Are uncooled optical transceivers for 25Gb/s DS0/US0 practical?

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Background

1. US and DS are in the O-Band
   - harstead_3ca_3_0317, liudekun_3ca_0317, Johnson_3ca_1_0117, guo_3ca_1_0117
   - US0 in Plan B supports **uncooled operation**
   - DS0 in Plan A and Plan B supports **uncooled operation**

2. Presumption:
   - uncooled 25G (US0/DS0) optical Transceiver is **practical**
   - uncooled 25G (US0/DS0) optical Transceiver is **cheaper** than cooled one

3. Operating case temperature of optical transceiver
   - -40ºC ~ 85ºC, or 0 ~ 85ºC

4. Up to 10G PON
   - uncooled optical transceivers were used
   - High performance InP based materials was used to make DFB lasers
   - Wavelength resources were abundant

5. NGEPON
   - Aluminum based materials are used to make 25G DFB lasers
   - Laser chip size is smaller, and current density is higher
   - Wavelength resources are not abundant in O-band

Analysis of 25Gb/s PR30 US Uncooled Tx Output Power

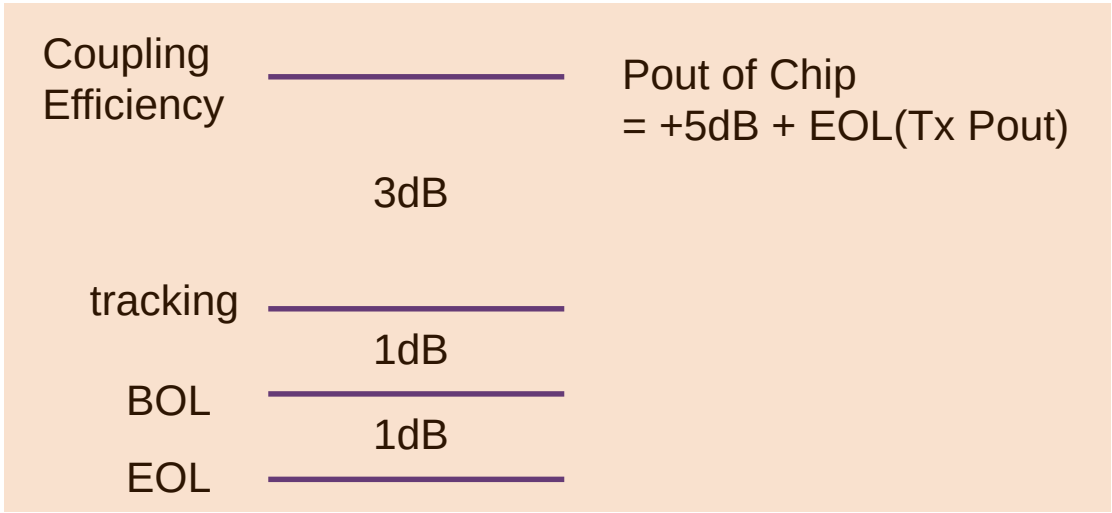
Output Power	conditions	Chip Power	References
7.0dBm	ONU Tx Pavg(min), Single 25G Tx, PR30	12dBm	Johnson_3ca_1_0317
6.5dBm	ONU Tx Pavg(min), EOL, I-temp, 45º diplexer	11.5dBm	**Harstead_3ca_1a_0716**
9.0dBm	ONU PR30 Pavg(min), 9dBm is beyond uncooled DML capability	-	Liudekun_3ca_4a_0317
4.0dBm	ONU Tx @ R/S reference point	9.0dBm	Guo_3ca_2_317
5.5dBm	25G TOSA, coupling 40%, **25ºC**, BOSA output	10.5dBm	**Tanaka_3ca_1_0716**

Assumptions:

- Chip to TOSA/ROSA coupling efficiency: 50% (3dB)
- BOL – EOL = 1dB
- Tracking error over temp. : 1dB
- Total loss from chip to Tx output: 5dB

Is it really possible to make Aluminum based uncooled DFB laser satisfying the following conditions?

- >10dBm(average) (>**peak power 20mW**) from DFB laser chip
- Highest operating temp. of chip: >90ºC
- High reliability
- Bandwidth for 25G NRZ data



Laser Chip : Uncooled vs. Cooled (1)

- Assumptions: 1. OLT and ONU transceivers use DFB lasers
  2. DFB lasers use Aluminum based material

	Uncooled	Cooled	Remarks
Laser temp.	> 90°C	50-55°C	**Cooled** TO laser usually set at ~55°C. **Uncooled** one may suffer >90°C. **Uncooled** laser chip is only guaranteed up to 85°C
BW	-	+	**Uncooled**: difficult to achieve high BW for 25G NRZ data at high temp.
SE	-	+	**Uncooled**: At high temp. SE is low. Higher current driving is needed for high output power. Possibility of thermal roll-over of I-P curve
SMSR	-	+	**Uncooled**: high yield of SMSR is difficult over wide operating temp. Usually SMSR is not guaranteed at low temperature
Reliability	-	+	**Uncooled**: High current, high temp operation may affect reliability significantly
High Pout	-	+	**Cooled** operation of laser at a temperature (55°C) is relatively easy to produce higher Pout than uncooled operation
Δ Pout	high: > 1dB	Low: < 1dB	PON ONU/OLT trx need high output power. Stable Pout of **cooled** trx can help in increasing of link budget.

- BW: bandwidth, SE: slope efficiency, SMSR: side mode suppression ratio, Pout: output optical power, I-P: current vs, optical Power, Trx: transceiver

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Laser Chip & Other Aspects : Uncooled vs. Cooled (2)

	Uncooled	Cooled	Remarks
Chip design & manufacturing	high	low	Design and manufacturing of **cooled type DFB laser** is easier than uncooled one. **More vendors** can make cooled lasers and play in the market. This will also make trx vendors easy to purchase laser chips from various vendors.
Wavelength resources	-	+	When using **cooled laser**, wavelengths in **O-band can be unleashed** and can potentially be used for sparse wavelength allocations
Power consumption	+	-	At high temp, uncooled DFB laser also need higher current driving. Power consumption of cooled type will be slightly higher. The delta between cooled/uncooled is ~300mW over industrial temperature range.
Assembly cost	low	high	Automated assembly may relieve cost of cooled TO

This is OES' view as a transceiver vendor, However, laser chip vendor's view may be different.

Cost Analysis of 25G SFP+28: cooled vs. uncooled

- Assumption : ONU/OLT transceiver will use APD type receiver

- A cost model is derived from an accurate cost model of 25G SFP+28 PIN transceiver
  - Replaced PIN cost with APD cost
  - APD cost was estimated as 2.5 times of 10G APD ROSA price
  - Prices of two vendors' 10G APD ROSA were used
- TEC(TEC, thermistor, controller) cost was added to calculate the cost model of cooled type transceiver

- **The premium of 25G cooled APD transceiver is in the range of 10% ~13.5% more compared to uncooled APD transceiver**

Other transceiver vendors may have different cost models and premiums.

Summary

1. **Benefits** of cooled optical transceivers for 25G US0/DS0 in NGEPON compared to uncooled ones are many.
   - By using cooled DFB lasers at relatively low temperature, chip design and manufacturing of DFB lasers become relatively **easier to achieve**;
     - Bandwidth for 25G NRZ modulation, higher output power, higher reliability, higher chip yield
     - Better SMSR yield, and potentially more chip vendors can play in the market
   - Stable output power with cooled Tx will be helpful in **increasing of link budget**
   - It will be possible to **unleash wavelengths** allocated for uncooled operation
     - This can be used for **sparse channel allocations**
2. **Drawbacks** of cooled optical transceivers
   - Higher power consumption
   - Higher assembly cost
   - Cost premium (10% ~ 13.5%)
3. **Drawbacks of cooled transceiver can be offset by benefits of cooled transceivers**

- **It will be worth reassessing of which one between uncooled/cooled transceiver will be better option to reduce the total cost of NGEPON network.**

Thank you.

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