Reliability and Emerging Capabilities of 1060nm VCSELs

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1060nm Wavelength

Existing OM2 fiber

1060nm VCSELs were first developed for proprietary applications

MMF can be optimized for OM3 / OM4 performance at 1060nm

Loss
2.1 dB/km
1.2 dB/km
0.9 dB/km

Chromatic dispersion

\[
D(\lambda) = \frac{S_0}{4} \lambda \left(1 - \frac{\lambda^2}{\lambda_0^2}\right)
\]

In here, \(S_0=0.101\) \(\lambda_0=1310\)
1060nm wavelength LD (VCSEL) with InGaAs active

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Wavelength (nm)

<table>
<thead>
<tr>
<th>900</th>
<th>1000</th>
<th>1100</th>
<th>1200</th>
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<tbody>
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Optical gain increase due to strain effect

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DLD growth velocity for GaAs/AlGaAs SQW is much higher than that for InGaAs/GaAs SQW (Especially in high current density)

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EBIC image after aging test

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*R.G. Waters et al., IEEE PTL, 2, pp531-533, 1990

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R.G. Waters et al., IEEE PTL, 2, pp531-533, 1990
Number of Optical Channels

Speed, power consumption, reliability, and cost become crucial.
Inherent Material Merit in 1060nm VCSELs with InGaAs SL-QW

✓ High Speed at high temperature, owing to high material gain
✓ Low power dissipation due to low built-in voltage, high quantum efficiency
✓ High material reliability due to slow dislocation velocity

High Speed characteristics

Power consumption characteristics

In-plane lasers with InGaAs active layer
Proven “Telecom grade” Reliability

E2 passivated 980nm pumps

Encouraging aging result for highly reliable operation (16-year).
Never reported for GaAs-active lasers.
Lots of terrestrial and under-sea usage.
## Summary for large scale reliability test

### Test procedure
- High temperature: 70, 90 and 120°C, Bias current: 6 mA
- Package: commercial 20pin DIP (air ambient; non-hermetic)
- Failure definition: 2 dB power degradation at 25°C and 6 mA
- Adopted acceleration factor: $E_a = 0.35$ eV, $n = 0$

<table>
<thead>
<tr>
<th>Condition</th>
<th>Quantity (number of chips)</th>
<th>Maximum aging duration (hours)</th>
<th>Device hours @40°C, 6 mA</th>
<th>Number of failures</th>
</tr>
</thead>
<tbody>
<tr>
<td>70°C, 6 mA</td>
<td>1,075</td>
<td>5,000</td>
<td>$8.0 \times 10^6$</td>
<td>0</td>
</tr>
<tr>
<td>90°C, 6 mA</td>
<td>1,121</td>
<td>5,000</td>
<td>$1.6 \times 10^7$</td>
<td>0</td>
</tr>
<tr>
<td>120°C, 6 mA</td>
<td>2,702</td>
<td>2,000</td>
<td>$5.4 \times 10^7$</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>4,898</td>
<td></td>
<td>$7.8 \times 10^7$</td>
<td>0</td>
</tr>
</tbody>
</table>

### 30 FIT/ch with confidence level of 90%
Over 20,000h Life test at 70C, 90C (I=6mA)

Threshold change

Power change
No eye pattern degradation was observed in both for 10Gbps and 25Gbps after long-term aging.
Preliminary reliability test

Promising result, comparable to those for 10Gbps was obtained.

One failure was infant failure

→ Screening condition was not adjusted for 25Gbps device.
**20Gbps transmission over OM2 MMF using 1060nm VCSEL**

Possibility to extremely low power consumption optical link ~1.5mW/Gbps

**Fig. 6: Eye patterns after transmission over a 100m OM2 optical fiber**

**Fig. 5: Measured OMA, eye opening, total jitter and extinction ratio as a function of the VCSEL DC bias at 20 Gbps.**

20 Gbps optical link with high efficiency 1060 nm VCSEL

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Conclusions

1060nm VCSELs can provide following features simultaneously:

✓ High Speed data transmission
✓ Low power dissipation
✓ High material reliability

Promising candidate for high speed, low power consumption, high reliability. In development for 28 Gbps applications