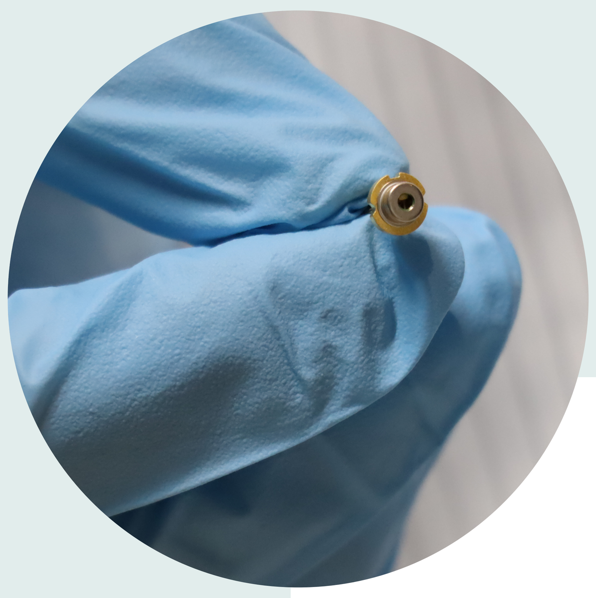
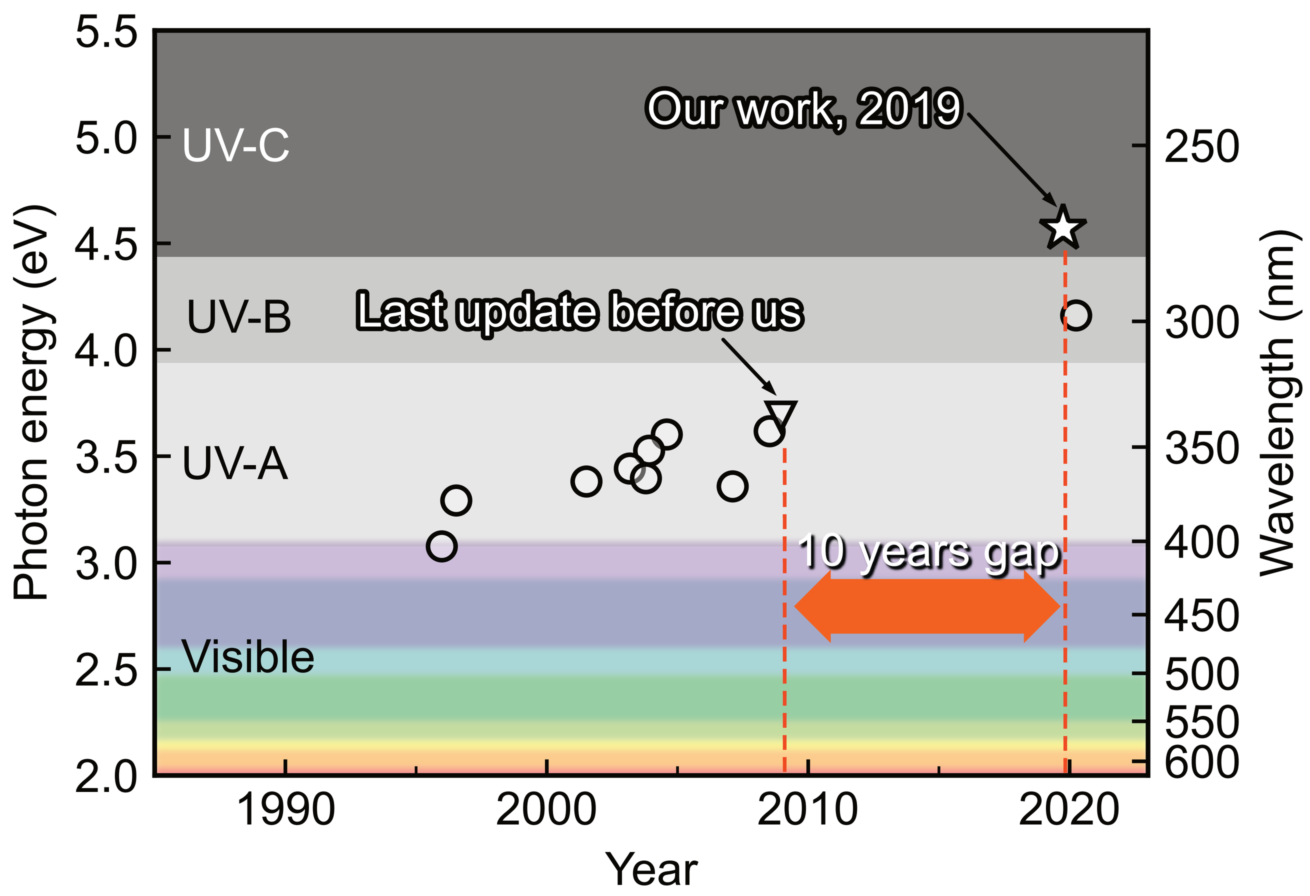
Development of a compact deep-ultraviolet laser source for precision microstructure measurement



Deep-ultraviolet laser diode (DUV LD)

A compact, energy-saving laser light source emitting wavelength less than 300 nm → **Next-generation light source for applications such as sensing, sterilization and microfabrication etc.**

Toward realization of DUV LD



[History of UV LDs] Since the first demonstration of blue-violet LDs in late1990s, a great deal of efforts have been made to realize LD of shorter wavelengths. Although, it takes more than 10 years to see breakthrough since the shortest 336 nm LD proposed in 2008.

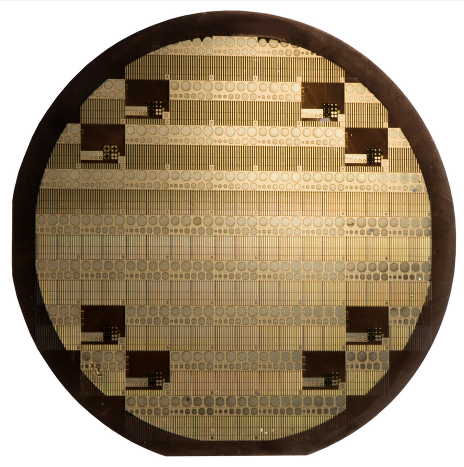
Challenges faced in pursuing DUV LDs, 2008~2018

- Insufficient AlGaN crystal quality
- Difficulty in controlling p-type conductivity of AlGaN

Our group

First demonstration of pulsed lasing, 2019

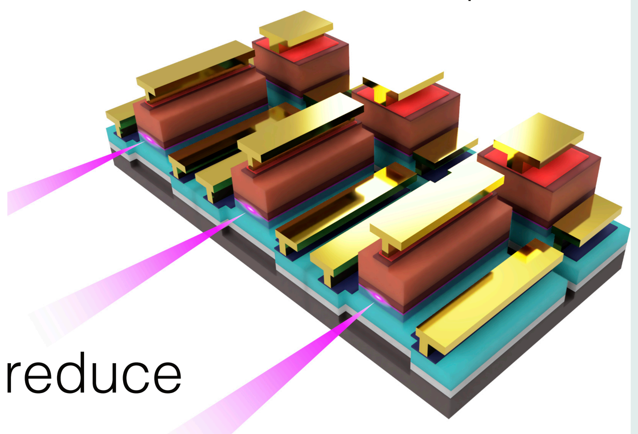
- High quality AlGaN using AlN single crystal substrate
- p-type conductivity control by polarization engineering



2-inch sc-AlN substrate, post electrode process

Further device performance improvements, 2020~

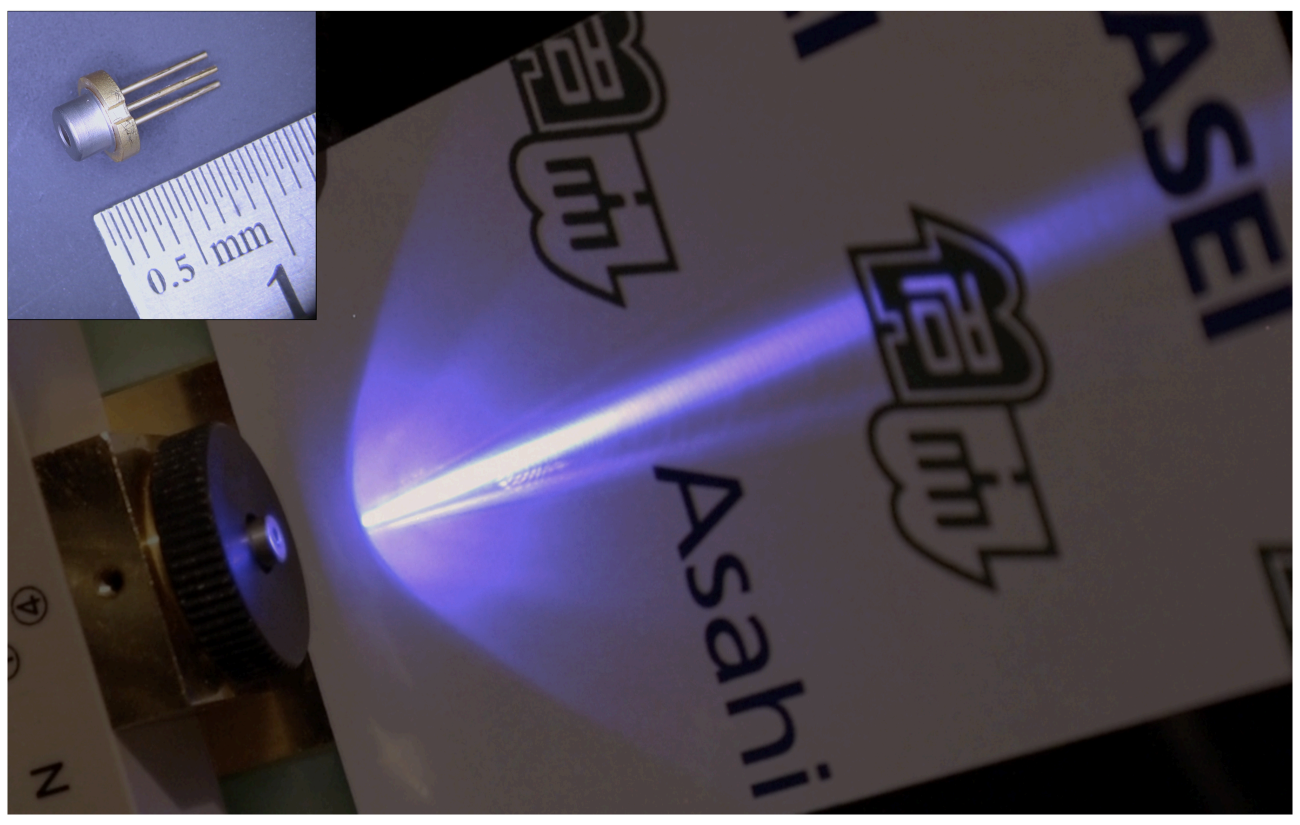
- Internal stress control to suppress dislocation
- Upgrade crystal AlGaN growth and structure design to reduce threshold current and voltage



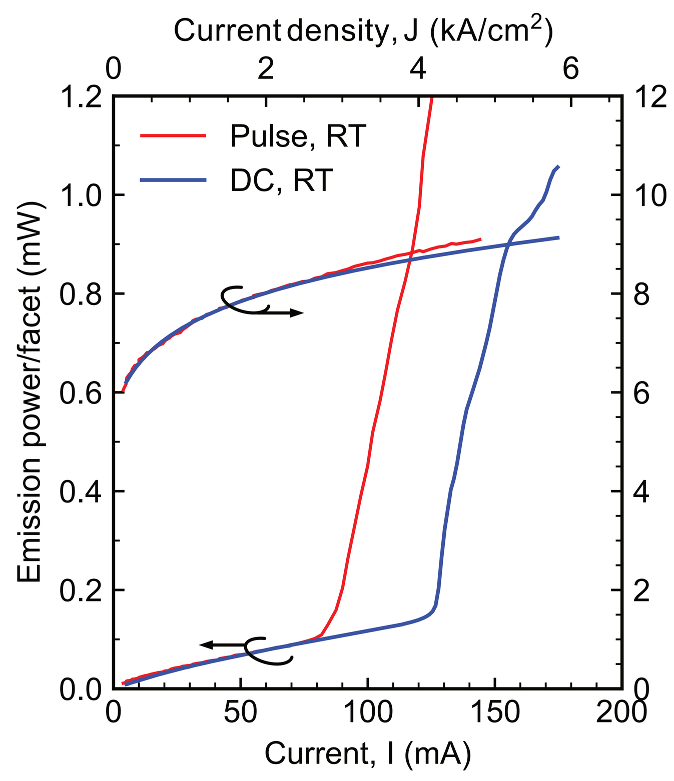
Integrated DUV LDs for high power application

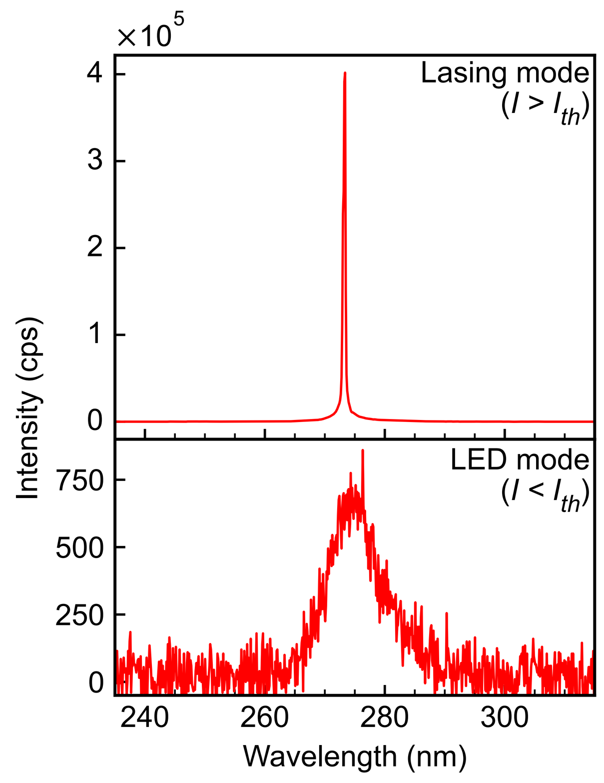
Fundamental technologies for LD integration have also been demonstrated

2022 Room temperature continuous lasing achieved with 274 nm DUV LD!



Continuous wave lasing emission projected onto a fluorescent screen.
The inserted picture shows a fabricated LD package.





[LEFT] Emission power-current-voltage charasteristics of DUV LD under pulse and direct current (DC) operation.

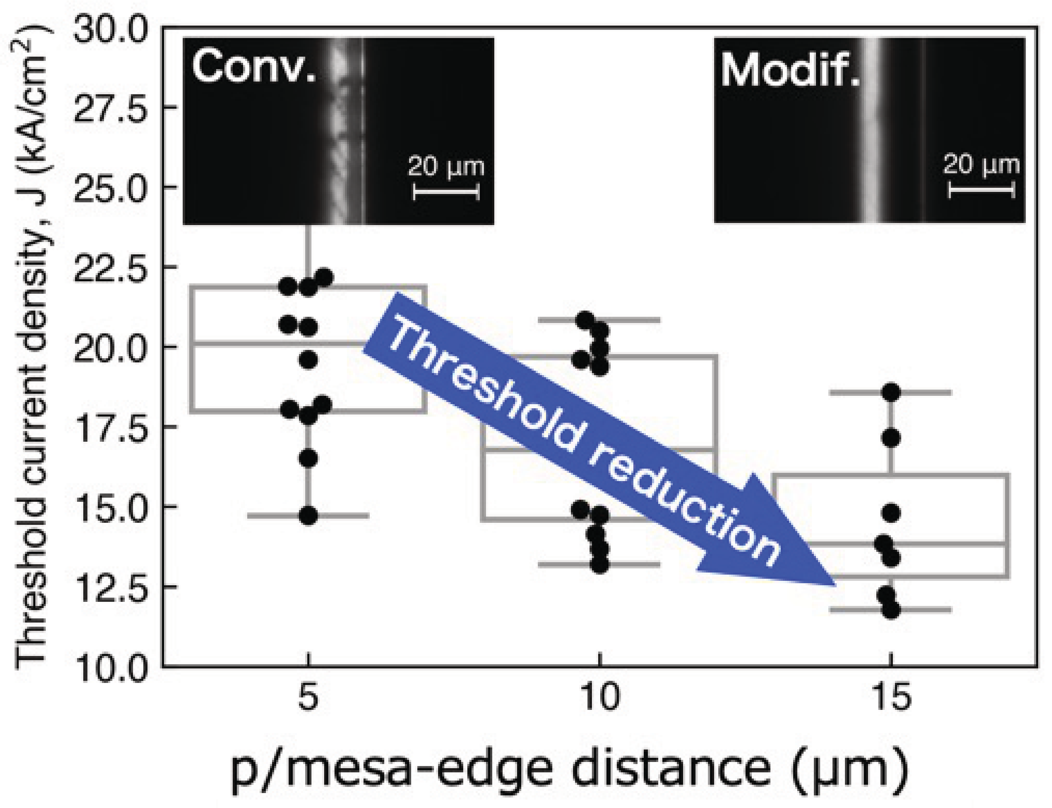
[RIGHT] Lasing spectrum above threshold current (lasing mode) and spontanious emission spectrum under threshold current (LED mode).

Press release

IMaSS

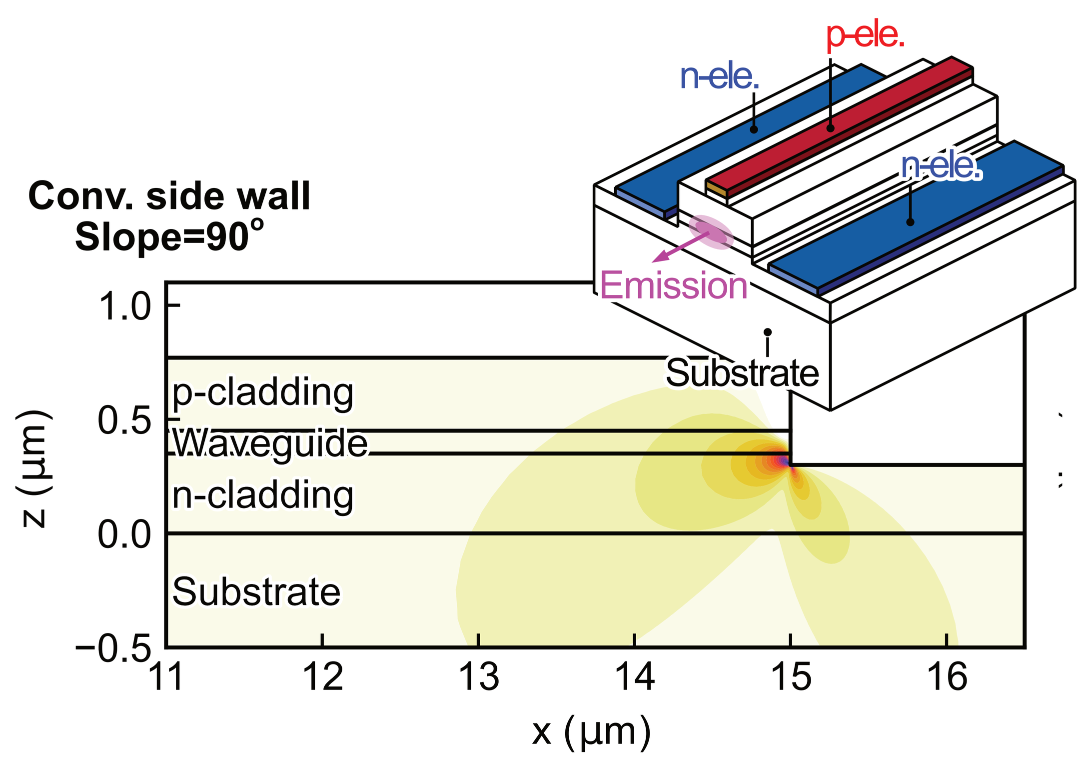
NU

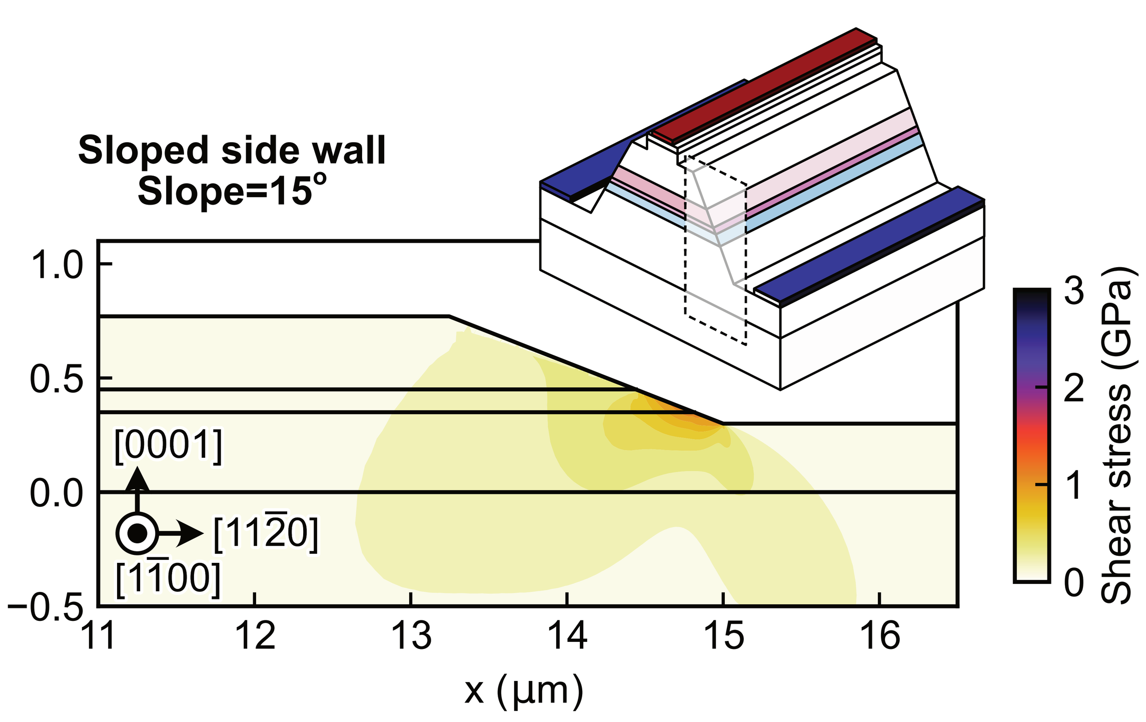
Key technology

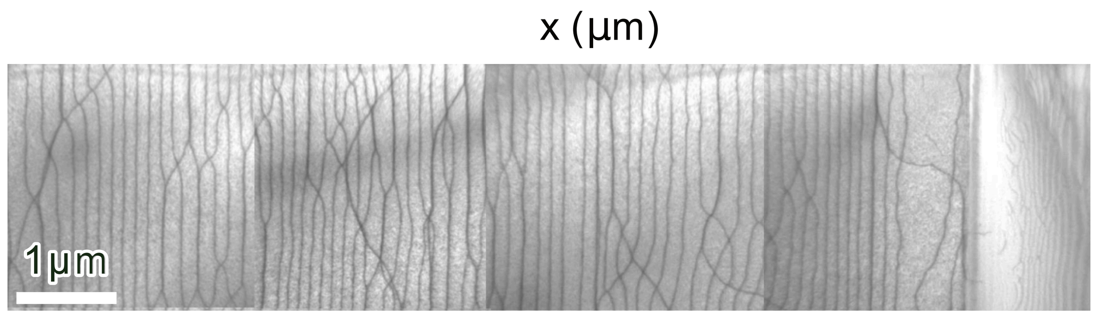


Conventional: Threshold current density increased due to defects.

It was reduced by shifting the p-electrode away from the mesa edge, but this resulted in an increase in operating voltage. Therefore, room-temperature continuous-wave lasing could not be achieved.







Comparison of conventional laser mesa structure [LEFT] and new mesa structure [RIGHT]

Schematic of each mesa structure, distribution of shear stress perpendicular to the mesa stripe, which is the cause of defect formation, and planar TEM image. In the new structure, the concentration of shear stress is suppressed and process-induced defects are no longer generated.

DUV semiconductor laser development will contribute to the evolution of semiconductor technology through applications in metrology, sensing, and laser processing.