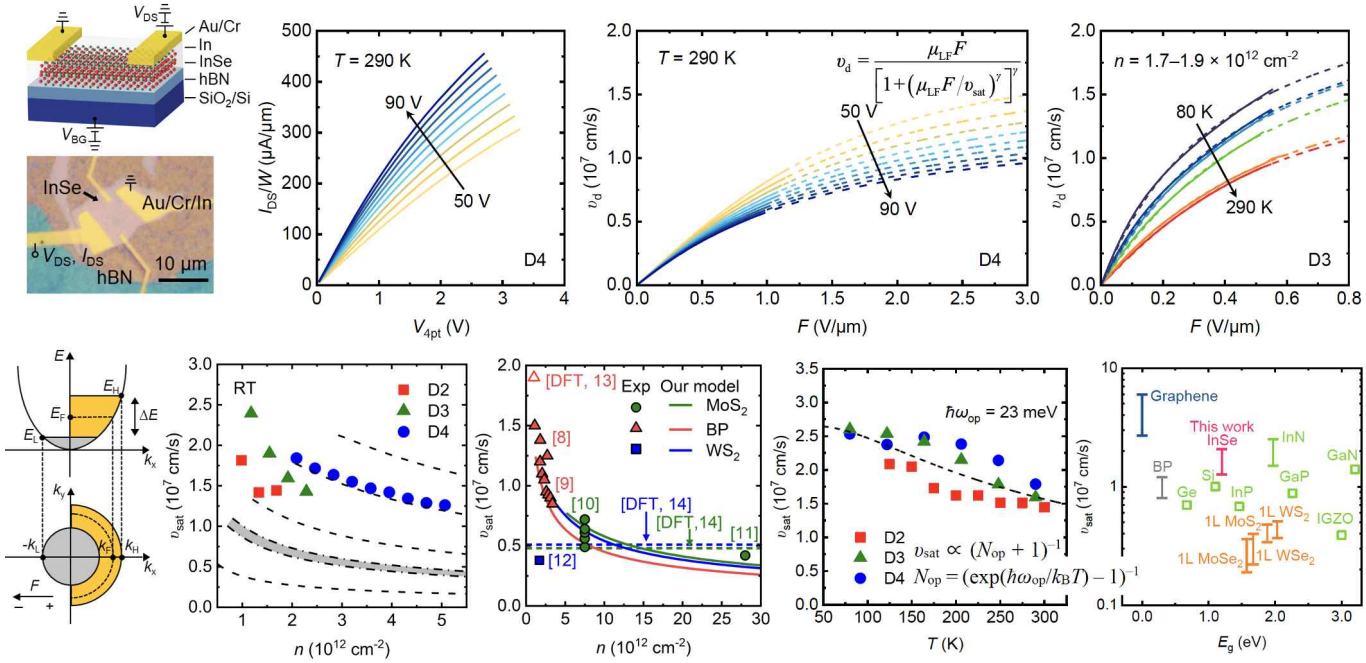
■ Introduction to the Lab.

CMOS scaling is now running into the nanoscale regime, where quantum nature of electrons comes in. While the limits of silicon are being reached, data in electronic devices keep exponentially expanding. This requires further scaling, lowering power, and improving speed, which are exciting challenges to both academia and industry. Nanoscale materials and their heterostructures are therefore experiencing a burst of activities lately, producing diverse scientific and technological breakthroughs including interesting quantum phenomena. We perform vigorous research in electron transport in nanostructured 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 move 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 novel high speed and low power nanoelectronics.

■ Selected Publications

- Dongju Yeom, Yeonghyeon Ko, Youngkyu Ko, Heungsoon Im, Jungi Song, Yongwook Seok, Hanbyeol Jang, Jaeha Hwang, Seokhun Jin, Kenji Watanabe, Takashi Taniguchi, and Kayoung Lee*, "Ternary transistors with reconfigurable polarities," *Advanced Functional Materials*, Early View. (**2025**).
- Minsu Kim, Dongju Yeom, Yongwook Seok, Jungi Song, Hanbyeol Jang, YiTaek Choi, Yeonghyeon Ko, Kenji Watanabe, Takashi Taniguchi, and Kayoung Lee*, "Superior p-type switching in InSe nanosheets for complementary multifunctional systems," *Nano Letters* 24, 16090 (**2024**).
  ** Highlighted on the supplementary cover*
  ** Covered by 26 media outlets including ChosunBiz, Herald Business, ETNews, and Donga Science.*
- Yongwook Seok, Hanbyeol Jang, YiTaek Choi, Yeonghyeon Ko, Minje Kim, Heungsoon Im, Kenji Watanabe, Takashi Taniguchi, Jae Hun Seol, Sang-Soo Chee, Junghyo Nah, and Kayoung Lee*, "High-field transport and high saturation velocity in multilayer indium selenide transistors," *ACS Nano* (**2024**).
  ** Highlighted on the cover.*
  ** Covered by 20 media outlets including Yonhap News, Herald Business, Newsis, and ETNews.*
- Jungi Song, Suyeon Lee, Yongwook Seok, Yeonghyeon Ko, Hanbyeol Jang, Kenji Watanabe, Takashi Taniguchi, and Kayoung Lee*, "Drain-induced multifunctional ambipolar electronics based on junctionless MoS2," *ACS Nano* (**2024**).
  ** Covered by 29 media outlets, including ChosunBiz, Yonhap News, Donga Science, and UPI Korea.*

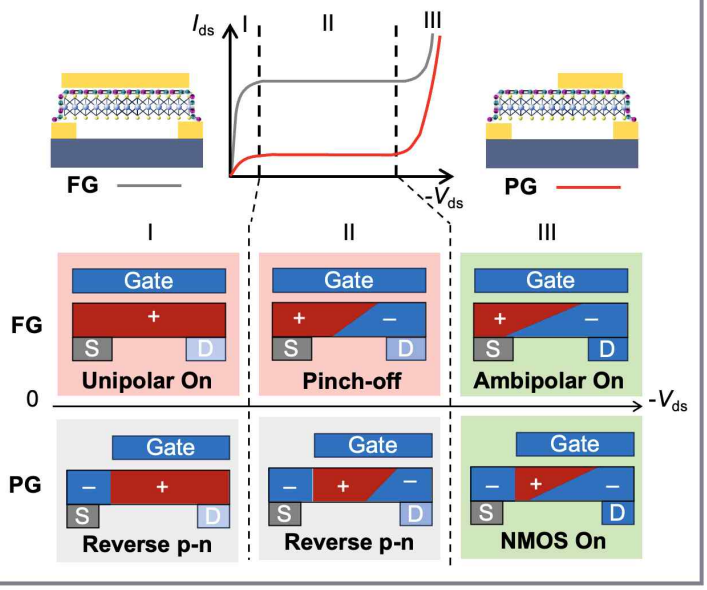
High-field electron transport and high saturation velocity in multilayer indium selenide transistors



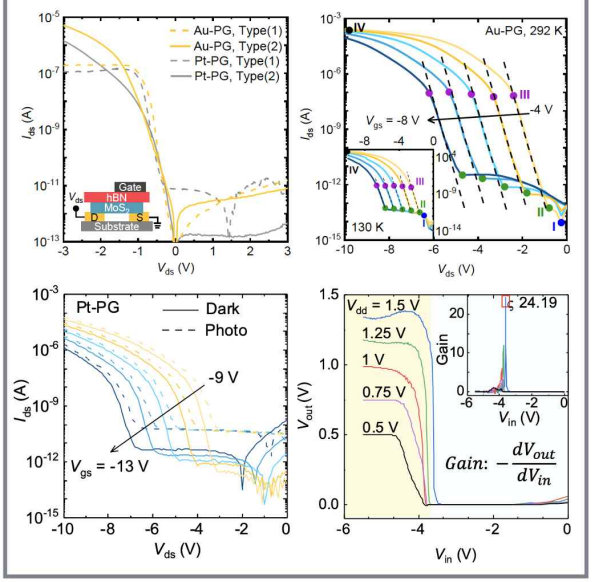
- Our experimentally measured v_{sat} values are overall larger than the estimated v_{sat} values based on optical phonon emission.
- $\hbar\omega_{op}$ of 23 meV results in a remarkable 60 % increase in v_{sat} when T is reduced from 290 to 80 K.
- Critical fields, $F_{critical} = v_{sat}/\mu_{LF}$, is 0.6–1.8 V/μm, which is less than 50% of that of Si.

Drain-induced multifunctional ambipolar electronics based on junctionless MoS_2

Ambipolar MoS_2 transistors with various structure



Multifunctional electronics



- The partially gate-coupled p-n junction
  → reconfigurable multi-functions
  → ambipolar FET, n-type unipolar FET, rectifiers, negative Zener diodes depending on V_{gs} and V_{ds}