ISDI Laboratory

(Innovative Semiconductor Device and Integration)

2021. 4.

아주대학교 전자공학과
허준석

Laboratory Information

허 준 석 (Heo, Junseok)

- 아주대학교 전자공학과 부교수
- (前) Postdoctoral Research Fellow, The University of Michigan
- The University of Michigan 박사, 서울대학교 학사
- 연구우수교수 (2019)
- LG연암재단 해외연구 교수 (2019)
- 삼성장학회 장학생 (2010)

Research area

- 2D/3D 반데르발스 이종 접합 소자 (CMOS BEOL 집적 가능 트랜지스터, 가시광/적외선 광대역 센서)
- (Ultra)wide bandgap (GaN, AlGaN, Ga_2O_3) 소자 (RF/Power HEMT for 5G/6G, 자외선 이미지 센서)
- III-V, 2D 반도체의 Si CMOS 모놀리식 집적 기술

Benefits

- 등록금 100% 보장 (TA 장학, 성적우수장학)
- 매월 인건비 지급
- 국내 및 해외 학회 참석 지원
- 논문 인센티브 지급
- 반도체 공정 장비 교육 및 다양한 자기개발 기회 제공

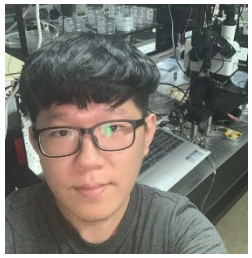
Members

대학원생

박영서

- PhD candidate
- 2D/3D heterojunction photodetectors, III-V optoelectronic devices

황어진

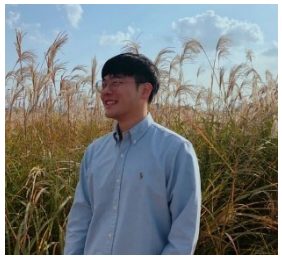


- MS student
- 2D/3D van der Waals heterojunction photodetectors

김다희

- MS student
- Photodetector dynamic characterization, Gas sensors

심영석



- MS student
- III-Nitride UV photodetectors

최우석

- MS student
- III-Nitride HEMT, Germanium transistor

홍성호

- III-N Power transistor

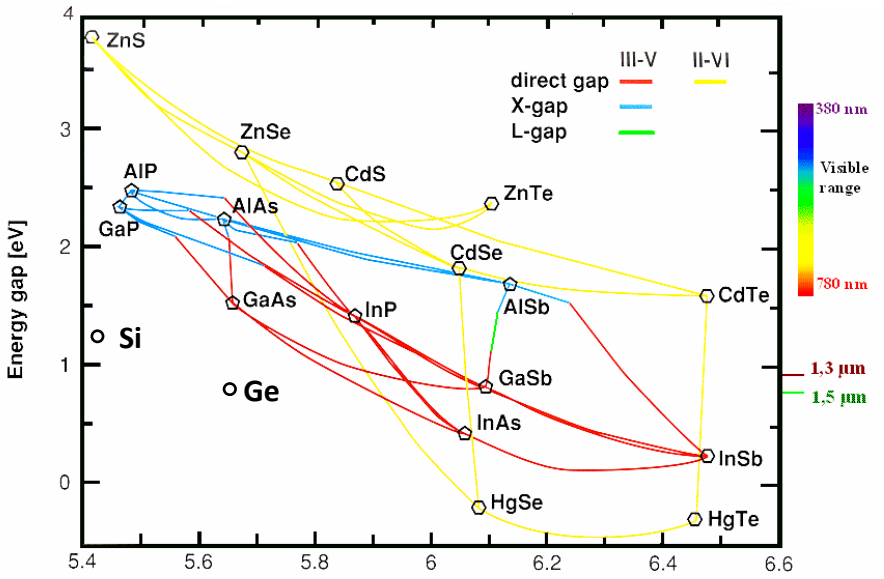
Alumni

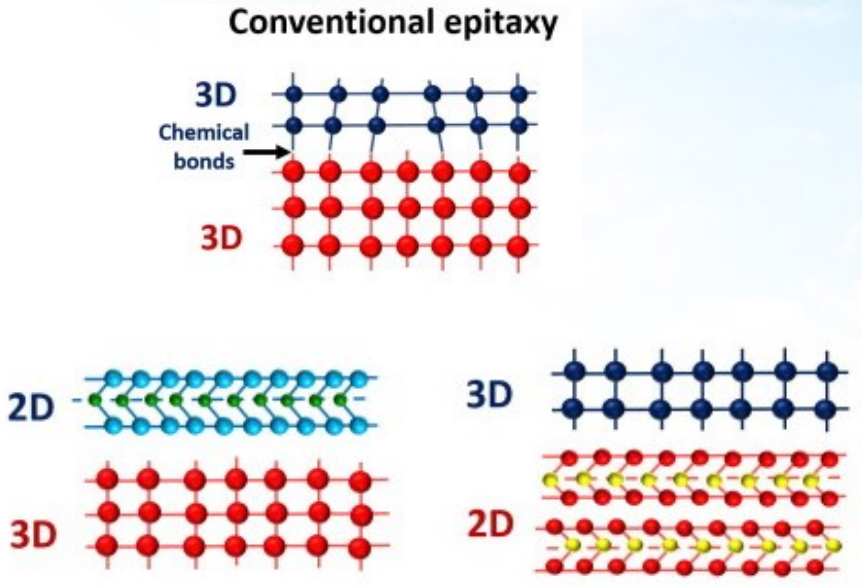
졸업생 현황

- 안정호 (2020년 석사): ㈜제니컴 (병역특례)
- 남성현 (2019년 석사): SK Hynix
- 김도현 (2019년 석사): 스태츠칩팩코리아
- 박진우 (2019년 석사): 원익그룹
- 이상현 (2019년 석사): 삼성전자
- 한승호 (2019년 석사): 삼성전자
- Afroja Akter (2016년 석사): 유학 (The University of Sydney)
- 윤현민 (2016년 석사): FPT software

Research area (I)

2D/3D van der Waals heterojunction devices





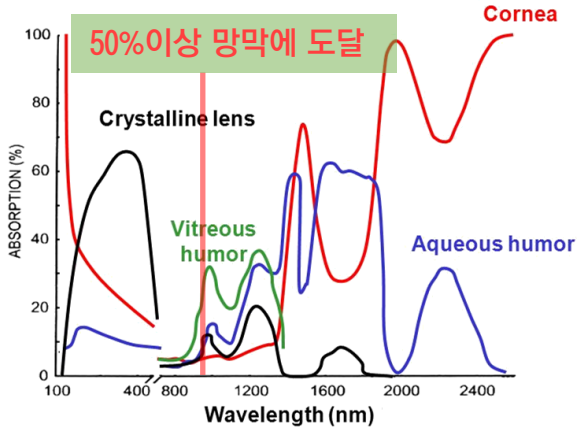
- The choice of materials that can be grown in conventional epitaxy is limited by the lattice constant of the substrate
- The 2D van der Waals (vdW) material relaxes the lattice constant constraint. 2D/3D vdW heterojunction opens up the possibility of various energy band alignment that could not be achieved with conventional epitaxy

Research area (I)

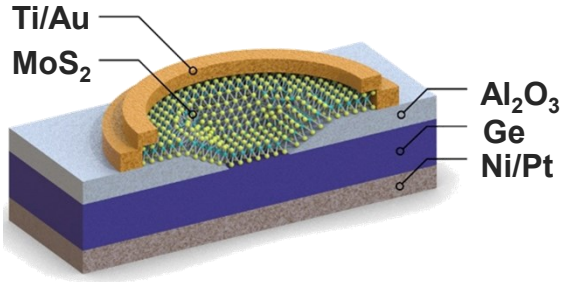
VIS/NIR wideband photodetectors

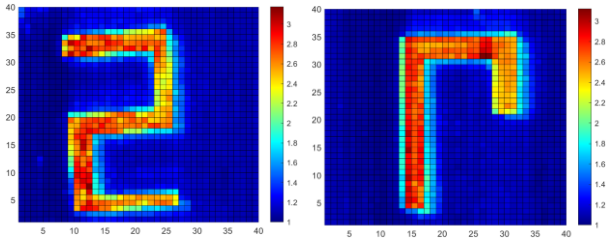
- Face recognition uses a 940 nm VCSEL, limited by the spectral response of the Si image sensor
  For eye safety, an image sensor capable of detecting a 1.55 μm long wavelength is required

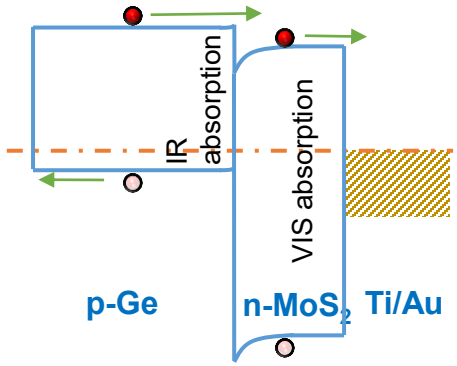
Spectral absorption of the different eye media



- MoS_2/Ge vdW heterojunction enables visible/near infrared wideband photodetection



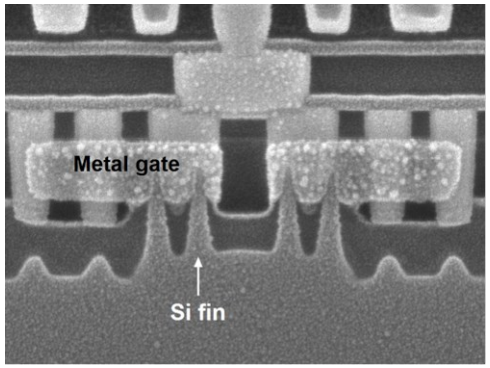




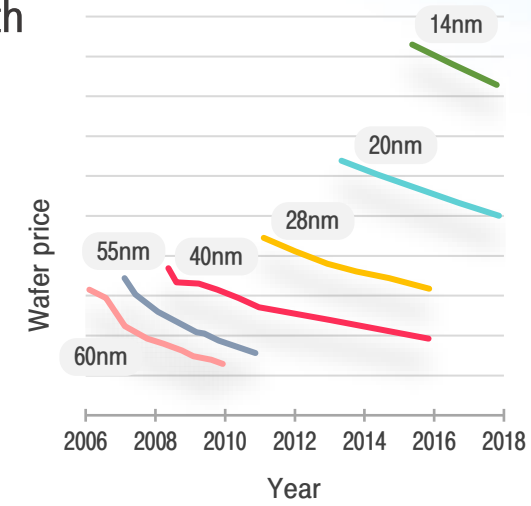
Research area (II)

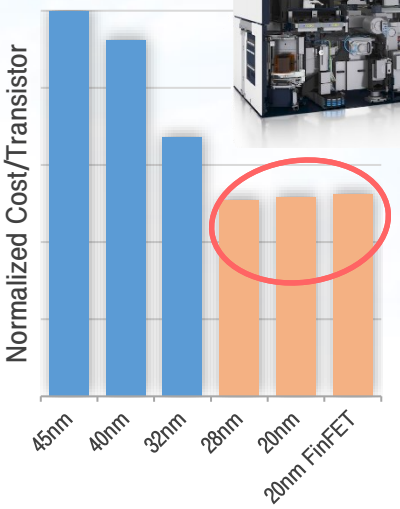
Monolithic 3D integration technology

- Scaling is no longer associated with lower average cost per transistor

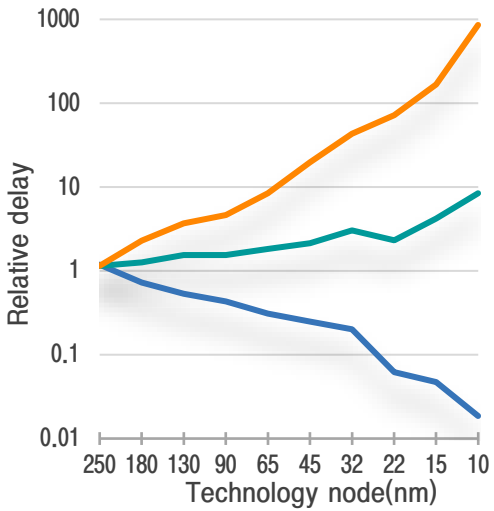


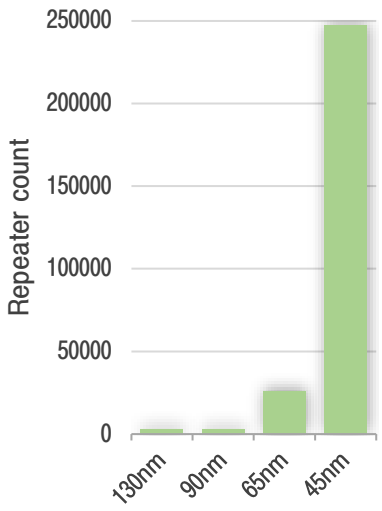
Exynos 7420 finFET (Credit: Samsung)






Credit: ASML

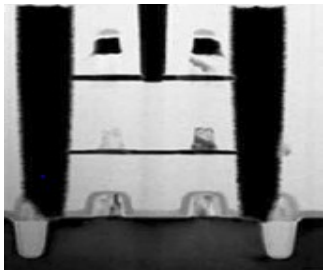




- Increase of wire resistivity and capacitance
  -〉 more buffers and repeaters needed

Previous work

- 3D stacked SRAM
- Epitaxial growth of Si
- IEDM 2009 by Samsung


Credit: Samsung

ISDI LAB Innovative Semiconductor Device and Integration
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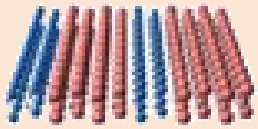
Innovative Semiconductor and Device Integration Laboratory

Research area (II)

Monolithic 3D integration technology

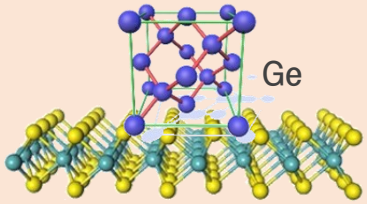
Si BEOL 집적 신재료 채널 CMOS 소자 및 설계 플랫폼 개발

웨이퍼 스케일 고전하이동도 신재료 채널소재 2종 개발



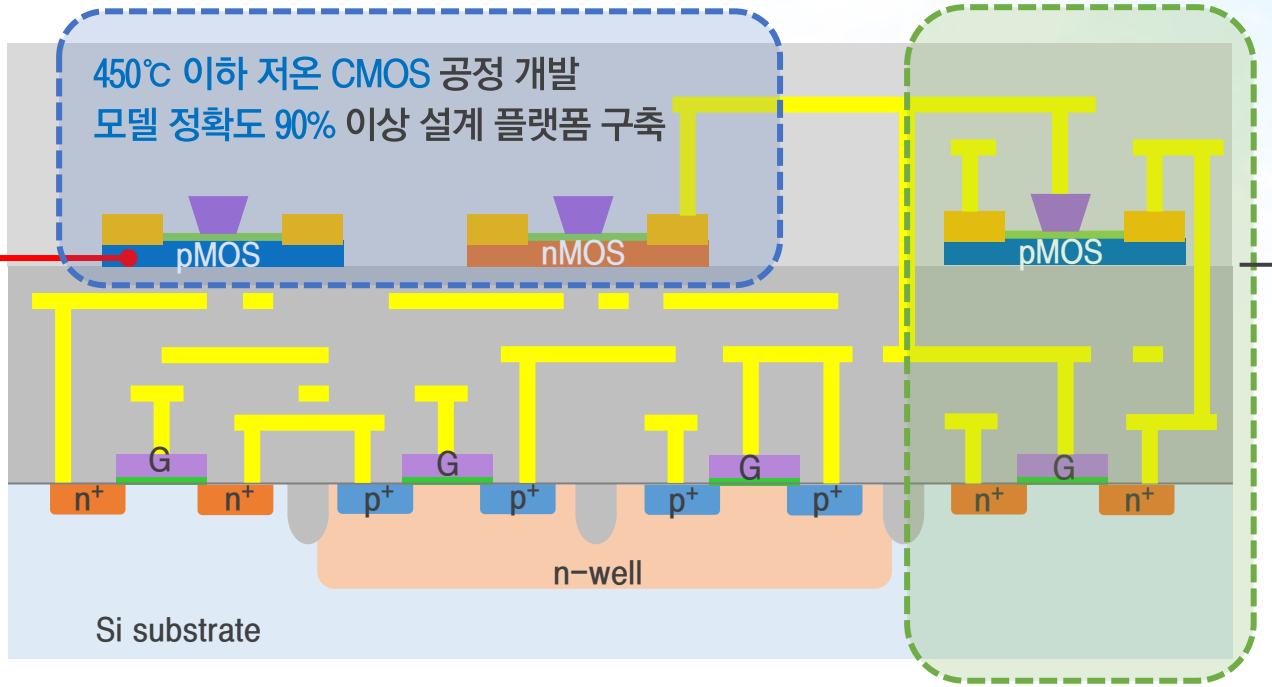
2D Metal Oxy-chalcogenides (Bi_2O_2Se 등)

전자 이동도 500$cm^2/V{\cdot}s$ 이상 목표



2D 소재(MoS_2 등)를 Seed로 하는 결정질 Ge

정공 이동도 400$cm^2/V{\cdot}s$ 이상 목표



Si CMOS/신재료 CMOS 융합 3차원 집적 기술 및 3차원 집적 응용 IP 개발

In-memory computing 응용 SRAM IP, 혼성신호 SoC 응용 Digital LDO IP 설계

2차원 집적 대비 Footprint 30%, 소비전력 30% 감소

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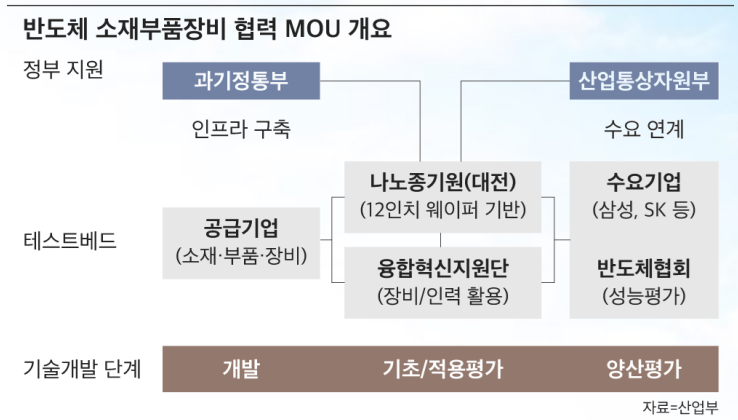
Research area (II)

Monolithic 3D integration technology

차세대지능형반도체사업단
Next-generation Intelligence Semiconductor Foundation

- 2029년까지 10년간 약 1조원 투입
- 전력소모 감소와 고성능 구현을 위한 미래소자 (과기정통부)
- 연산 속도 향상을 위한 설계기술 (과기정통부, 산업부)
- 미세화 한계를 극복하는 원자 단위 공정 장비 기술 (산업부)



1세부: 아주대학교

2차원 소재 시드 활용 고이동도 Ge 채널소재 성장 및 모놀리식 3차원 집적 기술 개발

허준석 교수 (아주대): 1세부 책임자
- 2D 소재 시드(Seed) Ge 채널 소재 개발
- 저온 (≤450℃) Ge CMOS 공정

(연세대)
- 제1 원리 계산 기반 원자 수준 시뮬레이션

(아주대)
- 신재료/Si CMOS 융합 설계 플랫폼 구축
- 모놀리식 3차원 집적 응용 IP 개발

총괄책임자: 허준석 교수

사업기간:
2020. 7. ~ 2023. 2.
총연구비: 약 29.7억

2세부: KAIST

2차원 metal chalcogenides 기반 초고이동도 소자 및 모노리식 3차원 집적

(KAIST): 2세부 책임자
- 2D Metal chalcogenides 채널 소재 개발

(UNIST)
- 채널 소재 및 계면에 대한 원자 단위 구조 및 조성 분석

(KAIST)
- 2D Metal chalcogenides CMOS 공정

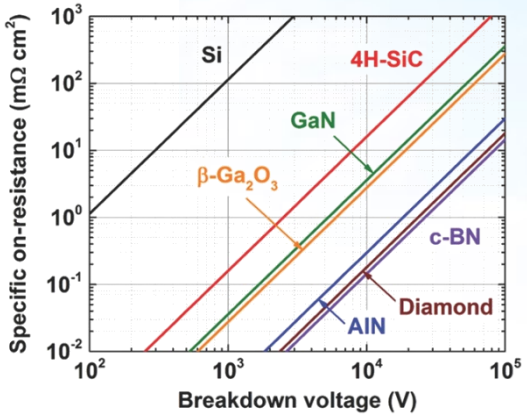
Research area (III)

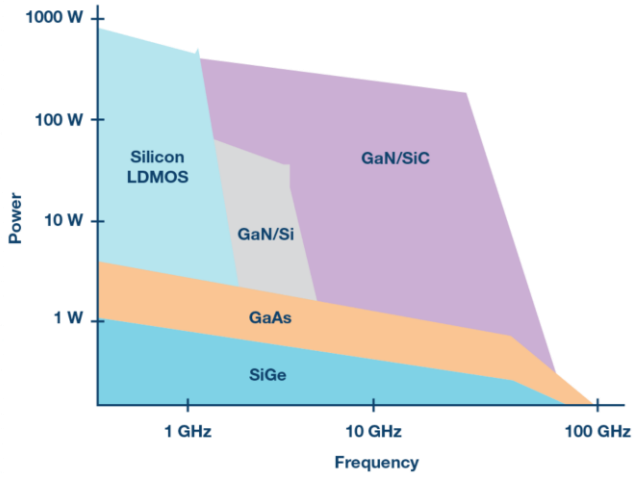
- (Ultra)wide bandgap devices

2018-2024 emerging materials' target markets

(Source: Emerging Semiconductor Substrates: Market & Technology Trends 2019 report, Yole Développement, 2019)

LD	LED	µLED	RF	Power
• Automotive lighting	• Water, air disinfection, purification by UV LEDs	• Displays • Display systems for VR/AR and MR	• 5G for cell phone industry • Solid state radar for military applications	• Electric/Hybrid electric vehicles • Renewable energies (wind, PV) • T&D • Rail
Bulk GaN	Bulk GaN, AlN, AlN Template, Ga_2O_3	Engineered substrates, GaN template	Diamond, Bulk GaN, Engineered substrates, AlN Template	AlN, Ga_2O_3, Diamond, Bulk GaN

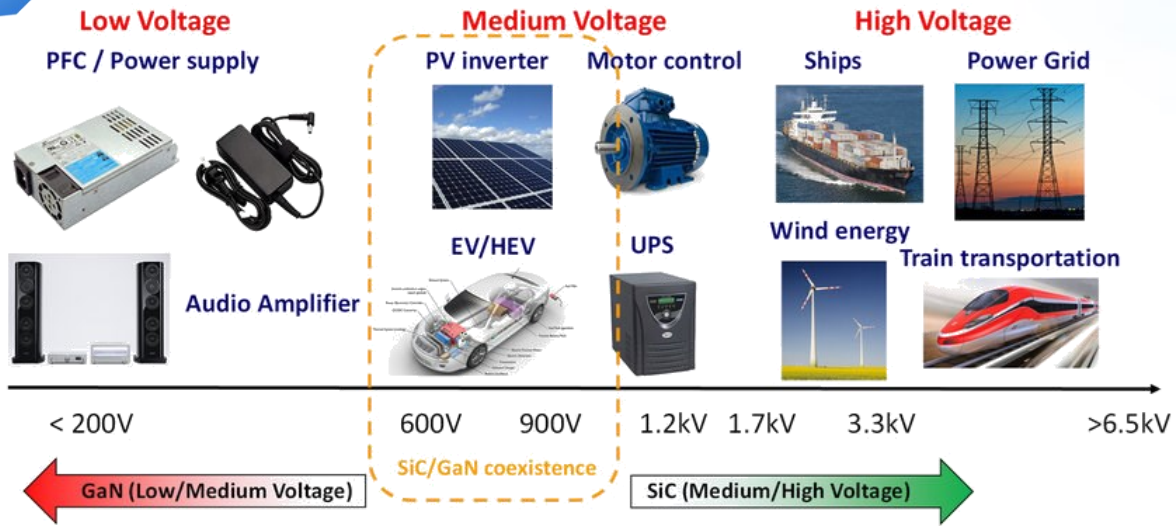




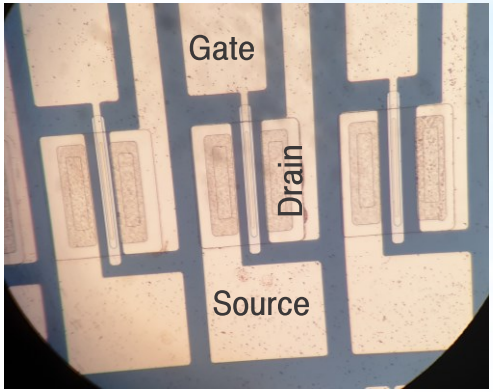
J. Y. Tsao, et al., Ultrawide-Bandgap Semiconductors: Research Opportunities and Challenges, Adv. Electron. Mater. 4, 1600501 (2018)

Research area (III)

(Ultra)wide bandgap devices



- AlGaN/GaN HEMT in ISDI Lab

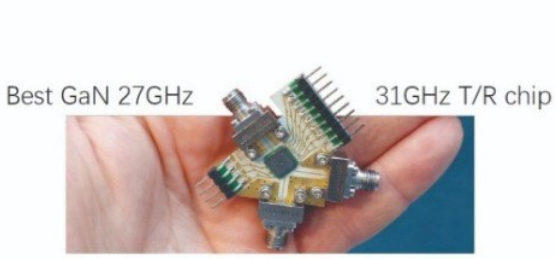


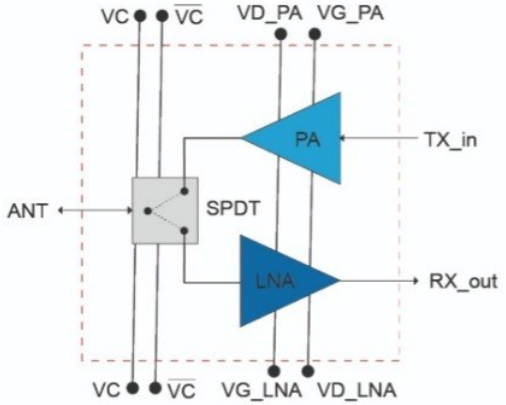
F. Roccaforte, et al., An Overview of Normally-Off GaN-Based High Electron Mobility Transistors, Materials 12, 1599 (2019)

- USB-C PD

https://www.belkin.com/in/p/P-WCH003/

- Fully integrated millimeter-wave 5G 26-34 GHz transmitter/receiver



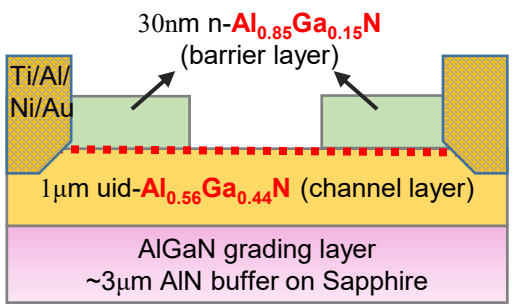


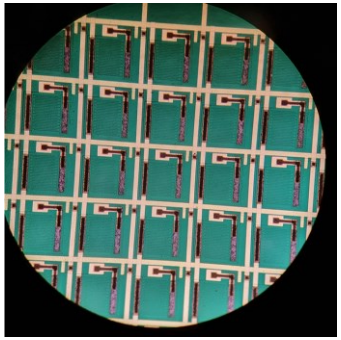
https://compoundsemiconductor.net/article/110303/Optimising_GaN_Heterostructures_For_5G/feature

Research area (III)

(Ultra)wide bandgap devices

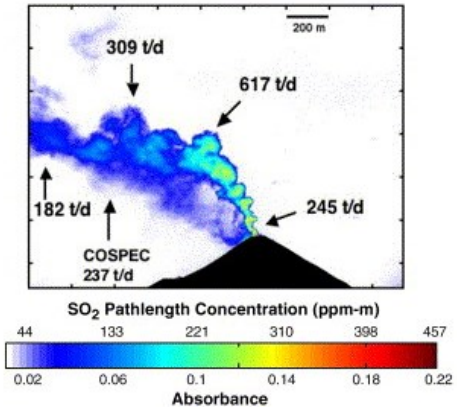
- MSM UVC Photodetectors





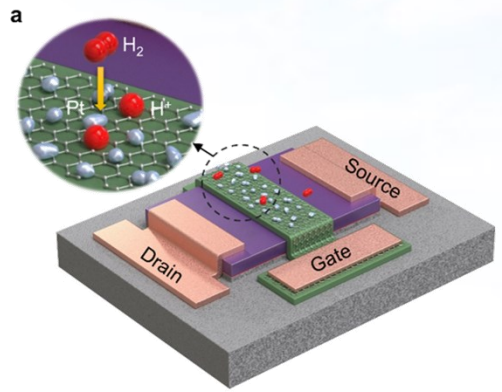
- Direct imaging possible with DUV, X-ray, and γ-ray
- Imaging at high temperature

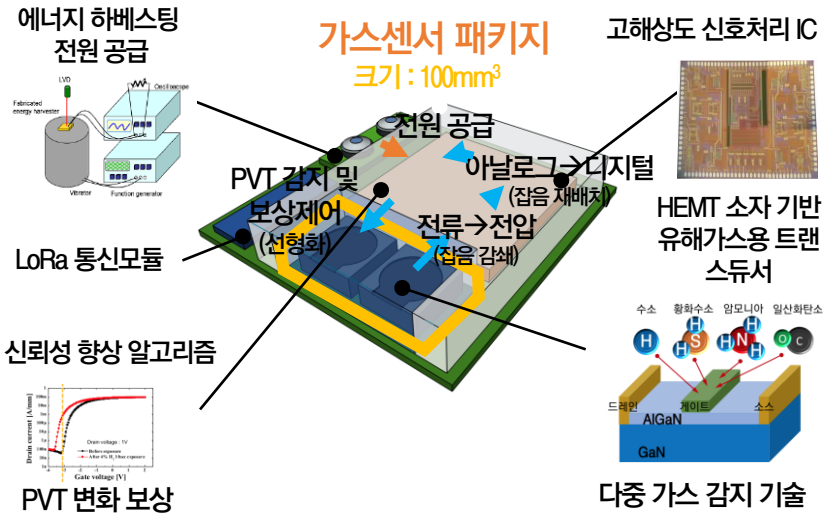
- Monitoring air pollutants, SO_2



- Monitoring power loss

- Hydrogen sensors





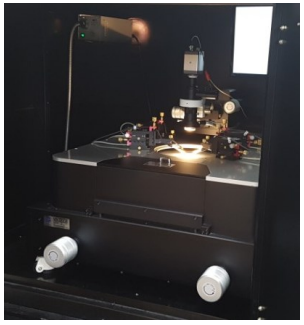
Journal of Volcanology and Geothermal Research, **161**, 47–56 (2007)

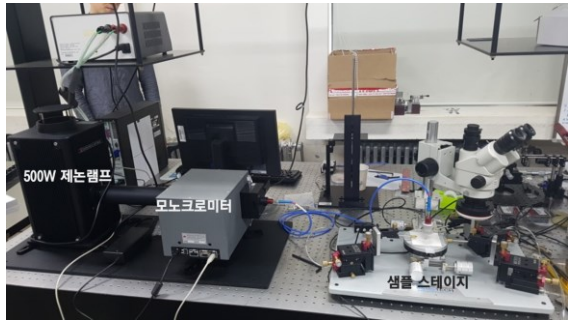
Facilities

Cleanroom for processing

- Photolithography tools (mask aligner, spinner, hot plate, oven), Etcher (Si etcher, O2 asher, ICP-RIE), Metallization (E-beam evaporator, Sputter), PECVD (SiOx, SiNx, a-Si), ALD

Characterization





- Probe station, Photoluminescence, Spectral photoresponse measurement, Cryostat (Optical/Electrical), Gas sensing chamber

UHV-CVD

- Germanium epitaxy

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