Active Distributed Feedback (DFB) Laser Diode (1300 nm 9 Well)

Reliability Data

Summary

The 9 Well Distributed Feedback (DFB) laser diode has been successfully qualified under the supervision of Agilent Quality and Reliability Engineering.

This report summarizes the qualification testing performed on the 9 Well DFB laser diode.

Introduction

The current Agilent chip design includes a 7 Well Strained-MQW active region with a grating fabricated the length of the cavity to ensure single mode operation. Increasing the number of quantum wells to 9 wells improves the temperature performance of the device. This new active region is exactly the same as that in the 9 well Strained-MQW laser diode which has been reported separately.

The material is grown by Agilent's proven Metal Organic Vapor Phase Epitaxy (MOVPE) process.

Reliability Testing

To date, a total of 1.72×10^6 device hours at a combination of +85°C, +95°C and +100°C have been obtained, which is equivalent to a total of 1.37×10^6 device hours at +95°C. The results have been collated from 106 wafers over 9 well DFB laser lifetest and laser validation programs. Table 1 summarizes this.

To establish the ESD threshold of the lasers devices from 8 wafers have been subjected to HBM ESD test as shown in Table 3.

Wear-out Failure Rate

Predicted times to failure have been calculated for individual devices on test using a model of the form: -

$$\frac{I-Io}{Io} = At^n$$

Where: -

I = drive current after time t
Io = drive current at time t = 0
A, n = constant obtained from the fitting process

Individual time to failure were obtained from 151 devices which have completed at least 2000 hours on life test, assuming a failure criteria of 50% increase in drive current for constant light output. These individual lifetimes have been plotted as a cumulative probability distribution (Figure 1) from which the wear-out lifetimes have been obtained as shown in Table 2. Previous studies have shown that the activation energy for wear-out of buried heterostructure lasers is in the range of 0.6 eV to 1.0 eV. The most pessimistic value of 0.6 eV has been used in this calculation.

Random Failure Rate

The random failure rate for the 9 well DFB has been calculated using 60% and 90% confidence limits as shown in Table 2. The Bellcore recommended activation energy for random failure rate of 0.35 eV has been assumed.

Conclusion

At the time of publication of this report, the 9 well DFB laser diode have successfully passed the qualification testing as defined by Agilent Quality and Reliability Engineering Department.

Table 1 - Summary of life test status for 9 well DFB wafers

	Wafer number	Number of devices	Number of hours completed	Temperature
1.	1V842	10	2600 hours	+85 °C
		10	6000 hours	+85 °C
		10	600 hours	+100 °C
		10	2600 hours	+100 °C
2.	2V843	10	2600 hours	+85 °C
		10	6000 hours	+85 °C
		20	2600 hours	+100 °C
3.	5V843	17	2600 hours	+100 °C
4.	5V581	10	2600 hours	+85 °C
		10	6000 hours	+85 °C
5.	2V581	10	2000 hours	+85 °C
		9	6000 hours	+85 °C
6.	4V581	10	2000 hours	+85 °C
		10	6000 hours	+85 °C
7.	1B509	20	2000 hours	+95 °C
8.	3B509	19	6000 hours	+95 °C
9.	4B509	10	1400 hours	+95 °C
		9	6000 hours	+95 °C
10.	5B509	10	1000 hours	+95 °C
		10	6000 hours	+95 °C

Note:
Both the coated and uncoated lasers performed equally at life test.
Wafer validation has so far provided 600 hours of data at +85 °C for >1500 devices from 96 wafers.

Table 2 - Summary of Reliability Data for 9 well DFB Laser

Parameter		Measured Value
Wearout median life at +95 °C		9.6×10^6 hours
Wearout median life at +25 °C		8.17×10^8 hours
Standard deviation		2.24
Wearout failure rate at +25 °C	after 5 years	<1 FITS
	after 10 years	<1 FITS
	after 20 years	<1 FITS
Wearout failure activation energy		0.6 eV
Random failure rate at +25 °C	@ 60% confidence level	<50 FITS
	@ 90% confidence level	<125 FITS
Random failure activation energy		0.35 eV

Note:
The random failure rate is limited by the number of hours on lifetest and therefore it is anticipated that the failure rate will decrease as more device hours are accumulated.

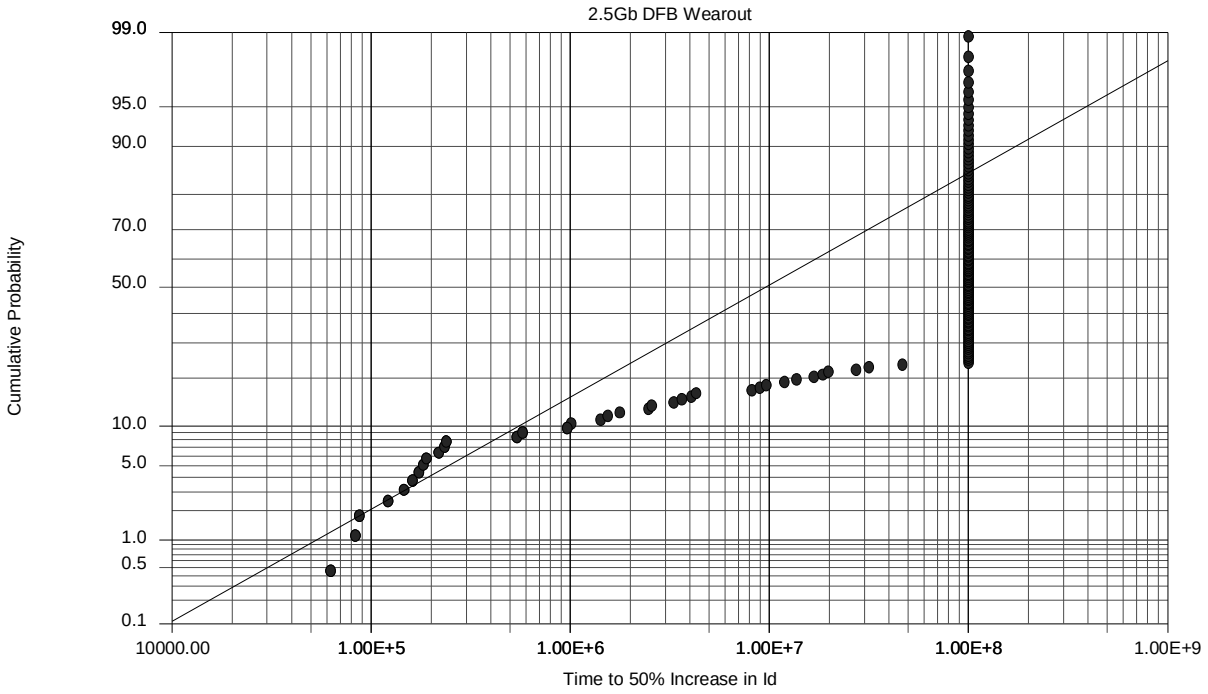

Figure 1 - Cumulative Probability Distribution of Predicted Lifetimes for 9 Well DFB Lasers at +95 °C

Note: Default readings of 1 x 10^8 hours indicate that enough degradation was not evident to extrapolate to the end of life condition.
To more accurately describe the behaviour of the data in the tail of the distribution, the line is fitted to all points below 1 x 10^6 (114 years) for a 50% increase in the drive. The statistics in Table 2 are derived from this fit.

Table 3 - 9 Well SMQW Laser HBM ESD Test Results

Wafer	Number of Devices	Mean ESD threshold at first change (kV)
2V581	5	1.8
4V581	5	1.9
5V581	4	2.2
1V842	5	2.0
2V843	5	2.0
1B509	5	2.6
3B509	5	2.7
5B509	8	1.5

Note:
Much higher ESD threshold level can be achieved at finished module level

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Malaysia, Singapore: (+65) 6271 2054
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Data subject to change.

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