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25G DML Wavelength Shift Measurement for 25G EPON ONU Wavelength Shift Estimate with Burst Mode

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Summary

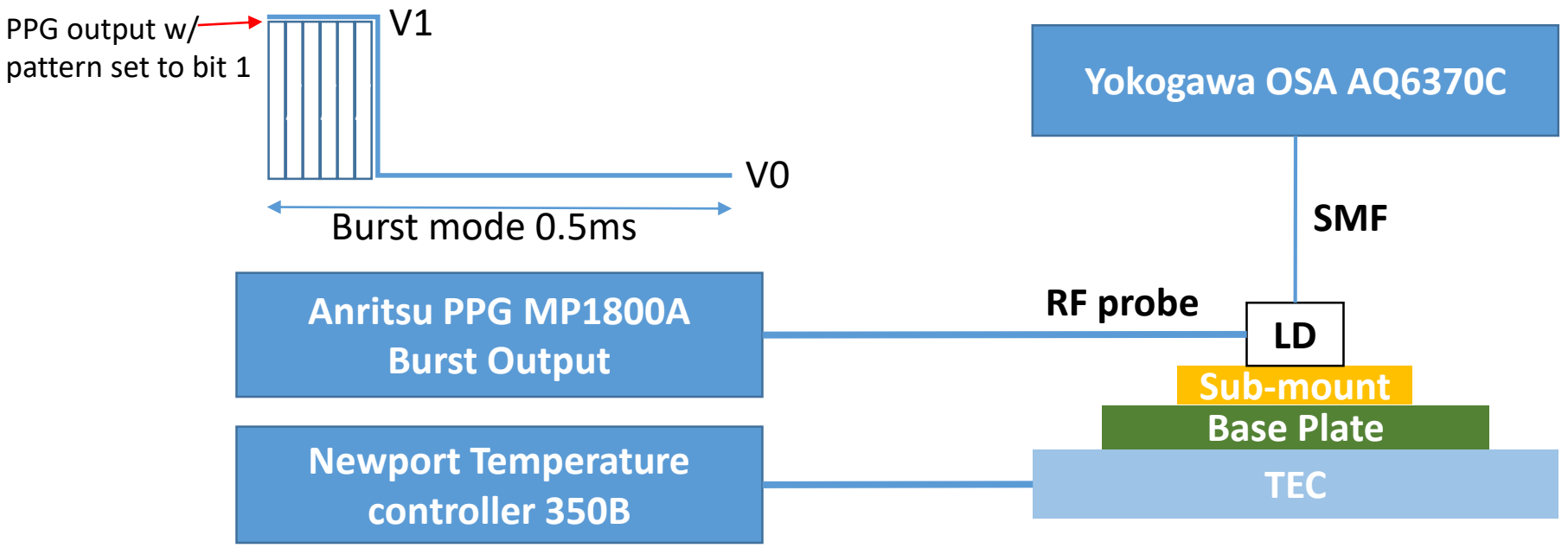
- Measured 25G Directly Modulated Laser (DML) wavelength shift with different pulse conditions to estimate wavelength shift of 25G EPON ONU burst mode operation
- Laser wavelength blue shift in burst mode is mainly caused by reduced self heating
- Measured with two different methods:
  - Use pulsed output from Anritsu 25G PPG to drive a 25G DML in chip-on-carrier (CoC) package mounted on a TEC temperature controlled base plate, and adjusting burst mode duty cycle: compared wavelength change to 25G NRZ
  - Use ILX pulsed current source to drive 25G DML in uncooled TOSA at several fixed pulse widths or fixed period of 0.1ms, with different duty cycle: compared wavelength change to DC
- For cooled DML, wavelength shift is up to -0.3nm to -0.7nm at low duty cycle of 5% to 1% with fixed period of 0.5ms tested using PPG burst mode driving:
  - Measured wavelength shift at 25°C and 45°C at operation current of 40mA and 60mA
- For uncooled DML TOSA, wavelength shift is up to -0.7nm to -1.2nm at pulse width from 100μs to 1us, and low duty cycle compared to DC wavelength at 25°C

Method 1: Cooled CoC with 25G PPG Burst Mode

- **COC WL was measured with TEC controlling temperature and PPG burst output driving laser**

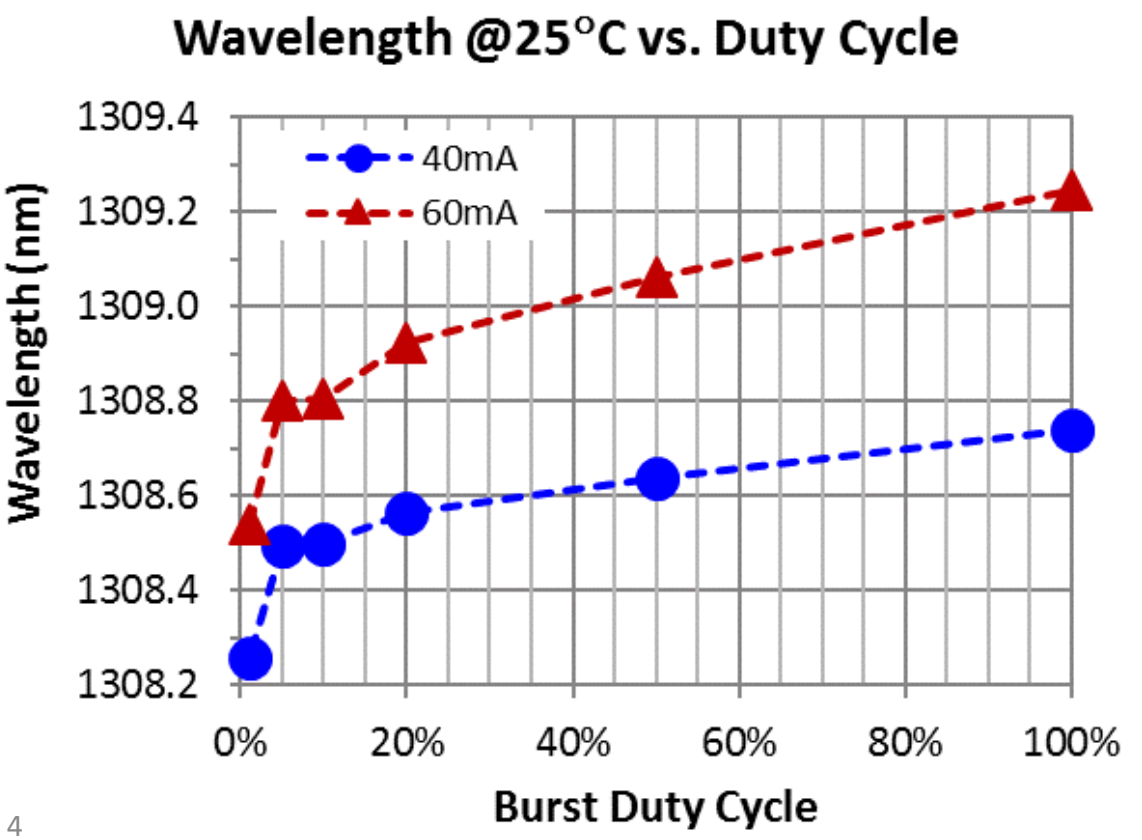
Burst Mode measurement: Clock=25.78125GHz, Burst Period=12.8Mbits (0.496ms)
PPG output at two different laser biases: Iop=40mA (V1=1.63V) and Iop=60mA (V1=2.16V)
When Burst Mode output is enabled, output level 1 (pulsed Vop output) to simulate pulsed

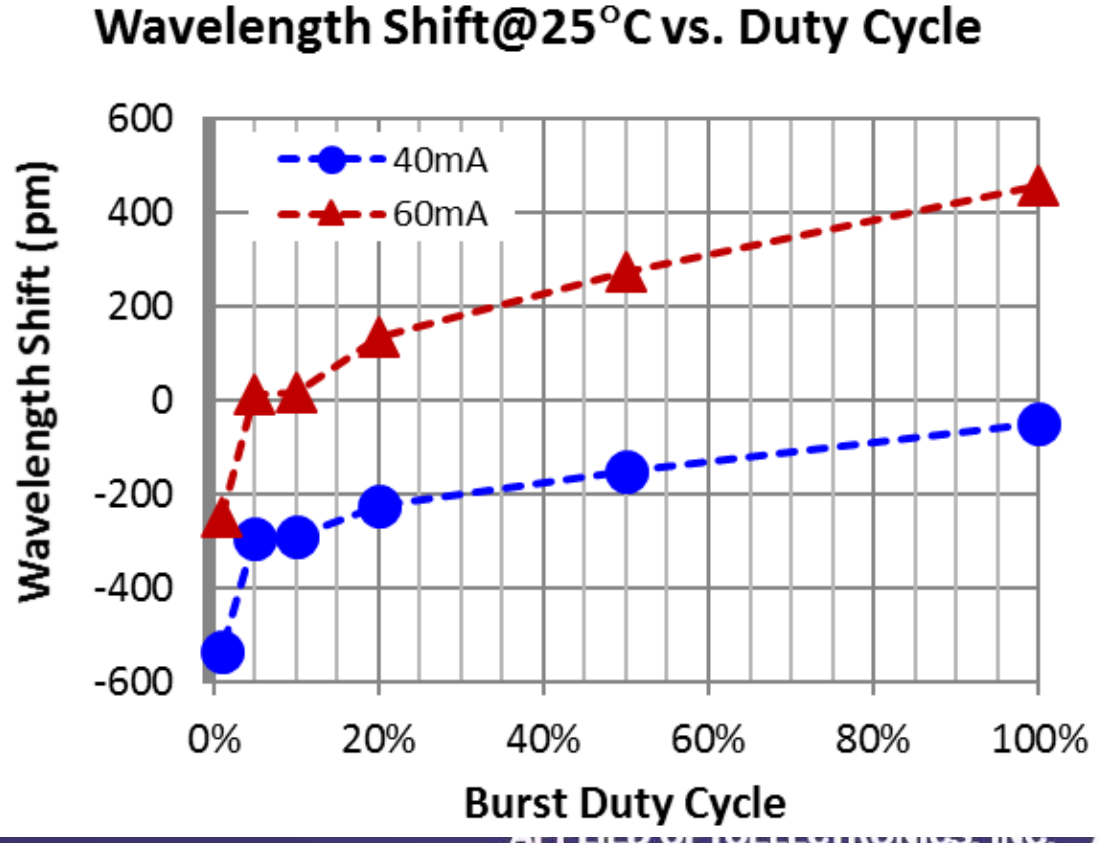
Use 25G PPG Burst Mode to simulate pulsed operation



Wavelength Shift on Cooled Chip-on-Carrier (COC) at 25°C

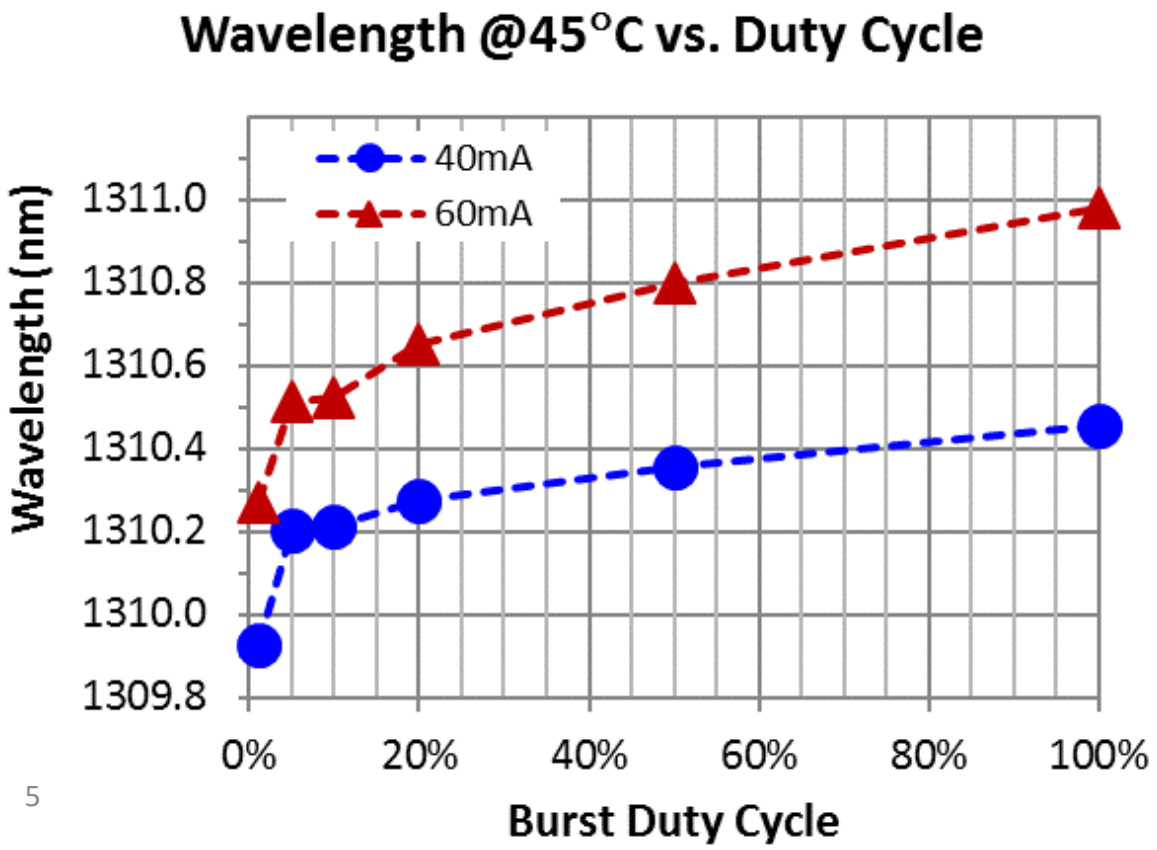
- 1310nm 25G DML on COC at Iop=40mA/60mA measured at 25°C base temperatures
- Wavelength shift (calculated from the difference to 40mA, 25G NRZ with ER=5.6dB, 1308.788nm) measured with the laser driving by the PPG pulsed output at different burst mode duty cycle
  - At Iop=40mA: WL shift -0.3nm at duty cycle down to 5% , and -0.5nm at 1% duty cycle
  - At Iop=60mA: WL shift -0.5nm at duty cycle down to 5% , and -0.7nm at 1% duty cycle.

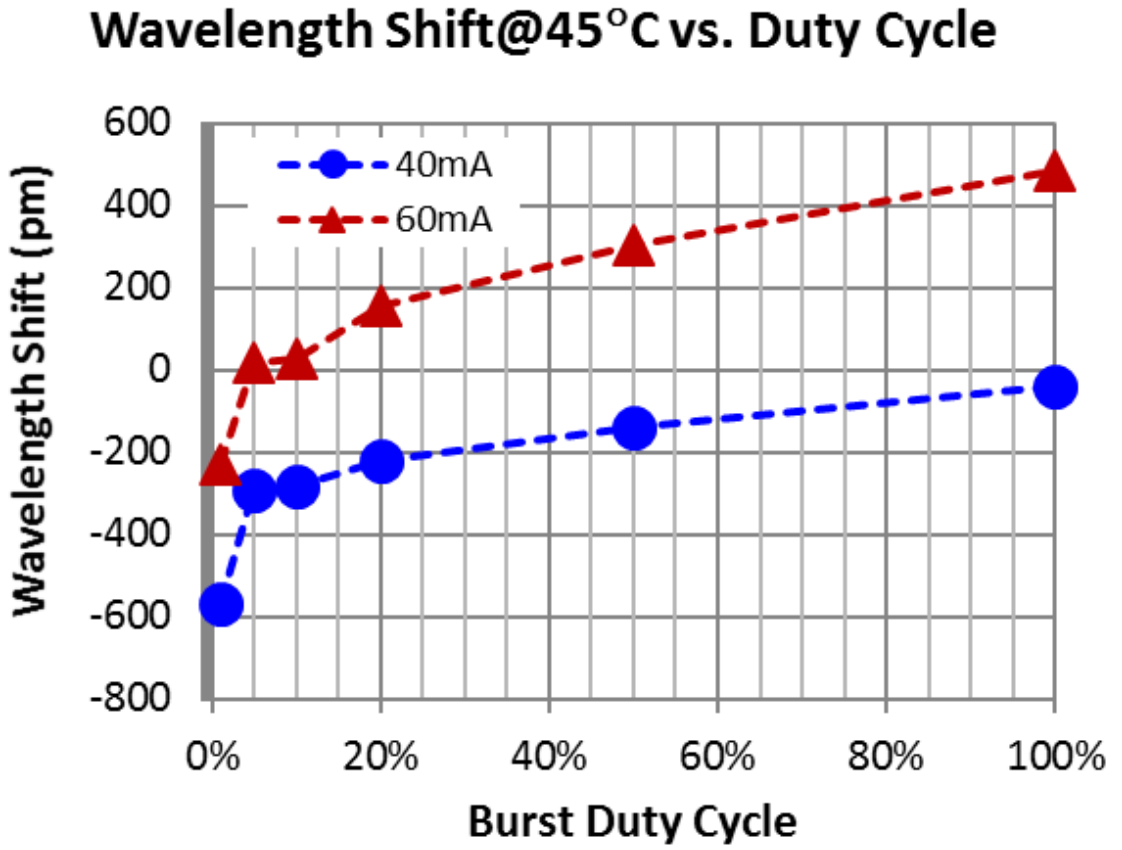




Wavelength Shift on Cooled Chip-on-carrier (COC) at 45°C

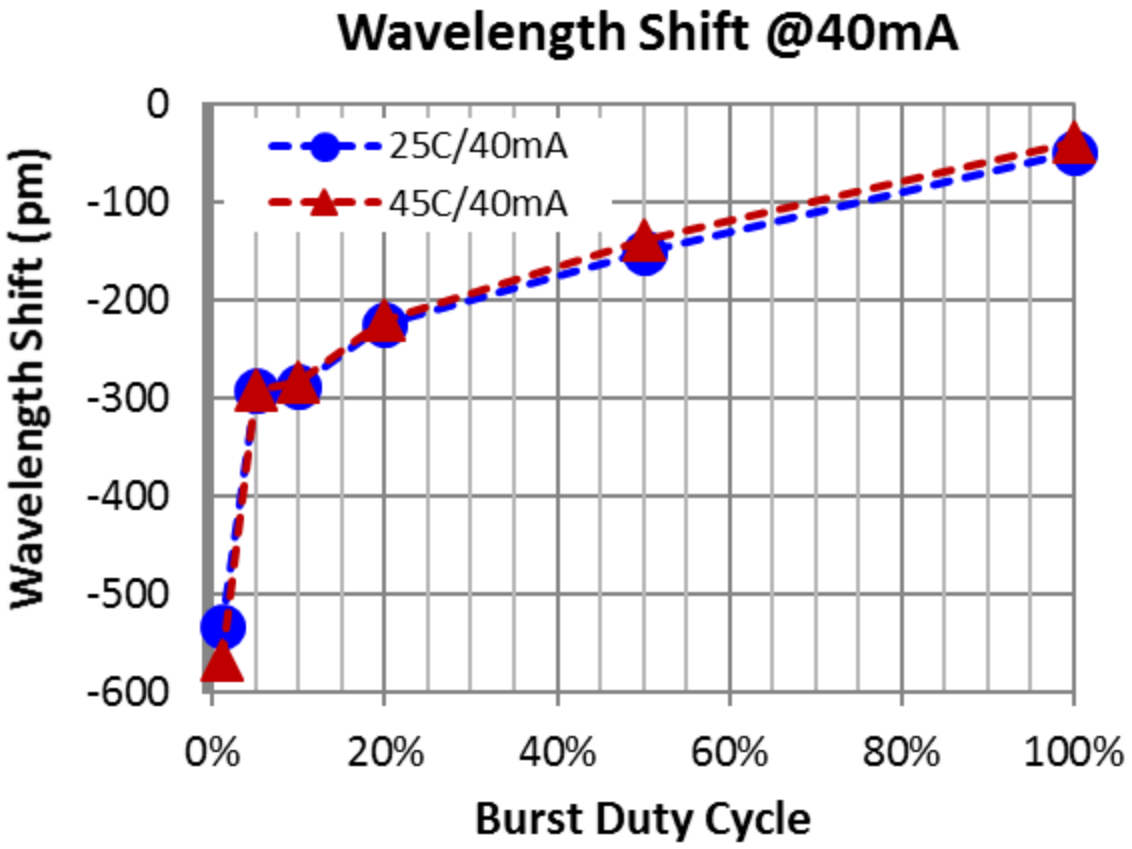
- **1310nm 25G DML on COC at Iop=40mA/60mA measured at 45°C base temperatures**
  - 25Gbps NRZ at ER=4.7dB peak WL1310.496nm, which is 1.7nm longer than at 25°C
- **Wavelength shift is almost the same as at 25°C for the same burst mode duty cycle**
  - At Iop=40mA: WL shift -0.3nm at duty cycle down to 5% , and -0.6nm at 1% duty cycle.
  - At Iop=60mA: WL shift -0.5nm at duty cycle down to 5% , and -0.7nm at 1% duty cycle.

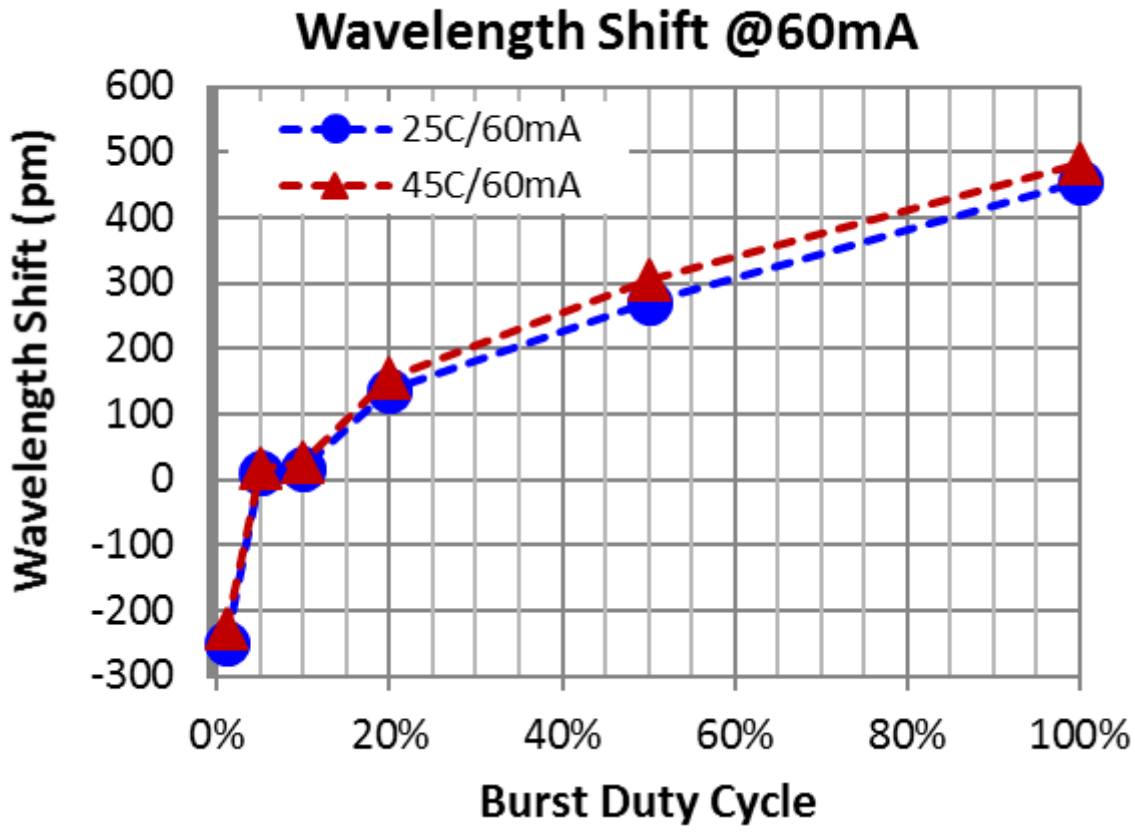




Wavelength Shift on Cooled Chip-on-carrier (COC) at Same Current

- **Wavelength shift is almost the same at 25°C and 45°C at the same current**

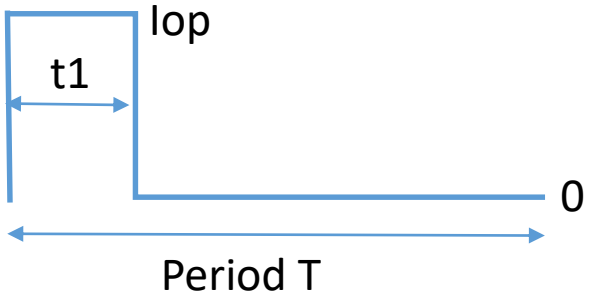




Method 2: Uncooled TOSA with Pulsed Current Driver

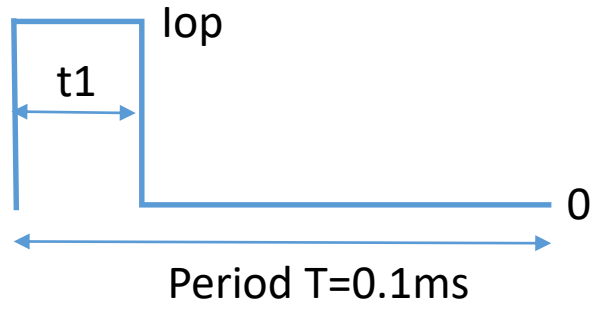
- **Also measured DC wavelength shift using ILX pulsed current source to drive 25G DML in uncooled TOSA at 60mA at several fixed pulse widths or fixed period of 0.1ms, with different duty cycles: compared wavelength change to DC at 40mA**
- **Wavelength shift is more due to more self-heating compared to CoC with TEC temperature control**

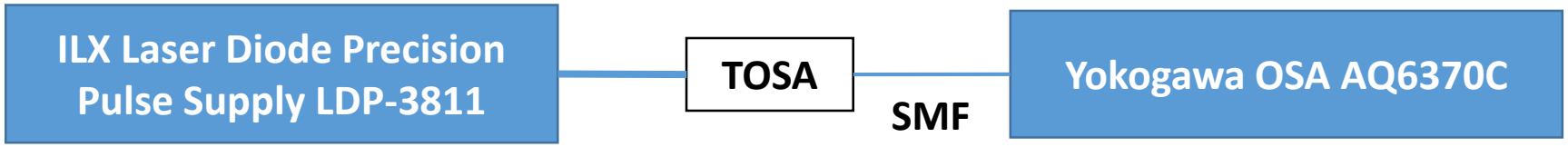
Fix pulse width t1
changing duty cycle
$\frac{t1}{T}$ (or period T)



or

Fix period T=0.1ms
changing duty cycle
$\frac{t1}{T}$ (or pulse width t1)

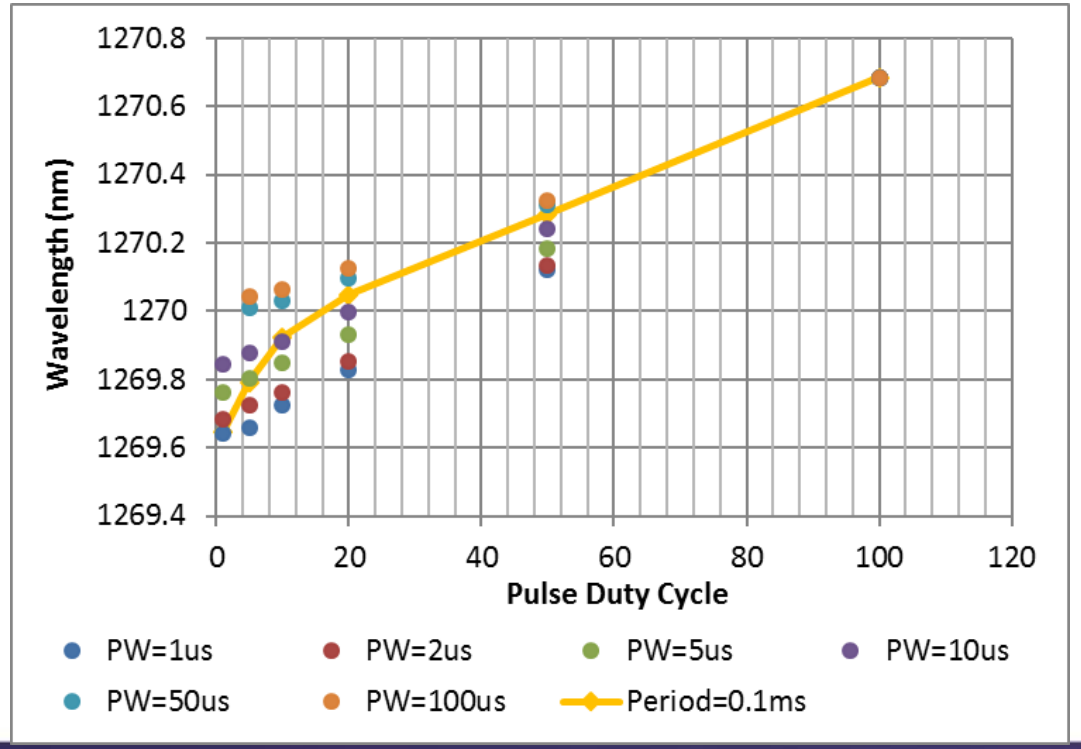




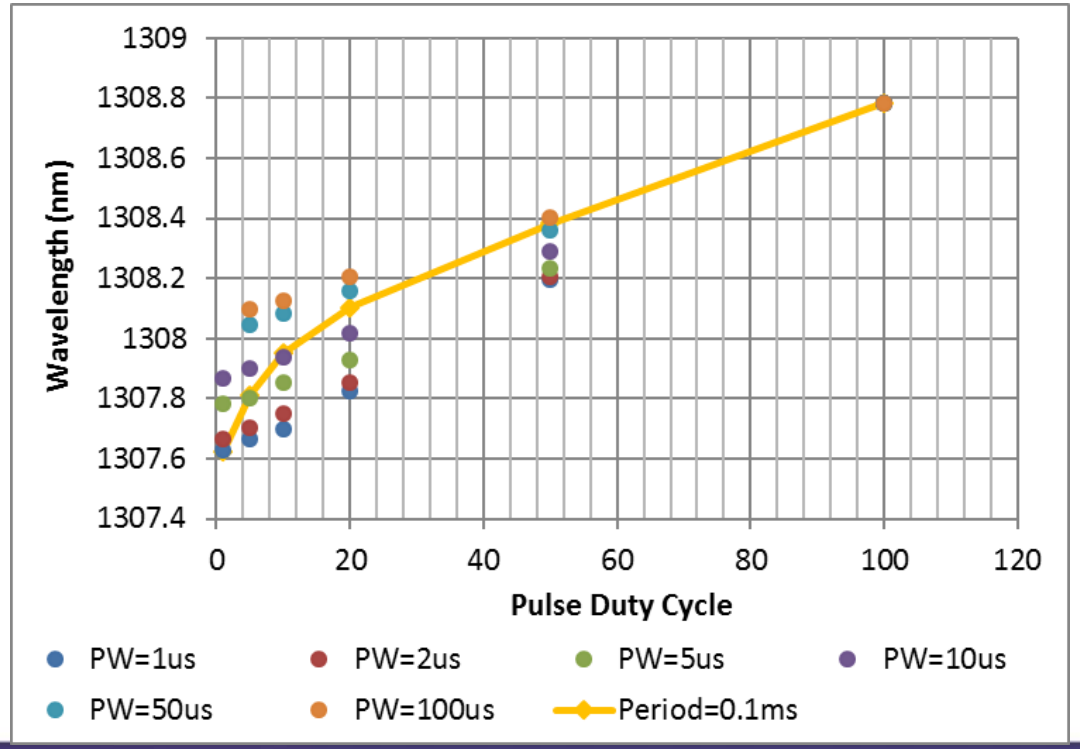
Wavelength Shift on uncooled 25G TOSA with Pulsed Current Generator

- Measured 1270nm and 1310nm 25G DMLs in uncooled TOSA at 25°C ambient temperature
- Wavelength shift (compared to Peak wavelength at DC and 40mA) measured with pulsed current generator at several fixed pulse widths (PW) or fixed period of 0.1ms with different duty cycles

1270nm 25G TOSA Wavelength at 25°C/60mA



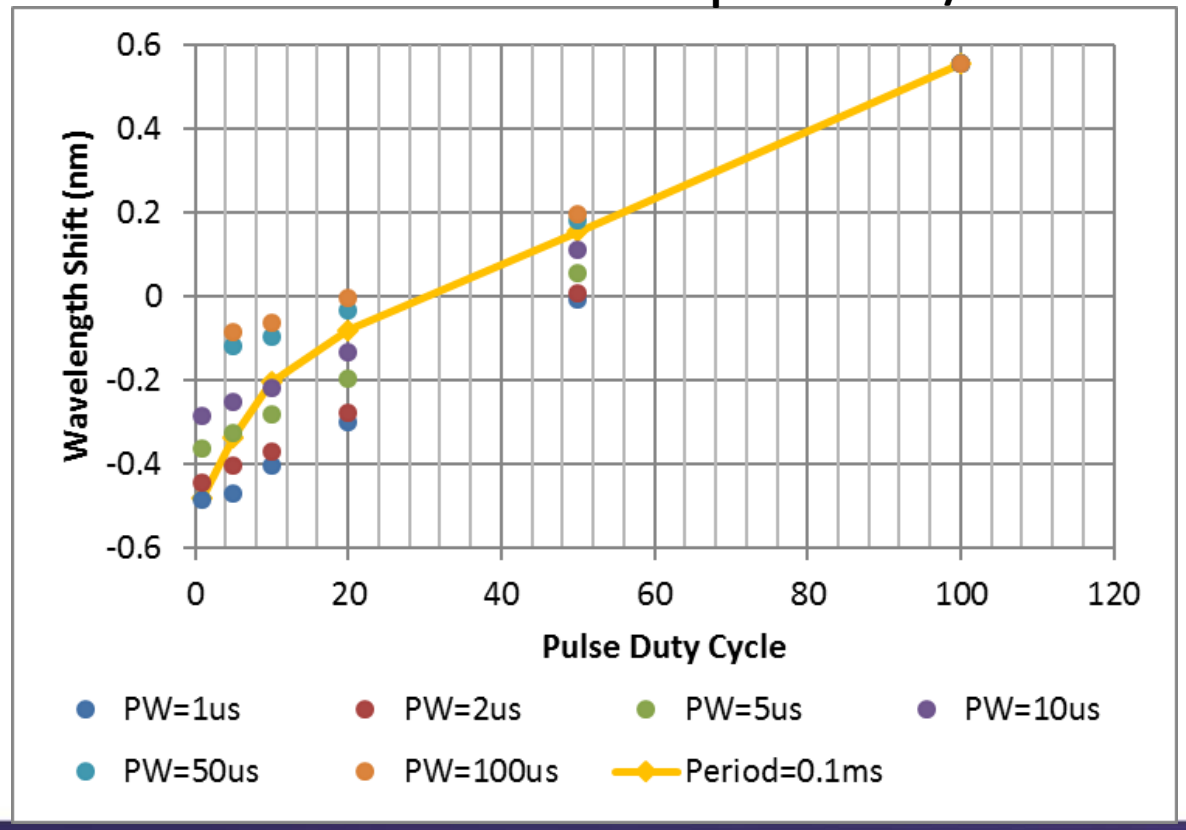
1310nm 25G TOSA Wavelength at 25°C/60mA



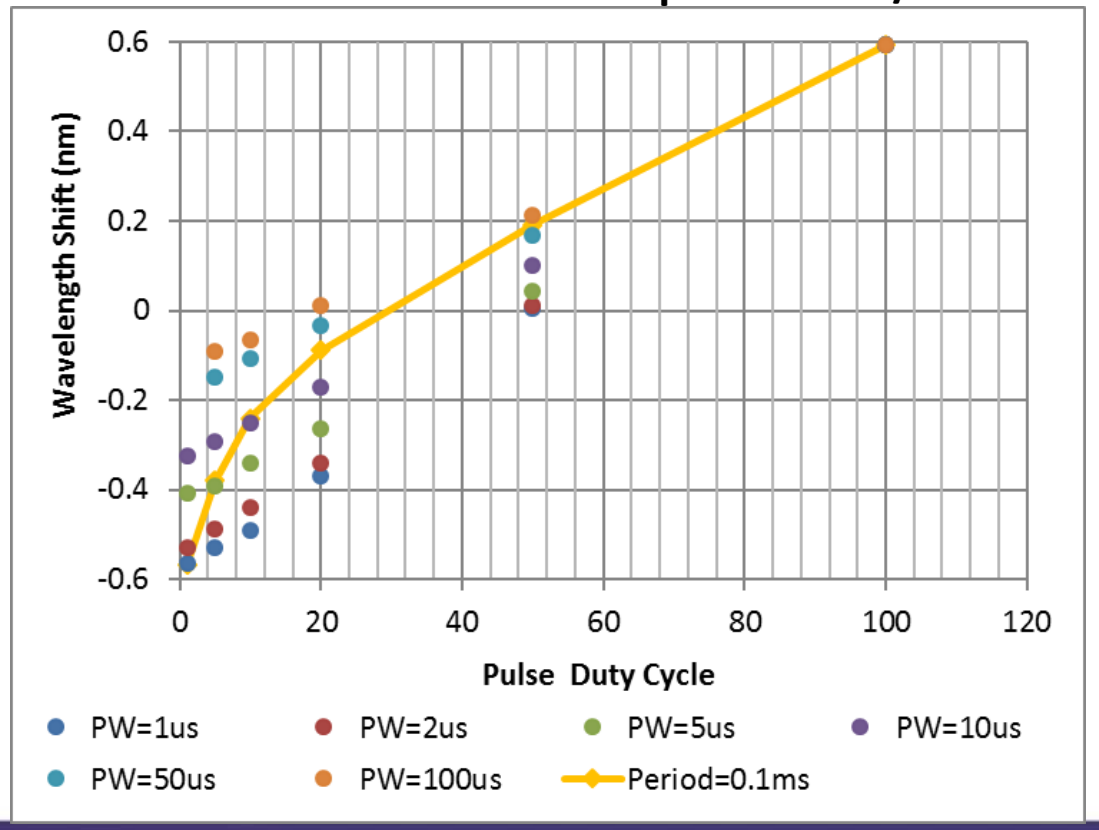
Wavelength Shift on uncooled 25G TOSA with Pulsed Current Generator

- Wavelength shift is up to from -0.7nm to -1.2nm at pulse width from 100μs to 1us, and low duty cycle compared to DC peak wavelength.
- Smaller pulse width has larger negative wavelength shift compared to DC due to less heating

1270nm 25G TOSA WL Shift compared to DC/40mA



1310nm 25G TOSA WL Shift compared to DC/40mA



Conclusion

- We measured 25G DML wavelength shift with different pulse conditions to estimate wavelength shift of 25G EPON ONU burst mode operation
- Cooled DML:
  - Wavelength shift is up to -0.3nm to -0.7nm was observed at low duty cycle of 5% to 1% with fixed bust mode period of 0.5ms
  - Wavelength shift at 25°C and 45°C is almost the same at the same current
  - Wavelength shift at 60mA is slightly larger than at 40mA
- Uncooled DML TOSA:
  - Measured both 1270nm and 1310nm 25G DML TOSAs
  - Wavelength shift is up to -0.7nm to -1.2nm at pulse width from 100μs to 1us, and low duty cycle compared to DC wavelength at 25°C
  - 1270nm device has slightly less wavelength shift than 1310nm device
  - Wavelength shift is more for uncooled DMLdue to worse heat dissipation from LD to ambient

Back up Slide – Typical Pulsed Laser Spectra

- **1310nm Cooled laser spectra at 25°C/40mA (Pulsed with different duty cycles)**