

LayTec In-Situ Seminar at ICMOVPE
Jeju, Korea

July 14, 2026
18:00~

In-situ measurements and control towards high-efficiency GaN-based VCSELs

Tetsuya Takeuchi
Meijo University

Our in-situ measurement tools from LayTec

EpiTT VCSEL

Reflectivity spectra

Small optical head



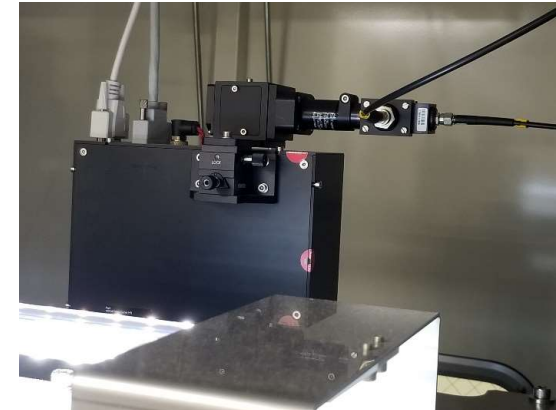
Many control units



EpiCurve[®] TT

Curvature

Large optical head



Currently both systems have been separately installed at different MOVPE reactors.
(**EpiTT VCSEL** is mainly used for epitaxial growth of our GaInN VCSEL structures)

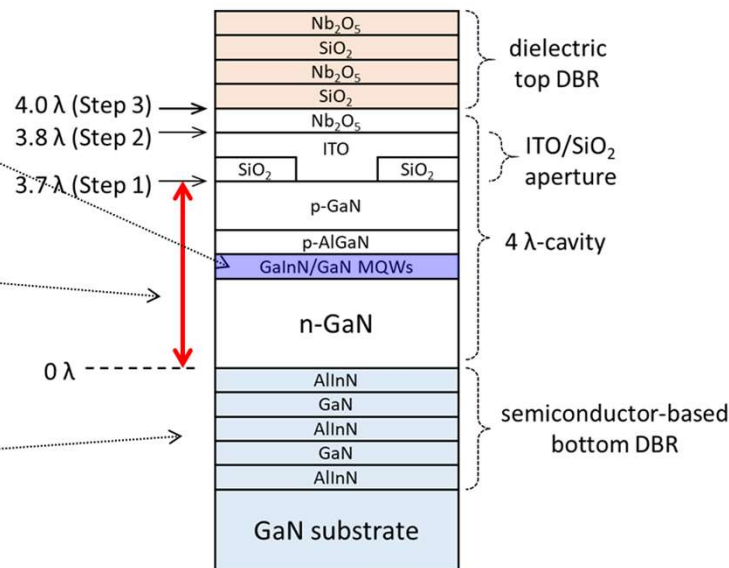
What is EpiTT VCSEL in Meijo used for ?

- Meijo utilizes EpiTT VCSEL for cavity length control in GaInN VCSEL

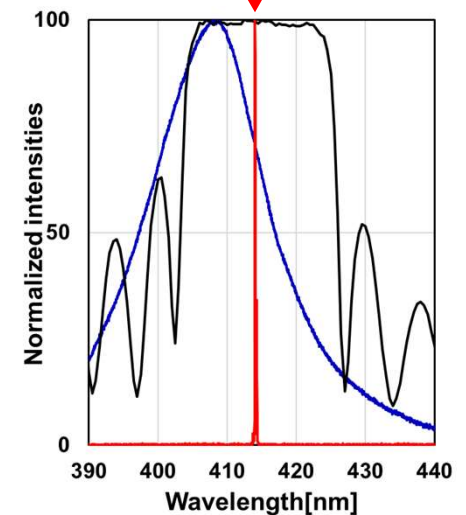
3. active layer peak wavelength

2. cavity resonance wavelength

1. DBR center wavelength

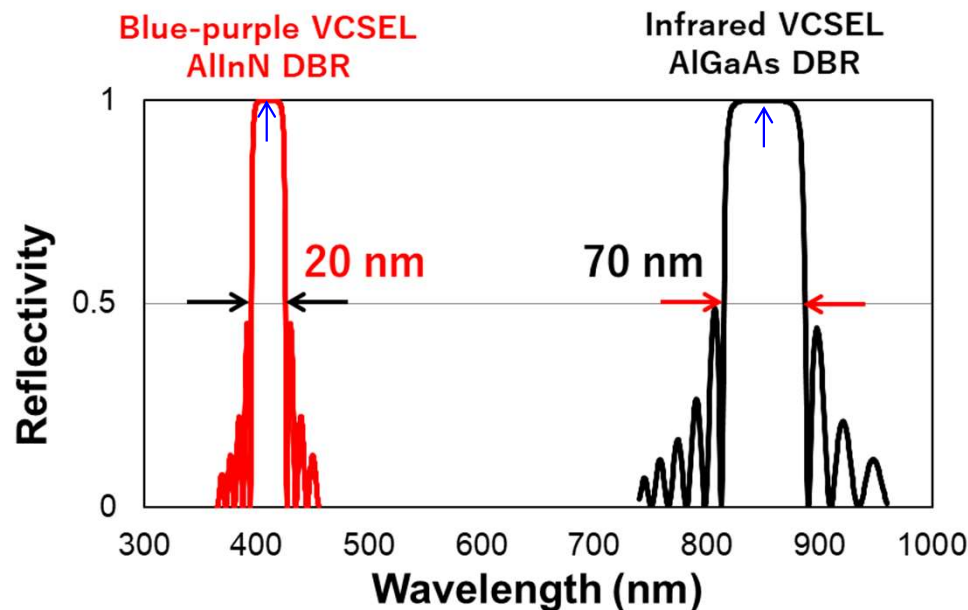


“cavity tuning”
(resonance WL)

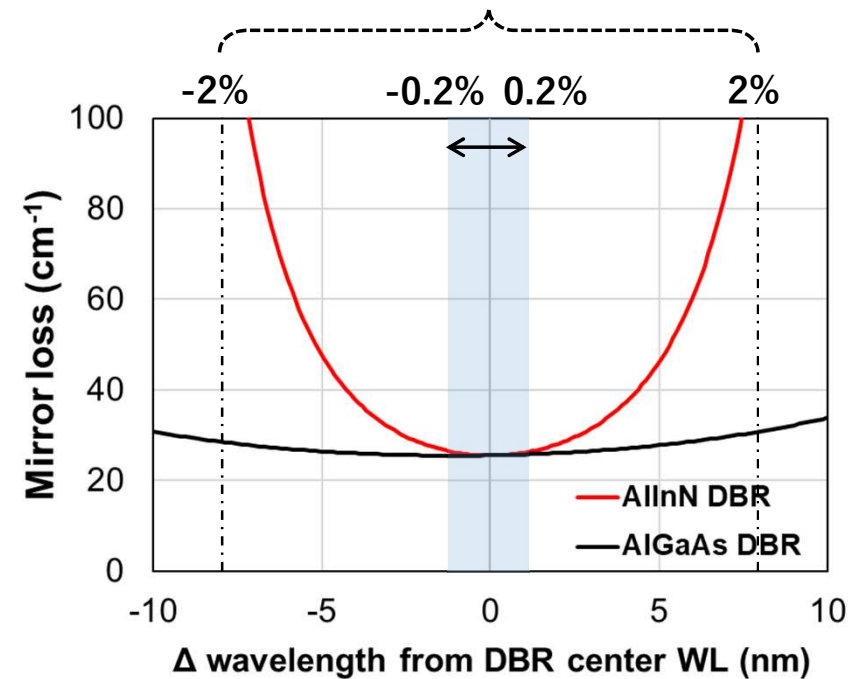


Narrow stopband of AlInN DBR

$\pm 2\%$ thickness variation: commonly observed in our MOVPE



AlInN DBR: much narrower stopband



→ $\pm 1\text{nm}$ (corresponding to $\pm 0.2\%$) required

$\pm 2\%$ variation (observed in our MOVPE) is unacceptable, resulting in unexpected large mirror losses₄

In situ reflectivity spectra measurement

In situ cavity length control of GaN-based vertical-cavity surface-emitting lasers with in situ reflectivity spectra measurements

Tsuyoshi Nagasawa¹, Kenta Kobayashi¹, Ruka Watanabe¹, Tetsuya Takeuchi^{1*}, Satoshi Kamiyama¹, M and Toshihiro Kamei²

EpiTT VCSEL installed to our MOVPE reactor

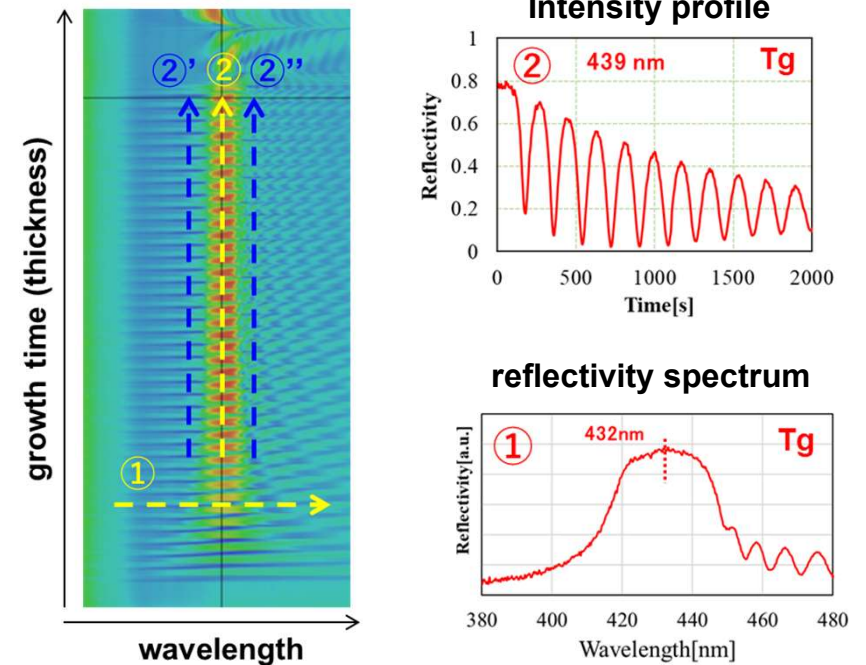
Small optical head



Many control units



2D (wavelength & thickness) mapping data

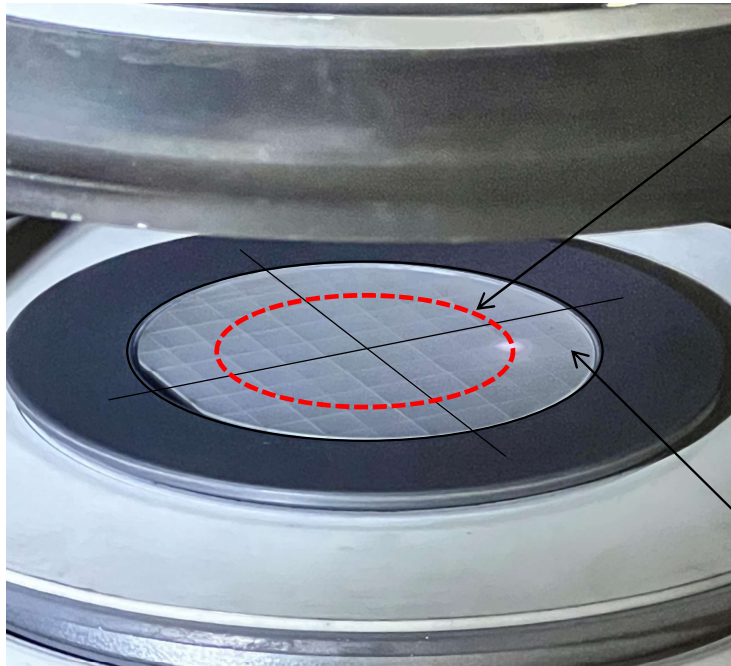


Intensity profile at desired wavelength, providing precise thickness information

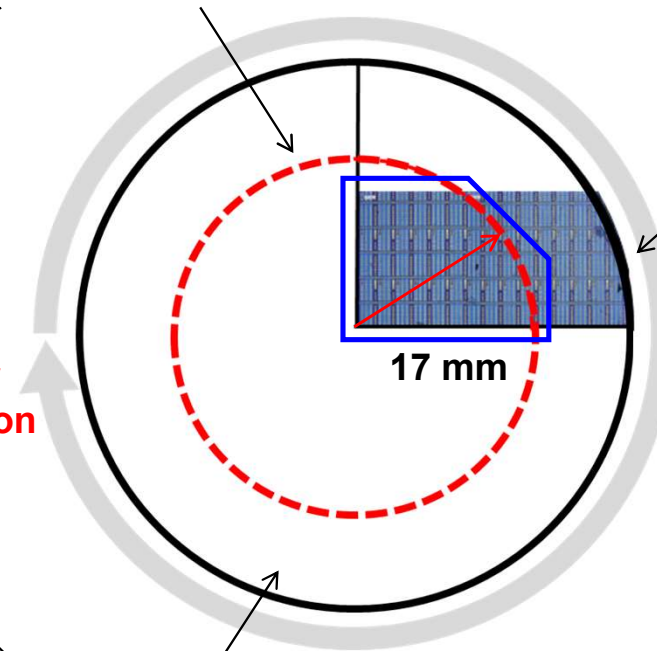
Monitoring point of in-situ reflectivity spectra

Monitoring point of
in situ measurement

17 mm away from wafer center



Wafer
rotation



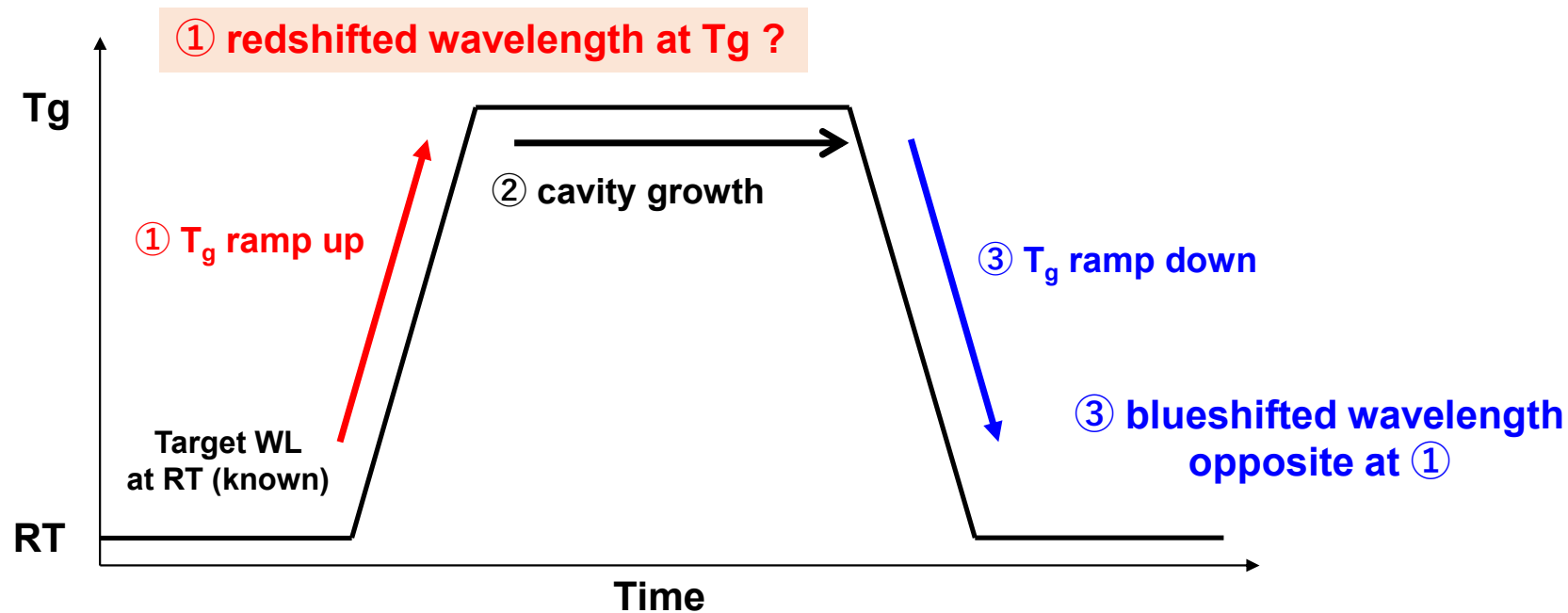
VCSEL wafer piece

1. Control cavity length
at monitoring point
(17 mm)
2. Nonuniformity in
0~17 mm area

2inch wafer

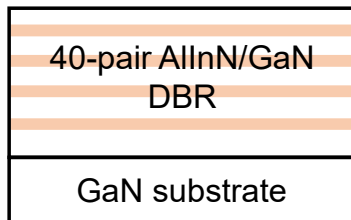
Cavity thickness control process

★ Target wavelength at RT, but control wavelength at T_g



① Wavelength shift from RT to T_g

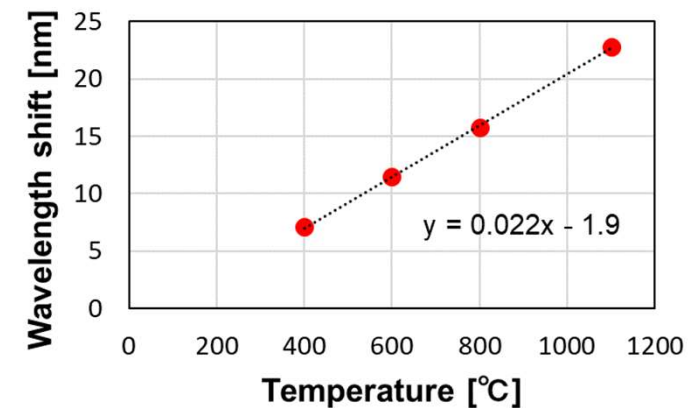
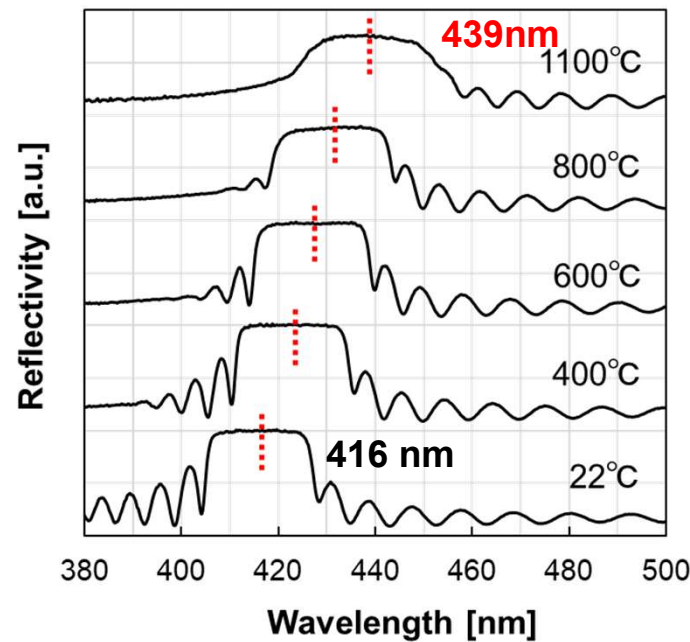
Sample:
40-pair AlInN/GaN DBR



center WL
at RT: **416 nm**

Measurement:
reflectivity spectra
from RT to T_g

reflectivity spectra



DBR center wavelength linearly redshifted **23nm** from **RT** to **1100°C** along with **0.022nm/°C**

Very important information to predict wavelength at RT from wavelength at T_g

Reflectivity intensity profiles during VCSEL growth

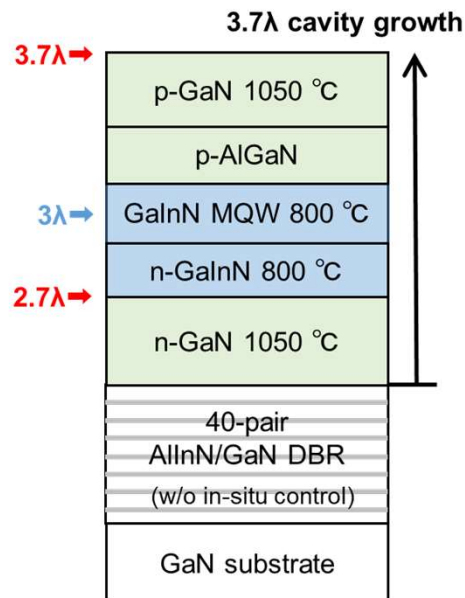
In situ cavity length control of GaN-based vertical-cavity surface-emitting lasers with in situ reflectivity spectra measurements

Tsuyoshi Nagasawa¹, Kenta Kobayashi¹, Ruka Watanabe¹, Tetsuya Takeuchi^{1*}, Satoshi Kamiyama¹, Motoaki Iwaya and Toshihiro Kamei²

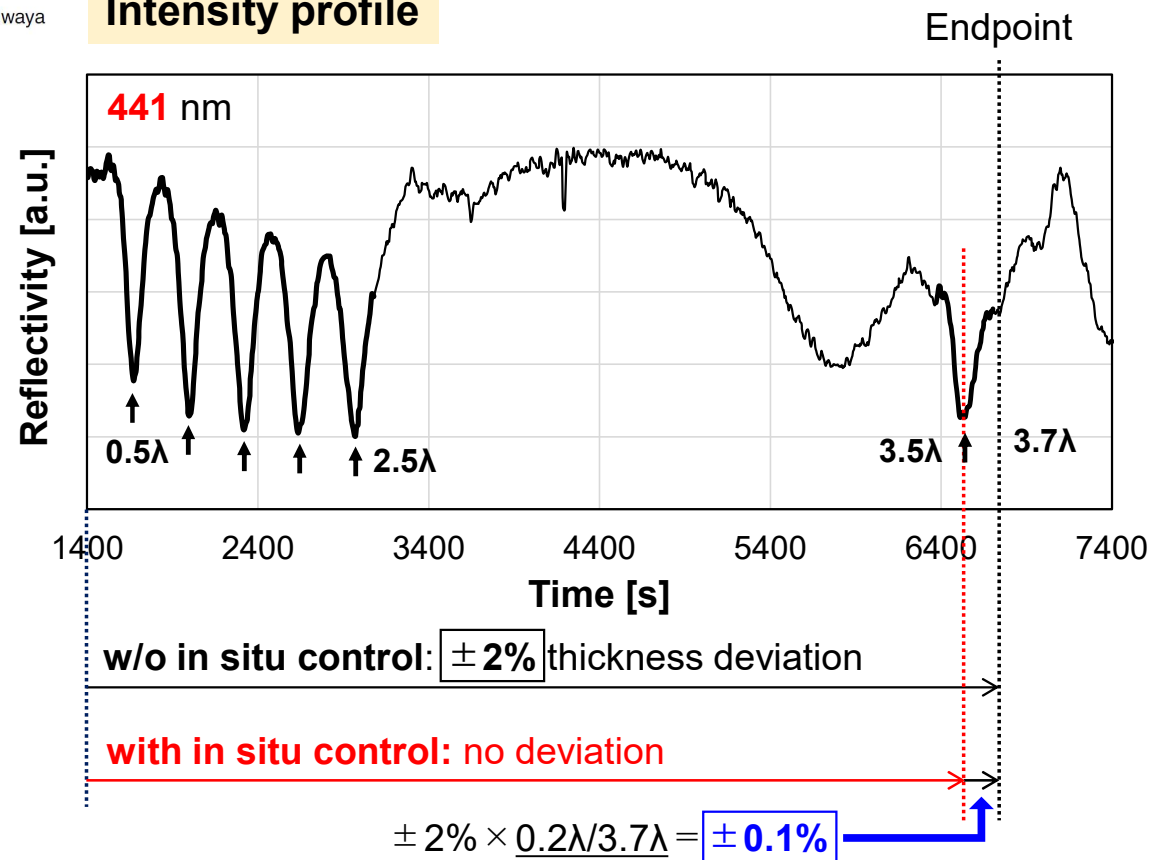
Jpn J Appl Phys 62, 066504 (2023)

Sample

3.7λ cavity growth for 4λ VCSEL



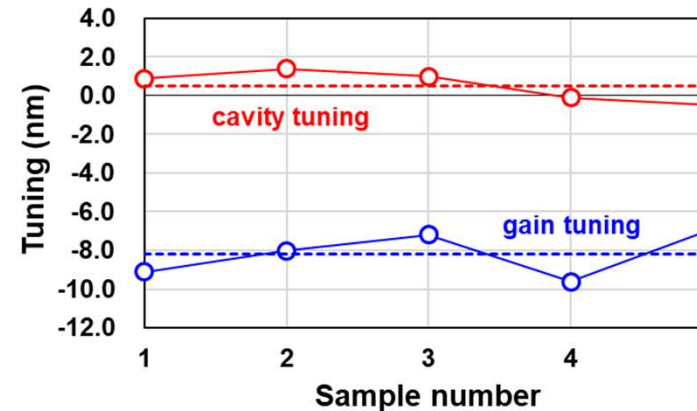
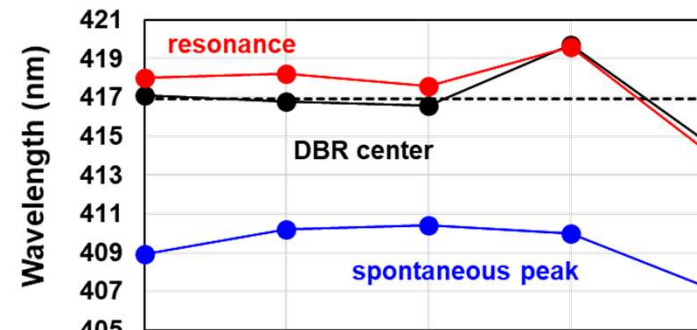
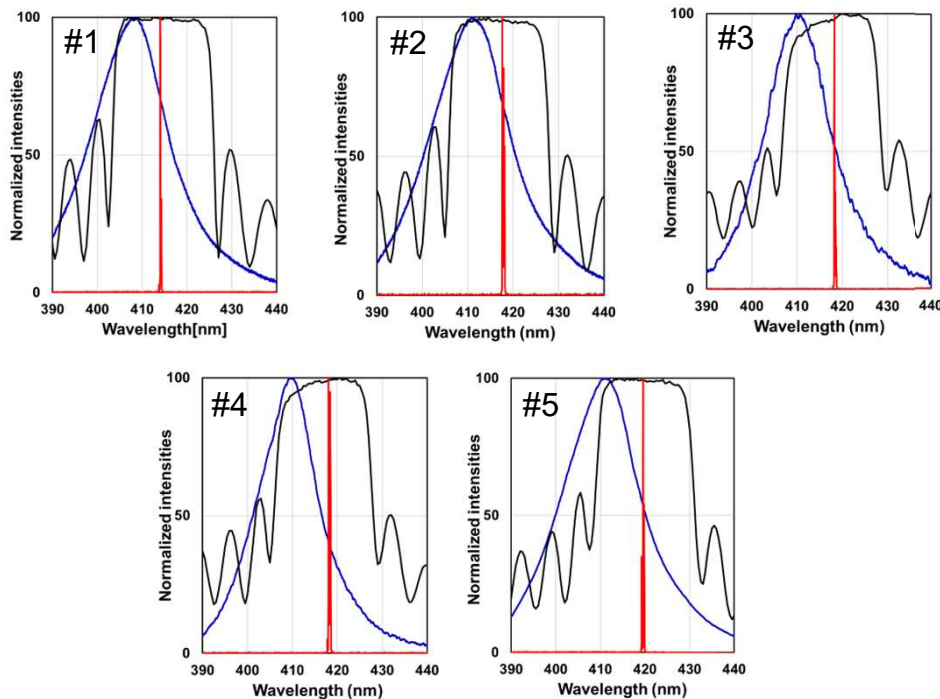
Intensity profile



Reproducibility of cavity tuning

Repeated 5 wafer growths and process (4λ cavity, 5μmΦ) but different runs (17 mm position)

spontaneous peak WL, lasing WL, DBR center WL

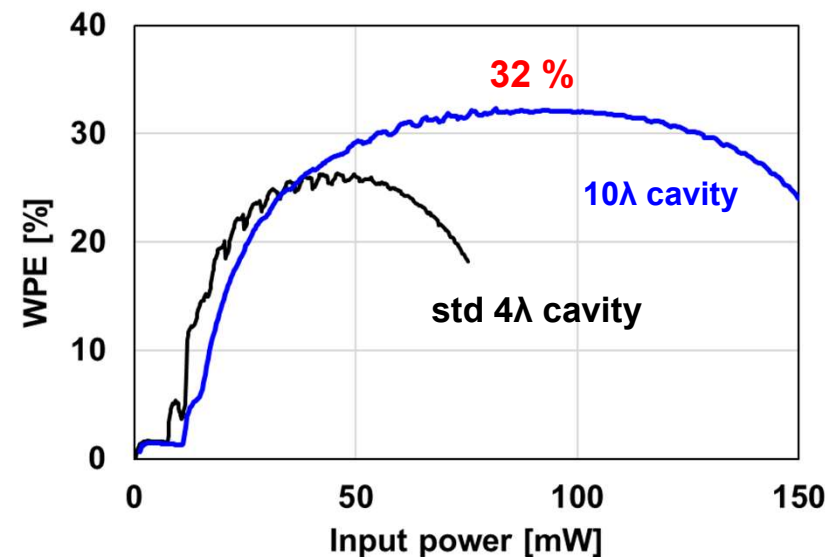
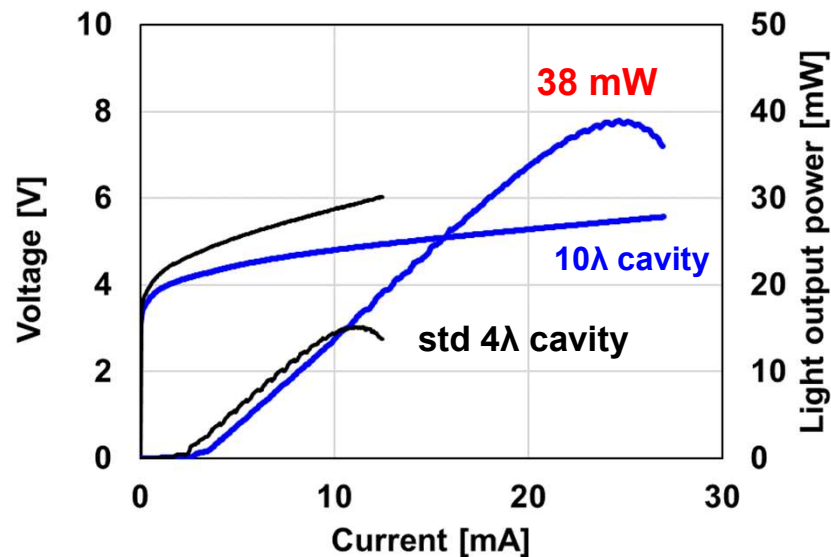


cavity tuning =
resonance WL – DBR center WL

gain tuning =
spontaneous WL – resonance WL

"cavity tuning" : very small variation, -0.11~ 0.35 %

VCSEL characteristics: std 4 λ vs 10 λ cavity



To the best of our knowledges,

- the highest LOP: **23.7 mW** from Stanley
- the highest WPE: **26.4%** from Sony and Meijo

Summary

- In-situ reflectivity spectra measurement system from LayTec is a powerful tool for GaN-based cavity length control with $\pm 0.4\%$ even in the second runs of the different cavity structures.
- One of them (10λ cavity) showed the highest LOP and WPE in GaInN VCSELs to the best of our knowledges.